GUNNISON SAGE-GROUSE RANGEWIDE CONSERVATION PLAN

April 2005

PLAN REPRESENTATIVES:
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National Park Service
Natural Resources Conservation Service
North American Mediation Associates
United States Forest Service
United States Fish and Wildlife Service
Utah Division of Wildlife Resources

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TABLE OF CONTENTS

APPENDICES

List of Figures

List of Tables

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I. EXECUTIVE SUMMARY

The Gunnison Sage-grouse Rangewide Conservation Plan is the culmination of almost 2 years of effort by the Rangewide Steering Committee and others. Yet in many ways, it is a continuation of a conservation planning process that began almost as soon as a Ph.D. student named Jessica Young verified her and other biologists' suspicions that the sage-grouse in Gunnison, adjacent areas in southwest Colorado, and a portion of southeast Utah were different than sage-grouse further north. Although not officially designated as a new species by the American Ornithologists' Union until 2000, the first local work group was formed in the Gunnison Basin in 1995, and their plan completed in 1997. Other local work groups quickly followed suit; local plans were completed for Crawford, Dove Creek and the San Miguel Basin populations in 1998, and for the Monticello (Utah), Piñon Mesa, and Poncha Pass populations in 2000.

This Rangewide Conservation Plan is intended to supplement local plans, and to offer a rangewide perspective, so as to ensure that the cumulative result of conserving local populations is conservation of the species. It is intended as guidance to aid in the Gunnison sage-grouse conservation efforts of federal land management agencies, various industry groups, the Colorado Division of Wildlife, and the Utah Division of Wildlife Resources, as well as local work groups. While we hope and trust that it will serve as a blueprint for management actions by these groups and others, and as a catalyst for increased attention and action, it is not a legal document, a regulatory document, a Recovery Plan under the Endangered Species Act (ESA), nor a NEPA (National Environmental Policy Act) decision document. Representatives of the U.S. Forest Service, Bureau of Land Management, National Park Service, and Fish and Wildlife Service participated in the preparation of this plan, but these agencies will consider this guidance as well as other information following established public participation protocols when preparing decision documents under NEPA or the ESA.

We include substantial information on Gunnison sage-grouse that was not available to local work groups when their plans were developed, such as new information on biology, genetic diversity, habitat use, population estimation, and a population viability analysis. We analyzed the capability of habitats to support grouse, and evaluated threats to local populations. For these reasons we strongly suggest local work groups review the Rangewide Conservation Plan in its entirety, update their local plans, and adopt the conservation strategies proposed in order to meet or exceed population and habitat target ranges identified.

A guiding philosophy of this plan is that conservation works best when implemented at the most local level possible. Maintaining sustainable local economies will in the long run be the most cost-effective and socially acceptable means to conserve Gunnison sage-grouse. It was our intent that this plan would provide the scientific basis upon which local and rangewide conservation efforts could be based.

Gunnison sage-grouse occupy a small fraction of their historical range, having been extirpated by habitat conversion from much of their presumed historical distribution in southwest Colorado, southeast Utah, northeast Arizona, and northern New Mexico. Distribution was probably always somewhat fragmented, but fragmentation has been greatly exacerbated by habitat loss. Currently (2004 data), we estimate approximately 3,200 breeding birds occur in 7 populations, approximately 2,400 of which occur in the Gunnison

Basin. Gunnison sage-grouse have relatively low genetic diversity compared to greater sage-grouse, and genetic information suggests most populations are isolated from each other.

Potential threats to Gunnison sage-grouse are varied, but numerous. Low genetic diversity, genetic drift from small population sizes, habitat issues (loss, degradation, and fragmentation from a variety of causes), the interaction of these with predator communities, and impacts of drought are the most significant threats facing Gunnison sage-grouse. Of these, by far the greatest threat is the permanent loss, and associated fragmentation and degradation of sagebrush habitat associated with urban development and/or conversion. We employed a spatially explicit model in an attempt to predict where most urban growth would occur between now and 2020, and evaluated parcel sizes as an index to short-term risk. The immediacy and extent of this threat varies from population to population and within subpopulations. Nevertheless, some level of land use planning, easements, fee-title acquisitions, or voluntary agreements not to develop private land, will be necessary in all populations.

A population viability analysis was conducted with *VORTEX* software as an aid to setting population size targets, and to determine which demographic parameters of sage-grouse influence population growth rates the most. *VORTEX* is a stochastic, individually based model, which means variability in survival and recruitment rates is incorporated. We also incorporated a severe drought into the model, which increased chick mortality over a 3-year period with a probability of occurrence of 1 in 100 years. Impacts of "normal" (less severe) droughts should be factored into the mean and variance of survival and recruitment rates used. The model suggested that chick mortality, followed by adult female mortality, most strongly influenced population growth rates. Relative extinction probabilities during a simulated 50-year period were very high for very small populations (less than 25 birds), and low (0 to 0.8%) for populations of 3,000 birds. Populations could only be considered "secure" (95% probability of persistence at stable growth rates) if they contained 500 or more individuals. Modeled loss of genetic diversity after 50 years was significant at all population sizes, but a population size of 3,000 retained 92-94% of genetic diversity initially present. Somewhat simplistic models of augmentation suggested extinction probabilities could be lowered substantially, and genetic diversity retention could be increased greatly, by supplementing small populations, if and when population sizes decline precipitously.

We evaluated alternative models for how sage-grouse population size increases as the amount of available habitat increases. The model in which sage-grouse populations increased linearly with increasing habitat size (no density dependence) was the best fit to the data. We used this model to estimate how many birds each population could support given the amount of habitat within currently occupied areas and other areas that could possibly be used with habitat improvement. Although habitat improvement could increase populations above modeled estimates, this analysis suggested that population targets in several local conservation plans are probably not achievable, given the amount of current and potential habitat.

Conservation strategies were identified for all significant threats to Gunnison sage-grouse, with a conservation goal of retaining large enough populations within the Gunnison Basin and elsewhere to have less than a 1% modeled risk of extinction, and to retain over 90% of genetic diversity over this 50-year time frame. While the Gunnison Basin is clearly the cornerstone for the preservation of this species, smaller populations retain 25% of the overall genetic diversity (not found in the Basin), and collectively represent a sizable pool of individuals to buffer catastrophic, unforeseen losses in the Gunnison Basin. Population targets were recommended for each population based on an assessment of current and potential habitat, potential habitat improvements, and conservation needs. Targets represent an expected long-range average, along with a range of variation expected around this long-term average: Gunnison – 3,000 (range 1,730-5,280), San Miguel Basin – 450 (260-792), Monticello, UT – 300 (173-528), Dove Creek – 200 (115-352), Crawford – 275 (159-484), Piñon Mesa – 200 (115-352), and Poncha Pass – 75 (43-132).

To achieve and maintain these population targets, we identified local conservation strategies and local habitat protection goals. The most significant threat to Gunnison sage-grouse is permanent habitat loss from urban development or conversion. To meet these goals we recommend protecting 90% of all habitats currently occupied, or that become occupied through future expansion, through some combination of voluntary agreements, land use planning, easements, fee-title acquisition or land trades. We also present habitat guidelines to serve as a benchmark against which to evaluate habitat conditions, and develop strategies to minimize habitat degradation from other causes.

The Rangewide Conservation Plan is the first up-to-date and rigorous assessment of rangewide population and habitat data for Gunnison sage-grouse. However, it was evident in developing this plan that there are many gaps in our knowledge about Gunnison sage-grouse and sagebrush habitat, particularly in the context of a constantly changing landscape. Therefore, the Steering Committee recognizes the need to continually reevaluate and revise local and rangewide conservation plans in the light of new information, tools, and techniques, as part of an adaptive management process. An adaptive management program is an iterative process that uses information from research and monitoring projects to evaluate the relative effectiveness of alternative management plans, identify where important information is lacking, and to develop more effective management plans in order to accomplish the population and habitat goals of the Rangewide Plan. The Steering Committee will develop and implement an objective and quantitative adaptive management program in cooperation with the signatories of the Rangewide Plan and the local work groups.

II. INTRODUCTION

A. Purpose

The Gunnison Sage-grouse Rangewide Conservation Plan (RCP) is intended to help reach the goal of increasing the current abundance and viability of Gunnison sage-grouse and their habitat. The purpose of the plan is to identify measures and strategies to achieve this goal. This will be accomplished by providing guidance, recommendations, and a rangewide perspective on Gunnison sage-grouse management to local work groups and other interested or affected parties and stakeholders.

The concern that led to the development of the RCP is that local conservation efforts may be sufficient to protect a local population of Gunnison sage-grouse (GUSG), but collectively they may be insufficient to conserve the species. Local conservation plans typically do not consider broader scale issues such as variation in genetic diversity among populations, regional population dynamics, dispersal, or landscape structure (e.g., habitat connectivity between populations or configuration of important habitat).

In addition, the 7 GUSG local conservation plans were written prior to publication of the U. S. Fish and Wildlife Service's (USFWS) Policy for Evaluation of Conservation Efforts (PECE) standards. The USFWS now uses the PECE standards as a guideline in determining whether, and to what extent, conservation plans will be considered when making listing and listing priority decisions. The RCP will provide guidance to local conservation groups and assist them in meeting the PECE standards through their conservation efforts.

It is our intent that the RCP will build upon the foundation established by the local conservation plans. This rangewide plan was developed as a resource upon which local conservation decisions can be based. This plan will supplement, not replace, local plans and the locally driven process that created them. The RCP will present the best available science for assessing target population goals and genetic diversity, as well as an assessment of possible tools to help reach these goals. Few conservation strategies are likely to be added to those already described in local conservation plans. However, this rangewide plan should assist local work groups and other stakeholders in prioritizing strategies, determining where to focus habitat improvements, refining techniques, and managing disturbances (see "Local Conservation Targets and Strategies", pg. 255). The Colorado Division of Wildlife (CDOW) and Utah Division of Wildlife Resources (UDWR) have the lead on implementation of the rangewide strategies recommended within the RCP ("Rangewide Conservation Strategies", pg. 202), until an implementation plan is complete.

The RCP is neither a National Environmental Policy Act (NEPA) decision document, nor a federal recovery plan. Any Candidate Conservation Agreement with Assurances (CCAA; see pg. 59 for details) developed by CDOW will be based on the RCP, and will include a NEPA process. Agency-specific use of this plan is outlined in each agency's respective signature page.

B. Goals and Scope of the RCP

The RCP goals are divided into 2 categories: Assessment and Strategy Goals. The goals are not listed in any particular order.

Assessment Goals:

The RCP will provide an assessment of the status of each population by accomplishing the following 5 goals:

1. Estimate current population size, amount and status of habitat, degree of genetic isolation, potential for recovery, potential for expansion, and odds of maintaining long-term protection.
2. Identify research needs and knowledge gaps.
3. Determine population and habitat requirements needed to sustain GUSG for the future.
4. Identify and discuss threats and issues that potentially impact GUSG, including those not covered in the local plans.
5. For each local GUSG conservation plan, assess the compliance with the USFWS PECE criteria and describe all threats to GUSG under the 5 USFWS listing factors.

Strategy Goals:

The aim of the RCP is to maintain, and increase where possible, the current abundance and viability of GUSG populations and habitats by accomplishing the following 7 goals:

1. Incorporate management strategies and options from local planning efforts and solicit participation in meeting RCP goals and objectives.
2. Develop and distribute information on management practices that result in diverse and productive sagebrush habitat.
3. Identify and promote beneficial rangewide conservation actions (e.g., potential habitat linkages and transplants as a means to maintain or enhance genetic diversity).
4. Increase public education and awareness of GUSG.
5. Address threats and risks and prioritize issues, by population, from a rangewide perspective (to aid in prioritizing management actions).
6. Identify funding sources and develop a process to set priorities for populations to receive funding for conservation easements, habitat improvements, fee titles, etc.
7. Upon completion of the RCP, have cooperating state and federal agencies sign a signatory page setting priorities for consideration of committing resources to this effort.

Scope

Conservation strategies, including transplants of GUSG to suitable but currently unoccupied range within historical range, will be considered within Colorado and Utah only. Thus, throughout the RCP, the word “rangewide” refers to GUSG range only within Colorado and Utah. Arizona and New Mexico, where GUSG were historically found, have chosen not to participate in this planning process. It is hoped that the scientific assessment, strategies, and guidelines contained within this plan can assist these states as they consider the potential for reintroduction and management of GUSG in their states.

C. Guiding Principles and Philosophy of the Gunnison Sage-grouse Rangewide Conservation Plan

The guiding principles of this plan are to (1) encourage and support conservation actions that meet the needs of GUSG and that promote diverse economic communities or minimize impacts to communities; (2) manage for a healthy sagebrush steppe ecosystem so that other sagebrush obligate species in the system will benefit; (3) create a plan that will be flexible enough to incorporate GUSG research findings and successful management practices into conservation actions (4) acknowledge the pivotal role private landowners and local work groups play in the recovery effort; and (5) maintain an atmosphere of cooperation, participation, and commitment among wildlife managers, landowners, private and public land managers, other stakeholders, and interested public in development and implementation of conservation actions.

Managing for sustainable local economies is a conservation philosophy that guides this plan because its authors and signatories believe that sustainable local economies are essential to successful conservation of the GUSG. Ultimately, the hope is to achieve within GUSG range “civic environmentalism” (Shutkin 2000:14). Shutkin (2000:22) asserts, “the best kind of American environmentalism fundamentally entails a holistic approach to environmental problems in that those problems and their solutions are seen as inextricably linked to social, political, and economic issues—what I collectively refer to as civic issues because each is directly associated with the quality of life of civil society, of community life in its totality”.

Shutkin (2000) perceives civic environmentalism as a stage of environmentalism with interest groups working together rather than vying to defeat each other. It is a process and an end point that reaches consensus and makes long-term plans that benefit both the environment and the community. He describes an explicit link between environmental problem solving and the goal of community building. Protecting the environment (and species within it) is joined to civic health and sustainable local economies; it becomes the ultimate expression of local control.

In a case study, Shutkin (2000:189) describes a conservation-based effort in the Elk River Valley in Routt County, Colorado. He summarizes the effort as follows: “Blending their agricultural, economic, and cultural concerns with a conservation and open space focus, the ranchers formulated a conservation-based development strategy to protect the area's rural heritage and ecology. They wanted to protect in perpetuity the open and productive character of the area that comprises the basis of its economic vitality. Unlike traditional conservation efforts, they were intent on protecting the area as a whole, not just islands of land, with working landscapes as a main feature" (Shutkin 2000:199). This group of ranchers partnered with environmentalists and citizens to defeat the proposed Catamount ski area. As a result they developed the Upper Elk River Valley Compact. This compact developed a set of planning and implementation principles that ultimately led to a county-wide plan to protect important wildlife habitat and open space while allowing growth and development. Great Outdoors Colorado (GOCO), a lottery-funded program that supports outdoor values including protection of wildlife, contributed $250,000 towards the first round of easements. GOCO then followed with a legacy grant of $6 million for Yampa River System protection. Recognizing that conservation easements cannot compete with developers dollar for dollar, this same group of ranchers developed a variety of marketing strategies to make sheep and cattle ranching profitable.

Similar approaches are used in addressing environmental problems. The Nature Conservancy (The Nature Conservancy 2004) describes economic sustainability as a key value: "We respect the needs of local communities by developing ways to conserve biological diversity while at the same time enabling humans to live productively and sustainably on the landscape. We know that lasting conservation success requires the active involvement of individuals from diverse backgrounds and beliefs, and we value the unique contributions that each person can make to our cause."

Zeller (1999:6) describes "community stewardship" which "takes the lessons of active land management practiced on individual properties and applies these on a community wide or landscape basis for the long-term benefit of the land, people and economy. Community stewardship focuses on large land complexes or regions and a process to tie the local and regional community to effective and long-term management of its natural resources."

Adopting support of sustainable local economies as a cornerstone of the RCP will help ensure its effectiveness and will avoid the obvious ecological consequences of the alternative scenario. Shutkin (2000:196) concludes that, "...the all-too-common refrain in the Rocky Mountain West (is) that a rancher's last crop is a subdivision."

D. Plan Duration

The GUSG RCP is a dynamic document designed to change and adapt to the needs of GUSG as they are identified. The RCP is a long-term plan that will terminate when the GUSG is removed from the Colorado Species of Concern List in Colorado and the Utah Sensitive Species List. For Colorado, this list includes, "Any species or subspecies of native wildlife which (1) has been removed from the State threatened or endangered list within the last five years, (2) is a Federal candidate or is Federally proposed for listing and is not already state listed, (3) the best available data indicate a 5-year or more downward trend in numbers or distribution and this decline may lead to a threatened or endangered status, or (4) is otherwise determined to be vulnerable in Colorado" (Colorado Division of Wildlife 1999:3). In Utah, species on the sensitive species list include species that are federally listed, are candidates for federal listing, or for which there is "credible scientific evidence to substantiate a threat to continued population viability" (Utah Division of Wildlife Resources 2005:1).

E. Mechanics of the RCP

Process and Structure

A rangewide steering committee (RSC) (Table 1), facilitated by Cathleen Neelan of North American Mediation Associates, developed the concept and process for plan development. When "we" or "our" is used within the RCP, it refers to the RSC. The RSC has broad representation from state and federal agencies from both Colorado and Utah (Table 1). The role of the RSC members was to guide the development of the RCP and to represent their agencies. After completion of the RCP, representatives from all agencies on the RSC will continue to operate as a committee to address strategies (where specified) in the RCP "Conservation Strategy" section (pg. 201). The directors of CDOW and UDWR have the ultimate authority for the plan.

Table 1. Gunnison sage-grouse RCP steering committee members.

Name	**Agency / Role**
Tony Apa	Colorado Division of Wildlife
Brad Banulis	Natural Resources Conservation Service/Colorado Division of Wildlife
Myron Chase	National Park Service
Julie Grode	U. S. Forest Service
Terry Ireland	U. S. Fish and Wildlife Service
Cathleen Neelan	Facilitator, North American Mediation Associates, LLC.
Jenny Nehring	Technical Writer
Al Pfister	U.S. Fish and Wildlife Service
Mike Phillips	Colorado Division of Wildlife and Technical Writer
Tom Remington	Colorado Division of Wildlife
Pam Schnurr	Colorado Division of Wildlife
Robin Sell	Bureau of Land Management
Barbara Ver Steeg	Technical Writer / Editor
Guy Wallace	Utah Division of Wildlife Resources

The committee reviewed numerous examples of statewide and rangewide conservation plans for different species to determine the most appropriate approach for the RCP. In many of the examples local plans had not already been completed. In our case, having local conservation plans already in place influenced the public involvement and development process for the RCP. It was decided that the RCP should be an overarching plan that ties together all the local plans and supplements them with a scientific analysis.

Most of the local plans employed a consensus approach in making decisions. For decisions regarding the RCP, consensus was reached among representatives of the agencies serving on the RSC. Sections 5 and 6 of the Endangered Species Act (ESA) direct state and federal agencies to cooperate to develop conservation activities that protect candidate species. Because the responsibility rests with state agencies and their federal cooperators, the decision ultimately is limited to them. Nevertheless, all agencies felt it was important to involve the public as much as possible in the RCP process, to garner support at the critical local level.

Public participation methods were used in association with the decision making process (Fig. 1). For the RCP, the decision and public involvement process is some place in the middle of the illustrated continuum, a decision with repeated opportunities for input and recommendations from stakeholders (Fig. 1). The far right of the decision-making process represents a consensus decision, the approach used for local plans; the far left of the decision process involves no pubic input and the responsible agencies make all decisions (Fig. 1).

Decision by Vested Power Alone	Decision with Minimal Input for Informed Consent	Decision with Repeated Opportunity to Provide Input	Decision Based on Recommended Stakeholder Consensus	Stakeholder Consensus Decision Making

DECISION-MAKING PROCESS

←less public involvement-----------------------------------more public involvement→

PUBLIC PARTICIPATION METHODS

No Public Input or Involvement	Public Hearings for Comment on Proposed Action	Series of Public Involvement Steps with Focus/work Groups	Direct Negotiations among Key Stakeholders	Stakeholder Negotiations Leading to Implementable Decision

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Fig. 1. Decision making process and public participation methods models.

The structure of the RCP resembles traditional conservation plans, with both a conservation assessment and a conservation strategy, but it also includes a section that separately details and analyzes potential threats to GUSG. The assessment was based on information extracted from local plans, and was then supplemented with the most contemporary research and scientific findings. For the strategy section we considered many of the same issues as the local plans, but added broader scale issues such as genetics, dispersal, and habitat linkages between populations. In order to understand the rangewide perspective of the importance and role of local populations to the future of GUSG , it is recommended that the reader go through the entire plan rather than focus solely on sections relating to a single population.

The writing style used for the plan generally follows that of the Journal of Wildlife Management, although we used English, rather than metric, measurements throughout. Scientific names of organisms are not provided in the text if a common name exists; all scientific names are provided in Appendix A (listed alphabetically by common name). A glossary of terms used in the plan follows the "Conservation Strategy", as does a list of acronyms (Appendix B). Lists of figures and tables immediately follow the "Table of Contents".

Information and Data Sources

We primarily relied on peer-reviewed scientific literature and graduate theses/ dissertations as supporting information in the RCP. However, as is the case for many wildlife species, important and reliable information for GUSG can be found in agency reports, both those with peer-review and those without. We used these agency sources when they were the only available information, or when they contributed significantly to available information on a particular topic. Likewise, we used internet web sites for information when necessary, citing the date the site was accessed.

Scientific Assessment and Review

To address broad scale, complex issues, a group of scientists was used (Table 2). Individuals were selected for this team because of their impartiality and/or technical expertise in a relevant scientific area. The RSC was unsuccessful in finding a neutral range management scientist familiar with sage-grouse research in a timely fashion to serve on this team. However, Robbie Baird-LeValley, a Colorado State University (CSU) extension agent, was consulted in development and review of grazing sections of this document.

The science team assisted in conducting an analysis of conservation needs for maintaining GUSG populations. "Conservation need" was interpreted broadly and included minimum viable population size, desired genetic diversity, and necessary habitat quantity and condition. The team was also charged with compiling best management practices for the sagebrush steppe that would aid in preserving/restoring the habitat base necessary. The Ecological Society of America was contracted to conduct a double blind review (4 reviewers) of the draft RCP (see "Technical Review" in Fig. 2). The review process was facilitated by the Western Association of Fish and Wildlife Agencies (WAFWA) and the RSC addressed input from the reviewers.

Table 2. Scientists who assisted in conducting analyses of GUSG population conservation needs for the GUSG Rangewide Conservation Plan.

Discipline	**Science Team**
Sage-grouse Biology	Dr. Tony Apa, Colorado Division of Wildlife Dr. Michael Phillips, Colorado Division of Wildlife Dr. Tom Remington, Colorado Division of Wildlife
Behavioral Ecology	Dr. Robert Gibson, University of Nebraska
Genetics	Dr. Sara Oyler-McCance, U.S. Geological Survey/Denver University Dr. Tom Quinn, Denver University
Population Ecology (Modeling)	Dr. Philip Miller, Conservation Breeding Specialist Group
Ecology and Restoration of Sagebrush Rangelands	Steve Monsen, U.S. Forest Service Shrub Sciences Lab, retired Dr. Alma Winward, U.S. Forest Service, retired
Spatially Explicit Modeling of Housing Development	Dr. David Theobald, Natural Resource Ecology Lab, Colorado State University
Modeling Habitat Quantity and GUSG Population Size	Dr. Michael Phillips, Colorado Division of Wildlife

Public Participation Process

In developing the RCP we relied on the 7 local conservation plans for our initial information. There was some diversity in issues, interest, and needs of stakeholders. The RSC, believing that stakeholder input and support are essential to the success of the plan, designed a public participation process (Fig. 2) offering several opportunities for public input.

The first opportunity for public input was an Issue Assessment conducted by the RCP facilitator. Approximately 38 stakeholders were contacted for one-on-one confidential interviews. The individuals who provided a diversity of opinions and interests were involved in development of the local conservation plans, representatives of organizations or special interest groups, petitioners, or others with vested interests in GUSG. The objective of these confidential interviews was to identify stakeholder interests and needs that might be addressed in the RCP. This information was summarized in a report and presented to the RSC with recommendations to consider during the development of the plan.

The second opportunity for public participation was at a Gunnison Sage-grouse Conference held in Norwood, Colorado, in September, 2003. During this conference, attendees (approximately 150-200 people) were provided an opportunity to discuss the RCP, their ideas for managing the species at the rangewide level, and prioritization of actions across the species' range. This was the first chance for many people to hear about the RCP and to learn about other local plans. Attendees' comments and suggestions were compiled and reviewed by the RSC.

A third opportunity for public input was offered in October, 2003 (the early writing stages of the plan). The RSC traveled to 6 different communities in south-central and southwestern Colorado, and eastern Utah, to meet directly with the work groups and other interested stakeholders. During these meetings ("Focus Group Meetings"), the RSC sought input from attendees and answered questions about the intent of the RCP. Valuable comments emerged from these discussions, and some of them resulted in altering the content of the RCP.

For regular updates on the RCP, interested members of the public were able to check the website (hosted by CDOW) for the plan (http://wildlife.state.co.us/species_cons/Gunnison_sage_grouse/index.asp). During the development of the RCP, items of interest, RCP progress, and several frequently asked questions were posted on this website.

Finally, stakeholders were provided an opportunity to review and comment on the draft RCP. These reviewers provided comments and recommendations to be considered for incorporation into the final version of the plan. Once the RCP is completed it will be provided to local work groups for consideration and incorporation into their plans, where, and if necessary. Because the RCP is a dynamic plan, further research will be continually incorporated and appropriate modifications will be made to the plan. Ultimately, the success of this plan and the conservation of GUSG will rely on conservation actions taken by local work groups and land managers within each population area.

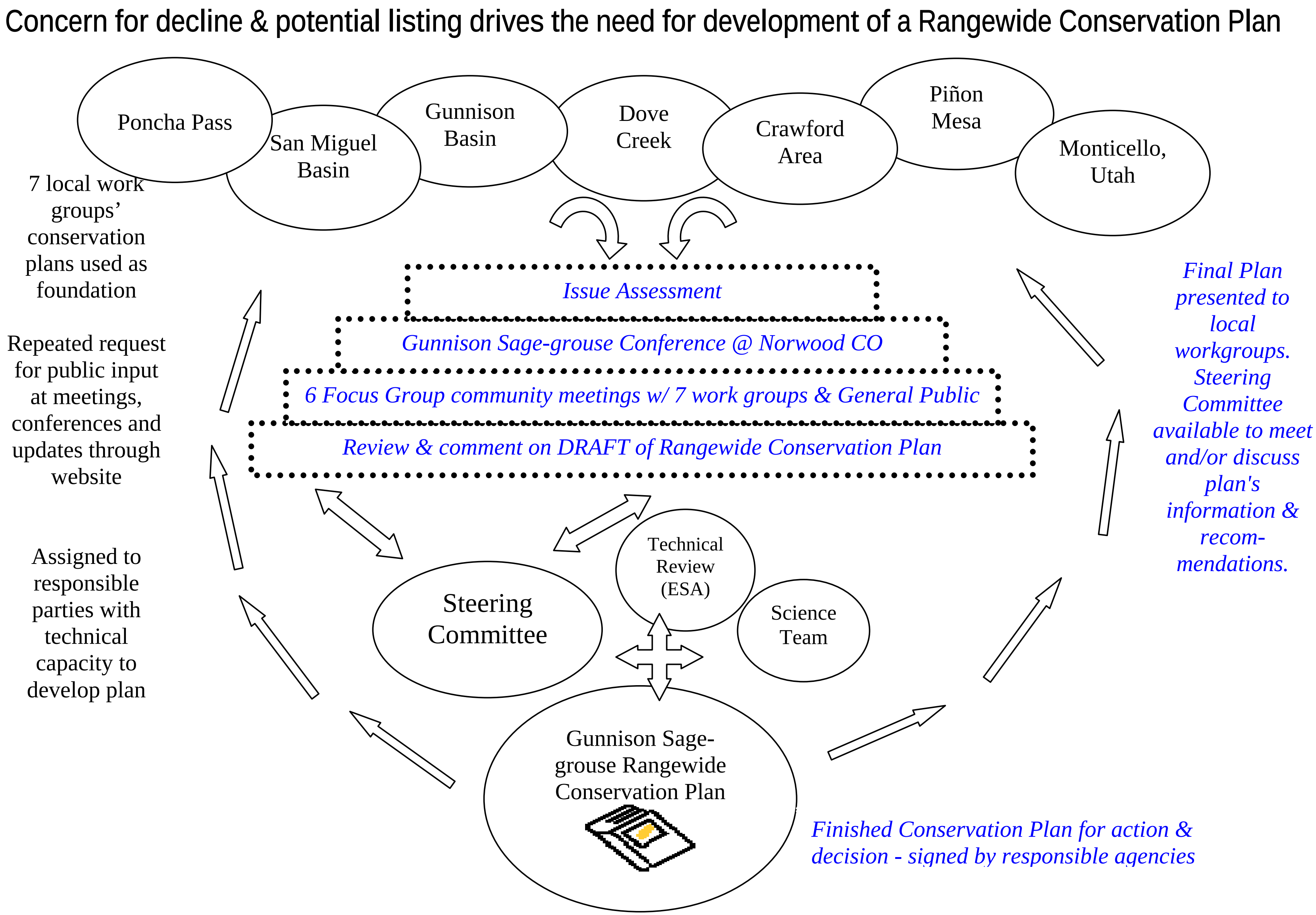


Fig. 2. Public participation model for rangewide conservation plan for Gunnison sage-grouse.

F. Socio-economic Considerations Including Consequences of Federal Listing

State and federal agencies involved in implementation of the RCP will coordinate with landowners, county, and local governments to develop the best solutions for GUSG conservation while maintaining social and economic values to the maximum extent possible. The RCP was developed to address issues of rangewide concern for the GUSG but is not intended to replace local conservation plans. Consequently, it is intended to work within local conservation plan considerations of social and economic values.

In the event of federal listing of GUSG under the ESA, the USFWS will use the RCP and local conservation plans as the basis to develop a federal recovery plan (FRP). The FRP will also seek to maintain social and economic considerations to the maximum extent possible while ensuring the survival and recovery of GUSG. In fact, in the July 1, 1994, Federal Register (59 FR 34272) the USFWS issued a policy stating that the USFWS will involve stakeholders in FRP preparation to minimize the social and economic impacts of implementing recovery actions. There are also funding and incentive programs to facilitate socio-economic considerations and conservation of the GUSG (Appendix C).

G. Management and Legal Authorities

There are many state, federal, and county regulations that offer protection to GUSG. Both Colorado and Utah have state laws and regulations to restrict possession of GUSG. Funding programs in both states support population and habitat conservation actions. Federal agencies including the Bureau of Land Management (BLM), United States Forest Service (USFS), National Park Service (NPS), Natural Resources Conservation Service (NRCS), and USFWS have laws, regulations, policies, and funding programs that authorize and support conservation actions for habitat and population management. In Colorado, several of the counties have provisions for wildlife and/or sage-grouse conservation.

Colorado Division of Wildlife

The CDOW, a branch of the Colorado Department of Natural Resources, has responsibility for the management and conservation of wildlife resources within state borders, including the conservation and management of threatened and endangered species, as defined and directed by state laws (i.e. Colorado Revised Statutes, Title 33 Article 1). Title 33 Article 1-101, Legislative Declaration states: “It is the policy of the State of Colorado that the wildlife and their environment are to be protected, preserved, enhanced and managed for the use, benefit, and enjoyment of the people of this state and its visitors. It is further declared to be the policy of this state that there shall be provided a comprehensive program designed to offer the greatest possible variety of wildlife-related recreational opportunity to the people of this state and its visitors and that, to carry out such program and policy, there shall be a continuous operation of planning, acquisition, and development of wildlife habitats and facilities for wildlife-related opportunities.”

In addition, the 5-year Strategic Plan for CDOW, adopted by the Colorado Wildlife Commission on January 11, 2002, emphasizes the importance of wildlife conservation. The plan lists 10 management principles, or 'core beliefs' that guide the agency in fulfilling its mission; these beliefs underscore the importance of wildlife conservation and maintenance of healthy, diverse and abundant wildlife. A specific section of this plan addresses species conservation. The vision statement of this section states: "Recognizing the pitfalls of single species management, the CDOW will emphasize the development of management approaches encompassing multi-species communities across the landscape. The CDOW defines species conservation as conserving, protecting, and enhancing Colorado's native wildlife, by taking the actions necessary to assure the continued existence of each species and thereby precluding or eliminating the need for state and/or federal listing. The CDOW will form partnerships with landowners, land management agencies, and others to manage, protect, enhance, and restore wildlife and their habitat. The CDOW will lead efforts to monitor wildlife communities and manage them as needed to prevent their decline. The CDOW will work aggressively with others to recover threatened and endangered species. The CDOW encourages partnerships to share in the vision to protect, enhance, and restore wildlife communities that need assistance to survive." The CDOW has authority to regulate possession of the GUSG, set hunting seasons, and issue citations for poaching of GUSG. In 2000, the CDOW closed the hunting season for GUSG in the Gunnison Basin, the only area then open to hunting for the species.

Utah Division of Wildlife Resources

Title 23 of the Utah Code is the Wildlife Resources Code of Utah and provides the UDWR the powers, duties, rights, and responsibilities to protect, propagate, manage, conserve, and distribute wildlife throughout the state. Section 23-13-3 declares that wildlife existing within the state, not held by private ownership and legally acquired, is property of the state. Sections 23-14-18 and 23-14-19 authorize the Utah Wildlife Board to prescribe rules and regulations for the taking and/or possession of protected wildlife. The hunting season for GUSG in Utah has been closed since 1989.

UDWR's wildlife management philosophies are reflected in its Mission Statement and Strategic Plan. The mission of the UDWR is to assure the future of protected wildlife for its intrinsic, scientific, educational, and recreational values through protection, propagation, conservation, and distribution throughout the state of Utah. The UDWR Strategic Plan calls for focusing efforts on increasing the abundance, distribution, and range for species of conservation need by sustaining and restoring habitat functions. A ten-year comprehensive wildlife conservation plan for Utah will be developed and implemented to address species/habitats of conservation need, their priorities, and the necessary actions and future changes.

Counties

The Board of County Commissioners of Gunnison County, Colorado, has: (1) the authority to protect and promote the health, welfare and safety of the people of Gunnison

County; (2) the authority to regulate land use, land planning and quality and protection of the environment in Gunnison County; and (3) has duly adopted regulations to exercise such authorities including the review, approval or denial of proposed activities and uses of land and natural resources. Section 5-206 of the Gunnison County Land Use Resolutions adopted in 2001, promotes conservation for sage-grouse and other wildlife through restriction and mitigation of development. Several of the other Colorado counties within current GUSG range in Colorado (Dolores, Mesa, Montrose, and San Miguel Counties) have general provisions for consideration of wildlife in development plans.

United States Forest Service

The United States Department of Agriculture (USDA) Forest Service (USFS) has authority for conservation of the GUSG through: 1) the Multiple Use-Sustained Yield Act (MUSY) of 1960 (P.L. 86-517, 74 Stat. 215, 16 U.S.C 528(note), 528-531); 2) the Sikes Act of 1960 (P.L. 86-797, 74 Stat. 1052, 16 U.S.C. 670 et seq., as amended); 3) the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (P.L. 93-378, 88 Stat. 476, as amended; 16 U.S.C. 1600(note), 1600-1614); 4) the National Forest Management Act (NFMA) of 1976 (P.L. 94-588, 90 Stat. 2949, 16 U.S.C. 472 et seq.) and its implementing regulations (36 CFR 219); 5) Public Rangelands Improvement Act of 1978 (P.L. 95-514, 92 Stat. 1806, 43 U.S.C. 1901-1908); and 6) USDA Regulation 9500-4 and the Forest Service Manual (FSM) Chapter 2600. MUSY directs the USFS to administer the National Forests for outdoor recreation (including wilderness), range, timber, watershed, and wildlife and fish purposes, in cooperation with interested State and local governmental agencies and others. "Multiple use" means the harmonious and coordinated management of the various surface renewable resources so that they are utilized in the combination that will best meet the needs of the American people. The Sikes Act provides authority for cooperative planning, habitat improvement, and providing adequate protection for threatened or endangered species under the Endangered Species Act of 1973 or species considered to be threatened, rare, or endangered by the State agency. RPA and NFMA provide for comprehensive, integrated planning that will provide for the diversity of plant and animal communities to meet overall multiple-use objectives. USDA Regulation 9500-4 directs the USFS to manage "habitats for all existing native and desired nonnative plants, fish and wildlife species in order to maintain at least viable populations of such species." USFS policy states: "To preclude trends toward endangerment that would result in the need for federal listing, units must develop conservation strategies for those sensitive species whose continued existence may be negatively affected by the forest plan or a proposed project." (FSM 2621.2)

Natural Resources Conservation Service

The USDA NRCS has authority for conservation of GUSG through: (1) the Soil Conservation and Domestic Allotment Act of 1936, as amended (PL 74-46; (2) the Department of Agriculture Reorganization Act of 1994 (PL 103-354; 7 U.S.C. 6962); and (3) the Farm Security and Rural Investment Act (Farm Bill) of 2002 (PL 107-171).

Bureau of Land Management

The United States Department of Interior (USDI) BLM has authority for conservation of GUSG through: (1) the Federal Land Management Policy Act (FLMPA) of 1976 (43 U.S.C. 1701 et seq.; 90 stat. 2743; PL 94-579; (2) the Sikes Act, Title II (16 U.S.C. 670 et seq.), as amended; and (3) the BLM Manual 6840, Special Status Species Management. Specifically, the FLMPA guidance on sensitive species authorizes that "the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air, and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals… (43 USC 1701 Sec. 102 (a) (8))."

Section 06 (C) of the 6840 Manual gives the following guidance on candidate species: "Consistent with existing laws, the BLM shall implement management plans that conserve candidate species and their habitats and shall ensure that actions authorized, funded, or carried out by the BLM do not contribute to the need for the species to become listed." Specific BLM guidance is outlined in the 6840 Manual. Section .12 of the 6840 Manual states: "Actions authorized by BLM shall further the conservation of federally listed and other special status species and shall not contribute to the need to list any special status species under provisions of the ESA, or designate additional sensitive species under provisions of this policy." The Department of Interior Fish and Wildlife Policy: State-Federal Relationships (43CFR Part 24.4 (c)) states in part that "…the Secretary of Interior is charged with the responsibility to manage non-wilderness BLM lands for multiple uses, including fish and wildlife conservation. In addition, the RCP is consistent with the BLM National Conservation Strategy for Sage-grouse (Bureau of Land Management 2004b).

United States Fish and Wildlife Service

The USDI USFWS has authority for conservation of the GUSG through: (1) the ESA of 1973, as amended; (2) the Fish and Wildlife Act of 1956, as amended; and (3) the Fish and Wildlife Coordination Act, as amended. Congress, in Section 2 of the ESA, declares that there is value in having incentives for conservation, and Section 5 of the Act, as amended in 1978, provides authority for agencies to engage in conservation activities for the protection of candidate species. Section 6 of the ESA directs that the "Secretary shall cooperate to the maximum extent with the states..." (16 U.S.C. 1535(a)). The Secretary of Interior may also authorize states for monitoring the status of candidate species (16 U.S.C. 1535(c)). The Fish and Wildlife Act of 1956, as amended, and the Fish and Wildlife Coordination Act, as amended, give authorities to the USFWS for enhancement of all fish and wildlife species and mitigation of impacts to fish and wildlife, particularly from Federal water development projects. The Federal Aid and Wildlife Restoration Act of 1937 (Pittman-Robertson Act), as amended, serves as the principal mechanism for providing federal assistance to states for the acquisition, restoration, and maintenance of wildlife habitat, for the management of wildlife areas and resources, and for research into problems of wildlife management (16 U.S.C. 669-669i).

National Park Service

The USDI NPS has authority for conservation of the GUSG through the 1916 NPS Organic Act (16 USC 1) which charges the NPS with management of parks to "... conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Additional authorities that guide the NPS are found in the General Authorities Act of 1970 (16 USC 1c(a)) and the Redwood Act of 1978 (16 USC 1a-1). Furthermore, the Presidential Proclamation establishing Black Canyon of the Gunnison National Monument (Proclamation No. 2033; March 2, 1933; 17 Stat. 2558), and the Memorandum of Agreement between the NPS and Bureau of Reclamation dated February 11, 1965, provide authorities for protection of the GUSG at Black Canyon of the Gunnison National Park and Curecanti National Recreation Area.

NPS Management Policies and the NPS-77 Natural Resources Management Guideline state that the NPS will seek to perpetuate the native animal life as part of the natural ecosystem of parks. They further define Species of Concern as all native animal species within a park that face an immediate danger of losing their natural role in an ecosystem because of human-induced change, which would include the GUSG. Regarding Species of Concern, NPS-77 states that the NPS should also look for opportunities to enter into cooperative and interagency agreements and memoranda of understanding with other federal and state agencies on research, monitoring, and management of the Species of Concern, and, where appropriate, promulgate regulations. The NPS must strive to protect the natural conditions and processes and the ecosystem integrity to the greatest extent possible for Species of Concern.

NPS-77 further states, "Management of Candidate species should, to the greatest extent possible, parallel the management of federally listed species." The NPS Management Policies identifies the management of threatened or endangered plants and animals as follows: "The Service will survey for, protect, and strive to recover all species native to national park system units that are listed under the ESA. The Service will fully meet its obligations under the NPS Organic Act and the ESA to both proactively conserve listed species and prevent detrimental effects on these species."

Memoranda of Understanding

In addition to the authorities listed above there are 2 Memoranda of Understanding (MOU) that promote conservation of the GUSG. The first, between members of WAFWA, was signed in July 1999 to promote conservation and management of sage-grouse and the sagebrush habitat upon which they depend. The 1999 MOU was signed by members of 13 states and 2 Canadian provinces who are members of WAFWA. The second MOU is between WAFWA, USFS, BLM, and USFWS. The MOU was signed in August 2000, and its purpose is to provide for cooperation among state, provincial, and federal agencies in development of a rangewide strategy for the conservation of sage-grouse and their sagebrush habitats.

H. PECE Standards

The ESA requires the USFWS to assess conservation efforts to protect a species. The PECE identifies criteria the USFWS will use in determining whether formalized conservation efforts that have yet to be implemented or shown to be effective contribute to making listing a species as threatened or endangered unnecessary. This policy applies to conservation efforts identified in conservation agreements, conservation plans, management plans, or similar documents developed by federal agencies, state and local governments, tribal governments, businesses, organizations, and individuals, or a combination of the above. The purpose of PECE is to ensure consistent and adequate evaluation of formalized conservation efforts and to guide development of conservation efforts that will sufficiently improve a species' status. Ultimately, successful PECE compliance would make listing the species unnecessary.

The PECE contains 9 criteria the USFWS will use to determine the certainty that the conservation effort will be implemented, and 6 criteria the USFWS will use to determine the certainty that the conservation effort will be effective. These criteria should not be considered comprehensive evaluation criteria. The certainty that a formalized conservation effort will be implemented and effective may also depend on species-, habitat-, location-, and effort-specific factors. The USFWS will consider all appropriate factors in evaluating formalized conservation efforts. The specific circumstances will also determine the amount of information necessary to satisfy these criteria.

The draft PECE was published on June 13, 2000 (65 FR 37102), and was finalized on March 28, 2003, (68 FR 15100-115). Although the local conservation plans pre-date PECE and do not cover all areas of existing GUSG range (specifically the Cerro Summit – Cimarron - Sims Mesa population), the plans include some criteria identified in the PECE. The RCP assesses how each local conservation plan complies with the PECE (Table 3). However, this assessment was conducted at a plan level, prior to explicit guidance on how to conduct PECE reviews. Subsequently, guidance has been provided that PECE reviews will be conducted for individual conservation actions (instead of for conservation plans). If the RCP undergoes a PECE review, it will be conducted during preparation of a listing decision and will follow the latest procedural guidance. Neither PECE review of the local conservation plans nor signature of the RCP by the USFWS constitutes a PECE review of the RCP.

Table 3. Evaluation of local conservation plans and PECE criteria.

	F = Fulfills entire criteria, P = Partially fulfills criteria, DN = Does not fulfill criteria.	GUNNISON SAGE-GROUSE POPULATION							
PECE Evaluation Factor	**Criteria**	**Cerro – Cimarron - Sims Mesa**	**Crawford**	**Dove Creek**	**Gunnison Basin**	**Piñon Mesa**	**Poncha Pass**	**Monticello Utah**	**San Miguel Basin**
A. The certainty that the conservation effort will be implemented.	1. The conservation effort; the party(ies) to the agreement or plan that will implement the effort; and the staffing, funding level, funding source, and other resources necessary to implement the effort are identified.	NO PLAN	P	P	P	P	P	P	P
	2. The legal authority of the party(ies) to the agreement or plan to implement the formalized conservation effort, and the commitment to proceed with the conservation effort are described.	NO PLAN	F	F	F	P	P	P	F
	3. The legal procedural requirements (e.g., environmental review) necessary to implement the effort are described, and information is provided indicating that fulfillment of these requirements does not preclude commitment to the effort.	NO PLAN	DN	DN	DN	DN	DN	DN	DN
	4. Authorizations (e.g., permits, landowner permission) necessary to implement the conservation effort are identified, and a high level of certainty is provided that the party(ies) to the agreement or plan that will implement the effort will obtain these authorizations.	NO PLAN	DN	DN	DN	DN	DN	DN	DN
	5. The type and level of voluntary participation (e.g., number of landowners allowing entry to their land, or number of participants agreeing to change sagebrush community management practices and acreage involved) necessary to implement the conservation effort is identified, and a high level of certainty is provided that the party(ies) to the agreement or plan that will implement the conservation effort will obtain that level of voluntary participation (e.g., an explanation of how incentives to be provided will result in the necessary level of voluntary participation).	NO PLAN	DN	DN	DN	DN	DN	DN	DN
	6. Regulatory mechanisms (e.g., laws, regulations, ordinances) necessary to implement the conservation effort are in place.	NO PLAN	P	P	P	P	P	P	P
	7. A high level of certainty is provided that the party(ies) to the agreement or plan that will implement the conservation effort will obtain the necessary funding.	NO PLAN	DN	DN	DN	DN	DN	DN	DN
	8. An implementation schedule (including incremental completion dates) for the conservation effort is provided.	NO PLAN	P	P	P	D	D	P	P
	9. The conservation agreement or plan that includes the conservation effort is approved by all parties to the agreement or plan.	NO PLAN	F	F	F	F	F	F	F

Table 3 (Con't). Evaluation of Local Conservation Plans and PECE Criteria.

	F = Fulfills entire criteria, P = Partially fulfills criteria, DN = Does not fulfill criteria.	GUNNISON SAGE-GROUSE POPULATION							
PECE Evaluation Factor	**Criteria**	**Cerro – Cimarron - Sims Mesa**	**Crawford**	**Dove Creek**	**Gunnison Basin**	**Piñon Mesa**	**Poncha Pass**	**Monticello Utah**	**San Miguel Basin**
A. The certainty that the conservation effort will be effective.	**1. The nature and extent of threats being addressed by the conservation effort are described, and how the conservation effort reduces the threats are described.**	**NO PLAN**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
	2. Explicit incremental objectives for the conservation effort and dates for achieving them are stated.	**NO PLAN**	**DN**	**DN**	**DN**	**DN**	**DN**	**DN**	**DN**
	3. The steps necessary to implement the conservation effort are identified in detail.	**NO PLAN**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
	4. Quantifiable, scientifically valid parameters that will demonstrate achievement of objectives, and standards for these parameters by which progress will be measured, are identified.	**NO PLAN**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
	5. Provisions for monitoring and reporting progress on implementation (based on compliance with the implementation schedule) and effectiveness (based on evaluation of quantifiable parameters) of the conservation effort are provided.	**NO PLAN**	**P**	**P**	**P**	**P**	**P**	**P**	**P**
	6. Principles of adaptive management are incorporated.	**NO PLAN**	**P**	**P**	**P**	**P**	**P**	**P**	**P**

III. CONSERVATION ASSESSMENT

A. Biology and Life History

Species Description

The largest grouse in North America is the sage-grouse, a species first described by Lewis and Clark in 1805 (Schroeder et al. 1999). Sage-grouse are charismatic birds known for their elaborate mating ritual where males congregate and "dance" to attract a mate on a specific strutting ground called a lek. Sage-grouse species in North America were once abundant and widespread but have declined throughout their range (Schroeder et al. 1999).

Sage-grouse are most easily identified by their large size, dark brown color, distinctive black bellies, long, pointed tails, and association with sagebrush habitats. Both sexes have yellow-green eye combs, which are less prominent in females. During the breeding season males have conspicuous filoplumes (specialized feathers on the neck), a black bib on a white upper breast and yellow-green air sacs on the chest.

For many years it was believed that all sage-grouse were a single species, known as the sage-grouse. In 2000, Young et al. (2000) identified GUSG as a distinct species. Geographic isolation, distinct genetic differences (Kahn et al. 1999, Oyler-McCance et al. 1999) and behavioral differences in strutting display separate GUSG from other sage-grouse, which are now called greater sage-grouse (Barber 1991, Young 1994, Young et al. 2000). The current ranges of the 2 species are not overlapping or adjacent (Schroeder et al. 2004). GUSG are also significantly smaller than greater sage-grouse (GRSG) in size of culmen, carpel, and tarsus, and they weigh approximately 1/3 less (Hupp and Braun 1991, Young et al. 2000). There are also distinctive plumage differences; GUSG males have more elaborate filoplumes and distinct, broad white barring on the tail feathers (Young et al. 2000).

Concern about the small population sizes and the long-term survival of the sage-grouse in current GUSG population areas started to surface in the early 1990's. These concerns lead environmental groups to petition the USFWS in January 2000 to list the species as endangered. On March 15, 2000, the USFWS designated the GUSG as a Candidate species for threatened and endangered status. Under this designation, the status of GUSG is reviewed annually to determine if it is still warranted for listing and, if so, to determine its listing priority, which is based on the taxonomy of the species and the magnitude and immediacy of threats to the bird.

Life History

Although GUSG and GRSG are different genetically, morphologically, and behaviorally with respect to strutting ground displays, their life histories and habitat requirements are believed to be similar (Young 1994). Most research exploring the life history and habitat requirements of sage-grouse has been conducted on GRSG and comparably little research has been done specifically on GUSG. Through the remainder of this document, the term sage-grouse is used when referring to sage-grouse in general. When information is known to be specific to GRSG or GUSG, the species acronym will be used. Except where referenced, the following life history information is taken from Schroeder et al. (1999) and applies to both GRSG and GUSG.

Sage-grouse require sagebrush throughout the year for food and cover. Unlike many other game birds, GRSG and GUSG do not possess a muscular gizzard and therefore lack the ability to grind and digest seeds and only occasionally, by accident, consume grit (Rasmussen and Griner 1938, Leach and Hensley 1954). With the exception of insects in the summer, the year-round diet of adult GRSG consists of leafy vegetation. Forbs dominate the summer diet and sagebrush leaves are used the rest of the year (Leach and Hensley 1954, Wallestad 1975).

In the spring, sage-grouse gather on traditional breeding areas commonly referred to as "strutting grounds," but more generally referred to as "leks" (Patterson 1952, Gill 1965). Lek sites are open areas that have good visibility (allowing sage-grouse a greater opportunity to avoid predation) and acoustical qualities so the sounds of display activity can be heard by other sage-grouse.

In Colorado, strutting occurs from mid-March through late May, depending on elevation (Rogers 1964), and the same would hold true for Utah. Males establish territories on leks in early March, but the timing varies annually by 1-2 weeks depending on weather condition, snow melt, and day-length. Males assemble on the leks approximately 1 hour before dawn, and strut until approximately 1 hour after sunrise each day for about 6 weeks (Scott 1942, Eng 1963, Lumsden 1968, Wiley 1970, Hartzler 1972, Gibson and Bradbury 1985, Gibson et al. 1991). The sage-grouse mating system is polygamous (a male mates with several females). Most females visiting the lek are bred by a few males occupying the most advantageous sites near the center of the lek (Scott 1942, Lumsden 1968, Wiley 1973a, Hartzler and Jenni 1988). Most females arrive on leks each morning after the males do, and depart while the males are still displaying. When a hen is ready to mate she invites copulation by spreading her wings and crouching (Scott 1942, Hartzler 1972, Wiley 1978, Boyce 1990). Males provide no parental care or resources and females generally leave the lek and begin their nesting effort immediately after mating.

Nests are not uniformly distributed within nesting habitat (Bradbury et al. 1989, Wakkinen et al. 1992) although some research indicates that 70-80% of all nests often occur within 2 miles of an active lek (Bradbury et al. 1989, Wakkinen et al. 1992). Research on GRSG in northwestern Colorado from 2001-2002 shows that female movements are more extensive than previously reported, with 46% (n = 78/169) of the radio-marked females nesting within 1.8 miles of the lek of capture, 76% (n = 128/169) within 4 miles, and 88% (n = 148/169 within 5.8 miles (Hausleitner 2003, A. D. Apa unpublished data). In addition, female grouse have been documented moving as far as 15-20 miles from the lek where they were captured (assumed to be the lek upon which they bred). In North Park, Colorado, Schoenberg (1982) reported an average GRSG lek to nest movement of 1.6 miles, and research in Idaho has shown movements that range from 2.1 – 3.0 miles (Wakkinen 1990, Fischer 1994, Apa 1998).

For GUSG, 85.2% (n = 69/81) of all nests were located within 4 miles from the lek of capture (Apa 2004, NPS unpublished data; see Appendix J, “GUSG Habitat Use Data”). When only considering the Gunnison Basin, 80% (n = 20/25) of nests were placed < 4 miles from the lek of capture (Young 1994, Apa 2004, NPS unpublished data). In contrast, only 68% (n = 17/25) of nests are placed < 3 miles from the lek of capture. GUSG lek-to-nest distances range from 0.6 – 0.83 miles at Poncha Pass (n = 3; Nehring and Braun 2000), 0.3 – 2.0 miles at Monticello, Utah (n = 3; Swenson 2003), and 0.1 – 12.6 miles for 6 of the GUSG populations (n = 37; Apa 2004). Young (1994) reported nest locations averaged 2.6 $\pm$ 2.2 miles from the nearest lek (n = 37) in the Gunnison Basin.

Nests are typically shallow bowls lined with leaves, feathers and small twigs placed on the ground at the base of a live sagebrush bush. GRSG clutch size ranges from 6 to 10 eggs, with 7 to 9 being the most common (Wallestad and Pyrah 1974, Connelly et al. 1993, Gregg et al. 1994, Schroeder 1997). In Moffat County, Colorado, GRSG clutch size averages from 5.7 eggs for yearling females to 7.0 eggs for adult females (overall average was 6.7 eggs; Hausleitner 2003). Young (1994) reported a mean clutch size for GUSG of 6.8 ± 0.7 (n = 24) eggs, and Swenson (2003) found GUSG clutches ranging from 6-10 in Utah (n = 3). Incubation does not start until the last egg is laid and eggs are incubated 27 to 28 days (Patterson 1952).

GRSG have one of the lowest nest success rates of all the upland game bird species (Schroeder 1997), ranging from 63% in Montana to 10% in Oregon (Drut 1994, Connelly et al. 2000). In Moffat County, nest success in 2001-02 ranged from 45% - 60% (Hausleitner 2003, A. D. Apa unpublished data). GRSG nest abandonment is not uncommon if the hen is disturbed. While re-nesting is infrequent, it does occur (Patterson 1952; Eng 1963; Hulet 1983; Connelly et al. 1991). Young (1994) reported that 1 (4.8%) GUSG female renested during her 3-year study. GUSG are less apt to re-nest than GRSG (Young 1994). Clutch size of re-nesting attempts varies from 4 to 7 eggs (Schroeder 1997). Hatching begins around mid-May and usually ends by July. Most eggs hatch in June, with a peak between June 10 and June 20. In Moffat County the mean clutch initiation date was 26 April in 2001 and 21 April for 2002 (Hausleitner 2003).

Chicks are precocial and leave the nest with the hen shortly after hatching. The availability of food and cover are key factors related to chick and juvenile survival. During the first 3 weeks after hatching, insects (beetles, ants, grasshoppers) are the primary food of GRSG chicks (Patterson 1952, Trueblood 1954, Klebenow and Gray 1968, Savage 1968, Peterson 1970; Johnson and Boyce 1990, Johnson and Boyce 1991, Drut et al. 1994b; Pyle and Crawford 1996, Fischer et al. 1996b). Diets of 4 to 8-week-old chicks were found to have more plant material (approximately 70% of the diet), of which 15% was sagebrush (Peterson 1970). Succulent forbs are predominant in the diet until chicks exceed 3 months of age, at which time sagebrush becomes a major dietary component (Gill 1965; Klebenow 1969; Savage 1969; Connelly and Markham 1983; Gates 1983; Connelly et al. 1988, Fischer et al. 1996b).

During the pre-egg laying period, females select forbs that are generally higher in calcium and crude protein than sagebrush (Barnett and Crawford 1994). Females with chicks move to areas containing succulent forbs and insects, often in wet meadow habitat, where cover is sufficiently tall to conceal broods and provide shade. Groups of unsuccessful females and flocks of males follow similar habitat use patterns but are less dependent on wet meadow areas than females with broods. Insects are consumed by adult grouse, but forbs and sagebrush leaves represent a majority of the diet (Rasmussen and Griner 1938, Moos 1941, Knowlton and Thornely 1942, Patterson 1952, Leach and Hensley 1954). Highly used forbs include common dandelion, prickly lettuce, hawksbeard, salsify, milkvetch, sweet clover, balsamroot, lupine, Rocky Mountain bee plant, alfalfa, and globemallow (Girard 1937, Knowlton and Thornley 1942, Batterson and Morse 1948, Patterson 1952, Trueblood

1954, Leach and Browning 1958, Wallestad et al. 1975, Barnett and Crawford 1994). The quantity of forbs in adult GRSG diets in summer varies with location.

As fall approaches, intermixing of broods and flocks of adult birds is common and the birds move from riparian areas to sagebrush-dominated landscapes that continue to provide green forbs. Fringed sagebrush is often a transitional food as grouse shift from summer to winter diets.

From late-autumn through early spring the diet of GRSG is almost exclusively sagebrush (Girard 1937, Rasmussen and Griner 1938, Bean 1941, Batterson and Morse 1948, Patterson 1952, Leach and Hensley 1954, Barber 1968, Wallestad et al. 1975). Many species of sagebrush can be consumed, including big, low, silver, and fringed sagebrush (Remington and Braun 1985, Welch et al. 1988, 1991, Myers 1992). GRSG have been shown to select differing subspecies of sagebrush for their higher protein levels and lower concentrations of monoterpenes (Remington and Braun 1985, Myers 1992). Grouse have been shown to gain weight over the winter (Beck and Braun 1978, Remington and Braun 1988), but in exceptionally harsh winters, fat reserves can decrease (Hupp and Braun 1989a).

During particularly severe winters sage-grouse are dependent on very tall sagebrush, which is exposed even above deep snow, providing a consistently available food source. GRSG are capable of making long movements (>18 miles) to find appropriate habitat. GUSG have been documented making movements as large as 17 miles (Root 2002). The extent of movement varies with severity of winter weather, topography, and vegetation cover.

GRSG winter range in Colorado varies according to snowfall, wind conditions, and suitable habitat (Rogers 1964). Sage-grouse may travel short distances or many miles between seasonal ranges. Movements in fall and early winter (September-December) can be extensive with some movements exceeding 20 miles. In North Park, Colorado, Schoenberg (1982) documented female GRSG moving more than 18 miles from winter to nesting areas. Hausleitner (2003) found that in Moffat County, Colorado, female GRSG moved an average of 6 miles from nesting areas to winter sites. The range of movements was extensive, and ranged from < 0.5 - 19 miles

Flock size in winter is variable (15-100+), with flocks frequently comprised of a single sex (Beck 1977, Hupp 1987). Many, but not all, flocks of GRSG males can over-winter in the vicinity of their leks, and by March they are usually within 2-3 miles of breeding areas used the previous year. These movements depend on whether the population is non-migratory or moves between 2 or more seasonal ranges (Connelly et al. 2000).

Annual survival rates of GRSG also vary (Table 4). Survival rates have been estimated from banding or radio telemetry studies. Survival of juveniles from hatch to fall has been estimated to be 38% in Wyoming (June 1963). The survival rate of GRSG varies by year, sex, and age (Zablan 1993). There is reasonable evidence to suggest that female GRSG have higher survival rates than males (Swenson 1986). This higher survival rate may be due to sexual dimorphism. Females have cryptic plumage and a more secretive nature versus the more elaborate plumage and display activities of males (Schroeder et al. 1999).

Table 4. Annual survival rates of GRSG.

GRSG Sample	Survival Rate	Location	Study
Adult females	55%	Colorado	Zablan 1993
Females	75%	Idaho	Connelly et al. 1994
Males	60%	Idaho	Connelly et al. 1994
Females	67%	Wyoming	June 1963
Males	59%	Wyoming	June 1963
Adult Females (2001-2002)	65%	Colorado	Hausleitner 2003
Yearling Females (2001-2002)	71%	Colorado	Hausleitner 2003
Adult females (2002-2003)	48%	Colorado	Hausleitner 2003
Yearling Females (2002-2003)	78%	Colorado	Hausleitner 2003

It is not unreasonable to expect that GUSG survival rates are similar to those of GRSG. Apa (2004) reported that GUSG survival from capture (April 2002) through 31 March 2003 for males was 0.48 ± 0.07 ($\underline{n}$ = 47) and for females was 0.57 ± 0.06 ($\underline{n}$ = 57). Survival across all the isolated populations was pooled to empirically compare GUSG male and female survival in the isolated populations to the Gunnison Basin (Apa 2004). Female survival in the isolated populations and Gunnison Basin was 0.52 ± 0.08 (n = 40) and 0.71 ± 0.11 (n = 17), respectively. Male survival in the isolated populations and Gunnison Basin was 0.51 ± 0.09 (n = 29) and 0.41 ± 0.12 (n = 17), respectively.

Habitat Requirements

The extensive literature describing seasonal habitat use by GRSG spans 9 western states and 60 years, but there is considerably less information available for GUSG (Hupp 1987, Hupp and Braun 1989b, Young 1994, Commons 1997, Swenson 2003, and Apa 2004). The following habitat descriptions are based on GUSG data when available, and on GRSG information when needed. In addition, if the quality of GUSG data is questionable, information from GRSG is used.

Sage-grouse use extensive landscapes throughout the year and can move great distances or have annual migratory patterns (Beck 1975, Wallestad 1975, Hulet 1983, Berry and Eng 1985, Connelly et al. 1988, Wakkinen 1990, Fischer 1994). Sage-grouse are wide ranging because they require a diversity of seasonal habitats (Connelly et al. 2000), and have specialized dietary requirements (see Schroeder et al. 1999 for numerous citations). Sage-grouse may use small portions of many different landscape types during different life stages (Connelly et al. 2000) and movements between small seasonal ranges may be extensive.

Sage-grouse habitat requirements may differ by season (Connelly et al. 2000). Connelly et al. (2000) segregated habitat requirement into 4 seasons: (1) breeding habitat; (2) summer - late brood-rearing habitat; (3) fall habitat; and (4) winter habitat. In some situations, fall and summer - late brood-rearing habitats are indistinguishable, but this depends on the movement patterns of the population and habitat availability. The breeding habitat category includes lekking, pre-laying female, nesting, and early brood-rearing habitat. Summer - late brood-rearing habitat includes habitat used during this period by males, non-brooding females, and females with broods. Fall habitat consists of “transition” range from late summer to winter, and can include a variety of habitats used by males and females (with and without broods). Winter habitat is used by segregated flocks of males and females (Beck 1977). Management of sage-grouse habitats should include all habitat types necessary for fulfillment of life history needs.

For the purpose of this plan, we have combined the summer - late brood-rearing and fall habitat into a single habitat category, "summer – fall", resulting in 3 overall seasonal habitats, rather than 4. Summer – late brood-rearing habitat is typically characterized by high elevation mesic areas, cropland, wet meadows, and riparian areas. Grouse continue to use these as fall approaches and there is a slow conversion of the diet from forbs to sagebrush. As mentioned earlier, in many cases these two seasonal habitats are indistinguishable, but in the future local information may provide additional insight as to when and where these 2 seasonal habitats can be clearly separated.

All the seasonal habitats described here include habitat used by brooding females, unsuccessful female, and male flocks.

Breeding Habitat (Leks, Pre-laying Habitat, Nesting Habitat, and Early Brood-rearing Habitat)

Leks (mid-March – mid-May)

There are no habitat investigations specific to GUSG strutting habitat. Most of the information collected is specific to GRSG.

Lek sites can be very traditional with grouse displaying in the very same location from year to year. Some leks are known to have been in use since the 1950's (Rogers 1964). Leks are usually located in small open areas adjacent to stands of sagebrush with 20% or greater canopy cover (Klott and Lindzey 1989). Openings may be natural or human created, including (but not limited to) small burns, drill pads, irrigated pasture, and roads (Connelly et al. 1981, Gates 1985).

Superficially, lek sites do not appear limiting (Schroeder et al. 1999), but they may vary in escape cover and quality of sagebrush (Patterson 1952, Gill 1965, Connelly et al. 1988, Connelly et al. 2000). The amount of land needed for males to strut can vary greatly. Lek sites are usually flat to gently sloping areas of <15% slope in broad valleys or on ridges (Hanna 1936, Patterson 1952, Hartzler 1972, Giezentanner and Clark 1974, Wallestad 1975, Dingman 1980, Autenrieth 1981, Klott and Lindzey 1989). Lek sites have good visibility and low vegetation structure (Tate et al. 1979, Connelly et al. 1981, Gates 1985), and acoustical qualities that allow sounds of breeding displays to carry (Patterson 1952, Hjorth 1970, Hartzler 1972, Wiley 1973b, 1974, Bergerud 1988, Phillips 1990). The absence of taller shrubs/trees or other obstructions appears to be critical for continued use of these sites by displaying males.

Sites chosen for display are typically close to sagebrush that is > 6 inches tall and has a canopy cover ≥ 20% (Wallestad and Schadweiler 1974). Usually leks are located in the vicinity of nesting habitat (Wakkinen et al. 1992) and are in areas intersected by high female traffic (Bradbury and Gibson 1983, Bradbury et al. 1986, Gibson et al. 1990, Gibson 1992, 1996). These sagebrush areas are used for feeding, roosting, and escape from inclement weather and predators. Males are usually found roosting in sagebrush stands with canopy cover of 20 - 30% (Wallestad and Schladweiler 1974).

Daytime movements of adult males GRSG during the breeding season do not vary greatly. Wallestad and Schladweiler (1974) found daily movements ranged between 0.2 and 0.8 miles from leks, with a maximum cruising radius of 0.9 to 1.2 miles. Ellis et al. (1987) reported that dispersal flights of male GRSG (to day-use areas) ranged from 0.3 – 0.5 miles, with the longest flights ranging from 1.2 – 1.3 miles. Carr (1967) reported that the cruising radius of male GRSG ranged from 0.9 – 1.1 miles. Rothenmaier (1979) found that 60 – 80% of male GRSG locations were within 0.6 – 0.7 miles of a lek. Emmons (1980) reported that male dispersal distances to day-use areas of 0.1 miles were common and that 67% of all use areas were greater than 0.3 miles from the lek. In addition, Schoenberg (1982) found that male daily movements averaged 0.6 miles, but ranged from 0.02 – 1.5 miles. No similar data are available for GUSG.

Pre-laying Habitat (late-March – April)

No information is available regarding pre-laying habitat for GUSG. Connelly et al. (2000) recommend that breeding habitat should include pre-laying habitat but little is known or understood about pre-laying habitat, even for GRSG. It has been suggested that pre-laying habitats should provide a diversity of vegetation to meet the nutritional needs of females during the egg development period. For pre-laying females in Oregon, Barnett and Crawford (1994) suggest that the habitat should contain a diversity of forbs that are rich in calcium, phosphorous and protein.

Nesting Habitat (mid-April – June)

GRSG prefer to nest under tall (11 – 31 inches) sagebrush (Connelly et al. 2000). Peterson (1980) found in North Park, Colorado that nest bushes averaged approximately 20 inches. In Moffat County, Colorado this value is slightly higher and ranges from 30 – 32 inches (Hausleitner 2003). Often, the actual nest bush is taller than the surrounding sagebrush plants (Keister and Willis 1986, Wakkinen 1990, Apa 1998). In northwestern Colorado, the nest bush was nearly 10 inches taller than surrounding shrubs (Hausleitner 2003). The canopy cover of sagebrush around the nest ranges from 15 - 38% (Patterson 1952, Gill 1965, Gray 1967, Wallestad and Pyrah 1974, Keister and Willis 1986, Wakkinen 1990, Connelly et al. 1991, Apa 1998, Connelly et al. 2000). Sagebrush canopy cover around nests in northwestern Colorado had a similar range of values, and averaged 27% (Hausleitner 2003).

Young (1994) reported GUSG nesting under sagebrush that had a mean height of 16.1 inches in the Gunnison Basin. In the Gunnison Basin, Apa (2004) found GUSG nested in areas with a mean sagebrush height of 18.6 inches. In contrast, non-use sites exhibited average mean sagebrush heights of 3.6 inches (Apa 2004). Average horizontal cover of sagebrush varied from 17.4 – 26.0% while non-sagebrush cover varied from 7.9 – 13.7%; non-sagebrush cover at non-use locations was 6.9%.

Good quality nesting habitat consists of live sagebrush with sufficient canopy cover, and substantial grasses and forbs in the understory (Connelly et al. 2000). Few herbaceous plants are growing in April when nesting begins, so residual herbaceous cover from the previous growing season is critical for nest concealment in most areas, although the level of herbaceous cover depends largely on the potential of the sagebrush community (Connelly et al. 2000). Reasonable and scientifically defensible habitat structure guidelines specific to GUSG need to be developed.

Nearly all nests are located beneath sagebrush plants (Patterson 1952, Gill 1965, Gray 1967, Wallestad and Pyrah 1974) and GRSG nesting under sagebrush plants have higher nest success than those that nest under plants other than sagebrush (Connelly et al. 1991). Sage-grouse nest sites also have an important component of herbaceous vegetation (Connelly et al. 2000). Grass heights are variable and as measured across the West range from 5 – 13 inches (Connelly et al. 2000). In addition, horizontal grass cover measurements are also variable and range from 4 – 51% cover. These measurements are similar to northwest Colorado data; Hausleitner (2003) reported that grass heights at nests ranged from 5-6 inches, grass cover averaged approximately 4%, and forb cover averaged about 7% (Hausleitner 2003).

Although not clearly understood, it is also believed that understory herbaceous cover (horizontal and vertical) is important for GUSG nesting habitat. Young (1994) found in the Gunnison Basin that nesting females used nest sites with horizontal grass and forb cover that averaged 9.5% and 3.7%, respectively. Apa (2004) found across southwestern Colorado that GUSG females nested in areas with grass cover of 24.9% and forb cover of 17.6%. Grass height was 4.0 inches and forb height was 1.6 inches.

Early Brood-rearing

Early brood-rearing habitat requirements are very similar to nesting habitat requirements. Early brood-rearing habitat is found relatively close to nest sites (Connelly et al. 2000), but individual females with broods may move large distances (Connelly 1982, Gates 1983). Early brood-rearing habitat is typically characterized by sagebrush stands with canopy cover of 10-15% (Martin 1970, Wallestad 1971) with herbaceous understories that exceed 15% cover (Sveum et al. 1998a, Lyon 2000). In Moffat County, Colorado, sagebrush stands average approximately 11% canopy cover and herbaceous understories average about 14% horizontal cover (Hausleitner 2003). High plant species diversity (sometimes also referred to as species richness) is also typical in early brood-rearing habitat (Dunn and Braun 1985, Klott and Lindzey 1990, Drut et al. 1994a, Apa 1998). Sagebrush heights ranged from 6 to 18 inches in Montana (Sveum et al. 1998a, Lyon 2000) and about 23 inches in Moffat County (Hausleitner 2003). Adjacent shrub areas of 20-25% canopy cover have been reported as preferred for escape and day roosting (Wallestad 1971; Dunn and Braun 1987), but night roosting sites in Moffat County, Colorado had only 4% sagebrush canopy cover and sagebrush height was 20 inches

In early summer, the size of the area used appears to depend on the interspersion of sagebrush types that provide an adequate amount of food and cover. Females and broods can select riparian habitats in the sagebrush type that have abundant forbs and moisture (Gill 1965; Klebenow 1969; Savage 1969; Connelly and Markham 1983; Gates 1983; Connelly et al. 1988; Fischer et al. 1996a). Females with broods remain in sagebrush uplands as long as the vegetation remains succulent, but may move to wet meadows as vegetation desiccates (Fischer et al. 1996b). Depending on precipitation and topography, some broods may stay in sagebrush/grass communities all summer while others shift to lower areas (riparian areas, hay meadows or alfalfa fields) as upland plant communities desiccate (Wallestad 1975).

Summer - Fall Habitat

As sagebrush communities continue to dry out and many forbs complete their life cycles, sage-grouse typically respond by moving to a greater variety of and more mesic habitats (Patterson 1952). Sage-grouse begin movements in late June and into early July (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer 1994). By late summer and into the early fall, females with broods, non-brood females, and groups of males become more social, and flocks are more concentrated (Patterson 1952). This is the period of time when GUSG can be observed in atypical habitat such as agricultural fields (Commons 1997).

From mid-September into October, GRSG prefer areas with more dense sagebrush (>15% canopy cover) and late green succulent forbs before moving to early transitional winter range where sexual segregation of flocks becomes notable (Wallestad 1975, Beck 1977, Connelly et al. 1988). During periods of heavy snow cover in late fall and early winter, use of mountain and Wyoming big sagebrush stands is extensive.

Winter

As late fall approaches weather events trigger movements to winter areas. The timing of this movement varies, influenced by yearly weather conditions. Winter habitat use depends upon snow depth and availability of sagebrush, which is used almost exclusively for both food and cover. Used sites are typically characterized by canopy cover > 25% and sagebrush > 12 - 16 inches tall (Shoenberg 1982) associated with drainages, ridges, or southwest aspects with slopes < 15% (Gill 1965, Wallestad 1975, Beck 1977, Robertson 1991). In Colorado, less than 10% of available sagebrush habitat is used during deep snow conditions by GRSG (Beck 1977) and GUSG (Hupp and Braun 1989b). When snow deeper than 12 inches covers over 80% of the winter range, GRSG have been shown in Idaho to rely on sagebrush greater than 16 inches in height in valleys for foraging (Robertson 1991).

Lower flat areas and shorter sagebrush along ridge tops provide roosting areas. During extreme winter conditions, GRSG will spend nights and portions of the day (when not foraging) burrowed into “snow roosts” (Back et al. 1987). Snow roosts are dug when snow has the proper texture by scratching with feet or by wing movements.

Hupp and Braun (1989b) found that most GUSG feeding activity during the winter occurred in drainages and on slopes with south or west aspects in the Gunnison Basin. In years with severe winters resulting in heavy accumulations of snow, the amount of sagebrush exposed above the snow can be severely limiting. Hupp and Braun (1989b) investigated GUSG feeding activity during a severe winter in the Gunnison Basin in 1984, where they estimated <10% of the sagebrush was exposed above the snow and available to sage-grouse.

In these conditions, the tall and vigorous sagebrush typical in drainages were an especially important food source for GUSG.

B. Distribution and Abundance

Distribution

Historic Distribution

Determining the historic range of GUSG is problematic for many reasons, most notably because of widespread loss of sagebrush habitats, which preceded scientific study of the species. Additionally, GUSG have been extirpated from many areas for which no useful zoological records or specimens exist. According to Young et al. (2000) the GUSG is believed to have historically occurred in Colorado, Kansas, Oklahoma, New Mexico, Arizona, and Utah. A more recent review of historical records, museum specimens, and potential sage-grouse habitat by Schroeder et al. (2004) concluded that GUSG are believed to have historically occurred in southwestern Colorado, northwestern New Mexico, northeastern Arizona, and southeastern Utah (Fig. 3). Accounts of GUSG in Kansas and Oklahoma are not supported with museum specimens and Schroeder et al. (2004) found potential inconsistencies with the historic records and the sagebrush habitat currently believed to be necessary for GUSG survival available in those areas. Applegate (2001) concluded that sage-grouse should be considered hypothetical in Kansas because none of the sagebrush species closely associated with sage-grouse occurred there. He attributed historical, anecdotal reports as mistaken locations or misidentification of lesser prairie chickens.

For these reasons, southwestern Kansas and western Oklahoma were not included on the historic GUSG range map (Schroeder et al. 2004). GUSG range is estimated to have been 21,376 mi^2 historically, and 1,822 mi^2 (8.5% of the original) is estimated to be the current species range (Schroeder et al. 2004). We modified the historical distribution map by Schroeder et al. (2004) in Colorado and Utah, based on several sources (Fig. 3, see pg. 34 for explanation).

Fig 3. Current and historical Gunnison sage-grouse range. See next page for details on numbers found on map.

Fig. 3. Current and historical GUSG range. This map is based on Schroeder et al. (2004), but has been modified in 6 ways (labeled on the map as #1 - # 6):

(1) Schroeder et al. (2004) described the 2 polygons in the north part of the pre-settlement range as being pre-settlement habitat for GUSG based upon 12 museum specimens (Table 5). The RSC questioned the accuracy of the inclusion of this area being GUSG pre-settlement habitat (as opposed to GRSG habitat) because the museum specimens were not actually reviewed by Schroeder et al. (2004). The RSC has requested photos of these specimens from the various host museums (Table 5) but has not yet acquired the documentation. Until these specimens are actually seen (and, if possible, genetic information is obtained), the RSC has agreed to refer to these areas as pre-settlement habitat for "Uncertain Sage-grouse Species". In either case, the RCP does not intend for any historical GUSG habitat in Garfield, Eagle, or Pitkin Counties, or in the portion of Mesa County that is illustrated under #1 (all in Colorado), to be managed as potential GUSG habitat, until or unless it is proven that the museum specimens in question are GUSG.

(2) This is an area the RSC expanded slightly over the pre-settlement distribution drawn by Schroeder et al. (2004). The UDWR recently mapped vacant/unknown and potential GUSG habitats (see pg. 54 for definitions). These mapped areas were based upon current and past distribution of sagebrush habitats. In a few areas, the newly mapped areas extended outside of the Schroeder et al. (2004) described area. The RSC agreed to include these small extensions to more accurately describe pre-settlement habitat in Utah.

(3) The Schroeder et al. (2004) map did not illustrate a pre-settlement habitat connection between the San Miguel and the Cerro Summit – Cimarron - Sims Mesa populations. Recent results from an analysis of genetic material by Oyler-McCance et al. (in press) (see "Genetics", pg. 47) document the exchange of genetic information between these populations. Based upon this evidence, we used the Colorado Vegetation Classification Project (CVCP, Colorado Division of Wildlife 2004b) GIS (Geographic Information System) data to identify habitats in the area between these 2 populations that are, or could have historically been suitable for GUSG use (e.g., current piñon-juniper habitat with sagebrush understory may have historically been sagebrush habitat). Thus, we extended the pre-settlement habitat in the region between the 2 populations.

(4) We questioned whether an area on the west side of the San Luis Valley, identified as presettlement habitat by Schroeder et al. (2004), had ever actually been GUSG habitat. The CVCP (Colorado Division of Wildlife 2004b), which used 82-foot (25 m) Landsat TM Satellite Imagery and ground truthing to derive vegetation classes showed few, if any, polygons of sagebrush or sagebrush-associated classes on the west side of the San Luis Valley. As a result, the RSC decided to label this area as "questionable" presettlement habitat. In addition, a rangewide strategy was designed to investigate the historical nature of this area using historic photos, soils, and other available information (see "Habitat Monitoring" rangewide strategy, pg. 220, Objective 3, Strategy 1).

(5) Based on the CVCP (Colorado Division of Wildlife 2004b) we added pre-settlement distribution on the east side of the San Luis Valley. Both the GIS data and a long-term CDOW employee's knowledge of the area suggest that GUSG were likely distributed on the east side of the valley, and that this was the area linked to pre-settlement GUSG distribution in New Mexico.

(6) We expanded the Schroeder et al. (2004) pre-settlement distribution map in 3 areas. All these areas (2 associated with the Gunnison Basin population, 1 with the Poncha Pass population) currently contain GUSG and/or sagebrush habitat. The broad scale used by Schroeder et al. (2004) for delineation of pre-settlement habitat could have understandably missed small areas like these. The RSC agreed to include these small extensions to more accurately describe pre-settlement habitat in Colorado.

Table 5. Museum specimens collected for area identified in Fig. 3 as "Uncertain Sage-grouse Species".

SEX	AGE	NUMBER	DATE	SPECIFIC LOCATION	COLLECTION	COLLECTOR
Female	Adult	DMNH-27087	7/12/1905	Between Colter and Spitzer's Neck near Grand River	Denver Museum of Natural History	A. H. Felger
Female	Adult	DMNH-27088	7/12/1905	Between Colter and Spitzer's Neck near Grand River	Denver Museum of Natural History	A. H. Felger
Male	Unknown	AM-315107	3/7/1906	Garfield County	Agassiz Museum, Harvard University	J. E. Thayer
Male	Unknown	AM-315106	3/22/1906	Garfield County	Agassiz Museum, Harvard University	J. E. Thayer
Female	Unknown	FMNH-131312	10/27/1902	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9295)
Female	Unknown	FMNH-131313	10/27/1902	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9296)
Male	Unknown	FMNH-131315	9/14/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9792)
Female	Unknown	FMNH-131314	9/15/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9791)
Female	Unknown	FMNH-131316	9/15/1903	Newcastle, Garfield County	Field Museum-Chicago	H. W. Marsden, L. B. Bishop (9793)
Unknown	Juvenile	AM-272666	7/7/1904	Newcastle, Garfield County	Agassiz Museum, Harvard University	From Peabody Museum
Male	Unknown	AMNH-353699	9/15/1903	Newcastle, Garfield County	American Museum of Natural History	Unknown
Female	Unknown	AMNH-353700	9/15/1903	Newcastle, Garfield County	American Museum of Natural History	Unknown

Current Distribution

GUSG currently occur in what have previously been considered 8 widely scattered and isolated populations in Colorado and Utah (Fig. 4). In Colorado, 7 GUSG population areas are: Cerro Summit – Cimarron - Sims Mesa, Crawford, Dove Creek, Gunnison Basin, Piñon Mesa, Poncha Pass, and San Miguel Basin. During the winter in some or most years, GUSG also inhabit a small portion of Grand County, Utah. These birds are believed to be part of the Piñon Mesa population that predominantly occupies and breeds in Mesa County, Colorado.

The Utah population is located near the town of Monticello and may be contiguous with the Dove Creek population in Colorado. Genetic data have also suggested these 2 populations could be considered one population (see “Genetics”, pg. 47). Thus, we consider them 2 subpopulations of a single population, but discuss them separately within the “Conservation Assessment” section because they occur in 2 states and each has its own local work group and local conservation plan. However, on RCP maps the 2 subpopulations are shown as a single population, and within the “Conservation Strategy” (pg. 201) we consider them as a single population from a conservation standpoint, although we specify some actions and targets for each state, again because of the separate entities and groups involved in managing the birds. Because we deem these 2 former “populations” as 1 population, we consider there to currently be 7 GUSG populations.

The Cerro Summit – Cimarron – Sims Mesa and San Miguel Basin populations both exhibit a patchy distribution of GUSG. As a result, we identify separate “subpopulations” within each. At Cerro Summit – Cimarron – Sims Mesa there are 2 subpopulations: (1) Cerro Summit – Cimarron; and (2) Sims Mesa. In San Miguel Basin there are 6 subpopulations: (1) Dry Creek Basin; (2) Hamilton Mesa; (3) Miramonte Reservoir; (4) Gurley Reservoir; (5) Beaver Mesa; and (6) Iron Springs.

Fig. 4. Locations of current Gunnison sage-grouse populations. The discontinuity in occupied habitat at the state line in the Dove Creek – Monticello area is not entirely a mapping artifact; where there is occupied habitat on the Colorado side there is an abrupt change to cropland on the Utah side of the border. The abrupt transition at the state border in the Piñon Mesa area may be due to differing mapping efforts between the states and is addressed in the “Habitat Monitoring” rangewide strategy (see Objective 1, Strategy 3, pg. 221).

Abundance

Lek Counts and Population Estimation

Inventory and monitoring of wildlife populations is an obvious prerequisite to conserving them, and is especially important when quantitative goals for species conservation have been developed. What is not obvious is how to accomplish inventory, and what level of resources is appropriate to commit to this task, since resources devoted to inventory and monitoring will not be available for other critical conservation tasks. Having very accurate and precise estimates of GUSG numbers does not in and of itself improve the species' status.

Population trends of sage-grouse have been monitored across the western U.S. using variations on a lek count methodology first described by Patterson (1952), who studied sage-grouse in Wyoming. Patterson speculated that the maximum number of males counted over 3 or 4 counts spread throughout the display period might be a useful index to sage-grouse population trends. Wildlife managers have monitored populations of many species through the use of indices, where a count or measurement is made of some characteristic of a population that is both convenient to measure and is thought to be related to abundance. With birds, indices are often based on vocalizations made during the breeding season, such as pheasant "crow" call counts, dove coo-count indices, and bobwhite whistling counts (Lancia et al. 1994). Anderson (2001) noted the weaknesses of this type of sampling, which may be convenient for wildlife managers, but does not lead to defensible estimates of population size or status. The index, whether it is pheasant crows or the number of male sage-grouse counted on a lek, has an unknown relationship to the larger population of interest.

As a result of the publication of Patterson (1952) the lek count became the standard for sage-grouse population monitoring. Patterson (1952) based the census on the belief that all males regularly attend leks. His suggested maximum of 3 or 4 counts made sense under this assumption, because given normal environmental variables associated with lek counts (e.g., cold temperatures, snow, predator harassment), it might take 3 or 4 trips to get a "good" count of all the males present.

The lek count protocol proposed by Patterson (1952) has weaknesses. Dalke et al. (1963:833) thought lek counts provided a reasonably accurate method of determining breeding population trends, but noted the high degree of variability in daily counts and suggested a "…need for more refined census methods as sage-grouse management becomes more intensive in the future." Jenni and Hartzler (1978:51) used and supported the technique but speculated that high variance in counts was because "…some unestablished birds wandered about visiting different leks on different mornings."

Beck and Braun (1980) presented a critical review of the practice of using lek counts to assess population trends or size. They pointed out that without information on the total number of leks in an area, attendance patterns of adult and yearling males, inter-lek movements, and the relationship between the maximum count and the population size, nothing could be concluded about population size or trends from lek counts. Despite these criticisms, the Western States Sage Grouse Committee essentially codified lek counts as a means to assess population trends 2 years later when it published its Sage Grouse Management Practices (Autenrieth et al. 1982). The publication advises caution in the interpretation of counts because of the high level of variance in the data, but no additional aid in interpretation of lek count data is given. The committee's most recent guidelines (Connelly et al. 2000) also suggest viewing lek data with caution, but state that lek counts (per Autenreith et al. 1982) provide the best index to breeding population levels. In an extension of that assumption, Connelly et al. (2000) reaffirm specific statements from Connelly and Braun (1997) that suggest there has been a 17 - 47% decline in breeding populations across their range.

Applegate (2000) and Anderson (2001) pointed out that index data cannot be extrapolated to estimates of animal density or abundance unless the proportion of the total population that is counted in the index method is known. For sage-grouse populations, this depends on (1) the proportion of leks that are known and counted; (2) the number and timing of counts conducted; (3) time of day in which counts are conducted; (4) lek attendance rates by yearling and adult males; and (5) the sex ratio of the population. All of these parameters are likely to vary significantly spatially and over time, yet when population estimates are derived from lek count data these parameters are assumed to be fixed constants.

Assumptions Made in Sage-grouse Population Estimation from Lek Counts

Lek count data have been used to make inferences about sage-grouse population trends for at least 50 years, without any credible scientific investigation into the relationship between lek counts and population size. Because of the interest in having population estimates for sage-grouse (and because of the lack of other efficient methods for population estimation of sage-grouse), it is now a common practice to use lek data to estimate the size of various populations of sage-grouse. Multiple untested assumptions are often made in using lek count data to estimate sage-grouse population size (Table 6). These usually include assumptions regarding population sex ratio, an estimate of the percentage of leks that are counted, and the percent of males in the population that are counted at leks. The Washington State Recovery Plan for Greater Sage-grouse (Stinson et al. 2004) also mentions that males could make inter-lek movements, but does not address this in its estimates (Stinson et al. 2004).

Table 6. Untested assumptions made in using lek count data to estimate sage-grouse population size.

Region/Source	Assumptions		
	Sex Ratio M:F	**Percentage of all leks that were located and counted**	**% of males (associated with the lek) that are actually counted**
Gunnison Basin/Gunnison Basin Conservation Plan (GBCP 1997)	1:2	80 %	(50 – 100 %) used 75 %
San Juan County, Utah/Utah Gunnison Sage Grouse Conservation Plan (SJCCP 2000)	1:2	Not described	75%
Nevada – statewide Conservation Plan (Neel 2001)	3:7 – 2:3	80 %	75 %
Washington State (Stinson et al. 2004)	1:1.6	100 %	100 %

Here we examine 4 assumptions made in estimating population from lek counts.

(1) *Percent of leks counted.* We recognize that lek counts may be useful as a trend indicator, under the assumption that a constant percentage of leks are detected. It is not necessary to know what the percentage of leks detected is, but to estimate population size, either all leks must be counted, or the proportion of the total that is counted must be estimated (lek detection probability).

Numerous studies have documented that lek densities vary considerably over time. Bradbury et al. (1989) found a persistent excess of large and small lek sizes. Within an area, lek numbers seem to increase roughly in proportion to population size (Cannon and Knopf 1981). Core or "traditional" leks increase in size, while satellite leks appear and disappear as populations increase and decrease. Thus, it is probably not reasonable to assume that the proportion of leks detected is constant over time unless search effort increases proportionally as populations increase. Managers and researchers are also far more likely to detect and count a higher proportion of leks at low population densities than at high densities. It is probably also not reasonable to assume unknown leks are of "average" size, because unknown leks are more likely to be satellite leks and thus smaller, and because detectability may be a function of number of males, larger leks may be more noticeable.

(2) Interlek Movements. Attendance by males at more than 1 lek is problematic, because birds may be counted multiple times at different leks, thus inflating population estimates, or they may not be counted at all if they are attending a different lek when counts occur. The ability of lek counts to serve as an index to population trends will not be affected by inter-lek movements if the movements are relatively constant from year to year.

Unfortunately, interlek movements are both significant and variable. Dalke et al. (1963) reported interlek movements by individual (banded) adult males varied by year from 22 - 47%. Dunn and Braun (1987) recorded no marked birds moving between leks in 1982, but 14 of 91 (15%) were observed at 2 or more leks in 1983. Emmons and Braun (1984) reported all (11) juvenile males attended from 2-4 leks during the breeding season, while interlek movements of adults were infrequent (3 of 11; 27%).

(3) Lek Attendance. Population estimates from lek count data assume that a constant proportion of males, often 75%, are detected by the maximum of 3-4 counts (e.g., Table 6). There is considerable evidence that lek attendance is highly variable due to age, social status, weather, body condition, and parasite load or disease. Patterson (1952:152) suggested that all males regularly attended leks, although the only data he presented to support this assertion was: "All these marked birds were identified morning after morning occupying the same territory on the strutting ground." He was examining marked birds with respect to territoriality in this reference, and the marking referred to birds he captured on leks and dyed, or birds he identified by tail feather patterns. Dalke et al. (1963:820) didn't calculate attendance rate for banded birds, but indicated that "…banded males were ordinarily absent from the strutting grounds from 1 to 3 days at a time…", and "The less dominant males were irregular in their visitations. The dominant males were present almost daily under all conditions." Dalke et al. (1963:822) also noted, "Banded males were often seen in the sagebrush adjacent to the strutting grounds," although this was attributed to trapping disturbance. Hartzler (1972) documented males with almost daily lek attendance and others that only sporadically attended leks in Montana. Wiley (1973a) stated that there was a "…large pool of non-lek males that exists in most lek species," and he further speculated (Wiley 1974) that attendance patterns of males were likely to be a function of density (lek size). Dunn and Braun (1987) reported daily attendance rate of marked adult males was only 43%, ranging from 3-96% for individual males. Daily attendance by yearling males was only 33% (Dunn and Braun 1987).

One bias in assessing attendance based on observations of banded birds is that apparent low attendance may be caused by mortality of banded birds. Emmons and Braun (1984:1023) studied male sage-grouse lek attendance with the objective "…to examine the daily attendance patterns on leks of male sage grouse during the breeding season," but lumped attendance across 5-day, 15-day, or season-long averages. Although their data indicated significant within-year and across-year variation even when lumped into 5-day intervals, they did not report what fraction of radio-marked males would be detected by normal counting protocols. Since 93% of the birds they based their attendance rates on were trapped while night-roosting on leks, it is probable they (and others) caught highly territorial, dominant males who regularly attend leks, and thus it is likely the estimate of lek attendance may be biased high.

The physical condition of sage-grouse can also affect their attendance at leks. Hupp and Braun (1989a) found that sage-grouse had depleted lipid and protein reserves following a severe winter in Colorado. This, and snow cover, caused the birds to largely delay initiating display activities until late April. There was substantial variation in lipid reserves across 3 years, which could impact lek attendance and display rates. The authors noted substantially higher variation in lek counts within a season for GUSG than for GRSG in North Park.

Boyce (1990) reported that males with avian malaria were significantly less likely to attend leks than males without malaria, and that malaria varied spatially and temporally across 11 leks in southeast Wyoming. Thus, disease prevalence has the potential to impact attendance rates and lek counts, and variability in disease prevalence may increase variability in attendance rates.

Walsh et al. (2004) studied attendance rates of radio-marked and color-banded male and female sage-grouse captured during winter in Middle Park, Colorado during 1 mating season. They found male daily attendance rates were highly variable (7-86% for adults, and 0-42% for yearlings), and influenced by age, date, and time of day. They documented that counts conducted between half an hour after sunrise and 1.5 hours after sunrise (typical when managers count more than 1 lek in a morning) detected only 74% and 44% of the actual high count of adults and yearlings for that day, respectively.

(4) Sex-ratio. Most population estimates derived from lek counts assume 2 females/male in the breeding population (e.g., Table 6). This assumption is based on long-term wing data obtained by determining sexing and ageing wings obtained at wing barrels or check stations (CDOW, unpublished report). It is apparent both from wing data and from population modeling that sex ratios vary markedly from year to year. This is because males encounter higher mortality rates as they mature and enter the breeding population (Zablan et al. 2003). Therefore the sex ratio will be a function of the age structure of the population; older age-structured populations will have high female-to-male sex ratios because this differential mortality will have had longer to operate. Following years of above average recruitment, populations will have female-to-male sex ratios closer to 1:1, since yearling and first-year adults will dominate the population and will have experienced little differential mortality. Sex ratios of yearling GUSG from wing data (CDOW, unpublished report) have ranged from 0.8 to 2.4 females/male from 1977 to 1993, while adult sex ratios have varied from 1.3 to 3.4 over the same period. It is apparent that assuming a constant sex ratio is not defensible since it masks real variability and the processes that create it. The long-term (1977 - 1993) average sex ratio was 1.6 yearling and adult females per yearling and adult male, significantly lower than the 2.0 females/male typically used in population estimation equations.

Alternative Methods of Population Estimation

Given the unreliability of the assumptions used, how do estimates derived from them compare to other, more rigorous estimates? Using mark-recapture statistical techniques, Walsh (2002) estimated the size of adult and yearling male and female GRSG populations in Middle Park over 1 breeding season. He compared them to population estimates derived from lek counts using standard assumptions (90% of leks are known and counted, 75% of males are counted, and there are 2 females/male in the population). He found that adjusted lek count estimates underestimated population size from mark-recapture estimates by 28%, because attendance rates were much lower than assumed and there were more females (2.3/male) than assumed.

Stiver (University of Nebraska, personal communication), using mark-recapture techniques, estimated there were 53 male and 115 female GUSG in San Miguel County in

Colorado in Spring, 2003. Extrapolation from the maximum of 4 lek counts using standard assumptions listed above yielded estimates of 41 males and 82 females, underestimating the mark-resight estimates by 23 and 29 %, respectively. The maximum of 4 counts of males represented only 53% of the male population (as estimated by mark-resight), well below the assumed 75%. Thus, estimates of population size extrapolated from lek count data using standard assumptions appear to significantly underestimate population sizes.

Mark-recapture methods have shown promise in developing population estimates with confidence intervals, but the difficulty in capturing and marking the proportion of the population necessary (Walsh 2002) suggest it will be practical only for small populations. Recent research (Wilson et al. 2003) has explored using individual DNA as a marker, eliminating the need to handle and mark individual birds. The CDOW is exploring the utility of using DNA assayed from fecal droppings as a mark-recapture technique. CDOW will also explore the practicality of using other methods to estimate lek and/or population density such as line-transects (Burnham et al. 1980). CDOW will continue to test the assumptions about male attendance and sex ratios implicit in estimating population size from traditional lek counts.

Conclusions

It is not defensible to generate population estimates for sage-grouse from lek counts by assuming that (1) all (or some fraction) leks are known; (2) unknown leks are of average size; (3) the maximum of 3 or 4 counts represents 75% of the males in the population; (4) there are exactly 2 (or any fixed ratio) females per male in the population; and (5) there is no variability in the assumptions across time, space, or population size. Unfortunately, that does not diminish the need for population estimates. It is difficult to evaluate past population trends, or to assess where we are relative to population targets or population viability without estimates of current population size. Either new methods need to be developed, or assumptions used to extrapolate from lek counts need to be evaluated and refined.

Estimating population size of GUSG by whatever means will be expensive and potentially disruptive to individual sage-grouse at varying levels. In the long-term, annual estimates of population size are probably unnecessary and may be counter-productive from the standpoint of diverting resources and impacting birds. However, currently annual lek counts represent the only method for monitoring trends in GUSG populations, and should be continued until better, more precise estimates can be obtained. Therefore, even though we recognize the lack of statistical reliability, we estimate population sizes from lek counts using the following assumptions:

1) All leks are known and counted (estimate is thus conservative if some leks are unknown).
2) The maximum of 3-4 counts represents 53% of males in each population (Stiver, unpublished data).
3) There are 1.6 females (yearling and adult) per male (yearling and adult) in the population. This is the long-term average estimated from wing data collected in the Gunnison Basin (CDOW, unpublished report).

The formula that incorporates these assumptions follows:

C = maximum male count on lek

$$\text{Population Estimate} = \frac{C}{0.53} + \left(\frac{C}{0.53} \times 1.6\right)$$

RCP Estimated Population Size

The total population size has recently been estimated to be fewer than 5,000 birds, of which fewer than 3,000 occur in the Gunnison Basin (Young et al. 2000). Each of the other 7 populations is reported to contain fewer than 500 birds, and several, including the Utah population, have fewer than 150 birds (Young et al. 2000). Using 2004 lek count data and the assumptions listed for this plan, we generated the current population sizes (Table 7).

Table 7. GUSG 2004 lek counts and population estimates.

Population	**Male High Count (Total for all leks)**	**Number of Leks (includes leks with 0 males present in 2004)**	**Estimated Population Size**
Cerro Summit–Cimarron - Sims Mesa	8	4	39
Crawford	26	5	128
Dove Creek	2	6	10
Gunnison Basin	498	78	2,443
Monticello, Utah	31	5	152
Piñon Mesa	29	8	142
Poncha Pass	8	1	39
San Miguel Basin	50	10	245
Total	**652**	**117**	**3,198**

Decline of Gunnison Sage-grouse

Although few would argue that GUSG populations have declined from historic levels, the extent of the decline has been debated. The issue has received a great deal of attention, but no scientific peer-reviewed scrutiny. In a document submitted to the USFWS as consideration for listing the species, Webb (2000:38) concluded that GUSG populations have undergone "…extremely rapid population declines from 1980 to 1990 and the present." This document also quoted from an unpublished memo from the CDOW that suggested the "…total number of Gunnison sage grouse has declined at least by 80-90% since 1950" (Webb 2000:45). This memo also qualitatively suggested that sage-grouse numbers in the Gunnison Basin "…have decreased at least by 50-60% since the early 1950's…" (Webb 2000:45). No rigorous quantitative analyses were conducted on these percentage calculations. Young (2003) suggests that historical numbers prior to 1950 are unknown, but were "…several orders of magnitude higher…" than current levels.

Young (2000, unpublished memorandum to biologists working with GUSG) concluded that there was a 66% decline in the Gunnison Basin population since 1953. This observation was based on a decline in the average number of males counted on leks, from 123 males/lek in 1953 to 30 males/lek in 1999. However, this parameter estimate could be misleading because it is dependent upon both the count of males, and the number of leks counted. During this period, it appears that many leks in the Ohio Creek area of the Gunnison Basin were lumped into a single lek for reporting purposes. This "lek" was reported to have 517 males in 1953 and 301 in 1954, but only 7 in 1957 (Rogers 1964:83-85). Further evidence of this lek combination is that Rogers (1964:83) described this complex as being "…in a shape of a large L, with a base approximately 4 miles wide and a long axis of about 12 miles…" Sandfort (1954:62) described this complex of breeding birds as "SW ¼ Section 22, SW ¼ Section 24, NE ¼ Section 27, Section 26, E ½ Section 35 and SW ¼ Section 36 T51N, R1W; N ½ Section 1, T50N, R1W, W ½ Section 6, T50N, R1E." Because of inconsistencies in "lek" definition in these early lek surveys, the RSC does not believe that the parameter of average number of males/lek is a defensible parameter to infer a specific decline in population.

Nevertheless, there has clearly been a historical decline in counts of GUSG males on leks, including in the Ohio Creek lek complex. Records for Ohio Creek show 517 and 301 males, in 1953 and 1954, respectively (Rogers 1964:83). The 1954 count reflected only 1 count/lek and is probably biased low. Recent counts in this area have ranged from 194 (2004) to 299 (1999). The recent high count of 299 is 42% lower than the 1953 count of 517, suggesting that declines in at least the Ohio Creek area may have been this high, or higher.

A standard lek count protocol has been used in Colorado since approximately 1996 (Colorado Division of Wildlife 2004a). Prior to that, lek counts were sporadically and very inconsistently conducted. For example, the high count of males attributed to the "Ohio Creek" lek/lek complex, was 517 in 1953, 301 in 1954, not reported from 1955-1956, 7 in 1957, and not counted again until 1959 (146 males) (Rogers 1964:83-91). Obviously, this level of variability reflects multiple factors affecting counts other than population variation.

Therefore, we do not disagree that there are fewer GUSG today than occurred historically. However, no level of sophisticated statistical analyses will precisely elucidate the degree of past declines. We chose to focus in the RCP on evaluating how many GUSG are necessary in the future to conserve this species, rather than the relative degree of population decline.

C. Genetics

There has been much concern about the viability of small populations and how it might be affected by demographic, environmental, and genetic stochasticity, as well as catastrophic events (Shaffer 1981, Soulé 1987). Although minimum viable population sizes vary enormously among species, it is generally thought that populations smaller than a few hundred individuals warrant careful scrutiny in this regard (Shaffer 1987). While the persistence of wild populations is usually influenced more by ecological effects (such as direct effects of catastrophes and environmental and demographic stochasticity) than by genetic effects, when they are reduced to small populations by artificial means such as habitat destruction, genetic factors and their interaction with ecological factors become increasingly important (Lande 1995a).

Previous genetic studies have used mitochondrial markers (Kahn et al. 1999) and both mitochondrial and nuclear markers (Oyler-McCance et al.1999) to compare GRSG populations from northern Colorado with GUSG. These genetic studies, as well as comparisons of morphology (Hupp and Braun 1991) and behavior (Young et al. 1994) led to the recognition of GUSG as a new species (Young et al. 2000). Since GUSG are now recognized as a new species it is necessary to investigate the population structure of the species so that a more comprehensive understanding of the species can be obtained.

Oyler-McCance et al. (in press) investigated population structure of GUSG using mitochondrial DNA (mtDNA) sequence data and data from 8 nuclear microsatellite loci. Their study included DNA from 264 individuals from 6 different geographic areas (Gunnison Basin, Curecanti [part of Gunnison Basin, see Fig. 5, pg. 50], Crawford, San Miguel, Dove Creek - Monticello, and Piñon Mesa) and 4 individuals from the Cerro Summit - Cimarron portion of the Cerro Summit – Cimarron - Sims Mesa area. The goal of their study was to provide strong estimates of population structure, genetic diversity, and relatedness among populations, and to apply this genetic data to management issues.

Oyler-McCance et al. (in press) found that levels of genetic diversity (Table 8) were highest in Gunnison, with an average of 5 alleles per microsatellite locus and 3 mtDNA haplotypes represented. The Gunnison population consistently had more alleles than other populations, and contained most of the alleles present in other populations. This is consistent with the fact that this population is the largest and most stable. All other populations had much lower levels of diversity. For example, Piñon Mesa averaged only 2.13 alleles per locus (Table 8). These lower levels of diversity in other GUSG populations are likely linked to small population sizes and a high degree of geographic isolation.

Forty-nine different alleles were identified in GUSG. Of these, the Gunnison Basin contained 37 (76% of the total). Collectively, the smaller populations contained 12 alleles (24% of the total) not identified in Gunnison. Although additional genetic sampling in the Gunnison Basin might have picked up 1 or 2 of these alleles that may be present, but rare, it appears that the smaller populations are adding to the genetic diversity present within the species. At least 1, perhaps 2 of the alleles not found in the Gunnison Basin may be due to introgression of GRSG with GUSG. These GUSG populations have been isolated from each other for probably less than 50 years, time enough to drift apart genetically but probably not enough time to accumulate a significant number of locally adaptive genetic mutations. Therefore, translocations of selected genotypes from the Gunnison Basin to smaller populations, and vice-versa, should increase local genetic diversity and the probability of retaining this genetic diversity over time.

At the species level, GUSG have low levels of genetic diversity, particularly when compared to GRSG. Oyler-McCance et al. (in review) sequenced the same mtDNA region among 44 populations of GRSG from across the range and found an average of 6.9 haplotypes per population, compared to an average of 2.33 found for GUSG. In the same study, Oyler-McCance et al. (in review) found an average of 5.88 microsatellite alleles per locus in GRSG using all but 1 (LLSD4) of the microsatellite loci used for GUSG. GUSG were found by Oyler-McCance et al. (in press) to have an average of 2.9 alleles per locus.

Table 8. Polymorphism of microsatellite loci among six populations of GUSG.

Population	Mean Sample Size[1] (SD)	Mean # Alleles per Population (SD)	% of Loci Polymorphic	Mean Observed Heterozygosity (SD)	Mean Expected Heterozygosity (SD)
Gunnison Basin	83.13 (4.45)	5.00 (3.85)	100	0.38 (0.22)	0.40 (0.20)
Curecanti	25.00 (1.46)	2.88 (1.25)	88	0.37 (0.17)	0.37 (0.18)
Crawford	22.50 (0.76)	3.00 (1.41)	88	0.41 (0.23)	0.43 (0.21)
San Miguel Basin	56.75 (2.55)	3.25 (1.98)	75	0.51 (0.09)	0.57 (0.10)
Dove Creek - Monticello	42.38 (2.26)	3.00 (1.77)	75	0.46 (0.24)	0.51 (0.22)
Piñon Mesa	19.50 (0.93)	2.13 (1.55)	50	0.36 (0.24)	0.42 (0.29)

[1] Mean sample size refers to the mean number of samples that amplified across the different loci. Even though there was a set sample size for each population (e.g., 30), not every individual sample amplified for every locus. Thus, for one locus there may be a sample size of 30 (everything amplified), but in additional loci perhaps only 29 samples amplified.

Although the importance of maintaining substantial genetic variation in small populations is debated, most agree that genetic variation is relevant to the health and viability of populations and that it must be addressed and monitored in management plans (O'Brien and Evermann 1988, Quattro and Vrijenhoek 1989). Bouzat et al. (1998a) and Westemeier et al. (1998) showed that fertility and hatching success of greater prairie chickens were reduced due to a genetic bottleneck caused by habitat loss. The GUSG, a close relative of greater prairie chicken (both are members of Tetraoninae), also appear to have experienced isolation and reduction in population size resulting from the loss of habitat (Fig. 3, pg. 33). Further, genetically depauperate populations may face enhanced susceptibility to parasitic agents or infectious disease such as West Nile Virus, which has been shown to be a significant threat for GRSG (Naugle et al. 2004).

Oyler-McCance et al. (in press) found that pairwise population F_{ST} values (a measure of genetic structure) showed congruent patterns of population genetic structure in both the microsatellite and the mitochondrial data. This suggests that all populations are genetically discrete units that can be considered distinct populations with the exception of Gunnison and Curecanti, which are closely linked geographically (Fig. 5). STRUCTURE (a software program that delineates how many genetically discrete "units" are best described by the data) analysis further substantiated their finding of a high degree of population structure and low amounts of gene flow by defining 6 populations (yet with Curecanti and Gunnison very closely related). Further, F_{ST} calculated among all 6 GUSG populations was found to be significantly higher than it was for GRSG Oyler-McCance et al. (in press). This is indicative of reduced gene flow among the 6 populations of GUSG in conjunction with increased genetic drift that is characteristic of small populations.

Fig. 5. Location of Curecanti within Gunnison Basin GUSG population area.

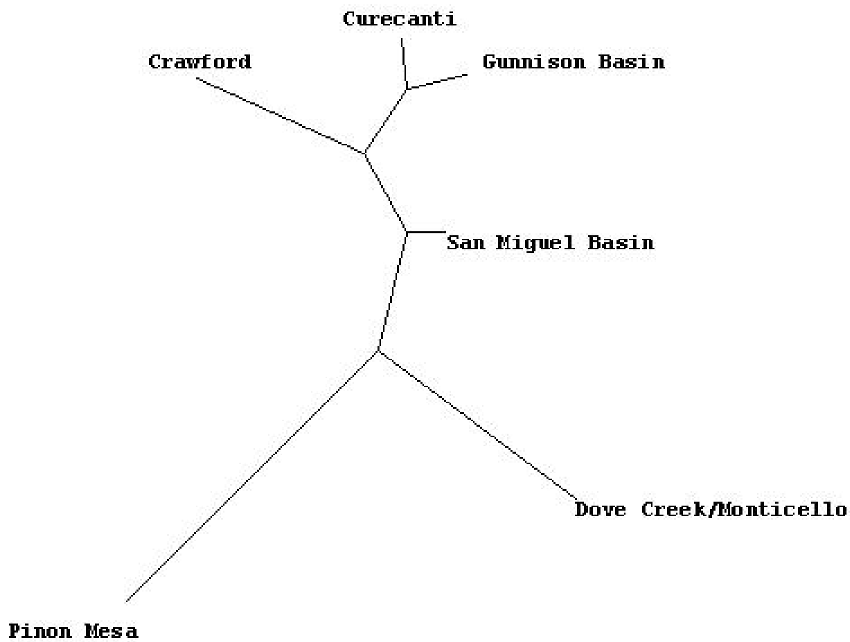
Historically, Dove Creek - Monticello, San Miguel, Crawford, and Piñon Mesa all had much more sagebrush habitat and probably larger GUSG populations that were somewhat connected through more contiguous areas of sagebrush habitat. Oyler-McCance et al. (2001) quantified the loss and fragmentation of sagebrush habitat in southwestern Colorado. They documented a 20% loss of sagebrush habitat between the late 1950's and the early 1990's, and that sagebrush in 37% of the plots examined was significantly fragmented. The clearing of sagebrush for cultivated crops, highway construction, ranch development, powerline placement, reservoir construction, and other facets of human settlement has destroyed and fragmented sagebrush habitats in southwestern Colorado. This has lead to the current isolation of these populations, which is consistent with the relatively low amounts of gene flow and isolation by distance documented here.

Both neighbor-joining trees generated by Oyler-McCance et al. (in press), constructed using different measures of genetic distance, showed similar topologies, with Gunnison and Curecanti closely linked, followed by Crawford and San Miguel (Fig. 6). The Dove Creek - Monticello and Piñon Mesa populations were consistently set apart from all other populations and from each other. These neighbor-joining trees as well as a significant Mantel test show that the geographic distances are correlated with genetic distances between populations.

Oyler-McCance et al. (in press) noted that a few individuals in their STRUCTURE analysis appeared to have the genetic characteristics of a population other than their own (Fig. 7), suggesting the possibility that they are dispersers from a different population. Using GeneClass2 software, Oyler-McCance et al. (in press) identified 3 potential first generation migrants. Two probable dispersers were individuals moving from San Miguel into Dove Creek - Monticello and Crawford. The San Miguel population itself appeared to have a mixture of individuals with differing probabilities of belonging to different clusters (Fig. 7). This suggests that San Miguel may act as a conduit of gene flow among the satellite populations surrounding the larger population in Gunnison. Additionally, Oyler-McCance et al. (in press) found that the 1 other potential disperser involved movement into Crawford from Curecanti. This is not surprising given their close geographic proximity (Fig. 4, pg. 38).

The 4 individuals from Cerro Summit - Cimarron included in the study by Oyler-McCance et al. (in press) were found to be more closely related to individuals from San Miguel than from Gunnison or Curecanti, which are closer geographically. This suggests a linkage between San Miguel and the Cerro Summit - Cimarron area that is surprising, given the geographic distance between them and the fact that the city of Montrose sits between them (Fig. 4, pg. 38). With a sample size of only 4 individuals, Oyler-McCance et al. (in press) found it hard to make strong conclusions about the genetic characteristics of Cerro Summit – Cimarron - Sims, yet they suggest that the Cerro Summit – Cimarron - Sims area may act as an important stepping-stone that links the larger populations of Gunnison, Curecanti, and San Miguel.

(1)



(2)

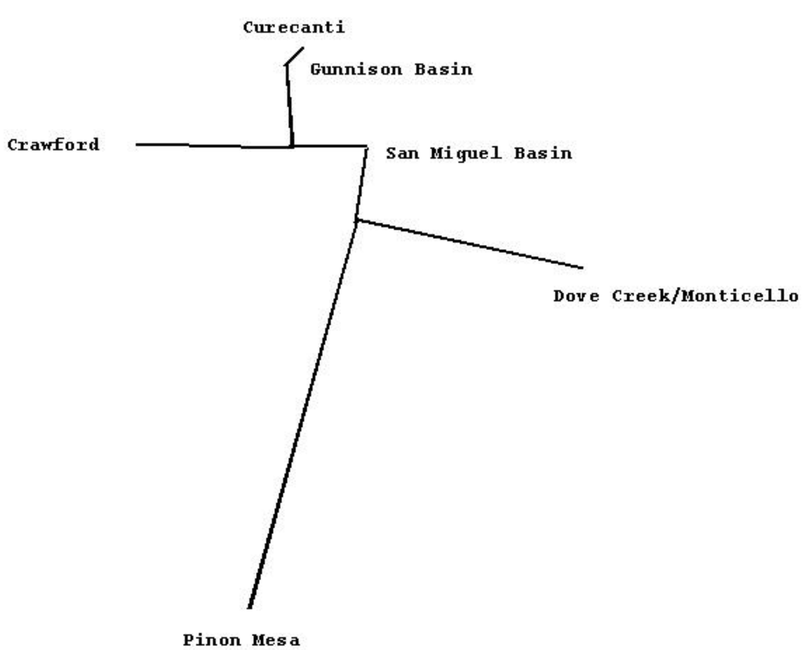


Fig. 6. Neighbor joining trees created from two genetic distances (1) proportion of shared alleles, and (2) F_{ST} (Oyler-McCance et al., in press).

Fig. 7. Results of STRUCTURE analysis conducted by Oyler-McCance et al. (in press). Each vertical bar represents an individual grouped into populations (1 = Gunnison Basin, 2 = Piñon Mesa, 3 = San Miguel Basin, 4 = Dove Creek - Monticello, 5 = Crawford, 6 = Curecanti, 7 = 4 samples taken from Sims Mesa). The colors on each vertical bar represent the probability of the individual belonging to a certain cluster. Each cluster is represented by a unique color.

D. GUSG Habitat Mapping Efforts

Mapping of GUSG habitat is key to assessing the current status of populations. There are 2 projects in progress that map current GUSG habitat. Current habitat for the RCP was generated using the CDOW habitat mapping effort described below.

RCP Habitat Mapping

CDOW is in the process of refining Wildlife Resource Information System (WRIS) mapping efforts for GUSG habitat. The following habitat definitions were used during the initial mapping portion of this project, and appear in maps in the RCP. For consistency, both CDOW and UDWR used these definitions for RCP mapping purposes.

Occupied Habitat: Areas of suitable habitat known to be used by GUSG within the last 10 years from the date of mapping. Areas of suitable habitat contiguous with areas of known use, which do not have effective barriers to sage-grouse movement from known use areas, are mapped as occupied habitat unless specific information exists that documents the lack of sage-grouse use. This category can be delineated from any combination of telemetry locations, sightings of sage-grouse or sage-grouse sign, local biological expertise, GIS analysis, or other data sources.

Vacant or Unknown Habitat: Suitable habitat for sage-grouse that is separated (not contiguous) from occupied habitats that either (1) has not been adequately inventoried, or (2) has not had documentation of grouse presence in the past 10 years.

Potentially Suitable Habitat: Unoccupied habitats that could be suitable for occupation of sage-grouse if practical restoration were applied. Soils or other historic information (photos, maps, reports, etc.) indicate sagebrush communities occupied these areas. As examples, these sites could include areas overtaken by piñon-juniper or converted to rangeland.

In the "Habitat Monitoring" rangewide strategy we recommend further refining these habitat definitions, particularly to distinguish between "Vacant" and "Unknown" habitat (see pg. 220, Objective 1).

BLM Habitat Mapping

An additional mapping effort was initiated by the BLM in 2002, through a contract with the Colorado Natural Heritage Program (CNHP), as part of a national agency mapping effort. With the help of other agency biologists, the Colorado BLM completed a statewide habitat risk map. BLM and CDOW biologists (primarily) hand-edited spatial information about sagebrush and sage-grouse habitats on 1:100,000 topographic maps based on Basin-wide vegetation inventory data and local knowledge of the area. They identified existing sage-grouse habitat in Colorado that appears to be in good condition, as well as habitat that is "at risk." For those habitats considered to be at risk biologists identified the specific threat or threats to the habitat (e.g., weeds, fire, lack of fire), and whether the "risk" threatened habitat quality or might result in habitat loss and/or fragmentation. In identifying habitat quality ("good" or "at risk"), biologists also considered whether the habitat quality in a habitat polygon was likely to significantly degrade within 5 years if no management actions were taken. CNHP organized, compiled, facilitated and produced the results of this mapping effort. These maps were not included in this plan due to their large size; currently, one can access the maps at local BLM field offices.

Four habitat quality risk factors were identified: (1) weed invasion; (2) piñon-juniper encroachment; (3) old and even-aged sagebrush overstory; and (4) poor herbaceous understory condition. Six factors causing habitat loss or fragmentation were noted: (1) weed domination; (2) piñon-juniper replacement; (3) oil and gas development; (4) powerline infrastructure development; (5) subdivisions (human development); and (6) existing or proposed land uses (ranging from land exchange to agricultural conversion).

For each polygon, any occurrence of sage-grouse was noted, and site-specific comments (e.g., wildfire, gravel pit, weed infestation associated with oil field) were recorded. The BLM habitat map will be updated every 5 years to reflect changes in habitat due to management, new information, or a consequence of nature (e.g., drought, fire, disease). These maps are expected to help identify and prioritize BLM budget, conservation actions, and management for sage-grouse on public lands. The maps will also be made available to other agencies and local work groups to use as a tool in sage-grouse management proposals and decisions.

E. Status and Distribution of Individual Populations

Cerro Summit – Cimarron - Sims Mesa Population

General Description

The Cerro Summit - Cimarron and Sims Mesa areas are considered 2 subpopulations and are described separately within this section. They are geographically separated and, to date, it is not known if sage-grouse move between the 2 areas. The Cerro Summit - Cimarron subpopulation is in Montrose County, centered about 15 miles east of Montrose, Colorado (Figs. 4 [pg. 38] and 8). The current spatial extent of the Cerro Summit - Cimarron subpopulation is approximately 31,900 acres. The habitat varies in elevation from 7,000 to 9,000 feet and consists of patches of sagebrush habitat fragmented by oakbrush and irrigated pastures. Patches of late-seral stage sagebrush are found primarily on steep hillsides. Landownership in the Cerro Summit - Cimarron area is approximately 81% private, 12% CDOW (Cimarron State Wildlife Area), 7% BLM, and 0.1% NPS (Fig. 8 and Appendix D). Land-use is primarily livestock grazing, hay production and recreation. The area includes large, relatively undisturbed tracts being managed as working ranches. However, portions of the area (less than 5 % of the occupied range), especially those with level terrain, are currently being subdivided for residential development.

The Sims Mesa Area is located in Montrose County about 7 miles south of Montrose, Colorado (Figs. 4 [pg. 38] and 8), and is approximately 5,300 acres. Elevation ranges from 6,000 to 7,000 feet and consists of small patches of sagebrush that are heavily fragmented by piñon-juniper, residential and recreational development, and agricultural lands. Landownership is roughly 44% private, 51% BLM, and 6% CDOW (Fig. 8 and Appendix D). Land-use at Sims Mesa is primarily ranching.

Fig. 8. Location, landownership, and habitat status of the Cerro Summit – Cimarron – Sims Mesa GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

Very little data exist on this population but it is thought to be small (RCP estimate based on 2004 lek count is 39 GUSG; see pg. 45) and widely dispersed. The first searches for sage-grouse in the area occurred in 1995 in the Cerro Summit – Sims Mesa region (Potter 1995). Nuclear DNA data suggest the Cerro Summit – Cimarron – Sims Mesa population is distinct and does not serve as a corridor that links the Gunnison Basin or other populations, but genetic information is limited (Oyler-McCance et al., in press). It is not known if GUSG move between Cerro Summit- Cimarron and Sims Mesa. In spring of 2000, 6 sage-grouse (4 males and 2 females) were transplanted from the Gunnison Basin to Sims Mesa. The 4 males removed their radio collars before release, and signals for the 2 females were lost after 2 weeks; thus, the fate of these birds is unknown.

There are 3 known lek sites at Cerro Summit - Cimarron (Cimarron, Coal Hill and Cerro), and 1 lek site in the Sims Mesa area (Table 9). Only the Cimarron and Coal Hill leks were active between 2001 and 2004. The inactive status of the Veo lek (Table 9) may be the result of a sagebrush herbicide treatment in 1995 that included at least half of the lek. The Cimarron lek was discovered in 2001 and is located on the Cimarron State Wildlife Area (SWA). The site was brush-mowed in 2000. Actual total counts of males for this lek are believed to be higher than reported because poor spring road conditions have frequently made it difficult or impossible to conduct lek counts at peak attendance time. It is likely that other leks exist in the area, but lek searches are difficult because of the high percentage of private land and lack of road access to the area. Searches in 2002, 2003, and 2004 yielded no new leks, although in 2003 sage-grouse sign was found on Sims and Moonlight Mesas, and 1 male was flushed from Moonlight Mesa in February, 2004.

Table 9. High male counts on leks in Cerro Summit – Cimarron - Sims Mesa population, 2001-2004 (CDOW, unpublished data).

Lek Name	**Landownership**	**2001 Male Count**	**2002 Male Count**	**2003 Male Count**	**2004 Male Count**
Cerro (Veo)	Private	0	0	0	0
Cimarron	Public (CDOW)	4	3	3	6
Coal Hill	Private	4	3	3	2
Sims Mesa	Public (BLM)	4	2	0	0
Total	**-**	**12**	**8**	**6**	**8**

Historic Information

Rogers (1964) noted a small population of sage-grouse in the Cimarron River drainage south of Cimarron but did not report population numbers. He did not report sage-grouse near Cerro Summit, but did note that lek count data from April 14, 1959 listed 4 individuals (including 2 males) at Cerro Summit. For the Sims Mesa area, Rogers (1964:115) states, " On the eastern slope of the Uncompahgre, a few sage grouse are found in the Simms (sic) Mesa-Duckett Draw area west of Colona and possibly in the Dry Creek area northwest of Montrose." A lek count at Sims Mesa conducted by Rogers on April 9, 1960 tallied 8 male grouse.

Local Conservation Plan

No local conservation plan or work group exists for the Cerro Summit – Cimarron - Sims Mesa population.

Habitat Improvements/Completed Conservation Actions

The Cimarron SWA has > 3,000 acres of sagebrush cover with the potential for habitat improvements to benefit GUSG. Several patches of shrubs were mowed (total area approximately 90-100 acres) in 2000, resulting in the establishment of a new lek in 2001. Boundary fences to exclude trespassing cattle from wetland areas are planned and thus far approximately 8 miles of fence have been repaired. No extensive habitat treatments are planned until additional distribution and habitat use data for sage-grouse are available. The CDOW earmarked $15,000 for additional habitat improvements adjacent to Cimarron SWA, completed in September 2004.

Efforts to implement habitat improvements in the Sims Mesa area are also pending until more is known about GUSG distribution and habitat use. This population is small and the effects of an ill-timed or poorly conceived habitat treatment project could result in loss of important sage-grouse habitat. However, the BLM has proposed a program to increase diversity in some of the plowed and seeded areas. This will likely involve herbicide applications and drilling a native grass/non-native forb mix (small burnet and ladak alfalfa), as funding becomes available. In 2003, 2 grazing permits at Sims Mesa were purchased by CDOW. The CDOW is also funding approximately 385 acres of habitat improvements at Sims Mesa to remove invading piñon-juniper, reduce sagebrush canopy cover, and reseed in areas with poor understory.

Easements/Candidate Conservation Agreements with Assurances

The majority (80%) of the Cerro Summit - Cimarron area is privately owned (Fig. 8) and cooperation with landowners is key to successful management and long-term population viability of GUSG. Currently (through 2003), 2,798 acres in occupied habitat, and 559 acres in potential habitat are under easement in Cerro Summit – Cimarron – Sims Mesa (Fig. 9; see also Appendix D). Efforts by the CDOW to establish easements have been limited, pending data on GUSG distribution.

In addition, several private property owners have shown interest in easements or Candidate Conservation Agreements with Assurances (CCAA). A CCAA is an agreement between the USFWS and 1 or more non-federal landowners that, "… provides non-Federal property owners who voluntarily agree to manage their lands or waters to remove threats to candidate or proposed species assurances that their conservation efforts will not result in future regulatory obligations in excess of those they agree to at the time they enter into the Agreement…" (U.S. Fish and Wildlife Service 2005). Currently no CCAA's exist for any of the GUSG areas. An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the Cerro Summit – Cimarron – Sims Mesa area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 9. Conservation easements in the Cerro Summit – Cimarron – Sims Mesa GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

Crawford Population

General Description

The Crawford population of GUSG is located in Montrose County, Colorado, about 8 miles southwest of the town of Crawford and north of the Gunnison River (Figs. 4 [pg. 38] and 10). Approximately 35,000 acres of habitat are currently occupied by GUSG. The Crawford area ranges in elevation from 5,084 feet at the Gunnison River to 9,020 feet near Cathedral Peak on the east side. The area is characterized by diverse topography including rocky drainages covered by piñon-juniper woodlands, rolling uplands dominated by big sagebrush and mountain big sagebrush, and gentle slopes with primarily hay meadows, saltbush, and wheatgrass. The region is semi-arid, with approximately 14 inches of precipitation falling annually on Fruitland Mesa. About 50% of this moisture occurs as winter snowfall. Basin big sagebrush and black sagebrush dominate the mid-elevation uplands. Of the land in the area, 63% is managed by the BLM, 13% is managed by the NPS and 24% is privately owned (Fig. 10 and Appendix D). The area includes rural housing and town sites as well as agricultural developments (especially orchards).

Fig. 10. Location, landownership, and habitat status of the Crawford GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

The Crawford Area Conservation Plan (CACP 1998) reported a 1996-1997 estimate of 129 – 228 GUSG in the Crawford population, based on counts of males at leks (CACP 1998; see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for Crawford (128) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45). Currently there are 4 active leks in the Crawford area (Table 10), all in sagebrush habitat adjacent to a 7-mile stretch of road and all on land managed by the BLM. This area represents the largest contiguous sagebrush-dominated habitat within the Crawford boundary.

Table 10. High male counts on leks in the Crawford population, 2001-2004 (CDOW, unpublished data).

Lek Name	Landownership	2001 Male Count	2002 Male Count	2003 Male Count	2004 Male Count
Dam	Public (BLM)	0	8	3	6
Fruitland	Public (BLM)	6	11	12	7
Middle	Public (BLM)	0	1	0	0
Range Cone	Public (BLM)	22	20	8	9
Section 35	Public (BLM)	0	2	1	4
Total	**-**	**28**	**42**	**24**	**26**

Historic Information

Rogers (1964) noted that sage-grouse were present in the Crawford area and estimated the population density to be less than 10 individuals/mi^2. He did not report any lek count data. Consistent lek counts in the Crawford area were initiated in 1978. Since that time, the number of active lek sites has fluctuated between 3 and 7, but historically individuals were counted on 15 different leks. GUSG have probably occurred in all suitable sagebrush habitats in the Crawford area (Fig. 10).

Local Conservation Plan

The Crawford Area GUSG work group formed in 1995 and the CACP (1998) was finalized and signed July 22, 1998. The CACP boundary includes current and probable or historic range of GUSG in Montrose and Delta Counties (CACP 1998). The probable or historic range designations are based on known historic use sites and sage-grouse observations, as well as the location of sagebrush habitat and suitable soil types for sagebrush.

Specific habitat problems identified in the Crawford Area Conservation Plan (CACP 1998:5) are (1) fragmentation of habitat components (i.e. too much distance between nesting and brooding areas, and wet areas); (2) invasion of piñon-juniper into sagebrush habitats; (3) inadequate grass and forbs in the sagebrush understory (limits brood-rearing habitat); (4) low vegetation age-class diversity (homogeneous old age stand exists); (5) low vegetation vigor; (6) poor vegetation conditions on leks (too much vegetation > 8 inches high); and (7) few mesic sites.

The primary population goal in the CACP (1998) is to maintain a minimum spring population of 225 individuals and to increase that to 480 individuals by 2010. Additionally, the plan aims to maintain a minimum of 4 active leks with at least 14 males/lek. The plan habitat goal is based on the population goal, to "Maintain on suitable sites across the Crawford landscape relative large, contiguous stands of sagebrush with a variety of vegetative conditions interspersed throughout, in the desired arrangement with good connectivity to provide the quantity and quality of sage grouse habitat to support at least the desired optimum population level by 2010" (CACP 1998:7).

To meet the population and habitat goals, 3 general conservation objectives are identified. They are to (1) maintain and improve the quality of GUSG habitat; (2) reduce fragmentation by preventing, minimizing, and mitigating past, present and future loss of GUSG habitat; and (3) identify and manage physical disturbances to reduce adverse effects to GUSG.

Conservation actions in the plan are divided into the following categories: information and education, monitoring, avoiding or mitigating permanent loss of habitat, restoring or improving the quality of grouse habitat and populations, reducing physical disturbance to sage-grouse, and improving community support and participation (CACP 1998).

Habitat Improvements/Completed Conservation Actions

The CDOW, BLM, and North Fork Habitat Partnership Program have completed approximately 5,800 acres of habitat improvement projects for GUSG in the Crawford area. These treatments include prescribed burns to develop wet meadow habitat and control piñon/juniper invasion (2,845 acres), piñon-juniper removal (700 acres), roller chopping (1,050 acres), rotobeating (1,200 acres), interseeding (20 acres), and improvement and development of new lek sites by mowing shrubs. In addition, 5 wet seeps have been developed off an existing waterline or by other means to enhance or create wet areas for GUSG. Several leks presently used for display are in areas that were brushbeat in 1994 and 1996. The BLM is continuing to control piñon-juniper invasion through the use of prescribed burns and mechanical treatments, with equipment such as the hydroaxe.

Easements/Conservation Agreements with Assurances

There are currently (data through 2003) conservation easements on 523 acres in occupied habitat, and 936 acres in potential habitat at Crawford (Fig. 11; see also Appendix D). There is potential interest in future easements.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the

Crawford area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 11. Conservation easements in the Crawford GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

Dove Creek Subpopulation

General Description

The Dove Creek GUSG subpopulation is located primarily in western Dolores County, Colorado, north and southwest of Dove Creek (Figs. 4 [pg. 38] and 12); a small portion of occupied habitat extends into San Miguel County (Fig. 12). The estimated area occupied by the subpopulation is approximately 28,300 acres and elevation ranges from 6,600 – 8,100 feet. Habitat north of Dove Creek is characterized as mountain shrub habitat, dominated by oakbrush interspersed with sagebrush. The area west of Dove Creek is dominated by sagebrush, but the habitat is highly fragmented and has a sparse understory that is primarily crested wheatgrass.

Approximately 87% of occupied habitat at Dove Creek is privately owned, and 13% is managed by the BLM (Fig. 12 and Appendix D). Land-use in Dove Creek is mostly agriculture, but a major subdivision called Secret Canyon Ranches lies within the boundary. The Secret Canyon Ranches subdivision is 2,700 acres (about 9% of the GUSG Dove Creek subpopulation occupied range) and has been subdivided into 35-50-acre tracts, although few of these tracts have been developed.

Apa (2004) measured vegetation characteristics at nest sites in Dove Creek and compared them to published habitat guidelines for sage-grouse (Connelly et al. 2000). He found that sagebrush canopy cover at 6 of 9 nest sites was below the recommended range for cover. Although grass cover was adequate at 80% of nest sites, grass height was well below the recommended guidelines (Connelly et al. 2000) at all nest sites; thus grass provided little concealment at nests. Perhaps poor cover, exacerbated by drought, was the reason why all but 1 nest failed during this study. Unmarked sage-grouse hens with broods were observed heavily using fields enrolled in the Conservation Reserve Program (CRP) in areas west of Dove Creek, and on the north side of town were seen moving up into oakbrush/mountain shrub communities with sagebrush in the understory.

Fig. 12. Location, landownership, and habitat status of the Dove Creek and Monticello GUSG populations. Habitat status definitions are provided on page 54. The abrupt discontinuity in occupied habitat at the state line is not entirely a mapping artifact; where there is occupied habitat on the Colorado side there is an abrupt change to cropland on the Utah side of the border. Resolving differences in "Potential" and "Vacant/Unknown" habitat mapping efforts between the states is addressed in the "Habitat Monitoring" rangewide strategy (see Objective 1, Strategy 3, pg. 221). The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

The Dove Creek Conservation Plan (DCCP 1998) estimated that the local subpopulation size in 1998 was from 81 to 135 individuals, based on extrapolation from counts of males at leks (see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for Dove Creek (10) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45). All lek sites in the Dove Creek area are located in agricultural fields on private lands (Table 11). Several leks are located in fields enrolled in the CRP program and planted to permanent grass cover, which makes them poor lek sites. Consequently, lek site locations are dynamic, moving often.

Table 11. High male counts on leks in the Dove Creek subpopulation, 2001-2004 (CDOW, unpublished data).

Lek Name	Landownership	2001 Male Count	2002 Male Count	2003 Male Count	2004 Male Count
Alfalfa	Private	2	0	0	0
Panoramic View	Private	20	0	3	0
Phantom	Private	0	0	0	0
Sage	Private	0	5	3	2
Sage Southeast	Private	0	9	0	-*
Section 18/Schutt	Private	0	4	1	0
Wheatfield	Private	5	2	1	0
Total	**-**	**27**	**20**	**8**	**2**

* As of 2004 this lek should not be considered separately from Sage lek – same birds likely attend both, depending on the year. Count both leks, but consider it 1 count.

Historic Information

Rogers (1964) reported that all sagebrush dominated habitats in Dolores and Montezuma counties were historically used by sage-grouse. The historic distribution was highly fragmented by piñon-juniper and rocky canyons.

Local Conservation Plan

The DCCP (1998) was completed November 23, 1998. It described the boundary of the Dove Creek GUSG management area as within Dolores County, which was based on field observations during 1994-1997, reports from landowners, radiotelemetry studies, and location of suitable habitat.

The DCCP (1998) lists several specific factors that may be seasonally limiting for GUSG. Suitable escape cover (relatively tall sagebrush) near leks is lacking in many cases. Grasses and forbs in the understory of some sagebrush areas are not adequate for nesting and brood-rearing. During late summer and fall, sage-grouse in the Dove Creek area often find the best grass and forb availability in drainage areas and on the margins of agricultural fields. But some of this habitat is dramatically reduced in fall after crops are harvested and pastures have been grazed. Snow depth may render sagebrush unavailable to GUSG in higher elevation areas northeast of Dove Creek.

The population goal described in the DCCP (1998) is to maintain a minimum of 5 active leks with an average of 10 males/lek, resulting in a spring population of 199 individuals. The optimum spring population goal listed in the plan is to have 6 active leks with 20 males/lek translating to a population of 480 individuals.

To achieve the population goal the plan lists the following 3 objectives, to (1) maintain and improve the quality of sage-grouse habitat; (2) reduce fragmentation by preventing, minimizing and mitigating past, present, and future loss of sage-grouse habitat; and (3) identify and manage physical disturbances to reduce adverse effects to sage-grouse (DCCP 1998:10)

Conservation actions in the DCCP (1998) are divided into the following categories: information and education, monitoring, avoiding or mitigating permanent loss of habitat, restoring or improving quality of grouse habitat and populations, reducing physical disturbance to sage-grouse, and improving community support and participation.

Habitat Improvements/Completed Conservation Actions

There have been few habitat treatments in Dove Creek. Approximately 400 acres of oakbrush have been mechanically treated to improve the area as sage-grouse habitat, and an additional 400-acre area mowed for big game use has been used by GUSG (Apa 2004). In 2002 the CDOW completed a 200-acre dixie harrow treatment with seeding on a private land parcel west of Dove Creek. In addition the CDOW constructed an interseeder for use in seeding sagebrush and understory species in CRP and other areas in Dove Creek. Three test plots (2-5 acres) were seeded with the interseeder in 2003: 1 in CRP (sagebrush seeded), 1 in non-native rangeland (sagebrush seeded), and 1 in sagebrush (grass/forb mix seeded).

Easements/ Conservation Agreements with Assurances

Easements on 1,013 acres in occupied habitat have been signed with landowners in the Dove Creek area (data current through 2003, Fig. 13; see also Appendix D). Dove Creek landowners have submitted a request for CDOW to purchase a potential total of 2,000 - 3,000 acres. The purchase is pending.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the Dove Creek area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 13. Conservation easements in the Dove Creek and Monticello GUSG area (data current through 2003). Habitat status definitions are provided on page 54. See Fig. 12 (pg. 69) for discussion of habitat discontinuities at the state line.

Gunnison Basin Population

General Description

The Gunnison Basin is an intermontane basin that includes parts of Gunnison and Saguache Counties, Colorado. The current GUSG range is approximately 593,000 acres, roughly centered around the town of Gunnison (Figs. 4 [pg. 38] and 14). Elevations in the area range from 7,500 to 9,500 feet. Uplands are moderately to steeply rolling and are dissected by permanent and intermittent stream drainages. Shallow eroded gulches are common on upland slopes and steep-sloped mesas occur in several parts of the Basin.

Big sagebrush dominates upland vegetation and has a highly variable growth form depending on local site conditions. On dry south slopes the sagebrush is short and widely spaced and on wetter sites it can be tall and vigorous. Generally, sagebrush rangelands below 8,500 feet are older stands with little understory. Higher elevation stands receive more moisture and have healthier understories, though many of these stands are monotypic with dense, closed canopies. Most of the valley bottoms along the major stream corridors have been converted to hay and pastureland.

Approximately 51% of the delineated GUSG range is managed by the BLM, 14% by the USFS, 2% by the NPS, 2% by the CDOW, 1% by the Colorado State Land Board, and 31% is privately owned (Fig. 14 and Appendix D). Land-use is primarily ranching and hay production, but residential subdivision development has been expanding out from Gunnison in the past 25 years.

Young (1994) reported 43.2% nest success for GUSG in the Gunnison Basin. This is on the low end of the normal range for sage-grouse. Apa (2004) documented 9 nesting attempts, of which 6 were successful (67%). Apa (2004) also reported on vegetation characteristics at nest sites and compared them to published guidelines for sage-grouse (Connelly et al. 2000). He found sagebrush canopy cover to be within the range suggested by the guidelines at 3 of 9 nests, and above the guideline standard at 6 of the 9 nests. Grass height at all 9 nests was below guideline levels, while grass cover was within guidelines at 2 of 9. In most sage-grouse habitats in Colorado sagebrush canopy conceals nests more than grass does. The guideline standards (Connelly et al. 2000) are dominated by published literature from the Great Basin and Northwest, where bluebunch wheatgrass and other bunch grasses predominate. Apa (2004) also reported vegetation characteristics at brood-rearing sites. Sagebrush canopy was within (or above) guidelines at 13 of 20 sites (65%), while forb cover was within the guideline range at 15 of 23 sites (65%).

The CDOW analyzed the sex and age composition of GUSG wings collected at check stations in the Gunnison Basin when hunting seasons were open. Chicks/hen in the harvest can serve as an index to productivity (integrates nest success and chick survival). Although quite variable, juveniles/hen in the harvest (excluding years with less than 100 wings) averaged 4.3, compared to the standard suggested by the sage-grouse guidelines of greater than or equal to 2.25 juveniles per hen for stable or increasing populations (Connelly et al. 2000). From 1977 to 1998, juvenile/hen ratios were below 2.25 only once. However, from 1977 to 1988, juveniles/hen averaged 5.2, but from 1989 to 1998, they averaged 3.6. Although the absolute numbers seem reasonable, the trend is clearly downward.

Fig. 14. Location, landownership, and habitat status of the Gunnison Basin GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

The Gunnison Basin GUSG population has been estimated at 1,992 (Colorado Division of Wildlife 2004a) based on counts of males on leks and using estimate assumptions like those in the GBCP (1997; see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for the Gunnison Basin (2,443) is also based on 2004 lek count data, but uses slightly different assumptions (see pg. 45).

Currently, approximately 78 leks are surveyed annually for breeding activity in the Gunnison Basin (Colorado Division of Wildlife 2004a). In the Gunnison Basin, these are divided into the following categories: (1) active – display and/or breeding activity by at least 2 males observed on at least 2 visits during the breeding season; (2) inactive – no display or breeding activity observed for the last 5 – 9 years; (3) unknown –less than 2 males were observed during 2 visits during the breeding season, or less than 2 visits were made during breeding season, or lek has been considered inactive for less than 5 years; and (4) historic – considered inactive for 10 or more years. In 2003, in the Gunnison Basin there were 36 active leks, 34 inactive leks, 10 leks of unknown status, and no historic leks (Colorado Division of Wildlife 2004a). Lek count data are summarized by lek area for the Gunnison Basin (Table 12). Approximately 45% of these leks occur on private land and 55% on public (primarily BLM) land.

Table 12. High male counts on leks in the Gunnison Basin population, 2001-2004 (CDOW, unpublished data). The high male count is the sum for all lek sites within each lek area.

Lek Area	Number of lek sites	2001 Male Count	2002 Male Count	2003 Male Count	2004 Male Count
Almont	2	7	5	3	6
Antelope	4	29	18	29	23
Chance Gulch	6	75	55	49	33
Eagle Ridge	5	71	77	80	46
Gold Basin	2	8	10	14	22
Hartman Gulch	1	34	33	35	33
Hippie/Sewell	1	37	26	5	10
Iola	5	9	7	14	6
Kezar Basin	2	30	20	21	22
Lost Canyon	3	3	3	4	4
McCabe Lane	1*	0	0	0	8*
Monson Gulch	3	12	15	8	12
Needle Creek	1	0	0	0	0
Ninemile	2	0	0	0	1
North Parlin	4	9	14	10	7
Ohio Creek	7	108	105	71	80
Pine Creek Mesa North	2**	3	2	1	0**
Pine Creek Mesa South	2	4	2	3	1
Razor Creek	2	19	14	8	2
Razor Creek Divide	1	33	23	17	19
Razor Dome	2	27	18	15	27
Sapinero North	1	14	14	6	8
Sapinero South	4	28	28	21	27
Six Mile	4	30	7	11	5
South Parlin	3	43	41	37	46
Sugar Creek	1	11	26	15	13
Tomichi Village	2	4	1	1	7
Waunita	3	48	40	17	23
Willow Creek	1	0	0	0	0
Woods Gulch	1	16	13	5	7
Total	**78**	**712**	**617**	**500**	**498**

* In 2004 another lek was found in this lek area – total leks becomes 2.
** Only 1 lek was counted in 2004.

Historic Information

It is likely that GUSG historically occurred in all suitable sagebrush habitats from east of Sargents (Marshall Creek, upper Tomichi Creek), west to Blue Creek (further west to at least Colorado Highway 347), north to at least Brush Creek and Taylor Park, and south to the Hinsdale-Gunnison County boundary and Cochetopa Park in Saguache County (GBCP 1997). Generally, there has been a contraction in occupied area at the periphery of the historic range. Rogers (1964) stated that Gunnison County had one of the largest sage-grouse populations in the state.

Local Conservation Plan

The GBCP (1997) was completed in June 1997. The GBCP (1997) was the first local conservation plan written and it served as a template for other work groups when writing their local conservation plans.

The primary population goal described in the GBCP (1997) is a minimum spring breeding population of 2,600 sage-grouse on 25 known active leks distributed throughout the Gunnison Basin, with an average of 26 males per lek. The optimum spring population goal is 3,600 individuals on 30 known leks that are well distributed throughout the Basin, with an average of 30 males per lek. The GBCP (1997) intent is to reach the optimum population numbers in 15 years. The overall habitat goal described in the GBCP is, “To manage the Gunnison Basin watershed in a manner that restores Gunnison sage grouse distribution and numbers as determined by the carrying capacity of the habitat” (GBCP 1997:8).

Three objectives were developed to achieve the population and habitat goals. They are to (1) maintain and improve the quality of GUSG habitat; (2) reduce fragmentation by preventing, minimizing, and mitigating past, present and future loss of GUSG habitat; and (3) identify and manage physical disturbances to reduce adverse effects to GUSG.

Conservation actions in the GBCP (1997) are divided into the following categories: information/education/coordination, research and monitoring, mapping and inventory, permanent loss of habitat, habitat quality and physical disturbance. Implementation of the conservation actions is outlined in 5 phases over 15 years.

Habitat Improvements/Completed Conservation Actions

Many habitat improvement projects in the Gunnison Basin were reported in 2002 and 2003 (Colorado Division of Wildlife 2002, 2003) (Table 13). Some additional BLM activities included maintenance on 4 existing grazing exclosures, incorporation of sage-grouse habitat objectives into some BLM grazing permit renewals, and protection of leks during the breeding season by closing some roads and signing others, mapping and monitoring habitat, and acquisition of 500 acres of private land to benefit GUSG management. A Watchable Wildlife site at Waunita Lek was approved and completed. Several grazing permit reductions/adjustments (often over 50%) have been made in the BLM Gunnison Field Office to benefit GUSG and GUSG habitat. In addition, aggressive drought management actions (including temporary non-use of grazing permits) were taken on public lands in 2002 and 2003 to protect the sagebrush community.

A recently identified threat to sagebrush habitat in the Basin is an increasing invasion of cheatgrass (CDOW CVCP Review 2002). The CDOW and Gunnison County Weed Coordinatior initiated a program to map, monitor, and control cheatgrass in 2002, when they mapped and treated 35 acres of cheatgrass. In 2003, that effort increased to 100 acres, and in 2004, the effort increased to 300 acres (participation included the BLM in 2004). Treatment of cheatgrass in Gunnison County is being done with fall applications of "Plateau" herbicide, after native cool season perennial grasses are dormant, to prevent damage to the native grasses that provide habitat for grouse.

A vegetation inventory study by CDOW, BLM, and NRCS was begun in Long Gulch in 2002. Discussions among the Gunnison County Rural Electric Association, CDOW, and USFS resulted in a powerline being rebuilt in its current path rather than in a new one through a lek area, and in a new substation being built below ground to minimize GUSG impacts.

Table 13. Habitat improvement projects reported by CDOW (Colorado Division of Wildlife 2002, Colorado Division of Wildlife 2003).

General Location	Project Description	Acres Treated (if applicable)	Project Completed By
Long Gulch	Brush mow/Seed	376	CDOW, BLM
Long Gulch	Mow/Fence/Seed	1	BLM
Long Gulch	Mow	70	NRCS
Long Gulch	Spike treatment	250	NRCS
Dutch Gulch	Wetland/riparian restoration (600 willow stems)	N/A	CDOW
Dutch Gulch SWA	Fencing	400	CDOW
West Antelope Creek	Brush Mowing	30	BLM
Tomichi Dome	New exclosure	N/A	BLM
Leaps Gulch	New exclosure	N/A	BLM
Antelope Creek Lek	Reseed burn area with mountain big sagebrush	320	BLM
	Spray cheatgrass	110	BLM, CDOW, County Weed Coordinator
McIntosh Mountain	Controlled burn (patchy result)	154	CDOW, BLM
Indian Creek Drainage	Controlled burn (patchy result)	22	CDOW, BLM
Kezar Basin	Mow/Seed	60	BLM, NRCS

Table 13. Habitat improvement projects reported by CDOW (Colorado Division of Wildlife 2002, Colorado Division of Wildlife 2003).

General Location	Project Description	Acres Treated (if applicable)	Project Completed By
Kaichen Easement	Riparian aspen/willow restoration		CDOW, landowner
Dutch Gulch SWA	Plant 5,000 willow stems within fence	N/A	CDOW
Long Gulch	Aerate/Partial seed (for drought effects)	47	CDOW
Monson Gulch	Aerate/Partial seed (for drought effects)	174	CDOW, BLM
South Parlin Flats	Aerate/Partial seed (for drought effects)	17	CDOW, BLM
Woods Gulch	Fence for riparian pasture	65	CDOW, USFS

Easements/Candidate Conservation Agreements with Assurances

Easements have been established on 26,145 acres in occupied habitat and 3,884 acres in potential habitat in the Gunnison Basin (data current through 2003, Fig. 15; see also Appendix D). This includes 310 acres in active lek habitat and 199 acres in inactive leks. In addition, in late 2003, the CDOW received approval to issue an RFP (request for proposal) for fee title acquisition of important grouse habitats in southwestern Colorado. As a result, the CDOW is in the process of purchasing private lands to protect leks in Blinberry Gulch and Chance Gulch.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the Gunnison Basin area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 15. Conservation easements in the Gunnison Basin GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

Monticello, Utah Subpopulation

General Description

The Utah subpopulation of GUSG is located in the southeastern corner of the state in San Juan County near the town of Monticello (Figs. 4 [pg. 38] and 12 [pg. 69]). The GUSG inhabit a broad, relatively flat, plateau on the northeast side of the Abajo Mountains, between 6,700 and 7,000 feet elevation. GUSG habitat in this area is generally characterized by large grass pastures and agricultural fields interspersed with fragmented patches of Wyoming sagebrush and black sagebrush. Annual precipitation averages about 12 inches and is very important in determining the availability of water and good brood habitat. There are no perennial water sources on this plateau.

Three types of GUSG conservation areas, each progressively smaller and nested within the previous area, have been designated in the San Juan County Conservation Plan (SJCCP 2000). A Conservation Area of over 800,000 acres was identified using current and historic habitats, GUSG observations, and remaining sagebrush areas in the county that may have the potential to provide suitable GUSG habitat. Within the Conservation Area, a Core Conservation Area of about 247,000 acres was delineated based on only current and historic use information. A Conservation Study Area (CSA) of approximately 59,700 acres was delineated within the Core Conservation Area using GUSG movement information obtained from a graduate research telemetry study. The CSA is similar to the area that is currently considered occupied habitat, but a small number of birds are known to exist outside the CSA. Currently occupied habitat is approximately 70,600 acres. This habitat consists of approximately 95% private land (most of which is currently enrolled in CRP), 4% managed by the BLM, and 1% by the state of Utah. The remaining private lands are used as rangeland pastures for cattle grazing or for dryland farming.

Population Information

There are currently 5 known leks in the Monticello subpopulation, but the East Seep lek has been inactive for 2 years. The males from the East Seep lek appear to have combined with a nearby lek, the Roring lek (Table 14). The number of males observed on the Roring lek nearly doubled in 2000 when the East Seep lek was abandoned. The Dodge Point lek was discovered in 1997 and is located outside the CSA. The number of males observed on this lek has continually declined since 1997 and no birds were found there in 2003.

The UDWR estimated a 2003 subpopulation size of 100-120 individuals. This estimate is based on a formula that assumes 75-90% of the males are being counted during spring lek counts and that the male to female ratio in the subpopulation is 1:2 (see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for Monticello (152) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45).

Table 14. High male counts on leks in the Monticello subpopulation, 2001-2004 (UDWR, unpublished data).

Lek Name	Landownership	2001 Male Count	2002 Male Count	2003 Male Count	2004 Male Count
BLM	Public (BLM)	4	3	4	4*
Dodge Point	Private	3	1	0	1
East Seep	Private	3	0	0	0
Hickman Flats	Private (protected by easement)	12	8	6	8*
Roring	Private	25	23	20	20
Total	**-**	**47**	**35**	**30**	**31***

* BLM and Hickman Flats leks are very close and grouse move between them, within and between days. Both are counted on the same day, and the combined total in 2004 was never higher than 10. Although separate high counts for these 2 leks total to 12, for the total high count we only used the total of 10 counted on both leks on a single day. Counts on the 2 leks should probably be combined in the future.

Historic Information

The historic range and population size of GUSG in Utah is not well documented. Lek sites in the Monticello area were first identified and counted in 1968 by UDWR. By 1970, annual counts were being conducted on 6 active leks. In 1974, brood-rearing and wintering areas were surveyed by UDWR biologists. Wings from hunter-harvested GUSG were also collected for sex and age ratio information beginning that year. Hunting for GUSG in the Monticello subpopulation was closed in 1982 due to declining trends in lek counts and hunter harvest. The hunt was reopened in 1985 to a shorter season and lower bag limit, then closed again 4 years later. GUSG hunting has not been allowed in the Monticello area since 1989.

Prior to 1968, there is no known written documentation of GUSG in the Monticello area. However, personal accounts of sage-grouse observations from long-time county residents indicated that the GUSG range extended considerably farther in all directions than the area that is currently occupied. Based on these personal reports, it is believed that GUSG inhabited areas that were about 25 miles north to the town of La Sal, about 15 miles south to Devil’s Canyon, farther east to the Colorado border, and farther west to the base of the Abajo Mountains.

Since lek surveys began in 1968, 3 active lek sites located on private property have been converted from sagebrush habitat to cropland or grazing pastures. The number of GUSG males attending these 3 sites declined rapidly and eventually the leks were abandoned. Approximately 2,000–3,000 acres of important sagebrush habitat within the CSA have been lost from conversion since the initiation of the CRP program in 1985. This was largely the result of private landowners “cleaning up” sagebrush areas adjacent to their idle farmlands under CRP.

Local Conservation Plan

The SJCCP (2000; Monticello subpopulation) was completed in November 2000 and an update was finalized in March 2003. The update primarily contains the results of recent research in the area and how this information should be applied to the SJCCP.

A primary goal of the SJCCP is to "ensure long-term conservation of GUSG within its historic range in San Juan County" but while preserving and enhancing "personal income on privately-owned agricultural lands" within the area (SJCCP 2000:17). A specific population objective to be met by the next 15 years is to have a spring breeding population of 500 individuals attending 6-8 leks, with an average of 20-25 males/lek.

Four habitat objectives for the core area are listed in the SJCCP (2000). They are to reestablish appropriate (1) breeding complex vegetation (including adequate escape cover) on 50-75% of the areas within 2 miles of known leks; (2) brood-rearing habitat on 50-75% of the area within 4 miles of known leks; (3) winter habitat on 50% of the areas; and (4) contiguous travel corridors (and to maintain these) (SJCCP 2000).

Conservation strategies in the SJCCP (2000) are divided into the following categories: develop public support and funding base for the conservation plan, monitoring and evaluation, species protection and population enhancement, restoring and improving habitat quality, and reducing physical disturbance.

Habitat Improvements/Completed Conservation Actions

As of February 2000, a total of 36,825 acres of private land within the Core Conservation Area has been enrolled in CRP. UDWR and NRCS developed a sage-grouse seed mixture for use in Monticello fields enrolled in the CRP. The cost of the seed and cost of preparing the land for seeding totaled over $1.2 million and involved a collaborative cost sharing effort among the UDWR, private land owners, the NRCS and the Farm Services Agency (FSA).

UDWR has been planting sagebrush seedlings and aerially seeding CRP fields with sagebrush to expand sagebrush cover in nesting and wintering areas. Cooperative UDWR-private landowner projects have been completed on a conservation easement property to thin shrub dominated sites with no understory, and to reseed them with grass-forb mixes to increase herbaceous cover. UDWR, NRCS, and USFWS have worked jointly to complete 2 water development projects on private lands. A well was drilled and a solar pump installed to spread water along a draw and create a wet meadow for brood-rearing habitat. Small drinkers were installed along an existing livestock water system to provide water for GUSG during summer months when livestock were not present.

Many CRP contracts in San Juan County expired in 1995. UDWR worked with NRCS and the FSA to designate San Juan County as a priority conservation area under CRP, because of GUSG. Designation as a priority conservation area meant that agricultural land submitted for CRP enrollment consideration did not have to meet the CRP erodibility index requirements. However, landowners could only qualify for the program if they agreed to implement approved wildlife conservation practices. Approximately 32,667 acres were enrolled in CRP as a direct result of this conservation priority initiative.

Easements/Candidate Conservation Agreements with Assurances

Two parcels of private land (2,240 and 320 acres) are protected for GUSG by in-perpetuity conservation easements (Fig. 13, pg. 72). Both parcels contain lek sites that have been active since lek counts were initiated by UDWR in the late 1960's. Other potential conservation easements or land purchases are being negotiated.

Piñon Mesa Population

General Description

The Piñon Mesa GUSG population is located in Mesa County, about 22 miles southwest of Grand Junction, Colorado (Figs. 4 [pg. 33] and 16). The estimated range currently occupied by GUSG at Piñon Mesa is approximately 38,900 acres. The area makes up the northwest end of the Uncompahgre Plateau and elevation ranges from 4,600 - 9,800 feet. The topography varies greatly and the area is noted for its canyon country, especially on the borders. Considerable moisture falls throughout the year in the higher elevations in the center of the area. The interior portions of Piñon Mesa are composed of mesas and canyons but the general terrain is less fragmented and more open. At lower elevations, saltbush, sagebrush, and greasewood are common. Piñon-juniper dominates on the lower and intermediate slopes. Oakbrush is found at higher elevations with patches of sagebrush and snowberry occurring in oakbrush openings. Sagebrush habitat is interspersed with patches of piñon-juniper and oakbrush. Landownership is 70% private, 28% BLM and 2% USFS (Fig. 16 and Appendix D). Land-use in the area is primarily livestock grazing, hay production and recreation, and development is occurring in some areas.

Fig. 16. Location, landownership, and habitat status of the Piñon Mesa GUSG population. Habitat status definitions are provided on page 54. Discontinuities in habitat at the state border may be due to differing mapping efforts between the states and is addressed in the “Habitat Monitoring” rangewide strategy (see Objective 1, Strategy 3, pg. 221). The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

A population estimate of 78-123 GUSG is reported in the Piñon Mesa Conservation Plan (PMCP 2000) and is based on the observation of 26 males on 4-5 leks (see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for Piñon Mesa (142) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45). In 2002, there were 6 known leks in the area (Table 15). The discovery of new lek sites was due to an abundance of grouse sign. The Piñon Mesa area may have additional lek sites, but the high percentage of private land, a lack of roads, and heavy snow cover during spring make locating additional leks difficult.

Table 15. High male counts on leks in the Piñon Mesa population, 2001-2004 (CDOW, unpublished data).

Lek Name	**Landownership**	**2001 Male Count**	**2002 Male Count**	**2003 Male Count**	**2004 Male Count**
Fish Park	Private	0	0	0	0
King's West (new in 2003)	Private	-	-	2	6
Luster Basin	Private	6	8	10	8
Nelson Creek	Private	6	2	0	2
Payne Mesa North	Private	4	0	2	1
Payne Mesa Pond	Private	10	10	5	4
Payne Mesa South	Private	5	7	4	4
2V Gate (new in 2003)	Private	-	-	2	4
Total	**-**	**31**	**27**	**25**	**29**

Historic Information

It is believed that GUSG historically occurred in all suitable sagebrush habitats in the Piñon Mesa area. This area is much larger than the currently occupied habitat. Rogers (1964) reported active grouse leks southwest of the Glade Park store (Fig. 16, junction of 16.5 road and other road leading southwest out of Colorado National Monument). The extent of the population has contracted, with only the most favorable habitats on Piñon Mesa being used today. Winter use of areas west of the Glade Park Store by migratory GUSG was documented in the winter of 2002/2003 (CDOW, unpublished data).

Local Conservation Plan

The PMCP (2000) was finalized on May 24, 2000. The plan boundaries are based on known historic use sites and sage-grouse observations, as well as the present potential of remaining sagebrush-dominated habitats. The overall goal of the plan is to: "Increase sage grouse numbers and distribution in the Piñon Mesa area while maintaining current ranching uses and a healthy landscape" (PMCP 2000:10).

The PMCP (2000) lists specific habitat quality concerns for the entire Piñon Mesa area as (1) invasion of piñon and juniper into sagebrush areas; (2) low vegetation class diversity (homogeneous old age stands exist); (3) low vegetation vigor; and (4) poor vegetation conditions on leks (too much vegetation greater than 8 inches high). At Glade Park additional habitat issues include (1) fragmentation of habitat components by housing development (i.e. too much distance between nesting, brooding, and wet areas); (2) inadequate grass and forbs in sagebrush understory; and (3) a short supply of wet areas and water sites. In addition, the PMCP (2000) identifies suitable winter habitat as possibly limiting in the Piñon Mesa population.

The primary population goal stated in the PMCP is to: "Maintain a sage grouse population in the Piñon Mesa area that is in balance with the carrying capacity of the habitat" (PMCP 2000:10). Specifically, the plan calls for a "…minimum spring population of at least 8 active leks (7 on Piñon Mesa and 1 on Glade Park) each with 15 males that are counted during spring lek counts." (PMCP 2000:10).

The PMCP habitat goal is to "Maintain and improve, on suitable sites across the Piñon Mesa landscape, relatively large, contiguous stands of sagebrush with a variety of vegetative conditions interspersed throughout, in the desired arrangement with good connectivity to provide the quantity and quality of sage grouse habitat to support the desired optimum population level by 2010" (PMCP 2000:10).

Three general conservation objectives are identified in the PMCP (2000). They are to (1) maintain and improve the quality of GUSG habitat; (2) reduce fragmentation by preventing, minimizing, and mitigating past, present and future loss of GUSG habitat; and (3) identify and manage physical disturbances to reduce adverse effects to GUSG.

Conservation actions in the PMCP (2000) are divided into the following categories: information and education, monitoring, avoiding or mitigating permanent loss of habitat, restoring or improving quality of grouse habitat and populations, reducing physical disturbance to sage-grouse, and improving landowner and community support and participation.

Habitat Improvements/Completed Conservation Actions

Nearly 3,000 acres of GUSG habitat in the Piñon Mesa area have been treated in the last 5 years, with funding coming from BLM, CDOW, and private landowners. Many of these treatments have occurred in unoccupied habitats with the intention of increasing suitable habitat and expanding the range of GUSG. Most of these habitat improvements have involved roller chopping to remove piñon-juniper with simultaneous seeding for grasses and forbs. Completed projects include lek development (40 acres), seeding (593 acres), clearing/mowing/cutting (and sometimes seeding) of piñon-juniper and tall sagebrush (approximately 4,581 acres), reseeding following fire (3,671 acres), and a burn that occurred in piñon-juniper (Dierich wildfire, approximately 2,533 acres).

Easements/Candidate Conservation Agreements with Assurances

Currently (through 2003), 7,266 acres in occupied habitat in the Piñon Mesa area are protected by perpetual conservation easements (Fig. 17; see also Appendix D). An additional 13,661 acres in potential habitat are under easement. Some existing conservation easements are being renegotiated to include provisions for protection and management of GUSG.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado of GUSG range (including the Piñon Mesa area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 17. Conservation easements in the Piñon Mesa GUSG area (data current through 2003). Habitat status definitions are provided on page 54. See Fig. 16 (pg. 86) for discussion of habitat discontinuities at the state line.

Poncha Pass Population

General Description

The Poncha Pass GUSG population is located in Saguache County and is centered about 10 miles northwest of Villa Grove, Colorado (Figs. 4 [pg. 38] and 18). The known population distribution is in the sagebrush habitat from the summit of Poncha Pass extending south for about 8 miles on either side of U.S. Highway 285 (Fig. 18); the estimated range of the population is about 20,400 acres and the area varies in elevation from about 8,020 - 9,020 feet. The vegetation is dominated by mountain big sagebrush, with some black sagebrush and oakbrush, especially in drainages. Sagebrush in this area is extensive and continuous with very little fragmentation. Vegetation inventory data illustrate that sagebrush habitat quality throughout the Poncha Pass area is adequate for GUSG (Nehring and Apa 2000). San Luis Creek runs through the area, providing a year-round water source and lush, wet meadow riparian habitat. The BLM manages 48% of the area, the USFS manages 26%, 24% is in private holdings, and 2% is managed by the Colorado State Land Board (Fig. 18 and Appendix D). Most of the area is managed for domestic livestock grazing, wildlife, recreation, and watershed values. Several permanent residences are established in the region, most of which are within a mile of Highway 285, and several ranch houses are scattered throughout the area.

Fig. 18. Location, landownership, and habitat status of the Poncha Pass GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

Population Information

The Poncha Pass Conservation Plan (PPCP 2000) estimated that the population at Poncha Pass ranges from 15 - 20 individuals, based on counts of males at leks (see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for Poncha Pass (39) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45).

Currently there is only 1 lek, located on BLM-administered land at Poncha Pass (Table 16). Lek activity monitoring at Poncha Pass has been inconsistent, but information from 1990 indicates that there may have been another lek 1 mile northeast of the current lek. Lek counts conducted in 1997 reported individuals displaying approximately 1 mile south of the current lek, indicating either that the Poncha lek location has shifted over the years or includes a greater area than currently thought. Consistent lek counts were initiated in 1999 by CDOW. Lek counts in 1999 dropped from 5 males to 1 male. In spring 1999, the known resident population at Poncha Pass consisted of 1 male and 5 - 6 hens (Nehring and Braun 2000).

Table 16. High male counts on leks in the Poncha Pass population, 2001-2004 (CDOW, unpublished data).

Lek Name	Landownership	2001 Male Count	2002 Male Count	2003 Male Count	2004 Male Count
Poncha Lek	Public (BLM)	5	9	7	8

In 1992, a CDOW effort to simplify hunting restrictions inadvertently opened the Poncha Pass area to sage-grouse hunting and at least 30 grouse were harvested from the Poncha Pass population. Declining numbers since 1992 have caused the CDOW to initiate transplants with GUSG trapped in the Gunnison Basin (Nehring and Apa 2000). In 2000, 24 GUSG were released at Poncha Pass, followed by additional transplants in 2001 and 2003 (Table 17). Transplanted individuals have been monitored for survival and reproduction. Approximately 68% of all transplanted individuals survived, which is higher than in previous attempts at transplanting sage-grouse in Idaho (Musil et al. 1993). Transplanted females have bred successfully (A. D. Apa, personal communication) and display activity resumed on the historic lek in spring 2001. Transplanted birds have used habitat beyond the area already in use by resident GUSG (Nehring and Apa 2000), suggesting that there is adequate available habitat for birds that are transplanted.

Table 17. Age and sex of GUSG transplanted to Poncha Pass, 2000-2002 (Nehring and Apa 2000, CDOW, unpublished data).

Transplanted Birds	**2000**	**2001**	**2002**
Adult Males	17	3	2
Yearling Males	0	6	1
Adult Females	4	4	2
Yearling Females	3	7	2
Total	**24**	**20**	**7**

Historic Information

According to Rogers (1964), GUSG historically occupied suitable habitats in the San Luis Valley but by the 1950's, all GUSG were thought to have been extirpated. Rogers (1964) ranked the Poncha Pass area as the best potential site for transplanting sage-grouse. In 1971 and 1972, approximately 30 GUSG from the Gunnison Basin were reintroduced at Poncha Pass by the CDOW and the BLM. Due to lack of monitoring, it is not known how successful the reintroduction was, but the population had persisted until the inadvertent hunting season jeopardized it after 1992.

Local Conservation Plan

The Poncha Pass Conservation Plan (PPCP 2000) was finalized on March 21, 2000. Area boundaries were drawn using known GUSG use sites, observations, and location of sagebrush-dominated habitats. The result is the area considered used, or potentially used by GUSG. Because of the small size of the Poncha Pass population, the PPCP states that, "…there is a strong possibility that this population will disappear unless another reintroduction is undertaken" (PPCP 2000:7).

The population goal in the PPCP (2000) is to have 2 active leks with a minimum of 10 males/lek, for an estimated minimum spring population of 81 individuals. The plan estimates the maximum sustainable population under optimum conditions to be 180 individuals.

The PPCP (2000) does not outline any specific habitat goals or objectives but it lists 3 general conservation objectives. They are to (1) discover (through field research and monitoring) issues that positively or negatively affect the well being of sage-grouse and incorporate this information into management actions to their benefit; (2) protect and improve sage-grouse habitat, as appropriate by reduction, prevention and/or mitigation of habitat fragmentation; and (3) identify and manage physical disturbances to reduce adverse effects to GUSG (PPCP 2000:8).

Conservation actions in the PPCP (2000) are divided into the following categories: inventory and mapping, research, monitoring, habitat quality, information/education/coordination, permanent habitat loss, and physical disturbance.

Habitat Improvements/Completed Conservation Actions

Currently there are no plans for habitat treatment work in the Poncha Pass area. Continued collection of distribution and habitat use data are necessary before some small-scale manipulations might be considered. This population is undoubtedly small and the effects of an ill-timed or poorly conceived habitat treatment project could be detrimental.

Easements/Candidate Conservation Agreements with Assurances

Negotiations have been underway on potential conservation easements in wet meadow habitat along San Luis Creek and in sagebrush habitat along the Lone Tree drainage, but no easements have been finalized.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the Poncha Pass area) to participate in the CCAA by signing up through the CDOW’s agreement, via certificates of inclusion, rather than directly with the USFWS.

San Miguel Basin Population

General Description

The San Miguel Basin population is located in Montrose and San Miguel Counties in Colorado. There are 6 GUSG subpopulations within the San Miguel Basin. The subpopulation areas are at Dry Creek Basin, Hamilton Mesa, Miramonte Reservoir, Gurley Reservoir, Beaver Mesa, and Iron Springs (Figs. 4 [pg. 38] and 19). Dry Creek Basin is 10 miles south of Naturita, Hamilton Mesa and Miramonte Reservoir are located about 11 miles southwest of Norwood, Gurley Reservoir is about 9 miles south of Norwood, Beaver Mesa is about 6 miles west of Placerville, and Iron Springs is about 4 miles north of Placerville. Some of these 6 areas are used year-round by GUSG, and others are used especially in particular seasons. Recent radiotelemetry studies (Apa 2004, J. Stiver, University of Nebraska, personal communication) have suggested that GUSG in the San Miguel Basin move widely and between subpopulations.

The terrain at Dry Creek Basin is bowl-shaped and elevation varies from 6,300 - 7,100 feet. The area occupied by GUSG is approximately 61,300 acres. Sagebrush habitat in the Dry Creek Basin area is patchy in distribution. Understory is either lacking in grass and forb diversity (i.e. <3 species/acre), or nonexistent. The central part of Dry Creek Basin contains highly alkaline soils and the region is dominated primarily by desert shrubs such as shadscale, greasewood, and low sage. The surrounding uplands are managed by the BLM and contain extensive, and generally contiguous, stands of Wyoming big sagebrush (A. Winward and S. Monsen, personal communication). Where irrigation is possible, private lands in the southeast portion of Dry Creek Basin are cultivated. Sagebrush habitat on private land has often been heavily thinned, or removed entirely. Most of the Dry Creek area is managed by the BLM (57%), CDOW (12%), or the Colorado State Land Board (1%), and the rest is privately owned (30%) (Fig. 19 and Appendix D).

A nearby disjunct area also used seasonally by this population is Hamilton Mesa, where elevation ranges from 8,500 to 8,900 feet (Fig. 19). Occupied habitat at Hamilton Mesa covers about 4,100 acres. GUSG are known to use this habitat during the summer, but it is not yet known whether it is used in other seasons. Hamilton Mesa is primarily in private ownership (85%), with limited Colorado State Land Board (11%) and BLM (4%) managed property (Fig. 19 and Appendix D).

The terrain at Miramonte Reservoir is flat, with elevation varying only from 7,800 - 8,000 feet. Occupied sage-grouse habitat is approximately 11,600 acres. Sagebrush stands at Miramonte Reservoir are generally contiguous with a mixed grass (>3 species/acre) and forb (>2 species/acre) understory. Low and black sagebrush are common with some mountain big sagebrush in drainages. Landownership is 76% private, 6% controlled by USFS, 15% managed by CDOW, and 2% by the BLM (Fig. 19 and Appendix D).

The Gurley Reservoir area is flat, with elevations ranging from 8,000 - 8,300 feet. Occupied GUSG habitat is about 6,900 acres. Sagebrush habitat in the Gurley Reservoir area is heavily fragmented and the understory is a mixed grass (>3 species/acre) and forb community (> 2 species/acre). Attempts to farm in Goshorn Flats in the early part of the 20th century led to the removal of much of the sagebrush. Ultimately, many of these attempts failed and agricultural activities now are restricted primarily to the seasonal irrigation of pasture. Sagebrush has re-established in most of these pastures, but grazing pressure and competition from introduced grass species have kept the overall sagebrush composition low. A large portion of the area (91%) is privately owned with the rest being managed by USFS (4%), BLM (3%) and the Colorado State Land Board (2%) (Fig. 19 and Appendix D).

Elevation at Iron Springs and Beaver Mesa ranges from 8,200 – 9,000 feet. Occupied habitat is approximately 5,700 acres at Iron Springs and 8,800 acres at Beaver Mesa. Sagebrush stands in Iron Springs and Beaver Mesa are contiguous and there is a mixed grass understory with species diversity > 3 species/acre. The Beaver Mesa area has numerous scattered patches of oakbrush not found in Iron Springs. Landownership in both areas is heavily private (Beaver Mesa – 99.5%, Iron Springs – 89%). The remaining portion of Beaver Mesa (0.5%) is managed by the BLM. At Iron Springs the remainder is managed by the USFS (6%), and the Colorado State Land Board (6%) (Fig. 19 and Appendix D).

Livestock production and farming are the primary landuses in the San Miguel Basin. Rural housing is common and some residential development is occurring.

Fig. 19. Location, landownership, and habitat status of the San Miguel Basin GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Managment 2002) has been modified; however inaccuracies may be present.

Population Information

A population estimate of 165-276 individuals, based on lek counts of males, is reported in the San Miguel Basin Conservation Plan (SMBCP 1998) (see "Lek Counts and Population Estimation", pg. 39). Note that the RCP population estimate for San Miguel Basin (245) is based on 2004 lek count data and uses slightly different assumptions (see pg. 45). There are 10 known leks in San Miguel Basin (Table 18). Lack of roads, restricted access on private land and snow conditions in the spring make lek searches in the area difficult.

Table 18. High male counts on leks in the San Miguel population, 2001-2004 (CDOW, unpublished data).

Subpopulation Area	**Lek Name**	**Ownership**	**2001 Male Count**	**2002 Male Count**	**2003 Male Count**	**2004 Male Count**
Dry Creek Basin	Desert	Private	14	7	4	0
	Nelson Creek	CDOW	4	3	1	1
	Triangle	CDOW	7	5	2	1
Beaver Mesa	Beaver Mesa	Private	0	3	6	No Count
	Beaver Mesa North	Private	8	6	0	3
	Beaver Mesa South	Private	6	3	0	1
Iron Springs	Iron Springs	Private	9	15	6	2
Gurley Reservoir	Cone	Private	5	5	5	7
Miramonte Reservoir	Miramonte	CDOW	27	31	16	19
	Redd Ranches	Private	N/A	N/A	11	18
Hamilton Mesa	None	N/A	-	-	-	-
Total	-		**80**	**78**	**51**	**52**

Historic Information

Rogers (1964) reported that all big sagebrush-dominated habitats in San Miguel and Montrose Counties were historically used by sage-grouse. This included portions of the

Paradox Valley, the area between Naturita and Nucla, the area immediately south of Norwood, Iron Springs Mesa as well as Beaver Mesa, the Miramonte Reservoir Basin, Gurley Reservoir, Cone Reservoir and extending west into Dry Creek Basin. The historic distribution was highly fragmented by piñon-juniper forests, rocky canyons, dry basins void of sagebrush, and ponderosa pine–aspen habitats.

Local Conservation Plan

The SMBCP (1998) was finalized on July 17, 1997, and revised on July 17, 1998. An addendum to the plan was completed in November 2001. The boundaries of the plan include areas presently and historically occupied by GUSG. They were drawn based on known historic use sites, sage-grouse observations and present potential of remaining sagebrush-dominated habitat.

The SMBCP (1998) lists minimum (255 sage-grouse within 3-5 years) and optimum (480 GUSG within 10-15 years) population goals. These numbers translate to at least 150 males counted on 7-8 active leks distributed throughout the San Miguel Basin.

Three general conservation objectives are identified in the SMBCP. They are to (1) maintain and improve the quality of GUSG habitat; (2) reduce fragmentation by preventing, minimizing, and mitigating past, present and future loss of GUSG habitat; and (3) identify and manage physical disturbances to reduce adverse effects to GUSG (SMBCP 1998:7).

Conservation actions in the SMBCP (1998) are divided into the following categories: information and education, monitoring, avoiding or mitigating permanent loss of habitat, restoring or improving habitat quality, reducing physical disturbance to sage-grouse, and improving and community support and participation.

The SMBCP addendum incorporates information gathered since 1997 to outline more specific conservation objectives and conservation actions. The actions outlined in the addendum are designed to address short-term needs as they are currently perceived.

Possible limiting factors were listed in the November 2001 addendum to the San Miguel Conservation Plan. Factors that may affect habitat quality include erosion and impacts from cattle and local wildlife in riparian areas (brood-rearing habitat), and inadequate understory, especially in late-seral stands of sagebrush, which reduces potential nesting and brood habitat. Habitat loss in the form of piñon-juniper encroachment is also a problem in some areas such as Dry Creek Basin. Although predation was identified as a threat to GUSG in this area, the addendum suggests that a reasonable alternative to predator control is to manage the landscape and habitat in ways that reduce predator success. An additional challenge facing GUSG management in the area is the large amount of privately controlled land. Cooperating with private landowners in the protection and management of GUSG will be key to the long-term success of any GUSG preservation effort.

Habitat Improvements/Completed Conservation Actions

Habitat improvement projects in the San Miguel Basin have been limited due to a lack of information on specific habitat use by GUSG in the area and to a large amount (53%) of private land in the area. In Dry Creek Basin, 600 acres of sagebrush were mowed and reseeded and piñon-juniper was removed at the periphery of the area known to be used by GUSG. The project is about half completed and was halted when drought conditions caused widespread sagebrush defoliation. It will be completed when participating agencies determine conditions are appropriate. Sagebrush mowing and reseeding of 40 acres of CDOW property was completed in 2001. In the Miramonte Reservoir area, the CDOW removed livestock grazing from a 1,350-acre parcel purchased in 2000. The area was also fenced, the county road was moved and reseeded, water sources were enhanced, and numerous erosion control efforts were undertaken. The CDOW conducted a 200-acre reseeding project on a burn that occurred on the Dry Creek Basin SWA in the summer of 2003. In the fall of 2003, the CDOW also initiated reseeding in both sagebrush, and non-sagebrush areas on the Dry Creek Basin SWA.

Easements/Candidate Conservation Agreements with Assurances

Currently (data through 2003), 883 acres in occupied habitat are protected by easement in the San Miguel Basin (Fig. 20; see also Appendix D). Of this, approximately 400 acres are at Hamilton Mesa, 230 acres at Iron Springs, and 250 acres at Miramonte Reservoir. Landowners at Beaver Mesa and Iron Springs have expressed some interest in further easements.

In 2000, the CDOW purchased 1,350 acres of GUSG habitat in the Miramonte Reservoir area, including a lek site and brood habitat. Additional tracts of land are for sale, but will require fee title transfer because the landowner has no interest in conservation easements.

An umbrella CCAA is being developed by the CDOW. If implemented, this CCAA would allow landowners within the Colorado portion of GUSG range (including the San Miguel Basin area) to participate in the CCAA by signing up through the CDOW's agreement, via certificates of inclusion, rather than directly with the USFWS.

Fig. 20. Conservation easements in the San Miguel Basin GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

IV. THREATS AND ANALYSIS

In this section we summarize the potential threats to current GUSG populations and/or habitats, and analyze (1) the risk of permanent GUSG habitat loss through urban development, (2) potential habitat linkages among populations, (3) population viability, (4) population augmentation options, (5) GUSG population size in relation to the amount of available habitat, and (6) population targets.

A. Threats Potentially Affecting GUSG

These topics are listed and discussed in alphabetical order. For the topics containing more detail, a short conclusion follows the general discussion.

Disease and Parasites

Nothing has been published about the types or pathology of diseases in GUSG; however, multiple bacterial and parasitic diseases have been documented in GRSG (Patterson 1952, Schroeder et al. 1999). Most infections reported produce no, or minor, ill effects in sage-grouse (Patterson 1952). Rangewide impacts of bacterial or parasitic diseases on sage-grouse have not been reported.

West Nile Virus

West Nile virus (WNV) is a relatively new and potentially important disease for sage-grouse (Naugle et al. 2004). The virus has rapidly spread through the country, occurring in all states (except Washington and Oregon) by December 2003. Transmission occurs when mosquitoes acquire the virus by biting an infected bird, and then transfer it by feeding on a new host (avian or mammalian). WNV causes illness and death in birds that have no natural resistance to the infection. Mortalities from the virus have been discovered in 234 bird species (Centers for Disease Control and Prevention 2004b). Most mortalities have occurred in the family Corvidae, which includes crows, ravens, and jays. The data are based on specimens brought to local health departments by the public for testing (Centers for Disease Control and Prevention 2002) and on laboratory tests (Komar et al. 2003). Six North American gallinaceous species, including the GRSG, are known to be susceptible to the virus (U. S. Geological Survey 2003).

In 2003, WNV was detected in all but 1 county in Colorado (San Miguel County) where GUSG are known to occur, but there have been no recorded cases of the virus in GUSG (Colorado Department of Public Health 2004). Although the virus was detected in wild bird, horse and/or mosquito samples, it does not appear the virus was widespread or that contact with sage-grouse was significant in 2003. There were no reports of the virus in San Juan County, Utah in 2003 (Centers for Disease Control and Prevention 2003). In 2004, WNV was detected in areas with GUSG in Gunnison, Mesa, and Montrose Counties in Colorado, and in San Juan County, Utah (Centers for Disease Control and Prevention 2004b, Colorado Department of Public Health 2004).

In early August 2004, WNV was confirmed in the remains of a radio-collared female GRSG in south Routt County, Colorado. Eight other radio-collared GRSG in the area continued to show normal activity. The virus was detected in areas with greater sage-grouse in Eagle, Garfield, Grand, Routt and Rio Blanco Counties in Colorado (Centers for Disease Control and Prevention 2004b, Colorado Department of Public Health 2004).

In 2004, the CDOW, in collaboration with the Colorado Mosquito Control Company (CMC) conducted a study to monitor both GUSG and mosquito populations in the Gunnison Basin. The CMC collected mosquitoes, determined species, and sent samples of the genus *Culex* to the Colorado Department of Health to test for the presences of WNV. *C. tarsalis* and *C. pipiens* are considered to be the most serious threat for transmitting the virus to avian species (Turell et al. 2001, Foster and Walker 2002, Centers for Disease Control and Prevention 2004a).

Simultaneously, the CDOW used radiotelemetry to monitor the survival and movement of GUSG in the Gunnison Basin. Monitoring movement will help assess the potential for GUSG to come in contact with *Culex* species. The majority of mosquito species (> 85%) were *Aedes* spp., *Ochlerotatus* spp. or *Culiseta* spp. These species are not considered to be effective in transmitting the virus to avian species (Turell et al. 2001, Foster and Walker 2002, Centers for Disease Control and Prevention 2004a). *C. tarsalis* has made up < 15% of the samples collected so far. No *C. pipiens* were found in any samples. Fourteen pooled *C. tarsalis* samples were tested and all were found to be negative for WNV. CDOW used radiotelemetry to track 16 GUSG (13 males, 3 females). Locations were recorded every 1-2 days. There were no mortalities among the marked grouse, nor were any observed among unmarked grouse.

Coccidiosis and Tularemia

Intestinal coccidiosis (caused by the protozoan *Eimeria* spp.) has occurred in outbreaks that seriously impact local sage-grouse populations (Carhart 1943, Grover 1944, Patterson 1952, Honess and Post 1968), but such outbreaks do not appear common. Typically, outbreaks have occurred in summer when grouse may concentrate around water sources (Carhart 1943, Wallestad 1975). Disease transmission occurs through ingestion of water contaminated by infected feces. Birds that recover from the infection carry some level of immunity (Friend and Franson 1999). A second disease reported to have local population effects in sage-grouse is tularemia, which is caused by the bacterium *Francisella tularensis* (Parker et al. 1932, Friend and Franson 1999). This disease is transmitted by ticks and is also uncommon (Friend and Franson 1999).

Avian Malaria

Avian malaria, caused by the protozoan *Plasmodium pediocetti*, does not decimate sage-grouse populations but may still have a negative effect on populations. The daily cycle of the disease causes infected birds to be less active in morning hours, thus affecting male sage-grouse courtship and reproductive success (Boyce 1990, Johnson and Boyce 1991). Avian malaria is transmitted by biting flies (Friend and Franson 1999).

Diseases of Captive Birds

The release of gallinaceous game birds, either native or exotic, in GUSG counties is a potential avenue for disease introduction. All game birds in the grouse (Tetraoninae) and wild turkey (Meleagridinae) subfamilies that are imported to Colorado must be certified as disease-free by an accredited veterinarian prior to importation. Disease testing occurs for *Salmonella pullorum* (Pullorum disease) and 3 species of *Mycoplasma* bacteria (*M. gallisepticum*, *M. meleagridis*, and *M. synoviae*). Pullorum disease and *Mycoplasma* spp. are of interest because of their potential impact if transmitted to captive poultry, not necessarily to wild galliforms. The Colorado Division of Animal Industry (state veterinarian) also requires testing for other diseases known to affect poultry, such as Newcastle disease. Disease testing is required if there has been a recent occurrence of Newcastle disease in the state/region exporting the birds. Birds such as pheasants, chukar, and quail may be imported into Colorado without disease screening of any kind. These are the 3 species most frequently found on game farms (Colorado Division of Wildlife 2004c). In 2003, there were commercial game bird farms licensed by the CDOW in 5 GUSG-inhabited counties (Delta, Dolores, Mesa, Montrose, and Saguache). An additional potential disease risk to sage-grouse could result from transportation of wild gallinaceous birds within the state, which also requires no disease testing.

In Utah, the state veterinarian requires that pheasants, chukar, and quail be tested for *S. pullorum*. Wild turkeys brought into Utah must be tested for *Mycoplasma* spp., as must all gallinaceous birds brought into Utah from other states by UDWR.

Pullorum disease is not known to have infected wild sage-grouse, but is found in gallinaceous birds raised in captivity (Friend and Franson 1999). This bacterial disease is septicemic and may cause high mortality in poultry (Western Wild Health Committee 2003). It is transmitted from bird to bird by inhalation of airborne bacteria or by ingestion (pecking at surfaces contaminated by infected feces) (Friend and Franson 1999). Pullorum disease may also be transmitted from parent to egg and/or chick.

Mycoplasmosis is generally respiratory in nature, though it may be subclinical, and often causes decreased egg production and/or chick survival in captive birds (Friend and Franson 1999, Western Wild Health Committee 2003). Mycoplasmosis transmission can be through direct contact with infected birds or contaminated equipment, airborne via dust or droplets, or through eggs (Friend and Franson 1999).

Newcastle disease is a very contagious disease caused by a virus, of which there are many strains. Some forms of Newcastle disease are very lethal, often causing 100% mortality in poultry flocks (Friend and Franson 1999). This disease has been found in captive gallinaceous birds, but not in wild sage-grouse (Friend and Franson 1999). The disease can cause a variety of effects, including paralysis (Friend and Franson 1999). Disease transmission can be airborne, by bird to bird contact, or through contaminated equipment, food or water (Friend and Franson 1999).

Conclusions

WNV currently poses the greatest disease threat to wild GUSG. Despite the fact that the most common game farm birds do not undergo disease testing when imported to Colorado, disease transmission from introduced gallinaceous birds to GUSG remains a low possibility.

The 2 diseases known to have caused local population problems for sage-grouse, coccidiosis and tularemia, are uncommon. The diseases tested for in imported grouse and turkeys (*Salmonella* and *Mycoplasma*) are not known to have an impact on wild sage-grouse. The possibility for diseases of introduced or captive birds to spread to GUSG would become more important if efforts to raise GUSG in captivity were initiated.

Fire and Fuels Management

Prior to European settlement, the sagebrush landscape was a mosaic of different sagebrush species, in varying seral stages, occupying areas with different soil, topographic, and moisture conditions (Miller and Eddleman 2000). Fires historically occurred in many sagebrush communities on a regular basis, ranging in frequency from 10 – 100 years, depending on the sagebrush species and local factors (Young et al. 1979, Wright and Bailey 1982, Howard 1999, Miller and Eddleman 2000). Fires spread in a patchy manner, especially in Wyoming big sagebrush, responding to the landscape mosaic and the amount and distribution of fuel in the understory (Howard 1999, Miller and Eddleman 2000). Natural fire regimes in sagebrush-dominated communities probably occurred on a variety of scales, from small to large.

How fire affects a sagebrush community depends on multiple local characteristics such as dominant sagebrush species, aridity, soils, topography, and disturbance (Bunting et al. 1987, Miller and Eddleman 2000). The 3 primary sagebrush species present in GUSG habitat are Wyoming big sagebrush, mountain big sagebrush, and black sagebrush, although basin big sagebrush also occurs at some sites. All 3 species are killed by fire, but can reestablish (McMurray 1986, Bunting et al. 1987, Howard 1999, Johnson 2000, Miller and Eddleman 2000), although recovery timeframes vary, especially depending on environmental conditions (Bunting et al. 1987). Wyoming big sagebrush can reestablish (often slowly) from the seedbank, or from seed produced by plants surviving the fire or from plants adjacent to the fire (Bunting et al. 1987, Howard 1999). However, adequate moisture for sagebrush seed germination is not present in all years or seasons, especially in the areas where Wyoming big sagebrush grows (Monsen 2005). Furthermore, the open aspect of many burned sites allows wind to move snow around, reducing moisture entrapment and further drying out the soil (Monsen 2005). Mountain big sagebrush can reseed from surviving plants or plants in adjacent habitat (Johnson 2000). Generally this species grows in sites with more reliable moisture (aiding in seedling establishment), but individual populations vary in their fire tolerance (Monsen 2005). Black sagebrush reseeds from off-site plants (McMurray 1986) and from the seedbank (Monsen 2005). Fire does not spread readily through black sagebrush because of its generally sparse vegetation (McMurray 1986), but in some cases cheatgrass has increased the fuel load and allowed fire to eliminate black sagebrush stands (Monsen 2005).

Many new disturbance factors have been introduced to the sagebrush landscape since European settlement, including livestock grazing, aggressive alien plant species, cultivation, and multiple factors associated with an increased modern human presence on the landscape (Young et al. 1979, Miller and Eddleman 2000). The resulting altered landscape has experienced significant changes in fire frequency, distribution, and intensity. Two new scenarios have emerged in some sagebrush habitats in the West. In sagebrush stands where aggressive alien weed species such as cheatgrass have become established, fire frequency may increase (Whisenant 1990, Billings 1994, Tirminstein 1999, Miller and Eddleman 2000), eventually changing the community to an annual grassland (Young et al. 1979, Connelly et al. 2000, Miller and Eddleman 2000). If fire suppression has occurred, sagebrush communities can advance successionally to piñon-juniper (Burkhardt and Tisdale 1969, Young and Evans 1981, Miller and Rose 1995, Miller et al. 2000). Fire suppression in some sagebrush areas may have contributed to expanses of monotypic late-seral stage habitat

(CACP 1998, DCCP 1998, PMCP 2000) that has been postulated to be vulnerable to widespread, intense fires (Young et al. 1979). In instances where sagebrush habitat has become fragmented and limited, there is potential for fire to eliminate the existing seed source, reducing the likelihood of natural regeneration.

In most GUSG population areas, cheatgrass is not currently a dominant problem and has not affected fire regimes. However, in many areas fire suppression has occurred, possibly reducing both the amount and quality of sage-grouse habitat (GBCP 1997, CACP 1998, DCCP 1998, SMBCP 1998, PMCP 2000). This creates a situation where small prescribed burns may be useful to open up large stands of late-seral stage sagebrush (Klebenow 1972), or to reduce advancing piñon-juniper in sagebrush habitat (Burkhardt and Tisdale 1969, Bunting et al. 1987, Miller et al. 2000). Extreme caution must be the dominant philosophy because uncontrolled wildfire or prescribed fire could be catastrophic for the existing sagebrush community. In areas where woody species (including piñon-juniper and Douglas fir) are encroaching on sagebrush habitat, mechanical treatments may be more effective than prescribed fire in keeping treatment areas small (see ”Habitat Enhancement” rangewide strategy, pg. 214, and “Fire and Fuels Management” rangewide strategy, pg. 206).

In addition to reducing the density of woody vegetation, prescribed fire can also improve native forb and grass understory growth and forb nutrition (Bunting et al. 1987, Miller and Eddleman 2000, Wirth and Pyke 2003). Thus, well-managed prescribed burning can be used as a tool to improve sage-grouse habitat, but great care must be taken to avoid exacerbating existing problems and to ensure weed invasion does not occur (Connelly et al. 2000, Nelle et al. 2000, Monsen 2005). Invasive weed management should be a part of any prescribed fire planning in GUSG range. The goal should be to re-introduce fire in a way that most closely reflects natural fire at the landscape scale and that meets the needs of GUSG. Sage-grouse use of burned habitat has been the subject of debate, but it appears that sage-grouse will use burned sites as long as the sites provide appropriate cover and food resources during the season of use (Slater 2003).

Genetics

There has been much concern about the genetic viability of GUSG populations (Oyler-McCance 1999, Oyler-McCance et al. 1999). The persistence of a population is typically influenced more by demographic processes than by environmental or genetic effects (Lande 1988, Caughley 1994, Soulé and Mills 1998). But when the number of individuals in a population declines to a very low level, genetic factors and their interaction with demographic and environmental factors (i.e., "extinction vortices") become increasingly important (Gilpin and Soulé, 1986, Lande 1988, Soulé and Mills 1998).

Small populations face 3 primary genetic risks: inbreeding depression, loss of genetic variation, and accumulation of new mutations. In this section we discuss each of these threats to population viability, and their relevance to GUSG populations (a discussion of genetic effective population size is found in Appendix E).

Inbreeding Depression

In geographically closed populations inbreeding is inevitable because individuals will become increasingly related. The genetic consequence of inbreeding is increased homozygosity (Falconer 1981). This increase in homozygosity can have individual and population consequences (Fig. 21), by either increasing the phenotypic expression of recessive, deleterious alleles (Charlesworth and Charlesworth 1987), or by a reduction in the overall fitness of individuals in the population, assuming there is increased fitness in being heterozygous (i.e., the heterozygote advantage; Wright 1977), or both (Kimura and Ohta 1971).

INBREEDING →	**GENETIC CONSEQUENCES→**	**INDIVIDUAL CONSEQUENCES→**	**POPULATION CONSEQUENCES**
	Increased homozygosity; increased potential for expression of recessive deleterious alleles, or loss of heterozygosity	Increased susceptibility to disease; physical deformity; reduced reproduction, increased mortality	Decreased recruitment; declining population growth rate; greater probability of extirpation or extinction

Fig. 21. Diagram of consequences of inbreeding.

Available evidence suggests that inbreeding is virtually universal (however, see Ralls et al. 1984), but inbreeding depression is rare and has highly variable effects (see Lynch and Walsh 1998, Crnokrak and Roff 1999, and Hedrick and Kalinowski 2000, for reviews). In a survey of 36 mammalian species, Ralls et al. (1988) estimated that a degree of inbreeding equivalent to parent-offspring mating reduced viability in captivity by 33%. Crnokrak and Roff (1999) reviewed 35 studies of inbreeding depression in the wild and found that 141 out of 157 populations showed reduced fitness in inbred individuals. In addition, Crnokrak and

Roff (1999) found that inbreeding depression in the wild was substantially stronger than in captivity. This agrees with experimental work showing inbreeding depression to be stronger in more stressful environments (Miller 1994). However, the effect of inbreeding on fitness differs widely among species (Price and Waser 1979, Ralls and Ballou 1983, Ralls et al. 1988, Laikre and Ryman 1991).

There is no evidence of inbreeding or inbreeding depression in sage-grouse. However, studies of greater prairie chickens in Illinois showed that fertility and hatching success of greater prairie chickens were correlated with a reduction in genetic variation due to a population bottleneck caused by habitat loss (Bouzat et al. 1998a, Bouzat et al. 1998b, Westemeier et al. 1998). However, there was no evidence that inbreeding depression was the mechanism creating the loss of genetic variation or the loss in fitness.

It is likely the deleterious effects of inbreeding will occur faster in small populations than in large ones (Frankham 1995). In a randomly-mating, geographically-closed population, with discrete generations and modest variation in reproductive success, the average inbreeding coefficient (F_t) increases according to

$$F_t = 1 - \left(1 - \frac{1}{2N_e}\right)^t \quad (1)$$

where t is the number of generations and N_e is the genetic effective population size (discussed in detail in Appendix E) (Hedrick 2000). Figure 22 graphs equation (1) for populations of 20, 100, and 500. Inbreeding occurs much faster in a population of 20 than a population of 500 individuals (Fig. 22). More specifically, the initial rate of increase is 25 times faster in a population of 20 than 500. This illustrates that avoiding small population size (even for a few generations) is essential for avoiding inbreeding and reducing the potential for inbreeding depression.

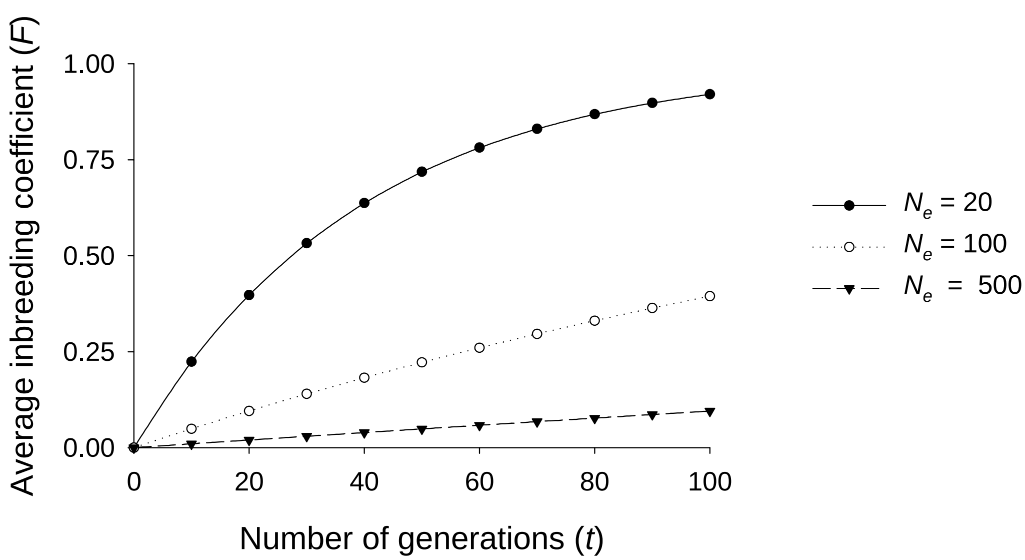


Fig. 22. The increase of average inbreeding coefficient as a function of genetic effective population size and the number of generations of breeding.

There is no consensus on how large a population must be to avoid biologically significant inbreeding depression, and there is little reason to believe that a single critical size or threshold exists. When inbreeding depression was first recognized as a threat to managed populations, Franklin (1980) and Soulé (1980) suggested that 50 individuals should be sufficient to avoid biologically significant inbreeding depression. This rule-of-thumb was based on anecdotal evidence that domesticated animals seemed to tolerate this level of inbreeding. Subsequent experimental inbreeding (in house and fruit flies), however, has shown that populations with a genetic effective size of 50 individuals often have substantial extinction rates (Latter et al. 1995, Bryant et al. 1999, Read and Bryant 2000). Although Franklin's (1980) and Soulé's (1980) guideline of 50 individuals has been shown to be too small, no larger size has emerged as a replacement guideline.

While inbreeding depression is considered a potential threat to small populations, we have no information to evaluate the relative threat of inbreeding to GUSG. We do not have adequate, long-term information on demographic rates (e.g., nest success, hatchability, juvenile or adult survival) to determine whether inbreeding depression is of concern. Inbreeding in small populations, such as sage-grouse, does not necessarily increase the likelihood of extinction (Caro and Laurenson 1994, Caughley 1994). Furthermore, it is possible that natural selection may purge deleterious alleles from the species, thereby eliminating the threat of inbreeding depression (Templeton and Read 1983, Lacy and Ballou 1998).

Loss of Genetic Variation

The loss of genetic variation, both within individuals and among populations, has the potential to reduce individual fitness and disrupt locally adapted populations (outbreeding depression). Adaptation to local changes in the environment is more likely to occur if there is large genetic variation among individuals in a population. In principle, populations with large amounts of genetic variation will have a greater chance of coping with climate change, exotic diseases, or other stresses. For example, O'Brien and Evermann (1988) found low variation in the major histocompatibility complex (an antigen-producing gene complex that plays a key role in the production of antibodies) in cheetahs, and documented a 50-60% mortality in cheetahs over a 3-year period due to a corona virus. They advocate that genetically depauperate populations face enhanced susceptibility to infectious disease or parasitic agents.

Genetic variation is introduced into populations by mutation. Natural and sexual selection work to eliminate deleterious alleles and retain favorable alleles. Genetic drift changes allele frequencies randomly, which leads to a net loss of genetic variation. For neutral loci, average heterozygosity (*H*) in a population declines according to

(2) $$H_{t+1} = H_t\left(1 - \frac{1}{2N_e}\right)$$

where *t* indicates the generation and N_e is the genetic effective size of the population (discussed in Appendix E). Note the similarity to Equation (1).

There is no consensus for how large populations must be in order to retain a level of genetic diversity that maximizes evolutionary potential. This question has been interpreted as how large a population must be in order for the processes of mutation and genetic drift to be balanced. Presumably, such a population would maintain its potential to adapt to local changes in the environment. Unfortunately, answering this question with confidence requires a more detailed understanding of mutation and heritability than is now available. Estimates currently range from 500 to 5000 individuals (Franklin 1980, Lande and Barrowclough 1987, Lande 1995), and these guidelines should be considered approximate.

GUSG have lower genetic diversity than GRSG (Oyler-McCance 1999, Oyler-McCance et al. 1999), but the consequences of this regarding threat of extinction are not well known. While genetic theory and empirical evidence suggest the loss of genetic diversity can have deleterious effects on reproductive fitness of individuals, the effect on the probability of extinction of a species can only be theoretically modeled (see "Population Viability Analysis", pg. 168). It has never been demonstrated that a population, much less a species, has gone extinct because of the loss of genetic diversity (Caro and Laurenson 1994).

Accumulation of New Mutations

Both genetic drift and natural selection change allele frequencies. The strength of natural selection is independent of population size, and the consequences of genetic drift are stronger in small populations than in large populations. One consequence of this is that if a population is small enough, slightly deleterious alleles behave as if they are neutral, and are almost as likely to increase as to decrease in frequency. When this is the case, slightly deleterious alleles can become fixed in the population. More specifically, alleles with selection coefficients less than $1/2N_e$ will respond to genetic drift in a manner similar to alleles that are selectively neutral (Kimura 1983).

Consider a population or species with a large number of individuals that then becomes reduced in size. Before population decline, deleterious alleles arise by mutation and are eliminated by selection. However, if the population declines in size enough, some deleterious mutations will become fixed. This accumulation of deleterious alleles may lead to extinction of the population, and this process is frequently called "mutational meltdown." The deleterious alleles responsible for mutational meltdown can be divided into 2 types: deleterious alleles existing at the time of population size reduction, and those that are new mutations. The negative impact of deleterious alleles existing at the time of population size reduction is essentially inbreeding depression. The mutational meltdown scenario predicts that in small populations the consequences of inbreeding depression will become magnified.

Mutational meltdown is probably the most controversial genetic threat to small populations. There is no doubt that genetic drift will cause mildly deleterious alleles to increase in frequency in small populations, but estimates for how large populations will have to be in order to prevent mutational meltdown vary dramatically. For example, Lande (1995b), Lynch et al. (1995), and Charlesworth et al. (1993) suggested that populations will need to have a genetic effective population size of 1000, 100, and 12 individuals, respectively, to avoid accumulating mutations. The wide discrepancy among these estimates is due to uncertainty regarding mutation rates. The process of mutation accumulation is slow when measured on a time scale relevant to most conservation applications. Even if mutational meltdown is a threat to small populations, it is expected to take hundreds to thousands of generations to occur.

Conclusions

Although there is no consensus for how large populations must be to avoid genetic problems associated with small population size, Shaffer (1987) states that populations smaller than a few hundred individuals warrant careful scrutiny in this regard. As noted above, it is highly debated whether reduced genetic variation reduces the viability of a population.

Small populations, (regardless of the amount of genetic variation) are at risk of extinction because of demographic fluctuations (Gilpin and Soulé 1986, Caughley 1994). Because of such factors, Lande (1988) and Caughley (1994) argued that, for conservation plans, demographic and behavioral concerns should be a higher priority than genetic concerns.

GUSG face many threats to survival, and these risks may interact. For example, climate change and exotic diseases may stress GUSG populations in the future, and populations with more genetic variation should be able to deal with these stresses better than populations with less genetic variation (e.g., Keller and Waller 2002 and references therein). The low levels of genetic diversity found in GUSG, particularly when compared to GRSG, may be of concern for the conservation of GUSG. However, even though research is needed to evaluate the impact of low genetic diversity on population viability (see "Research" rangewide strategy, pg. 247, Objective 5, Strategy 3), there is currently no direct evidence of inbreeding depression in GUSG. The maintenance of current genetic diversity in GUSG populations is addressed in "Population Viability Analysis" (pg. 168).

Grazing

Grazing is a major use of sagebrush rangelands in the West. Although it is likely that livestock and wild ungulate grazing (and associated land treatments), particularly historical over-grazing, have altered plant composition, increased topsoil loss, and increased spread of exotic plants (particularly cheatgrass), the impacts on sage-grouse are much less clear. It is recognized that current livestock stocking rates are substantially lower than historic levels, when GUSG numbers were presumed to be high. However, it is impossible to identify and/or quantify all other factors related to GUSG populations and habitat during the same time period. Thus, we are unable to derive a direct correlation between causative historic conditions. Because there are several recent thorough reviews of this topic we chose to primarily present quotations directly from these articles. Specifically, Rowland (2004) recently reviewed the literature on the effects of grazing on GRSG. Other recent reviews of the impact of grazing on sagebrush steppe habitats and bird communities were presented by Entwistle et al. (2000), Wambolt et al. (2002), Knick et al. (2003), Connelly et al. (2004), and Crawford et al. (2004).

General Debate

Wambolt et al. (2002:24) framed the debate over grazing in a perceptive manner:

> "Livestock grazing is possibly the most contentious, polarizing, politically charged and complex issue facing those who make and implement public land policy. Advocates for removing livestock argue that their "evidence" of ecological damage is incontrovertible, and their opponents argue that grazing can be managed in a sustainable and ecologically friendly manner (Clifford 2002). Attempts to integrate empirical results have not quelled the argument that "the science is out there" to bolster the argument of any of the various interests in this contentious debate (Vavra et al. 1994). In the middle are land managers, mostly from federal agencies. On one hand, anti-grazing interests accuse land managers of not making the difficult decisions necessary to get livestock off of public land. At the same time, grazing interests accuse land managers of making decisions based on weak or nonexistent science and/or data. The key policy issue before us is this: to restore grouse populations, sagebrush systems will have to be managed for the benefit of the bird. How this affects livestock grazing is a complex question. Overall, most of the research on sage-grouse habitat needs took place, and continues to take place, on habitats that are grazed. We can see from the range of data that grouse and grazing coexist in many, if not most, areas so we know with reasonable certainty that grouse and livestock are not mutually exclusive."

Rowland (2004:17-19) noted the difficulty in finding studies with direct evidence of grazing impacts on sage-grouse:

> "Effects of livestock grazing on vegetation species composition and structure in the sagebrush community have been well documented (Vale 1974, Owens and Norton 1992, Fleischner 1994, West 1999, Belsky and Gelbard 2000, Jones 2000, Anderson and Inouye 2001). However, few empirical studies report the responses of sage-grouse to grazing, and experimental research on effects of livestock on sage-grouse is lacking (noted by Braun 1987, Guthrey 1996, Beck and Mitchell 2000, Connelly et al. 2000b, Rowland and Wisdom 2002). No published studies on the effects of livestock grazing on sage-grouse were manipulative experiments in which cause-effect relationships could be measured. Instead, many studies imply negative effects of livestock grazing on sage-grouse by noting that grazing systems must be designed such that adequate herbaceous and shrub cover for nesting or brood rearing are maintained (e.g., Gregg et al. 1994, DeLong et al. 1995, Sveum et al. 1998). For example, DeLong et al. (1995) found that predation rates on sage-grouse nests in Oregon were negatively related to percent cover of tall grass and medium-height shrubs, and suggested that practices, such as livestock grazing, that remove grass cover may negatively affect nesting sage-grouse. Interactions of livestock grazing with other factors, such as wildfire, are complex and not widely studied."

Impacts on Sage-grouse Habitat

Rowland (2004:17-19) summarized studies that suggested negative impacts to sage-grouse habitat:

> "Beck and Mitchell (2000) summarized potential effects of livestock grazing on sage-grouse habitats, and cited only four references that provide empirical evidence of direct negative effects of livestock grazing on sage-grouse, as follows. Of 161 nests examined in Utah, two were trampled by livestock (one sheep, one cattle) and five were deserted due to disturbance by livestock (Rasmussen and Griner 1938). In Nevada, sage-grouse habitat in wet meadows was degraded through overgrazing by domestic livestock and altered system hydrology (Oakleaf 1971, Klebenow 1985; as reported by Beck and Mitchell 2000). Klebenow (1982) examined sage-grouse habitat use in relation to grazing at the Sheldon NWR in Nevada, where sheep and cattle had grazed for >130 yr. Dominant sagebrush species at the refuge were low sagebrush, mountain big sagebrush, and Wyoming big sagebrush. Grasses included Sandberg and Cusick's bluegrass (Poa secunda and P. cusickii, respectively) in wet meadows, and Sandberg bluegrass and mat muhly (Muhlenbergia richardsonis) in dry meadows. A rest-rotation system was implemented for cattle grazing in 1980 over the majority of the refuge, where season-long grazing had occurred historically; a smaller portion had previously been managed under deferred rotation. Meadows heavily grazed by livestock (e.g., with few forbs and grasses and dense shrubs present) were avoided by sage-grouse, with the exception of use for

> free water when available (Klebenow 1982). (No explicit definitions were provided for light versus moderate or heavy grazing.)"

In some cases, there were positive impacts on sage-grouse habitat (Rowland 2004:17-19):

> "Some positive effects of livestock grazing were noted. When cattle were introduced into a meadow with residual grass, sage-grouse initially preferred the grazed openings, which had an effective cover height (sensu Robel et al. 1970) of 5 to 15 cm, compared to 30 to 50 cm in the lightly grazed surrounding areas. Grouse avoided dense, ungrazed basin wildrye meadows but were observed in adjacent wildrye that was grazed. One 40-ha meadow that was lightly grazed by cattle (41 yearling heifers, 60 days in June-August) was used throughout the summer by sage-grouse and had more sage-grouse (100) than any other meadow on the refuge. Effective cover height in the meadow did not decrease below 5 cm during the summer."

Impacts on Sage-grouse Behavior and Demographics

Studies that focused on sage-grouse behavior and demographic parameter response to grazing reported mixed impacts (Rowland 2004:17-19):

> "Danvir (2002) reported two instances of nest abandonment related to livestock grazing in northern Utah during 7 yr of observations; one was caused by cattle, the other by sheep. Sage-grouse behavior on leks did not appear to be altered by the presence of cattle grazing (Danvir 2002). Sheep grazing in Idaho did not appear to disrupt use of leks by sage-grouse (Hulet 1983). Autenrieth (1981), however, cautioned against grazing sheep in sage-grouse winter habitat. He also suggested that livestock use of meadows occupied by sage-grouse, as well as livestock drives in sage-grouse habitat, could be detrimental to sage-grouse. In Wyoming, nesting densities of sage-grouse were considerably lower (10 nests/100 ha) in areas heavily grazed by domestic sheep compared to adjacent sites with moderate grazing (28 nests/100 ha) (Patterson 1952). Nest desertion caused by migrant bands of sheep also was documented (Patterson 1952).
>
> Heath et al. (1998) compared sage-grouse nesting and breeding success at three ranches with different grazing operations and levels of predator control in Wyoming. They found that, despite heavier livestock use (removal of >50% of annual herbaceous production, and grazing by both sheep and cattle) and long-term predator control on one ranch, nesting and breeding success of sage-grouse did not differ substantially among the three sites. Chick survival to 21 days was, however, greater on the ranch with lighter grazing, suggesting that predator control did not fully compensate for the greater reductions in herbaceous production (Heath et al. 1998). Further, hens were documented leaving the more heavily grazed ranch to nest elsewhere but returning to that ranch to rear broods (Heath et al. 1998). In a

similar study, Holloran (1999) examined sage-grouse habitat use and productivity in relation to grazing management strategies at four ranches in southeastern Wyoming. He found no differences in nest success, brood survival, or numbers of chicks fledged among the ranches. Some differences in habitat use by sage-grouse were found among the ranches; however, these could not be ascribed to differences in grazing pressure, but were ascribed to differences in soil types and precipitation patterns (Holloran 1999). Above-average precipitation during the study, however, may have obscured any potential differences in habitat suitability for sage-grouse among sites. Neither of these studies employed control sites or replication."

Grazing Rotation, Intensity, and Timing

Rowland (2004:17-19) noted research specifically investigating different grazing methods:

> "Research on upland meadows in Nevada showed that pastures under a rest-rotation system provided better production of those forb species eaten by sage-grouse than did pastures that were not rested, but sage-grouse also used a pasture not grazed by cattle for 10 yr (Neel 1980). The author concluded that light grazing in meadows might enhance habitat for sage-grouse. Evans (1986, as reported in Beck and Mitchell 2000) also found that grazing by cattle stimulated production of forb species used by sage-grouse in upland meadows in Nevada".

Crawford et al. (2004:10) described the results of grazing on sagebrush plant communities as follows:

> "Research suggests that moderate livestock grazing or less in mid to late summer, fall, or winter is generally compatible with the maintenance of perennial grasses and forbs in sagebrush habitat (Pechanec and Stewart 1949; Mueggler 1950; Laycock and Conrad 1967, 1981; Gibbens and Fisser 1975; Miller et al. 1994; Bork et al. 1998). Herbaceous species in sagebrush plant communities are predominantly cool-season (C-3) plants that are vulnerable to defoliation during late spring and early summer. Heavy grazing (approximately 60% or greater utilization by weight) during this time has predictable results: 1) the vigor, yield, and cover of late-seral grasses and forbs decrease; 2) early-seral species (including annual grasses) may increase; 3) sagebrush density and canopy cover may increase (Craddock and Forsling 1938, Pechanec and Stewart 1949, Mueggler 1950, Laycock 1967, Bork et al. 1998); and 4) transition of sagebrush uplands to higher ecological status is inhibited (Mueggler 1950, Eckert and Spencer 1986, Laycock 1987)".

Recommendations

Crawford et al. (2004:11) discussed recommendations for timing of grazing to reduce impacts in riparian areas important for brood-rearing:

> "Timing of grazing greatly influences the effects of livestock grazing in meadows and riparian areas. These sites are particularly vulnerable in late summer when excessive grazing and browsing may damage riparian shrubs, reduce the yield and availability of succulent herbs (Kovalchik and Elmore 1992), and cause deterioration of riparian function over time (Klebenow 1985). However, moderate utilization by livestock in spring, early summer, or winter is sustainable in non-degraded meadow and riparian areas within sagebrush habitat (Shaw 1992, Clary et al. 1996, Mosley et al. 1997). Moderate use equates to a 10-cm residual stubble height for most grasses and sedges and 5-cm for Kentucky bluegrass (Mosley et al. 1997, Clary and Leininger 2000). Shrub utilization should not exceed 50-60% during the growing season, and at least 50% protective ground cover (i.e., plant basal area + mulch + rocks + gravel) should remain after grazing (Mosley et al. 1997). While hydrophytic shrubs may not directly serve as sage-grouse habitat, they do impact the stability of riparian and meadow habitats important to sage-grouse (Winward 2000). The length of time livestock have access to meadows may be more important than the level of utilization; it has been suggested that livestock access be limited to 3 weeks (Myers 1989, Mosley et al. 1997). In riparian and meadow habitat degraded by heavy livestock utilization, rest from grazing may be necessary for recovery (Clary and Webster 1989)."

Based on her literature review, Rowland (2004:24) recommended the following:

> "Manage livestock grazing through stocking rates and season of use on all seasonal ranges of sage-grouse to avoid habitat degradation (Paige and Ritter 1999, Beck and Mitchell 2000, Wisdom et al. 2000), especially on recently disturbed sites, such as those sprayed or burned (Braun et al. 1977). In nesting and brood-rearing habitats, ensure that grazing does not reduce herbaceous understory cover below levels that serve as a deterrent to potential predators of eggs and chicks (Connelly et al. 2000b, Hockett 2002). Healthy native understories also support insects and forbs that are important in diets of pre-laying hens and chicks (Johnson and Boyce 1990, Barnett and Crawford 1994, Drut et al. 1994b). Riparian areas and wet meadows used for brood rearing are especially sensitive to grazing by livestock; in these habitats, removal of livestock before the nesting season may be prudent (Beck and Mitchell 2000, Hockett 2002)."

Grazing Management: Related Structures and Activities

Structures and activities associated with grazing management can have multiple and variable affects on sage-grouse and sage-grouse habitat. Fences, corrals, windmills, and other structures related to livestock grazing can cause mortality of grouse by collisions, and provide perches that raptors may use, which could increase avian predation on grouse (Call and Maser 1985). Grazing structures, such as fences or stock tanks, also influence livestock distribution, which may have a positive or negative effect on GUSG and their habitat, depending on the resulting distribution. Livestock may trample grouse nests, and tightly herded livestock near nesting areas may cause nest abandonment. Conversely, salting locations or historic sheep bed grounds have been used as lek sites, as long as adjacent habitat continues to provide adequate hiding cover. Water developments may alter existing GUSG habitat by congregating livestock use in previously unused upland habitat, or by lowering water tables associated with riparian areas. However, water developments can also be used to improve overall riparian habitat condition by drawing livestock and wild ungulates away from previously degraded areas.

If the livestock reduce and degrade the understory significantly, hiding cover is reduced, potentially increasing predation on grouse. Vegetation manipulations to improve livestock forage can impact prairie grouse in different ways, depending on pre-existing and resulting habitat conditions. Removal of brush essential for grouse nesting or wintering cover can adversely impact grouse reproduction and survival, but brush treatments in less critical or degraded grouse habitat may increase habitat capability (Giesen and Connelly 1993, Giesen 1998, Connelly et al. 2000). In any case, vegetation treatments should be planned and implemented to maintain adequate suitable habitat for GUSG while other areas are recovering. Potential impacts, both positive and negative, from grazing related structures are usually localized in nature, and should be considered and addressed.

Wild Ungulate Effects on Sage-grouse Habitat

The effect of wild ungulates on GUSG and their habitat has been raised as an issue that requires greater understanding. Direct physical confrontation between GUSG and pronghorn antelope, elk, or mule deer is probably not a major concern, although an instance has been observed of an elk consuming sage-grouse eggs in Wyoming (Holloran and Anderson 2003). Others have observed mule deer and GRSG in Middle Park, Colorado using sagebrush areas for forage that otherwise would have been inaccessible if not for elk breaking trails and exposing sagebrush during deep snow conditions (D. Freddy, CDOW, personal communication). Hobbs et al. (1996) documented a decline in available dead perennial grasses and early spring live perennial grasses as elk densities increased. They further noted a small increase in quality of the forage as elk densities were increased, due to the increased digestibility and nitrogen content of new forage. They suggested that competition for forage between elk and domestic livestock will primarily only be a concern during heavy snowfall years, when wild ungulates are concentrated in large densities on lower elevation winter ranges (Hobbs et al. 1996). These conditions could negatively impact nesting cover for sage-grouse in extreme situations. Ultimately, further research needs to be conducted to fully understand the effects of wild ungulate grazing on sage-grouse.

Conclusions

Grazing by domestic and wild ungulates has played an important role in shaping the current vegetation communities in GUSG range. Rowland (2004) provided a literature review addressing the issue of the impacts of grazing on sage-grouse. This review suggested there has been no experimental research that demonstrates grazing alone is responsible for the reduction in sage-grouse numbers. However, several studies have been conducted that show grazing may be one factor that has contributed toward the condition of sage-grouse habitat and use of it by sage-grouse, and many studies have demonstrated the effect of various grazing practices on vegetation. In fact, grazing should be used as a tool to maintain and improve seasonal habitats for sage-grouse. Enough is known about GUSG habitat requirements to make reasonable recommendations to design management practices to maintain and improve GUSG habitat (see Appendix H, "GUSG Structural Habitat Guidelines"). Developing grazing systems and management plans that would achieve desired vegetation composition and structure, including shrubs, forbs, and grasses, should benefit both GUSG and domestic and wild ungulates.

Habitat Quality

Quality of GUSG habitat is not addressed in the RCP as a separate threat or issue because it is taken into account under the individual activities or factors that impact habitat quality. These include “Fire and Fuels Management” (pg. 107), “Grazing” (pg. 114), “Mining, Energy Development, and Human Community Infrastructure” (pg. 127), “Noxious and Invasive Weeds” (pg. 131), “Predation” (pg. 134), and “Weather/Drought” (pg. 143).

Hunting

GUSG are still classified as a game species in Colorado, but they have not been hunted in the Gunnison Basin since 2000, when the Colorado Wildlife Commission eliminated the season. The Wildlife Commission took this action when lek count population indices failed to meet the 5% per year increase (calculated as a change in a 3-year moving average), as suggested in the Gunnison Basin Conservation Plan. Hunting has not occurred in other Colorado populations of GUSG since at least 1995, when the Piñon Mesa area was closed, although a clerical error created an inadvertent season at Poncha Pass in 1992. Utah has not allowed hunting within the current range of GUSG since 1989.

Prior to 2000, hunting had occurred in the Gunnison Basin continuously since 1953, with variable season lengths and bag limits over the years. Season lengths and bag limits were generally restrictive (3-day season and bag and possession limit of 2 birds) from 1953-1978, but were then gradually liberalized. Season length increased to 7 days in 1978, 9 days in 1979, 16 days from 1980-88, 30 days in 1989-91, 34 days in 1992, and 33 days in 1993, then decreased to 16 or 17 days from 1994-1999.

Harvest estimates from the Gunnison Basin are available, but there is no information on fall population size, so a harvest rate cannot be determined. Harvest estimates for 1995-1999 (Table 19) should be unbiased since a permit or prior registration was required (which provided an accurate sampling frame) and several attempts were made to contact all permit holders by phone (which largely eliminated non-response bias). Prior to that time, estimates were generated from mail-in surveys, but numerous studies have shown that this type of survey tends to overestimate harvest because successful hunters are far more likely to respond than unsuccessful hunters.

Table 19. Hunter numbers and harvest (estimate ± 95% confidence limit) of GUSG in the Gunnison Basin, estimated from a telephone survey of permit holders (1995-1997) or Hunter Information Program registrants (1998-1999).

Year	Estimated Hunters	Estimated Harvest
1995	229 ± 15	298 ± 34
1996	197 ± 16	269 ± 37
1997	154 ± 8	191 ± 16
1998	187 ± 64	278 ± 4
1999	95 ± 40	127 ± 1

Whether hunting impacts the rate of population growth of sage-grouse remains a subject of some debate, since experimental research on the topic has not been conducted. It is not known to what extent fall hunting is compensatory or additive to natural mortality. Hunting is not likely to be completely compensatory or completely additive. Relative to other gallinaceous birds, sage-grouse are fairly long-lived, lay moderate sized clutches, and are relatively poor re-nesters, all of which suggest hunting may be more additive than for shorter-lived, more productive galliforms. Harvest oriented towards juveniles and/or males will be more compensatory than harvest of adult females. A reported direct recovery rate of 7-10% of banded birds in North Park, Colorado occurred from 1973 to 1990 (Zablan et al. 2003), a period when the number of displaying males counted increased from about 580 to over 1,500. That is not to suggest hunting caused the observed increase in displaying males, but it demonstrates that this increase was not prevented under significant harvest.

Based on telemetry studies in Idaho, Connelly et al. (2000) suggested that successful adult hens were disproportionately vulnerable to harvest. Johnson and Braun (1999) conducted a population viability analysis based on the North Park GRSG population and concluded hunting could reduce growth rates.

Lek Viewing

It has been postulated that human activities associated with the viewing of strutting sage-grouse on leks may have impacts on the grouse. The Gunnison local work group suggested that a decline in lek counts at one of the South Parlin area leks (in the early 1990's) may have been due to unmanaged lek viewing (GBCP 1997). However, there has been very little research on this topic. Profera (1985) conducted an experiment evaluating the distance at which GRSG responded to various disturbances, but the findings were inconclusive. She suggested that females flushed at larger approach distances to disturbance than males. She also found that male response to disturbance was related to the number of females present (Profera 1985). Baydack and Hein (1987) evaluated the response of sharp-tailed grouse to experimental lek disturbances in Manitoba, but the results are of questionable utility regarding lek viewing because all disturbances were placed on the center of the lek.

In the absence of controlled experiments, some information may be obtained from case studies of individual leks used for viewing activities in the past. For the past 25 years a GRSG lek in north-central Colorado (Coalmont lek) has been used for lek viewing. Birdwatchers are referred to this site by both the CDOW and the BLM. Since 1987, a detailed description of how to access this lek has been included in "A Birder's Guide to Colorado" (Holt and Lane 1987) and the location has been common knowledge among birders. Although GRSG populations have fluctuated over this period, the long-term trends appear stable. Counts on the Coalmont lek (Fig. 23) reflect both this variability and a similar long-term stable trend, suggesting there may be no impact to grouse due to lek viewing. The local Chamber of Commerce has conducted organized tours to view sage-grouse displays on an additional lek (Boetcher lek) since 1999 (2-3, 2-day tours per year in late April and early May). Lek counts have increased during this period (Fig. 23).

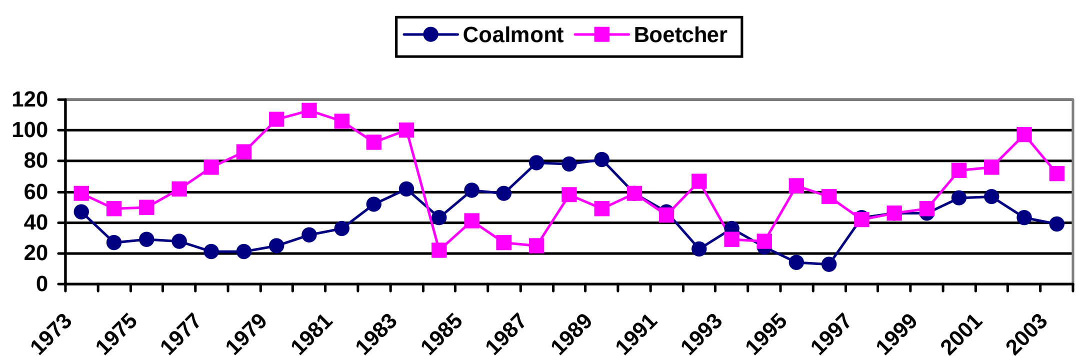


Fig. 23. Lek counts at 2 leks where public lek viewing is allowed in northern Colorado.

The CDOW established a Watchable Wildlife site at the Waunita lek in the Gunnison Basin. Recently, the site has been developed to include a rockwall and screen behind which a viewing trailer is hidden. The site also includes an outhouse, information panels, and parking area. In 2003, Sisk-a-dee, a non-profit conservation group, attempted to mitigate and document potential impacts of this site and corresponding GUSG viewing protocol on GUSG (Sisk-a-dee, unpublished report, 2003). Volunteers from Western State College (WSC) manned the site each day to help enforce compliance with viewing protocols. Viewers were asked to arrive in the dark at least 1 hour before sunrise and remain quietly in the trailer until all birds had departed the lek. Observers mostly followed the protocols, with 88% of vehicles complying, although there were a "few" violations of protocol. Human-related disturbances were credited with flushing grouse from the lek on only 2 of 34 days (although no human-related reasons for birds flushing are listed in the detailed table). Waunita has been a dedicated viewing lek since 1999, without obvious impacts to the number of males counted, in comparison to other leks in the same lek area (Doyleville, Fig. 24).

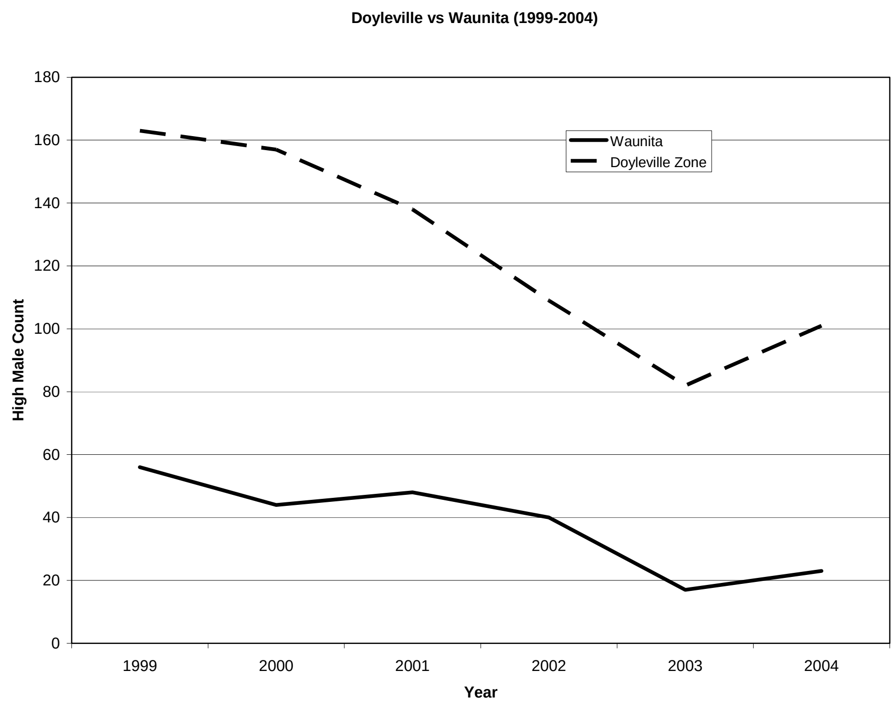


Fig. 24. Lek count data from Waunita Watchable Wildlife lek and other leks in the same (Doyleville) lek area.

Critical experiments to assess the impacts of lek viewing on sage-grouse (or other prairie grouse) have not been conducted and are needed. A first step is to critically evaluate sage-grouse biology and behavior and propose hypothetical impacts. An obvious disturbance would be to flush birds from the lek, which could hypothetically affect individuals and/or a population.

Sage-grouse are frequently flushed off leks by predators and respond to this disturbance in various ways. Boyko et al. (2004) described how GRSG react to predators visiting lek sites. It is likely that sage-grouse perceive humans on and near leks as predators and respond to them as they do to predators. Human disturbance, particularly if it is additive to disturbance by predators, could reduce the time the lek is active and reduce its size (by lowering attendance by "subordinate" males). Lek size has been postulated to affect the appeal of the group to females. Hence, a conceivable secondary effect might be to reduce the numbers of females mating there. Mating skew (the degree of domination by 1 male) tends to go up on small leks, so fewer males may participate in mating if disturbance reduces attendance and recruitment. However, this could be offset by lower skew on other leks attended by displaced birds. Disturbance during the peak of mating could result in some proportion of females not breeding, and females might shift breeding activities off-lek if disturbances were chronic.

Perhaps a more interesting possibility (from a population ecology perspective) is that disturbance might affect nesting habitat selection by females. Even though some females nest far from their lek of capture (and presumed mating), leks are typically close to areas in which females nest. If females move to poorer quality habitat farther away from disturbed leks, nest success could decline. If chronic disturbance caused sage-grouse to recruit to a new lek site away from preferred and presumably higher quality areas, both survival and nest success could decline. Whether any or all of these are real issues would presumably depend on timing and degree of disturbance.

Although impacts of lek viewing have not been demonstrated, studying the hypothesized impacts listed above would be challenging. In any case, it is prudent to take measures to avoid potential negative impacts to GUSG through careful management of lek viewing.

Mining, Energy Development, and Human Community Infrastructure

This section summarizes the effects on GUSG of mining, energy development, powerlines, pipelines, cables, wind turbines, communication towers, and roads. Although the activities and structures covered in this section are not all related, their potential risks to GUSG are similar: (1) habitat loss, fragmentation, and degradation; (2) direct disturbance and mortality of grouse; and (3) increases in predation pressure. Some of these activities have an obvious effect on habitat (e.g., habitat loss resulting from construction of utility or mining structures), and for others there is evidence of impacts on individual grouse (e.g., mortality from collisions with powerlines), but not necessarily on populations. Nevertheless, most of the threats in this section have not been rigorously studied in any prairie grouse species. The possible risks to GUSG of each type of activity or structure are discussed.

Habitat Loss, Fragmentation, and Degradation

Construction of any structure in sagebrush habitat (including overhead or underground powerlines, pipelines, and cables, wind turbines, communication towers, and fences) will inevitably result in some habitat loss. If construction is extensive, it could fragment habitat in a way that might negatively affect GUSG. Habitat fragmentation could force grouse to move across more open areas (less optimal habitat), potentially exposing them to predators more frequently than in contiguous habitat. Oil and gas drilling may decrease the amount of contiguous GUSG habitat through construction of wells, well pads, access roads, compressor stations, pipelines, power lines, produced water containment pits, and sludge pits (Massey 2001). Sand, gravel, and other mineral extraction may result in abandoned mining pits, mining infrastructure, access roads, and overburden placement in sagebrush habitat.

Lack of coal reserves in GUSG range negates any potential threat from coal mining (Bureau of Land Management 1998), but the distribution of other energy reserves is germane to several of the GUSG populations (Bureau of Land Management 1999, Fig. 25). The greatest possibility for oil and gas drilling in GUSG habitat is in all of the Dove Creek, San Miguel Basin, and Monticello, Utah areas, the northern quarter of the Crawford population, and the western half of the Cerro Summit – Cimarron - Sims Mesa population (Fig. 25). The eastern half of the Cerro Summit – Cimarron - Sims Mesa population, a small eastern portion of the Piñon Mesa population, and the northern half and southeast corner of the Gunnison Basin population, are all within areas with low potential for oil and gas drilling. The only areas that have no potential for oil and gas drilling are approximately the southern half of the Gunnison Basin population, the entire Poncha Pass population, and almost all of the Piñon Mesa population. The southern 3/4 of the Crawford population has medium potential for oil and gas development.

Sand, gravel, and other mineral mining activities frequently occur adjacent to existing river and stream channels and in old river channel meanders, which, in GUSG range, may represent brood-rearing habitat. This type of mining may also be located close to towns or areas of impending development, potentially affecting other GUSG seasonal habitats.

Construction of any substantial structure or road, as well as use of access roads can cause increased deposition of dust on plants and invasion of non-native plants, potentially degrading GUSG habitat. Soil erosion, disruption and/or contamination of water sources, and lowering of water tables may also result from oil and gas drilling related activities (Wyoming Game and Fish Department 2003, Bureau of Land Management 2004a), and, although unlikely, could affect sage-grouse habitat. Reclamation efforts may also inadvertently introduce noxious or invasive weeds, altering the sagebrush community.

Disturbance to and Collision Mortality of Grouse

It has been proposed that disruption of normal grouse behavior and productivity can result from various disturbances associated with oil and gas development (Braun et al. 2002, Lyon and Anderson 2003) and powerlines (Robel, in press).

Aspects of oil and gas activities that could disturb prairie grouse include exploratory shot wells, Vibroseis trucks, other exploration vehicles, drill rigs, construction vehicles, venting, flaring, compressor station noise, and human presence. GUSG were observed flushing from a lek when a compressor station switched on (J. Garner, CDOW, personal communication). Alternatively, Attwater's prairie-chickens and lesser prairie-chickens may use well pads or other physically disturbed areas related to oil and gas activities for lek sites (Lutz 1979, Hagen et al. 2004), although further disturbance to the leks and other seasonal habitats may occur (Hagen et al. 2004). In a secondary effect, roads created for oil and gas exploration and drilling could lead to increased recreational use of an area and associated human disturbances (Massey 2001, Wyoming Game and Fish Department 2003). Sand, gravel, and other mineral extraction could cause disturbance to grouse during extraction, sorting and crushing operations.

Grouse mortality may be caused by collisions with wind turbines, communication towers (and associated guy wires), fences, and structures in various utility corridors. The USFWS has proposed a set of guidelines to minimize the danger of collision with wind turbines (Manville 2004). GRSG in Utah have been observed flying into telephone lines (Borell 1939), and Ligon (1951) reported that lesser prairie-chickens were killed by power lines and telephone wires in New Mexico. GUSG collisions with powerlines have also been reported in Colorado (J. Stiver, University of Nebraska, personal communication). Braun (1998) suggested that collision with fences (especially woven wire fences) was a potential factor in sage-grouse decline. Connelly et al. (2000) noted that grouse have been observed hitting or narrowly missing fences or grouse remains have been found next to fences. The impact of collisions on populations of grouse has not been investigated.

Increased Predation Pressure

Elevated structures of various types may provide perch sites for raptors that can prey on grouse. Ellis (1984) described an instance of a golden eagle that changed the strutting behavior of GRSG on a lek in Utah. Ellis (1987) attributed changes in sage-grouse movements on a lek and a shift in lek location in northeastern Utah to construction of a 345-KV transmission line within 660 ft of the lek. Braun et al. (2002) reported that a sage-grouse population in Wyoming inhabiting 40 lek areas within 0.25 miles of power lines had a significantly lower growth rate than a sage-grouse population using lek areas farther away. Increased avian predation was the suggested cause of the lower growth rate. A recent study in Nevada regarding the effects of new transmission lines on sage-grouse in relation to avian predators, concludes in a preliminary progress report (Collopy and Lammers 2004) that the numbers of avian predators documented during surveys did not change significantly after construction of the new powerline. They also documented that the perch deterrents used on the new, as well as the existing powerlines, did not prevent perching, but there was evidence that they did reduce the amount of time spent perching for all species. Apart from actual predation impacts, if grouse perceive a greater threat of harassment and/or predation, they might avoid areas with overhead structures.

Spread of West Nile Virus

Oil and gas drilling may produce water containment pits that could conceivably become mosquito breeding habitat in areas where water was not previously present. Sand and gravel pits are often left as open water ponds after completion of mining, also potentially enhancing mosquito habitat. Any increase in the distribution and numbers of mosquitoes could pose a risk to GUSG because these insects spread WNV (see "Disease and Parasites", pg. 103).

Fig. 25. Potential oil and gas reserves in current GUSG range. Data sources include Bureau of Land Management (1999) for the potential oil and gas resource and lease data and Colorado Oil and Gas Conservation Commission (2005) and the Utah Division of Oil (2004), Gas and Mining for the well location data.

Noxious and Invasive Weeds

A noxious weed is legally defined in Colorado as being non-native and having 1 or more of the following characteristics: (1) aggressively invades or is detrimental to economic crops or native plant communities; (2) is poisonous to livestock; (3) carries detrimental insects, diseases, or parasites; or (4) the presence of the plant is detrimental to environmentally sound management of natural or agricultural ecosystems (Code Title 35 (Agriculture), Article 5.5 (Noxious Weed Act), 103 (Definitions); Colorado Department of Agriculture 2003). There are also plant species, both native and exotic, that are not designated as noxious but are aggressive in growth habit and are considered invasive.

Noxious and invasive weeds have been identified as an important issue in the Crawford, Gunnison Basin, and Piñon Mesa GUSG populations. Stakeholders are concerned with cheatgrass invasions, and the Crawford area local work group has also mentioned knapweed and thistle. Cheatgrass in the Gunnison Basin is receiving research attention from CSU and WSC, as well as treatment with herbicides (Colorado Division of Wildlife 2003).

Cheatgrass and several species of knapweed and thistle are on the Colorado Noxious Weed List (Colorado Department of Agriculture 2003). All of the Colorado GUSG counties have county noxious weed programs, most of which identify knapweed and thistle species, but not cheatgrass, as noxious weeds listed for county control purposes. Noxious and invasive weeds are not known to directly threaten the physical health of GUSG. However, the invasive characteristics of these weedy plants could cause a decline in quality and/or quantity of sage-grouse habitat, thus affecting population parameters.

Cheatgrass is a species that thrives in disturbed, and especially burned, areas (Vallentine 1989, Whisenant 1990). It can even increase fire frequency (Whisenant 1990, Billings 1994, Miller and Eddleman 2000), favoring itself and potentially inhibiting perennial seedling establishment (Wright and Bailey 1982, Whisenant 1990, Grahame and Sisk 2002). A cheatgrass invasion into sagebrush habitat can lead to an eventual conversion of sagebrush/grass (perennial) community to sagebrush/grass (annual) or annual grass rangeland (Connelly et al. 2000, Miller and Eddleman 2000). Sage-grouse food sources vary through the year and include primarily sagebrush, forbs, and insects, but not grasses (Schroeder et al. 1999). In some cases, cheatgrass invasion encourages other exotic species such as knapweed and thistle (Grahame and Sisk 2002)

Pesticides

Insecticides

The pesticides used to control insects (insecticides) are those most likely to affect sage-grouse. Insects are generally a minor diet item for adult sage-grouse but the importance to chicks has been well documented (Patterson 1952, Klebenow and Gray 1968, Johnson and Boyce 1990, Fischer et al. 1996a). Insects, especially ants (Hymenoptera) and beetles (Coleoptera), can comprise a major proportion of the diet of juvenile sage-grouse (Patterson 1952) and are important components of early brood-rearing habitats (Drut et al. 1994a). Fischer et al. (1996a) found that insect abundance was greater at brood-rearing areas than at non-brood sites. Johnson and Boyce (1990) reported that survival and growth rates of sage-grouse chicks were proportional to the amount of insect material in the diet. Early brood-rearing habitats are generally close to nesting habitat and are often relatively open areas with abundant herbaceous cover (Sveum et al. 1998a). These areas may include farmlands and irrigated croplands adjacent to sagebrush habitats.

Impacts of insecticide spraying to sage-grouse may be direct or indirect and are dependent on type of insecticide used, timing of insecticide spraying, and site-specific factors affecting use by sage-grouse, such as crop types and proximity to sagebrush cover. Direct (acute) toxicity of insecticides to sage-grouse occurs through consumption of animal or plant materials with sufficiently high amounts of residue to kill them, dermal absorption, or vapor inhalation through the mucosa of the respiratory tract (Smith 1987). Indirect (subacute) impacts are the disruption of neuronal and endocrinological systems affecting immune function, development and behavior. Another important indirect impact is the reduction of an important food supply for chicks.

Insecticides are used primarily to control insects causing damage to cultivated crops on private lands. The application of insecticides, primarily to control grasshoppers and Mormon crickets, has also occurred on public lands. Infestations of Russian wheat aphids have occurred in GUSG occupied range in Colorado and Utah. Disulfoton, a systemic organophosphate that is extremely toxic to wildlife, was routinely applied to over a million acres of winter wheat crops to control the aphids during the late 1980's. More recently, an infestation of army cutworms occurred in sage-grouse habitat along the Utah-Colorado state line. Thousands of acres of winter wheat and alfalfa fields were sprayed with insecticides such as permethrin by private landowners to control army cutworms. There has been 1 reported instance of sage-grouse mortality following application of organophosphate and carbamate pesticides to cultivated crops in Idaho (Blus et al. 1989).

The arrival of WNV in GUSG range presents an additional potential problem with insecticides. Infection with WNV could threaten GUSG populations, but use of insecticides to control mosquitoes which transmit the virus could have detrimental effects on sage-grouse. Use of larvicides such as Bti (*Bacillus thuringiensis israelensis*), which have extremely low toxicities to vertebrates, can greatly mitigate risks (Rose 2004). Available adulticides include synthetic pyrethroids such as permethrin, which are applied at very low concentrations and have very low vertebrate toxicity (Rose 2004). Organophosphates such as malathion have been used at very low rates to kill adult mosquitoes in and near urban areas for decades, and are judged relatively safe for vertebrates (Rose 2004).

Herbicides

Historically, different combinations of herbicides (pesticides applied to plants) and seasons of applications were developed to remove sagebrush, other unwanted woody shrubs, and weedy annuals from western rangelands (Tueller and Evans 1969, Evans and Young 1975, Evans and Young 1977). The use of herbicides has the potential to directly and indirectly impact GUSG. The impacts can be through direct contact (Ward et al. 1942, Post 1951, Blus et al. 1989) or indirectly through modification of components of the habitat. These modifications can include the removal of sagebrush (Carr and Glover 1970, Klebenow 1970) and the reduction of forbs or insects (Eng 1952).

Herbicide applications of 2,4-D (2,4-dichlorophenoxy acetic acid) or tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) were commonly used to kill large expanses of sagebrush, leaving the standing dead skeletons of the shrubs with low risk of soil erosion. However, herbicides, if used full strength during the growing season, have killed or injured many forbs (Crawford et al. 2004). More recently, thinning of sagebrush density by Tebuthrion, rather than sagebrush removal from large areas, has been the focus of some treatments (Emmerich 1985, Olson and Whitson 2002).

Predation

Sage-grouse and Predators

Predation is frequently cited as a major cause of mortality in sage-grouse (Bergerud 1988, Schroeder et al. 1999, Connelly et al. 2000). Predation rates vary seasonally. The period of highest mortality for yearling and adult males occurs during the lekking (breeding) season, for yearling and adult females during nesting and brood-rearing, and for juveniles during the first few weeks after hatch (Patterson 1952, Schroeder et al. 1999, Schroeder and Baydack 2001). However, the effect of predation on the fluctuations and viability of sage-grouse populations has never been investigated (Connelly and Braun 1997, Connelly et al 2000, Schroeder and Baydack 2001). Schroeder and Baydack (2001) suggest that nest predators may have an important impact on sage-grouse population dynamics given the high variation in nest success. Nest predation may be higher, more variable, and have a greater impact on small, fragmented populations. The population viability analysis of GUSG presented in this plan (see pg. 168) suggests that juvenile survival may be a limiting factor for population growth. Predation may be an important factor in juvenile mortality, but nutrition, habitat quality, and environmental conditions also affect juvenile mortality (Pyle and Crawford 1996, Sveum et al. 1998a).

Sage-grouse have evolved with native predators, and consequently have developed traits to survive with high predation pressures. For example, both yearling and adult females attempt to nest, lay moderately large clutches, and attempt to renest if nests are destroyed by predators (Svedarsky 1988, Schroeder 1997). Grouse have also adapted anti-predator behaviors such as crouching low or seeking cover under vegetation in the presence of predators, or flying in the opposite direction of attack from avian predators (Hartzler 1974, Ellis 1984, Schroeder et al. 1999). Females perform displays (e.g., erratic movements or dragging their wings on the ground) to distract predators from nests (Schroeder et al. 1999). GRSG females have also been documented defending their nests from ground squirrels (Schroeder 1997), and Girard (1937) observed females attacking predators in the defense of their broods.

Predator Community and Interactions

If there is an effect of predation on sage-grouse populations, it will depend on the species composition of the predator community. There is no published information on the species of predators of GUSG, but predators of GRSG have been well documented (Schroeder et al. 1999). Predators that depredate juvenile and adult GRSG include avian predators such as golden eagles, red-tailed hawks, ferruginous hawks, Swainson's hawks, northern harriers, gyrfalcons, northern goshawks, Cooper's hawks, American kestrels, merlins, and great-horned owls; and mammalian predators such as coyotes, red foxes, weasels, and bobcats. Predators that mainly depredate eggs include avian predators such as common ravens, American crows, and black-billed magpies; and mammalian predators such as badgers, ground squirrels, raccoons, and striped skunks.

The composition and density of predator communities can vary greatly across space and time (Greenwood 1986, Johnson et al. 1989, Sargeant et al. 1993, Sovada et al. 1995). The effect of predation on the demographic structure and population fluctuations of GUSG is unknown, but will likely depend on the composition of the predator community. Avian predators, primarily corvids, were major predators of GRSG nests in Idaho (Autenrieth 1981) and Washington (Vander Haegen 2002), while ground squirrels and badgers were major nest predators in Colorado (Gill 1965) and Wyoming (Patterson 1952). Giesen (1995) documented very poor nesting success in North Park, Colorado, in 1993 and 1994 (22% of 42 nests and 27% of 20 nests, respectively). Most nest loss (87%) was due to depredation, primarily by Richardson's ground squirrels. It is possible that most mammalian predation will be on eggs. Only coyotes and red foxes are likely to prey on all grouse life stages. Most raptor predation will be on juveniles and older age classes, while other avian predators (e.g., common ravens, American crows and black-billed magpies) will mainly affect clutches.

Increasing residential development has been identified in most GUSG local conservation plans as a risk to GUSG. Development not only contributes to the loss of sage-grouse habitat, but it also increases the likelihood that non-native predators (e.g., feral cats and dogs) will be introduced into local GUSG populations. Development can also contribute to increased populations of predators (e.g., red foxes, American crows, and common ravens) that are frequently associated with altered landscapes that provide additional denning or nesting sites, or additional food resources from agricultural waste grain or landfills.

There are other complex ecological consequences associated with predation that must also be addressed before specific management strategies can be recommended. This includes the behavioral and spatial interactions of predators with GUSG and with other predator species. Removing predators from a specific area can lead to a functional and/or numerical response by other predators. Predators compensate for predator removal by either moving into vacated areas (functional response) (Sargeant 1972, Gese et al. 1989) or by producing larger litters that typically have higher survival rates (numerical response) (Knowlton 1972). The reproductive and movement characteristics of predators such as red foxes (Allen 1983), raccoons (Fritzell 1978) and striped skunks (Greenwood and Sargeant 1994) make it possible for these species to respond quickly to predator removal programs.

Furthermore, it has been argued that removing dominant predators from an ecosystem can result in increased populations of lower trophic-level predators - i.e., "mesopredators" such as red foxes, raccoons, ground squirrels and feral pets (Soulé et al. 1988, Rogers and Caro 1998, Crooks and Soulé 1999). The increased population densities of lower trophic-level predators may compensate for the removal of dominant predators such that overall predation rates are not affected (Parker 1984, Greenwood 1986). Predator control programs that focus on removing coyotes can lead to increased populations of red foxes (Sargeant et al. 1987, Voigt and Earle 1983). Red foxes may have a more profound effect on sage-grouse populations than coyotes. In prairie ecosystems, red foxes are a major predator of grassland birds (Sargeant et al. 1984, Greenwood et al. 1987, Johnson et al. 1989) and have a greater impact on nest success of grassland birds than do coyotes (Johnson et al. 1989). Both coyotes and red foxes are territorial and red foxes avoid areas with coyotes (Voigt and Earle 1983). Areas with high densities of coyotes have low densities of red foxes and higher overall nest success (Sovada et al. 1995). Therefore, behavioral and spatial interactions between predator species are complex, and compensatory predation may undermine predator control programs that focus on a single predator species. Attempts at controlling multiple mammalian predators may lead to increased predation rates by avian predators.

Predator Control - Background

Numerous predator control studies in prairie ecosystems have had variable success in increasing waterfowl nest success or productivity (Greenwood 1986, Sargeant et al. 1995). The variability may be partly due to restrictions on the methods allowed (Sargeant et al. 1995), but may also be due to compensatory predation from predator species not included in the control program, or by a numerical and/or functional response by predators included in the program. Predator removal was most successful in small (< 1,236 acres), intensively managed waterfowl nesting areas (Balser et al. 1968, Chesness et al. 1968, Duebbert and Lokemoen 1980, Greenwood 1986, Sargeant et al. 1995). However, moderate improvements in nest success and brood production have been documented for predator removal programs that used multiple methods over relatively larger (<64,247 acres) areas (Balser et al. 1968, Schranck 1972, Duebbert and Kantrud 1974, Duebbert and Lokomoen 1980, Garrettson et al. 1996). However, increases in nest success as a result of predator removal programs tend not to last beyond the duration of active predator removal (Chesness et al. 1968, Duebbert and Kantrud 1974) and generally have not resulted in significant recruitment or population growth in prey populations over time (Cote and Sutherland 1997).

Legal restrictions on some predator control techniques (e.g., trapping and poisoning) may influence a predator control program. In Colorado, it is unlawful to kill wildlife by trapping or poison unless a landowner can provide evidence of ongoing damage to livestock or crops and that other methods not prohibited by law have failed (Colorado Constitution, Title 33: Article 6). Even then, trapping is allowed only for a 30-day period each year. Utah allows predator control (Utah Code sections 23-14-18 and 23-14-19) only if predator management plans specifically define the predation problem and prey species, identify the strategies and methods to be used, and establish measurable objectives for the predator control. Some poisons such as sodium monofluoroacetate (1080) have been banned on federal lands since 1972. The ban was put in place due to a lack of evidence that poisons such as 1080 effectively controlled predator populations (particularly coyote populations), and because nontarget animals (e.g., badgers, eagles, livestock and pets) were often unintentional victims.

Predator Control - Methods

A variety of lethal and nonlethal predator control methods have been developed (Lokemoen 1984, U. S. Department of Agriculture 1994). Occasionally, multiple methods are used to increase the effectiveness of predator control programs, but typically methods are designed for specific predator species in localized areas and are limited by budget and personnel constraints (U. S. Department of Agriculture 1994). Most methods focus on controlling mammalian nest predators, but some target avian nest predators.

Lethal predator control methods are the most traditional and controversial of predator management programs (U. S. Department of Agriculture 1994). These methods include both species-specific chemical toxicants (e.g., zinc phosphide for rodents, sodium cyanide for canids, and DRC-1339 for blackbirds) and non-target strychnine or arsenic based toxicants (U. S. Department of Agriculture 1994). They also include methods such as shooting (e.g., aerial gunning of coyotes), kill-traps, catch and kill techniques (i.e., euthanizing predators after capturing them in leg-hold traps, snares or box traps), killing offspring in dens (used mostly for coyotes and red foxes), or destruction of nests/eggs/hatchlings of avian predators (U. S. Department of Agriculture 1994).

Non-lethal predator control strategies can be divided into small-scale (intensive) methods or relatively large-scale (extensive) methods. Small-scale predator control methods are typically designed to repel predators from well-defined important areas (e.g., a small block of dense nesting habitat). One type of small-scale method involves building fences (predator exclosures) around small blocks of nesting habitat (Lokomoen et al. 1982, Lokomoen 1984, Greenwood et al. 1990) or around individual nests (Sargeant et al. 1974). These barriers can be effective, but are often expensive.

Scare tactics are another type of small-scale method that attempt to disrupt predators from their normal hunting behavior and potentially repel them in important areas. Scare tactics can include distress calls (or calls from avian predators that are designed to ward off other avian species, such as common ravens and American crows), strips of flagging attached to fence lines, bright lights (spotlights) or loud noises (e.g., propane exploders, gunfire, pyrotechnics, or ultrasonic devices) that are triggered by a predator, or scarecrows. Scare tactics are relatively inexpensive; however, many predators (particularly canids) are quick to adapt to the tactics. Some tactics such as bright lights and loud noises may be more annoying to people than to predators.

Another small-scale nonlethal predator control strategy involves altering predator behavior through aversion techniques (Nicolaus et al. 1982, 1983, Nicolaus 1987, Conover 1989, 1990). The techniques attempt to train individual predators to either avoid prey items such as eggs or avoid important areas. Chemically treated eggs are placed where they will be commonly encountered by a predator. The method works only if the predator associates the eggs with the chemical's taste, otherwise predators will continue to disturb nests and destroy eggs to determine if they contain the chemicals (Conover 1989). Other aversion techniques include repellents broadcast over an important area (U. S. Department of Agriculture 1994). Repellants are typically nontoxic, aversive chemicals applied to trees or fence posts. Scent stations are also used to repel predators, but are used only for territorial predators such as canids. Chemical repellants are regulated by the Federal Insecticide, Fungicide and Rodencide Act as administered by the Environmental Protection Agency. Aversion techniques have not been demonstrated to be consistently successful and are relatively expensive and labor-intensive (Greenwood and Sovada 1996).

Another nonlethal approach is to inhibit reproduction of predators through sterilization (U. S. Department of Agriculture 1994). It is argued that inhibiting reproduction will reduce predation rates since parents will have fewer offspring to feed and ultimately, the predator population size will decline as a result of lower recruitment. However, any gains from the approach are likely to be offset by compensatory predation from other species and by a functional response by predators (i.e., untreated predators from adjacent areas move into the treated area in response to the decreased population density).

Habitat Management as Predator Control

Habitat management, as a nonlethal approach to predator control, is receiving increasing attention. A variety of habitat related techniques have been suggested for predator control, including: 1) managing the composition and configuration of habitats at landscape scales, 2) small-scale restoration and management of vegetation structure for cover from predation, 3) managing habitats to enhance (or diminish) the presence of alternative prey, and 4) removing den or nesting sites, and perching sites from important habitats.

The quantity of nesting habitat in the landscape has been correlated to the nesting success of grassland birds and has often been linked to the rate of predation (Kirsch, 1974, Greenwood et al. 1987, 1995, Connelly et al. 1991, Andren 1992, Ball 1996). Furthermore, the composition and configuration of habitats in the landscape can influence the movement patterns and ability of predators to find nests of grassland birds (Kuehl and Clark 2002, Phillips et al. 2003, 2004). Large blocks of nesting habitat in landscapes with alternative habitat types, such as pastures that have food resources attractive to predators (Greenwood et al. 1999), decrease the foraging efficiency of mammalian predators in grassland ecosystems (Phillips et al. 2003, 2004). The fragmentation of important habitat is considered an important mechanism in the decline of many avian populations (Wilcove 1985, Johnson and Temple 1986, 1990) and has been correlated to the type and density of the predator community (Robinson et al. 1995, Yahner 1996, Vander Haegen et al. 2002). It is argued that habitat fragmentation increases predation by decreasing the amount of cover habitat for birds while increasing the amount of habitat easily traveled and searched by predators (e.g., edge habitat). Studies have indicated that the rate of predation is highest in small, linear patches of nesting habitat (Chesness et al. 1968, Haensly et al. 1987, Mankin and Warner 1992). Management of sagebrush habitat at the landscape scale may be a cost effective way to reduce the effect of mammalian predation on GUSG.

Habitat with adequate shrub and grass structure may provide sage-grouse and sage-grouse nests some protection from predators (DeLong et al. 1995, Sveum et al. 1998b). It is suggested that dense vegetation structure will prevent predators from detecting nests. Several studies in prairie ecosystems have reported high nest success for grassland birds in areas with dense vegetation (Schranck 1972, Duebbert and Lokemoen 1976, Livezy 1981, Cowardin et al. 1985, Sugden and Beyersbergen 1986, 1987). The success of the approach may depend on patch size as well as the predator community. Mammalian predators that use olfactory cues to search for prey may not be affected as much by vegetation structure as avian predators that rely more on visual cues.

One possible management tool that has been suggested for controlling predators is managing habitat (or supplementing food resources) so that there is greater abundance of alternative prey (or food resources) either in, or adjacent to, areas of important nesting or brood-rearing habitat. The assumption is that predators will alter their behavior and search for prey items (i.e., alternate prey such as rodents and lagomorphs) that are more abundant or require less energy to find and consume than nests or broods. Therefore, predation rates may be greater for grouse if alternate prey are scarce. However, the few studies that have addressed the question have not been conclusive. Nest success of grassland birds has either improved (Angelstam et al. 1984, Crabtree and Wolfe 1988), shown no response (Greenwood et al. 1998), or declined in the presence of alternative prey (Vickery et al. 1992). Conflicting results may be due to complex predator-prey population dynamics such that temporal or spatial population fluctuations of alternative prey may be too erratic for a predictable predator response.

It has been suggested that predator populations (both the species and population abundance) may be controlled by removing den sites, such as abandoned farmsteads, and nesting or perching structures, such as powerlines and fences (Fleskes and Klaas 1991, Herkert 1994, Greenwood et al. 1995, Larivierre et al. 1999). However, there has been no research on the influence of these structures on predator or sage-grouse populations.

Manipulating habitat to influence predator communities may be the most cost-effective long-term predator control method. However, habitat manipulation will take time and it may not be feasible to reverse the trends in habitat loss and fragmentation for some populations (e.g., in areas of residential development). Because some GUSG populations are so small and are embedded in highly fragmented and developed landscapes, intensive predator control should be considered as a short-term management tool where legally feasible. An integrated program that includes both intensive and extensive predator control methods may be the most effective but will likely be costly. Any predator control program must include long-term monitoring of both predator and GUSG populations in order to evaluate the effectiveness and validity of the program.

Conclusions

Before a predator control program is implemented, research is necessary to: (1) evaluate the demographic status of GUSG populations; (2) eliminate other contributing factors to population fluctuations (e.g., drought or disease); (3) address the behavioral and spatial interactions of predators and sage-grouse; (4) identify the extent of predation pressures and contributing predator community; and (5) evaluate the role of predation on the long-term viability of sage-grouse populations.

The development of an effective predator management program is problematic given the complexity of the ecological and legal consequences, lack of reliable information, and public resistance to lethal predator control (Messmer et al. 1999). However, predator control may be necessary under some circumstances for GUSG populations with small numbers of grouse in isolated and fragmented populations. In these cases, a predator control program should be designed for a specific GUSG population, since the relevant predator community will likely vary for each population. An integrated program that includes both intensive and extensive (lethal and nonlethal) predator control methods may be the most effective, but will likely be costly. Predator control may be valid only if nest success and/or female (or brood) survival is exceptionally low. The population viability analysis of GUSG that we present (“Population Viability Analysis”, pg. 168) indicates a higher extinction probability for populations with < 25 breeding individuals.

Therefore, predator control measures should be considered if a local GUSG population is, (1) below 25 breeding individuals or 25% of the long-term population goal (especially, if it is a declining or recently augmented population); (2) nest success is < 25%, and/or female (or brood) survival is < 45% (Connelly et al. 2000); and (3) the population is assessed as a high conservation priority (see Table 41, pg. 303). Quantifiable objectives within a specific time-frame must be specified, and long-term monitoring of both predator and prey communities (sage-grouse as well as other prey species), are necessary in order to objectively evaluate the success of the program. All predator management plans in Colorado will follow directives of the Colorado Wildlife Commission Mammalian Predator Management Policy and be submitted to the Wildlife Commission and the Director of the Division of Wildlife for review and approval or rejection. In Utah, the UDWR and the Utah Wildlife Board regulate predator management by establishing rules and policies, and by developing and implementing predator management plans. Through an MOU with UDWR, Wildlife Services, a branch of the Utah Department of Agriculture, is responsible for handling livestock depredation problems.

Recreational Activity

It has been postulated that recreational activity might have a negative effect on GUSG. Although there has been no research into or evidence to support this possibility, a review of the potential recreational effects on wildlife in general is instructive. Recreation on lands managed by the BLM is a significant land use (Connelly et al. 2004) and recreational use of national forests has increased 76% since 1977 (Rosenberg et al. 2004). Human activities such as recreation can impact wildlife through four primary routes: (1) exploitation; (2) disturbance; (3) habitat modification; and (4) pollution (Knight and Gutzwiller 1995). Exploitation refers to immediate death from hunting, trapping, or scientific collection (see "Hunting", pg. 122). Unintentional disturbance to individual animals may result from activities such as birdwatching, wildlife photography, hiking, biking, or motorized use through habitat. Recreationists may inadvertently modify vegetation, soil, water, and even microclimates, which in turn can impact species associated with these affected habitats. Some wildlife species are indirectly affected by pollution, such as human trash, including food and plastic objects.

If recreation does impact GUSG, disturbance is the most likely factor to affect the species. Most studies on wildlife species have documented immediate, rather than long-term responses to disturbance (Knight and Gutzwiller 1995). Some of these potential responses are behavioral changes, including nest abandonment and a change in food habits, as well as physiological changes, such as elevated heart rates.

Wildlife viewing has the potential to negatively affect wildlife. Avid birders sometimes intentionally seek out rare or spectacular species, such as GUSG. Because viewing activities sometimes occur during sensitive times of year (e.g., strutting/nesting), they have the potential to negatively affect wildlife behavior, if not managed properly (see "Lek Viewing", pg. 124). Of five different recreation-user groups at a wildlife refuge in Florida, photographers were the most disruptive, since they were most likely to stop, leave their vehicles and approach wildlife (Klein 1993, as cited in Knight and Gutzwiller 1995).

Dispersed recreational activities, such as off-road vehicle use, backpacking, hiking, cross-country skiing, and horseback riding, have increased dramatically in recent years. These activities are geographically extensive in nature and have the ability to disrupt wildlife in many ways, particularly by displacing animals from an area. Most documented responses have been behavioral and short-lived (Knight and Gutzwiller 1995).

Disturbance during a species' breeding season may affect individual productivity. Wildlife may respond to disturbance during the breeding season by abandoning their nests or young, leading to reproductive failure. Human activity can also alter parental attentiveness, increasing the vulnerability of the young to predators, disrupting feeding patterns, or exposing the young or eggs to adverse environmental stress.

One extension of human recreation in wildlife habitats is the effect on wildlife of domestic dogs that might accompany recreationists. Dogs can cause disturbance, harassment, displacement, and/or direct mortality of wildlife. Authors of many wildlife disturbance studies concluded that dogs with people, dogs on-leash, or loose dogs provoked the most pronounced disturbance reactions from their study animals (Sime 1999). Dogs extend the zone of human influence when off-leash. Potential consequences of dogs off-leash are primarily harassment, due to the predator instinct of dogs to chase/hunt animals. Harassment by dogs can lead to physiological stress, as well as the separation of adult and young, or flushing incubating birds from their nest. Displacement, whether caused by dogs or humans, also has the potential to increase predation by the natural predators, as well, by increasing the vulnerability of adults and young.

Weather/Drought

Colorado and Utah can experience extreme climatic conditions during all seasons. Long periods of below average precipitation, above average summer temperatures, above average snowfall, or below average winter temperatures may have adverse effects on sage-grouse reproductive success and survival. In fact, prolonged drought during the 1930's and in the latter part of the 20th century coincided with declines in grouse populations throughout their range (Patterson 1952, Fischer 1994, Hanf et al. 1994). Extreme climatic conditions that occur during critical life cycle sequences have the potential to adversely affect the abundance and quality of food resources and hiding cover (Hanf et al. 1994, Fischer et al. 1996b).

Severe winter conditions may reduce grouse survival, although evidence to support this is not conclusive (Wallestad 1975, Beck 1977, Robertson 1991). Winter snow accumulation forces birds to move to areas blown free of snow or areas with sagebrush which extends above the snow (Eng and Schladweiler 1972, Wallestad 1975, Beck 1977, Hupp and Braun 1989b, Robertson 1991). A severe winter in 1983-84, with a long period of extreme cold and heavy snow, is believed to have been a factor in decline in GRSG population in northwestern Colorado and GUSG populations in the Gunnison Basin.

Poor weather conditions in the spring may influence sage-grouse production (Connelly et al. 2000). Good winters followed by relatively wet springs can increase grouse production (Wallestad 1975, Autenrieth 1981) by resulting in good insect and forb production. In contrast, severe spring weather (cold temperature combined with rain and wind) that coincides with hatching can decrease production (Wallestad 1975).

GRSG can be very sensitive to fluctuations in annual moisture (Patterson 1952, Fischer 1994, Hanf et al. 1994). Sage-grouse summer diet, especially that of chicks, is heavily dependent on insects and succulent plant growth. GRSG populations decline in years of low precipitation, most likely due to low nest success and/or poor chick survival (Hanf et al. 1994; Fischer et al. 1996b). Quality nesting cover requires sagebrush canopy as well as forb and grass cover to hide hens and their nests. Severe drought conditions, such as those much of the western states experienced in 2002-2004, may have hindered the production of grasses, forbs, and sagebrush.

Some sagebrush communities across the range of the GUSG experienced defoliation, die-off, and loss of understories in 2003 due to lack of water (2002 drought), insects, and possibly pathogens (Wenger et al. 2003). Conversely, some stands of sagebrush that appeared to be in poor condition also experienced high seed production in the fall of 2003, as well as a release of young sagebrush, other shrubs, grasses, and forbs. Consequently, some disturbance to the vegetation community may help to set back succession of sagebrush within otherwise undisturbed communities, thus possibly improving sagebrush and understory quality and quantity.

Threats Summarized by ESA Listing Factor

The ESA listing factors evaluate threats to a species and are used to determine whether a species is threatened or endangered, thereby warranting listing under the ESA. Here we give a general summary of the threats to GUSG, grouped by ESA listing factors. In addition, the potential issues affecting each GUSG population have been identified separately by the USFWS, CDOW, UDWR, The Nature Conservancy, and in GUSG local conservation plans (Table 20). Some of the threats listed in Table 20 are specific local issues that we discuss under a more general topic (e.g., "Urban Development" and "Agricultural Conversion" are discussed in the RCP under "Habitat – Risk of Permanent Loss", pg. 149). For further background on a given topic, see appropriate topics earlier in this section, "Threats and Analysis" (beginning pg. 103).

Listing Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range.

Size of GUSG range and quality of GUSG habitat have been reduced by direct habitat loss, fragmentation, and/or degradation from building development, road and utility corridors, fences, energy development, conversion of native habitat to hay or other crop fields, alteration or destruction of wetland and riparian areas, incompatible livestock management, competition for winter range by big game, and creation of large reservoirs.

Listing Factor B: Overutilization of the species for commercial, recreational, scientific, or educational purposes.

GUSG populations have not been overused for commercial, scientific, or educational purposes, but some of the smaller populations may have been impacted by legal and illegal hunting. The Gunnison Basin population had a hunting season through 1999; whether or not hunting impacted the Gunnison Basin population is debatable. None of the other populations has been included in a hunting season for many years, and it is unlikely that any of the populations (including Gunnison Basin) will have a hunting season in the foreseeable future. With increased awareness of the plight of sage-grouse by the public and increased attention by state wildlife law enforcement personnel, it is believed that little illegal hunting currently occurs and may be limited to incidental shootings.

Because the GUSG is a newly designated species, many bird-watchers wish to add GUSG to their "life lists". Increased numbers of observers could cause disturbance to sage-grouse at commonly known or newly discovered lek sites. Concern over disturbance by birdwatching has been specifically mentioned for the Gunnison Basin and Crawford Area populations.

Current research efforts that include trapping, banding, and radio-marking GUSG are not believed to adversely affect populations, although 1 local plan expressed concern over potential impacts from increased research levels.

Listing Factor C: Disease or predation affecting the species.

No disease problems have been detected in GUSG, but the recent appearance of West Nile virus and its known impact on some bird species could be a threat to GUSG, especially in the smaller populations, in the near future. It is also possible that other game birds, such as turkeys, pheasants, and chukars could transmit diseases to sage-grouse.

Predation on sage-grouse by many mammalian and avian predators has been observed (Schroeder et al. 1999). Most loss of potential productivity is through nest failure, which is often caused by ground or avian predators (Schroeder et al. 1999). Structures such as fences, buildings, and utility poles provide hunting perches for raptors, and if placed near lek sites they might be detrimental to sage-grouse.

Listing Factor D: The inadequacy of existing regulatory mechanisms to protect the species.

For a detailed description of existing management and legal authorities for the protection of GUSG see "Management and Legal Authorities" (pg. 14). The GUSG is a sensitive species in Colorado and Utah. The CDOW and UDWR have authority for setting hunting seasons and possession limits and for enforcement against poaching and harassment. However, the state wildlife agencies do not have authority for protecting against habitat loss. Furthermore, federal land management agencies do not have authority to protect against habitat loss on private land.

There have been many actions taken on private land to conserve GUSG and the willingness of landowners to carry out these actions offers great potential for conservation of the species on private land. The RCP is needed to direct rangewide population goals, transplant/genetic needs, and reestablishment of habitat linkages between populations and subpopulations. Furthermore, participation in federal programs directed towards private land management is voluntary and dependent on program funding. Actions carried out by federal land management agencies on federal lands are also dependent on funding. Wildlife programs of the BLM and USFS have received funding specifically for sage-grouse in recent years, but further habitat improvements are needed, especially on BLM land, which represents 42% of the currently occupied GUSG habitat in Colorado and Utah (Appendix D).

Listing Factor E: Other natural or manmade factors affecting the species' continued existence.

Other factors that may affect continued existence of GUSG include fire suppression (allowing encroachment of sagebrush habitat by piñon and juniper or old and even-aged stands of sagebrush), overgrazing by elk, deer and domestic livestock, drought, disturbance or mortality caused by off-highway-vehicles, disturbance by construction projects or oil and gas development, harassment from people and pets, continuous noise that impairs acoustical quality of leks, inbreeding depression, herbicides, insecticides, pollution, and competition for habitat from other species.

Table 20. Current and potential issues affecting GUSG populations. Issues have been identified in the following documents: C = Local Conservation Plan; D = Colorado Division of Wildlife, Annual Candidate Status Review Summaries (Colorado Division of Wildlife 2002, 2003); F = U. S. Fish and Wildlife Service, 2003 Candidate Review Form; U = Utah Division of Wildlife, Strategic Management Plan for Sage-grouse; N = The Nature Conservancy, (The Nature Conservancy 2002).

USFWS Listing Factor	Issue Affecting GUSG	GUNNISON SAGE-GROUSE POPULATION							
		Cerro – Cimarron - Sims Mesa	Crawford	Dove Creek	Gunnison Basin	Monticello Utah	Piñon Mesa	Poncha Pass	San Miguel Basin
Factor A: Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range	Urban Development	D, F, N	C, D, F, N	C, D, F, N	C, D, F, N	C, F	C, D, F, N	C, D, F	C, D, F, N
	Roads	D, F, N	C, D, F	C, D, F	C, D, F	C, F	C, D, F, N	C, D, F	C, D, F, N
	Utility Corridors	D, F, N	C, D, F	C, D, F	C, D, F	C, F	C, D, F, N	C, D, F	C, D, F, N
	Fences	D, F	C, D, F	C, D, F	C, D, F	C, F	C, D, F	C, D, F	C, D, F
	Oil and Gas Wells					U			D, F, N
	Oil and Gas Pipelines	N	C	C, F	C	C, U	C, N	C	C, F, N
	Mining				C, F			C, D	C, F
	Agricultural Conversion	D, F	C, F	C, D, F, N	C, F	C, F, U	C, D, F	C, F	C, D, F
	Wetland/Riparian Alteration	D, F	C, F	C, F	C, F, N	C, F	F	F	C, F
	Livestock Management	D, F, N	C, F, N	C, F, N	C, F, N	C, F, U	C, F, N	C, F	C, F, N
	Big Game Grazing/Browsing	F, N	C, F	C, F	C, F	F	C, F	C, F	C, F, N
	Reservoirs		C		C, F				C, F
	Poor Habitat Quality/Quantity	D, F, N	C, D, F, N	C, D, F, N	C, D, F, N	C, F, U	C, D, F, N	C, F	C, D, F, N
	Habitat Fragmentation	D	C	C, D	C	C	C	C	C, D

USFWS Listing Factor	Issue Affecting GUSG	GUNNISON SAGE-GROUSE POPULATION							
		Cerro – Cimarron - Sims Mesa	Crawford	Dove Creek	Gunnison Basin	Monticello Utah	Piñon Mesa	Poncha Pass	San Miguel Basin
Factor B: Overutilization for Recreational, Commercial, Scientific, or Educational Purposes	Lek Viewing		D, F		C, D, F, N	U		C	
	Hunting		C		C, F		C	C, F	
	Poaching			C	C	U			C
	Recreation	D, F, N	C		C, F, N	C	C	C	C
	Lek Counts/Monitoring		C	C	C		C	C	C, F
	Sage-grouse Research	F	C, F	C, F	C	F	C, F	C, F	D
	Vegetation Experiments								

Table 20 (con't). Current and potential issues affecting GUSG populations. Issues have been identified in the following documents: C = Local Conservation Plan; D = Colorado Division of Wildlife, Annual Candidate Status Review Summaries (Colorado Division of Wildlife 2002, 2003); F = U. S. Fish and Wildlife Service, 2003 Candidate Review Form; U = Utah Division of Wildlife, Strategic Management Plan for Sage-grouse; N = The Nature Conservancy, (The Nature Conservancy 2002).

USFWS Listing Factor	Issue Affecting GUSG	GUNNISON SAGE-GROUSE POPULATION							
		Cerro - Cimarron - Sims Mesa	Crawford	Dove Creek	Gunnison Basin	Monticello Utah	Piñon Mesa	Poncha Pass	San Miguel Basin
C. Disease or Predation.	Disease	D, F	D, F	C, F	C, F, N	C, F	C, F	C, F	C, D, F
	Predation	D, F	D, F, N	F	D, F	F	F	C, F	D, F

USFWS Listing Factor	Issue Affecting GUSG	GUNNISON SAGE-GROUSE POPULATION							
		Cerro – Cimarron - Sims Mesa	Crawford	Dove Creek	Gunnison Basin	Monticello Utah	Piñon Mesa	Poncha Pass	San Miguel Basin
Factor D: Inadequate Regulatory Mechanisms.	Conflicting Land Zoning	D, F	F	F	C, F	F	F	F	F
	Conflicting Regulations and Policies*		C	C	C				C, F
	Inadequate Conservation Funding	F	F	F	F	F	F	F	F
	Inadequate Habitat Protection Regulations	F	F	F	F	F	F	F	F
	Inadequate Regulations for Native/Exotic Releases					U			

Table 20 (con't). Current and potential issues affecting GUSG populations. Issues have been identified in the following documents: C = Local Conservation Plan; D = Colorado Division of Wildlife, Annual Candidate Status Review Summaries (Colorado Division of Wildlife 2002, 2003); F = U. S. Fish and Wildlife Service, 2003 Candidate Review Form; U = Utah Division of Wildlife, Strategic Management Plan for Sage-grouse; N = The Nature Conservancy, (The Nature Conservancy 2002).

USFWS Listing Factor	Issue Affecting GUSG	GUNNISON SAGE-GROUSE POPULATION							
		Cerro – Cimarron - Sims Mesa	Crawford	Dove Creek	Gunnison Basin	Monticello Utah	Piñon Mesa	Poncha Pass	San Miguel Basin
Factor E. Other Natural or Manmade Factors Affecting Species' Existence	Piñon-Juniper Encroachment	F	C, D, F	C, F	F	F, U	C, D, F	F	D, F
	Oakbrush Encroachment	D, F		C, F			C, F		D, F
	Fire Suppression	D	C, N	C	C, N		C, D, N		C
	Sagebrush Community Changes	D	C	C	C	C	C, D	D	C, D
	Exotic Weed Invasion	D, N	D		C, D, F	C	D, F, N		D F, N
	Drought Impacts to Sagebrush Habitat	D, F	C, D, F	C, F	C, D, F	C, F	C, D, F	C, F	C, D, F
	Motorized Vehicles	N	C	C	C, F, N	C	C	C	C
	Disturbance from Construction	F	F	F	C, F	F	F	F	F
	Harassment from People/Pets	D, F, N	C, F	C, F	C, F, N	F	C, F	C, F	C, F
	Noise Impacts to Leks	F	C, F	C, F	C, F	F	C, F	C, F	C, F
	Geographic Isolation	D, F	F	F		F, U	F	C, F	F
	Herbicide Use	D, F	C, F	F	C, F	C, F	F	F	C, F
	Insecticide Use	F	F	F	F	C, F, U	F	F	F
	Pollution	F	F	F	C, F	F	F	F	F
	Competition from Other Species	D, F	C, F	C, F	C, F	C, F	C, F	F	C, F
	Inappropriate Vegetation Treatments	F, N	C, F	C, F, N	C, F, N	F	C, F, N	C, F	C, F, N
	Soil Erosion		C	C	C			C	C, D

B. Habitat – Risk of Permanent Loss

Problem Definition

There is no other issue more fundamental to the long-term preservation of GUSG than protection of the sagebrush and other habitats on which they depend. The decline in distribution and abundance of GUSG is due largely to conversion of native habitats to crop production, reservoirs, or developments. Oyler-McCance et al. (2001) compared low-level aerial photographs from the 1950's and 1990's and concluded 20% of sagebrush-dominated areas in southwestern Colorado had been lost in that time frame. They noted much of the sagebrush habitat outside the Gunnison Basin had been converted to other uses before their earliest photos, and hence was not captured in the analysis. They also found 37% of their study plots had experienced substantial fragmentation of sagebrush, and concluded if current trends in habitat loss continued, GUSG could become extinct. Type conversion or development results directly in loss of habitat, degradation of remaining habitat from fragmentation, as well as indirect impacts from associated factors (e.g., roads, fencing, powerlines, increased human activity), and may facilitate introduction of novel predators and noxious weeds.

Riebsame et al. (1996) described a changing pattern in residential development in Colorado which began in the 1970's and continues today: a significant amount of home building now occurs in subdivisions and large lots far from existing townsites. Exurban development for primary population growth and for second homes has been a significant cause of loss of sagebrush habitats. Theobald et al. (1996) described trends in exurban development in the East River Valley in Gunnison County from 1964 to 1994. They documented an increase in total road length from 114 to 183 miles over this period, and an increase in building numbers (216 to 552). Nearly 90% of the buildings were located in low-elevation meadow, grassland, and sagebrush cover types.

Regulatory and Other Relief

Protection of habitats from permanent loss on publicly owned and managed lands seems straightforward, but protection of habitat quality from other land uses such as grazing, energy development, and recreation may be needed. Protection of habitat from permanent loss on private land is much more problematic. Authority for regulating land use on non-federal lands was delegated to the 63 counties in Colorado in 1974. All units of local governments including counties, cities, and towns were given authority to regulate land use within their jurisdictions (C.R.S. 29-20-101).

In Colorado, the CDOW is required by statute (C.R.S. 106-7-104) to provide counties with information on "significant wildlife habitat", and provide technical assistance in establishing guidelines for designating and administering such areas, if asked. Counties may, but are not required to, protect land from activities that would cause immediate or foreseeable material danger to significant wildlife habitat, or endanger a wildlife species.

Normally conversion of land zoned as agricultural from one agricultural use, such as native pasture containing sagebrush to another use, such as cropland, would not come before a county zoning commission, so typically habitat loss of that nature is not regulated. State statute exempts parcels of land of 35 acres or more per home from regulation, so county zoning laws can only restrict developments with housing densities greater than 1 per 35 acres (C.R.S. 30-28-101).

A recent change in Gunnison County's land use code exempts from regulation as subdivisions parcels with 2 houses per 35 acres or larger. This right to build a house or cabin (or 2 in Gunnison County) on parcels of 35 acres or larger means regulatory measures alone will never guarantee protection of important habitat from development. Where such development is a likely threat, other protections such as easements or fee-title acquisition of important habitats will be necessary. Maintaining sustainable rural economies (where traditional land uses compatible with sage-grouse are profitable) can significantly reduce threats associated with subdivisions.

Private property owners have a right to develop their land. Those that develop early may gain little reward compared to those who wait for land values to inflate. Ironically, those who are most reluctant to develop may suffer the most harm if a species becomes listed and the regulatory provisions of the ESA are enforced. Long-term and community-based planning to direct growth and development to appropriate areas, along with compensations for restrictions on developments in important areas are the most efficient way to accomplish conservation.

Risk Assessment of Habitat Loss Among Populations

We employed a variety of methods to assess the relative extent of risk of permanent habitat loss to aid in identifying the need for, and to aid in prioritizing, conservation measures among populations. As discussed above, major factors causing permanent habitat loss within GUSG range include human population increases (and resultant housing developments and associated infrastructure such as roads, fences, and powerlines), conversion to agriculture, and development of energy resources such as oil and gas extraction of mining. We used U.S. Census Bureau data to examine projected human population increases. We also identified acres enrolled in the CRP as potentially at risk. Sage-grouse in some populations use these fields seasonally to some extent, but if fields are not re-enrolled, or the program does not continue, this would very likely represent a permanent habitat loss to these populations. Risk of habitat loss from extraction of oil and gas resources was evaluated using BLM relative rankings of potential oil and gas reserves (none, low, medium, or high potential; Fig. 25, pg. 130).

The United States Census Bureau projected population growth between 2000 and 2020 for each county in the United States, accessible through the Colorado Department of Local Affairs website (Colorado Department of Local Affairs 2004). They also projected the increase in housing units that would be expected from this population increase based on a 10-year average of residents per housing unit. These increases are shown in Table 21 for each population of GUSG, based on the data for the county in which the population resides. It should be noted that county-wide projections may only serve as a crude index to permanent habitat loss for GUSG, since growth may be concentrated in urban areas away from currently occupied habitat. The current density of people is also provided, to scale the threat; i.e., a 50% increase in population may be more significant from a baseline of 50 people/mi^2 (rising to 75) than it is for a population of 2 people/mi^2 (rising to 3).

Table 21. Summary of threats that may cause permanent habitat loss, by population.

Population	Population Growth[1]	Growth in Housing Units[2]	People/ mi^2 (County)	Agricultural Conversion[3]	Energy Development Potential[4]	Acres in CRP[5]	Known Development Threats
Cerro Summit – Cimarron - Sims Mesa	68%	68%	25	-17%	Low - High	0	-
Crawford	51%	58%	24	-3%	Medium High	0	Elk Ranch subdivision
Dove Creek	32%	30%	2	-2%	High	26,485	2,700 acres (Secret Canyon subdivision – 9%)
Monticello, Utah	30%	54%	2	no data	High[6]	36,800	-
Gunnison Basin	25%	30%	5	-22%	None - Low	60	-
Piñon Mesa	40%	56%	55	-6%	None - Low	0	-
Poncha Pass	34%	31%	3	-10%	None	0	Some parcels for sale
San Miguel Basin	71%	62%	9	28%	High	3,358	-

[1] Based on Census Bureau projections for county population resides in, 2000-2020.
[2] Calculated by dividing population projections by the 10-year average of residents per housing unit.
[3] Indexed as percent change in total acres in cropland from 1987-1997.
[4] Based on BLM rankings of potential oil and gas reserves (see Fig. 25, pg. 130).
[5] Grassland habitats enrolled in the Conservation Reserve Program for 10-year periods, which are subject to conversion back to cropland.
[6] Monticello subpopulation received a "High" rating for potential energy development based on its proximity to the Dove Creek subpopulation, and because of the existence of active and inactive wells in or near the currently occupied population area (Fig. 25, pg. 130).

Montrose County was identified as one of the fastest growing counties in the country, with human population and associated housing units expected to increase 68% from 2000 to 2020 (Table 21). Although the greatest current density, and presumably future development, is in and near Montrose, growth is likely to impact private property currently used by GUSG in Cerro Summit - Cimarron - Sims Mesa, and potential linkages connecting the San Miguel population to Crawford (Table 21, and Fig. 29 on pg. 167).

Nearby Delta County (Crawford population) was also projected to increase greatly in population and housing density, with increases of 51 and 58%, respectively (Table 21). This may impact the relatively small amount of private land not already protected by easement in the currently occupied habitat within the Crawford population (~15% of currently occupied habitat), although most of this growth is likely to occur in and near the towns of Delta and Crawford.

The Dove Creek sub-population is in Dolores County, which had a low density of only 2 people/mi^2 in 2000 and is expected to grow by 32% by 2020 (Table 21). Presumably much of this growth will occur in Dove Creek and thus away from GUSG habitat, but "full build-out" of the Secret Canyon subdivision will result in significant permanent loss of some of the best habitat available to this population. Dolores County has over 26,000 acres enrolled in the CRP program, some of which is used seasonally by sage-grouse. San Juan County (Utah) has similar growth projections, although it has no platted subdivisions. San Juan County has 36,800 acres enrolled in CRP, of which about half is within occupied sage-grouse habitat.

Gunnison County had a relatively low population density (5 people/mi^2), with population and housing increases of 25 and 30%, respectively, projected to 2020. Presumably much of this increase will occur in the towns of Gunnison and Crested Butte, as opposed to sagebrush habitats used by sage-grouse.

Mesa County, which contains the Piñon Mesa population, had a relatively high population density of 55 people/mi^2, and high projected increases of 40% in population and 56% in housing units by 2020 (Table 21). Although these current and projected densities are heavily influenced by Grand Junction, the proximity of Piñon Mesa to Grand Junction suggests it could be influenced by this growth.

The Poncha Pass population resides in Saguache County, which had a low population density of 3 people/mi^2 and a projected increase of 34% by 2020, with a similar increase in housing units. This may underestimate risk to sage-grouse, because the scenic aspect of this portion of the San Luis Valley may concentrate development in and near occupied sage-grouse habitat. In addition, northern Saguache County is becoming somewhat of a bedroom community for people working in Salida, due to the high-cost housing in Chaffee County. This may accelerate development of housing on small tracts of land on the south side of Poncha Pass and increase traffic on Highway 285.

The San Miguel population occupies several areas in San Miguel County. Although San Miguel County had 9 people/mi^2 in 2000, most residents live in the town of Telluride or several smaller communities, including Norwood. This county has experienced a 28% increase in cropland between 1987 and 1997, which probably resulted in loss of sagebrush habitats, and which could continue to some degree. The population in San Miguel County is expected to increase markedly by 2020 (71% increase in people and 62% in housing units).

Conversion to Agriculture Uses

Assessing risk of permanent loss of sagebrush habitats from conversion to land uses other than urban or exurban development is difficult since models of this type of loss have not been developed. Fortunately, the available evidence suggests conversion to agricultural uses has largely ceased. Acreage in cropland actually declined in Delta (3% decline), Dolores (2%), Gunnison (22%), Mesa (6%), Montrose (17%), and Saguache (10%) Counties from 1992-1997 (Colorado Agricultural Statistics). Acreage in cropland increased by 28% during this period in San Miguel County, although it is not clear whether this increase was caused by conversion of sagebrush. Acreage in pastureland also decreased in Dolores, Gunnison, Mesa, San Miguel, and Montrose Counties, by 7, 20, 6, 13, and 21%, respectively, from 1992-1997. Pastureland increased in Delta County by 7% and Saguache County by 1% during this period.

Spatially Explicit Analysis of Impacts of Additional Housing Units

We used 2 methods to further assess the risk of additional housing development in GUSG habitat. The intent of this analysis is to identify areas where risk of housing development is important, to aid agencies and work groups in habitat protection efforts. Details of the analysis are provided in Appendix F.

Dr. David Theobald, Natural Resource Ecology Lab, Colorado State University, developed a Spatially Explicit Regional Growth Model (SERGoM v1), designed to depict the location and density of current and projected future private land housing units across the coterminous U.S. Although the current model has not yet been published (Theobald, in review), the general procedure and rationale for a previous version of the model are described in Theobald (2003). Future growth in housing units was based on Census Bureau county-level projections for population growth. The number of housing units this growth was apportioned to was determined using the county-level average of people/household, taken from 2000 census data. Growth in housing units was allocated spatially using a formula that considered recent (1990-2000) housing growth rates for a specific location and accessibility to the nearest urban core. Assumptions of this approach are that: (1) future growth patterns will be similar to those found in the past decade; (2) people/household in the future will match that in the 2000 census data; (3) future growth is likely to occur nearby current high growth areas or "hot spots"; (4) housing units cannot occur on public land, water areas, etc.; (5) growth will be concentrated in areas closer (in terms of travel time, not just distance) to urban core areas over major roads; and (6) housing density will not decline over time (housing growth projections are additive to current housing densities).

We applied Dr. Theobald's model and resultant predicted housing density dataset in a GIS analysis to evaluate the potential acreage impacted by development in 2020 for each population of GUSG (for detailed report, see Appendix F). We are not aware of any published work that indicates what level of housing development impacts or eliminates sage-grouse use of habitat. In this initial analysis we chose 320 acres/housing unit as the threshold below which we expect impacts, and above which we do not. This estimate was used with the following rationale: (1) over 38,500 acres within 1.86 miles of leks in the Gunnison Basin have more than 1 housing unit/320 acres now (2000), yet grouse use has continued; (2) only 4 of 41 active leks have no housing units within 1.86 miles; and (3) 35 of 41 active leks have at least some area with housing densities greater than 1 unit/320 acres. This threshold was chosen keeping in mind the large amount of public (and therefore protected) habitat in the Gunnsion Basin. We do not suggest that if the large block of public land were developed at this density (1 housing unit/320 acres) that grouse would not be impacted.

The modeled housing density in 2000 is shown in Fig. 26, while projected housing densities (without intervention) in 2020 are shown in Fig. 27 (note that white areas are the protected lands; i.e., public). Areas of growth in housing are identified in Fig. 28. Numerical estimates of acreage in each housing class modeled for 2000, projected to 2020, and increases from 2000 to 2020 by housing density class are shown for the smaller populations (Table 1, Appendix F) and for the Gunnison Basin (Table 2, Appendix F). The challenge in wisely allocating habitat protection dollars is to protect important areas where development will occur at a density that precludes use by sage-grouse, or will significantly impact grouse. At the same time there is little point in allocating resources to areas already impacted so as to preclude grouse use, or to areas where housing densities will be so low as to have negligible impact to grouse. Consequently, we identified areas and acreages projected to increase from housing densities of 1 unit per 320 acres or larger to 1 unit per 320 acres or less. Our results indicate, for the most part, that housing outside of urban areas progresses through housing density classes, therefore the key areas are those that move from 1 unit per 320 acres or more to 1 unit per 160-320 acres, although occasionally densities may jump to the 80-160 acre/housing unit class.

The model predicting development to unsuitable housing densities seemed to perform poorly (underestimated development) outside the Gunnison Basin, where second home development or proximity to population centers or high growth areas such as Grand Junction, Montrose, or Telluride may trump local demographic growth as causes of development. In some cases, the model suggested little or no future development in areas already platted with lots marketed for sale. Clearly, we have a long-term need to develop better predictive models which take these factors into account (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223, Objective 1, Strategy 9). In the interim, we used another approach to identify habitats at greatest risk of development in the next 3-5 years. Typically, land is subdivided into smaller parcels prior to sale and development. It is these smaller (<80 acres) parcels that are probably most immediately susceptible to development to densities that would negatively impact grouse. Larger parcels may be subdivided, but this process will occur over a longer time horizon, allowing time to respond. We mapped private land parcels by parcel size categories for each population (excluding Gunnison Basin; see figures in Appendix F) as a tool to help agencies, work groups, and land trusts in assessing development risk and prioritizing habitat protection efforts for GUSG (see Appendix F). We present an analysis of future development by population using both methods of assessing risk.

Fig. 26 Modeled housing densities for unprotected lands, 2000.

Fig. 27 Projected housing densities for unprotected lands, 2020.

Fig. 28. Areas of growth from modeled year 2000 to 2020, for areas less than 320 acres per unit, on unprotected lands.

Prioritization of Habitat Protection Efforts

We incorporated the information from Table 21 and the analyses of risk of permanent habitat loss from housing development (see Appendix F) into an assessment of the relative importance of each population to the overall conservation of GUSG. We also examined the relative amount of acreage these threats applied to (private property not already protected by easement) to develop a priority ranking for habitat protection (Table 22). This priority ranking is not absolute; individual properties in populations with a medium priority may have greater importance than individual properties in higher ranking populations. Also, state boundaries, administrative boundaries, and other factors influence rankings at those levels. Rankings are relative to one another; a medium ranking is not meant to imply that habitat protection is not important in that population. Rather, habitat loss is likely to be less of an immediate threat in a population with a medium ranking than in a population with a high ranking. This table and the rankings within are intended as a guide to assist agencies in planning, and ultimately in maximizing the efficiency of habitat protection efforts.

Table 22. Relative conservation importance, threat of permanent habitat loss, area subject to threat, and assessment of priority ranking for protection of habitat among populations of GUSG.

Population	**Conservation Importance**	**Threat of Habitat Loss from Housing Development**	**Private Land, Not Protected, acres (%)**	**Protection Priority**
Cerro Summit - Cimarron – Sims Mesa	Uncertain	High	25,709 (69%)	Medium
Crawford	High	Medium	5,283 (15%)	Medium
Dove Creek	High	High	23,237 (82%)	Medium-high
Monticello, Utah	High (portions)	Low	53,178 (89%)	Medium-high
Gunnison Basin	Very High	Medium	156,055 (26%)	High
Piñon Mesa	High	High	20,052 (52%)	High
Poncha Pass	Low	Medium	4,900 (24%)	Low-medium
San Miguel Basin	High	High (portions)	52,522 (52%)	Very high

It is apparent from this analysis that the threats that could cause permanent or long-term habitat loss for GUSG are substantial, yet vary widely across populations. Substantial public ownership in Crawford, the Gunnison Basin, Poncha Pass and portions of the San Miguel Basin will help mitigate some of these threats, as will no-development easements held by CDOW, UDWR, NRCS, and non-governmental organizations (NGO's). Conversely, substantial portions of the Dove Creek - Monticello, Piñon Mesa, Cerro Summit – Cimarron – Sims Mesa, and some portions of the San Miguel Basin areas are privately owned and are located in areas where significant population growth is expected. Some increase in housing and other development can probably be accommodated in these areas without significantly impacting GUSG, but we hypothesize that densities much in excess of 1 housing unit/320 acres will cause GUSG populations to decline. Greatest impacts are likely when seasonal habitats most important to GUSG, such as areas used during moderate to severe winters, or lek/nesting/brood-rearing areas, are lost. This distinction is probably lost in small populations where, because of small size and existing or potential fragmentation, any loss of habitat may negatively impact grouse.

Any attempt at prioritizing the importance of populations for protection purposes is likely to be polarizing, yet it is necessary to ensure that scarce resources accomplish the greatest good towards the protection of the species. We attempted to incorporate the relative conservation importance of the population (based largely on population size and hence, viability), current population and housing density, projected increase in population and housing density to 2020, amount of land already protected by virtue of public ownership or easement, energy development potential, and known subdivisions to categorize priority for protection from permanent loss.

The San Miguel Basin rated the highest (very high) in terms of protection priority, by virtue of high conservation importance, high projected growth, high energy development potential, and large amounts of private land, not otherwise protected (52%; Table 22). This population appears to at least minimally serve to genetically connect several of the other populations.

The Gunnison Basin and Piñon Mesa rated high in terms of protection priority, for different reasons. The Gunnison Basin has a large amount of public land, but some very important habitat areas are on private land and subject to development. Current human densities are relatively low, and future population increases are low relative to other populations, but the extreme conservation importance of this population suggests any loss of important habitat must be prevented or mitigated. Over half the area of Piñon Mesa is privately owned, and current and future housing densities are projected to be much higher than Gunnison. These threats, and the size of this sage-grouse population warrant a high protection priority.

The Dove Creek - Monticello population ranked medium-high in priority. Its conservation importance is high because of past and potential future population size, but threats in general are not as immediate as in some other populations. If energy development increases in this area, priority for this population may increase. Relatively low current human densities, and low growth rates, predominately concentrated in urban areas, suggest housing development threats are lower than other areas. The major exception to this is the Secret Canyon subdivision on the Dove Creek side, a 2,700-acre area already platted into ranchette lots, with some already developed. Lack of water and power are presently restricting development, but this should be seen as an opportunity for acquiring or protecting key parcels and not as a long-term impediment to development.

Crawford has high conservation importance, but is largely (85%) publicly owned or protected, which makes it less of a priority (medium) for protection than other populations. This doesn't mean remaining key parcels should not be considered.

Cerro Summit – Cimarron – Sims Mesa, or at least some of this area, is facing significant growth and development potential. The uncertain status of this population in terms of size, viability, and connectivity to other populations makes it relatively lower in priority for protection (medium) than other populations. This ranking should be revisited if additional research indicates a significant change in status.

Finally, Poncha Pass was given a low-medium ranking. Its small area and small population size preclude it from having a high conservation importance, and although there is some threat of development, it is not as high as in other areas. Opportunities to protect the remaining 4,900 acres not already publicly owned should be pursued opportunistically, particularly when parcels in higher ranking populations are not available.

C. Habitat Linkages Among GUSG Populations

Theory and Background

Using corridors to link isolated populations is often proposed as a conservation strategy for species in fragmented landscapes (Mann and Plummer 1995, Meffe and Carroll 1997, Rosenberg et al. 1997). It is assumed the linkage will increase movement between populations and will decrease the probability of extinction of the species by stabilizing population dynamics (i.e., reducing the threat of demographic stochasticity) and reducing the threat of inbreeding depression. However, studies have been unable to demonstrate that individuals actually use corridors, much less whether corridors influence the demographic parameters that increase the probability of survival of the species (Simberloff and Cox 1987, Hobbs 1992, Beier and Noss 1998).

Habitat linkages do not necessarily mean corridors. Corridors are defined as narrow, linear strips of habitat typically used by a species that connect larger blocks of habitat and are surrounded by unsuitable (unused) habitat (Turner et al. 2001). We have defined linkages as a heterogeneous landscape, within the historical range of GUSG, composed of isolated patches of landcover types frequently used by sage-grouse (for a list of landcover types see Tables 23 [pg. 165] and 24 [pg. 166]). Habitat within linkages is composed of a mosaic of contrasting land forms, landcover types, and land uses.

The effectiveness of a potential linkage will depend on the ability of GUSG to move among the isolated patches in a landscape; i.e., the relative "connectivity" of patches in a landscape (Taylor et al. 1993). The ability of sage-grouse to disperse may be influenced by the landscape composition (how much of the suitable landcover types are present in the landscape), configuration (the size and shape) of the patches, distance between patches in the landscape (Dunning et al. 1992), as well as the physical nature (land forms) of the landscape that can either facilitate or impede dispersal (Henein and Merriam 1990). These factors are not completely independent. Increased habitat composition is typically correlated with increased patch size and decreased distance between patches. The effectiveness of a potential linkage will also depend on the quality of habitat in the isolated patches and the relative ability of sage-grouse to use (or move through) the surrounding unsuitable habitat. The effectiveness of linkages may also depend on predator behavior. The linear nature of corridors or the fragmented patches of habitat in a linkage may lead to greater predator foraging efficiency (Phillips et al. 2003).

Methods are available for quantifying landscape composition and configuration (Turner 1989, Turner et al. 1991, McGarigal and Marks 1995) and connectivity (Fahrig and Paloheimo 1988a, 1988b, Heinen and Merriam 1990). There are very few empirical data on the connectivity of landscapes for a given species; however, the idea has led to the development of increasingly complex percolation (or diffusion) models (Czaran 1998). These models involve generating 2-dimensional grids ("landscapes"). Each cell of the grid is assigned a particular landcover type (most models use only 2 landcover types: “used” and “not used”). The arrangement of the cells within the grid is manipulated to represent varying degrees of patch size, shape and distribution. By varying movement capabilities (dispersal distance), the models can be used to analyze the ability of a hypothetical animal to move ("percolate") across the grid. These models have shown that changes in landscape composition, patch size, distance between patches, corridor length and width can affect species dispersal, abundance and probability of extinction (Fahrig 1997, 2001, 2002, Haddad 1999, With 2002). These models have also illustrated thresholds in habitat fragmentation that affect a species' ability to move through landscapes (With and Crist 1995, With 2002) and the species' probability of extinction (Fahrig 2001, 2002). In these models, increasing fragmentation has little effect on movement and species persistence until a critical threshold of fragmentation impedes the ability of individuals to disperse and survive (i.e., the distances between patches become too large and the amount of habitat in the landscape becomes too small).

While percolation models are instructive, the question remains whether our proposed linkages contain the appropriate habitat to be effective avenues for movement between populations by sage-grouse. Seasonal movement and dispersal patterns of GUSG are not known well enough to be able to predict whether the birds will use linkages, or if they do, what composition and configuration of landcover types within the linkage will best facilitate movement and keep confounding factors (such as predation) to a minimum. Our GIS analysis has identified extensive potential areas for linkages between current populations (see "Mapping Potential GUSG Habitat Linkages" below), but the quality of the landcover types, relative to movement requirements, remains unknown. It is also not certain that sage-grouse will restrict dispersal movements to landcover types frequently used during seasonal movements, or if they will use atypical sage-grouse habitats (e.g., agricultural lands and right-of-ways). Furthermore, it is not clear what the effect of current population distributions will have on the probability of individuals using linkages. Individuals from small populations may be less likely to disperse across linkages (i.e., behave more like a non-migratory population) than individuals from larger populations that may already exhibit migratory behaviors. Understanding the effect of landscape structure on dispersal patterns of GUSG is a critical step toward evaluating the effectiveness of the proposed population linkages.

<u>Mapping Potential GUSG Habitat Linkages</u>

We used GIS data to describe potential habitat linkages among populations in Colorado and Utah. Data used for Colorado were recently available through the CVCP (Colorado Division of Wildlife 2004b). In this data set, vegetation layers were derived from 30-m Landsat TM satellite imagery. For Utah we used the vegetation layer from the Utah Gap Analysis (also from 30-m Landsat TM satellite imagery; Edwards et al. 1995). Soils data layers would have been beneficial in the delineation, but these data are not available in digital format in all areas.

We selected vegetation classes that contain current sagebrush communities, as well as those classes that may have contained sagebrush communities historically (e.g., piñon-juniper - sagebrush mix). Linkages are comprised of a non-contiguous and patchy mix of the classes (Tables 23 and 24).

Table 23. Vegetation classes from the Colorado Vegetation Classification Project used to identify GUSG habitat linkages in Colorado (Colorado Division of Wildlife 2004b).

Class Name	Class Description
Rangeland	Consists of grass/forb range, shrub/brush range, or mixed range.
Shrub/Brush Rangeland	Consists primarily of sagebrush, saltbrush, greasewood, and snakeweed.
Bitterbrush Community	Shrubland principally dominated by bitterbrush. Often associated with rabbitbrush, sagebrush, greasewood, various grasses, and mixed cacti.
Salt Desert Shrub Community	Low-elevation shrublands found on alluvial salt fans or flats. Component species may include: saltbushes, greasewood, sagebrushes, horsebrushes, and spiny hopsage.
Sagebrush/Grass Mix	Codominant sagebrush shrubland and perennial grassland.
Sagebrush Community	Sagebrush with rabbitbrush, bitterbrush.
Sagebrush/Gambel Oak Mix	Shrubland codominated by big sagebrush and Gambel oak.
Mesic Mountain Shrub Mix	Oak dominant with sagebrush, snowberry, grass.
Snowberry/Shrub Mix	Mountain deciduous shrubland dominated by mountain snowberry. Often associated with Saskatoon serviceberry, sagebrush, squawbush, rabbitbrush and Gambel oak.
Sagebrush/Greasewood	Shrubland co-dominated by sagebrush and greasewood. Secondary species may include rabbitbrush.
Shrub/Grass Forb Mix	Mixed grass/forb and shrub/grass rangeland.
Sagebrush/Mesic Mountain Shrub	Co-dominant sagebrush mesic mountain shrubland consisting of mountain big sagebrush and any combination of mountain snowberry, service berry, squaw apple or bitterbrush often with a grass/forb understory. Understory species may include, among others, elk sedge, bluegrass, needlegrass, arrowleaf balsamroot, lupines, penstemons, Indian paintbrush, and mariposa lily. Often found at the higher elevations of the sagebrush zone, on north facing slopes, in basins, or on other mesic sites.
Sagebrush/Rabbitbrush Mix	Co-dominant sagebrush and rabbitbrush shrubland. Principal shrub species include basin big sagebrush, Wyoming big sagebrush, rubber rabbitbrush, sticky rabbitbrush, or small rabbitbrush.
Xeric Mountain Shrub Mix	Deciduous woodland (or tall shrubland) dominated by mountain mahogany or curlleaf mountain mahogany. Associated species may include sagebrush, rabbitbrush, Mormon tea, or scattered piñon pine or Utah juniper.
Serviceberry/Shrub Mix	Deciduous woodland (or tall shrubland) dominated by Utah and Saskatoon serviceberry. Primary associated shrub species include big sagebrush, mountain snowberry, and Gambel oak.
Piñon-Juniper-Sagebrush Mix	Co-dominant piñon-juniper and sagebrush.
Piñon-Juniper--Mountain Shrub Mix	Co-dominant piñon -juniper and oak, mountain mahogany or other deciduous shrubs.
Juniper/Mountain Shrub Mix	Co-dominant juniper species and oak, mountain mahogany, or other deciduous shrubs.
Juniper/Sagebrush Mix	Co-dominant woodland and shrubland. Woodland consists of Utah juniper at densities around 25%. Big sagebrush grows in the interspaces between the trees and may comprise 25% cover or more.

Table 24. Vegetation classes from the Utah Gap Vegetation Layer used to identify GUSG habitat linkages in Utah (Edwards et al. 1995).

Class Name	**Class Description**
Sagebrush/Perennial Grass	Co-dominant sagebrush shrubland and perennial grassland. Principle shrub species include sagebrush. Principle grass species include bluebunch wheatgrass, sandburg bluegrass, crested wheatgrass, needlegrass, sand dropseed, blue grama, Thurber's needlegrass, western wheatgrass, Indian ricegrass, and galleta. Associated principal shrub species include rabbitbrush, bitterbrush and oak. Associated principal grass species include cheatgrass.
Sagebrush	Shrubland principally dominated by big sagebrush, black sagebrush, low sagebrush or silver sagebrush. Primary associated tree species include juniper, piñon, mountain mahogany and ponderosa pine. Primary associated shrub species include rabbitbrush, snakeweed, winterfat, shadscale, and bitterbrush.
Grassland	Perennial and annual grasslands. Principle perennial grass species include bluebunch wheatgrass, sandburg bluegrass, crested wheatgrass, basin wildrye, galleta, needlegrass, sand dropseed, blue grama, Thurber's needlegrass, western wheatgrass, squirreltail, and Indian ricegrass. Principle annual grass species include cheatgrass. Primary associated shrub species include sagebrush, shadscale, greasewood, and creosote. Primary associated tree species include juniper.
Agriculture	Row crops, irrigated pasture and hay fields, dry farm crops.*

* The vegetation classification in Utah does not distinguish between agricultural and CRP lands. CRP lands are used by sage-grouse as brood areas, hence the agriculture class is included in Utah for this analysis.

Potential linkages were added to existing mapped areas that include occupied, potential, and vacant/unknown habitats (Fig. 29). Hence, a habitat identified as a linkage may not in and of itself link existing occupied habitat polygons, but the combination of linkage, vacant/unknown, and potential habitats will link occupied habitat polygons. These linkages should be considered only as potential areas.

Fig. 29. Potential linkages in GUSG habitat.

D. Population Viability Analysis

Concepts and Principles

Population viability analysis (PVA) is a risk analysis tool that has been used for about 20 years by conservationists and biologists to predict the relative probability of extinction for a wildlife population under various management scenarios, in order to aid in decision-making for population management (Shaffer 1991, Boyce 1993, McCarthy et al. 2001, Reed et al. 2002). In most cases, PVA uses available population information to develop a model (a simplified representation of a real system) that simulates how the population functions (Shaffer 1991, Boyce 1993). The model can then be used to project various future scenarios and predict resulting outcomes for the population. The model may incorporate many factors that affect the status of a population, such as environmental stochasticity (e.g., normal variation in weather and available food supply), demographic stochasticity (e.g., breeding success, survival), catastrophes (e.g., drought, disease), genetic stochasticity (e.g., inbreeding, genetic drift), and interaction among these factors (Gilpin and Soulé 1986, Shaffer 1991). These factors enter the life of an individual as events that occur with particular probabilities, rather than with absolute certainty, at any given time (see Appendix G).

An individual with extensive knowledge of a population may have a "mental model" of how the population behaves, but this information is difficult to share with others and cannot be assessed objectively or quantitatively. Computer simulations are regularly used in PVA to allow for complex models that are explicitly stated and can be tested (Shaffer 1991, Appendix G).

PVA is particularly effective in making "relative" predictions, such as how a population or species may be affected by various alternative management strategies, or the relative risk to different populations, allowing managers to prioritize conservation efforts among the populations (Beissinger and Westphal 1998, Boyce 2001, Ellner et al. 2002, McCarthy et al. 2003). Another strength of PVA is the complexity that it can accommodate; multiple factors and their interactions can be integrated into the process of evaluating a population's relative extinction risk (Shaffer 1991, McCarthy et al. 2003). In addition, sensitivity analysis can identify the parameters in the model (e.g., adult survival rate) that have the largest impacts on the modeled population (Reed et al. 2002). PVA results can be used to identify future research needs by exposing the parameters for which data are weakest or lacking (Reed et al. 2002), which is particularly important if sensitivity analysis shows those parameters are key to the population's persistence.

One of the criticisms of PVA is that the increasing availability of user-friendly PVA software allows some users to generate population persistence predictions without a full understanding of assumptions and limitations in the model, and while ignoring weaknesses in data supporting the model (Beissinger and Westphal 1998, Boyce 2001, Reed et al. 2002). "Absolute" predictions, such as a precise probability of population extinction, are not realistic, but relative predictions are more reliable (Beissinger and Westphal 1998, Ellner et al. 2002, McCarthy et al. 2003). Because a PVA uses a model, it will not present a complete picture of the system of interest, but an approximation of it, and results must be used with this in mind (Reed et al. 2002, McCarthy et al. 2003). PVA will likely be based in part on inadequate data (Beissinger and Westphal 1998, Boyce 2001), especially because data for populations at risk may be limited (Shaffer 1991, Boyce 1993) and the populations may be difficult to study. However, if the limitations are recognized, a PVA can offer an opportunity to direct future research towards obtaining more reliable data, more precise estimates of population parameters, to modify the model to improve its performance, and to frame testable hypotheses about how the population/system functions (Boyce 1993, Beissinger and Westphal 1998, Reed et al. 1998, McCarthy et al. 2003). McCarthy et al. (2003:987) concluded that, "The process of parameter estimation, model construction, prediction, and assessment should be viewed as a cycle rather than a one-way street."

Current Model

Thus, as with many analytical tools, PVA can be very useful in the decision-making process for managing species at risk, but only if used properly (Boyce 1993, Beissinger and Westphal 1998, Ellner et al. 2002, McCarthy et al. 2003). We contracted with the Conservation Breeding Specialist Group (CBSG) to develop a PVA for GUSG (see full report in Appendix G). Dr. Philip Miller of CBSG used a simulation software program called *VORTEX* (Miller and Lacy 2003b) to estimate relative extinction probabilities and loss of genetic diversity over time for various population sizes, and to determine the sensitivity of GUSG population growth rates to various demographic parameters.

VORTEX is a Monte Carlo model that simulates the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. It is an individual – based model that follows the fate of each animal in a theoretical population as the individual encounters various life and environmental events during a given year. These events occur with a user-specified probability, and the model will run for a user-specified number of consecutive years. By following the entire population, it is possible to estimate relative population extinction risk and loss of genetic diversity in a specified time period.

Baseline Parameters and Simulations

Demographic parameters used in the GUSG PVA included type of breeding system, age at first reproduction, several measures of reproductive success, sex ratio, mortality rates, and environmental carrying capacity. We also incorporated a severe drought frequency of a single event (which persists for 3 years) each 100 years, and estimated an increase in chick mortality over the 3-year drought period. For each parameter, we used available data, prioritized as follows: (1) GUSG data; if not available, then (2) GRSG data from Colorado and Utah; if not available, then (3) GRSG data from other locations (see Appendix G for specific data sources used). These are 2 closely related grouse species and we do not expect demographic parameters to vary greatly between these species. Some recruitment data collected by CDOW in 2002 are specific to GUSG. These data were collected during a period of severe prolonged drought and resultant population decline, so any results obtained from these data must be interpreted accordingly. We chose a time interval of 50 years for population projections because we felt uncertainty at 100 years was too great to allow reasonable predictions.

Parameters that we did not incorporate in the PVA included density-dependent reproduction, effects of disease, inbreeding depression, and habitat loss or fragmentation. We have no data to determine which or how demographic rates will be affected by these factors. West Nile virus is a potential threat to GUSG (see "Disease and Parasites", pg. 103). However, our lack of knowledge about the disease precludes us from being able to make reasonable predictions at this time. West Nile virus should be included in future analyses as we learn more about the epidemiology of the virus. Inbreeding depression can potentially influence population parameters in small populations (see "Genetics", pg. 109); however, we currently have no data to evaluate whether inbreeding is a significant factor or whether there is a population size threshold at which inbreeding becomes significant (i.e., which GUSG populations might be at risk because of inbreeding). We have no data to determine which or how demographic rates will be affected by habitat loss or fragmentation. Without this information, the only alternative in the VORTEX software is to truncate the carrying capacity used in the simulations (see Appendix G, pg. G-26). We have no information that allows us to conclude GUSG (or GRSG) demography is density dependent, or to even estimate what the effect might be on GUSG population dynamics. We used the GUSG PVA to evaluate the relative risk of extinction for each population under the current conditions (i.e., the risk of extinction if nothing changes). It is the aim of this plan to minimize additional habitat loss. Therefore, we concluded that a valid GUSG PVA should not include these potential factors until we have some reliable data that can be used to estimate how specific demographic parameters are influenced by the various factors.

Baseline simulations using recent demographic data showed long-term (50 years) growth rates ranging from –5% to 15%, depending on the data sets used to estimate different parameters. This baseline model analysis is instructive in that it provides plausible upper and lower bounds on population growth that are reasonable in the shorter-term (i.e., on the order of 5-10 years).

Relative Extinction Risk

This stage of analysis investigated the relationship between the sizes of GUSG populations and their relative probability of extinction, based on a range of potential intrinsic rates of population growth. Because of the inherent uncertainty in understanding current trends in GUSG population size, we elected to develop the risk analysis under multiple scenarios that differed in their underlying growth rates. This should provide insight into the future potential dynamics of dispersed populations that may be assumed to be growing or declining at rates within the scope of this analysis. We are thereby developing a sort of "template" upon which the future of a given population may be evaluated under presumed conditions of growth and size.

There were a total of 99 separate models (11 long-term growth rates ranging from -4% to 15%, and 11 initial population sizes ranging from 20 to 3,000; Fig. 30; see Table 6 in Appendix G, pg. G-20). Results suggest that very small GUSG populations (< 25) are at a high risk of extinction during a 50-year period, even when the population is expected to increase in size over the long-term. In contrast, individual GUSG populations can be considered "secure" (< 5% extinction probability) if they contain 500 birds or more and have a stable population size (Fig. 30).

Based on this analysis, an attempt was made to fit an equation to the relative extinction risk data at a long-term average growth rate of zero so that an estimate of extinction risk could be obtained for any desired population size. A slightly modified dose-response curve, used primarily in the biomedical community, was used as it seemed an appropriate descriptor of the relationship between population size and relative extinction risk (see Appendix G). The fit of this equation for our data was excellent.

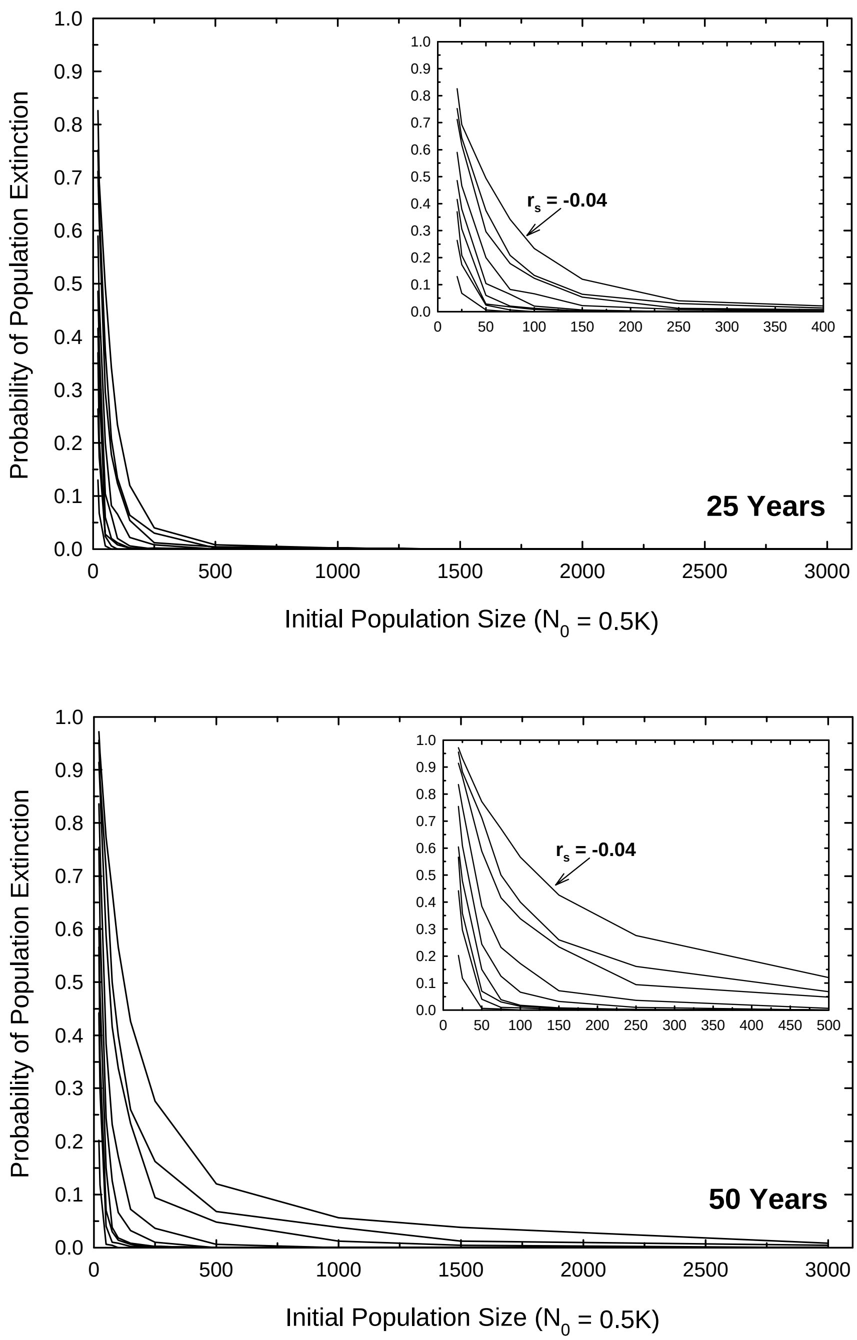


Fig. 30. GUSG population risk analysis. Plots show relative risk of extinction after 25 years (top panel) and 50 years (bottom panel) for simulated populations with specific long-term expected annual stochastic growth rates ranging from -0.04 (towards the top-right portion of each primary panel) to 0.15 (towards the bottom-left portion of each primary panel). For a given initial population size, higher growth rates lead to lower risks of extinction. Smaller inset panels magnify the results for smaller initial population sizes.

Sensitivity Analysis

One of the advantages of a detailed, individually-based population model is that demographic parameters can be varied one at a time across the normal range of variation while holding all others constant to see which have the greatest impact on population growth. An analysis of the sensitivity of population growth rates to variation in various demographic rates (e.g., nest success, adult survival, chick survival) can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identified biologically plausible minimum and maximum values for each of a subset of demographic parameters (Fig. 31). For each of these parameters, we constructed 2 simulations, with a given parameter set at its prescribed minimum or maximum value, and all other parameters remaining at their baseline value. The performance of these alternative models was then compared to that of our starting baseline model (in this case the model that relied most heavily on GUSG data). This analysis suggested that GUSG population dynamics are most sensitive to variation in adult female reproductive success and chick mortality.

The next step was to develop a set of models with the goal of identifying minimum levels of survival necessary to prevent GUSG population decline. A total of 60 individual models were constructed that provided all possible combinations of 2 levels of reproductive success, 5 levels of chick mortality, and 6 levels of adult mortality. This approach also more effectively addressed the relationship between reproductive success and age-specific mortality required for population growth (Fig. 32). Several conclusions can be drawn from the results of these models: (1) greater adult mortality results in less flexibility in allowable levels of chick mortality; (2) higher levels of reproductive success allow for higher levels of acceptable mortality; and (3) the models are more sensitive to chick than adult mortality. Note that this does not necessarily mean these parameters can be improved with management or that these are the parameters that put GUSG populations most at risk of extinction.

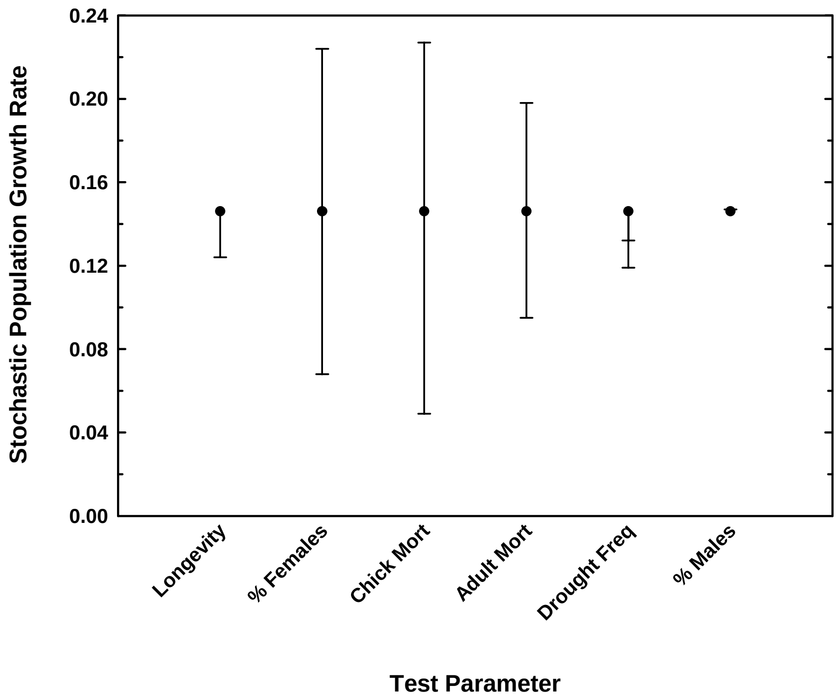


Fig. 31. Demographic sensitivity analysis of a simulated GUSG population. Stochastic population growth rate for a set of models in which the specific parameter is varied across a range of biologically plausible values. The baseline model growth rate of 0.146 is given by the central data point for each parameter. The general model of sage-grouse population dynamics is most sensitive to uncertainty in those parameters giving the widest range in simulated population growth rates.

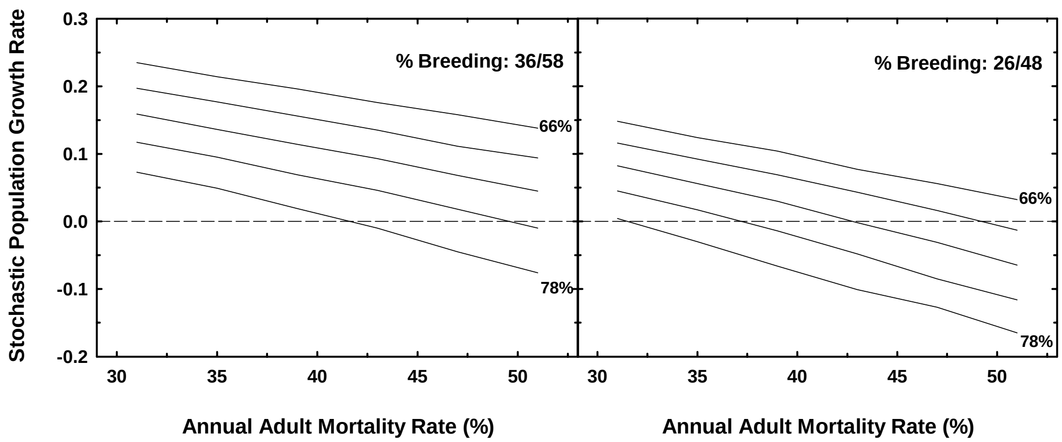


Fig. 32. Gunnison sage-grouse population mortality analysis. Plots give average population growth rate (*r*) as a function of annual mortality rate of adults with individual lines corresponding to different levels of chick mortality. Two panels correspond to variable levels of adult female reproductive success.

Maintenance of Genetic Diversity

The question of genetic diversity maintenance in GUSG populations of various sizes was also addressed. We ran a series of models with initial population sizes of 2,000, 2,500, and 3,000, with carrying capacity set at twice the initial size. The percent of adult males participating in breeding was set at 3 different levels: 10%, 20%, and 33%. Results show that from 90-94% of the genetic diversity can be maintained over 50 years using these parameters (see Table 8 in Appendix G, pg. G-24). Increasing population size from 2,000 to 3,000 birds does not markedly improve the maintenance of genetic diversity at any given proportion of males participating in breeding.

Population Augmentation and Relative Extinction Risk

Several GUSG populations are small enough that sequential drought years, disease, or extreme weather events could push numbers or genetic diversity below the level from which they can recover without population augmentation. In our PVA exercise we simulated the effect on relative extinction risk of adding additional birds to populations (ranging from 100 – 300 birds) when the populations declined, because of stochastic variation, by 50% of the initial population size.

We modeled infusions of 10–40 birds, and had the model make as many transplants as necessary (in a 50-year timeframe) to bring the population back above the 50% reduction trigger. Augmentations effectively reduced the populations' extinction probabilities to zero (Table 25). Genetic diversity retained after 50 years was increased by 21-64%, depending on initial population size, resulting in an overall genetic diversity retained through transplants of 66 – 82% (Table 25).

Under the assumptions used in this model, augmentation with releases of 10 birds were as successful at reducing extinction probability as augmentation with 40 birds, and nearly as successful in retaining genetic diversity (Table 25). Although the model augmented more often when fewer birds were transplanted (because the population stayed below the 50% trigger longer), the total number of birds released over the 50-year period was lowest when 10-bird releases were simulated. For example, for populations of 100 birds, using 10-bird releases resulted in an average of 6.7 releases and a total of 67 birds released over 50 years. For the same population size, 40-bird releases occurred 2.7 times, but the resulting total number of birds released was 108 (Table 25). Looking at any single release size, it took more releases (and hence more total birds) to keep larger populations above the 50% trigger than for smaller populations. This is simply because it takes more birds to increase a larger population by a certain proportion than to increase a smaller population by the same proportion.

We conducted a second augmentation scenario identical to the first except that the trigger for augmentation was a 75% decline from the initial population size. For any combination of release size and original population size, it took fewer releases to raise populations above the 75% (Table 26) than the 50% trigger (Table 25). However, the genetic diversity retained by a population that only had to stay above a 75% decline was lower than one that had to remain above the 50% trigger (Tables 25 and 26).

Table 25. Results of simulations augmenting populations of 100, 200 and 300 birds with 10-40 sage-grouse when populations declined by 50%[a]. Simulations resulted in an extinction probability of approximately 0.

Initial Population Size: 100 (transplant trigger = 50)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	6.7	67	0.657	108 (54)
20	4.4	88	0.666	116 (52)
30	3.4	102	0.690	119 (50)
40	2.7	108	0.675	124 (49)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.334			0.421	93 (63)

Initial Population Size: 200 (transplant trigger = 100)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	8.1	81	0.735	213 (110)
20	5.2	104	0.749	225 (106)
30	3.8	114	0.762	245 (105)
40	3.1	124	0.768	241 (99)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.132			0.563	183 (127)

Initial Population Size: 300 (transplant trigger = 150)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	8.6	86	0.794	313 (169)
20	5.6	112	0.809	341 (160)
30	4.9	147	0.819	364 (159)
40	4.0	160	0.820	359 (154)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.060			0.656	268 (191)

[a] Simulations were run for a 50-year time period. Growth rate was set at 0. Initial genetic diversity was assumed to be 1.0.

Table 26. Results of simulations augmenting populations of 100, 200 and 300 birds with 10-40 sage-grouse when populations declined by 75%. [a] Simulations resulted an extinction probability of approximately 0.

Initial Population Size: 100 (transplant trigger = 25)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	3.0	30	0.591	89 (57)
20	1.8	36	0.601	96 (57)
30	1.5	45	0.600	100 (57)
40	1.2	48	0.594	99 (55)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.334			0.421	93 (63)

Initial Population Size: 200 (transplant trigger = 50)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	2.9	29	0.685	184 (116)
20	2.2	44	0.688	187 (117)
30	1.6	48	0.681	197 (117)
40	1.1	44	0.693	206 (109)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.132			0.563	183 (127)

Initial Population Size: 300 (transplant trigger = 75)				
# Birds Transplanted Per Augmentation	Mean # Times Population Received Transplants	Mean # Birds Moved in 50 Years	Genetic Diversity	Mean Population Size (SD)
10	3.7	37	0.740	279 (184)
20	2.3	46	0.753	288 (173)
30	1.6	48	0.749	300 (176)
40	1.6	64	0.766	294 (171)
If no augmentation occurs:				
Probability of extinction within 50 years is 0.060			0.656	268 (191)

[a] Simulations were run for a 50-year time period. Growth rate was set at 0. Initial genetic diversity was assumed to be 1.0.

Under the simplistic modeling approach used by *VORTEX*, which does not factor in variability in survival rates of released birds, more frequent but smaller releases seem more effective. The potential for stochastic events to completely remove small numbers of released birds suggests releases of at least 20 birds may be warranted if triggers are hit, and perhaps larger for larger initial population sizes. Under the admittedly simplistic model *VORTEX* uses for augmentations, a trigger for beginning transplant efforts at a 75% reduction from the initial population size (or target) was as effective at reducing relative extinction risk and almost as effective at maintaining genetic diversity, yet required less than half as many transplant efforts and birds.

Conclusions

As mentioned earlier, PVA is a useful tool for evaluating relative extinction risks of various size populations, but not for predicting a precise risk of extinction for each GUSG population. We have explored the relative extinction risk and loss of genetic diversity in different population sizes, as well as the relative effects of different population augmentation scenarios. The PVA illustrates that (1) there is a low risk of extinction for the species range-wide (i.e., the risk of extinction for a stable population of 500 is less than 5% over a 50-year period); (2) there is a great deal of uncertainty in the risk of extinction in the small populations due to our lack of information on the demography of GUSG and the effects of habitat loss, fragmentation and disease on GUSG behavior and population trends; (3) 90-94% of the genetic diversity can be maintained over 50 years; and (4) augmentation of approximately 10 birds every 5 years into the smaller populations can significantly reduce their risk of extinction.

Even though the smaller GUSG populations have a relatively high probability of extinction, they are vital to the long-term success of GUSG. Multiple populations across a broad geographic area provide insurance against a catastrophic event threatening the entire species. In addition, the aggregate number of individuals across all populations increases the probability of demographic persistence and preservation of overall genetic diversity by providing an important genetic reservoir.

We used the GUSG PVA to assist us in evaluating the relative conservation value of each GUSG population (Table 41, pg. 303) and to identify critical gaps in our knowledge of GUSG (see "Research" rangewisde strategy, pg. 247, Objective 1, Strategies 4 and 6; Objective 2, Strategy 1; Objective 5, Strategies 1, 2, 3 and 4; and Objective 6). The predictive nature of the model can be improved with more reliable data of GUSG behavior and population trends.

E. Population Augmentation

Translocation

Translocation of GUSG has been proposed as a means to augment small populations. A donor population would provide birds to augment either the population size or genetic diversity of a smaller recipient population, or to establish a new population. Current techniques for transplanting prairie grouse are labor intensive, expensive, and only moderately successful (Toepfer et al. 1990). The typical approach for transplanting sage-grouse has been to obtain birds during the spring. The grouse are captured at night on or near leks, using spotlights and long-handled nets (Giesen et al. 1982, Wakkinen et al. 1992). Birds are transported to the release area and released at daybreak the following morning, using a "soft-release" technique (Musil et al. 1993). This involves placing the birds in a release box on a lek and remotely opening the door when display activity begins at dawn. Ideally, birds walk out of the box and associate the release area with breeding activity.

CDOW has had some success with this technique (see Poncha Pass "Population Information", pg. 93), as have others (Musil et al. 1993), but capturing sufficient numbers of individuals can be difficult. In addition, adult males captured in the spring have already established a territorial affiliation with leks. Some transplanted males have been depredated when they move long distances in an apparent attempt to return to these leks. Juvenile males move much less and appear more willing to accept the release lek and area, presumably because they have not yet established a behavioral affiliation with a lek. Transplanting only juveniles makes obtaining sufficient numbers of birds even more problematic because there are relatively few of them, and they tend not to roost on and near leks where they can be more easily captured.

To date, female sage-grouse translocated in the spring have not attempted to nest during the year of capture, whether caught early or late in the breeding season (CDOW, unpublished data). Thus, translocated hens must survive for a year from release to contribute to population growth. With an average adult female survival of about 65% and nest success of 50% or less, many hens must be moved for a transplant to result in females successfully breeding and further augmenting the recipient population.

The Gunnison Basin GUSG population is the obvious source population for transplant purposes, both because it is so much larger than all others (and thus more able to absorb the loss), and because it has the most genetic diversity. Concern has been expressed that loss of birds trapped during the breeding season may impact the population in the Basin. Although the number of birds trapped and transported out of the Gunnison Basin has been small (51 over 3 years; 2000-2002), it is apparent that removing females during spring will reduce recruitment of young. Because mortality is already high in early life stages for sage-grouse (eggs, chicks, and juveniles), removing individuals in any of these stages for transplantation will likely not add to the mortality of that stage. Thus, moving eggs, chicks, or young of the year, instead of yearling and adult birds during the breeding season, would be far less likely to negatively impact the Gunnison Basin population.

Captive Breeding

Captive breeding could also be used to provide birds for transplant or augmentation purposes. Although the original breeding stock would likely come from the Gunnison Basin, releases beyond that point would come from captive-born progeny, which would eliminate any further impact to the Gunnison Basin population. Extensive experience by Colorado and many other states has illustrated that although raising some gallinaceous birds in captivity is relatively easy, establishing wild populations from these captive-reared birds is very difficult, expensive, and only rarely successful. Failures are usually due to extremely poor survival and reproduction of captive-reared birds (Trautman 1982, Krauss et al. 1987, Leif 1994).

Excessive mortality is usually blamed on behavioral differences between captive-reared and wild-reared birds. Leif (1994) showed that even when captive-reared female pheasants were held over winter and released into high quality habitats just prior to nesting, high mortality and nest abandonment meant they produced only 9% as many young as wild hens in the same habitat. Liukkonen-Anttila (2001) studied differences in morphology and physiology of captive- and wild-reared birds in an attempt to explain the high mortality of released birds. He found significant differences in morphology and physiology caused by captive conditions and diets that may increase mortality of released birds. His findings suggest that some increases in survival might be possible if birds are exposed to more natural diets and allowed adequate space to develop flight and cardiac muscles prior to release.

Sage-grouse

Captive rearing and release programs for grouse are relatively uncommon compared to efforts with turkeys or exotic game birds like pheasants. Bump et al. (1947) raised about 2,000 ruffed grouse in captivity. Even after 12 years of refinement of techniques the authors still noted a propensity for captive-reared chicks to die in large numbers in the first month of life, a trait common to all captive efforts studied, and to the wild. Efforts to raise sage-grouse in captivity date to 1958, when a Texas game bird breeder obtained 30 eggs of GRSG from Wyoming (Pyrah 1960). Twenty-four of the 30 eggs collected hatched (80%), and 17 chicks reached approximately 4 weeks of age. Losses were attributed to accidents, stomach worms, coccidiosis, and inversion of the proventriculus. Only 2 grouse survived to 8-months.

Idaho began a sage-grouse captive breeding program in 1960. Efforts included having captive hens produce young, rearing chicks from eggs collected in the wild, and testing various nutrition plans on sage-grouse (Pyrah 1963, 1964). Success in egg incubation was variable (Pyrah 1963, 1964), and many first-year birds succumbed to disease (salmonellosis, *Pseudomonas aeuginosa*, and aspergillosis; Pyrah 1963). Attempts at captive mating were largely unsuccessful (Pyrah 1963). Survival of the few chicks produced by captive hens was poor and was attributed to poor maternal nutrition during laying (Pyrah 1963). Hatching of eggs collected in the wild was better (87%), and 61% of the chicks hatched survived through the summer (Pyrah 1963). Chick mortality resulted from accidents, disease, and vitamin E deficiency. Wild-caught chicks were more difficult to handle than captive-reared chicks, and “ate sparingly of prepared feed and gained little weight because of it” (Pyrah 1963:8. A diet of pelleted ration with 20% protein, supplemented with “greens and mealworms” was most successful.

Batterson (1997) described successfully propagating sharp-tailed grouse and sage-grouse in captivity in Oregon, without providing details. Batterson and Morse (1948) described an artificial propagation experiment, where 9 eggs were obtained from an abandoned sage-grouse nest and placed under a bantam hen on April 20, 1942. Seven chicks hatched, of which 1 was stepped on and killed by the hen the first day. The 6 survivors were successfully reared to 6-weeks of age when they were released. No information was obtained on subsequent survival.

Wiseman and Bird (1969) conducted a study to develop a ration that would maintain sage-grouse in captivity. They collected 9 eggs from a wild nest in Sweetwater County, Wyoming, and successfully hatched 9 chicks. One chick had its leg severed by the incubator and another had extremely short legs and was destroyed.

Huwer (2004) used sage-grouse chicks hatched and imprinted in captivity to evaluate the extent to which forb abundance affects chick growth rates. She collected 44 eggs from wild sage-grouse nests in spring of 2002 in Middle Park, and successfully hatched 36 (82%) in an incubator. These chicks were imprinted to humans, and subsequently exposed, beginning at 3-days of age for a total of 29 days, to sites with high, medium, or low forb abundance. Mortality during the first week was high; survival to 30-days was 25%. In 2003, 46 of 68 eggs hatched (68%), and survival of chicks through the entire 54-day study period was 68 %.

Other Prairie Grouse

There have been numerous published reports on attempts to propagate other prairie (lekking) grouse in captivity, including lesser prairie chickens (Coats 1955), greater prairie chickens (Trautman et al. 1933, Handley 1935, Ramey 1935, Etter 1963, Shoemaker 1964, McEwen et al. 1969, Kruse 1984), and sharp-tailed grouse (McEwen et al. 1969). Some of these efforts to breed adults and rear young in captivity were successful, although fertility and hatchability rates were often below those seen in the wild; but survival after release was not reported.

Recently, extensive research has been conducted on the endangered Attwater's prairie chicken, in an attempt to develop methods for reintroduction in Texas. In 1990, research began into captive breeding of greater prairie chickens as surrogates for lesser prairie chickens (Jurries et al. 1998). Researchers encountered photoperiod and temperature problems, but ultimately had 3 of 4 hens successfully breed. Eggs collected from wild Attwater's prairie chicken nests were also successfully hatched. However, problems arose with the deaths of 2 wild males brought into captivity, (who died from impaction of the gastrointestinal tract resulting from dietary supplements). Another grouse died of avian pox. The facility also suffered an outbreak of the viral disease, avian reticuloendotheliosis, and was quarantined. Data from this facility and other captive-breeding facilities in Texas indicate the source of the disease was from the outside, likely from migratory birds.

Captive breeding of Attwater's prairie chickens also occurred at the Fossil Rim Wildlife Center and Houston Zoological Gardens. In 1992, eggs collected from wild nests hatched, but most chicks were lost to toe and leg deformities or to an outbreak of infectious enteritis (Smith 1993). Only 5 of the 42 chicks produced survived to breeding age. During 1995-96, 14 hens laid 126 eggs, egg viability was 48%, hatching success was 80% (49 chicks) and 21 chicks were raised to at least 8 weeks of age. Three birds were lost to great-horned owl depredation in the pens and 9 birds were released on the Attwater's Prairie Chicken National Wildlife Refuge.

At the Houston Zoo, 8 females produced 165 eggs, of which 154 were viable; 108 chicks hatched, and 78 chicks survived to 8 weeks. Sixty Attwater's from the Houston Zoo were ultimately released into the wild. A pilot release of 13 males occurred in August of 1995, of which 2 survived to March of 1996. "Refined techniques" resulted in the survival of 31 of 69 Attwater's released in 1996 to the 1997 breeding season. Fifty chicks were released in 1997, supplementing a wild population of 58 birds. There are now captive breeding facilities in Abilene, College Station, Houston, San Antonio, and Tyler, Texas. Ultimately, over 500 eggs were produced.

Recently, several adult pairs were released into individual protected enclosures. This approach has not been successful, suffering nest abandonment, depredation of eggs and young by snakes and fire ants and loss of young to unknown causes. Survival of captive-reared Attwater's prairie chickens released in August to the following spring has been as low as 15% and averaged only 36% despite refinement of release techniques (Preisser and Yelin 1999).

Summary

The literature survey on this topic suggests it is likely, given a substantial commitment of funds and staffing, that GUSG could be successfully bred and raised in captivity. Production capability would not be large because sage-grouse don't breed well in captivity (and as a result they tend to lay infertile eggs) and they are determinate layers who won't continue to lay as eggs are removed (A. D. Apa, CDOW, personal communication). Research into methodologies to collect sperm and artificially inseminate captive hens, or pen construction that would facilitate captive breeding would be beneficial to increase the proportion of eggs that are fertile. There is very limited information on sage-grouse to indicate how likely captive-produced young would be to survive in the wild. However, there is a great deal of relevant information from research on other gallinaceous birds to suggest it will be very low, unless innovative strategies are developed and tested.

Potential Approaches for GUSG

There may be other manipulative strategies to enhance genetic diversity or increase populations of grouse that fall short of captive breeding and release, but that have a higher likelihood of success and would contribute to conservation of these species. We briefly evaluate 5 of these ideas, roughly in order of decreasing potential for success and increasing risk to existing populations.

(1) *Transplant Eggs to Populations in Need*

Oyler-McCance (1999) recommended trapping and releasing 6 GUSG hens into the Dove Creek subpopulation to enhance apparently low genetic diversity. This strategy is further elaborated in the Conservation Strategy (see "Genetics" rangewide strategy, pg. 208). Transplants to augment a failing population at Poncha Pass have been successful to date, but thus far females released have not nested in the year they are trapped and transplanted. One alternative could be to use radio-transmitters to locate nests during laying, and transfer eggs from the source (Gunnison Basin) population or from captive production to nests in populations that need demographic rescue or augmentation to enhance genetic diversity. Clutch size in birds with precocial young that do not require parental feeding may be regulated by nutrition of the hen at the time of laying. Sage-grouse clutch sizes typically range from 7-9, but it is possible that hens could brood and raise substantially larger clutches. This would require further investigation. The technique would require radio-marked females so their nests could be located. Artificial eggs could be placed in the nest bowls so that some eggs remain and prevent abandonment. Other eggs lost to predators could then be replaced with eggs produced in captivity. This would be a means of "ensuring" successful nesting. Given the substantial investment in this approach, it may be worthwhile to evaluate techniques to protect nests from predators (see "Predation" rangewide strategy, pg. 243).

(2) *Incubate Eggs in Captivity to Reduce Depredation Losses*

Nest success in grouse seldom exceeds 50%, and can be substantially lower. Another possible method to increase nest success could be to remove eggs from grouse nests and incubate them in captivity, then replace either eggs or chicks in the nest. This strategy was used very successfully with peregrine falcons where egg-shell thinning was the main problem. Hard plastic eggs were substituted when the real eggs are removed so the female continued to incubate. Huwer (2004) found that GRSG hens in Colorado readily accepted chicken eggs (which are larger and a different color than sage-grouse eggs) when their eggs were removed, continuing to lay and ultimately incubating the clutch. Four of 4 GUSG, and 3 of 3 GRSG hens accepted hard plastic eggs the same size, shape, and color as wild eggs (A. D. Apa, CDOW, personal communication). Using this approach, eggs could be replaced 2-3 days prior to hatch so that normal imprinting occurs, or experiments could be conducted to see if hens accept newly hatched chicks and vice-versa. Pilot studies with GRSG suggest chicks less than 5-days old readily accept, and are adopted by, wild hens (A. D. Apa, CDOW, personal communication).

(3) *Supplement Wild-reared Broods with Captive-produced Young*

For this strategy to be successful, a key assumption is that hens must be willing to adopt captive-reared chicks. There is substantial evidence, only recently collected, to suggest that this technique is possible. The CDOW released 3, 14-day old GRSG chicks to another brood hen last spring when a radio-marked brood hen died. Those chicks were successfully adopted. In a pilot study conducted in the spring of 2004, 17, 1-7 day-old captive reared GRSG chicks were released with wild females with chicks of similar age (A.D. Apa, CDOW, unpublished data). The survival rate at 50 days was 0.42, similar to the survival rate of wild chicks at 50 days (0.38; A.D. Apa, CDOW, unpublished data). CDOW researchers have also observed brood mixing where radio-marked chicks joined broods of different hens. This has also been observed with radio-marked chicks and hens in Oregon (M. Gregg, personal communication) and Idaho (N. Burkpile, personal communication). CDOW researchers have also observed an instance where radio-marked chicks from a depredated hen were adopted by a non radio-collared hen. Apa (CDOW, personal communication) described a hen, known to be unsuccessful in her nesting attempt, who adopted and successfully raised a chick from another brood. Research with radio-marked GRSG chicks in Idaho indicates there is substantial brood mixing among sage-grouse hens (N. Burkpile, personal communication). This suggests that captive-produced chicks can be released into existing broods. The big advantage to this approach is that only broods, not nests, need to be located or disturbed. It is not known whether chicks produced in captivity will accept brood hens, to what extent this might be dependent on chick age at time of release, or whether survival would be similar to wild chick survival. As mentioned above, preliminary information suggests that chicks less than 5-days old readily accept, and are adopted by, wild hens (A. D. Apa, CDOW, personal communication). This will be further evaluated through research.

(4) *Raise Grouse in Captivity and Release to Populations in Need*

This option would be an operational captive breeding and release program. It would require extensive research to evaluate the best methods for raising grouse, including pen construction, diets, artificial insemination, and disease prevention, as well as the best way to reintroduce grouse to the wild. It is the highest risk technique, in that probability of success is low, and there is potential for either introducing disease into existing populations or shifting genetic frequencies over time. The rapid expansion of both chronic wasting disease and whirling disease show how easily release or escape of captive-reared wildlife can create serious disease problems in the wild. If this option is explored it must be under extremely tight disease prevention protocols. Rearing facilities should be placed within the area where release will occur, and the source of birds must be local as well to minimize risk of spreading disease.

(5) *Maintain a Captive Flock as a Genetic Diversity Bank*

The Gunnison Basin is probably the only GUSG population large enough to maintain the genetic diversity needed to offset genetic drift and to ensure the species can adapt to future challenges. At least conceptually, we envision the Gunnison Basin as a source of genetic diversity and individuals that can be used to augment low diversity or population size in case of catastrophic events in other populations. This assumption would be challenged if a catastrophic event like a disease outbreak or prolonged drought occurs in the Gunnison Basin. It may be prudent to maintain a captive flock or flocks (zoos serve this purpose for other species) with diverse genetic makeup to allow us to introduce these genotypes or bring populations back in case of crisis.

F. Analysis: GUSG Population Size in Relation to the Amount of Available Habitat

Model Development

One of the key questions in the conservation and management of GUSG is how much habitat is needed to sustain a given population size over time. We examined this relationship using the mean high male counts at leks and the amount of available habitat within each sage-grouse population. Note that high male counts were used instead of population estimates that are derived from adjusted lek counts. Adjusted lek counts make assumptions that may introduce additional error that cannot be accounted for in model estimates. We used long-term lek counts only if there was a specific protocol and consistent effort for counting leks. We used 10 years of lek count data, 1995-2004, for GUSG populations (except for Poncha Pass, which included only 3 years, 2002-2004; Table 27).

Because there is such a large gap in available habitat between the Gunnison Basin population and the other GUSG populations, we conducted a separate analysis that combined lek counts from both GRSG (Fig. 33) and GUSG populations. We used 6 years of data, 1999-2004, for GRSG populations (except for Middle Park, which included 7 years of data, 1998-2004, and North Park, which included 32 years, 1973-2004; Table 27). Mean high male counts were weighted for each population by the number of years of counts included in the mean. The Sims Mesa and Cerro Summit - Cimarron populations were not included in the analysis. Assessments of the number of males in this population are unreliable because access to these areas has been difficult in spring. We did not include lek counts from the Piceance Basin or Moffat County - Zone 2 (Fig. 33) due to inconsistent lek counts or because the habitat is not comparable to that in other sage-grouse populations.

Table 27. Summary statistics for number of males counted on leks used in the regression for GUSG populations (*n* = number of years of lek counts and includes the 2004 lek counts, * = GRSG population).

Population	***n***	**Area (acres)**	**Mean # of Males**	**Standard Deviation**	**Minimum**	**Maximum**
Poncha Pass	3	14,781	8.0	1.00	7	9
Piñon Mesa	10	24,185	26.3	4.79	16	33
Crawford	10	34,908	39.9	11.58	24	55
San Miguel Basin	10	85,999	62.5	16.46	42	91
Dove Creek – Monticello	10	86,483	66.5	24.16	33	104
Moffat Co. – Zone 1*	6	110,068	168.9	38.93	133	241
Moffat Co. – Zone 4*	6	125,842	159.9	102.45	32	329
Moffat Co. – Zone 6*	6	167,453	353.4	89.67	261	479
Moffat Co. – Zone 3B*	6	207,487	546.9	196.03	236	742
Moffat Co. – Zone 3A*	6	227,087	501.4	153.76	356	709
Middle Park*	7	234,620	264.0	46.61	182	313
Moffat Co. – Zone 3C*	6	280,661	114.5	34.10	56	142
Moffat Co. – Zone 5*	6	300,643	255.3	28.41	202	282
North Park*	32	405,041	877.2	319.21	446	1,521
Gunnison Basin	10	530,464	605.4	95.30	449	723

Fig. 33. Locations of GRSG populations used in analysis of sage-grouse population size and amount of available habitat.

A GIS analysis was used to estimate the amount of available habitat within each population. For this analysis, available habitat is a subset of the vegetation cover types within Occupied Habitat (for definition, see pg. 54): we selected only the cover types within Occupied Habitat that would most likely be used by sage-grouse (e.g., sagebrush or sagebrush-grass communities). Note that this results in different total acreages for each population area than those given in the Conservation Assessment ("Status and Distribution of Individual Populations", pg. 56).

We used several mathematical models to examine the relationship between the mean high count of males on leks and the amount of available habitat (Figs. 34 and 35). We included a linear model that assumed a density independent relationship between the number of individuals in a population and the amount of available habitat. A linear model assumes a constant relationship between population density and the amount of available habitat. The relationship should be linear as long as there is no change in the behavior (e.g., movement patterns) or spatial correlation of sage-grouse as the amount of habitat changes. However, since the plot of the data seems to indicate a nonlinear relationship between the 2 variables, we examined 2 nonlinear models: a quadratic and an exponential model (Figs. 34 and 35). Due to the small number of populations (n = 6 GUSG and n = 9 GRSG populations), we restricted the number of models to a quadratic (i.e., a second degree polynomial) to avoid over-fitting the data. Nonlinear models assume population densities may not be independent of the amount of habitat available and that the behavior and spatial correlation of individuals changes as the amount of available habitat changes. For instance, habitat in smaller populations may be of poorer quality and therefore, may have a lower than predicted population density. In contrast, populations with large amounts of available habitat may have a lower than predicted population density if individuals do not use all available habitat or space use by individuals increases with increasing available habitat.

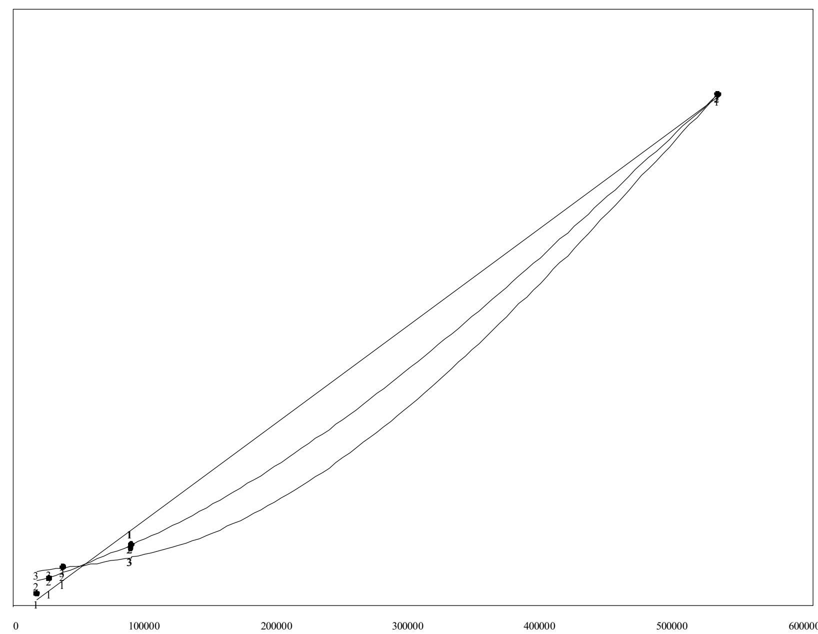


Fig. 34. All models relating the number of males (mean high count at leks) within each GUSG population (● = mean high count of males at leks for each population, n=6; area is in acres). 1 = linear model, 2 = quadratic model, 3 = exponential model.

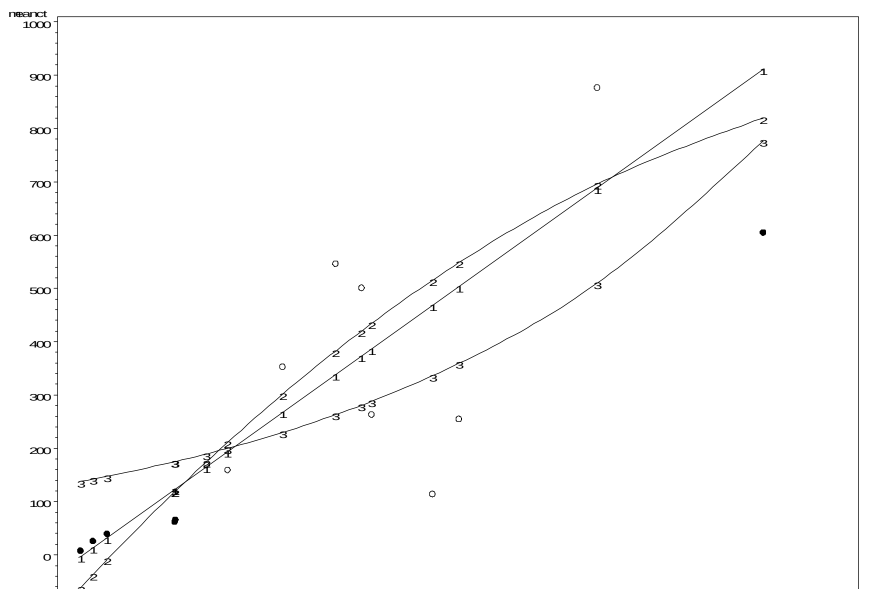


Fig. 35. All models relating the number of males (mean high count at leks) within each GUSG and GRSG population (● = mean high male counts for GUSG populations, n = 6; ○ = mean high male counts for GRSG populations, n = 9; area is in acres). 1 = linear model, 2 = quadratic model, 3 = exponential model.

Model Selection

We used an information-theoretic approach to evaluate the model that best describes the relationship between the 2 variables (Akaike 1973, Burnham and Anderson 1998). Akaike Information Criterion (AIC) is a refinement of maximum likelihood techniques for parameter estimation and is derived from the Kullback-Leibler distance used in information theory (Kullback and Leibler 1951). The Kullback-Leibler distance is a measure of the difference between the data ("reality") and the model used to estimate reality. More specifically, AIC is the maximum log-likelihood for a model with a set of parameters (θ) for a given set of data (y) (AIC = -2ln[L(θ|y) + 2 K], where K is the number of parameters in the model). As the number of parameters in the model increases, the precision of the model increases and the difference between the model and reality typically decreases (i.e., -2ln[L(θ|y) gets smaller). However, additional parameters do not always contribute significant information to a model. AIC penalizes a model by the number of parameters used to fit the data (i.e., 2K gets bigger while -2ln[L(θ|y) gets smaller). The objective is to select a model that does not over-fit (large number of parameters and highly precise) or under-fit (a simple model with few parameters but not very precise) a given set of data. The model with the smallest AIC value is considered the most parsimonious (i.e., the best balance between simplicity and precision) and therefore, the most reasonable model for a given set of data.

Due to the small number of Gunnison and GRSG populations, we used the corrected AIC (AICc, Hurvich and Tsai 1989) to rank the models. Since AIC (and AICc) is a relative ranking technique, we computed the Akaike weight (w_i) to illustrate the relative likelihood of each model (Akaike 1978). Note that the Akaike weights sum to 1.0. The larger the weight the more plausible the model for making inferences based on the data. All models were log-transformed in order to better meet the assumption of homogeneity of variances across dependent variables (area) and to make the residuals of the linear and nonlinear models comparable for model selection. The original (real scale) data were used to compute the parameter estimates for each model.

Based on the AICc and the Akaike weights (w_i), the linear model is the best model for relating the mean high male lek counts to the amount of available habitat for both GUSG data (Table 28A) and for GRSG and GUSG data combined (Table 29A). The quadratic model (w_i = 0.25) could be considered along with the linear model (w_i = 0.73) for the GUSG data given that the Akaike weight of the linear model is only approximately 3 times greater than the quadratic model. A general rule of thumb is that a superior model should have approximately 8 times the Akaike weight over competing models (Burnham and Anderson 1998). However, the linear model is more intuitive given the negative y-intercept, which implies a minimum area of available habitat is necessary to support a sage-grouse population (Fig. 35). Using parameters from the discrete linear model (Table 28B) for estimating the number of males on leks using GUSG data is,

$$\hat{y} = -17.05 + 0.0012(\text{area}) + \varepsilon$$

Both the AICc and the Akaike weights (w_i) indicate the linear model (w_i = 0.82) is the best model for relating the mean high male lek counts to the amount of available habitat for the combined GRSG and GUSG data (Table 29A). The Akaike weight for the linear model is more than 4 times greater than the quadratic (w_i = 0.18) and exponential models (w_i = <0.01). Note that the coefficients for the additional parameter in the quadratic models (β_2) for both sets of data do not add much information to either model (Tables 28B and 29B). Using parameters from Table 29B, the discrete linear model for estimating the number of males on leks using the combined GRSG and GUSG data is,

$$\hat{y} = -30.0 + 0.002(\text{area}) + \varepsilon$$

Table 28: A) Log-transformed data for model selection, B) parameter estimates using real scale data for analysis of the number of males (mean high count at leks) for a given amount of habitat within each sage-grouse population (GUSG only).

A. Log-transformed Data: Model	**d.f.**	**MSE**	**F**	**P >F**	**R^2**	**AICc**	**w_i**
1. Linear $\ln(\hat{y})=\ln(\beta_o + \beta_1 x) + \varepsilon$	4	0.71	99.4	<0.001	0.961	- 1.38	0.73
2. Quadratic $\ln(\hat{y})=\ln(\beta_o + \beta_1 x + \beta_2 x^2)+ \varepsilon$	3	0.83	43.0	0.006	0.966	0.73	0.25
3. Exponential $\ln(\hat{y})=(\ln\beta_o + \gamma * area) + \varepsilon$	4	2.03	32.2	0.005	0.889	5.05	0.02

B. Real Scale Data: Model	**β_o**	**β_1**	**β_2**	**γ**
1. Linear $\hat{y} = \beta_o + \beta_1 x + \varepsilon$	-17.05	0.0012	-	-
2. Quadratic $\hat{y} = \beta_o + \beta_1 x + \beta_2 x^2 + \varepsilon$	14.48	0.0005	<0.0001	-
3. Exponetial $\hat{y} = \beta_o e^{\gamma * area} + \varepsilon$	31.48	-	-	0.0056

Table 29. A) Log-transformed data for model selection, B) parameter estimates using real scale data for analysis of the number of males (mean high count at leks) for a given amount of habitat within each sage-grouse population (GUSG and GRSG data combined).

A. Log-transformed Data: Model	**d.f.**	**MSE**	**F**	**P >F**	**R^2**	**AICc**	**w_i**
1. Linear $\ln(\hat{y})=\ln(\beta_o + \beta_1 x) + \varepsilon$	13	2.08	93.9	<0.0001	0.878	13.3	0.82
2. Quadratic $\ln(\hat{y})=\ln(\beta_o + \beta_1 x + \beta_2 x^2)+ \varepsilon$	12	2.25	43.5	<0.0001	0.879	16.3	0.18
3. Exponential $\ln(\hat{y})=(\ln\beta_o + \gamma * area) + \varepsilon$	13	4.20	39.9	<0.0001	0.754	24.6	<0.01

B. Real Scale Data: Model	**β_o**	**β_1**	**β_2**	**γ**
1. Linear $\hat{y} = \beta_o + \beta_1 x + \varepsilon$	-30.0	0.002	-	-
2. Quadratic $\hat{y} = \beta_o + \beta_1 x + \beta_2 x^2 + \varepsilon$	-101.7	0.003	<0.0001	-
3. Exponential $\hat{y} = \beta_o e^{\gamma * area} + \varepsilon$	131.1	-	-	.00334

Using the mean high male lek count loses information about year to year variation. Therefore, we repeated the above analysis using lek counts from each year instead of the mean. Using the individual lek counts results in the same mean and predicted values from the regression, but the variances are larger and potentially more realistic (Fig. 37). A summary of statistics and parameter estimates for the real scale data for GUSG and for the combined GRSG and GUSG data are provided (Table 30).

The linear model is the most parsimonious and reasonable for both sets of data. However, we recommend the linear model using only GUSG data (Figs. 36 and 37). The combined data (Fig. 38) provided additional information that illustrates the efficacy of the linear model and the potential variability in the number of males for a given amount of habitat. The steeper slope for the combined data implies a more rapid growth in the number of males on leks in response to adding habitat to the population. However, it is more reasonable to use the GUSG data for making inferences about GUSG populations.

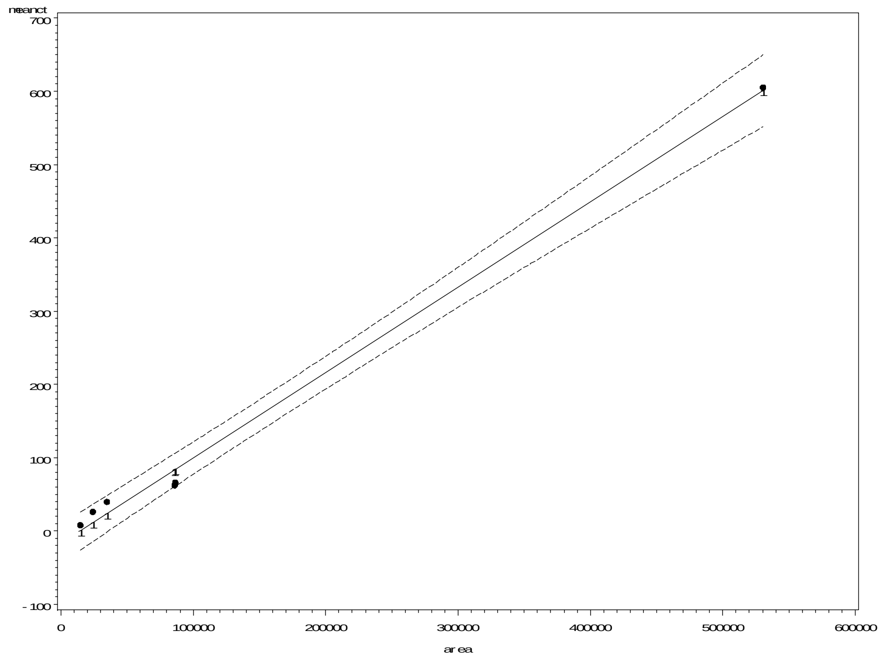


Fig. 36. Linear model (with 95% confidence interval [C.I.] for mean values) relating the number of males (mean high count at leks) within each GUSG population (● = mean high count of males at leks for each population, n = 6; area is in acres).

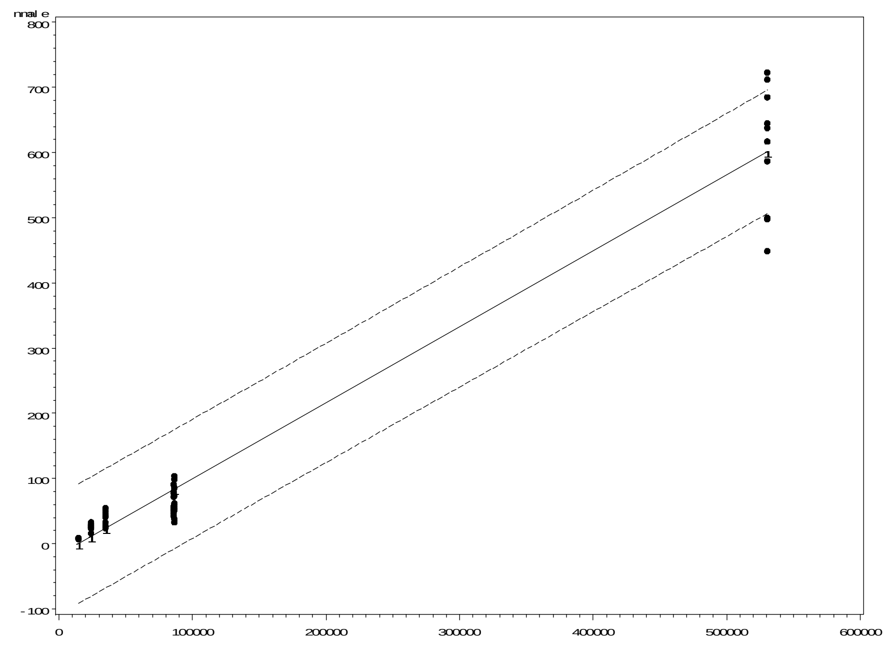


Fig. 37. Linear model (with 95% C.I. for individual predicted values) relating the number of males (mean high count at leks) within each GUSG population (● = mean high count of males at leks for each population, n = 6; area is in acres).

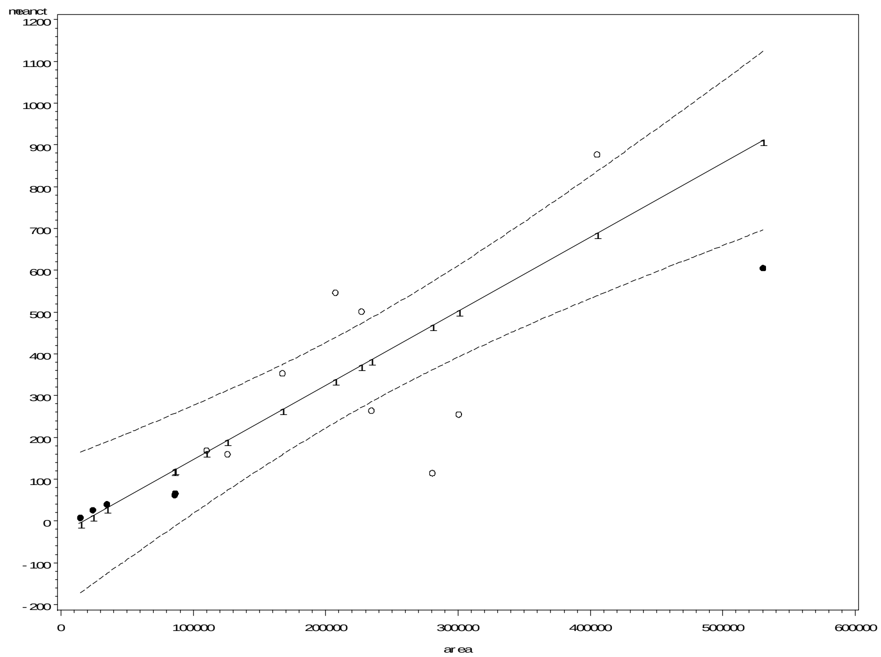


Fig. 38. Linear model (with 95% C.I. for mean values) relating the number of males (mean high count at leks) within each GUSG and GRSG population (● = mean high male counts for GUSG populations, n = 6; ○ = mean high male counts for GRSG populations, n = 9; area is in acres).

Computing 95% C.I. for Predicted Values of the Number of Males Counted on Leks

We recommend using lek counts from individual years (instead of the mean lek counts) to compute a 95% C.I. for predicted number of males (Fig. 37). As mentioned earlier, this model includes the year to year variation in lek counts and is therefore potentially more realistic (i.e., the variance, estimated by the *MSE*, is larger). The 95% C.I. for the number of males (y_i) for a given amount of habitat (x_i) is computed as,

$$\text{C.I.} \;=\; \hat{y} \pm t_{0.5,\text{d.f.}} \sqrt{MSE\left[1+\frac{1}{n}+\frac{(xi-\bar{x})^2}{SS(X)}\right]}$$

and the 95% C.I. for the expected mean number of males ($\bar{y}$) for a given amount of habitat is computed as,

$$\text{C.I.} \;=\; \hat{y} \pm t_{0.5,\text{d.f.}} \sqrt{MSE\left[\frac{1}{n}+\frac{(xi-\bar{x})^2}{SS(X)}\right]}$$

where $\hat{y}$ is the predicted number of males on leks for a given amount of available habitat (i.e., $\hat{y} = \beta_o + \beta_1(x_i)$), $t_{0.5,d.f.}$ is the critical value for the *t*-distribution for a given number of degrees of freedom ($t_{0.5,51} = 2.009$ for GUSG populations and $t_{0.5,132} = 1.978$ for combined GRSG and GUSG populations), the parameters β_o and β_1 are from Table 30, *MSE* is an estimate of variance from Table 30, *n* is the number of lek counts($n = 53$ for GUSG counts and $n = 134$ for combined GRSG and GUSG counts), x_i is the amount of habitat for a given population, $\bar{x}$ is the mean available habitat computed from values in Table 27 ($\bar{x} = 129{,}470$ acres for the combined GUSG populations, $\bar{x} = 189{,}048$ acres for GRSG and GUSG populations), and *SS(X)* is the sum of squares for available habitat across all populations. *SS(X)* = 197,714,267,836 for GUSG data. *SS(X)* = 301,073,810,470 for GRSG and GUSG data combined.

For example, if there are 50,000 acres of habitat, the predicted number of males on leks ($\hat{y}$) is estimated as,

$$\hat{y} = \beta_o + \beta_1(x_i)$$
$$\hat{y} = -17.05 + 0.0012(50{,}000)$$
$$\hat{y} = 43$$

The parameters β_o and β_1 are for GUSG data (see Table 30). Using the values given above and in Table 30 for GUSG data, the 95% C.I. range for expected number of males is computed as,

$$\text{C.I.} = 43 \pm 2.009\sqrt{2{,}029.5\left[1 + \frac{1}{53} + \frac{(50{,}000 - 129{,}470)^2}{197{,}714{,}267{,}836}\right]}$$
$$= 43 \pm 92.8$$

The 95% C.I. range for the mean number of males is computed as,

$$\text{C.I.} = 43 \pm 2.009\sqrt{2{,}029.5\left[\frac{1}{53} + \frac{(50{,}000 - 129{,}470)^2}{197{,}714{,}267{,}836}\right]}$$
$$= 43 \pm 20.4$$

Therefore, the expected number of males could potentially range from 0 to 136 males in any given year and the mean number of males over time should be between 23 and 63 males. See Table 31 for 95% C.I. for other possible amounts of available habitat.

Table 30. Summary statistics and parameter estimates of a linear model using lek counts from each year (real scale data) to analyze the number of males for a given amount of habitat for A) GUSG only and B) GRSG and GUSG combined.

A. Gunnison sage-grouse only							
Model	**d.f.**	**MSE**	**F**	**P > F**	**R^2**	**β_o**	**β_1**
$\hat{y} = \beta_o + \beta_1 x + \varepsilon$	51	2,029.5	1,252.9	<0.0001	0.961	-17.05	0.0012
B. Greater and Gunnison sage-grouse							
$\hat{y} = \beta_o + \beta_1 x + \varepsilon$	132	56,539.2	192.5	<0.0001	0.593	-30.0	0.002

Table 31. 95% C.I. for expected number of males (95% C.I. : y_i) and expected mean number of males (95% C.I. : $\bar{y}$) for a select range of habitat acreages.

Habitat (acres)	$\hat{y}$	**95% C.I.: y_i**		**95% C.I.: $\bar{y}$**	
		Minimum	**Maximum**	**Minimum**	**Maximum**
20,000	7.0	0	101	0	32
25,000	13.0	0	107	0	38
50,000	43.0	0	136	23	63
85,000	85.0	0	177	70	100
150,000	163.0	72	254	150	176
300,000	343.0	245	441	306	380
500,000	583.0	464	701	507	659

G. GUSG Population Targets Development

Population targets must take into account that even healthy sage-grouse populations fluctuate tremendously over time and should be used as relative indicators of a given population's status and trend. A good example is in North Park, Colorado, where lek counts of GRSG have been monitored with similar intensity of effort for over 30 years. The average number of males counted on leks was 862, but that average was punctuated by counts as low as 497 (1986) and counts as high as 1,521 (1979) (Fig. 39). Thus, even in an area of relatively stable habitat, 2-3 times more males were counted in high years than in low years. Total males counted in low and high years were 60 and 176% of the long-term average, respectively. Given this variation, lek counts in most years will be substantially above or below the long-term average (Fig. 39).

We chose population targets for GUSG that are based on a long-term population average and modified by the potential for GUSG to expand into vacant or potentially suitable habitat (see Table 32, pg. 256). The long-term population averages for GUSG are based on 10 years of lek counts from 1995-2004 (except for Poncha Pass which included only 3 years of lek counts, 2002-2004; see Table 27, pg. 187 for mean and standard deviation of number of males counted on leks for each GUSG population). Vacant and potentially suitable habitat is based on a GIS analysis and modified by expert opinion of CDOW and UDWR biologists. These modifications are unique for each GUSG population (see discussion for each population in the "Local Conservation Targets and Strategies", beginning pg. 255). We also present a population range that illustrates the normal expected population fluctuation.

Since population targets are based on current population estimates and potential habitat conditions, they should be modified as habitat conditions and availability change. We do not know, and can not predict, the effect of changes in landscape features (e.g., habitat composition, patch configuration, and land use patterns) on GUSG behavior and population dynamics; therefore, population targets should be modified as we improve our knowledge of landscape features and how they are used by GUSG (see "Adaptive Management Process" pg. 302). We anticipate increases in population levels and targets upon implementation of the habitat management strategies described within the RCP that will minimize the likelihood of extinction or endangerment of GUSG.

We also define a minimum population threshold below which certain conservation actions should be initiated and expedited. If a series of population estimates for a given population continually declines toward a threshold, managers should increase efforts to evaluate the decline and potential conservation actions before the population passes the threshold. We set a reasonably conservative threshold at 30% below the current population targets. In the North Park data set (Fig. 39), the number of GRSG males counted on leks declined below a 30% threshold (approximately 600 males) in 6 of 31 years. Since North Park is a relatively stable population, the 30% threshold creates an error rate (false-positives) of 19% (6/31). If the first 3 years of the data set are excluded (many lek locations were still being discovered), then male counts fell below the threshold in only 3 of 28 years, for a false positive rate of about 11%. This seems to give a reasonable probability of detecting real long-term declines while protecting against panic when population declines are within normal ranges of variation. While the population targets should be modified as conditions change, the threshold is based on current conditions and will not change (i.e., we consider current population and habitat conditions to be the baseline for evaluating future GUSG trends as well as the basis for determining whether to expedite conservation activities even as population levels increase).

The PVA developed for GUSG (see "Population Viability Analysis", pg. 168) describes the relative risk of extinction across a range of population sizes. The PVA illustrates, 1) that there is a low risk of extinction for the species rangewide (i.e., the risk of extinction for a stable population of 500 is less than 5% over a 50-year period) and 2) there is a great deal of uncertainty in the risk of extinction in the small populations due to our lack of information on the demography of GUSG. The uncertainty is increased by our lack of knowledge about how habitat loss, habitat fragmentation, disease, and landscape changes may affect the viability of GUSG populations. Therefore, we did not use the PVA to set specific population targets.

Despite these uncertainties, the risk of extinction is relatively higher in the smaller populations than in the Gunnison Basin. The smaller populations are important to the long-term viability of GUSG because they: 1) increase species abundance rangewide, 2) minimize the threat of catastrophic events to the species since the populations are widely distributed across the landscape, and 3) provide additional genetic diversity not found in the Gunnison Basin.

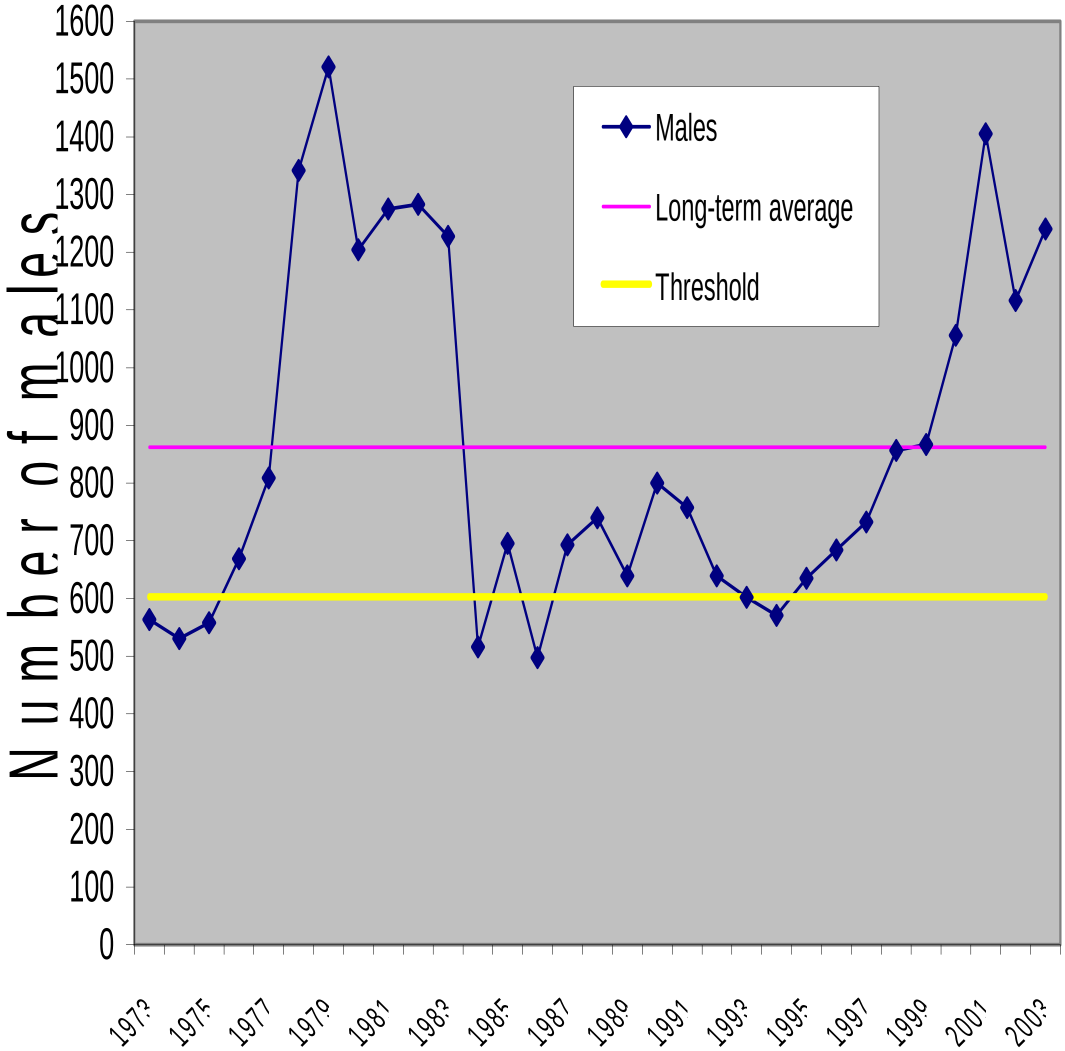


Fig. 39. Example of lek count target-setting in a long-term stable GRSG population in North Park, Colorado, from 1973-2004.

V. CONSERVATION STRATEGY

The purpose of the RCP is to identify measures and strategies to achieve the goal of protecting, enhancing, and conserving GUSG and their habitats. This section presents the RCP's conservation strategy. We provide: (1) an overview of the rangewide perspective on population objectives; (2) strategies that address specific issues on a rangewide basis; and (3) recommended local conservation targets and strategies for each population. It is expected that the local conservation plans will be updated to address the local strategies presented here. The RSC views the strategies presented in "Local Conservation Targets and Strategies" (pg. 255) as the minimum efforts; in some cases, local groups may choose to undertake efforts beyond those described in the RCP.

The rangewide strategies are linked to each other and the local strategies in a number of ways. Many of the rangewide strategies, or components of them, are referred to within individual local conservation strategies, when relevant for the individual population (e.g., "Grazing", "Habitat Enhancement", and "Habitat Protection from Permanent Loss"). Others are primarily rangewide in nature (e.g., "Habitat Linkages"), to be addressed by agencies across the range of GUSG. Two of the rangewide strategies, "Information and Education" and "Research", will benefit all populations when they are implemented, but they are not specifically mentioned in any local strategy. Other rangewide strategies are to be used primarily in response to unplanned events, such as "Disease and Parasites", or "Weather/Drought", and should be referenced if such an event occurs in any individual population.

The rangewide and local strategies rely on and/or refer to some important components of the plan that are appendices:

Appendix B clarifies the entities listed under "Responsible Parties" in the conservation strategies (it also identifies acronyms in the plan);

Appendix C identifies funding opportunities for GUSG conservation;

Appendix F provides background on the spatially explicit model of housing growth in within GUSG range, and provides some guidance to local managers in identifying land most at risk of development;

Appendix H ("GUSG Structural Habitat Guidelines") identifies specific vegetation structure components necessary for GUSG seasonal habitats;

Appendix I ("GUSG Disturbance Guidelines") provides recommended buffers around GUSG seasonal habitats that should be observed in regard to habitat disturbance, as well as timing restrictions on activities that could disturb GUSG;

Appendix J (GUSG Habitat Use Data) illustrates the data used in development of Appendix I;

Appendix K Monsen (2005) has presented a manual addressing the restoration of sagebrush communities. We offer a summary and table of contents of this manual and recommend using Monsen (2005) for all GUSG habitat enhancement and restoration efforts (copies of Monsen 2005 are available on CD from CDOW; contact Pam Schnurr at Pam.Schnurr@state.co.us);

Appendix L provides suggested management practices for oil and gas development in GUSG habitat.

A. Overview of Rangewide Population Objectives

This plan is intended to help protect and improve sufficient habitat and implement other measures across the range of GUSG to ensure that the species has minimal (<1%) modeled risk of extinction over a 50-year time frame. Populations will be managed to retain 90% or more of genetic diversity over this same time frame. As outlined in the PVA, the Gunnison Basin GUSG population is the only population large enough to have a very high probability of surviving random demographic stochastic events over this time frame. It is also the only population large enough in and of itself to maintain a reasonably large degree of genetic variation over time. The Gunnison Basin therefore is the cornerstone for conservation of this species.

Preservation of smaller populations is also important. Smaller populations will be managed so that collectively they represent a sizable pool of both individual sage-grouse (> 1,000) and genetic diversity (80%). We will manage and protect habitats for population extinction probabilities of less than 5-10% (without artificial augmentation) over a 50-year time frame for Crawford, San Miguel Basin, and Dove Creek - Monticello, Utah. If population levels drop below 50-75% of the target we will augment numbers so that actual extinction risks will be minimal (see “Population Augmentation” rangewide strategy, Objective 1, Strategy 3, pg. 241). Limits on available habitat in other populations (Cerro Summit – Cimarron - Sims Mesa, Piñon Mesa, Poncha Pass) suggest local extinctions may occur without intervention. These habitats should be managed and protected to make the risk of extinction as low as possible, given existing and potential habitat constraints. Periodic demographic rescue may be necessary, and infusions of genetic material to counter loss of genetic diversity will be necessary.

B. Rangewide Conservation Strategies

Conservation strategies to be addressed on a rangewide basis are listed here. See “Threats and Analysis” (pg. 103) for background on specific threats and issues. Many of these strategies are to be implemented in response to certain scenarios or conditions, or are to be conducted annually/continually. In a few cases there is a specific singular target completion date, and in those instances the completion date is listed below the responsible group(s). In the next section, local strategies (recommended actions for local work groups and stakeholders) are listed. In many cases, the local strategies refer to protocols or guidelines developed here in the rangewide strategies section. Rangewide strategies are listed in alphabetical order.

While all rangewide and local conservation issues ultimately need to be addressed at some level, clearly some issues are of higher priority and will impact the conservation of GUSG more than others. Following is a discussion of the relative priority of rangewide conservation issues, since one of the main intents of the rangewide plan is to identify and prioritize these issues. Priorities may differ at local population levels. Implementation of some rangewide strategies will apply to all populations and work groups; others will be implemented by state or federal agencies. This prioritization is intended as guidance to local work groups and agencies as local conservation plans, and other agency plans and decision are revised, developed, and implemented.

The top 5 priority rangewide strategies, in order of priority, follow:

(1) Protection of occupied habitats from permanent loss is clearly the highest priority conservation strategy. If permanent habitat loss from development (primarily) or conversion is not addressed, successful implementation of all the other conservation strategies is not likely to be successful in conserving GUSG. Not all populations have equal conservation value, or are at equal risk of development; prioritization of habitat protection efforts is covered in "Prioritization of Habitat Protection Efforts" (pg.160). An equally important strategy is preventing significant degradation, whatever the cause, of existing habitat that is seasonally important to grouse. Research to evaluate the impacts of positive habitat improvements, and help mitigate impacts of various forms of development must occur.

(2) The second highest priority rangewide conservation strategy is to stabilize existing populations demographically and genetically through augmentation, and establish new populations in historically occupied habitats which are evaluated and deemed suitable. Reintroductions should be pursued cautiously. While they potentially can be a rapid means to increase numbers of GUSG, if habitat is not of a sufficient size and quality to maintain the birds, the reintroduction process may simply act as a drain on existing populations and may polarize local work groups. Augmentation techniques should be evaluated and improved.

(3) A slower, but perhaps surer, conservation strategy is habitat improvement within currently occupied and adjacent potential habitats. Relative gains from habitat improvements will vary across populations. PVA modeling suggested populations were strongly influenced by chick mortality, so employment of grazing systems or habitat improvement projects designed to increase forb and grass understories in sagebrush areas used for brood rearing should increase population growth rates and size. Greatest benefits will be in areas with demonstrable deficiencies in existing understories.

(4) Management of all wildlife proceeds in the face of considerable uncertainty, and it should be clear from this plan that the impacts of many management and other actions on GUSG are poorly understood. This uncertainty demands an adaptive management approach, which requires monitoring of how the "system", both sage-grouse and their habitats, is responding. Monitoring must not only be conducted to see how we are doing relative to the conservation goals set in this plan and others, but it must be done in a manner that increases our understanding of how sage-grouse respond. This is a high conservation priority. Implicit in this strategy is research to better estimate sage-grouse population size and means to effectively assess and evaluate quality.

(5) Finally, the 5th priority of the rangewide strategies is to protect from permanent loss historically used habitats that are not currently occupied by grouse. These are areas we've mapped as suitable, but unoccupied, or as "potentially suitable" habitat. These areas may, with proper restoration, serve as areas of expansion or as linkages connecting populations. These are obviously desirable outcomes, but they are in no way assured, and attempting to secure them in the short-term takes scarce resources away from the protection of currently

occupied habitats, considered far more critical to the future of GUSG. This strategy should be employed if and when resources permit.

Disease and Parasites

WNV currently poses the most serious potential disease threat to GUSG populations. Outbreaks of other diseases are possible, but they have typically been localized and may pose a threat to only the smallest GUSG populations. Efforts should be devoted to disease detection and management response in the event of infected GUSG. In addition, more needs to be known about the risk of disease transmission from other gallinaceous birds to GUSG.

Objective 1: Minimize occurrence and impact of diseases that threaten GUSG populations.	
Available Strategies	**Responsible Group**
1. Monitor GUSG and other species for presence of WNV in GUSG counties.	CDOW, UDWR, County and State Health Departments
2. In localized areas where the West Nile virus has been detected, control mosquitoes through applications of appropriate EPA regulated larvicides and/or adulticides in order to protect GUSG in the area.	CDOW, UDWR, County Governments
3. Investigate GUSG susceptibility to and inheritance of immunity to WNV (see "Research" strategy [pg. 247], Objective 6).	National Wildlife Research Center, CDOW, UDWR
4. If GUSG are infected with disease (other than WNV) that threatens a population: investigate, isolate, and control source of disease, and if possible, treat GUSG.	CDOW, UDWR
5. Investigate the possible need to conduct standard disease screening on all game birds before they are imported into or moved within GUSG range in Colorado.	CDOW Completion Date: 2005

Fire and Fuels Management

Appropriate management of fire in GUSG sagebrush habitat is crucial to maintaining and restoring the health of sagebrush communities. Fire planning, fire suppression, fire rehabilitation, the use of prescribed fire, and fuels treatments in and around GUSG habitat must be well planned and executed, using an interdisciplinary approach. As is always the case, human safety supercedes all recommendations with regard to wildfire response in GUSG habitat.

Fire management plans should consider potential fire effects in GUSG habitat so that an appropriate response to wildfires can be coordinated among the often numerous entities that may be involved in initial response. Fire suppression objectives should be clearly articulated in the local fire management plan so they can be effectively communicated to appropriate fire fighting officials and teams. If "Wildland Fire Use" (using lightning-ignited fires to manage resources or derive some benefit) is an option, the objectives and constraints need to be clearly expressed in the fire management plan to enhance the decision making process and to provide direction for managing the "Wildland Fire Use" fire.

Fire suppression activities to manage GUSG habitat need to be sensitive to objectives and constraints. Examples include, but are not limited to: 1) large back-fire operations to control wildfires may not be desirable and should be avoided if possible since the burnout itself may consume significant GUSG habitat; and 2) using dozers and engines in or near seasonal habitats should be avoided, if possible. Rehabilitation and restoration measures following a wildfire may be essential to ensure that a healthy sagebrush community reestablishes following wildfire. Monsen (2005) recommends some general restoration practices, including reseeding burned habitat in the same year of a burn, in late fall or early spring. Proper seedbed preparation is also important, as are weed control measures, and the use of native species seed mix is encouraged (Monsen 2005). Site specific rehabilitation should be based on local conditions (e.g., potential for natural regeneration, risk of invasive species, and erosion potential).

Prescribed fire, if applied at an appropriate scale, can be a viable tool to manage GUSG sagebrush habitat and to protect it from catastrophic wildfires. Prescribed burning can also be used as a fuels reduction tool adjacent to GUSG habitat to reduce the likelihood of wildfire spreading from adjacent fuel types (e.g., piñon-juniper, oakbrush, or ponderosa pine). Prescribed burning in spring and fall can effectively create a mosaic of small open patches in which forbs and grasses thrive and fuels are reduced (see "Habitat Enhancement" rangewide strategy, pg. 214, and "GUSG Structural Habitat Guidelines", Appendix H). Currently, successful prescribed burning in GUSG habitat uses snow fields, wet areas, and various topographic aspects to limit the size of patches. Fire plans need to consider the need for small patch sizes.

Mechanical treatments can be used as a fuel reduction tool in much the same manner as prescribed burns, to reduce the potential for catastrophic fires in GUSG habitat, wildland/urban interface, or human infrastructure areas. Mechanical fuels treatments, when developed and implemented using an interdisciplinary approach, can be very effective in meeting both the fuel/fire objectives as well as some habitat objectives (see "Habitat Enhancement" rangewide strategy, pg. 214). Reseeding following mechanical treatment and prescribed burning may be necessary to reduce the potential for invasive weeds and to maintain a desired shrub, grass and forb species mix.

In most GUSG populations, due to the already highly fragmented habitat, any planned habitat treatment (e.g., prescribed fire or fuels treatment) should be conducted at a small scale (Connelly et. al 2000; also see “GUSG Disturbance Guidelines”, Appendix I). However, the size of treatment should be established after examining existing conditions (e.g., sagebrush species present, topography, previous fire history, type and distribution of seasonal habitat), cumulative areas of sagebrush modification, and potential of the proposed site.

Objective 1: Manage wildfire, prescribed burns and fuel treatments to minimize detrimental effects on GUSG populations and to improve GUSG habitat.	
Available Strategies	**Responsible Group**
1. Plan fire suppression response to potential wildfires in important GUSG habitat. Share fire response and GUSG seasonal habitat information with county, fire district, and federal fire fighting officials to plan and implement appropriate response to wildfires in these areas.	BLM, CDOW, NPS, NRCS, UDWR, and USFS
2. Manage habitat mosaics and fuels in GUSG areas to minimize the possibility of damaging wildfires. Use prescribed burning and mechanical fuels treatments at an appropriate scale to reduce the potential for catastrophic wildfires in and adjacent to GUSG habitat and to improve the quality and quantity of GUSG habitat (see “Habitat Enhancement” rangewide strategy, pg. 214).	BLM, CDOW, NPS, NRCS, UDWR, and USFS
3. Use prescribed burning at a small scale, when appropriate, to improve the quality and quantity of GUSG habitat (Connelly et al 2000; see also “GUSG Structural Habitat Guidelines”, Appendix H, and Monsen 2005).	BLM, CDOW, NPS, NRCS, UDWR, and USFS
4. For burns in Wyoming sagebrush that are larger than 5 acres in occupied or potential GUSG habitat, encourage reseeding (see “Habitat Enhancement” rangewide strategy, pg. 214).	BLM, CDOW, NPS, NRCS, UDWR, and USFS
5. Evaluate response of habitat (see “Habitat Monitoring”, pg. 220) to all burns and mechanical fuel reduction treatments.	BLM, CDOW, NPS, NRCS, UDWR, and USFS

Genetics

The low level of genetic diversity found in GUSG, particularly when compared to GRSG, is of conservation concern. While there is nothing that can be done to increase genetic diversity within the species, steps may be taken to attempt to maximize the probability of maintaining the current levels of variation. This could involve translocations of individuals among populations, to decrease the probability of losing alleles due to random genetic drift, which is a strong force in small populations. The Dove Creek - Monticello and Piñon Mesa populations were found to have particularly low allelic diversity and the highest levels of monomorphism (Oyler-McCance et al. in press). This fact, coupled with their small population sizes, suggest that these 2 populations are most at risk of negative genetic impacts and may be the best candidates for translocations from the largest, most genetically diverse population in Gunnison Basin. Many biologists advocate moving at least 1 individual per local population per generation to prevent population insularization caused by habitat loss and fragmentation (Franklin 1980, Frankel and Soulé 1981, and Allendorf 1983). This may be a good rule of thumb for GUSG.

Translocations should likely focus on females rather than males, since not all males breed, given the lek breeding system (see “Population Augmentation” rangewide strategy, pg. 241). The possibility of translocating fertilized eggs or chicks should be investigated as an alternative to translocating live females. Sufficient numbers of females (or eggs or chicks) should be translocated to assure that at least 1 translocated individual breeds in the following breeding season and successfully passes its genes to the next generation. The success of translocations should be monitored by following translocated individuals and monitoring their reproductive success. In addition, the genetic makeup of the population could be assessed through a genetic survey in subsequent years. Because baseline (pre-translocation) data are available (Oyler-McCance et al. in press), it is possible to track changes and monitor the genetic diversity of a population.

Further, signs of inbreeding (characteristics of fitness as they relate to genetic diversity) must be more closely examined. Comparisons of reproductive success (e.g., hatchability, chick survival) across the range should be carried out. Research on reproductive features (e.g., sperm function, egg normality), parasite load, and disease resistance (e.g., major histocompatibility complex variation) should be conducted, to make comparisons both within the GUSG and between the GRSG and GUSG.

Oyler-McCance et al. (in press) found that the San Miguel population may act as a conduit to gene flow among the small satellite populations. Surprisingly, they found a link between San Miguel and Cerro Summit – Cimarron - Sims Mesa, suggesting gene flow between these areas. The Cerro Summit – Cimarron - Sims Mesa population has not been well studied and deserves further attention. Additionally, habitat restoration and protection in areas between San Miguel and Gunnison should be a priority for conservation of the species in an attempt to facilitate natural movement among these populations.

While genetic concerns may be only one of several priorities for GUSG conservation and management, along with other issues (e.g., habitat loss and quality), they warrant consideration. Conservation activities should include monitoring and maintaining genetic diversity, preventing future habitat loss and fragmentation, enhancing existing sagebrush communities, and restoring sagebrush communities that have been converted.

Objective 1: Maintain > 90% of the genetic diversity present within GUSG over the next 50 years.	
Available Strategies	**Responsible Group**
1. Maintain a relatively large (~3,000) long-term average population within the Gunnison Basin.	BLM, CDOW, NPS, USFS, USFWS

Objective 2: Maintain 80% or more of the genetic diversity present within GUSG in areas outside the Gunnison Basin by 2015, so that genetic diversity can be (largely) restored in the case of loss within the Gunnison Basin.	
Available Strategies	**Responsible Group**
1. Increase genetic diversity within smaller populations through augmentation with eggs, chicks, or adults until collectively they represent 80% or more of the diversity within the Gunnison Basin.	CDOW, UDWR
2. Conduct research to evaluate use, maintenance, and possible enhancement of habitat corridors among populations that facilitate dispersal of individuals between populations and enhance genetic diversity.	BLM, CDOW, NPS, UDWR, USFS, USFWS

Objective 3: Maintain genetic diversity present within individual populations of GUSG so that each contains 70% of overall genetic diversity.	
Available Strategies	**Responsible Group**
1. Increase genetic diversity within smaller populations through augmentation with eggs, chicks, or adults.	CDOW, UDWR Completion Date: 2015

Objective 4: Develop and maintain a repository of genetic diversity in captivity.	
Available Strategies	**Responsible Group**
1. Develop captive breeding and rearing techniques to facilitate meeting objective 1 and 2 above, and to facilitate maintenance of a captive flock as a living genetic diversity bank if necessary.	CDOW
2. Archive samples encompassing the entire range of genetic diversity present within GUSG.	CDOW, Denver University, UDWR

Objective 5: Monitor genetic diversity within the Gunnison Basin and smaller populations.	
Available Strategies	**Responsible Group**
1. Continue to obtain blood and other tissue samples as birds are captured for other purposes and submit for genetic testing.	CDOW, Denver University, NPS, UDWR, USFWS
2. Continue to develop and refine, if it proves feasible, techniques to obtain DNA from fecal droppings so that genetic testing can be accomplished without capturing birds.	CDOW, Denver University

Objective 5: Monitor genetic diversity within the Gunnison Basin and smaller populations.	
Available Strategies	**Responsible Group**
3. Develop and implement a genetic diversity monitoring plan and schedule.	BLM, CDOW, Denver University UDWR, NPS, USFS
	Completion Date: 2007

Grazing

Healthy sage-grouse populations and ungulate grazing are not incompatible, if managed properly. Grazing is an important component of western rural economies. Continuation of sustainable ranching operations may prevent permanent conversion of sagebrush, such as through development and subdividing for housing. Site-specific research about the effects of livestock grazing on sage-grouse is lacking. Given all of this, we developed general recommendations for grazing to maintain sage-grouse habitats with diverse grass, forbs, and shrubs. If long-term monitoring indicates a downward trend in the vegetation and sage-grouse habitat, then adjustments should be made to livestock grazing management and wild ungulate population objectives.

Ultimately, site potential and environmental conditions will dictate vegetation composition, height, and density across landscapes. Grazing management practices may maintain or improve rangeland health and should be used to achieve and sustain desired vegetation conditions throughout GUSG range. Rangeland vegetation should be given the opportunity to either grow before grazing, or re-grow after grazing. This can be accomplished by controlling the distribution of grazers, duration of use, and the time of year livestock graze a particular location.

Although monitoring of grazing effects on GUSG habitat is a rangewide objective, implementation and scheduling of monitoring must be done by land managers at the local level.

Objective 1: Manage grazing to improve GUSG habitat and minimize conflicts between grazers and grouse, while providing for sustainable agriculture.	
Available Strategies	**Responsible Group**
1. Use grazing management guidelines (pg. 212) that list practices to benefit GUSG and GUSG habitat in order to meet GUSG structural habitat guidelines (Appendix H).	BLM, CDOW, Private Landowners, NPS, NRCS, USFS, UDWR
2. Incorporate specific sage-grouse habitat objectives into Land Health Assessments under Standards 3 & 4 (maintenance of healthy plant, animal & special status species) on BLM administered lands.	BLM
3. Reevaluate and implement plans for managing specific populations of big game (Data Analysis Unit plans in Colorado; elk and deer herd unit management plans in Utah), particularly for maintaining elk populations at management objectives.	BLM, CDOW, Private Landowners, USFS, UDWR
4. Develop wild ungulate winter habitat objectives to meet seasonal GUSG requirements.	BLM, CDOW, Private Landowners, UDWR, USFS
5. Develop strategies to draw ungulates away from treatment areas to allow proper recovery.	BLM, CDOW, Private Landowners, USFS, UDWR

Objective 1: Manage grazing to improve GUSG habitat and minimize conflicts between grazers and grouse, while providing for sustainable agriculture.	
Available Strategies	**Responsible Group**
6. Use and develop incentive programs to encourage private landowners to rest pastures, if needed, to benefit sage-grouse habitat (e.g., grass banks, resting allotments).	BLM, CDOW, NRCS, SCD, USFS, UDWR

Objective 2: Monitor grazing management effects on GUSG and GUSG habitat.	
Available Strategies	**Responsible Group**
1. At the end of the growing season (or as necessary throughout the year), monitor GUSG habitat and total utilization (e.g., cattle, sheep, wild ungulates, insects), and/or vegetation structure available during the important grouse use period, and adjust grazing management plans as necessary to achieve desired vegetation structure for GUSG (See "Habitat Monitoring" rangewide strategy, pg. 220, and Appendix H).	BLM, CDOW, NRCS, Private Landowners, UDWR, USFS
2. If monitoring evaluation indicates vegetation structure is not meeting structural habitat guidelines (Appendix H) for seasonal habitats (within the potential of a site) over 2 consecutive years, identify the problem and implement needed actions (see the guidelines below) to resolve problem.	BLM, CDOW, NRCS, Private Landowners, UDWR, USFS
3. Evaluate impact of grazing on GUSG and develop grazing BMP's for sage-grouse management (see "Research" rangewide strategy, pg. 247, Objectives 2 and 8).	BLM, CDOW, NRCS, UDWR, USFS

The grazing management guidelines presented here represent a partial list of grazing management practices that may be compatible with achieving GUSG habitat objectives. Local grazing prescriptions should specify timing, intensity, duration, and frequency of grazing, that together provide a recovery period for plant health and maintenance, and fit the specific circumstances (both biotic and abiotic factors) unique to that area, including other resource or operational considerations. This site specificity also maximizes potential flexibility or opportunities for each situation including incorporating private, state, and/or federal lands to reach habitat objectives.

Grazing Management Guidelines for GUSG:

1. With GUSG seasonal habitat use in mind, control the distribution of livestock, duration of use, and the time of year that livestock graze a particular location by using grazing systems such as rest-rotation, deferred rotation, or high intensity/short duration. Allow for growth or re-growth in each pasture during each growing season to provide quality vegetation and vegetation height requirements during periods of sage-grouse seasonal use (refer to "GUSG Structural Habitat Guidelines", Appendix H).

2. Use alternative pastures to avoid using sage-grouse seasonal use areas during or immediately before important use periods, if possible.

3. Where possible, do not graze the same pasture at the same time of year for consecutive years. If not possible, develop smaller grazing units within large pastures using salting, supplements, water, herding, or fencing to facilitate improved grazing practices.

4. Avoid over-utilization around riparian areas, water sources, bottoms and draws, and along benches, by diverting more utilization to slopes and ridge tops.

5. If needed, limit livestock use from pastures or allotments or change management plans when abnormal environmental events occur (e.g., drought, heavy snow fall, flooding) and stress vegetation.

6. As necessary, periodically graze lek sites moderately to heavily, to maintain site openness that GUSG require. Note: temporary fencing, herding, or increased stocking rate could be used, but needs to be limited to specific lek site, so as to not overgraze surrounding area.

7. Avoid placing salt, minerals or supplements near leks.

8. The timing and location of livestock turnout and trailing should not contribute to livestock concentrations in lek areas during the breeding season (late March through May).

9. Develop, when needed, alternative water sources to distribute livestock and improve water availability for wildlife and GUSG.

10. If monitoring data indicate forb vigor is not at proper condition or is declining, defer spring grazing periodically to increase forb vigor and occurrence. Lightly or moderately graze deferred areas following nesting or in the fall. Monitor to determine actual growth of grass during spring and summer deferment.

11. For late-successional sagebrush stands that don't meet habitat objectives for GUSG seasonal habitats, use mechanical, chemical, or grazing treatments that will rejuvenate new sagebrush growth and improve sagebrush quality and age diversity, as well as understory.

12. Treat sagebrush (e.g., mechanical, grazing, or chemical treatments) and manage grazing in historic riparian areas to increase riparian zone and raise the water table to reestablish riparian grasses and shrubs for brood-rearing habitat.

13. To improve vegetation composition and forage, plant forb seed in rangelands that lack forbs and have enough moisture and the soil characteristics to establish and support forbs.

14. Defer grazing in treatment areas for 2 full growing seasons after treatment, unless needed for seedbed preparation or desired understory and overstory are established.

Habitat Enhancement

Numerous observational studies have correlated the decline of sage-grouse populations with sagebrush treatment (Klebenow 1969, Wallestad and Pyrah 1974, Wakkinen 1990, Connelly et al. 1991, Gregg et al. 1994) or removal projects, but there is little research quantifying the positive impacts of habitat "improvements." Although it is widely accepted by wildlife management professionals that improving the quality of habitat can increase survival, recruitment, or other demographic parameters, hence leading to population increases, there has been little experimental research on sage-grouse that demonstrates this concept.

Evaluating Effects of Habitat Quality on GUSG

Recently, new techniques have been developed that may allow a more direct evaluation of habitat quality on sage-grouse chick survival, chick growth, and nest success. Huwer (2004) exposed human-imprinted GRSG chicks to habitats with low, medium, and high forb abundance levels to test the widely-held belief that high forb levels are important to chick growth and survival. She found chick growth rates were positively related with forb abundance level, but no similar association was documented with survival. Artificial nest studies (DeLong et al. 1995, Watters et al. 2002) coupled with telemetry studies (Gregg et al. 1994, Aldridge and Bingham 2002) have found increased nest success when nests were located in areas with higher levels of grass and forbs in the understory.

An alternative landscape level approach is to evaluate the relationship between population size and habitat quality; i.e., compare the average population density in areas with generally "good" habitat to population density in "poorer" quality habitat. This process could help explain some of the variability not explained by the mathematical relationship between amount of habitat and average population size (see "Analysis: GUSG Population Size in Relation to the Amount of Available Habitat", pg. 186). For example, if an analysis shows a linear relationship between the amount of habitat and abundance of a species, individual data points will usually lie somewhat above or below the line.

Although subjective and qualitative, the relationship between the quality of habitat within a given population and population size may be discernable. GRSG populations with relatively good habitat (intact sagebrush stands with age-class diversity and high quality understories) such as North Park and portions of northwestern Colorado, have recent lek counts above the number predicted by the habitat regression model (Fig. 38, pg. 195). In contrast, GUSG areas with relatively poor quality (and highly fragmented) sagebrush habitats such as Dry Creek and Monticello are below the predicted number (Fig. 38, pg. 195).

Habitat Improvement Approach

Public land management agencies will continue to improve the quality of sagebrush communities on public land through grazing management, fencing, re-seeding, fuels management, and other treatment projects. In addition, the CDOW and UDWR manage properties within the range of GUSG to improve habitat quality. CDOW and UDWR also build habitat improvement strategies into management plans on easements that are acquired. The NRCS provides technical advice on sage-grouse habitat improvement projects (giving them high priority), and continues to avoid funding sagebrush removal projects that could prove detrimental to sage-grouse.

To assist with habitat improvement on private land, the RCP identifies funding sources and programmatic guidelines for local work groups to use as cost-share opportunities to implement habitat improvement strategies (Appendix C). Potential habitat improvement options available to the work groups are identified in the "Local Conservation Targets and Strategies" section for each population (beginning pg. 255). In addition, the ecological relationships and taxonomy of sagebrush and associated communities are available (Monsen 2005, Winward 2004), as well as treatment techniques that can be applied to improve or maintain healthy sagebrush communities. We offer several recommendations and observations regarding habitat improvements:

(1) Habitat improvement should be directed at specific and quantifiable ecological problem(s) (Monsen 2005, Winward 2004). Projects should have specific and quantifiable goals. Some past and current projects have the goal of enhancing the herbaceous (grass and forb) understory in areas that already have sufficient structural characteristics given the ecological status of the community. Expensive sagebrush manipulation projects that provide short-term herbaceous results should be viewed cautiously. Effort is best directed towards, for example, truly degraded sagebrush communities (e.g., breeding habitat that does not meet the "GUSG Structural Habitat Guidelines", Appendix H), improving riparian areas, reconstituting water tables by repairing down-cut banks, or piñon-juniper removal.

(2) The PVA analysis (pg. 168) illustrates that modeled GUSG population growth rates are most sensitive to nest success and chick survival. Therefore improvement, maintenance, or protection of productive breeding and summer habitat may show the greatest return for the effort and/or money.

(3) Treatments should be sufficient in aggregate (over time) to have a population level effect, but individual projects should be relatively small in scale if they involve the removal of sagebrush (Connelly et al. 2000).

(4) Have patience. Many of the local conservation plans have unrealistic expectations regarding how quickly projects could or should be accomplished, and how quickly vegetation and GUSG populations might respond. Habitat improvement projects are expensive, often require extensive review, and are long-term in nature. It is important to schedule treatments and management actions in a manner that maintains adequate suitable habitat while other areas are recovering.

(5) In all habitat planning efforts, consult and apply the concepts and techniques provided in Monsen (2005) and Winward (2004).

Specific Steps for Habitat Improvement

A strategy for increasing and protecting sage-grouse populations includes the restoration of vegetation conditions that improve seasonal habitat needs for sage-grouse. Three essential steps are suggested for designing habitat restoration projects for GUSG.

The first step is to identify the sage-grouse seasonal habitat component in the project area that is lacking or needs improvement (see “GUSG Structural Habitat Guidelines”, Appendix H). For instance, good nesting habitat consists of live sagebrush with sufficient canopy cover and an adequate grass and forb understory (see “GUSG Structural Habitat Guidelines”, Appendix H). If nest success is documented or suspected to be less than optimal, then conditions may exist where improvement of the shrub overstory or herbaceous understory in breeding habitat delineated for the population of interest may require intervention.

The second step is to gain an understanding of the site characteristics (site potential and community identification) of the area needing improvement. Of primary importance is identification of the individual species or subspecies of sagebrush that exists in the area. The RSC strongly recommends the use of Winward (2004) to identify the taxonomy and distribution of sagebrush in Colorado. It is essential that this step is completed prior to further planning as the sagebrush species or subspecies naturally adapted to the site of interest will determine the suite of possible management actions for a successful treatment. Attempting to change community types (e.g., black sagebrush to Wyoming big sagebrush) is inadvisable (Monsen 2005). Sagebrush species have evolved to differing ecological conditions. Knowledge of the vegetation, soils, and precipitation regimes of the treatment area need to be acquired (Monsen 2005). For instance, basin big sagebrush communities normally occupy deeper soils with slightly higher soil moisture than sites dominated by Wyoming big sagebrush. Occurrence of silver sagebrush, black sagebrush, and low sagebrush is related to specific soil conditions (Winward 1983).

The third step is to select the appropriate management and remedial treatment measures that could be successfully applied to the site to assist in meeting treatment goals. Monsen (2005) recently completed a detailed manual addressing the myriad of issues associated with sagebrush community restoration. We recommend that managers consult and apply Monsen (2005) to assist and guide the treatment planning phase of the project to design appropriate restoration options and application of techniques (e.g., timing of treatments, reestablishment of sagebrush, seeding practicality, seedbed preparation).

Objective 1: Conduct proper background planning for vegetation restoration/improvement projects that provide the structural habitat requirements in breeding, summer - fall, and winter sage-grouse habitats	
Available Strategies	**Responsible Group**
1. Identify sage-grouse habitat treatment objective in treatment area (see “GUSG Structural Habitat Guidelines”, Appendix H).	BLM, CDOW, NPS, NRCS, UDWR, USFS
2. Identify ecological site characteristics and sagebrush species associated with project area.	BLM, CDOW, NPS, NRCS, UDWR, USFS
3. Utilize Monsen (2005), and select appropriate treatment options suitable for the site characteristics and treatment objectives.	BLM, CDOW, NPS, NRCS, UDWR, USFS
4. Work cooperatively with the Uncompahgre Plateau Project and other entities in the development and storage of native seed for restoration purposes.	BLM, CDOW, NPS, NRCS, UDWR, USFS

Objective 2: Conduct and monitor restoration techniques for improvement of the vegetation structure requirements necessary for productive breeding, summer - fall, and winter sage-grouse habitats.	
Available Strategies	**Responsible Group**
1. Conduct pre-restoration monitoring using a recognized technique appropriate to measure treatment objective	BLM, CDOW, NPS, NRCS, UDWR, USFS
2. Implement appropriate treatment/restoration action(s) (Monsen 2005)	BLM, CDOW, NPS, NRCS, UDWR, USFS
3. Monitor vegetation response to treatments in manner/timing appropriate to treatment type (see "Habitat Monitoring" strategy, pg. 220).	BLM, CDOW, NPS, NRCS, UDWR, USFS
4. Evaluate the impact of treatments on GUSG (see "Research" strategy, pg. 247, Objective 2).	CDOW, UDWR

Habitat Linkages Among Populations

We have identified extensive areas for potential linkages between currently isolated GUSG populations (see "Habitat Linkages Among GUSG Populations", pg. 163). These linkages may enhance the demographic and genetic viability of GUSG. These heterogeneous landscapes are composed of patches of landcover types frequently used by sage-grouse (e.g., sagebrush and sagebrush-grass mix) within a mosaic of contrasting land forms and land uses. Updated GIS analyses are needed to refine the distribution and evaluate the relative effectiveness of potential linkages. The effectiveness of a potential linkage will depend on the ability of GUSG to move among the isolated patches within a linkage. These movement patterns will likely depend on the composition (how much of the suitable landcover types are present in the landscape) and configuration (the size and shape) of the patches in the landscape. Seasonal movement and dispersal patterns of GUSG are not known well enough to be able to predict whether the birds will use linkages, or how landscape features may facilitate or impede dispersal movements. Understanding the effect of landscape features on dispersal patterns of GUSG is a critical step toward evaluating the effectiveness of the proposed population linkages (see Objective 1 below, and "Research" rangewide strategy, pg. 247, Objective 2, Strategy 1). Development of linkages between current GUSG populations is a relatively low conservation priority. Our first priority is to protect as much of currently occupied habitat as necessary, and then work towards establishing linkages as we gain more knowledge about land cover types and how they are used by GUSG.

Objective 1: Understand how sage-grouse move and disperse through fragmented and patchy habitats and how vegetation composition and landscape features facilitate or impede dispersal.

Available Strategies	**Responsible Group**
1. Design and conduct research to measure GUSG movement patterns and dispersal across contiguous and fragmented habitats, and how landscape features, such as vegetation composition and landscape, facilitate or impede dispersal.	BLM, CDOW, NPS, USFS

Objective 2: Facilitate gene flow and dispersal of sage-grouse among populations and subpopulations across habitat linkages.

Available Strategies	**Responsible Group**
1. Refine identification of potential linkages and prioritize possible habitat linkages between populations based on additional knowledge gained through research and updated GIS analyses.	BLM, CDOW, NPS, UDWR, USFS
2. Protect from permanent loss linkages that are demonstrated to allow for gene flow among populations (for protection strategies, see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223).	BLM, CDOW, NPS, USFS

Objective 2: Facilitate gene flow and dispersal of sage-grouse among populations and subpopulations across habitat linkages.	
Available Strategies	**Responsible Group**
3. Based on additional knowledge gained through research, identify areas on publicly owned land where habitat improvement efforts could restore functional linkages among populations.	BLM, CDOW, NPS, UDWR, USFS
4. Based on additional knowledge gained through research, identify areas on privately owned land where habitat improvement and protection efforts could restore functional linkages among populations.	CDOW, UDWR
5. Conduct habitat treatments to restore functional linkages among populations where feasible.	BLM, CDOW, NPS, UDWR, USFS

Habitat Monitoring

An adaptive management approach is recommended for all actions designed to benefit sage-grouse habitat. This means important sage-grouse habitat should be identified, habitat quality should be assessed, and changes in habitat should be monitored. This habitat monitoring will allow managers to evaluate management success, refine management programs, and identify additional habitat management needs (see “Habitat Enhancement” rangewide strategy, pg. 214). For GUSG, we will focus habitat monitoring at 2 scales: the rangewide (or landscape) scale, and the local (local population or conservation plan) scale.

Rangewide monitoring for GUSG will be based on the 2 rangewide mapping and habitat assessment efforts described in the Conservation Assessment of this plan (see “GUSG Habitat Mapping Efforts”, pg. 54). Upon completion of the RCP, a more intensive CDOW mapping effort will be undertaken, primarily to further refine the current habitat categories. Habitat definitions will be adjusted and new definitions will be incorporated into future CDOW mapping efforts to improve landscape level habitat mapping efforts.

GUSG seasonal habitat should be mapped (see Objective 1, Strategy 8); until then, the following seasonal habitat definitions should be used:

Breeding Habitat: Sagebrush communities delineated within 4 miles of an active strutting ground (lek) (see “GUSG Disturbance Guidelines”, Appendix I, for discussion). Breeding habitat includes active strutting grounds (leks), nesting and early brood-rearing habitat (Connelly et al. 2000), usually in use from mid-March through late-June.

Summer – Fall Habitat: vegetation communities including sagebrush, agricultural fields, and wet meadows (Connelly et al. 2000) that are within 4 miles of an active strutting ground (lek) (see “GUSG Disturbance Guidelines”, Appendix I for discussion).

Winter Habitat: sagebrush areas (Connelly et al. 2000) that have sufficient shrub height to be above winter snow cover (see “GUSG Disturbance Guidelines”, Appendix I for discussion).

Local scale habitat monitoring quantifies vegetation structural characteristics and plant species diversity. Ideal habitat conditions vary among different GUSG seasonal habitats such as breeding, summer - fall, and winter (see “GUSG Structural Habitat Guidelines”, Appendix H). Data from local habitat monitoring can serve to (1) assess current vegetation conditions; (2) compare current vegetation conditions with established habitat guidelines; and (3) evaluate the short-term and/or long-term vegetation response to environmental changes or human-induced treatments (project effectiveness monitoring).

Local habitat monitoring and assessment efforts must be consistent so that information can be shared, compiled, and compared across the range of GUSG. Therefore, *minimum* data standards will be developed in compliance with the accepted BLM/USFS monitoring protocol for use in occupied or potential sage-grouse habitat. It is understood that local offices, agencies, and work groups may collect additional data (within budget and personnel constraints), to achieve specific monitoring objectives.

Objective 1: On a rangewide basis: identify and delineate current GUSG habitat and track future changes in habitat.	
Available Strategies	**Responsible Group**
1. Develop inventory technique(s) for searching "vacant/unknown" habitat areas to determine grouse presence/use and to assist in distinguishing between and delineating (using GIS mapping) "suitable vacant" areas and "suitable unknown" areas.	CDOW Completion Date: 2005
2. Develop survey technique(s) to use in searching for new or unknown leks.	CDOW Completion Date: 2005
3. Update CDOW and UDWR habitat map using new habitat categories: "Suitable Occupied", "Suitable Unknown", "Suitable Vacant", and "Potentially Suitable Habitat" *. Within the "Potentially Suitable Habitat" category, consider relative restoration priority of each habitat area. Resolve mapping issues with all mapped categories at CO/UT state line.	BLM, CDOW, NPS, NRCS, UDWR, USFWS, USFS Completion Date: 2006
4. Review and update GUSG rangewide habitat-related mapping efforts.	BLM, CDOW, UDWR Completion Date: Every 10 years
5. Delineate sagebrush communities by species and/or groups of species using GIS modeling techniques.	BLM, CDOW, NPS, NRCS, UDWR, USFS
6. Create a central GIS database to track all sagebrush modification treatments and natural disturbances across GUSG range. This task will include database maintenance and updates.	BLM, CDOW, NPS, NRCS, UDWR, USFS, USFWS Completion Date: 2006
7. Define GUSG seasonal habitats for use in GIS mapping. Incorporate GIS modeling techniques such as slope and aspect, observational data, and habitat assessment data into the definitions.	CDOW, UDWR Completion Date: August, 2005
8. Map GUSG seasonal habitats in a GIS as defined in Strategy #7 above.	BLM, CDOW, NPS, NRCS, UDWR, USFS, USFWS Completion Date: June, 2006
9. Evaluate the impact of the amount and spatial arrangement of GUSG habitat on GUSG (see "Research" rangewide strategy, pg. 247, Objective 2.)	CDOW, UDWR
10. Develop a method of reporting and archiving data that facilitates evaluation of the effectiveness of management programs and how they meet the habitat objectives outlined in this plan.	BLM, CDOW, NPS, NRCS, UDWR, USFS, USFWS Completion Date: 2005

* *Suitable Occupied Habitat*: Areas known to be used by sage-grouse within the last 10 years from the date of mapping. "Use" is defined as (1) radiotelemetry locations; (2) confirmed observations of grouse or grouse sign by reliable sources; or (3) documented use reported in unpublished reports or publications.

Suitable Unknown Habitat: Suitable and historic habitat adjacent to *Suitable Occupied Habitat*, where use by sage-grouse has not been documented but could occur. Habitat is similar to that within known occupied habitats.

Suitable Vacant Habitat: Sagebrush habitat within the historic range of sage-grouse that is not mapped as the above 2 categories (*Suitable Occupied* or *Suitable Unknown*).

Potentially Suitable Habitat: Habitat that is capable of producing sagebrush communities that could be occupied by sage-grouse, but would require a human- or non-human-induced perturbation. These areas have soils or other historic information (photos, maps, reports, etc.) indicating that sagebrush was the predominant cover type. These sites could include areas that have succeeded to non-sagebrush cover types (e.g., piñon-juniper).

Objective 2: On a local basis: identify and delineate current GUSG habitat and track future changes in habitat.

Available Strategies	**Responsible Group**
1. To establish the minimum information to be collected in local habitat monitoring: write a standard protocol that identifies which habitat variables should be measured (e.g., grass height), and which techniques should be used to measure them.	RSC Completion Date: 2005
2. Assess habitat condition using standard protocol and compare results to "GUSG Structural Habitat Guidelines" (Appendix H). Report data in format developed in Objective 1, Strategy 10.	BLM, CDOW, Local Work Groups, NPS, NRCS, UDWR, USFS
3. Obtain funding sources to support monitoring implementation on a rangewide basis for local populations.	RSC
4. Evaluate the impact of vegetation condition on GUSG (see "Research" rangewide strategy, pg. 247, Objective 2).	CDOW, UDWR

Objective 3: Determine if the west side of the San Luis Valley should be considered historic GUSG habitat.

Available Strategies	**Responsible Group**
1. Using historic photos, historic accounts, soils information, and other available information, determine whether the area mapped as 'Questionable' pre-settlement habitat (Fig. 3, #4, pg. 33) actually contained sagebrush at one time.	RSC Completion Date: 2005

Habitat Protection from Permanent Loss

Protecting GUSG habitat from permanent loss is key to conserving the species. Although conversion of sagebrush habitat to new agricultural fields could impact GUSG, the most serious threat of habitat loss is from subdivision development. Maintaining sustainable rural economies, where traditional land uses compatible with sage-grouse are profitable, can significantly reduce threats associated with subdivision development. This strategy is not intended to address permanent or temporary habitat loss due to factors other than housing development or agricultural conversion.

While protecting 100% of all habitats used by GUSG in each population might be desirable, attempting to do so in any one population will detract resources from protecting the most important habitats in other populations (since habitat protection is very expensive and funding is likely to be limited). From a conservation standpoint, some habitat loss can probably be absorbed by GUSG, or mitigated by habitat improvements or additions. For this reason we set an objective of protecting 90% of the seasonally important habitats (as mapped; see "Habitat Monitoring" rangewide strategy, pg. 220, Objective 1, Strategy 8 for strategy regarding mapping seasonal habitats) for each population.

Note that Table 22 (see pg. 160) should be used to assist in ranking habitat protection priorities among populations, given limited funding.

Objective 1: Maintain 90% of seasonally important habitats (combined public and private, as mapped) within each population, by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154, and Appendix F). If seasonally important habitats are not mapped for a given population, the objective is to maintain 90% of those vegetation communities within occupied habitat that are likely used by GUSG (for discussion of these communities see "Model Development", pg. 186).	
Available Strategies	**Responsible Group**
1. Obtain conservation easements and implement management plans through the CSCP program.	CDOW
2. Complete conservation easements and management agreements for qualifying landowners as allowed by available funding.	CDOW, NGO's, UDWR
3. Develop and implement CCAA's with private landowners willing to maintain or enhance important habitat for GUSG.	CDOW, UDWR, USFWS Completion Date: 2006 or if/when GUSG are listed under the ESA.
4. Establish GIS datalayer of conservation easements that have sage-grouse considerations, using common attributes among populations and agencies.	RSC, CDOW, NGO's, UDWR
5. Incorporate sage-grouse considerations into existing easements as opportunities arise and innovative ideas become available.	CDOW, NGO's, NRCS, UDWR

Objective 1: Maintain 90% of seasonally important habitats (combined public and private, as mapped) within each population, by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154, and Appendix F). If seasonally important habitats are not mapped for a given population, the objective is to maintain 90% of those vegetation communities within occupied habitat that are likely used by GUSG (for discussion of these communities see "Model Development", pg. 186).	
Available Strategies	**Responsible Group**
6. Obtain fee title to important habitats through purchase, land exchanges, or mineral rights acquisition.	BLM, CDOW, NRCS, USFS, UDWR
7. Enroll important habitats in conservation programs with incentive payments to landowners under the Farm Bill (e.g., CRP, EQIP, WRP, WHIP, Grassland Reserve).	CDOW, NGO's, NRCS, UDWR, USFWS
8. Work with county governments to discourage interference of urban development with objective 1. Provide information to county governments on status, location, and possible effects of different land uses on sage-grouse in their county. Provide examples of policy language used by other counties.	CDOW, NGO's, UDWR, USFWS
9. Develop better predictive models to identify areas at high risk of permanent habitat loss and of high value to GUSG in order to assist with prioritization of habitat protection efforts.	CDOW, UDWR, BLM, NRCS, USFWS, USFS Completion Date: 2009

Objective 2: Evaluate development potential and protection needs within vacant/unknown and potential habitats.	
Available Strategies	**Responsible Group**
1. Complete conservation easements and management agreements for qualifying landowners as allowed by available funding.	CDOW, NGO's, UDWR
2. Develop and implement CCAA's with private landowners willing to maintain or enhance important habitat for GUSG.	CDOW, UDWR, USFWS Completion Date: 2006 or if/when GUSG are listed under the ESA.
3. Incorporate sage-grouse considerations into existing easements as opportunity arises and innovative ideas become available.	CDOW, NGO's, NRCS, UDWR
4. Obtain fee title to important habitats through purchase, land exchanges, or mineral rights acquisition.	BLM, CDOW, NRCS, USFS, UDWR
5. Enroll important habitats in conservation programs with incentive payments to landowners under the Farm Bill (e.g., CRP, EQIP, WRP, WHIP, Grassland Reserve).	CDOW, NGO's, NRCS, UDWR, USFWS

Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads

Potential negative impacts of structures in this category include loss and fragmentation of GUSG habitat, decline in habitat quality, and disturbance to GUSG. Research has not yet been conducted that clearly demonstrates these possible impacts (see "Research" rangewide strategy, pg. 247, for proposed research), but it is prudent to minimize the potential for impacts whenever possible. Each type of structure is addressed in a separate objective, but note that a single type of industry or activity might generate multiple structures and thus multiple objectives should be referenced for that activity (e.g., wind turbine development may include wind turbines, roads, and fences). Information here is drawn from the "GUSG Disturbance Guidelines" presented in Appendix I.

Objective 1: Minimize the potential for negative impact of POWERLINES and other UTILITY CORRIDORS on GUSG and their habitat.	
Available Strategies	**Responsible Group**
1. Identify and map existing powerlines and other utility corridors in GUSG range.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies Completion Date: 2006
2. For placement of new powerlines or other utility corridors, GUSG seasonal habitats should be mapped and avoided whenever possible. If seasonal habitats are not mapped, construction should be avoided within the buffers described in "GUSG Disturbance Guidelines" (Appendix I).	BLM, CDOW, Local Work Groups, NPS, UDWR, USFS
3. If utility corridors are constructed within mapped GUSG seasonal habitats encourage burial of the utility, or retrofit powerlines and other overhead structures to deter raptor perching.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
4. To minimize GUSG collisions with powerlines or other overhead structures, encourage appropriately marking structures when they are near leks and other important seasonal GUSG habitat.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
5. Activities associated with utility corridors should be conducted according to the "GUSG Disturbance Guidelines" (Appendix I). Routine maintenance and emergency repairs are not restricted by the timing guidelines.	BLM, CDOW, NPS, UDWR, USFS
6. If habitat disturbances occur that will require habitat restoration, the potential vegetation community needs to be identified (Winward 2004) and a diverse seed mixture of native shrubs, grasses, and forbs should be used (Monsen 2005).	BLM, CDOW, NPS, UDWR, USFS

Objective 1: Minimize the potential for negative impact of POWERLINES and other UTILITY CORRIDORS on GUSG and their habitat.	
Available Strategies	**Responsible Group**
7. Evaluate the impact of powerlines and other utility corridors on GUSG and GUSG habitat (see "Research" rangewide strategy, pg. 247, Objectives 2 and 7).	CDOW, UDWR, Utility Companies

Objective 2: Minimize the potential for negative impact of WIND TURBINES and COMMUNICATION TOWERS on GUSG and their habitat.	
Available Strategies	**Responsible Group**
1. Identify and map existing wind turbines and communication towers in GUSG range.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
	Completion Date: 2007
2. For placement of new wind turbines or communication towers, GUSG seasonal habitats should be mapped and avoided whenever possible. If seasonal habitats are not mapped, construction should be avoided within the buffers described in 'GUSG Disturbance Guidelines" (Appendix I).	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
3. If wind turbines or communication towers are constructed closer to GUSG habitat than the minimum distance guidelines, retrofit all aspects of towers to deter raptor perching.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
4. To minimize GUSG collisions with wind turbines, communication towers, and associated guy wires, encourage appropriately marking structures and/or altering tower features when near leks and other important seasonal GUSG habitat.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
5. Activities associated with wind turbines, communication towers, and associated infrastructure should be conducted according the "GUSG Disturbance Guidelines" (Appendix I). Routine maintenance and emergency repairs are not restricted by the timing guidelines.	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
6. If habitat disturbances occur that will require habitat restoration, the potential vegetation community needs to be identified (Winward 2004) and a diverse seed mixture of native shrubs, grasses, and forbs should be used (Monsen 2005).	BLM, CDOW, NPS, STL, UDWR, USFS, Utility Companies
7. Evaluate the impact of wind turbines, communication towers, and associated infrastructure on GUSG and GUSG habitat (see "Research" rangewide strategy, pg. 247, Objectives 2 and 7).	CDOW, UDWR, Utility Companies

Objective 3: Minimize the potential for negative impact of FENCES on GUSG and their habitat.	
Available Strategies	**Responsible Group**
1. For placement of new fences, GUSG seasonal habitats should be mapped. New fences should not be placed within 0.6 mi of active leks.	BLM, CDOW, NPS, STL, UDWR, USFS
2. If fences are constructed closer than 0.6 mi to leks, or within other known GUSG seasonal habitats, then when possible, placement of fences should use topographic features to minimize possibility of GUSG collisions. Fences should be clearly marked for increased visibility and decreased probability of collision. Discourage the use of net-wire fencing if possible to allow easier movement of grouse under fences. Consider options to reduce possibility of raptors perching on fences. If fences are needed for seasonal livestock use, consider using let-down fences that can be put down during times of non-use.	BLM, CDOW, NPS, NRCS, STL, UDWR, USFS
3. Timing of activities should be modified according to the GUSG seasonal habitat in the area and the timing guidelines provided in Appendix I.	BLM, CDOW, NPS, NRCS, STL, UDWR, USFS
4. If habitat disturbances occur that will require habitat restoration, the potential vegetation community needs to be identified (Winward 2004) and a diverse seed mixture of native shrubs, grasses, and forbs should be used (Monsen 2005), if possible.	BLM, CDOW, NPS, NRCS, STL, UDWR, USFS
5. Evaluate the impact of fences on GUSG and GUSG habitat (see "Research" rangewide strategy, pg. 247, Objectives 2 and 7).	CDOW, UDWR

Objective 4: Minimize the potential for negative impact of ROADS on GUSG and their habitat.	
Available Strategies	**Responsible Group**
1. Identify and map roads in GUSG range.	BLM, CDOW, NPS, UDWR, USFS Completion Date: 2010
2. For placement of new roads, GUSG seasonal habitats should be mapped and avoided whenever possible. If seasonal habitats are not mapped, construction should be avoided within the buffers described in "GUSG Disturbance Guidelines" (Appendix I).	BLM, CDOW, County Governments, NPS, STL, UDWR, USFS
3. Timing of activities should be modified according to the GUSG seasonal habitat in the area and the timing guidelines provided in Appendix I.	BLM, CDOW, County Governments, NPS, STL, UDWR, USFS

Objective 4: Minimize the potential for negative impact of ROADS on GUSG and their habitat.	
Available Strategies	**Responsible Group**
4. If new roads are constructed within GUSG habitat, encourage appropriate governing authorities to restrict speed limits to 35 mph. Road should be constructed to avoid line-of-sight between strutting males and road/associated traffic.	BLM, CDOW, NPS, STL, UDWR, USFS
5. Consider GUSG habitat when determining allocation designations for user created routes. This should be done when developing activity or LUP level Travel Management Plans.	BLM, NPS, USFS
6. If habitat disturbances occur that will require habitat restoration, the potential vegetation community needs to be identified (Winward 2004) and a diverse seed mixture of native shrubs, grasses, and forbs should be used (Monsen 2005).	BLM, CDOW, County Governments, NPS, NRCS, STL, UDWR, USFS
7. Evaluate the impact of roads on GUSG and GUSG habitat (see "Research" rangewide strategy, pg. 247).	CDOW, UDWR

Hunting

If GUSG populations increase, there may be renewed interest in hunting the species. It is important to identify the steps necessary to address this possibility in a reasonable and biologically sound manner.

Objective 1: Institute recreational harvest of GUSG when and if populations can sustain it.	
Available Strategies	**Responsible Group**
1. Retain closed seasons while GUSG are classified as a candidate, threatened or endangered species.	CDOW, UDWR
2. Develop models to evaluate the impact of hunting removal of adult and juvenile male and female grouse under assumptions of additive vs. compensatory removal.	CDOW
3. Consider, with appropriate public input, opening hunting seasons when GUSG is no longer either a Candidate species for, or on, the list of threatened and endangered species. If the decision is made to allow hunting, develop season structures and other regulations to restrict harvest to 5-10% of the fall population, and to shift harvest away from adult females to the extent practical.	CDOW, UDWR

Information and Education

Informing and educating people about GUSG biology and status, threats to the species, and proposed conservation measures will provide people with an understanding of conservation concerns and perhaps introduce people to an otherwise unfamiliar but interesting avian species native to the western United States.

If planned and executed properly, actual learned objectives can be achieved through some of the current educational practices. Educational goals and objectives such as having participants know and demonstrate understanding of the monetary impact hunting and fishing have, as well as knowing and demonstrating understanding of how endangered species may act as indicator species, have all been successfully accomplished through educational practices. Educational programs have been successful through (1) focusing on school-aged students who will take newly acquired knowledge and communicate that understanding to their guardians at home; and (2) building a solid base of understanding for future generations by reaching youth.

The most successful educational activities in the past have usually been interactive. With manipulative games, interactive CD's, or hands on science, students have the best chance to relate to the concepts being taught. There are 2 basic ways of approaching these activities: (1) using a wide-range but "thin" approach; or (2) using a more specific targeted audience with in-depth coverage. Because GUSG populations are concentrated in specific parts of Colorado and Utah, we recommend targeting a specific audience for the most effective outcome. It is essential to keep landowners informed of the need for habitat protection and improvement, and to provide them information on effective techniques to achieve conservation goals.

Objective 1: **Keep landowners, public land managers, all potential stakeholders, and school children informed about the GUSG and its conservation.**	
Available Strategies	**Responsible Group**
1. Make the RCP and other relevant GUSG conservation information available to the public (e.g., on the RCP website)	CDOW, RSC
2. Continue participation in and dissemination of information to local GUSG work groups.	CDOW, UDWR
3. Establish and show demonstration areas to educate land managers about what good sage-grouse habitat is and how to create and maintain it.	BLM, CDOW, NPS, NRCS, UDWR, USFS
4. Establish and present an award(s) to recognize landowners that implement practices that benefit sage-grouse.	CDOW, NRCS, UDWR
5. Develop a GUSG student curriculum for students in selected school districts within the range of the GUSG.	CDOW, NGO's Completion Date: 2007

Lek Viewing

The protection of GUSG is dependent upon public interest in the species and support of conservation measures. Viewing courtship displays on leks may be of great interest to members of the public, which may translate into additional support for conservation. Nevertheless, lek viewing needs to be managed properly to avoid negative impacts to populations.

Objective 1: **Allow for public viewing of lek activity while minimizing harassment of GUSG at leks.**	
Available Strategies	**Responsible Group**
1. Design and enforce a lek viewing protocol that minimizes potential impacts to GUSG.	BLM, CDOW, Local Work Groups, NPS, UDWR, USFS Completion Date: By lekking season, 2006.
2. Treat lek locations as sensitive information.	BLM, CDOW, NPS, UDWR, USFS
3. Educate public about ethical viewing practices.	BLM, CDOW, Local Work Groups, NPS, UDWR, USFS
4. On public land, promote no more than 1 lek per population as a viewing site.	BLM, CDOW, Local Work Groups, UDWR, USFS
5. Monitor lek attendance patterns at viewing and control leks.	CDOW, UDWR
6. Evaluate the impact of lek viewing on GUSG (see "Research" rangewide strategy, pg. 247, Objective 7).	CDOW, UDWR

Noxious and Invasive Weeds

Although not a principal threat to GUSG populations, limited noxious weed invasions have occurred in some population areas. If not properly contained, these invasions can dramatically degrade the sagebrush habitat upon which GUSG depend. It is important that all work groups take actions now to monitor and minimize weed invasion while it is still manageable.

Objective 1: Minimize impact of noxious and invasive weeds on GUSG habitat.	
Available Strategies	**Responsible Group**
1. Identify and map undesirable noxious and invasive weed invasions that occur within GUSG habitat.	BLM, CDOW, County Governments, NPS, NRCS, SCD, STL, UDWR, USFS
2. Develop and implement control measures for noxious and invasive weeds.	BLM, CDOW, County Governments, NPS, NRCS, Private Landowners, SCD, STL, UDWR, USFS
3. Prevent new damaging invasions of noxious and invasive weeds in GUSG habitat.	BLM, CDOW, County Governments, NPS, NRCS, Private Landowners, SCD, STL, UDWR, USFS
4. Monitor effectiveness of treatments and/or spread of noxious and invasive weeds in GUSG habitat.	BLM, CDOW, County Governments, NPS, NRCS, Private Landowners, SCD, STL, UDWR, USFS
5. Integrate and coordinate weed management efforts with adjacent entities to increase effectiveness.	BLM, CDOW, County Governments, NPS, NRCS, SCD, STL, UDWR, USFS

<u>Oil & Gas Development and Mining</u>

Potential development in GUSG habitat from coal mining activities is minimal. Sand, gravel and other mineral mining activities may be associated with river channels within GUSG habitat. Appropriate suggested management practices (SMP's) for mineral development should be implemented during the planning and implementation phase of all mining sites to minimize impacts to the species (see energy and mineral SMP's in Appendix L). The following narrative provides additional information concerning oil and gas development procedures to aid the reader in the understanding and application of the recommended conservation strategies.

Federal energy resources are developed in Utah and Colorado through a leasing and permitting system. Rules and responsibilities are governed largely by the owner and/or regulator of the mineral estate. It is important to recognize that split estate situations often exist, where someone other than the surface owner owns the mineral estate for a particular parcel of land.

BLM manages the oil and gas resources on public lands as well as those federal minerals where the surface has been patented. BLM and USFS identify the lands open to leasing in their Land Use Plans (LUP's). The LUP's also identify any stipulations and/or conditions of approval needed to mitigate impacts.

Future development is managed on a site-by-site basis via permit with Conditions of Approval after site specific environmental analysis and a sufficient bond is posted. In those cases where the surface and mineral owners are different, both the BLM and state oil and gas commissions require the mineral owner to obtain a surface use agreement prior to permit approval. If the mineral owner is unable to obtain a surface use agreement, both the BLM and state oil and gas commissions have regulatory processes to address the surface use agreement issue. No NEPA analysis is required on private minerals/ non-federal land development processes. However, the owner and operator must abide by rules and regulations of the Colorado Oil and Gas Conservation Commission (COGCC) or the Utah Division of Oil, Gas, and Mining (UDOGM).

This section will be used primarily by those involved with and knowledgeable about the mining and energy industry in some way. Nevertheless, some basic background on the oil and gas development process is useful. The "typical" scenario leading to oil and gas development has several steps:

(1) Geophysical Exploration occurs (more detail follows). During this phase, the reservoir target is identified and a leasing nomination is submitted. Geophysical exploration may occur after the leasing stage as well.

(2) Leasing Stage. An LUP or associated amendment is developed using the NEPA process. Land that is available for oil and gas leasing is identified and stipulations are developed to mitigate impacts. Once a lease is granted, the oil and gas operator has a legal right to reasonable access to the lease for exploration and development, within the stipulation attributed to each parcel.

(3) Drilling Operations (more detail follows). An application for permit to drill (APD) is submitted, and if approved, an exploratory well is drilled. If the result is a "dry hole", the

well is plugged and reclamation occurs. Other APD's are submitted and approved and more exploratory wells are drilled until the company declines further exploration or a producing well is drilled. Once discovery is made, additional wells are drilled. These are development wells and fall under "Production Operations" below.

(4) Production Operations (more detail follows). A right-of-way for a pipeline is obtained and pipeline is installed. Production equipment is installed on the wellpad. The operator makes visits to the wellpad to make sure operations proceed properly and to adjust equipment. Operator submits sundry notices for other operations requiring approval, along with additional APD's. As wells become depleted, the operator obtains approval to plug the well and conduct reclamation.

Details of several of these stages follow, including clarification of which types of activities require various government leases and approvals.

Geophysical Exploration is a general term used for various indirect exploration methods which use geophysical instruments and methods to determine subsurface condition (i.e., the potential for oil and gas) by analysis of such properties as specific gravity, electrical conductivity, or magnetic susceptibility. A geophysical survey is the use of one or more geophysical techniques in geophysical exploration, such as earth currents, electrical, infra-red, heat flow, magnetic, radioactivity and seismic activity.

Most modern seismic exploration is based on the collection of data over a 2- or 3-dimensional grid. This requires thousands of geophones (instruments that detect Earth motions) placed on the ground and recording systems capable of recording ground motion from as many sites. The seismic wave is typically generated by either using a surface vibrator, i.e., a Vibroseis truck, or by an explosive source. Explosive sources are either placed in a drilled shot hole and exploded, or placed on the surface and exploded.

An oil and gas lease is not required to perform geophysical operations on federal lands. Federal approval to perform geophysical operations is required on surface lands administered by BLM or Forest Service.

Drilling Operations include all actions/phases associated with drilling an oil and gas well. They include access road construction, wellpad construction, drilling operations and completion operations. Drilling operations on federal oil and gas leases require an approved APD. Drilling operations consist of the use of a rotary drilling rig to drill a hole to the reservoir target and running open log holes. Completion operations include running cased hole logs, perforating the casing, installing the wellhead and facilities, and any stimulation of the reservoir, including hydraulic fracturing. If the well is dry and/or uneconomic, complete site reclamation is required.

An exploratory (wildcat) well is any well drilled beyond the known productive limits of any pool or field. A development well is any well drilled within the known productive limits of a pool or field for the purpose of obtaining oil and/or gas from the producing formation(s) in that field.

Production Operations include all actions/phases associated with production of oil and gas that occur after the drilling and completion of the well. They include pipeline construction, production equipment installation (separators, dehydrators, tanks), meter installation, compression installation, oil sales and hauling, water disposal and hauling, and interim wellpad reclamation activities. Production operations are approved via sundry notices and/or right-of-ways. Sundry notices are required to change wellbore configuration, change metering and measurement, or for anything with new surface disturbance. Complete site reclamation occurs in the future after the well depletes and becomes uneconomic.

An oil and gas lease is required for all drilling and production activities. Inspections to assure compliance with regulations, stipulations and other orders are made by BLM and the COGCC or UDOGM.

Additional strategies that relate to Oil and Gas operations may be listed under the "Human Infrastructure" rangewide strategy (pg. 225).

Objective 1: Minimize mining and energy development impacts to GUSG habitat through planning. These strategies may differ in their application to the separate GUSG populations (as opposed to those in Objective 2).	
Available Strategies	**Responsible Group**
1. Identify federal lands open for Oil and Gas leasing during the land use planning process, while considering the impacts of mineral development on currently unleased GUSG habitat. Cumulative impacts of both leased and unleased GUSG habitat will be analyzed through projected development (reasonable foreseeable development- RFD) in the planning process.	BLM, USFS
2. Specific mitigation and exception criteria will be evaluated and implemented during the federal land use planning process and attach them to the lease as stipulations upon issuance.	BLM, USFS
3. Wherever possible, incorporate 'conditions of approval' (site specific mitigation measures) on proposed operations, consistent with lease rights. Mitigation outside of standard lease rights may be implemented if it is demonstrated that a combination of alternative mitigation measures does not reduce impacts to an acceptable level and those impacts constitute unnecessary and undue degradation of public lands and resources OR if mitigation is voluntarily implemented by the operator.	BLM, USFS
4. Encourage oil and gas companies to participate on local GUSG conservation work groups.	BLM, CDOW, UDWR, USFS
5. On private lands encourage CCAA development that incorporates SMP's for mineral development (see Appendix L).	CCAA Cooperators, CDOW, Private Landowners, UDWR, USFWS
6. Encourage counties, local work groups and private landowners to be involved in state oil and gas commission meetings, in order to comment on wellpad spacing densities and comprehensive planning within GUSG habitats.	BLM, CDOW, County Governments, Local Work Groups, NRCS, Private Landowners, UDWR, USFS

Objective 1: Minimize mining and energy development impacts to GUSG habitat through planning. These strategies may differ in their application to the separate GUSG populations (as opposed to those in Objective 2).	
Available Strategies	**Responsible Group**
7. If federal mining estate development is planned within potential breeding habitat (4-mile radius of an active lek): (a) delineate and field validate GUSG seasonal habitats, using methods identified in Connelly et al. 2003, until minimum data standards are established under "Habitat Monitoring" Objective 1, Strategies 7 and 8, Objective 2, Strategy 1.) Review of field data and habitat delineation should be coordinated with local CDOW or UDWR and/or BLM field biologists. (b) Complete a comprehensive development plan for the Geographic Area (except for exploratory wells), which includes measures to avoid or minimize loss of breeding habitat, such as clustering wellpads and associated infrastructure in non-sagebrush habitats.	BLM, CDOW, Oil and Gas Companies, UDWR, USFS
8. Apply "Suggested Management Practices (Appendix L) to minimize long term habitat loss and fragmentation in all sage-grouse seasonal habitats using best available science as guidelines (Connelly et al. 2000) and "GUSG Disturbance Guidelines" (Appendix I).	BLM, CDOW, COGCC, NPS, NRCS, Oil and Gas Companies, Private Landowners, UDOGM, UDWR, USFS
9. The following Lease Notice will be applied to new leases where necessary: "In order to protect crucial GUSG habitat, timing restrictions and controlled surface use may be applied beyond the 60 day and 200 meter standard lease rights. A wildlife and/or botanical inventory may be required prior to approval of operations. The inventory data will be used to apply conservation measures such as relocation of roads, pads, pipelines and other facility designs to reduce the impacts of surface disturbance on crucial GUSG habitat."	BLM, USFS

Objective 2: Minimize mining and energy development impacts to GUSG Habitat. These strategies apply to GUSG rangewide (as opposed to those in Objective 1).	
Available Strategies	**Responsible Group**
1. On federal lands or areas with federal mineral rights, apply a lease stipulation of NSO (no surface occupancy) within 0.6 (6/10ths) mile radius of active leks, for new leases.	BLM, USFS

Objective 2: Minimize mining and energy development impacts to GUSG Habitat. These strategies apply to GUSG rangewide (as opposed to those in Objective 1).	
Available Strategies	**Responsible Group**
2. Encourage and/or offer to have agency biologists attend notice of staking on-site visits on private lands, as well as state and federal mineral estates, to locate well pads and roads outside of important sage-grouse habitat whenever possible. a. Provide a digital layer of important sage-grouse habitat to Oil and Gas (O&G) Conservation Commission to identify opportunities for coordination. b. Encourage agency biologists to talk with O&G companies about willingness to participate in site visits. c. Educate oil and gas companies on GUSG habitat and the importance of protecting key sites.	BLM, CDOW, COGCC, NPS, NRCS, Private Landowners, UDOGM, UDWR, USFS
3. Develop evaluation and monitoring process for meeting reclamation objectives using standard criteria. a. Develop standard monitoring methods for evaluation. b. Identify and implement incremental habitat reclamation objectives.	BLM, CDOW, COGCC, UDOGM, USFS, UDWR
4. Recommend setting bonds sufficient to ensure appropriate GUSG habitat reclamation is met.	BLM, COGCC, County Governments, Local Work Groups, UDOGM, USFS
5. Develop a mitigation process (similar to USFWS mitigation policy). a. Use off-site mitigation, where appropriate to achieve sage-grouse habitat objectives. b. Investigate, evaluate and implement mitigation trusts/banking opportunities, where appropriate.	BLM, CDOW, UDWR, USFS, USFWS
6. Avoid or minimize impacts of sand and gravel operations on sage-grouse habitat. (see mineral and energy SMP's in Appendix L) a. Locate operations outside of lek buffer. b. Place sand and gravel pits in an area with the least amount of impact to brood-rearing habitat (1000 ft. outside of riparian areas where feasible).	BLM, CDOW, NPS, Private Landowners, USFS, UDWR
7. Investigate the impacts of mining and energy development on GUSG habitat (see "Research" rangewide strategy, pg. 247, Objective 2).	CDOW, UDWR

Objective 3: Minimize mining and energy development impacts to GUSG from human disturbance.	
Available Strategies	**Responsible Group**
1. Specific mitigation and exception criteria are evaluated and implemented during the land use planning process and are attached to the lease as stipulations upon issuance.	BLM, USFS
2. Wherever possible, incorporate 'conditions of approval' (site specific mitigation measures) on proposed operations, consistent with lease rights, to avoid important seasonal habitat use periods. Mitigation outside of standard lease rights may be implemented if it is demonstrated that a combination of alternative mitigation measures does not reduce impacts to an acceptable level and those impacts constitute unnecessary and undue degradation of public lands and resources OR if mitigation is voluntarily implemented by the operator.	BLM, COGCC, UDOGM, USFS
3. Encourage CCAA development on private lands which incorporates SMP's for mineral development (see Appendix L).	CDOW, UDWR, USFWS Completion Date: 2006
4. Encourage on private lands and incorporate on federal lands appropriate GUSG conservation measures on all geophysical exploration, to avoid important seasonal habitat use periods.	BLM, CDOW, COGCC, NPS, Private Landowners, STL, UDOGM, UDWR, USFS
5. Prohibit activities during the lekking season within a 0.6 mi. buffer around the lek, or if not possible, avoid the lek buffer from sunset to 2 hours after sunrise. Leks – March 20- May 15 (Exploration, Drilling, Production)	BLM, NPS, Private Landowners, STL, USFS
6. Avoid human activities and construction in mapped seasonal GUSG habitats during the time periods identified in Appendix I.	BLM, Oil and Gas Companies, USFS
7. Investigate impacts of mining and energy on GUSG (see "Research" rangewide strategy, pg. 247, Objective 7).	CDOW, UDWR

Pesticides

Conservation strategies for insecticide use should focus efforts (by NRCS) on (1) educating agricultural producers and cooperators about the potential impacts of insecticide spraying on sage-grouse; and (2) evaluation of specific insecticide types and timing of applications in an effort to minimize the impacts to sage-grouse. Insecticide application should be avoided during early brood-rearing (May-June) when use of insects by sage-grouse chicks is highest. In situations where insecticide application in sage-grouse habitat is unavoidable, alternative insecticides of lower toxicities should be recommended. The use of biological control to control crop-damaging insects and mosquitoes should be encouraged as an alternative to insecticide application whenever possible.

If herbicides are to be used for vegetation management, recommended guidance should be followed (see Objective 2) with care taken to minimize impacts to GUSG.

Objective 1: Avoid insecticide-related direct and indirect mortality to sage-grouse.	
Available Strategies	**Responsible Group**
1. Avoid spraying insecticides in sagebrush areas in May and June; avoid spraying in croplands/riparian areas in July and August.	BLM, CDOW, County Governments, NRCS, Private Landowners, UDWR, University Extension
2. Use alternative chemicals that have lower toxicity to sage-grouse.	BLM, CDOW, County Governments, NRCS, Private Landowners, UDWR, University Extension
3. Investigate the use of natural enemies to crop-damaging insects.	CDOW, NRCS, UDWR, University Extension
4. Develop an educational campaign to provide agricultural producers with information on the effects of insecticides on sage-grouse, possible alternative chemicals or control methods, and application timing that minimizes impacts to sage-grouse chicks.	CDOW, NRCS, UDWR, University Extension
5. Develop an incentive program to encourage agricultural producers to use less toxic methods of insect control.	CDOW, NRCS, UDWR, University Extension
6. Evaluate potential impacts to GUSG when insecticide use is proposed to reduce threats to resources on public lands, such as WNV spread.	BLM, CDOW, NPS, NRCS, UDWR, USFS

Objective 2: Apply herbicides in conjunction with existing guidance, while minimizing impacts to GUSG.	
Available Strategies	**Responsible Group**
1. Apply herbicides in conjunction with recommended guidance in Monsen (2005), where appropriate.	BLM, CDOW, County Governments, NPS, NRCS, Local Work Groups, Private Landowners, UDWR, USFS
2. Apply herbicides on BLM land consistent with BLM Vegetation Treatment EIS (1991).	BLM, CDOW, UDWR

Population Augmentation

Some of the smaller GUSG populations are likely to need augmentation to either avoid extinction or to boost genetic diversity (see "Genetics" rangewide strategy, pg. 208). In addition, it might be feasible to expand current populations and/or to establish new populations in historic habitat. Research into the possible avenues for doing this, including translocations and captive breeding, is necessary.

Objective 1: Reduce modeled extinction probabilities of small populations to less than 1% in 50 years through augmentation with wild-trapped or captive produced birds.

Available Strategies	**Responsible Group**
1. Conduct, by 2010, research to evaluate success of translocating eggs or very young chicks to nests or brood hens (see "Research" rangewide strategy, pg. 247, Objective 3).	CDOW, UDWR, and Other Research Institutions
2. Conduct by 2010, research on captive breeding and rearing techniques (see "Research" rangewide strategy, pg. 247, Objective 3).	CDOW, UDWR, and Other Research Institutions
3. Evaluate procedures to augment populations that decline to 50% of target population size. If a population declines to 75% of target population size, then initiate augmentations with translocated or captive-reared eggs or chicks, following protocols to be developed based on current knowledge (to be modified by research results from strategy 1 above; see discussion in "Population Augmentation" pg. 180). Birds could be transplanted from the Gunnison Basin provided at least 450 males were counted on leks in the spring preceding the transplant.	CDOW, UDWR
4. Establish by 2010, if research in 1 and 2 above prove the efficacy, a captive breeding facility to serve as a reservoir of genetic diversity and to produce eggs and/or young to augment existing populations (as in 3) or genetic diversity until habitat and populations increase and stabilize.	CDOW

Objective 2: Establish sage-grouse populations in all historic, vacant, but suitable habitat through release of wild-trapped or captive produced birds.

Available Strategies	**Responsible Group**
1. Evaluate potential for historic but currently unoccupied sagebrush habitats of 15,000 acres or larger to support GUSG by 2008.	CDOW, UDWR
2. Develop re-introduction protocols based on research discussed above by 2010.	CDOW, UDWR
3. Reintroduce translocated and/or captive-produced eggs and /or young into vacant historical habitat judged suitable.	CDOW, UDWR, USFWS

Population Monitoring and Targets

Current methods of estimating GUSG population size from lek counts make many unsupported assumptions. Research to address these assumptions and establish a more precise estimate is needed.

The population targets in this plan are based on current population estimates and potential habitat conditions (see "GUSG Population Targets Development", pg. 198). Habitat conditions and availability are expected to change over time, necessitating the need for reevaluation of population targets. In addition, population targets should be modified as knowledge of GUSG behavior and use of landscape features improves.

Objective 1: Assess GUSG population size and trends and provide for the long-term monitoring of GUSG.	
Available Strategies	**Responsible Group**
1. Using results of the "Research" strategy (pg. 247, Objective 1), develop statistically defensible methods to estimate population size and/or trends.	CDOW, UDWR
2. Maintain consistent current lek count protocols, but use research results to establish protocols for future population monitoring and record keeping, including mechanisms to insure consistent implementation and reporting.	CDOW, UDWR

Objective 2: Reevaluate population targets as habitat conditions change and knowledge increases with regards to GUSG behavior and population dynamics.	
Available Strategies	**Responsible Group**
1. Use adaptive management approach (pg. 302) to re-evaluate current population targets. Set population targets for any newly established populations.	CDOW, UDWR
	Completion Date: Starting in 2010 and every 5 years thereafter.

Predation

Because some GUSG populations are so small and are embedded in highly fragmented and developed landscapes, intensive predator control should be considered as a short-term management tool when predation causes significant population declines and where legally feasible. An integrated program that includes both intensive and extensive predator control methods may be the most effective but will likely be costly. Any predator control program must follow guidelines established by the CDOW and the UDWR, and include quantifiable objectives and long-term monitoring of both predator and GUSG populations in order to evaluate the effectiveness and validity of the program.

Objective 1: Protect GUSG from excessive predation when populations (3-year average) fall below 25 birds or to 25% of the long-term average goal.	
Available Strategies	**Responsible Group**
1. Identify relevant predator species within local GUSG populations that meet the trigger described above (see “Research” rangewide strategy, pg. 247, Objective 4).	BLM, CDOW, NPS, Other Research Institutions, UDWR, USFS, USFWS
2. Determine age-specific mortality and identify relative risks from avian and mammalian predation within local GUSG populations meeting the trigger described above (see “Research” rangewide strategy, pg. 247, Objective 4).	BLM, CDOW, NPS, Other Research Institutions, UDWR, USFS, USFWS
3. Evaluate whether predator control aimed at specific predator species is an effective management tool that increases production and recruitment of sage-grouse in the local populations meeting the trigger above (see “Research” rangewide strategy, pg. 247, Objective 4).	BLM, CDOW, NPS, Other Research Institutions, UDWR, USDA (APHIS), USFS, USFWS
4. Implement research to better understand the behavioral and spatial interactions of predators with prey and other predator species (see "Research" rangewide strategy, pg. 247, Objective 2, Strategy 2, and Objective 4)	BLM, CDOW, NPS, Other Research Institutions, UDWR, USDA (APHIS), USFS, USFWS
5. Evaluate the large-scale effects of landscape structure (composition and configuration of landcover types) and small-scale effects (vegetation structure and predator exclosures) on predator-prey interactions (see “Research” rangewide strategy, pg. 247, Objective 4).	BLM, CDOW, NPS, Other Research Institutions, UDWR, USDA (APHIS), USFS, USFWS
6. Evaluate land use practices that may increase predator populations (e.g., residential development and landfills that may provide artificial food sources for several species of avian and mammalian predators) (see “Research” rangewide strategy, pg. 247, Objective 4).	CDOW, County Governments, UDWR
7. Evaluate the effect of abandoned structures (e.g., farmsteads) that may serve as denning or nesting sites for predators (see “Research” rangewide strategy, pg. 247, Objective 4).	CDOW, UDWR

Objective 1: Protect GUSG from excessive predation when populations (3-year average) fall below 25 birds or to 25% of the long-term average goal.	
Available Strategies	**Responsible Group**
8. If research establishes predator control is likely to be effective, then develop and implement predator management strategies designed for specific GUSG population that is in accordance with CDOW, UDWR, and Federal regulations and policies.	BLM, CDOW, NPS, UDWR, USDA (APHIS), USFS, USFWS

Recreational Activity

Although it has been suggested there might be impacts to GUSG from recreational activities, research is needed to investigate this possibility. General guidelines for minimizing disturbance to GUSG will be useful in addressing any potential impacts.

Objective 1: If recreational activity is suspected in population declines, use experimentally designed studies to evaluate the cause and effect of recreational activity on the productivity and population viability of GUSG.	
Available Strategies	**Responsible Group**
1. Evaluate the effect of recreational activities on mating behavior (e.g., the number of males and females attending leks, time spent on leks by males and females, disturbance of courtship displays on leks by males, or the number of copulations (see “Research” rangewide strategy, pg. 247, Objective 7).	CDOW, Other Research Institutions, UDWR
2. Evaluate the effect of recreational activities on nesting and brood-rearing success (e.g., examine whether nest site selection, nest success and brood survival is greater in areas with little or no disturbance from human activities than areas with intensive recreational use (see “Research” rangewide strategy, pg. 247, Objective 7).	CDOW, Other Research Institutions, UDWR
3. Evaluate the effect of recreational activities on winter flocks (e.g., does snowmobiling decrease winter survival rates of sage-grouse (see “Research” rangewide strategy, pg. 247, Objective 7).	CDOW, Other Research Institutions, UDWR
4. Evaluate the effect of recreational activities on recruitment and long-term population dynamics of GUSG (see “Research” rangewide strategy, pg. 247, Objective 7).	CDOW, Other Research Institutions, UDWR

Objective 2: If it is demonstrated recreational activities are detrimental to the productivity and recruitment of GUSG, then implement strategies to minimize the affect of recreational activities.	
Available Strategies	**Responsible Group**
1. Minimize the effect of recreational activities on publicly-owned properties (where appropriate) by: a. Closing roads that are within 0.6 miles of a lek during the lekking season (March - May). b. Posting warning signs along roads within 2.0 miles of leks. Signs should indicate that the area is important for GUSG breeding and traffic (including hiking, biking, off-road vehicles) in the area is discouraged, March-May, especially at dawn and dusk (see "GUSG Disturbance Guidelines", Appendix I). c. Discouraging recreational activities in areas identified as GUSG winter habitat (during the winter). d. Permanently closing or relocating secondary roads and/or trails where appropriate, within areas identified as important seasonal GUSG habitat. e. If pets are determined to be a significant predator or disturbance factor of sage-grouse and sage-grouse nests (see "Research" rangewide strategy, pg. 247), then pets should be prohibited (or on a leash) in important breeding and nesting areas.	BLM, CDOW, NPS, UDWR, USFS
2. Minimize the effect of recreational activities on privately-owned properties by: a. Encouraging landowners to limit public access to leks and nesting areas on their property by posting warning signs. b. Assisting landowners in developing a responsible lek viewing program that controls access and limits disturbance to leks (see "Lek Viewing" rangewide strategy, pg. 231).	CDOW, Local Work Groups, Private Landowners, UDWR
3. Distribute informational material on the potential harmful effects of recreational activities on breeding, nesting, and winter areas based on results of research studies.	BLM, CDOW, Local Work Groups, NPS, UDWR, USFS

Research

There has been a great deal of speculation about the causes of the recent decline of GUSG populations. Unfortunately, there are few or no data derived from research studies to evaluate the various hypotheses for decline or the effectiveness of conservation actions to reverse it. This section is a summary of specific research needs that have been noted throughout the RCP. This list is meant only to illustrate where information is needed for GUSG. Among the many threats that face GUSG, some people have expressed concern that some research methods (e.g., trapping and radiotelemetry) may potentially harm grouse. While the RSC acknowledges those concerns, it should be noted that all research projects are peer-reviewed and evaluated by an Animal Care and Use Committee. Furthermore, we do not consider research to be a significant threat to a population or, ultimately, to the survival of GUSG. Information gained from scientific studies is indispensable for improving our understanding of the behavior and population dynamics of GUSG. This knowledge is critical to developing reasonable and defendable conservation and management actions and plans. An effective management program will require research studies that incorporate an adaptive management approach that uses acquired scientific information in the implementation of revised research and management plans.

Among the research objectives listed below, we consider the following objectives and their strategies to be the highest priority research needs:

- Objective 1: Develop and evaluate protocols for the inventory and monitoring of GUSG (Strategies 1, 2, 3, 4, 6, and 7).
- Objective 2: Evaluate the effect of habitat quality and quantity on the behavior (e.g., seasonal movement and dispersal) and population dynamics of GUSG (Strategies 1, 2, 3, 4, 5, and 6).
- Objective 3: Evaluate augmentation and captive rearing techniques on the population dynamics of GUSG (Strategies 1, 3, and 4).

Objective 1: Develop and evaluate protocols for the inventory and monitoring of GUSG populations and to evaluate factors that influence the population ecology of GUSG.	
Strategies	**Responsible Group**
1. Determine the validity of using lek counts to estimate population abundance by evaluating the impact of lek attendance (male and female), interlek movement, and sex ratio on population estimation. Evaluate the sources of observer bias and the effect of variability in lek counts on the long-term population dynamics of GUSG.	CDOW, UDWR and Other Research Institutions
2. Evaluate whether lek counts can be calibrated and measurements of accuracy and precision can be assessed using mark-resight or sightability models.	CDOW, UDWR and Other Research Institutions
3. Evaluate alternative methods for estimating population abundance (e.g., line transects or DNA fingerprinting using fecal samples).	CDOW, UDWR and Other Research Institutions

Objective 1: Develop and evaluate protocols for the inventory and monitoring of GUSG populations and to evaluate factors that influence the population ecology of GUSG.	
Strategies	**Responsible Group**
4. Determine the causes of mortality in different age and sex classes and the consequences for population dynamics.	CDOW, UDWR and Other Research Institutions
5. Examine the correlation (and time lag) between the variation in annual productivity and subsequent lek counts and its impact on the precision of population estimates.	CDOW, UDWR and Other Research Institutions
6. Refine the population viability assessment of GUSG based on more accurate and precise estimates of demographic parameters.	CDOW, UDWR and Other Research Institutions

Objective 2: Evaluate the effect of habitat quality and quantity on the behavior and population dynamics of GUSG.	
Strategies	**Responsible Group**
1. Evaluate the effect of the amount, configuration and composition of contrasting habitat types (including sage-grouse seasonal habitats) on sage-grouse behavior (e.g., movement and dispersal), species distribution, productivity, and population dynamics. Map and analyze landscape metrics (e.g., edge density, fragmentation, heterogeneity, fractal dimension), using the most reliable and current GIS data (see Objective 2, Strategy 7) and examine the spatial and temporal correlation with sage-grouse population dynamics. Evaluate the potential for dispersal of individuals into currently unoccupied suitable habitat.	CDOW, UDWR and Other Research Institutions
2. Evaluate the efficacy of remote sensing products and technologies in order to develop GIS databases of sufficient spatial resolution to evaluate the effect of changes in landcover types and land uses on the distribution and population dynamics of GUSG.	BLM, CDOW, UDWR, USFS, USGS, and Other Research Institutions
3. Develop a spatially-explicit population model that incorporates current estimates (with appropriate estimates of temporal and spatial variation) of demography (Objective 1, Strategy 6) and movement (Objective 2, Strategy 1) in order to evaluate the relative effects of changing land uses on GUSG populations.	CDOW, UDWR and Other Research Institutions
4. Evaluate the effect of vegetation structure (e.g., sagebrush canopy height and cover, forb and grass height, diversity, and abundance) on sage-grouse productivity (nest success and brood survival), adult survival and population dynamics.	CDOW, UDWR and Other Research Institutions

Objective 2: Evaluate the effect of habitat quality and quantity on the behavior and population dynamics of GUSG.	
Strategies	**Responsible Group**
5. Examine the temporal and spatial variation in environmental conditions that affect sagebrush habitat (e.g., defoliation or die-off of sagebrush as a result of drought) and their effects on sage-grouse productivity and demographics.	CDOW, UDWR and Other Research Institutions
6. Examine the effects of different habitat treatments on the behavior (e.g., movement patterns), productivity, and population dynamics of sage-grouse.	CDOW, UDWR and Other Research Institutions
7. Evaluate the effect of varying grazing management practices (domestic and wild ungulates) on the quality of sagebrush habitat (e.g., grass and forb abundance, diversity, and vegetation structure) and its relationship to sage-grouse productivity, demographics and population viability; use results to develop grazing BMP's for sage-grouse.	CDOW, UDWR and Other Research Institutions
8. Evaluate the potential impact of, and techniques for, converting CRP to sagebrush habitat on sage-grouse distribution and population viability.	CDOW, UDWR and Other Research Institutions
9. Evaluate the effect of powerlines, fences, roads, mining, energy development (including wind turbines), and other human infrastructure on habitat use, production, nest success, and mortality rates of the different age and sex classes of sage-grouse.	CDOW, UDWR, Utility Companies and Other Research Institutions

Objective 3: Evaluate augmentation and captive rearing techniques on the population dynamics of GUSG.	
Strategies	**Responsible Group**
1. Evaluate the effect of population augmentation on sage-grouse demographics and genetic diversity.	CDOW, UDWR and Other Research Institutions
2. Evaluate timing and procedure of translocating adults (male and female) between existing populations.	CDOW, UDWR and Other Research Institutions
3. Evaluate the effectiveness of translocating eggs or chicks to nests or brood hens.	CDOW, UDWR and Other Research Institutions
4. Evaluate the effectiveness of a captive-breeding program for population augmentation and translocations by: 1) evaluating the potential for maintaining a captive population, 2) evaluating the effect of hatching chicks in captivity on juvenile survival and recruitment, and population viability, and 3) evaluating the efficacy of translocating captive reared chicks to brood hens.	CDOW, UDWR and Other Research Institutions

Objective 3: Evaluate augmentation and captive rearing techniques on the population dynamics of GUSG.	
Strategies	**Responsible Group**
5. Evaluate timing and procedure of translocating (reintroducing) individuals of varying age and sex classes into currently unoccupied but suitable sagebrush habitat.	CDOW, UDWR and Other Research Institutions

Objective 4: Examine the effect of predation on GUSG behavior and population dynamics and monitor predator and prey populations.	
Strategies	**Responsible Group**
1. Identify relevant predator species within local GUSG populations that meet the trigger described in the "Predation" rangewide strategy (pg. 243).	CDOW, UDWR and Other Research Institutions
2. Determine age-specific mortality and identify relative risks from avian and mammalian predation within local GUSG populations meeting the trigger described in the "Predation" rangewide nstrategy (pg. 243).	CDOW, UDWR and Other Research Institutions
3. Evaluate whether predator control aimed at specific predator species is an effective management tool that increases production and recruitment of sage-grouse in the local populations meeting the trigger described in the "Predation" rangewide strategy (pg. 243).	CDOW, UDWR and Other Research Institutions
4. Implement research to better understand the behavioral and spatial interactions of predators with prey and other predator species.	CDOW, UDWR and Other Research Institutions
5. Evaluate the large-scale effects of landscape structure (composition and configuration of landcover types) and small-scale effects (vegetation structure and predator exclosures) on predator-prey interactions.	CDOW, UDWR and Other Research Institutions
6. Evaluate land use practices that may increase predator populations (e.g., residential development and landfills that may provide artificial food sources for several species of avian and mammalian predators).	CDOW, UDWR and Other Research Institutions
7. Evaluate the impact of perch sites for avian predators (e.g., fences and power lines).	CDOW, UDWR and Other Research Institutions
8. Evaluate the effect of abandoned structures (e.g., farmsteads) that may serve as denning or nesting sites for predators.	CDOW, UDWR and Other Research Institutions
9. Evaluate methods to deter predation on leks (e.g., nest protection structures, fencing).	CDOW, UDWR and Other Research Institutions

Objective 5: Examine the population genetics and evaluate conservation programs to maintain genetic diversity of GUSG.	
Strategies	**Responsible Group**
1. Evaluate the relative effectiveness of translocating females, chicks, or eggs, in maintaining genetic diversity in each sage-grouse population.	CDOW, UDWR and Other Research Institutions
2. Examine the variation in mating skew among males in each sage-grouse population and evaluate whether mating skew is a function of the number or size of leks.	CDOW, UDWR and Other Research Institutions
3. Determine the extent, cause and consequence of inbreeding depression in sage-grouse and its effect on productivity and population dynamics.	CDOW, UDWR and Other Research Institutions
4. Assess the potential for genetic drift in each sage-grouse population (i.e., measure the fluctuation in alleles or haplotypes over time) and evaluate the effect on the loss of genetic diversity.	CDOW, UDWR and Other Research Institutions

Objective 6: Evaluate the relative risk of WNV to GUSG.	
Strategies	**Responsible Group**
1. Determine the level of susceptibility and survival patterns of each age and sex class.	CDOW, UDWR and Other Research Institutions
2. Examine the spatial interaction of mosquito species that are the main vectors of the virus (e.g., *Culex tarsalis* and *C. pipiens*) with seasonal habitat use by GUSG (i.e., evaluate whether sage-grouse are more likely to be exposed to the virus in relatively wetter brood-rearing habitat than in lekking and nesting habitats).	CDOW, UDWR and Other Research Institutions
3. Examine whether sage-grouse can develop immunity to the virus and whether the immune response can be inherited.	CDOW, UDWR and Other Research Institutions
4. Examine the potential impact of the virus on the population dynamics and viability.	CDOW, UDWR and Other Research Institutions

Objective 7: Evaluate the impact of disturbances on the population dynamics of GUSG.	
Strategies	**Responsible Group**
1. Evaluate the effect of recreational activities (e.g., lek viewing, hiking, camping, off-road vehicles, etc.) on the mating behavior and life history patterns of sage-grouse.	CDOW, UDWR and Other Research Institutions

Objective 7: Evaluate the impact of disturbances on the population dynamics of GUSG.	
Strategies	**Responsible Group**
2. Evaluate the impact of agricultural and residential development (c) on the distribution and population dynamics of sage-grouse.	CDOW, UDWR and Other Research Institutions
3. Evaluate the impact of oil and gas development on the distribution and population dynamics of sage-grouse.	CDOW, UDWR and Other Research Institutions
4. Evaluate the impact of trapping and radio-marking or other research tools on the behavior, survival and productivity of sage-grouse.	CDOW, UDWR and Other Research Institutions

Objective 8: Investigate the interactions and interrelationships of species in sagebrush ecosystems.	
Strategies	**Responsible Group**
1. Evaluate the spatial and temporal interactions between different trophic levels (e.g., predators and prey) and between similar trophic levels (e.g., examine the impact of grazing by deer and elk on the quality of sagebrush habitats and its effect on sage-grouse behavior and productivity).	CDOW, UDWR and Other Research Institutions

Weather/Drought

Drought conditions and other extreme climatic conditions, such as abnormally high snowfall years or extremely cold years, appear cyclical and are nothing that sage-grouse have not experienced before. However, competing uses for water and land use provide additional challenges that need to be managed cooperatively and creatively. Therefore, climatic conditions should be monitored to determine how management practices can be used to maintain and improve habitat conditions.

In a report summarizing sagebrush defoliation in some GUSG areas, Wenger et al. (2003) state: "Several years of drought in western Colorado have stressed many plant communities. It has been suggested that the cumulative impacts from drought and insect or pathogen activity caused the defoliation and mortality (A. Winward, and S. Monsen, personal communication) of sagebrush in affected areas." Observations of such 'sagebrush die-off' events in recent years have been documented in Gunnison, Dry Creek Basin, near Monticello UT (106,000 acres), as well as in other GUSG habitat areas.

Objective 1: Investigate the effects of variable climatic conditions on GUSG.	
Strategies	**Responsible Group**
1. Monitor climatic conditions and research direct impact on sage-grouse survival, reproductive success, nest success, recruitment, movements, and habitat use.	CDOW, UDWR, Other Research Institutions
2. Monitor climatic conditions and evaluate effects on vegetation and insects that might affect sage-grouse cover and forage.	BLM, CDOW, UDWR, Other Research Institutions
3. Monitor sagebrush die-off events when and where they occur, using standard protocol and habitat attributes as outlined in the “Habitat Monitoring” strategy (pg. 220).	BLM, CDOW, Private Landowners, UDWR, USFS

Objective 2: Manage sage-grouse cover and forage in anticipation of drought conditions.	
Strategies	**Responsible Group**
1. Develop grass banks for livestock producers to graze during extreme conditions.	BLM, CDOW, NRCS, UDWR, USFS
2. Develop additional water sources for wildlife and livestock to minimize impact to existing riparian, wetland, and wet meadow areas.	BLM, CDOW, NRCS, UDWR, USFS
3. Manage invasive vegetation in riparian, wetland, and wet meadow areas to improve water table.	BLM, CDOW, NPS, NRCS, UDWR, USFS
4. In areas experiencing sagebrush defoliation due to drought or other natural factors, adjust grazing management, prescriptive fire, and/or vegetation management to minimize additive impacts.	BLM, CDOW, Private Landowners, NPS, NRCS, UDWR, USFS

Plan Implementation and Funding Allocation

An important part of any successful planning process is an implementation schedule with associated costs, and identification of current or potential funding. This plan endeavors to meet criteria identified by the USFWS for evaluation of conservation efforts when making listing decisions (PECE). The PECE criteria call for:

- The conservation effort; the party(ies) to the agreement or plan that will implement the effort; and the staffing, funding level, funding source, and other resources necessary to implement the effort are identified.
- Explicit objectives for the conservation effort and dates for achieving them are stated.
- Provisions for monitoring and reporting progress in implementation (based on compliance with the implementation schedule) and effectiveness (based on evaluation of quantifiable parameters) of the conservation effort are provided.

For each strategy or task, this plan has identified the responsible parties and the completion date where appropriate. Funding mechanisms are summarized in Appendix C. However, the estimated cost of the tasks has not yet been developed and a comprehensive implementation schedule must be developed.

Objective 1: Meet the PECE criteria with regards to implementation of the plan, identification of costs and funding sources, and mechanism to report progress.	
Strategies	**Responsible Group**
1. Develop a multi-year implementation plan that includes implementation schedule, costs, funding mechanisms, prioritization, and tasks leads.	RSC
	Completion Date: 2005
2. Develop provisions for monitoring and reporting progress in plan implementation.	RSC
	Completion Date: 2005
3. Report on plan effectiveness utilizing provisions developed in #2.	RSC
	Completion Date: Annually

C. Local Conservation Targets and Strategies

For each GUSG population, we offer a discussion of and rationale for the conservation target. Specific recommended strategies are divided into 3 sections for each population: (1) Habitat Protection; (2) Habitat Improvement; and (3) Population Management. Many of the strategies refer the local reader/manager to broader protocols or strategies in the preceding "Rangewide Strategy" section. Note that the strategies are not presented in any order of priority; all the strategies given for each population are important. The guidance provided here may be used to update local conservation plans. The targets and recommended strategies are thought to be sufficient to conserve GUSG. However, local groups may choose to aim for additional conservation measures.

Local conservation targets were established by analyzing the modeled population capacity based on the current occupied acreage, the currently un-occupied (but apparently suitable) habitat, and the amount of habitat that could potentially be created through restoration and management of currently unsuitable, but potential habitat (Table 32). Potential, but currently unsuitable habitat was a broad category that included areas not likely to be convertible to sage-grouse habitat given any degree of economic sustainability (such as cropland in Dove Creek and Monticello, or houses in Piñon Mesa), so not all habitat in that category was considered when establishing targets. Assumptions used about habitat suitability are discussed within each population summary.

For data analysis in this section as well as in "Analysis of Population Size in Relation to the Amount of Available Habitat" (pg. 186), we refined the "Occupied Habitat" category. Local CDOW and UDWR biologists identified vegetation classes that are used by GUSG within the "Occupied Habitat" category for each population (data from the CVCP or the Utah Gap Analysis dataset). For instance, the "Occupied Habitat" boundary may have included classes not used by grouse, but found scattered within the boundary (e.g., ponderosa pine). These classes were eliminated from the analysis used to determine acreage needed to support certain numbers of grouse. Hence, the "Occupied Habitat" numbers in tables within this section are a subset of the actual occupied habitat acreage and are referenced as selected classes. The "Vacant" and "Potential" habitat categories were not refined or changed.

Table 32. Occupied, vacant, and potential habitat, modeled population capability, recent population size, and future population target, by GUSG population. See "RCP Habitat Mapping" for definitions of habitat types (pg. 54), and see "Status and Distribution of Individual Populations" (pg. 56) for maps of occupied, vacant, and potential habitat for each population.

Population	Habitat Estimates (acres)			Modeled Population Capability (males), total [1]			Recent Population [2]		
	Occupied [3]	Vacant [4]	Potential [5]	Occupied [6]	Occupied + Vacant	Occupied + Vacant + Potential	Males	Total	Future Target
Gunnison	530,464	22,879	157,240	(620) 3,039	(647) 3,174	(836) 4,099	605	2,968	3,000
Crawford	34,908	18,136	61,848	(25) 122	(47) 229	(121) 593	40	196	275
San Miguel	85,999	41,360	61,783	(86) 423	(136) 666	(210) 1,030	62	304	450
Dove Creek	26,907	52,747	237,492	(15) 75	(79) 385	(364) 1,783	30	147	200
Monticello, UT	59,576	56,824	75,285	(54) 267	(123) 602	(213) 1,045	37	182	300
Piñon Mesa	24,185	63,584	136,361	(12) 59	(88) 433	(252) 1,236	26	128	200
Poncha Pass	14,781	0	27,794	(1) 4	(1) 4	(34) 167	8	39	75
Cerro Summit - Cimarron - Sims	37,145	4,874	20,462	(28) 35	(33) 164	(58) 284	7	34	TBD

[1] Estimated from regression of occupied habitat vs. population estimate derived from high count of males.

[2] Based on multiple-year average of lek counts with comparable sampling effort; time period for each population same as habitat model (see pp. 186-187).

[3] Acreage of habitat within each population thought to be occupied by sage-grouse, as delineated by local biologists. Vegetation classes that are used by grouse were selected by local biologists within occupied range boundary.

[4] Acreage of apparently suitable habitat that is not currently known to be occupied habitat, as delineated by local biologists.

[5] Acreage of habitat that could, with intensive management, be suitable for sage-grouse, as delineated by local biologists.

[6] Population estimate converted from average of recent lek counts as: (average number of males/0.53) + [(average number of males/0.53)*(1.6)]; (see pg. 45).

Cerro Summit - Cimarron - Sims Mesa

Primary Issues to be Addressed

The areas of primary focus for this population are the need to obtain better population monitoring data, the need for development of habitat linkages between these areas and other populations, protection of habitat from permanent loss, habitat enhancement and restoration, maintenance of genetic diversity, and grazing management.

Population monitoring is critical for this small population. It is suspected that lek counts underestimate the total number of males in the population, but lack of road access, snow depth, and extensive private land make searches difficult.

A significant portion of the population area is private property in relatively small tracts and could be at risk for development. The most significant of these is the subdivided area south of Montrose Lake. However, at the Cerro Summit - Cimarron area the Cimarron SWA provides a protected core area, and some conservation easements have been negotiated (see Fig. 9, pg. 61, Appendix D, and Fig. 1 in Appendix F). At Sims Mesa much of the core GUSG use area is in private hands (Fig. 2 in Appendix F), and though there is some risk of development on private land, property prices are high. Substantial funds would be needed to protect adequate habitat for this population.

The habitat in this area is highly fragmented and restricted in size, and much of the habitat consists of even-aged stands of sagebrush, as well as areas with piñon-juniper encroachment. At Cerro Summit – Cimarron habitat fragmentation has occurred primarily through sagebrush removal and oakbrush advancement. Landowners should be encouraged to thin, rather than remove, sagebrush. Poor habitat conditions in the Sims Mesa area include lack of understory in non-treated sagebrush areas (primarily private lands), lack of understory diversity in treated areas (domination by crested wheatgrass in the plowed and seeded areas on BLM property), piñon-juniper invasion, sheet erosion, gully formation, and invasive weeds, primarily cheatgrass. Nearly all BLM-managed property on Sims Mesa was plowed and seeded with crested wheatgrass for grazing in the 1980's. Though the sagebrush has slowly returned, the understory remains almost entirely crested wheatgrass.

The limited available habitat suggests that local extinctions may occur without intervention. The current habitat needs to be managed and protected to make the risk of extinction as low as possible. Periodic demographic rescue may be necessary, and infusions of genetic material to counter loss of genetic diversity will probably be necessary.

Livestock grazing needs to be better managed through adjustments in stocking levels and timing to allow for enhancing, restoring, and/or maintaining sage-grouse habitat to meet recommended guidelines. Pasture fencing on some lands may be an effective means of improving grazing management to allow for sage-grouse habitat improvement.

Strategies to assist with these and other issues are provided in this section.

Population Target

We lack sufficient information on population size, historical trends, and habitat suitability to effectively plan conservation efforts for this population. Since 1999, counts of males on 4 known leks (2 currently used) have ranged from 5 to 12. Genetic information suggests this population is not functionally connected to the Gunnison Basin or to Crawford, but may have received migrants from the San Miguel Basin. It appears unlikely that habitats in these areas are capable of supporting more than about 100 grouse (Table 32, pg. 256), and that may require extensive habitat improvement. Even at that, the 50-year extinction probability would be about 35%. Under current habitat conditions and population sizes, extinction is highly likely without intervention. This population also has relatively low potential for serving as a reservoir for demographic or genetic rescue of other populations. The main conservation value of this area may be to serve as a potential linkage area for genetic dispersal. As such, habitat protection efforts and priorities related to linking populations, rather than population goals, are suggested for this area until and unless further research indicates substantially larger population size or potential.

Table 33. Vegetation classification of occupied habitat and adjacent areas that are delineated as “vacant/unknown” and “potentially suitable” (for definitions, see pg. 54) in the Cerro Summit – Cimarron – Sims Mesa population area. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

Vegetation Classification	**Category**					
	Currently Occupied		**Vacant/Unknown use**		**Potentially Suitable**	
	Acres *	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	18,926	51	1,725	35	8,834	43
Grass/forb rangeland	3,893	11	442	9	1,973	10
Gambel Oak	2,766	7	70	1	1,578	8
Mountain shrub	2,639	7	415	9	460	2
Piñon-Juniper dominant	3,863	10	1,172	24	3,193	16
Coniferous/deciduous trees	681	2	689	14	628	3
Agriculture	2,972	8	-	-	3,438	17
Other	1,405	4	351	7	358	2
Total	**37,145**	**100**	**4,864**	**100**	**20,462**	**100**

*Note: In this population area, acreage includes all vegetation types within the delineated boundary of the Occupied Habitat. Not enough information is known about which vegetation classes are selected by sage-grouse in this area to select utilized vegetation classes.

Formation of a local work group and development of a local conservation plan is encouraged. Further research is clearly warranted. The habitat protection goal enumerated should be sufficient to maintain dispersal through this area, and to maintain grouse if a significant population is detected.

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: If research indicates this area functions as an effective linkage for gene flow among populations, maintain 75% of occupied habitat (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F).		
Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect occupied sage-grouse habitats at significant risk of permanent loss**.**	BLM, CDOW, County Governments, NGO's	Ongoing and by 2020
2. Establish Local Work Group for this population and develop work group plan.	BLM, CDOW, County Governments, NGO's, NPS, NRCS, Private Landowners	2008

HABITAT IMPROVEMENT

Strategy 1: Improve existing habitat on Sims Mesa to meet habitat quality guidelines (Appendix H).		
Task(s)	**Responsible Group(s)**	**When**
1. Improve, where deficient, understory grass and forb components within nesting and early brood-rearing areas associated with the Sims Mesa lek (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM	2020

Strategy 2: Develop additional GUSG habitat in un- or under-utilized Occupied Habitat as well as in Potential Habitat areas.		
Task(s)	**Responsible Group(s)**	**When**
1. Remove piñon-juniper that is invading sagebrush parks within currently occupied or potential habitat on Sims Mesa (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM	2020

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, County Governments, NPS, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Governments, Local Work Group, NPS	ASAP
3. Implement recommendations from rangewide strategy on "Oil & Gas Development and Mining" (pg. 233).	BLM, Oil and Gas Companies, Private Landowners	As needed

Strategy 5: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220).	BLM, CDOW, Local Work Group	As needed
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group	2005-06

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW	Annually

Strategy 2: Minimize disturbances to GUSG population (see Appendix I).		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group	As needed
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, Local Work Group, Utility Companies	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241), if and when population size is determined to be large enough to warrant.	CDOW, Local Work Group	As needed
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208), if and when population size is determined to be large enough to warrant.	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220)	BLM, CDOW, NPS	Begin in 2006; Complete in 2008
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220)	BLM, CDOW, NPS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per "Habitat Monitoring" rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, NPS	July, 2006

Crawford

Primary Issues to be Addressed

The issues of primary focus for this population are habitat enhancement and restoration, expansion of occupied habitat, and protection of habitat from permanent loss, especially in potential areas of expansion.

The apparent recent decline in the Crawford population (Table 10, pg. 64) may be due in part to drought conditions that reduced forbs, insect production, and wet meadow areas, all of which are important elements of brood habitat. In addition, past management activities, including fire suppression and selective livestock grazing, have resulted in piñon-juniper encroachment as well as late-seral shrub growth, specifically serviceberry and oakbrush. Several known historic lek sites are believed to be inactive because of piñon-juniper invasion or overgrowth of sagebrush and grass in what were once more open areas. The local work group has used funding from the BLM, CDOW, and the North Fork Habitat Partnership Program to increase available habitat by reducing acreage of piñon/juniper through controlled burns (2,845 acres), cutting (700 acres), or roller chopping (1,050 acres) trees. Analysis of GIS vegetation data indicates another 13,000 acres of sagebrush habitat could be added through piñon/juniper removal.

The local work group has accomplished other significant habitat improvement. Brood-rearing habitat, particularly late brood-rearing habitat along wet meadows or riparian habitat appears limiting. Efforts to cut, brushbeat, or otherwise control juniper, oakbrush, or other tall shrubs near lek sites that could conceal predators should continue. Steve Monsen, a noted shrubland restoration expert (USFS, retired) has commented that of the GUSG population areas he has visited, the Crawford Area is the most productive and favorable for accomplishing sagebrush restoration (S. Monsen, personal communication).

Expansion of the area occupied by sage-grouse is necessary in this population in order to meet population goals (see below). Piñon-juniper and late-seral shrub expansion have contracted the range of sage-grouse at Crawford. Currently identified Potentially Suitable Habitat (see Fig. 11, pg. 67) could support additional sage-grouse with the application of habitat restoration measures such as piñon -juniper and oakbrush removal and/or thinning.

Overall, threats due to habitat conversion or development within currently occupied range have been largely mitigated in Crawford. The majority of occupied sagebrush habitat is publicly owned (76%). Another 9% of occupied habitat is privately owned but protected by easement, bringing the total protected acreage to 85%, near the 90% habitat protection goal. The NPS has a conservation easement on about 2,000 acres, while the CDOW has secured an easement on a 560-acre parcel, and is working with the same landowner on an additional easement on a nearby parcel of 300 acres. An elk ranch that occupies the eastern edge of the main grouse habitat area auctioned off several hundred acres of land in the summer of 2004 in 40-acre plots for cabin/home sites. Fortunately, 7 of these lots were purchased by a landowner who is interested in working with the CDOW on protecting them with easements. Protection of many of the 45 lots in the east-central portion of the occupied area should be a priority. Potential habitat that birds may expand to with habitat improvement is a mix of public and private, and additional habitat protection strategies may be necessary if and when birds utilize these areas.

Strategies to assist the local work group with these issues, as well as others, are provided in this section.

Population Target

We have set a goal of a long-term average breeding population of 275 birds at Crawford (Table 32, pg. 256). At stable growth rates, this population size has a 50-yearextinction probability of approximately 9%, without intervention. A population that averages 275 birds (over approximately 10 years) would be expected to fluctuate between 159 and 484. Currently, based on extrapolations from male counts, there may be about 125 birds in Crawford, but populations in the late 1990s may have been as high as 175 to 200 birds. We estimate about 35,000 acres of habitat is currently occupied (Table 34). Based on our habitat model (see GUSG linear model, discussion begins pg. 186), that amount of habitat, if of average quality, should support an average of about 122 sage-grouse.

We estimate there is an additional 18,000 acres that is suitable but unused, which increases the modeled capacity to 229 sage-grouse (Table 34). Even at that, it is apparent additional habitat must be added and/or habitat quality must be enhanced if we are to meet our population target. We have identified a potential, but currently unoccupied area of 61,848 acres. About 41% of this area is currently dominated by sagebrush communities (Table 34). Removing piñon-juniper and Gambel's oak stands could make much of this area usable by grouse.

Table 34. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in the Crawford population area. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

	Category					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	27,759	80	5,585	31	25,481	41
Saltbush	182	<1	5,647	31	328	1
Irrigated Agriculture	-		4,599	25	-	-
Agriculture	465	1	458	3	13,069	21
Piñon-Juniper dominant	3,213	9	476	3	6,826	11
Gambel oak dominant	953	3	-	-	6,738	11
Other	2,336	7	1,371	7	9,406	15
Totals	**34,908**	**100**	**18,136**	**100**	**61,848**	**100**

The CACP (1998) stated a population goal of a minimum of 225 individuals in the spring, with the objective of increasing that to 480 individuals by 2010. Neither of those goals is likely to be attainable. A minimum population of 225 would correspond to an average population of about 375 birds. Our regression analysis suggests maintaining an average population size of 375 birds would require over 76,000 acres of habitat, and 480 birds would require about 94,000 acres of habitat, both significantly above what is currently occupied (~35,000 acres), or what could probably be added through intensive management.

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitat (combined public and private), as well as additional habitat in areas of expansion (if and when GUSG use them), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F).		
Task(s)	**Responsible Group(s)**	**When**
1. Use all available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect GUSG habitat on private land.	CDOW, County Governments, NGO's	Ongoing and by 2020

HABITAT IMPROVEMENT

Strategy 1: Develop 3,500 acres of additional GUSG habitat in un- or under-utilized Occupied Habitat as well as in Potential Habitat areas.		
Task(s)	**Responsible Group(s)**	**When**
1. Remove encroaching piñon/juniper from 3,500 acres within currently occupied or potential habitat (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, NPS, NRCS	2015
2. Develop an additional 5–10 wet-meadow habitat areas for potential brood-rearing sites and conduct annual maintenance on existing structures (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, NRCS	2010

Strategy 2: Complete an assessment of breeding/early brood-rearing habitat quality based on "GUSG Structural Habitat Guidelines" (Appendix H); develop and implement a plan to improve areas that are deficient.		
Task(s)	**Responsible Group(s)**	**When**
1. Complete habitat quality assessment to determine areas not meeting structural guidelines; develop plan to improve areas that are deficient (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW	2006
2. Brush beat or otherwise control sagebrush and other shrubs on lek sites (Monsen 2005). (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NRCS	As needed
3. Improve understory grass and forb component within nesting and early brood-rearing areas where necessary to meet habitat guidelines (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW	2006 and ongoing

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Incorporate recommendations from rangewide strategy on "Grazing" (pg. 211) into grazing management plans on 25,000 acres.	BLM, CDOW, NRCS	2010
2. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, County Governments, NPS, Utility Companies	ASAP
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Governments, Local Work Groups, NPS	ASAP

Strategy 5: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220).	BLM, CDOW, Local Work Group, NPS	Ongoing
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group, NPS	2005-06

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW, Local Work Group	Annually

Strategy 2: Minimize disturbances to GUSG population (see Appendix I).		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group	2005
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, CDOW, Local Work Group, NPS, Utility Companies	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW, Local Work Group	As needed
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208).	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level ("Habitat Monitoring", pg. 220)	BLM, CDOW, NPS, USFS	Begin in 2006; Complete in 2008
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level ("Habitat Monitoring", pg. 220)	BLM, CDOW, NPS, USFS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per "Habitat Monitoring" rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, NPS, USFS	July, 2006

Gunnison Basin

Primary Issues to be Addressed

Primary issues for the Gunnison Basin population include protection of habitat from permanent loss, grazing management, habitat enhancement and restoration, the need for management of lek viewing, and the importance of the population for research and augmentation efforts.

The main threat to GUSG in the Gunnison Basin is loss and fragmentation of habitat, especially due to residential development (risk of development is discussed in detail in "Habitat – Risk of Permanent Loss", pg. 149). Although a majority (69%) of occupied habitat within the Gunnison Basin is under public ownership and protected from conversion, about a third of lek sites (37%), production areas (34%), and winter range (32%) are privately owned. GUSG in the Ohio Creek drainage are particularly vulnerable because much of the land, including lek sites, is privately owned and in danger of development.

Livestock management in the Basin continues to need to be administered to maintain high quality grouse habitat while optimizing livestock utilization through stocking levels, timing of stocking, and livestock use of riparian areas. Grazing allotments up for permit renewal need to have conservation objectives incorporated into the grazing management.

Exotic plant invasions (e.g., cheatgrass) in some areas may lead to deterioration or loss of habitat, and a lack of adequate forb and or grasses in sagebrush understory also reduces habitat quality in some areas. Mapping and condition assessment of sage-grouse habitats in the Gunnison Basin need to be continued, so that habitat below recommended guidelines can be identified and improved. Data on nest success and chick survival (indexed by chicks per hen in the harvest) suggested that habitat quality was about average in the Gunnison Basin, although there appears to be a recent declining trend in productivity (see "Gunnison Basin Population", pg. 73). Habitat treatments designed to increase vegetation cover, particularly understory vegetation, at nest sites could presumably increase nest success. The relative gain may not be great, given site potential and reasonably good nest success already. Targeting brood-rearing habitat might be a more effective approach. Habitat improvement aimed at increasing the forb component of deficient early brood-rearing habitat or wet meadow/riparian habitats for late brood-rearing may be very beneficial.

The public has demonstrated interest in viewing GUSG in the Gunnison Basin, particularly strutting males at leks. Providing managed lek viewing opportunities limited to a single area allows for this activity while reducing potential impacts to many leks. Management of the site is needed to provide guidance for human activities and development of facilities to minimize potential impacts to the grouse, as well as to provide informational and educational opportunities to the public.

As the core population of GUSG, the Gunnison Basin population will continue to be invaluable for conducting needed research, as well as contributing birds to augment other populations and genetic diversity in other populations, when necessary.

Strategies to assist the local work group with these issues, as well as others, are provided in this section.

Population Target

The population target for the Gunnison Basin is set at a long-term (10-year) average of 3,000 breeding birds (Table 32, pg. 256). The average population estimate from 1995-2004 was less than 3,000 birds, based on an extrapolation of lek counts. Because of the importance of this population to the overall conservation of the species, it is essential to obtain accurate estimates of the true size of this population. The challenge will be to protect and enhance enough of the important seasonal habitats to direct and mitigate effects of development that will continue to occur so that the population remains at this level over the long term. Although a great deal of work has already been done toward the protection and improvement of GUSG habitat in the Gunnison Basin, development and other conversions of sagebrush habitats continue in the Basin. Habitat protection through easements, fee-title acquisition, land-use restrictions, or by other means is the highest conservation priority for this population.

In our PVA analysis, an initial population size of 3,000 had extinction probabilities of less than 1% at all growth rates used in the model, and a nearly zero probability of extinction at stable growth rates. In the *VORTEX* simulations, this population size also retained from 90-93% (depending on assumptions of the percent of males which breed) of genetic diversity over 50 years. A population with a long-term average of 3,000 breeding birds could expect normal fluctuations between 1,730 and 5,280 breeding birds, based on analysis of long-term trends in high counts of males on leks in North Park (see “Analysis: GUSG Population Size in Relation to the Amount of Available Habitat”, pg. 186).

Based on analysis of data collected during the Basinwide vegetation classification project (Colorado Division of Wildlife 2004b), we estimate sage-grouse occupy about 530,500 acres of sage-grouse habitat in the Gunnison Basin (Table 35). Our analysis of long-term average population sizes at varying habitat acreages suggests the occupied acreage, if of “average quality” would support about 3,039 birds (see Table 32, pg. 256). Including the 23,000 acres of apparently suitable, but currently unoccupied habitat suggests the GUSG population could be about 3,174 birds. About 56% of this vacant habitat is dominated by coniferous vegetation (suggesting use may be seasonal) or located northeast of the current population near Taylor Reservoir (which would require transplanting GUSG that could potentially create a new isolated population). Therefore, we consider vacant habitat will not provide many opportunities for expanding the current GUSG range. Another 157,000 acres of potential habitat was delineated which, if improved, could support grouse. Just under half (46%) of this category was in sagebrush communities, while 31% was classified as some type of forested habitat. If about half of this potential habitat category could be improved to support grouse (78,620 acres), this habitat could add almost an additional 400 grouse. However, complex landownership patterns may limit the opportunities for expanding the current GUSG population into areas with unsuitable habitat (Fig. 14, pg. 74). The greatest potential is perhaps in the Curecanti region of the Basin (Fig. 5, pg. 50). Furthermore, qualitative assessments of sagebrush habitat in some of the potential sites suggest restoration will require a long-term habitat management plan that will not likely produce immediate increases in the GUSG population.

Table 35. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in the Gunnison Basin. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

Vegetation Classification	**Category**					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
	Acres	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	407,045	77	7,990	35	72,308	46
Coniferous/deciduous trees	27,917	5	12,779	56	52,398	33
Willow	2871	<1	1,325	6	1,655	1
Grass/forb rangeland	42,763	8	-	-	14,404	9
Other	49,867	9	785	3	16,475	11
Total	**530,464**	**100**	**22,879**	**100**	**157,240**	**100**

The GBCP (1997) described a minimum spring breeding population of 2,600 sage-grouse on 25 leks, and an optimum spring population goal of 3,600 on 30 leks. If the 2,600 birds was a true minimum (i.e., the lowest the population would get), then that population would be expected to average about 4,300 birds, well above the optimum population goal. It is more likely the stated 2,600 bird target would represent an average population size, in which case the population would fluctuate between about 1,560 and 4,575.

Several entities, including the CDOW, hold conservation easements on 23,836 acres of private land within occupied range. The top conservation priority for this population should be to protect seasonally important habitats on private land that are at significant risk of conversion. About 6,500 acres of privately owned severe winter range, nesting and brood-rearing areas are projected to increase to unsuitable housing densities by 2020. There is significant overlap between seasonal habitats at risk of development; protection of many individual properties will protect multiple seasonal habitats.

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of seasonally important habitats (combined public and private, as mapped), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154, and Appendix F).

Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect important seasonal sage-grouse habitats from permanent loss.	BLM, CDOW, County Governments, NPS, USFS	Ongoing and by 2020

HABITAT IMPROVEMENT

Strategy 1: Identify areas where GUSG habitat is significantly below guidelines.		
Task(s)	**Responsible Group(s)**	**When**
1. Use demographic data, habitat use data, vegetation data, and Basin-wide data to identify and map areas where habitat quality is below recommended levels and may be limiting sage-grouse productivity.	BLM, CDOW, Local Work Group, NPS, NRCS, USFS	2006

Strategy 2: Improve 15,000 acres of existing seasonal habitats to meet habitat quality guidelines (Appendix H).		
Task(s)	**Responsible Group(s)**	**When**
1. Improve summer - fall habitat where forb component is significantly below guidelines through fencing, spring development, or other means (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NPS, NRCS, USFS	2010
2. Improve understory grass and forb component within nesting and early brood-rearing areas where necessary to meet habitat guidelines (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NPS, NRCS, USFS	2015
3. Complete habitat improvement options on approximately 1,000 acres as specified in NFWF and Wetlands Initiative Grant in Long Gulch. Improve breeding habitat in Long Gulch through treatments that may include, but are not limited to: enhancing water sources, fencing, vegetation treatments, prescribed fire, interseeding, brush beating (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW	2007
4. Incorporate sage-grouse habitat recommendations into existing conservation easements that don't contain them, where possible.	CDOW, NGO's	2010

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Establish GUSG local conservation plan objectives on grazing allotments up for permit renewal. This is an ongoing project in the Gunnison Basin. Currently, 113,000 acres of allotments without local conservation objectives are up for renewal.	BLM, Local Work Group, Private Landowners, NRCS, USFS	2009

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
2. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners, USFS	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225).	BLM, CDOW, County Governments, NPS, STL, USFS, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Governments, Local Work Group, NPS, STL, USFS	ASAP

Strategy 5: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220).	BLM, CDOW, Local Work Group, NPS, NCRS, USFS	Ongoing
2. Monitor recovery of sagebrush stands that recently died or experienced defoliation due to drought and associated stresses, and implement restoration treatments if necessary.	BLM, CDOW, NRCS, USFS	As needed
3. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group, NPS, USFS	2005-06

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW, Local Work Group	Annually

Strategy 2: Minimize disturbances to GUSG population (see Appendix I).		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group, NPS	2005 and ongoing
2. Implement recommendations from rangewide strategy on "Recreational Activity" (pg. 245).	BLM, Local Work Group, NPS, USFS	As needed
3. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, CDOW, Local Work Group, NPS, STL, Utility Companies	As needed

Strategy 3: Contribute birds to augment population and genetic diversity of other populations.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW, Local Work Group	ASAP and ongoing
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208).	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220).	BLM, CDOW, NPS, USFS	Begin in 2006; Complete in 2008
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level ("Habitat Monitoring", pg. 220).	BLM, CDOW, NPS, USFS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per "Habitat Monitoring" rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, NPS, USFS	July, 2006

Monticello, Utah and Dove Creek, Colorado

Primary Issues to be Addressed

Primary issues for this population include habitat loss to subdivision and issues surrounding CRP renewal, poor habitat quality and quantity, increased oil and gas development (in Utah), low existing genetic diversity, and lack of linkages between Monticello and Dove Creek as well as between sub-groups of birds within the Dove Creek area.

The threat to GUSG in the Dove Creek area from subdivision development is discussed in detail in "Habitat – Risk of Permanent Loss", pg. 149. Almost all occupied habitats in both states are in private ownership. Population growth in this area does not present a great risk, but tract sizes are relatively small and important habitats are at some risk. Much of the core habitat available and used by birds north of Dove Creek occurs within the 2,700-acre Secret Canyon Ranches subdivision. Full build-out of this subdivision, plotted largely to 35- and 40-acre lots, would probably extirpate the Colorado subpopulation. One individual has bought up many of the more critical lots and has attempted for several years to interest the BLM in a trade of some sort. It is essential that the 733 acres he now owns, which connect existing BLM and CDOW parcels, come into public ownership or protection in some way. About 800 acres in the Dove Creek area have been enrolled in 20-year term easements. UDWR and BLM have obtained about 2,700 acres in perpetual easements in the Monticello area.

The CRP represents another short-term (10-15 year) habitat protection program. In Utah, almost 37,000 acres of privately owned cropland within the CCA have been enrolled in CRP, while Dolores County, Colorado, also has about 37,000 acres of CRP. Forty thousand acres of CRP are up for renewal under the Farm Bill in the next 2 to 3 years. CRP has protected this area from agricultural use and development. If this program is not continued, most of these lands will most likely be put back into agricultural production, primarily with winter wheat crops, or used as pastures for cattle grazing. It is critical to this GUSG population that those parcels are renewed.

CRP has provided a considerable amount of brood-rearing habitat because of its forb component. Grazing of CRP in Utah occurred in 2003 under emergency Farm Bill provisions, due to drought. A new Farm Bill program which allows grazing of CRP is available to eligible landowners. Grazing of CRP would significantly reduce cover for sage-grouse broods.

The CRP has not greatly increased the amount of sagebrush cover. Significant use of CRP as nesting or winter habitat will require establishment of sagebrush stands in these fields, and this should be a conservation priority. UDWR has had some success establishing sagebrush seedlings in CRP, but has had little success so far planting sagebrush seed. On CRP fields where sagebrush plantings have occurred, grazing could be used as a tool to reduce competition from established grasses.

Habitat quality and quantity within this area are characterized by low elevation sagebrush stands that have low understory cover, lack diversity, and are dominated by aggressive non-native species. In Monticello, most nesting areas are in poor condition due to lack of herbaceous cover as a result of drought and grazing management practices. Long-term drought has also reduced the availability of wet meadow habitat for brood-rearing. CRP fields are used heavily by grouse as brood-rearing areas but vary greatly in plant diversity and forb abundance, and generally lack any shrub cover. Sagebrush patches have progressively become smaller and highly fragmented limiting the amount of available winter habitat for this subpopulation. Sage-grouse sub-populations in both states show very restricted movements both daily, seasonally, and from leks to nest and brood-rearing sites (Apa 2004; Swenson 2003). They also had relatively low survival and low nest success, all indicative of poor habitat. Sage-grouse in smaller populations with more fragmented and poorer quality habitat had higher mortality rates than did sage-grouse in larger and more contiguous habitats (Apa 2004).

Additional risks to GUSG habitat exist from oil, gas, and wind power development. In the Monticello area, oil and gas leases have been acquired or applied for on state and federal mineral rights on over 5,000 acres of private property in current occupied grouse habitat. One drill has been constructed and additional drilling could be expected to occur in the next few years. There is also current interest and speculation in wind energy development on GUSG habitat in the Monticello area. A wind test tower (anemometer) has been erected at a site approximately 1.5 miles from a lek site. Landowners in the area have been contacted by power company contractors about leases for wind power development.

From a conservation standpoint, several key points stand out. Because of poor recruitment and somewhat elevated adult mortality (both likely aggravated by drought), counts of males on the Colorado side have declined to 8 in 2003 and 2 in 2004. Oyler-McCance (1999) reported low genetic diversity in this population even when populations were substantially larger, and suggested translocations to augment genetic diversity. Colorado population centers appear to be isolated to the point where they communicate sparingly, and while apparently still genetically linked to Utah birds, they do not appear well linked demographically to Utah birds. Converting cropland back to functional sagebrush communities will be difficult, and while feasible on a small scale, may not be feasible on a large scale except for what can be accomplished through set-aside programs under the Federal Farm Bill; CRP, CREP, and Grassland Reserve. Currently, county-level acreage caps, allowance of seed mixes without sagebrush seed, and emergency (or managed) haying and grazing in these programs restrict their ability to help conserve sage-grouse.

Strategies to assist the local work groups with these issues, as well as other, are provided in this section.

Population Target

These populations appear genetically linked, or at least they were in the recent past. It is assumed that they either are, or could be, demographically linked through dispersal, so population targets will be combined to determine extinction probabilities. Because this population straddles 2 states and 2 local work groups, a suggested allocation of this joint target to each state and local work group is proposed. Declines in numbers of males counted on leks have been dramatic in Dove Creek in recent years, probably due to drought impacting recruitment. We may be undercounting males slightly due to our difficulty in locating leks, which seem to be moving around as grass cover increases in CRP fields. Given current population levels at Dove Creek, translocations for demographic rescue and to increase genetic diversity will be required when drought-induced habitat deficiencies subside. Re-establishing habitat linkages between Colorado and Utah population centers will be critical to long-term persistence. Otherwise, these population centers will function as 3 small populations with high extinction probabilities.

A combined population goal (average) of 500 is probably attainable, with habitat protection and improvement (see Table 32, pg. 256). At stable growth rates, this population size has a 50-year extinction probability of about 5%, without intervention. A population that averages 500 birds (over 10 years) would be expected to fluctuate between 288 and 880. The current population is well below the lower limit of this range now. Utah, based on a high count of 30 males in 2003, estimates a spring population of 100-120. Dove Creek had over 50 males in 1999, suggesting a population of about 150 birds, but has since declined to 8 males in 2003 and 2 males in 2004.

UDWR estimates that sage-grouse currently occupy about 60,000 acres of sagebrush and cropland, while CDOW estimates about 27,000 acres of sagebrush habitats currently exist in Dove Creek (Tables 39 and 40). Based on recent trends in lek counts and the amount of habitat currently used and potentially available (Tables 36 and 37), an allocation of the 500-bird target of 300 to Utah, and 200 to Colorado, seems defensible. This population is threatened by continued conversion of sagebrush habitats to agriculture, or to subdivisions on the Colorado side. To ensure the long-term persistence and achievement of the 500-bird population objective, large amounts of habitat (~100,000 acres) must be protected and enhanced. Based on our model, approximately 13,000 acres of additional habitat is required to obtain this goal (see GUSG linear model, discussion begins pg. 186).

Population targets in the respective local conservation plans were 500 breeding individuals by 2015 in the Monticello subpopulation and a minimum of 200 and an optimum of 480 breeding individuals in Dove Creek. It is highly unlikely that any of these population objectives are feasible as long-term averages, given any degree of economic sustainability.

Table 36. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in Monticello area. Classification is based on GIS data (Edwards et al. 1995).

	Category					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	30,774	52	35,416	62	14,459	19
Grassland/dry meadow	2,805	5	5,797	10	1,797	3
Gambel Oak	2,889	5	2,560	5	2,340	3
Mountain shrub	157	~0	181	<1	62	~0
Piñon-Juniper dominant	-	-	7,740	14	10,718	14
Agriculture	22,951	38	2,550	4	44,610	59
Other	-	-	2,580	5	1,298	2
Totals	**59,576**	**100**	**56,824**	**100**	**75,284**	**100**

Table 37. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in Dove Creek. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

	Category					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	6,211	23	7,552	14	29,745	13
Grass/forb rangeland	3,567	13	10,766	20	28,590	12
Gambel Oak	1,165	4	6,380	12	4,339	2
Mountain shrub	1,307	5	6,160	12	3,954	2
Piñon-Juniper dominant	3,749	14	16,859	32	17,121	7
Rabbitbrush/grass mix	3,953	15	108	_	24,444	10
Agriculture	6,798	25	3	_	109,071	46
Other	157	<1	4,919	9	20,228	9
Totals	**26,907**	**100**	**52,747**	**100**	**237,492**	**100**

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitat (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F). In addition, retain protection through CRP re-enrollment of 25,000 acres in Monticello, Utah, and 15,000 acres in Dove Creek, Colorado.

Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect important seasonal sage-grouse habitats from permanent loss in Monticello, Utah area.	BLM, County Governments, NGO's, UDWR	Ongoing and by 2020
2. Develop prioritization criteria for and strongly recommend the re-enrollment of 25,000 acres of CRP in occupied and potential sage-grouse habitat in Monticello, Utah, and 15,000 acres of CRP in Dove Creek, Colorado.	CDOW, UDWR, NRCS	By 2007

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitat (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F). In addition, retain protection through CRP re-enrollment of 25,000 acres in Monticello, Utah, and 15,000 acres in Dove Creek, Colorado.		
Task(s)	**Responsible Group(s)**	**When**
3. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect important seasonal sage-grouse habitats at significant risk of permanent loss in Dove Creek. Develop, cooperatively with the BLM and Secret Canyon Homeowners Association, a strategy for development that protects important sage-grouse areas.	BLM, CDOW, County Governments, NGO's, Secret Canyon Homeowners Association	By 2020

HABITAT IMPROVEMENT

Strategy 1: Develop 4,200 acres of additional GUSG habitat in Dove Creek and 5,800 acres in Monticello, and create a habitat linkage between the 2 subpopulations.		
Task(s)	**Responsible Group(s)**	**When**
1. Eliminate piñon/juniper from and develop sage-grouse habitat on 800 acres between Hickman Flat and the Utah-Colorado state line, or at the periphery of occupied habitat (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, Local Work Group, NRCS, UDWR	2010
2. Eliminate piñon/juniper from 1,200 acres between currently occupied habitat north of Dove Creek and vacant/unknown habitat encompassing the Spud Patch area (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, Local Work Group, NRCS, UDWR	2010
3. Use habitat improvement techniques identified in (Monsen 2005) to establish sagebrush in 5,000 acres of CRP, other idled cropland, or other areas within 3 miles of lek sites within Utah.	BLM, Local Work Group, NRCS, UDWR	2010
4. Use habitat improvement techniques identified in (Monsen 2005) to establish sagebrush in 3,000 acres of CRP, other idled cropland, or other areas within 4 miles of lek sites within Colorado.	CDOW, Local Work Group, NRCS	2010

Strategy 2: Improve existing breeding habitat to meet habitat quality guidelines (Appendix H) on 500 acres in Dove Creek and 500 acres in Monticello.		
Task(s)	**Responsible Group(s)**	**When**
1. Brush beat or otherwise control sagebrush and other shrubs on lek sites (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Groups, NRCS, UDWR	As needed
2. Improve understory grass and forb component within nesting and early brood-rearing areas where necessary to meet habitat guidelines on west side of Dove Creek subpopulation and in Utah subpopulation area (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, NRCS, UDWR	2010
3. Protect brood-rearing habitat in CRP by restricting haying and grazing, or providing incentives not to hay and graze.	CDOW, NRCS, Private Landowners, UDWR	2005

Strategy 3: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Oil & Gas Development and Mining" (pg. 233).	BLM, Local Work Groups, NRCS, STL, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, Local Work Group, STL, UDWR, Utility Companies	As needed
3. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners, UDWR	As needed
4. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Governments, Local Work Groups, UDWR	As needed

Strategy 4: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220).	CDOW, Local Work Groups, UDWR	Ongoing

Strategy 4: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group, UDWR	2005-06
3. Investigate opportunities to expand currently occupied habitat into Vacant/Unknown or Potentially Suitable habitats that would also begin to establish linkages between sub-populations.	BLM, CDOW, Local Work Group	2008
4. Monitor recovery of sagebrush stands that recently died or experienced defoliation due to drought and associated stresses, and implement restoration treatments if necessary.	BLM, CDOW, Local Work Group, UDWR	As needed

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution, and to evaluate potential areas for expansion.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW, Local Work Groups, UDWR	Annually
2. Evaluate vacant habitat at La Sal, Lisbon Valley, and Hatch Point (Utah), and Spud Patch (Colorado) to determine habitat suitability and potential for re-introduction.	BLM, CDOW, Local Work Group, UDWR	2005-06
3. Evaluate the Near Draw/Far Draw area of "the Glade" to determine habitat suitability and potential for reintroduction.	BLM, CDOW	2005-06

Strategy 2: Minimize disturbances to GUSG population (see Appendix I).		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group, UDWR	As needed
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, NRCS, Local Work Groups, STL, Utility Companies, Oil and Gas Companies	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241). Conduct transplant of 40 or more birds over several years to recover population and increase genetic diversity in Dove Creek.	CDOW, Local Work Group, UDWR	ASAP
2. If vacant habitat at La Sal, Lisbon Valley, and Hatch Point (Utah), and Spud Patch (Colorado) is determined to be suitable, reintroduce birds following recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW, UDWR	2007 or later
3. If the Near Draw/Far Draw area of "the Glade" is determined to be suitable, reintroduce birds following recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW	2007 or later

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Groups, Private Landowners, UDWR, USDA (APHIS)	As needed
2. Given nest success is below the 25% trigger indicated in the predator management strategy, determine specific predators reducing nest success and evaluate effectiveness of control methods on these predators.	CDOW, Local Work Group, UDWR	2005-06

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220)	BLM, CDOW, UDWR, USFS	Begin in 2006; Complete in 2008

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220).	BLM, CDOW, UDWR	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per "Habitat Monitoring" rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, UDWR	July, 2006

Piñon Mesa

Primary Issues to Be Addressed

Primary threats to this population are habitat loss from development and subdivision, declines in habitat quality, genetic isolation and associated lack of genetic diversity, and the need to increase acreages of occupied habitat by establishing connectivity with other suitable or potentially suitable habitats, and with other populations.

A serious long-term threat for the entire area is the subdivision of private lands into increasingly smaller parcels for development (risk of development is discussed in detail in "Habitat – Risk of Permanent Loss", pg. 149). The proximity of the Glade Park area to Grand Junction has made it an attractive area for development. This development has resulted in fragmentation and loss of sage-grouse habitat. The eastern 1/3rd of the occupied range is essentially all privately owned. The southern portion of this area contains about 2,000 acres in tracts less than 160 acres, and an additional 3,600 acres in tracts between 160 and 320 acres that could be subdivided.

Habitat quality concerns include the invasion of piñon and juniper into sagebrush areas, inadequate grass and forbs in sagebrush understory, poor vegetation conditions on leks, and a short supply of wet areas, meadows, and water sites. In addition, invasive species such as cheatgrass have increased in some areas and are out-competing native grasses and shrubs.

This population has very low genetic diversity, indicative of its isolation from other populations. Historically, connectivity to other populations probably occurred along the Uncompahgre Plateau south and west towards the San Miguel Basin, and possibly to the east towards Crawford.

The expansion of sage-grouse in this population is limited by currently available suitable habitat. A large area of potentially suitable habitat exists adjacent to currently occupied habitat (see Fig. 17, pg. 90) and offers options for acreage and population expansion.

Strategies to assist the Local Work Group with these issues, as well as others, are provided in this section.

Population Target

Although the local conservation plan for this population calls for a minimum spring count of 120 males (thought to correspond to 480 breeding birds by 2010), because of restricted habitat this goal is highly unlikely. Our habitat model suggests 480 birds would need about 94,000 acres, or almost 4 times what is currently thought to be occupied (see GUSG linear model, discussion begins pg. 186). Counts in the last 6 years have fluctuated between 23 and 33 males. We currently estimate that sage-grouse occupy about 24,000 acres, with another 63,000 acres adjacent to the occupied area that was historically occupied (Table 38). With continued habitat protection, restoration, and expansion through piñon-juniper removal, it is possible that a long-term (10 year) average population of 200 breeding birds, ranging between 115 and 352, could be maintained. At stable growth rates, this population size has an extinction probability of about 15%.

Transplants to augment the population's low genetic diversity are needed as a short-term fix, while potential connectivity through habitat treatments and transplants along the Uncompahgre Plateau should be investigated. Sage-grouse occupied the Dominguez Creek area of the northern Uncompahgre Plateau as recently as the 1980's. Potentially suitable habitat exists to the north of Piñon Mesa and also to the east on Clark's Bench and Snyder Flats (see Fig. 17, pg. 90). Habitat improvement in these areas could provide additional occupied acreage for this population.

Seventy percent of occupied habitat, and 75% of potentially suitable habitat is privately owned. Protecting seasonally important habitats from development will be critical. About a quarter (7,314 acres) of the currently occupied habitat has already been protected by conservation easements.

Table 38. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in Piñon Mesa area. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

	Category					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	18,799	78	21,354	34	45,343	33
Grass/forb rangeland	1,214	5	2,104	3	4,321	3
Gambel Oak	-	-	13,084	21	10,467	8
Mountain shrub	2,295	9	5,671	9	5,620	4
Piñon -Juniper dominant	1,640	7	11,930	19	57,368	42
Coniferous/deciduous trees	-		6,784	11	4,595	3
Other	237	1	2,657	4	8,647	6
Totals	**24,185**	**100**	**63,584**	**100**	**136,361**	**100**

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitats (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154, and Appendix F).

Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect occupied sage-grouse habitats at significant risk of permanent loss on Piñon Mesa.	BLM, CDOW, County Governments, Local Work Group, NGO's	Ongoing and by 2015

Strategy 2: Maintain 90% of occupied habitats (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F) on Glade Park and other currently unoccupied areas, if and when they become occupied.		
Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect important sage-grouse habitats at significant risk of permanent loss on Glade Park.	BLM, CDOW, County Governments, NGO's	By 2015

HABITAT IMPROVEMENT

Strategy 1: Develop 5,000 acres of additional GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Eliminate piñon/juniper from 5,000 acres on Piñon Mesa (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NRCS	2010

Strategy 2: Improve 2,000 acres of existing breeding habitat to meet habitat quality guidelines (Appendix H).		
Task(s)	**Responsible Group(s)**	**When**
1. Brush beat or otherwise control sagebrush and other shrubs on lek sites (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NRCS	As needed
2. Use habitat improvement techniques identified in (Monsen 2005) to improve nesting cover (sagebrush canopy, understory) associated with leks on Piñon Mesa to meet minimum vegetation guidelines (Appendix H) or until nest success averages 50% (see "Habitat Enhancement" rangewide strategy, pg. 214).	BLM, CDOW, Local Work Group, NRCS	2010
3. Use habitat improvement techniques identified (Monsen 2005) to improve forb component of brood-rearing habitat associated with leks on Piñon Mesa where hens are known to remain to raise young (see "Habitat Enhancement" rangewide strategy, pg. 214).	BLM, CDOW, Local Work Group, NRCS	2010

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Incorporate recommendations from rangewide strategy on "Grazing" (pg. 211) into grazing management plans on 10,000 acres for existing conservation easements.	CDOW, NGO's Private Landowners	2010
2. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners, USFS	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, County Governments, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Government, Local Work Group, USFS	ASAP
3. Implement recommendations from rangewide strategy on "Oil & Gas Development and Mining" (pg. 233).	BLM, CDOW, Oil and Gas Companies, Private Landowners	ASAP

Strategy 5: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220), particularly monitoring of status of recovery of sagebrush die-off areas.	BLM, CDOW, Local Work Group, UDWR	As needed
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group	2005-06
3. Investigate opportunities to expand currently occupied habitat into Vacant/Unknown or Potentially Suitable habitats that would also begin to establish linkages between other populations.	BLM, CDOW, Local Work Group, UDWR	2008

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW, Local Work Group	Annually

Strategy 2: Minimize disturbances to GUSG population (see Appendix I).		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group	2005 and ongoing
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, Local Work Group, Utility Companies	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW, Local Work Group	As needed
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208).	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level (see "Habitat Monitoring" rangewide strategy, pg. 220)	BLM, CDOW, UDWR, USFS	Begin in 2006; Complete in 2008

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level (see “Habitat Monitoring” rangewide strategy, pg. 220).	BLM, CDOW, UDWR, USFS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per “Habitat Monitoring” rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, UDWR, USFS	July, 2006

Poncha Pass

Primary Issues to be Addressed

The threat of extinction of this population is relatively high, because of its small size, and there is limited opportunity for habitat expansion to improve the outlook for the population. In addition, there are some risks to GUSG and their habitat from residential development, recreation, and mining.

Due to the small size of currently available habitat, the associated small sage-grouse population size that can be supported may be subject to local extinctions without intervention. Periodic demographic rescue may be necessary and infusions of genetic material to counter loss of genetic diversity will be required over time. However, depending upon available resources, efforts may need to be weighed against needs of other small populations having much larger acreages of available habitat, and hence, greater probability of being self-sustaining.

Residential development on private land is a threat to GUSG at Poncha Pass (risk of development is discussed in detail in "Habitat – Risk of Permanent Loss", pg. 149). The area is scenic, easily accessed via Highway 285, and some interior parcels of land are in small tracts and currently for sale.

There is some threat from cumulative physical disturbances associated with recreation in the area. In addition, a mica mine was recently proposed near Poncha Pass, and although the application has been withdrawn, the possibility of a mine (and potential negative impacts on GUSG and their habitat) remains.

Strategies to assist the Local Work Group with these issues, as well as others, are provided in this section.

Population Target

Historical information on population size is very limited since lek counts were not conducted prior to the recent transplant (2000). This population was thought to have been established and has persisted since the initial transplants in the early 1970's. It is possible there were 50-75 sage-grouse during this interval. This population size has about a 40-60% extinction probability over a 50-year time period. This population has relatively low potential for serving as a reservoir for demographic or genetic rescue of other populations. We set a long-term (10-year) average target of 75 birds (Table 32, pg. 256), but extraordinary efforts will not be undertaken to achieve it because the functional difference between a population of 30-40 and 75 is not great.

Clearly all populations that fluctuate independently of Gunnison Basin have conservation value and merit protection, but extraordinary attempts to sustain Poncha Pass that divert resources from other, larger populations more likely to persist, are probably not warranted. Nevertheless, available suitable but unused habitat makes translocation a viable option. Habitat quality is generally good, and recent efforts have improved it. About 24% of the currently occupied habitat is privately owned.

Habitat expansion opportunities at Poncha Pass are very limited, although sage-grouse do have opportunities to expand into some apparently suitable, but un-used habitat (Table 39). At this small acreage (15,000) the habitat model (see pg. 186) is not instructive.

Although no habitat protection goal is enumerated, opportunities to permanently protect private habitat that do not directly compete with protection of privately held habitat in other populations (such as BLM land trades or easements) should be explored.

Table 39. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in Poncha Pass area. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

	Category					
	Currently Occupied –Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	9,478	64			48	-
Grass or grass/forb	1,777	12			3,225	12
Rabbitbrush/grass mix	2	0			4,932	18
Shrub/grass/forb mix	1,614	11			14,825	53
Piñon -Juniper dominant	398	3			698	3
Riparian shrub, sedge, forb	**77**	<1			2,987	11
Other	1,434	10			1,079	4
Totals	**14,781**	**100**	**-**	**-**	**27,794**	**100**

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitats (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154 and Appendix F).

Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect occupied sage-grouse habitats at significant risk of permanent loss.	BLM, CDOW, County Government, NGO's	Ongoing

HABITAT IMPROVEMENT

Strategy 1: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners, USFS	ASAP

Strategy 2: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, County Governments, STL, USFS, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Governments, STL, USFS	ASAP
3. Implement recommendations from rangewide strategy on "Recreational Activity" (pg. 245).	BLM, Local Work Group, USFS	As needed

Strategy 3: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Habitat Monitoring" (pg. 220), particularly monitoring of status of recovery of sagebrush die-off areas.	BLM, Local Work Group	Ongoing
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, STL, USFS	2005-06

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	BLM, CDOW, Local Work Group	Annually

Strategy 2: Minimize disturbances to GUSG population.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group	As needed
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" strategy (pg. 225), and "Oil & Gas and Mining" strategy (pg. 233).	BLM, CDOW, Local Work Group, STL, USFS, Utility Companies	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation" (pg. 241).	CDOW, Local Work Group	As needed
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208).	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level ("Habitat Monitoring" strategy, pg. 220)	BLM, CDOW, USFS	Begin in 2006; Complete in 2008

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level (“Habitat Monitoring” strategy, pg. 220)	BLM, CDOW, USFS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per “Habitat Monitoring” rangewide strategy, Objective 1, Strategy #7 (see pg. 220).	BLM, CDOW, USFS	July, 2006

San Miguel Basin

Primary Issues to be Addressed

Primary threats to this population are recent dramatic increases in natural gas development, habitat loss to development and subdivision, poor habitat quality, and effects of drought. An additional challenge facing GUSG management in the area is the large amount of privately controlled land. Cooperating with private landowners in the protection and management of GUSG will be key to the long-term success of the GUSG preservation effort.

Oil and gas exploration activities in the San Miguel Basin have increased dramatically in recent months. Exploration and production activities are scheduled to expand in the near future and associated probable affects on sage-grouse are of great concern.

Residential development is a major threat to GUSG in the San Miguel Basin, especially at Iron Springs and Gurley Reservoir. Good progress has been made on fee title acquisition in the Miramonte Reservoir and Dry Creek Basin areas (1,350 and 1,500 acres, respectively), with discussions/negotiations on additional easements (by CDOW, San Miguel Open Space) and land swaps (BLM) ongoing here and in other areas. The local work group is currently (November 2004) working to establish a process to prioritize habitat protection among the subpopulations.

Past or current sagebrush removal has reduced habitat at Dry Creek Basin, Gurley Reservoir, and Beaver Mesa. At Dry Creek Basin remaining sagebrush patches were subjected in the past to overgrazing and continue to succeed to a late-seral sagebrush community dominated by sagebrush, lacking in understory, and not ideal for GUSG use. Habitat loss in the form of piñon-juniper encroachment is also a problem in some areas, particularly in Dry Creek Basin. The southern third of the range at Beaver Mesa is private property managed by working ranches, and past conversion of sagebrush habitat to seasonally irrigated pasturelands has left little sagebrush cover in most of this area.

Following the drought of 2002, approximately 75% of the total sagebrush canopy in Dry Creek Basin was lost to sagebrush defoliation (Wenger et al. 2003). Although most plants survived and exhibited signs of recovery in 2003, there were significant areas, particularly in the low sage, where over 90% of the plants died (Wenger et al. 2003). The decrease in lek attendance in Dry Creek Basin is of great immediate concern and is most likely related to poor habitat conditions exacerbated by the recent drought. Additions to the breeding population in Dry Creek Basin through augmentation should be seriously considered.

Strategies to assist the local work group with these issues, as well as others, are provided in this section.

Population Target

A long-term (10-year) average population target of 450 birds was established (Table 32, pg. 256). Although recent population peaks may have approached this level, maintaining it as a long-term average will be a challenge given the current condition of vegetation and poor site potential of Dry Creek Basin (which comprises about 60% of occupied habitat for the population), and development pressures elsewhere. At stable growth rates, this population size has a 50-year extinction probability of about 5%, without intervention. A population that averages 450 birds would be expected to fluctuate between 260 and 792. A breeding population with a long-term average of 450 would require about 90,000 acres of average quality habitat (see GUSG linear model, discussion begins pg. 186). This is close to the total acreage now occupied, (85,999 occupied, with an additional 41,524 vacant and 61,783 potentially suitable, Table 40). However, this habitat exists in 6 distinct and separated geographic areas which probably reduces its ability to maintain grouse.

We identified 41,360 acres of presumably suitable habitat in the Basin as vacant or of unknown use (Table 40). Analysis of plant communities in this vacant category suggests this area would be suitable primarily for late summer brood rearing (dominated by mesic mountain shrubs [23%], Gambel oak [18%], rangeland [13%], conifers and/or deciduous trees [17%], and subalpine grass communities [10%]), with less than 7% of the acreage dominated by sagebrush communities. It is likely much of this vacant, unknown use category currently receives summer use by grouse, and unlikely this category has potential to increase populations year round.

Although an additional 62,000 acres was identified as potential habitat, much of this is privately held (63%) and only 34% is currently classified with sagebrush as the dominant vegetation. While about a third of the vegetation is dominated by piñon-juniper, only about 5% has sagebrush or mountain shrubs as an understory to the piñon-juniper. While some gains can no doubt be realized by piñon-juniper removal and other treatments, it is unlikely much of this can be converted to suitable habitat in the future.

Table 40. Vegetation classification of occupied habitat and adjacent areas that are delineated as "vacant/unknown" and "potentially suitable" (see pg. 54 for definitions) in San Miguel Basin. Classification is based on GIS data (Colorado Division of Wildlife 2004b).

	Category					
	Currently Occupied – Selected Classes		**Vacant/Unknown use**		**Potentially Suitable**	
Vegetation Classification	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Sagebrush dominant	40,890	48	4,026	10	25,481	41
Grass/forb rangeland	19,136	22	5,435	13	4,548	7
Gambel Oak	7,338	9	7,433	18	6,738	11
Mountain shrub	8,069	9	9,616	23	18	-
Piñon -Juniper dominant	-		410	1	5,640	9
Coniferous/deciduous trees	1,350	1	7,408	18	1,849	3
Agriculture	920	1	91	-	13,069	21
Other	8,296	10	6,941	17	4,440	7
Totals	**85,999**	**100**	**41,360**	**100**	**61,783**	**100**

The SMBCP (1998) listed minimum population goals of 255 sage-grouse by spring of 2002, and an optimum goal of 480 by 2007-2012.

Protecting significant seasonal habitats in private ownership within core areas like Miramonte, Dry Creek, and Hamilton Mesa will be essential to either meet this target or maintain GUSG in this population. Maintaining breeding sub-populations in the Gurley Reservoir and Beaver Mesa - Iron Springs areas will be particularly challenging given that these areas are almost entirely privately held (91, 100, and 92%, respectively) and land prices are high. Collectively these areas have represented 33-41% of the breeding population of the entire San Miguel Basin in recent years, so they are very significant. Areas of immediate and high conservation importance include the area west and south of Gurley Reservoir that is already subdivided into small lots, and currently offered for sale. As discussed earlier, additional habitat protection in Miramonte and Hamilton Mesa will be necessary in time, while protection of Iron Springs Mesa may be beyond our means.

Recommended Conservation Strategies

HABITAT PROTECTION

Strategy 1: Maintain 90% of those vegetation communities likely used by GUSG within occupied habitats (combined public and private), by protecting the necessary proportion of those private lands that are at risk of development from conversion to unsuitable housing densities (see "Spatially Explicit Analysis of Impacts of Additional Housing Units", pg. 154), and Appendix F.		
Task(s)	**Responsible Group(s)**	**When**
1. Select from available options (see "Habitat Protection from Permanent Loss" rangewide strategy, pg. 223) to permanently protect occupied sage-grouse habitats at significant risk of permanent loss in the San Miguel Basin.	BLM, CDOW, County Government, NGO's, USFS	Ongoing and by 2020

HABITAT IMPROVEMENT

Strategy 1: Develop 1,000 acres of additional GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Eliminate piñon /juniper from 1,000 acres within Dry Creek Basin (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NRCS	2010

Strategy 2: Improve 560 acres of existing breeding habitat to meet habitat quality guidelines.		
Task(s)	**Responsible Group(s)**	**When**
1. Brush beat or otherwise control sagebrush and other shrubs on lek sites (see "Habitat Enhancement" rangewide strategy, pg. 214 and Monsen 2005).	BLM, CDOW, Local Work Group, NRCS	As needed

Strategy 2: Improve 560 acres of existing breeding habitat to meet habitat quality guidelines.		
Task(s)	**Responsible Group(s)**	**When**
2. Use habitat improvement techniques identified in Monsen (2005) to improve nesting cover (sagebrush canopy, understory) associated with leks within Dry Creek Basin to meet minimum vegetation guidelines or until nest success averages 50% (see "Habitat Enhancement" rangewide strategy, pg. 214).	BLM, CDOW, Local Work Group, NRCS, USFS	2010
3. Use habitat improvement techniques identified in (Monsen 2005) to improve forb component of brood-rearing habitat associated with leks within the Dry Creek Basin where hens are known to remain to raise young (see "Habitat Enhancement" rangewide strategy, pg. 214).	BLM, CDOW, Local Work Group, NRCS, USFS	2010

Strategy 3: Use grazing to manage for high quality GUSG habitat.		
Task(s)	**Responsible Group(s)**	**When**
1. Develop and implement grazing management plans on 5,000 acres by incorporating sage-grouse habitat objectives into conservation easements.	CDOW, NGO's, NRCS	2010
2. Incorporate grazing management practices (such as those presented on page 212) for both cattle and sheep that are compatible with, or enhance, GUSG habitat (see Appendix H) on federal and state lands during the permit renewal process, or when monitoring indicates need.	BLM, CDOW, NRCS, Private Landowners, USFS	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225).	BLM, CDOW, County Government, STL, USFS, Utility Companies	As needed
2. Implement recommendations from rangewide strategy on "Noxious and Invasive Weeds" (pg. 232).	BLM, CDOW, County Government, STL, USFS	ASAP
3. Implement recommendations from rangewide strategy on "Oil & Gas Development and Mining" (pg. 233).	BLM, CDOW, Oil and Gas Companies, Private Landowners, STL, USFS	ASAP

Strategy 4: Minimize GUSG habitat fragmentation and degradation.		
Task(s)	**Responsible Group(s)**	**When**
4. Move road away from Desert Lek.	BLM, County Government, Private Landowner	2007

Strategy 5: Monitor existing and new GUSG habitat for quality.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on Habitat Monitoring" (pg. 214), particularly monitoring of status of recovery of sagebrush die-off areas.	BLM, Local Work Group, USFS	Ongoing
2. Evaluate suitability of vacant/unknown habitat classification and determine if habitat improvement techniques may enhance suitability.	BLM, CDOW, Local Work Group, USFS	2005-06

POPULATION MANAGEMENT

Strategy 1: Monitor population and area to detect changes in GUSG numbers and distribution.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations in the "Population Monitoring and Targets" rangewide strategy (pg. 242).	CDOW, Local Work Group	Annually

Strategy 2: Minimize disturbances to GUSG population.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Lek Viewing" (pg. 231).	BLM, CDOW, Local Work Group, USFS	2005
2. Implement timing restrictions provided in rangewide "Human Infrastructure: Powerlines, Other Utility Corridors, Wind Turbines, Communication Towers, Fences, and Roads" (pg. 225) strategy, and "Oil & Gas and Mining" strategy (pg. 233).	BLM, CDOW, Local Work Group, Oil and Gas Companies, STL, USFS, Utility Companies	ASAP

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Population Augmentation") pg. 241).	CDOW, Local Work Group	As needed

Strategy 3: Augment population and genetic diversity.		
Task(s)	**Responsible Group(s)**	**When**
2. Implement recommendations from rangewide strategy on "Genetics" (pg. 208).	CDOW	As needed

Strategy 4: Manage predators to reduce excessive predation.		
Task(s)	**Responsible Group(s)**	**When**
1. Implement recommendations from rangewide strategy on "Predation" (pg. 243).	CDOW, Local Work Group, Private Landowners, USDA (APHIS)	As needed

Strategy 5: Collect field information to refine and map habitat and GUSG use areas.		
Task(s)	**Responsible Group (s)**	**When**
1. Conduct inventory of vacant/unknown habitat areas using inventory technique developed at a rangewide level ("Habitat Monitoring", pg. 214)	BLM, CDOW, USFS	Begin in 2005; Complete in 2008
2. Search for new or unknown existing leks utilizing survey methodology developed at rangewide level ("Habitat Monitoring", pg. 214)	BLM, CDOW, USFS	Begin in 2006; Repeat every 3-5 years
3. Map GUSG seasonal habitats in a GIS as defined per "Habitat Monitoring" rangewide strategy, Objective 1, Strategy #7 (see pg. 214).	BLM, CDOW, USFS	July, 2006

D. Adaptive Management Process

Adaptive management is considered a flexible, iterative approach to long-term management of biological resources that is directed over time by the results of ongoing monitoring and research activities and other information. This means that objectives, biological management techniques, and the assumptions behind both are regularly evaluated in light of monitoring results and new information on species needs, land use, and a variety of other factors. These evaluations are used to adapt both management objectives and techniques to better achieve overall management goals as defined by measurable biological objectives.

The RCP describes the measures believed at this time to be necessary to conserve GUSG. In addition, monitoring populations and habitats are recommended strategies for each GUSG population (“Local Conservation Targets and Strategies”, beginning pg. 255), and follow-up monitoring is advised for all habitat treatments, and in the “Fire and Fuels Management” and “Grazing” rangewide strategies (see pgs. 206 and 211, respectively). However, as the status of the species and its habitats change, the information available on species requirements and management prescriptions increases. A more formal adaptive management process to deal with these changing issues will be needed. This process will assess the effectiveness of the existing conservation strategy and propose additional or alternative conservation measures, as appropriate.

Development of the adaptive management process will be completed in a cooperative and coordinated manner with, and under, the direction of the RSC, and with direct input from the signatories of the RCP and the local work groups. The RSC will facilitate implementation of the adaptive management process by annually evaluating the status of meeting the identified habitat and population goals. The annual evaluation will involve the RSC working with the local work groups to (1) monitor GUSG population trends and ecosystem health; and (2) evaluate the effectiveness of management activities in meeting the habitat and population goals of the RCP and in ameliorating the threats identified in the RCP, or any threats identified in the future.

The adaptive management process will provide an objective, quantitative evaluation of the effectiveness of (1) management actions in attaining strategies and objectives outlined in the RCP; and (2) inventory, monitoring, and research results and interpretation. The adaptive management process should provide scientifically sound data and analysis to assist resource managers in allocating and providing funds and scientific resources when undertaking resource management and conservation actions.

E. Summary

Within the conservation strategy section we have established population targets for 6 of the 7 populations, evaluated their relative extinction probabilities using results from a PVA analysis, and developed conservation strategies that we feel can be used to maintain populations at, or above, the population targets. These population targets and extinction probabilities, as well as the range of population sizes expected over time, are summarized in Table 41. Each population is also assigned a relative level of conservation importance, from a rangewide perspective (Table 41). Not surprisingly, Gunnison Basin is ranked as the very highest in terms of conservation importance, because it is the current core population of the entire species. Crawford, San Miguel Basin, Monticello - Dove Creek, and Piñon Mesa are considered high value for conservation importance, and conservation actions should continue to be directed to these populations as well. These populations provide expansion and connection opportunities for GUSG and may serve to maintain the species, should a catastrophic event occur in Gunnison Basin. Until additional population information can be gathered for the Cerro Summit – Cimarron – Sims Mesa area, conservation strategies are recommended to maintain habitat and reduce disturbance (beginning on pg. 259), but a population target is not identified.

A summary of the relative importance of each topic addressed under "Rangewide Conservation Strategies" (beginning pg. 202) for each population is provided in Table 42. This table, along with the detailed "Local Conservation Targets and Strategies", will enable local work groups and others to evaluate which rangewide strategies should be pursued for each population. Table 42 can help direct resources and efforts through applicable rangewide strategies.

Table 41. Population targets, expected ranges, 50-year extinction probabilities, and conservation importance of GUSG populations.

Population	Target, as Long-term Average[1]	Range Low – High	50-year Extinction Probability[2]	Conservation Importance
Gunnison Basin	3,000	1,730-5,280	< 1%	Very High
Crawford	275	159-484	~ 10%	High
San Miguel Basin	450	260-792	~ 6%	High
Monticello – Dove Creek	500 (300/200)	288-880	~ 7%	High
Piñon Mesa	200	115-352	~ 15%	High
Poncha Pass	75	43-132	~ 42 %	Low
Cerro Summit - Cimarron – Sims Mesa	TBD	N/A	-	Uncertain
Total	**4,500**	**-**	**-**	**-**

[1] Long-term average is 10-year average for GUSG.
[2] Extinction probabilities are for stable population growth over 50 years ($r_s = 0.0$).

Table 42. Relative importance of individual threats and opportunities for each population of GUSG, ranked among and within populations. These issues are identified in "Rangewide Conservation Strategies" (beginning pg. 202), and appear in the table in the same order they occur in that section. Relative ranks are as follows: L = Low, LM = Low-Medium, M = Medium, MH = Medium-High, H = High, VH = Very High

ISSUE OR THREAT	POPULATION						
	Cerro Summit – Cimarron – Sims Mesa	Crawford	Gunnison Basin	Monticello – Dove Creek	Piñon Mesa	Poncha Pass	San Miguel Basin
Risk of Disease and Parasites	LM	LM	LM	M	LM	LM	LM
Risk of Wildfire or Need for Fire and Fuels Management	LM	LM	M	M	LM	LM	MH
Risk of Genetic Problems	MH	M	LM	H	H	LM	L
Need for Grazing Management	MH	M	MH	MH	M	M	MH
Need for Habitat Enhancement / Restoration	MH	MH	MH	VH	LM	LM	MH
Need for Development of Habitat Linkages	H	H	L	VH	VH	LM	H
Need for Habitat Monitoring	H	H	H	H	H	H	H
Need for Habitat Protection from Permanent Loss	MH	MH	H	H	M	L	H
Need for Management of Human Infrastructure	L	L	M	M	L	L	H
Need for Management of Hunting	L	L	L	L	L	L	L
Need for Information and Education	H	H	H	H	H	H	H
Need for Management of Lek Viewing	L	M	MH	M	L	L	L
Risk from Mining / Energy Development	L	L	M	H	L	L	VH
Risk from Noxious and Invasive Weeds	LM	L	M	MH	L	L	LM
Risk from Pesticides	L	L	L	M	L	L	L
Need for Population Monitoring	VH	L	M	L	H	L	M
Need for Predation Management	L	L	L	M	L	L	M
Risk from Recreational Activity	LM	L	M	L	LM	L	LM
Need for Research	H	MH	MH	MH	MH	LM	MH
Need for Translocations	M	M	L	VH	VH	MH	M
Weather / Drought Impacts	M	M	M	H	M	M	VH

VI. GLOSSARY

(where a definition is a direct quotation, quotation marks are omitted but the source is cited)

active lek For the purpose of this plan, we primarily adopt the Connelly et al. 2000 definition of an active lek as a open area that has been attended by $\geq$ 2 male sage-grouse in $\geq$ 2 of the previous 5 years. However, this definition is derived mainly from observations of leks in large, stable populations and may not be appropriate for small populations with reduced numbers of males attending leks in fragmented sagebrush communities. Therefore, for the smaller GUSG populations outside of the Gunnison Basin, an active lek is defined as an open area where one or more sage-grouse have been observed on more than one occasion, engaging in courtship or breeding behavior. An area used by displaying males in the last 5 years is considered an active lek.

additive mortality Occurs when a factor causes mortality in a population in addition to natural mortality caused by predators, disease, etc.

adult A sage-grouse that is at least 15 months of age and has entered or is about to enter its second breeding season (Connelly et al. 2003).

adulticide An insecticide that specifically targets the adult form of an insect species

age structure The relative number of individuals of each age in a population (Campbell et al. 1999).

air sacs A part of the respiratory system unique to birds; a thin-walled structure through which air flows during respiration. With the lungs, the air sacs allow air to flow along a one-way route so that newly inhaled air does not mix with older air in the system, unlike the dead-end respiration system of mammals (Elphick et al. 2001). Male sage-grouse inflate and "pop" their air sacs during their mating display.

alien (plant species) A species that is not indigenous to a region (Science Dictionary 2004).

allele A particular form of a gene, where multiple such forms occur (Wilson 1992).

anemometer An instrument to measure wind speed (Science Dictionary 2004).

antibody A protein (immunoglobulin) molecule, produced by the immune system, that recognizes a particular foreign antigen and binds to it; if the antigen is on the surface of a cell, this binding leads to cell aggregation and subsequent destruction (Science Dictionary 2004).

antigen A molecule whose shape triggers the production of antibodies (immunoglobulins) that will bind to the antigen. A foreign substance capable of triggering an immune response in an organism (Science Dictionary 2004).

arena An area where sage-grouse display.

aspergillosis A respiratory tract infection caused by fungi of the genus *Aspergillus*, of which *A. fumigatus* is the primary species responsible for infections in wild birds (Friend and Franson 1999).

banding Marking individual birds by placing metal or plastic rings (bands) on the legs, making the birds individually identifiable when recaptured (Elphick et al. 2001).

behavioral ecology A heuristic approach based on the expectation that Darwinian fitness (reproductive success) is improved by optimal behavior (Campbell et al. 1999).

best management practice Methods that have been determined to be the most effective, practical means of maintaining or reaching a habitat management goal.

biological diversity (or biodiversity) Refers to the variety among living organisms and the complexity of the ecological systems in which they live. Diversity is defined by the number of different types of items in a system and the relative frequency of these different types (Decker et al. 1991).

biological control The management of a pest species by the introduction of a natural enemy or predator.

bottleneck A reduction of a population, typically by a natural disaster, such that the surviving population is no longer genetically representative of the original population (Campbell et al. 1999).

breeding habitat If GUSG breeding habitat has not been mapped, it is defined as sagebrush communities delineated within 4 miles of an active strutting ground (lek(see "GUSG Disturbance Guidelines", Appendix I, for discussion). Breeding habitat includes active strutting grounds (leks), nesting and early brood-rearing habitat (Connelly et al. 2000), usually in use from mid-March through late-June.

brooding A behavior in which parents warm nestlings or young that cannot maintain their own body temperatures. While young are still in the nest, a brooding adult may appear to be incubating eggs (Elphick et al. 2001).

brushbeat A management practice that is used to "thin" sagebrush areas that are too thick (do not allow for enough under-story for sage-grouse habitat).

brush mow A management practice that is used to "thin" sagebrush in habitat areas that are too thick (do not have enough under-story that is suitable for sage-grouse). Instead of beating the over-story, the area is mowed.

candidate species A species that will be or is being considered for listing as endangered or threatened by the ESA.

canopy cover a) The percentage of the ground included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species (usually used for the herbaceous plants); or b) The percentage of the ground covered by a projection of the crown, stems, and leaves of the plant onto the ground surface (usually used for shrubs) (Connelly et al. 2003).

carpel A measurement from the wrist to the tip of the longest primary feather, with wing slightly flattened.

census A complete count of a species in a given area (Patton 1992)

chick A sage-grouse up to 10 weeks of age (Connelly et al. 2003).

chronic wasting disease A wildlife disease (akin to bovine spongiform encephalitis) that affects deer and elk.

clutch size The number of eggs laid by an individual female.

Coleoptera An order of insects; includes beetles.

compensatory mortality Occurs when another factor is a replacement for the natural mortality caused by predators, disease, and so forth (Patton 1992).

consensus (approach) Using an approach where unanimity is required for decisions.

conservation easement A legal agreement which places a restriction upon the use of land, which advances conservation goals.

Conservation Reserve Program A program, created in the Food Security Act of 1985, to retire from production up to 45 million acres of highly erodible and environmentally sensitive farmland. Landowners who sign contracts agree to keep retired lands in approved conserving uses for 10-15 years. In exchange, the landowner receives an annual rental payment, cost-share payments to establish permanent vegetative cover and technical assistance. The CRP reportedly has reduced erosion by up to 700 million tons per year. The FAIR Act of 1996 extends authorization to enroll land through 2002 and caps maximum CRP acreage at 36.4 million acres, its 1995 level. The Act also makes the program spending mandatory and finances it through the Commodity Credit Corporation. (Science Dictionary 2004).

conservation strategy An approach for protecting a particular species, habitat, or ecosystem.

contiguous touching; meeting or joining at the surface or border (McKechnie 1983).

controlled burn A fire set intentionally, with specific vegetation and weather prescriptions, in order to achieve a specific resource objective.

corridor A more or less continuous connection between land masses or habitats. In terms of conservation biology, a connection between habitat fragments in a fragmented landscape (Science Dictionary 2004).

Corvidae Taxonomic family of birds that includes crows, ravens, jays and magpies.

cover An indication of the relative amount of shelter or protection of all vegetation at a given point; normally used to assess nesting habitat (Connelly et al. 2003).

crude protein The approximate amount of protein in foods that is calculated from the determined nitrogen content by multiplying by a factor (as 6.25 for many foods and 5.7 for wheat) derived from the average percentage of nitrogen in the food proteins and that may contain an appreciable error if the nitrogen is derived from nonprotein material or from a protein of unusual composition.

cruising radius The maximum distance that a male sage-grouse travels on and around a lek during lekking season.

cryptic Appearance that allows something to match its background

culmen On birds, a region or measurement from the tip of upper mandible to the insertion of feathers above mandible (Schroeder et al.1999).

curtailment Reduction in extent or quantity; imposition of a restriction.

defoliation Process in which a plant loses its leaves.

demographic (rates) The specific properties of a population regarding birth rates, death rates, age distributions, sex ratios, and size of population (Wilson 1992).

density dependent Having influence on individuals in a population that varies with the degree of crowding in the population (Ricklefs 1979).

density independent Having influence on individuals in a population that does not vary with the degree of crowding in the population (Ricklefs 1979).

depredated The act of a nest being destroyed by a predator.

desiccate To become dry.

determinate layer A bird species that will not continue to lay eggs indefinitely if eggs are removed or disappear from the nest.

discrete generation A age cohort that is individually separate and distinct from all others.

dispersal Movement of individuals to new living areas. Includes both the initial movements from the place of birth to the first site at which the bird will attempt to breed (natal dispersal) and subsequent movement from one breeding location to another (adult dispersal). Also, wandering by individuals away from the breeding range and habitats in late summer, especially in herons and related species (postbreeding dispersal) (Elphick et al. 2001).

display A ritualized signal intended to convey a specific message (Elphick et al. 2001).

distribution The area or range over which a species is found (Elphick et al. 2001).

diversity Variety, or a range of different things.

dixie harrow A particular piece of equipment used to thin older sagebrush stands in an effort to stimulate understory growth of forbs and grasses.

dominant males The males of a lek who obtain the most area of the lek, who win wing fights, facing pasts, and chases, and, typically, mates more than other males on the lek. Also see Schroeder et al. 1999.

dryland farming A method of farming in semiarid areas without the aid of irrigation, using drought-resistant crops and conserving moisture.

ecosystem A biological community of interacting organisms and their physical environment.

effective population size The number of individuals that would give rise to the calculated loss of heterozygosity, inbreeding or variance in allele frequencies if they behaved in the manner of an idealized population (Frankham et al. 2002).

endangered species An organism in imminent danger of extinction throughout all or a significant portion of its range (Elphick et al. 2001).

exotic (game bird) A species that is not indigenous to a region (Science Dictionary 2004).

extinction The state or process of ceasing or causing something to cease to exist: the state or process of a species, family, or larger group being or becoming extinct.

extinction vortex A small population incurs inbreeding and random genetic drift which leads to the loss of genetic variability, then a reduction in individual fitness and population adaptability, which leads to lower reproduction and higher mortality, ending with a smaller population.

extirpated Eradicated, or exterminated from a given region.

extrapolate In statistics to estimate or infer (a value, etc.) on the basis of certain variables within the known range (McKechnie 1983).

exurban Having to do with a region beyond the suburbs of a city or town.

F_{ST} A measure of genetic structure (or lack of it). F_{ST} values close to 0 mean that there is essentially enough gene flow among groups to consider them one panmictic group. Values significantly higher than 0 represent cases (such as with GUSG) where there is very little gene flow, which results in highly differentiated groups.

federal recovery plan A document that will be referred to for guidelines for maintaining, protecting, and preserving a species and its and habitat if the species is listed as threatened or endangered by the USFWS.

fee-title acquisition The acquiring of land in fee title through donation, bargain sale, or outright purchase.

filoplume Specialized feather; in sage-grouse, long black feathers arising at the back of the neck

fire suppression When natural or prescribed burning is not allowed.

(Darwinian or reproductive) fitness A measure of the relative contribution of an individual to the gene pool of the next generation (Campbell et al. 1999).

forb An herbaceous plant which is not a grass (Science Dictionary 2004).

gallinaceous Belonging or pertaining to the Order Galliformes, comprising the grouse, pheasants, turkeys, partridges, domestic fowls, etc. (Cooperrider et al. 1986).

gene flow The movement of genes from one population to another by way of interbreeding of individuals in the two populations (Science Dictionary 2004).

genetic Of or relating to genes or heredity.

genetic distance An estimate of the number of electrophoretically detectable amino acid (codon) differences between homologous proteins (genes) in different species. (Ricklefs 1979)

genetic diversity (or variation) The variation that exists in a given set of genes, whether in an organism or a population. The ability of a population to provide the hereditary mechanisms needed for adaptive change and dynamic evolution to future breeding individuals of the species (Emmel 1976).

genetic drift Change in the gene pool as a result of chance and not as a result of selection, mutation, or migration (Keeton and Gould 1986).

genetically discrete units A group or population that is more genetically similar to themselves than any other group.

genotype The specific allelic composition of a cell, either of the entire cell or more commonly for a certain gene or a set of genes. The genes that an organism possesses (Science Dictionary 2004).

Geographic Information System (GIS) A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data in a geographic context. (Science Dictionary 2004).

geographic isolation When a group of individuals within a population becomes separated by man-made or natural barriers can no longer mate with individuals outside of the population. No individual is able to enter or exit the population without being born there or dying.

geographically closed (population) A population that is separated by some physical barrier from other populations, and which has no dispersal with any other population of the same species.

habitat Place where an animal normally lives or where individuals of a population live (Lindzey 2001).

(habitat) connectivity A measurement of how habitat areas are spatially arranged relative to each other.

(habitat) degradation Decline in the quality of a habitat.

habitat fragmentation The breaking up of a habitat into unconnected patches interspersed with other habitat which may or may not be inhabitable by species occupying the habitat that was broken up. The breaking up is usually by human action, as, for example, the clearing of forest or grassland for agriculture, or residential development (Science Dictionary 2004).

(habitat) linkage Areas between existing habitat patches, that, if made into suitable habitat, will increase movement between populations and will decrease the probability of extinction of the species by stabilizing population dynamics.

(habitat) polygon In a GIS, a separate patch of a given habitat.

(habitat) treatment An action that alters a given habitat, usually to improve its quality.

haplotype A set of closely linked genetic markers present on one chromosome which tend to be inherited together (not easily separable by recombination). Some haplotypes may be in linkage disequilibrium (Science Dictionary 2004).

hatching success The proportion or percentage of eggs that successfully hatch from a clutch.

herbaceous (vegetation) Having characteristics of an herb; a plant with no persistent woody stem above ground (Science Dictionary 2004).

herbicide A chemical pesticide designed to control or destroy plants, weeds, or grasses (Science Dictionary 2004).

heterozygote advantage A mechanism that preserves variation in eukaryotic gene pools by conferring greater reproductive success on heterozygotes over individuals homozygous for any one of the associated alleles (Campbell et al. 1999).

heterozygous Having two different alleles for a given genetic character (Campbell et al. 1999).

historic habitat Areas where viable populations have not occurred within five years or more.

historic lek A formerly active lek that has not been utilized for display or breeding within the last 10 years (Colorado Division of Wildlife 2004a).

horizontal cover An average calculation/estimation of the vegetation that provides aerial cover to the ground.

horizontal structure The type of plants that actually provide the horizontal cover to the ground (e.g., sagebrush, bitterbrush, rabbitbrush, greasewood).

hydroaxe Hydrolic powered mower that can mulch large diameter woody species.

Hymenoptera The order of insects including ants, wasps, bees, and sawflies.

imprint(ing) Period of rapid and usually stable learning during a critical period of early development of a member of a social species, involving recognition of its own species; may involve attraction to the first moving object seen (Lindzey 2001).

inactive lek To be considered inactive for a given season, a lek must have zero males in attendance for at least two count periods. For the official status of a lek to be considered Inactive, a lek needs to be seasonally Inactive for five consecutive years (Colorado Division of Wildlife 2004a).

inbreeding coefficient The probability of homozygosity by descent (having common ancestors). The probability that a zygote obtains copies of the same ancestral gene from both its parents because they are related (Science Dictionary 2004).

inbreeding depression A decline in reproductive fitness due to mating of related individuals.

incubate The natural or artificial heating of an egg that has been laid. Incubation is required for embryo development. The average incubation period for GUSG is 27 days.

index A relative measure used as an indicator of the true state of nature (Thompson et al.. 1998).

index monitoring An assessment protocol that collects data that usually represent at best a rough guess at population trends (and at worst may lead to an incorrect conclusion) (Thompson et al. 1998).

inference A conclusion derived from reasoning.

insecticide A pesticide compound specifically used to kill or prevent the growth of insects (Science Dictionary 2004).

interlek Area or distance between leks.

introgression The transplantation of genes between species resulting from fertile hybrids mating successfully with one of the parent species (Campbell et al. 1999).

juvenile A sage-grouse that is more then 10 weeks of age but has not entered into its first breeding season (Connelly et al. 2003).

Lagomorpha Order of mammals including hares, rabbits, and pikas.

landscape structure The characteristics (biotic and abiotic) that make up the landscape.

larvicide Insecticide that specifically targets the larval stage of an insect species.

lek An arena where male sage-grouse display for the purpose of gaining breeding territories and attracting females. These arenas are usually open areas with short vegetation within sagebrush habitats, usually on broad ridges, benches, or valley floors where visibility and hearing acuity are excellent.

lek area A grouping of leks that is loosely based on proximity to other leks and the potential for birds to move between multiple leks (Colorado Division of Wildlife 2004a).

lek count The high count of males from all lek sites on the same day; which are taken at 7-10 day intervals between late March and mid-May.

life cycle The entire lifespan of an organism from the moment it is conceived (usually at fertilization) to the time it reproduces (Wilson 1992).

life history The significant features of the life cycle through which an organism passes, with particular reference to strategies influencing survival and reproduction (Science Dictionary 2004).

limiting factor A condition whose absence or excessive concentration, is incompatible with the needs or tolerance of a species or population and which may have a negative influence on their ability to thrive (Science Dictionary 2004).

lipid A small water-insoluble biomolecule generally containing fatty acids, sterols, or isoprenoid compounds (Science Dictionary 2004).

local conservation plan A document, prepared by landowners, stakeholders and (non-federal) government agencies to address conservation concerns for a given species in a given area.

local work group In the case of GUSG, a group formed to address GUSG conservation concerns and to write a local conservation plan.

locus The position of a gene, DNA marker or genetic marker on a chromosome (Science Dictionary 2004).

major histocompatibility complex A group of highly polymorphic genes whose products appear on the surface of cells imparting the property of self (belonging to that organism). A genetic region found in all mammals whose products are primarily responsible for the rapid rejection of tissue grafts between individuals (Science Dictionary 2004).

mark-resight Estimating the number of individuals in a population by capturing, marking, and re-capturing individuals. This assumes that there is not birth, death, immigration, or emigration within the population (White et al. 1982).

mating skew An unequal sharing in reproduction by group members.

meadow Year-round wet areas that form in low depressions along the drainage patterns of the high sagebrush plains (Taylor 1992).

mean The arithmetic average; the sum of the data divided by the sample size (Science Dictionary 2004).

Meleagridinae The subfamily of turkey species.

mesic Referring to habitats with plentiful rainfall and well-drained soils (Ricklefs 1979).

mesopredator Lower trophic level predator (as opposed to dominant predator).

metapopulation A set of local populations within some larger area, where typically migration from one local population to at least some other patches is possible" (Hanski and Simberloff 1997).

microsatellite Any of numerous short segments of DNA that are distributed throughout the genome, that consist of repeated sequences of usually 2 to 5 nucleotides, and that are often useful markers in studies of genetic linkage because they tend to vary from one individual to another.

minimum viable population The smallest isolated population size that has a specified percent chance of remaining extant for a specified period of time (Meffe and Carroll 1997).

mitochondrial marker A genetic element which can be readily detected by phenotype, cytological or molecular techniques, and used to follow a mitochondrial chromosome or chromosomal segment during genetic analysis (Life Science Glossary 2004).

model A simplified representation of a real system.

Monte Carlo (model) A population modeling method in which a large quantity of randomly generated numbers are studied using a problematic model to find an approximate solution to a numerical problem that would be difficult to solve by other methods.

morphological The physical make up of the species. One of the characteristics that makes species unique.

mutation A rare change in DNA of genes that ultimately creates genetic diversity (Campbell et al. 1999).

neighbor-joining tree A method of illustrating the relatedness of different phyletic groups.

nest success A measurement of the success (completion of the laying, incubating, and hatching process) of a nest, even if the chicks do not live beyond hatching.

nonnative (plant) A species that is not indigenous to a region (Science Dictionary 2004).

non-use (locations)

nuclear DNA DNA (deoxyribonucleic acid) found in the nucleus of a cell.

nuclear markers A genetic element which can be readily detected by phenotype, cytological or molecular techniques, and used to follow a nuclear chromosome or chromosomal segment during genetic analysis (Life Science Glossary 2004).

oakbrush *Quercus gambelii.*

obligate Essential, necessary; unable to exist in any other state, mode, or relationship; restricted to one particularly characteristic mode of life (Science Dictionary 2004).

occupied habitat As defined for mapping used in the RCP: Areas of suitable habitat known to be used by GUSG within the last 10 years from the date of mapping. Areas of suitable habitat contiguous with areas of known use, which do not have effective barriers to sage-grouse movement from known use areas, are mapped as occupied habitat unless specific information exists that documents the lack of sage-grouse use. This category can be delineated from any combination of telemetry locations, sightings of sage-grouse or sage-grouse sign, local biological expertise, GIS analysis, or other data sources.

olfactory cues Signals transmitted by odor.

Overburden Rock and soil cleared away before mining (Science Dictionary 2004).

parameter A variable, measurable property (Science Dictionary 2004).

parasite load A measure of the number of parasites carried by an organism.

patchy A distribution that is not continuous.

pesticide Substance or mixture intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant (Science Dictionary 2004).

petitioner In the case of this plan, a person or entity who petitions the USFWS to have a species considered for endangered or threatened status under the ESA.

phenotypic expression The observable manifestation of a specific genetic makeup; those observable properties of structure and function of an organism as modified by genetic structure in conjunction with the environment (Science Dictionary 2004).

Phasianidae The avian family that includes all upland games species except quail and Northern Bobwhite (Elphick et al. 2001).

photoperiod The length of time an organism is daily exposed to light, especially with regard to how that exposure affects growth and development (Science Dictionary 2004).

piñon-juniper A vegetation community that contains both *Pinus* spp. and *Juniperus* spp.

polygamous Having a mating system in which one male mates with more than one female (polygyny) or one female mates with more than one male (polyandry).

polymorphism Occurrence of more than one distinct form of individuals in a population (Ricklefs 1979).

(demographic) population A biological unit at the level of ecological integration where it is meaningful to speak of a birth rate, a death rate, a sex ratio and an age structure in describing the properties of the unit (Emmel 1976).

(genetic) population A group of sexually interbreeding individuals (Strickberger 1985).

population structure A description of a population using estimates of the numbers of individuals in different age and sex categories.

population trend An important average change in magnitude and direction of some population parameter within a specified area across multiple time intervals (Thompson et al.. 1998).

potentially suitable habitat As defined for mapping used in the RCP: Unoccupied habitats that could be suitable for occupation of sage-grouse if practical restoration were applied. Soils or other historic information (photos, maps, reports, etc.) indicate sagebrush communities occupied these areas. As examples, these sites could include areas overtaken by piñon-juniper or converted to rangeland.

precocial Pertaining to birds and mammals born with their eyes and ears open, covered by down or fur, and able to run about shortly after hatching or birth (Lindzey 2001).

prescribed burn A fire set intentionally, with specific vegetation and weather prescriptions, in order to achieve a specific resource objective.

presettlement (habitat) Habitat that existed prior to European settlement in North America.

proventriculus The division of the stomach in birds that secretes digestive enzymes and passes food from the crop to the gizzard.

pyrethroid Any of several synthetic compounds similar to pyrethrin, used as an insecticide.

quantitative Capable of being measured (McKechnie 1983).

radiotelemetry A technique used to study wildlife by attaching a radio transmitter to an animal.

range The geographic area or spatial distribution in which a species is normally found (Elphick et al. 2001).

Rangeland A habitat in which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs. This includes lands revegetated naturally or artificially when routine management of the vegetation is through manipulation of grazing. Rangelands include natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.

rangewide In this case, it includes all of the populations of GUSG found in Colorado and Utah.

recessive An allele that is not expressed in the heterozygous condition (Science Dictionary 2004)

recruitment The influx of new members into a population by reproduction or immigration (Science Dictionary 2004).

renest Any nesting attempt that follows the loss of an initial nest (Connelly et al. 2003).

riparian (habitat) Areas adjacent to rivers and streams with a different density, diversity, and productivity of plant and animal species relative to nearby uplands (Science Dictionary 2004).

roost Rest or sleep. Also a place where birds rest or sleep.

sagebrush steppe ecosystem A steppe ecosystem dominated by various species of sagebrush (Taylor 1992).

satellite lek A relatively small lek (usually less than 15 males) that develops near a large lek during years with relatively high grouse populations (Connelly et al. 2003).

septicemic A systemic disease caused by pathogenic organisms or their toxins in the bloodstream.

seral (stage) A stage that occurs as a habitat succeeds from one community type to another.

sex ratio The ratio of one gender to another within a given population (usually expressed as the ratio of males to females).

sexual dimorphism The phenomenon when males and females in a species have different appearances.

shrub-steppe Temperate zone vegetation with the understory dominated by grasses and a conspicuous shrub element providing a relatively open understory above the grass layer (Connelly et al. 2003).

single species (management) Management that focuses on one species without considering other species in the community.

species A taxon that is a subset of a genus and that may contain on or more subspecies (races) (Connelly et al. 2003).

species richness The absolute number of species in an assemblage or community (Science Dictionary 2004).

stakeholder An individual who has an interest in a particular issue or topic.

steppe A non-forested region dominated by grasses and low shrubs (Taylor 1992).

stochasticity the quality of lacking any predictable order or plan .

STRUCTURE A software program that delineates how many genetically discrete "units" are best described by the data. It considers each individual's collective genotypes without regard to what "population" was previously assigned to it. It clusters all individuals with similar genotypes into groups. It then assigns each individual a probabilty of belonging to each.

subpopulation A group of organisms of the same species living within a sufficiently restricted geographical area such that any member can potentially mate with any other member (Hartl and Clark 1997).

succession The chronological sequence of vegetation and associated animals in an area; or, continuous colonization, extinction, and replacement of species' populations at a particular site, due either to environmental changes or to the intrinsic properties of the plants and animals (Science Dictionary 2004).

summer – fall habitat If GUSG summer – fall habitat has not been mapped it is defined as vegetation communities including sagebrush, agricultural fields, and wet meadows (Connelly et al. 2000) that are within 4 miles of an active strutting ground (lek) (see “GUSG Disturbance Guidelines”, Appendix I, for discussion).

sundry notice a standard form to notify of or approve well operations subsequent to an Application for Permit to Drill, in accordance with Forest Service or BLM regulations

systemic organophosphate Any of several organic compounds containing phosphorus, some of which are used as fertilizers and pesticides.

tarsus (plural tarsi) The lower leg. The major bone in this region of the leg is the tarsometatarsus, which is a fusion of structures called ankle and foot bones in mammals (Elphick et al. 2001).

taxonomy Classification, especially of animals and plants into phyla, species, etc. (McKechnie 1983).

Tetraoninae A Phasianidae subfamily that includes prairie chickens, ptarmigan, and grouse species.

threatened species An organism likely to become endangered within the foreseeable future throughout all or a significant portion of its range (Elphick et al. 2001).

topography The surface features of an area.

trophic level Position in the food chain determined by the number of energy-transfer steps to that level (Ricklefs 1979)

understory The vegetation layer between the overstory or canopy and the groundcover of a forest community, usually formed by shade tolerant or young individuals of emergent species. May also refer to the groundcover if no trees or shrub layer is present (Science Dictionary 2004).

vacant/unknown habitat As defined for mapping used in the RCP: Suitable habitat for sage-grouse that is separated (not contiguous) from occupied habitats that either (1) has not been adequately inventoried, or (2) has not had documentation of grouse presence in the past 10 years.

variable A property that may have different values in various cases (Science Dictionary 2004).

variance In statistics, a measure of the variation around the central class of a distribution; the average squared deviation of the observations from their mean value (Science Dictionary 2004).

variation The differences among parents and their offspring or among individuals in a population (Science Dictionary 2004).

whirling disease An infectious, often fatal disease of salmonid fish (as trout and salmon) that is caused by a protozoan (*Myxobolus cerebralis* syn. *Myxosoma cerebralis*) of the order Myxosporidia which attacks cartilage of the head and spinal cord especially of young fish and that causes the fish to swim in circles and is marked by skeletal deformities.

wildland fire use The management of naturally ignited wildland fires to accomplish pre-stated resource management objectives in predefined areas that are within fire management plans (National Interagency Fire Center).

wing barrel A barrel or other container placed in areas frequented by bird hunters and used as a collection site for wings from hunter-harvested birds(Connelly et al. 2003).

wing data Information resulting from samples collected from wing barrels.

winter habitat sagebrush areas (Connelly et al. 2000) within 6 miles of an active strutting ground (lek) (see “GUSG Disturbance Guidelines”, Appendix I, for discussion) that have sufficient shrub height to be above winter snow cover.

yearling A sage-grouse that has entered its first breeding season but not completed its second summer molt, normally between 10 and 17 months of age (Connelly et al. 2003).

VII. LITERATURE CITED

This section contains all literature cited in the RCP, including literature cited in all appendices.

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Zeller, M. 1999. Stewardship of land, an investigation into the state of the art, The INNW Fund, Menlo Park, California; ftp://cnlm.org/pub/stewardship.pdf.

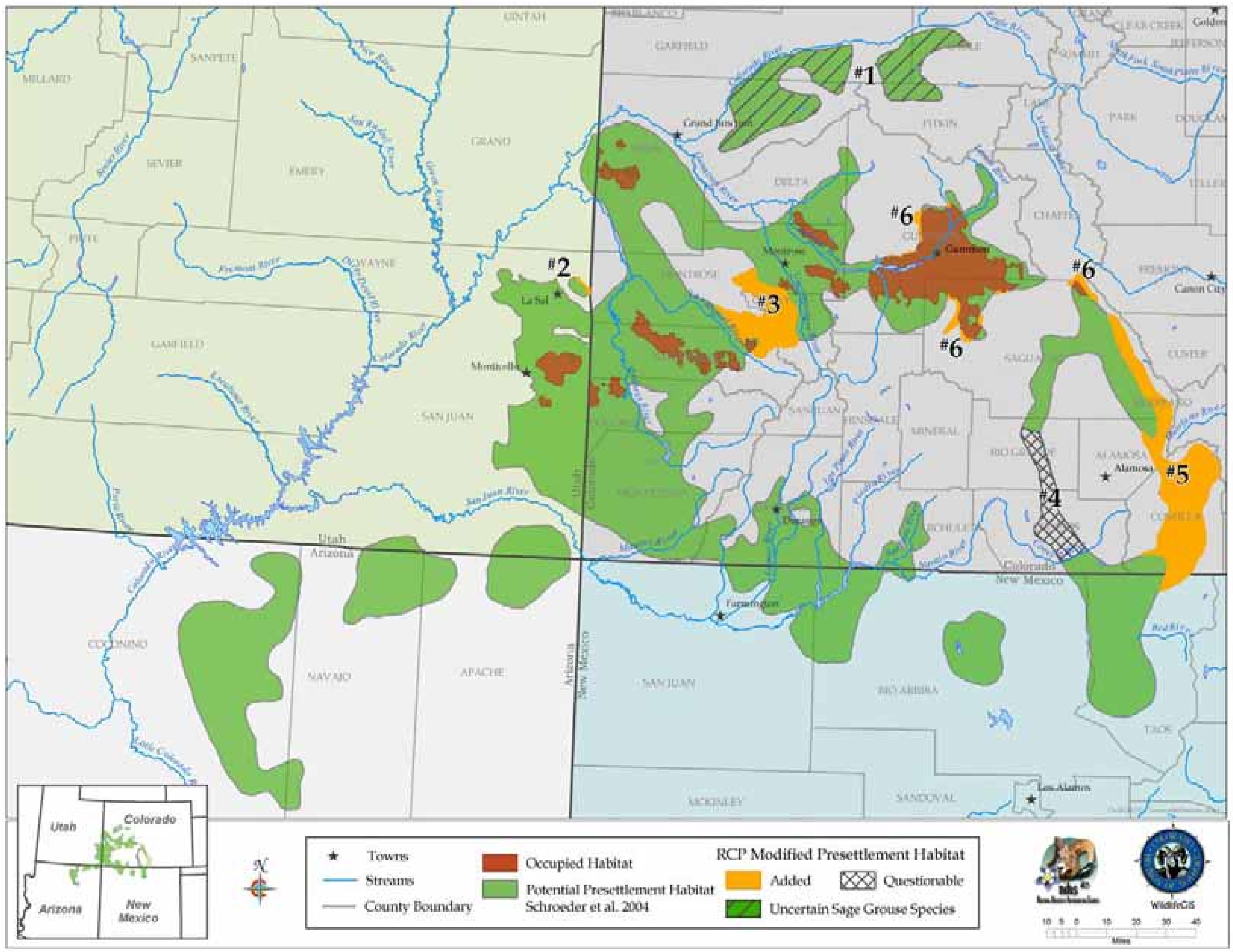


Fig. 3. Current and historical Gunnison sage-grouse range. See next page for details on numbers found on map.

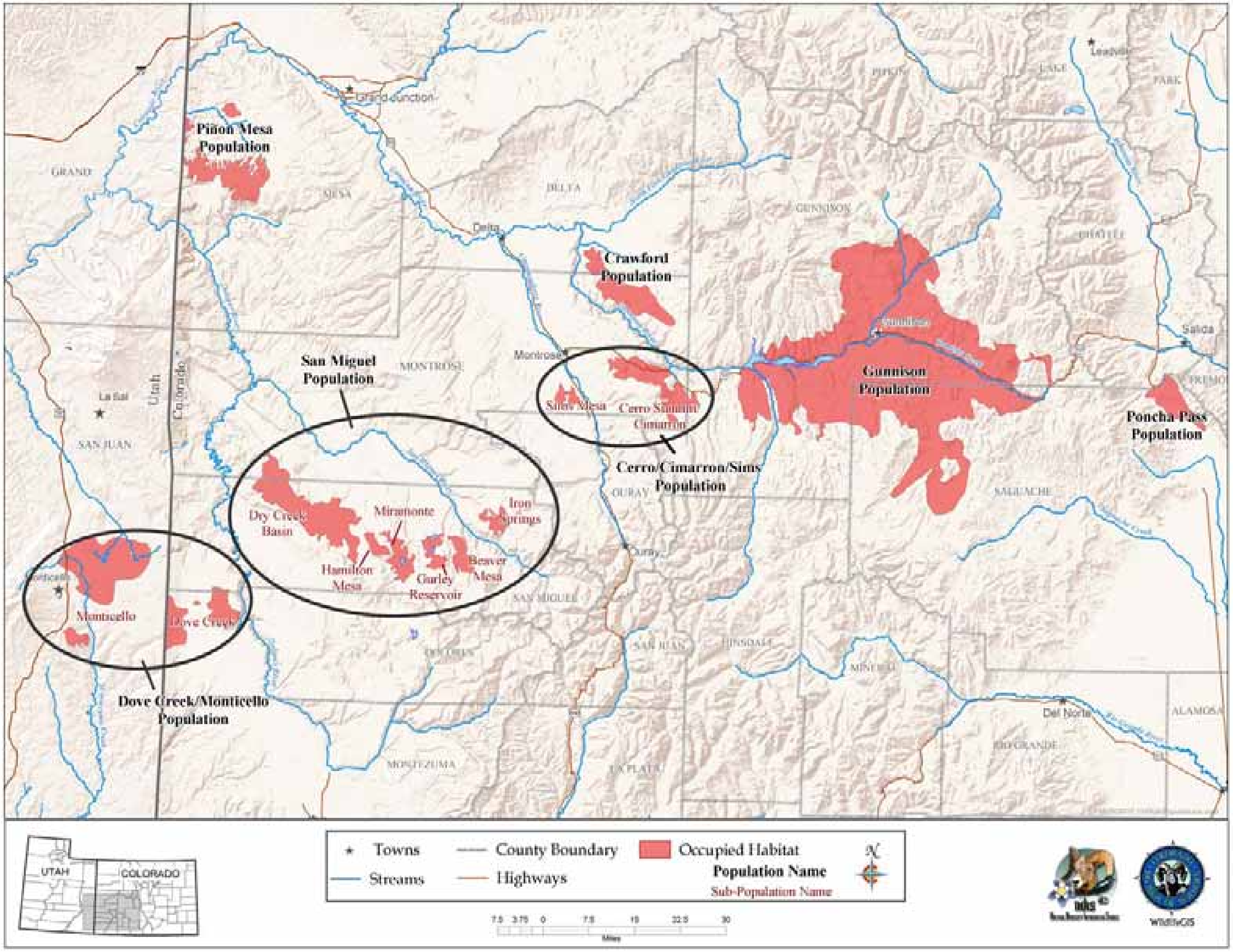


Fig. 4. Locations of current Gunnison sage-grouse populations. The discontinuity in occupied habitat at the state line in the Dove Creek - Monticello area is not entirely a mapping artifact; where there is occupied habitat on the Colorado side there is an abrupt change to cropland on the Utah side of the border. The abrupt transition at the state border in the Piñon Mesa area may be due to differing mapping efforts between the states and is addressed in the "Habitat Monitoring" rangewide strategy (see Objective 1, Strategy 3, pg. 221).

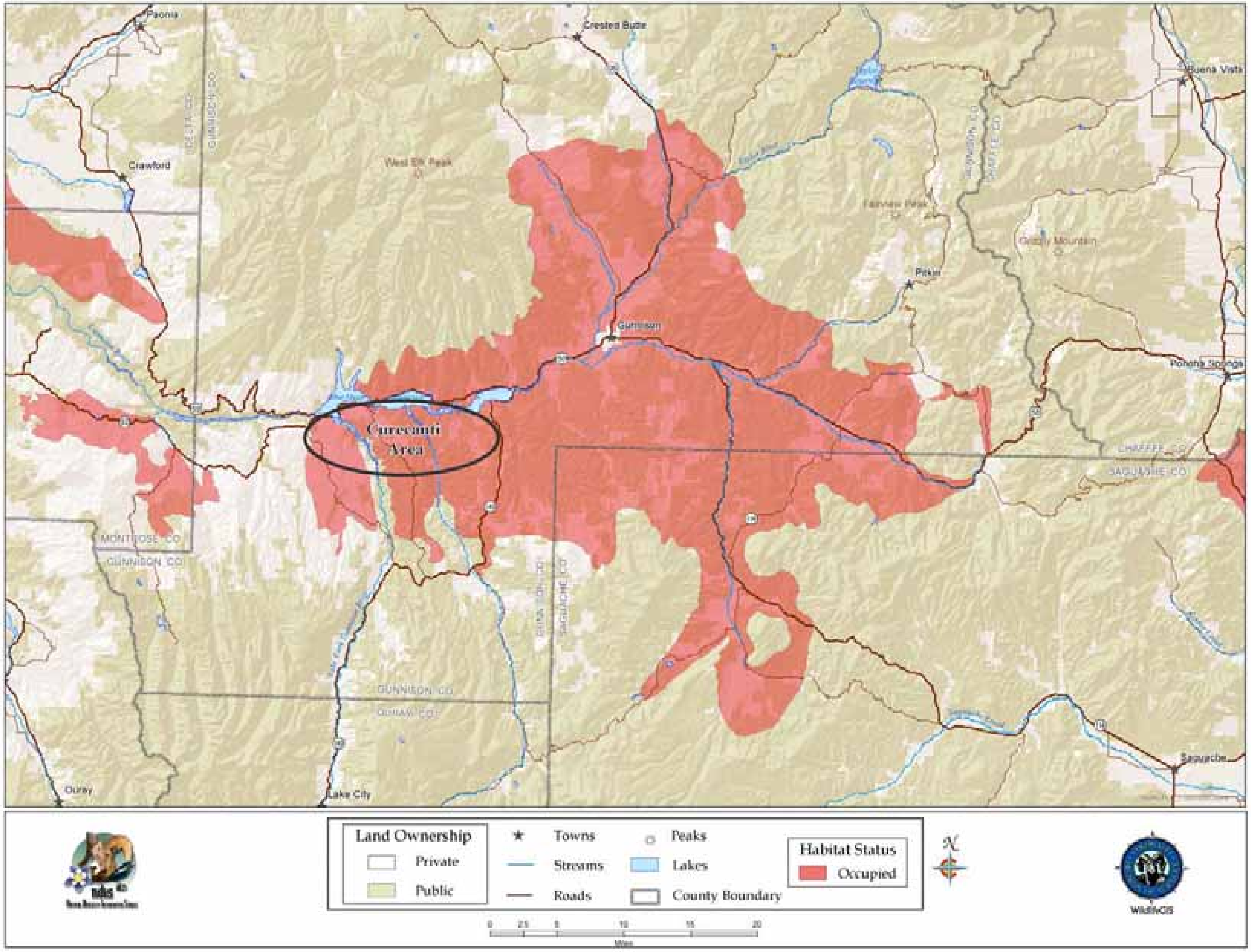


Fig. 5. Location of Curecanti within Gunnison Basin GUSG population area.

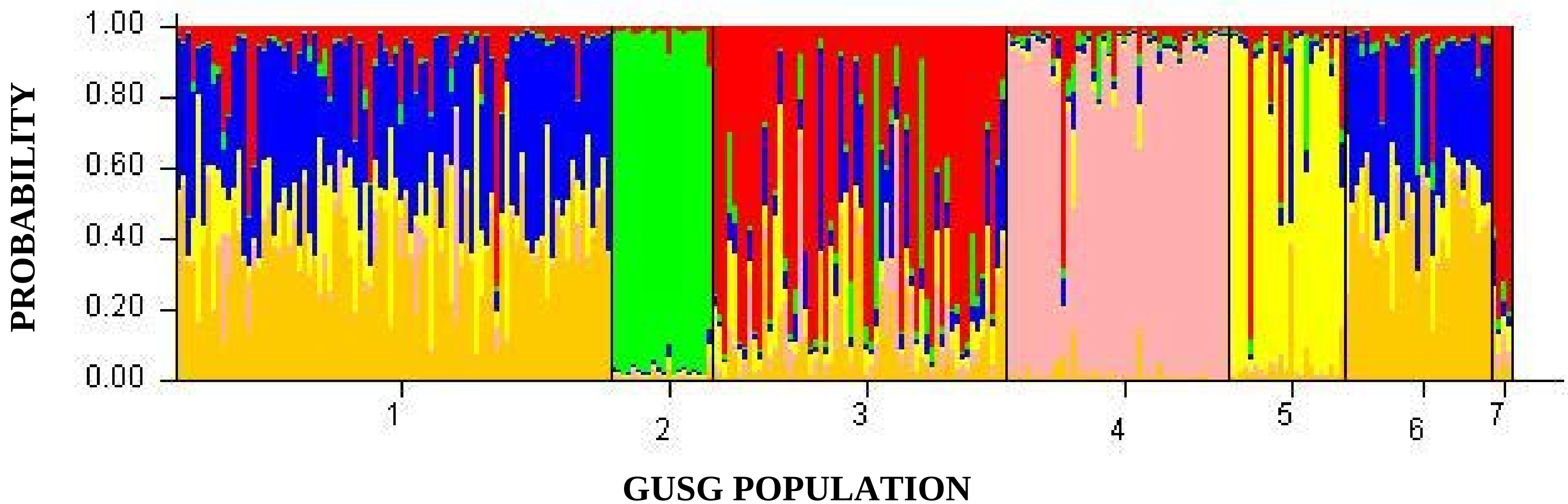


Fig. 7. Results of STRUCTURE analysis conducted by Oyler-McCance et al. (in press). Each vertical bar represents an individual grouped into populations (1 = Gunnison Basin, 2 = Pińon Mesa, 3 = San Miguel Basin, 4 = Dove Creek - Monticello, 5 = Crawford, 6 = Curecanti, 7 = 4 samples taken from Sims Mesa). The colors on each vertical bar represent the probability of the individual belonging to a certain cluster. Each cluster is represented by a unique color.

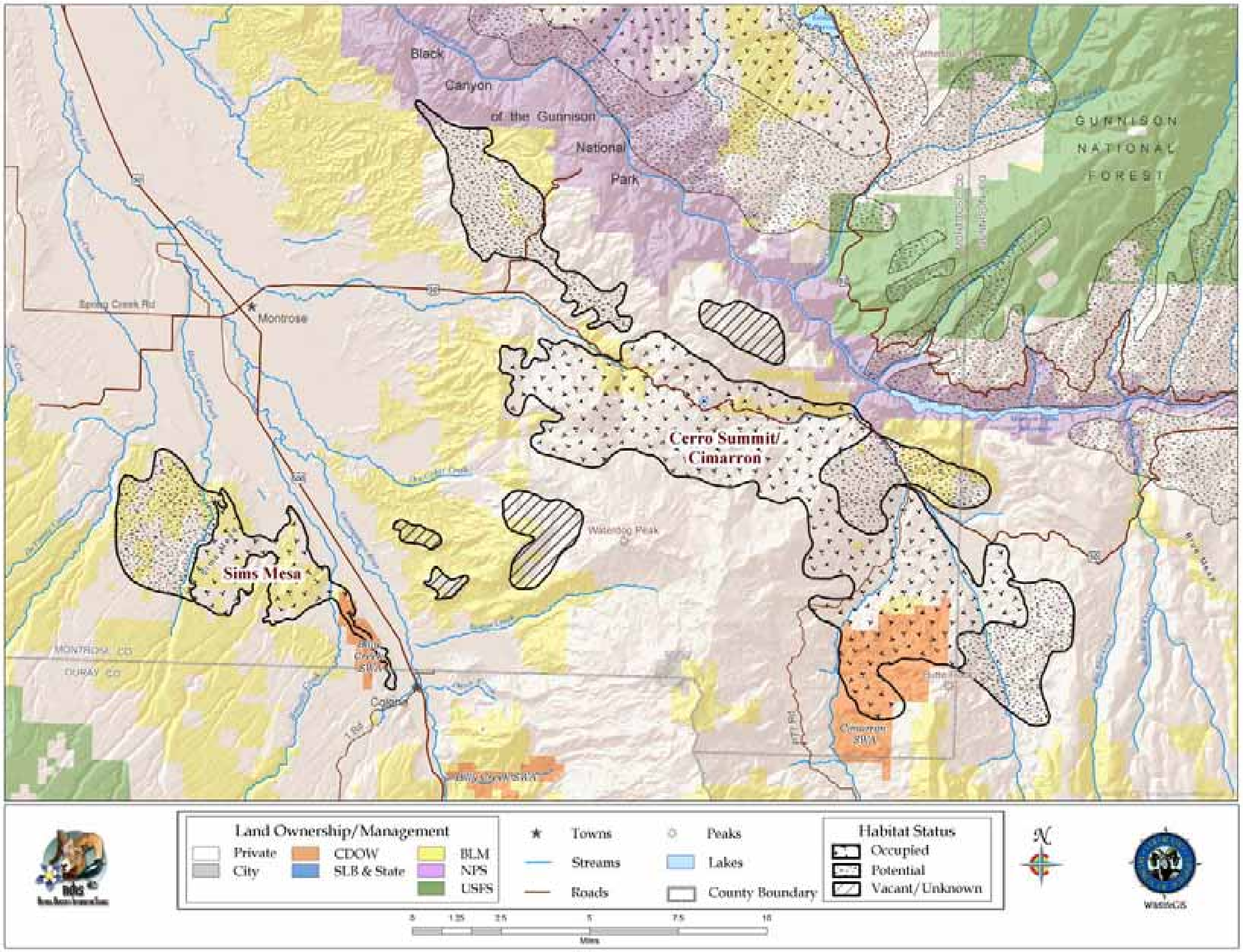


Fig. 8. Location, landownership, and habitat status of the Cerro Summit – Cimarron – Sims Mesa GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

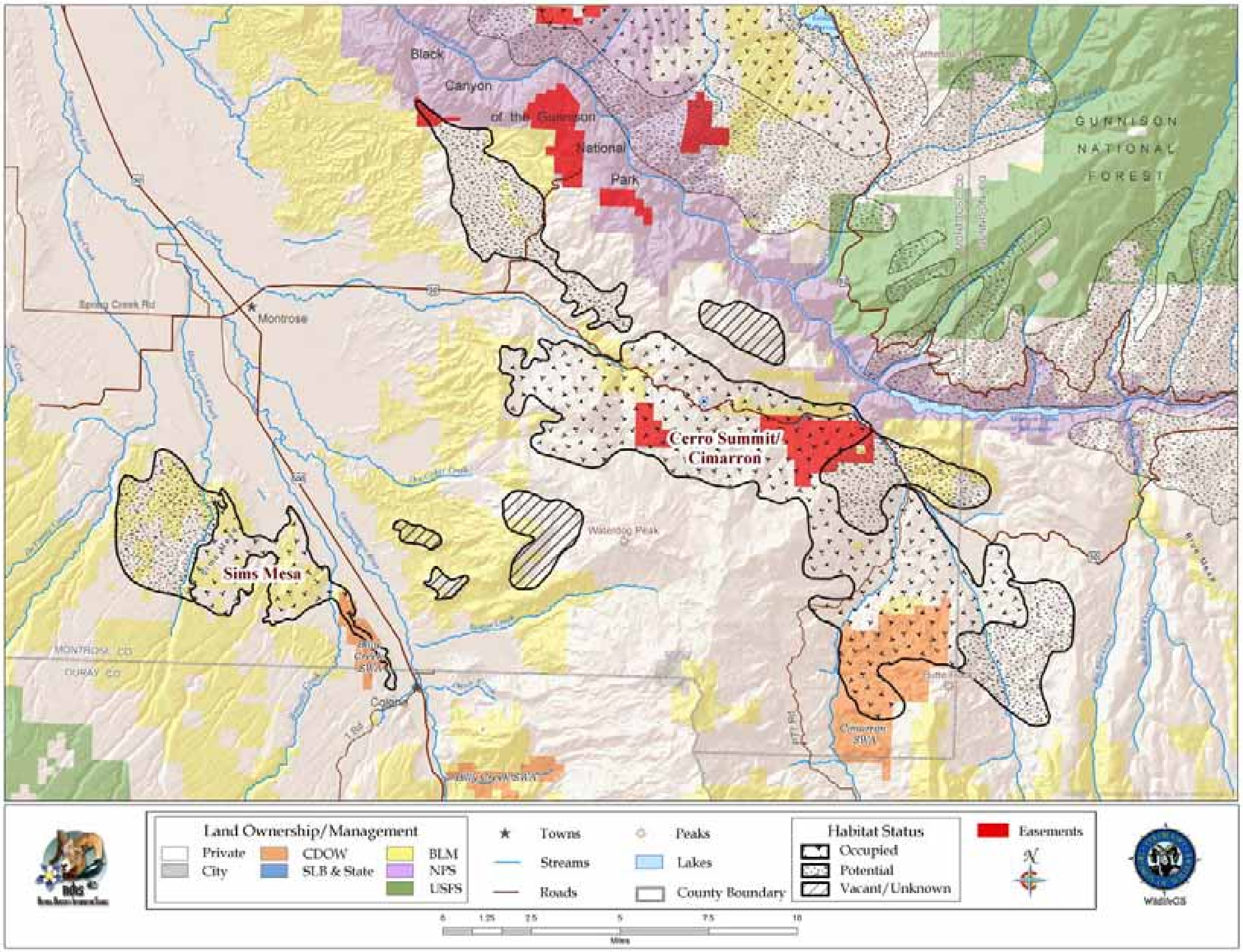


Fig. 9. Conservation easements in the Cerro Summit – Cimarron – Sims Mesa GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

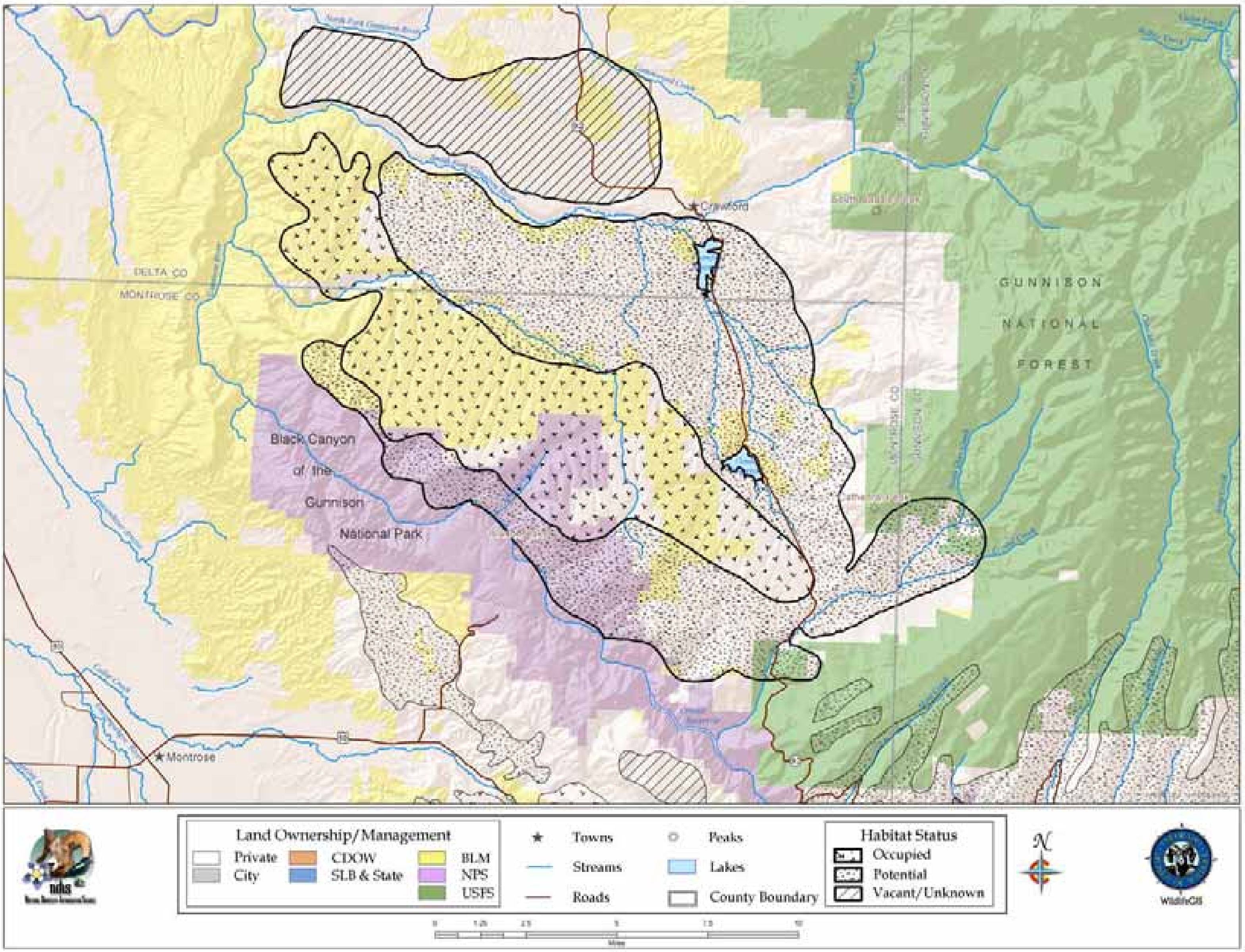


Fig. 10. Location, landownership, and habitat status of the Crawford GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

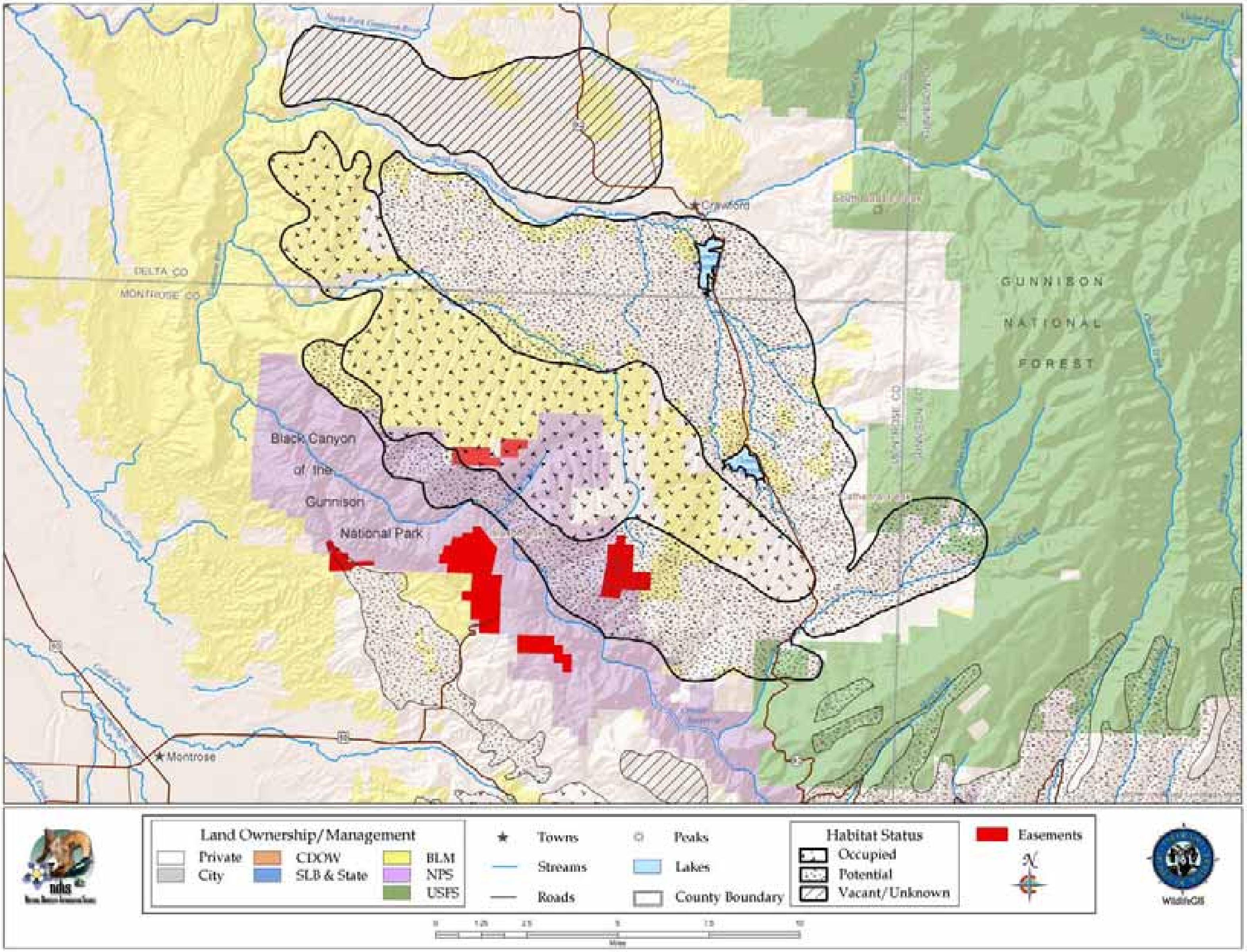


Fig. 11. Conservation easements in the Crawford GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

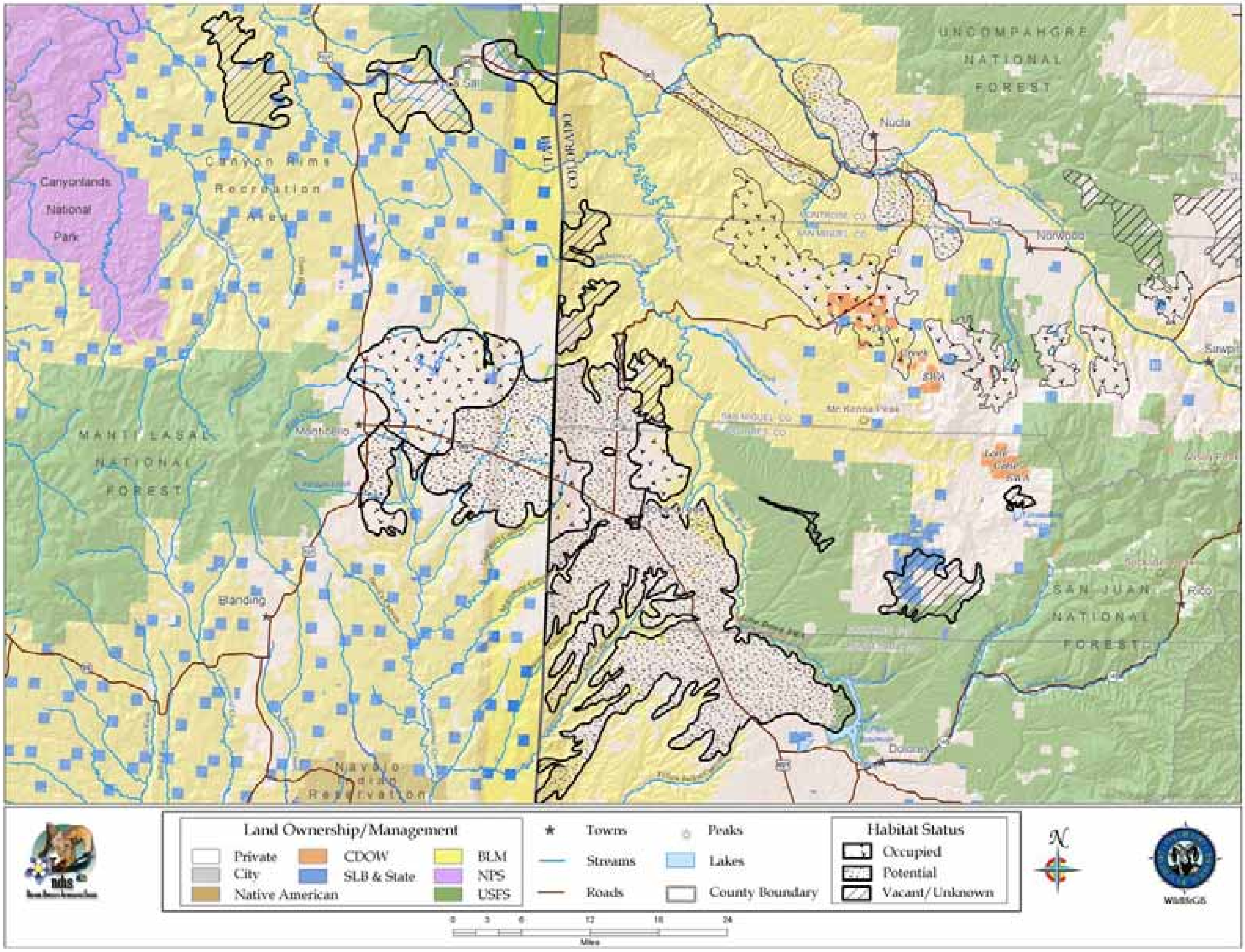


Fig. 12. Location, landownership, and habitat status of the Dove Creek and Monitcello GUSG populations. Habitat status definitions are provided on page 54. The abrupt discontinuity in occupied habitat at the state line is not entirely a mapping artifact; where there is occupied habitat on the Colorado side there is an abrupt change to cropland on the Utah side of the border. Resolving differences in “Potential” and “Vacant/Unknown” habitat mapping efforts between the states is addressed in the “Habitat Monitoring” rangewide strategy (see Objective 1, Strategy 3, pg. 221). The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

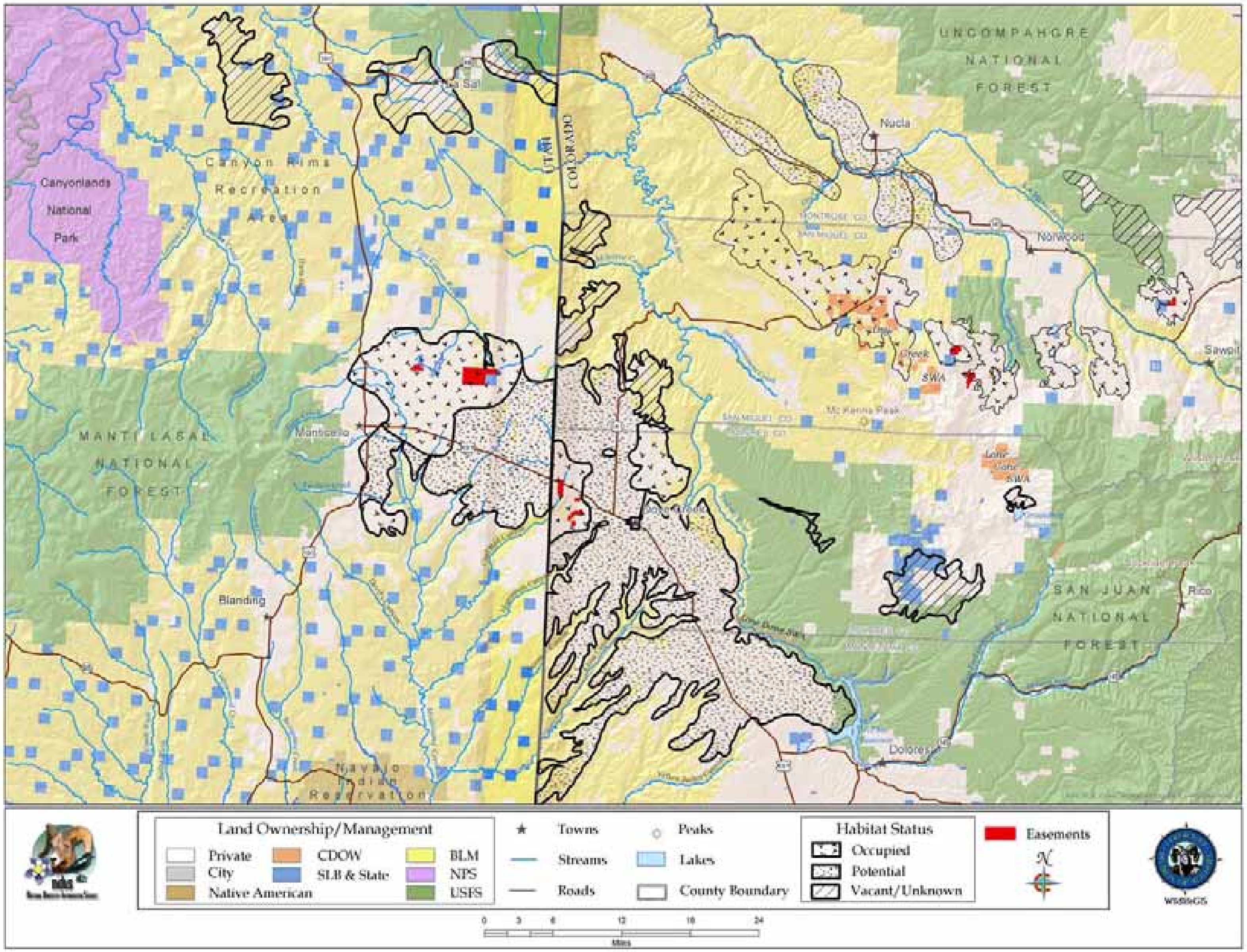


Fig. 13. Conservation easements in the Dove Creek and Monticello GUSG area (data current through 2003). Habitat status definitions are provided on page 54. See Fig. 12 (pg. 69) for discussion of habitat discontinuities at the state line.

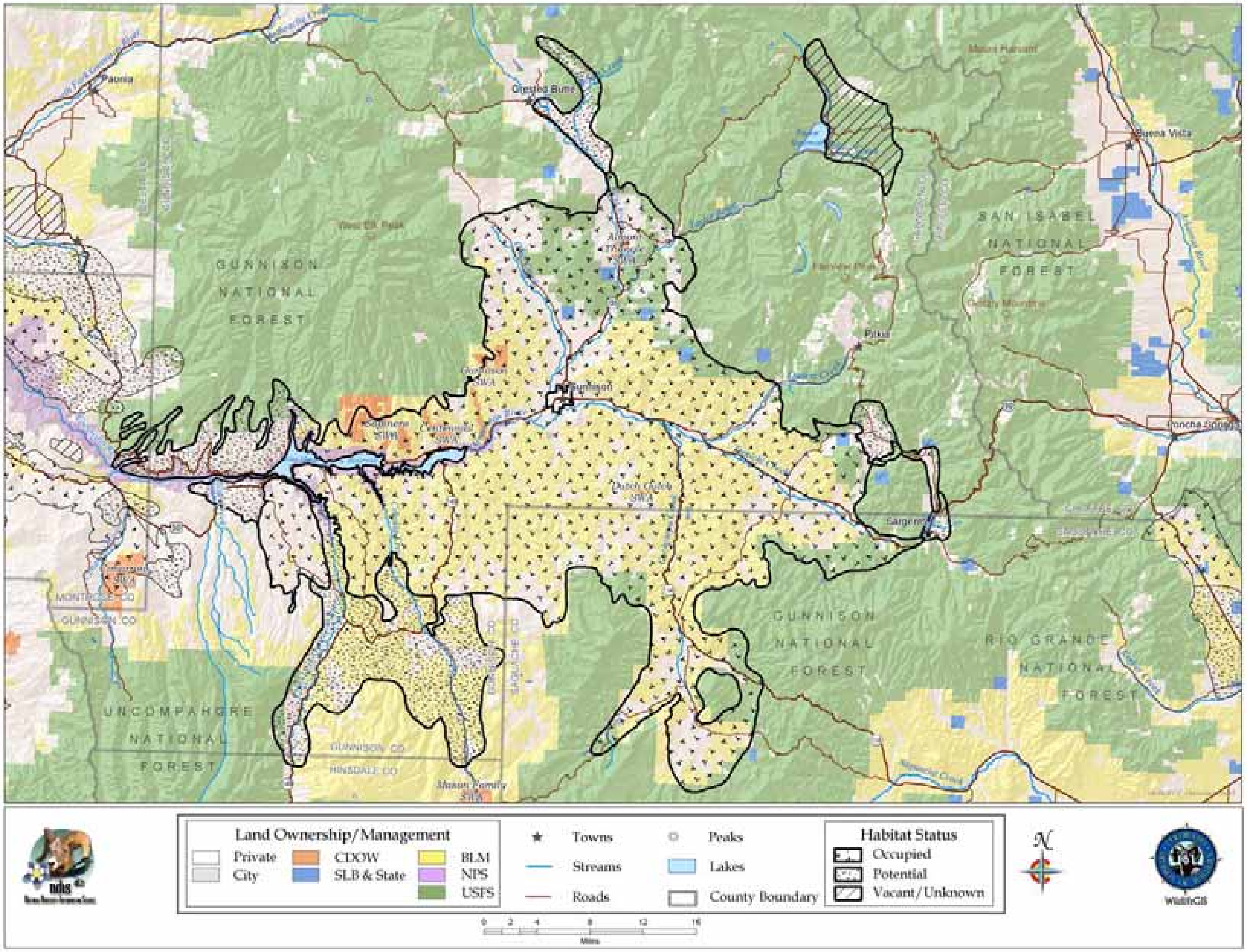


Fig. 14. Location, landownership, and habitat status of the Gunnison Basin GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

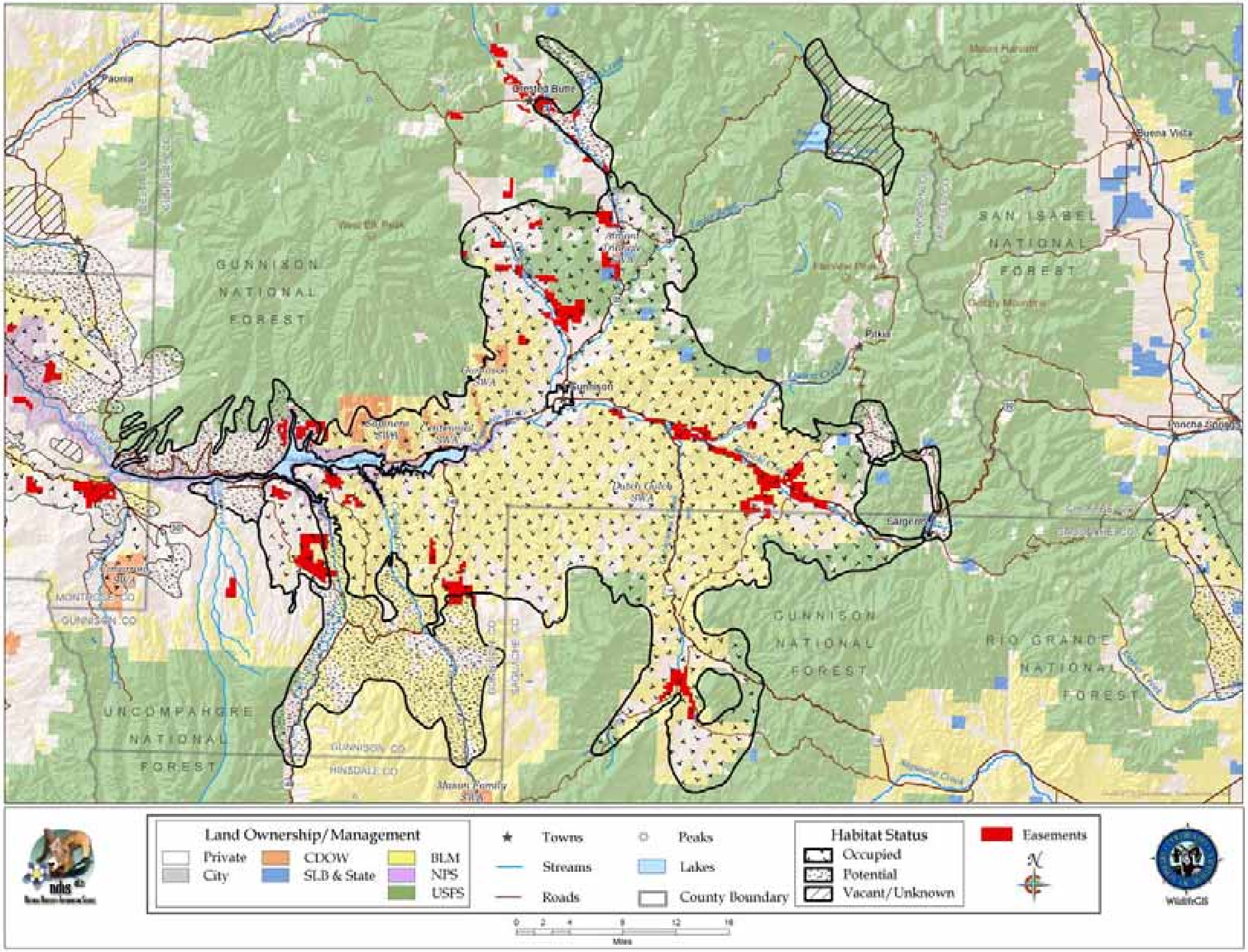


Fig. 15. Conservation easements in the Gunnison Basin GUSG area (data current through 2003). Habitat status definitions are provided on page 54.

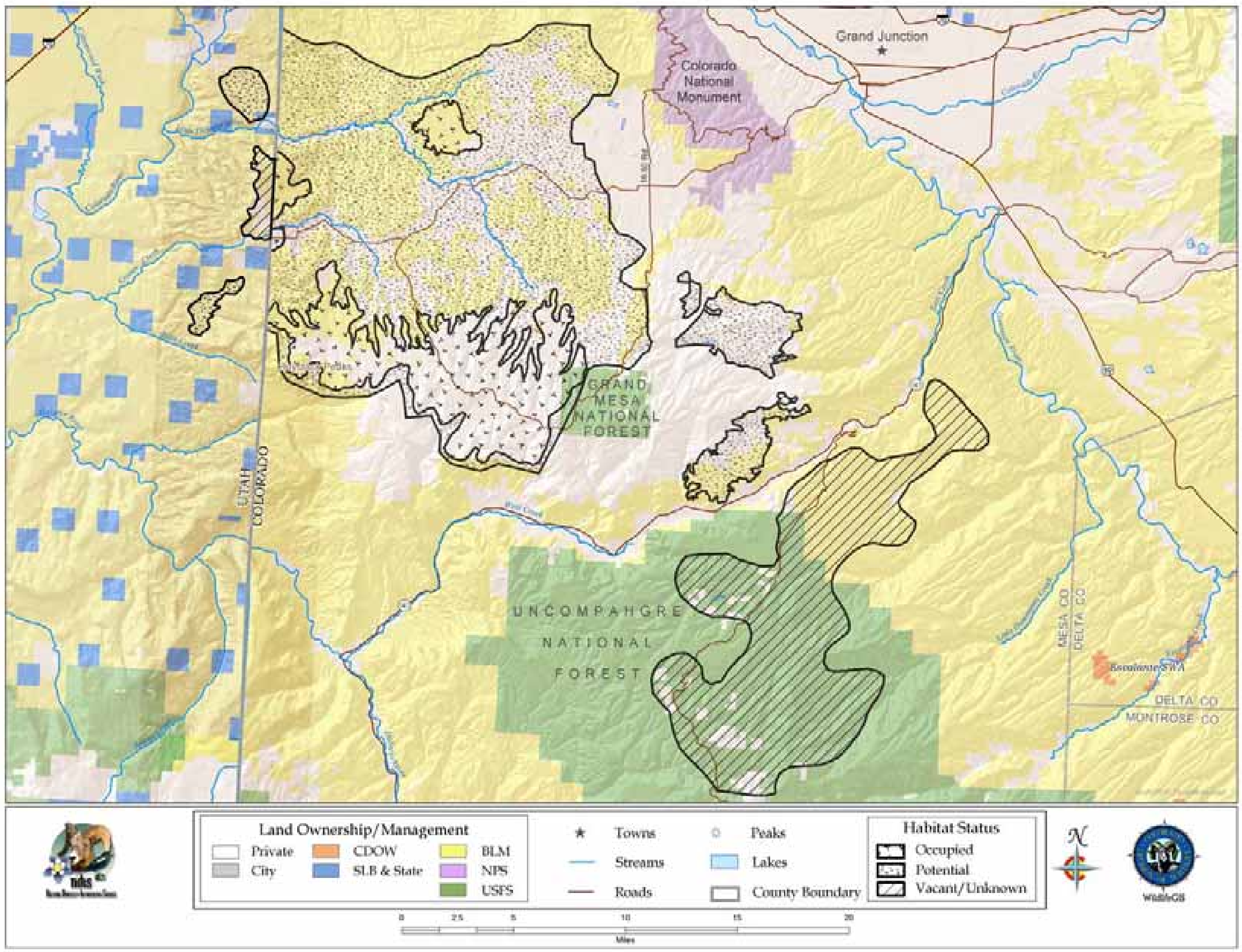


Fig. 16. Location, landownership, and habitat status of the Piñon Mesa GUSG population. Habitat status definitions are provided on page 54. Discontinuities in habitat at the state border may be due to differing mapping efforts between the states and is addressed in the "Habitat Monitoring" rangewide strategy (see Objective 1, Strategy 3, pg. 221). The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

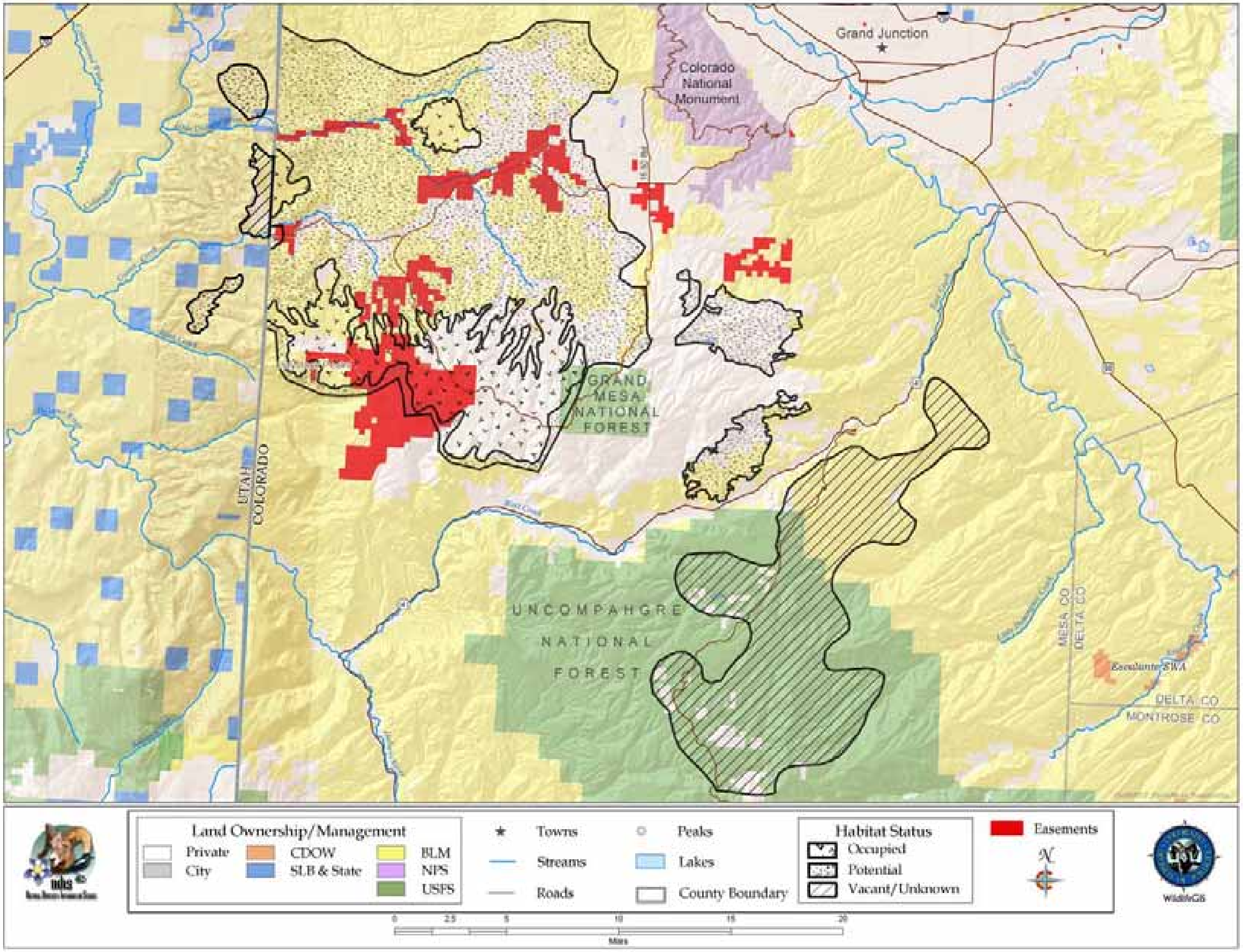


Fig. 17. Conservation easements in the Piñon Mesa GUSG area (data current through 2003). Habitat status See Fig. 16 (pg. 86) for discussion of habitat discontinuities at the state line.

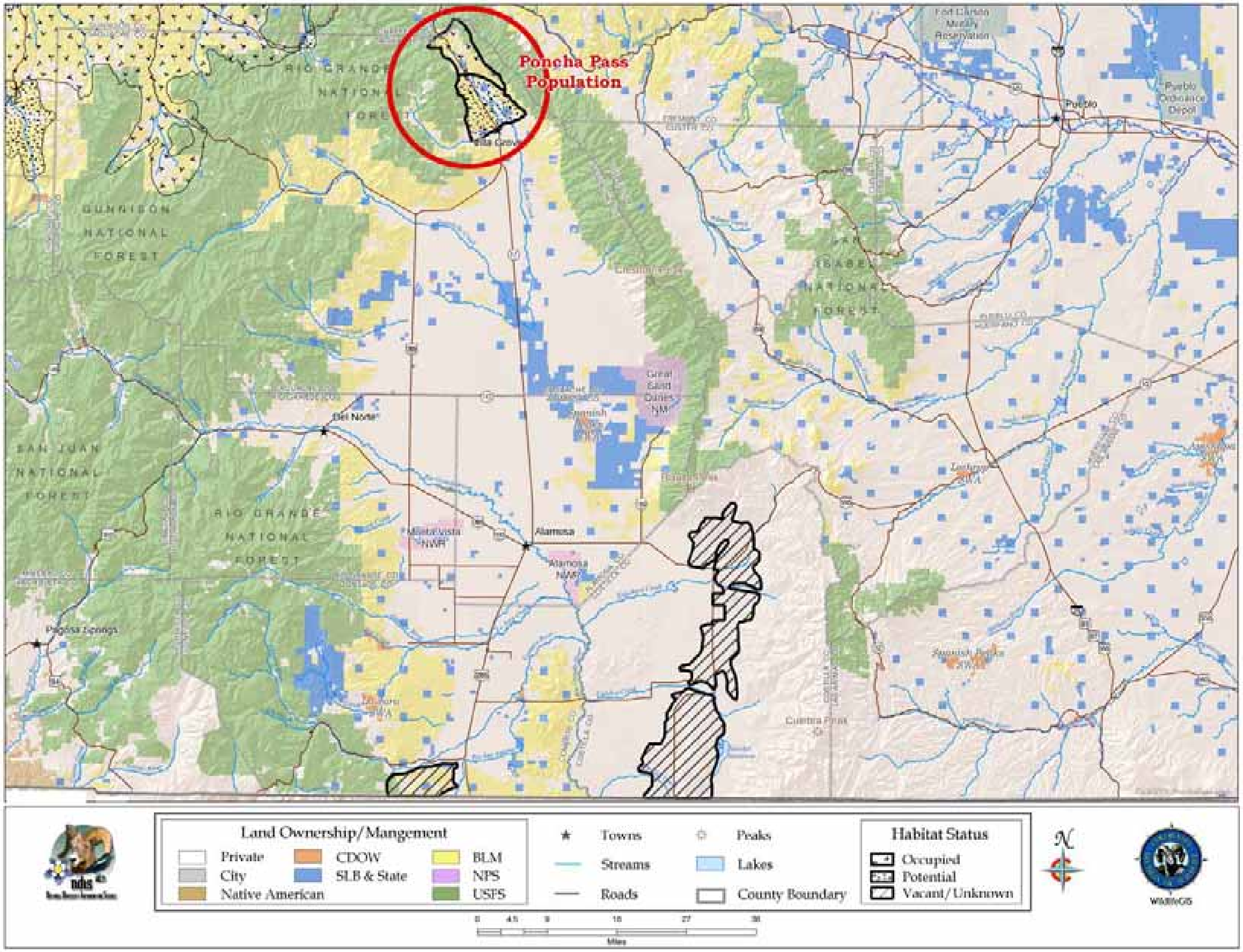


Fig. 18. Location, landownership, and habitat status of the Poncha Pass GUSG population. Habitat status definitions are provided on page 54. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

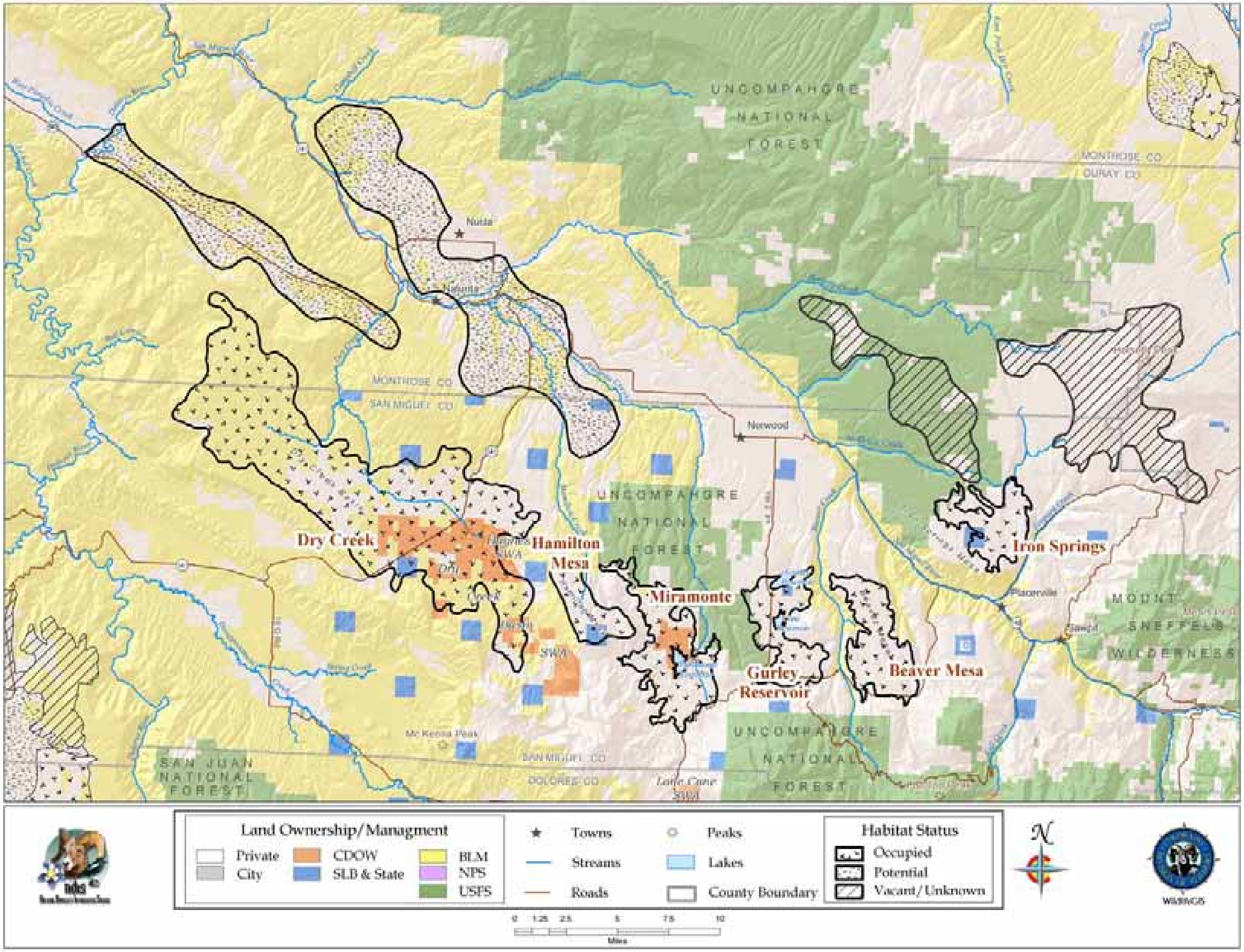


Fig. 19. Location, landownership, and habitat status of the San Miguel Basin GUSG population. Habitat status definitions are provided on page 54. The Hughes SWA has been recently acquired and was not used in the analysis. The original landownership data layer (Bureau of Land Management 2002) has been modified; however inaccuracies may be present.

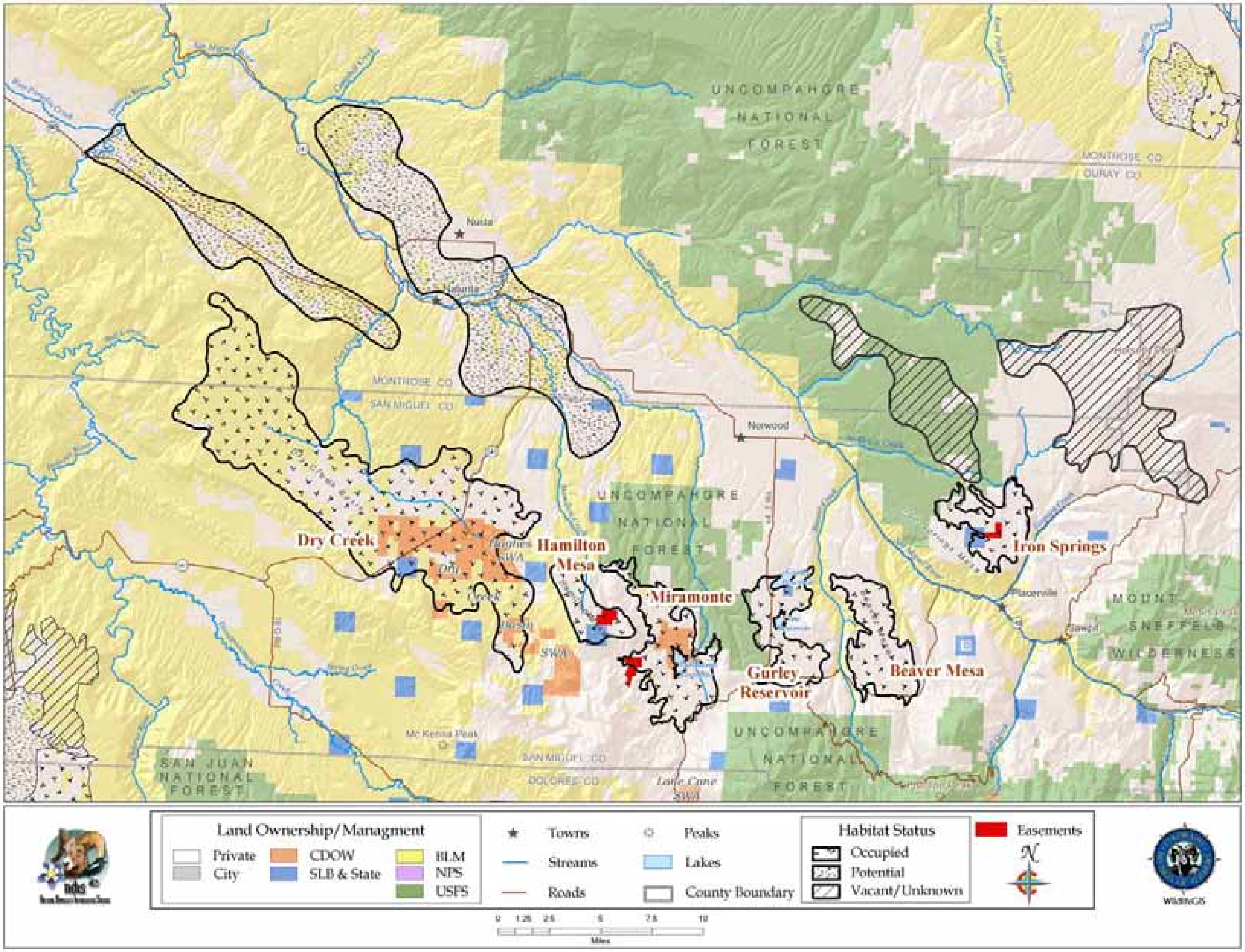


Fig. 20. Conservation easements in the San Miguel Basin GUSG area (data current through 2003). Habitat status definitions are provided on page 54. The Hughes SWA has been recently acquired and was not used in the analysis.

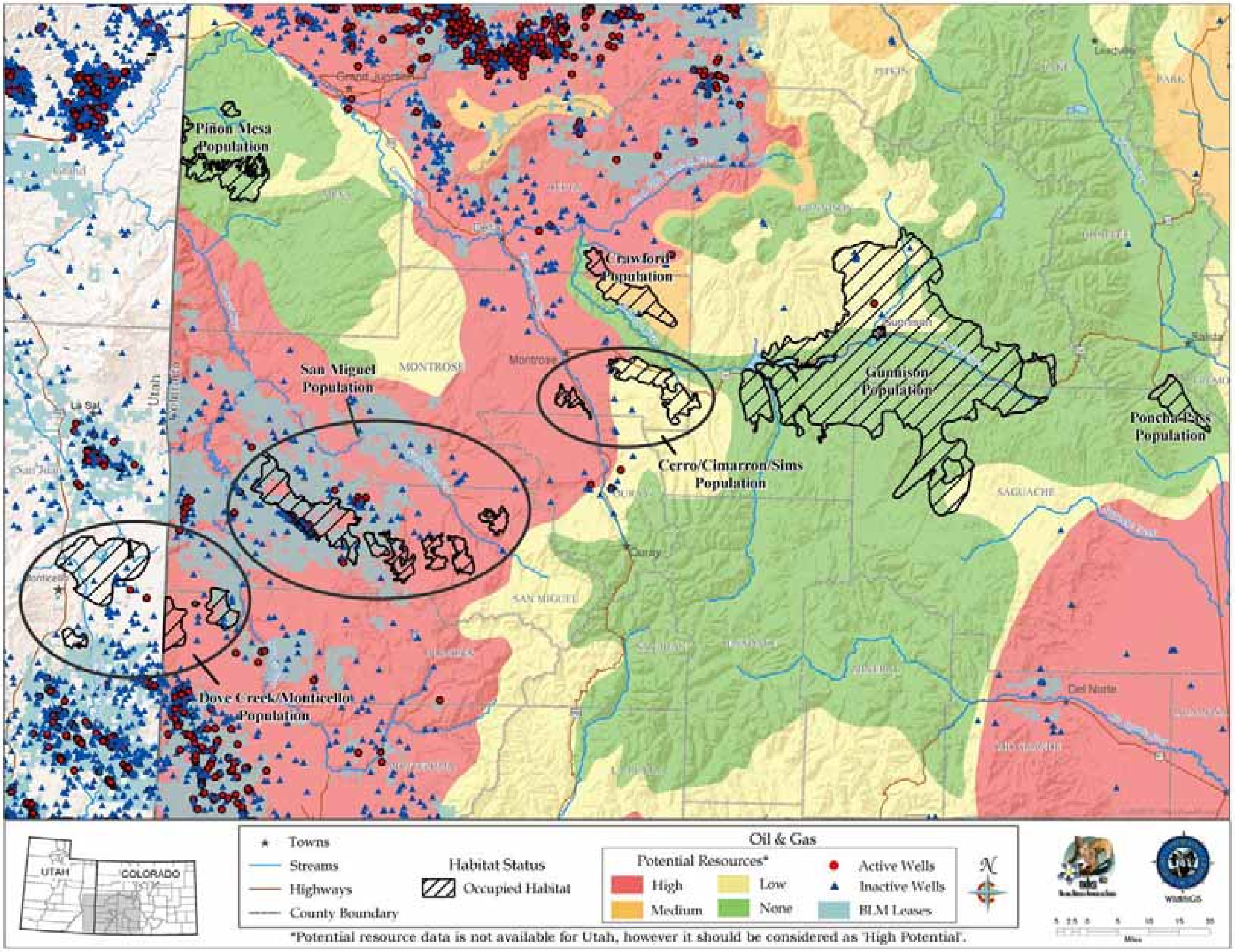


Fig. 25. Potential oil and gas reserves in current GUSG range. Data sources include Bureau of Land Management (1999) for the potential oil and gas resource and lease data and Colorado Oil and Gas Conservation Commission (2005) and the Utah Division of Oil (2004), Gas and Mining for the well location data.

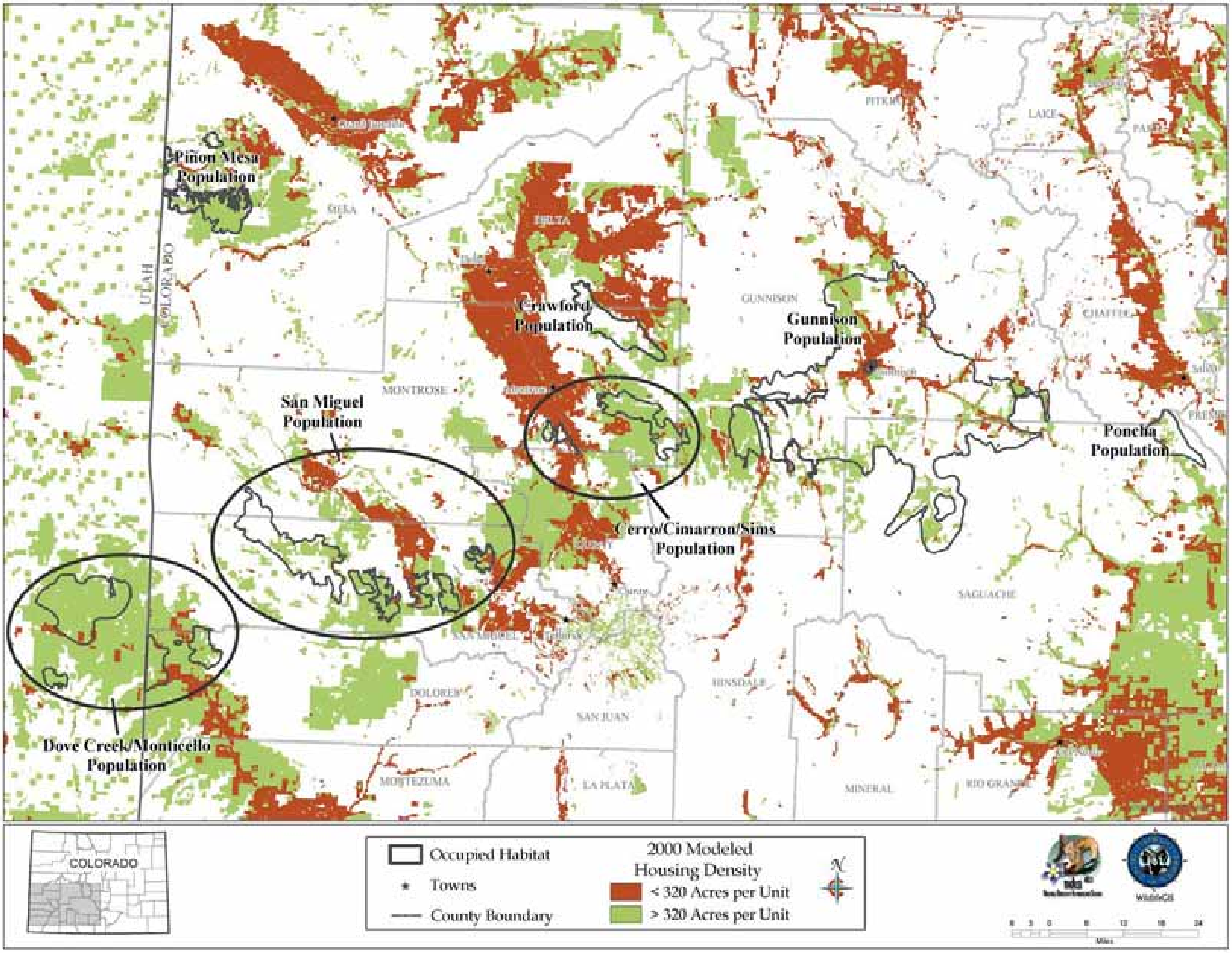


Fig. 26. Modeled housing densities for unprotected lands, 2000.

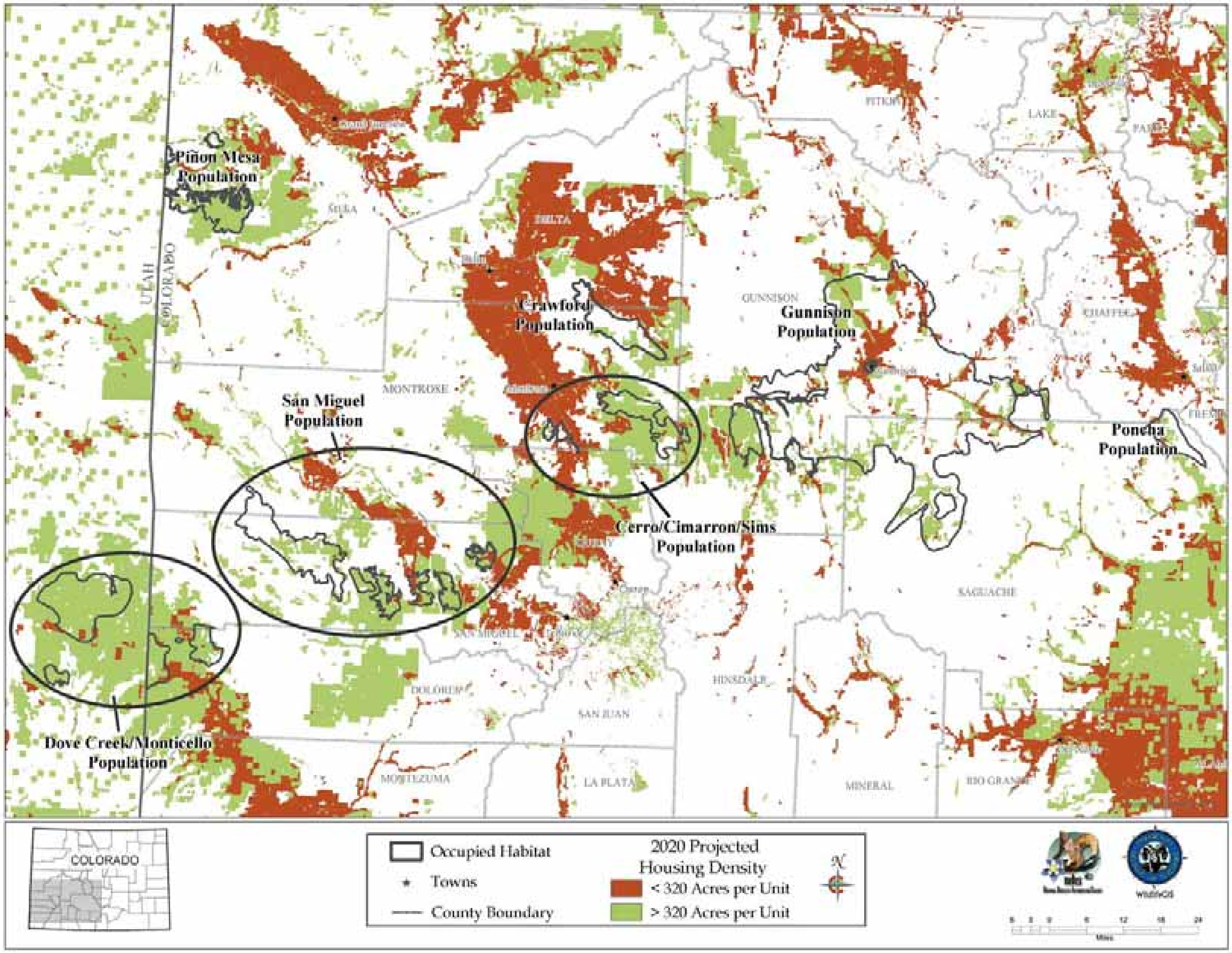


Fig. 27. Projected housing densities for unprotected lands, 2020.

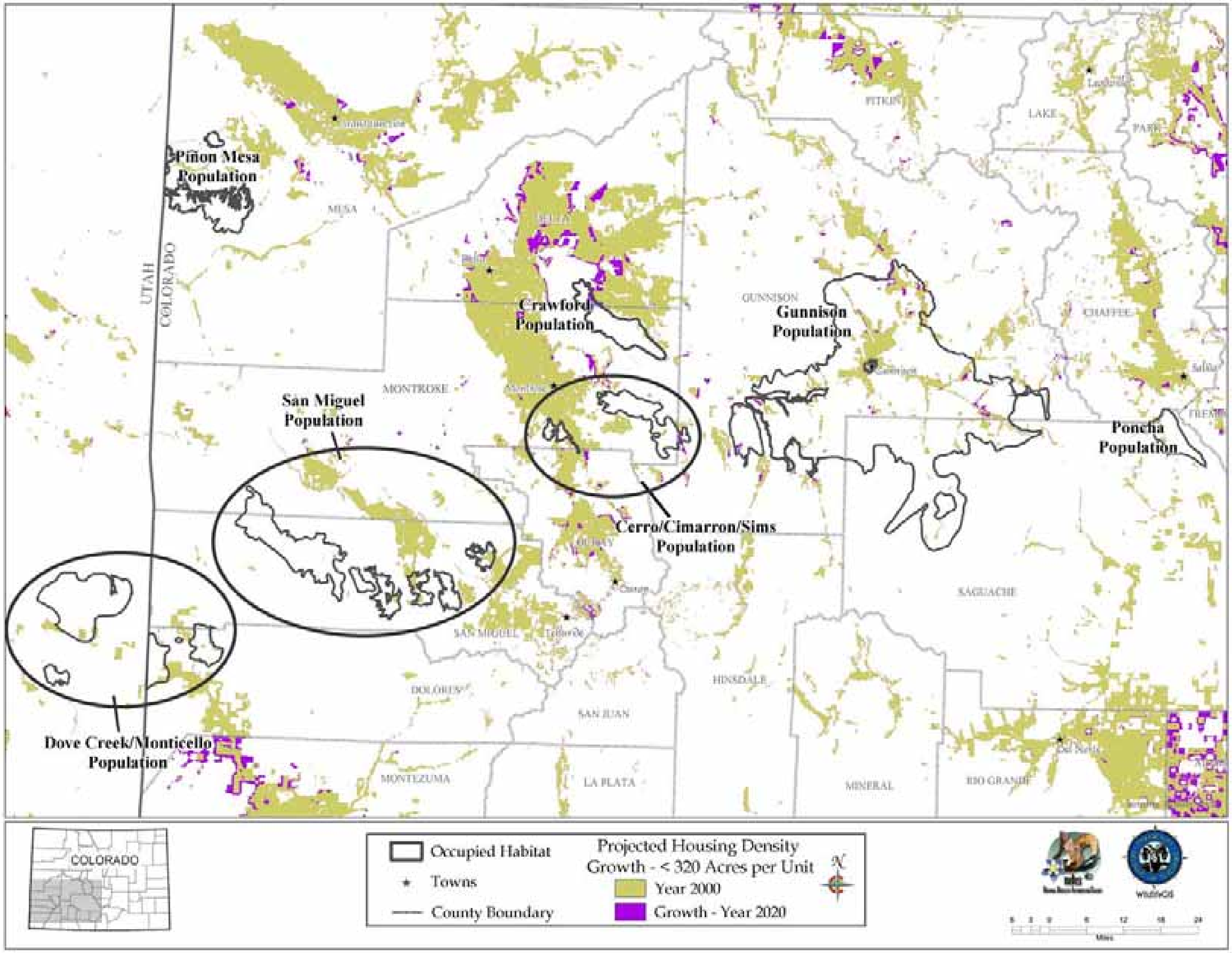


Fig. 28. Areas of growth from modeled year 2000 to 2020, for areas less than 320 acres per unit, on unprotected lands.

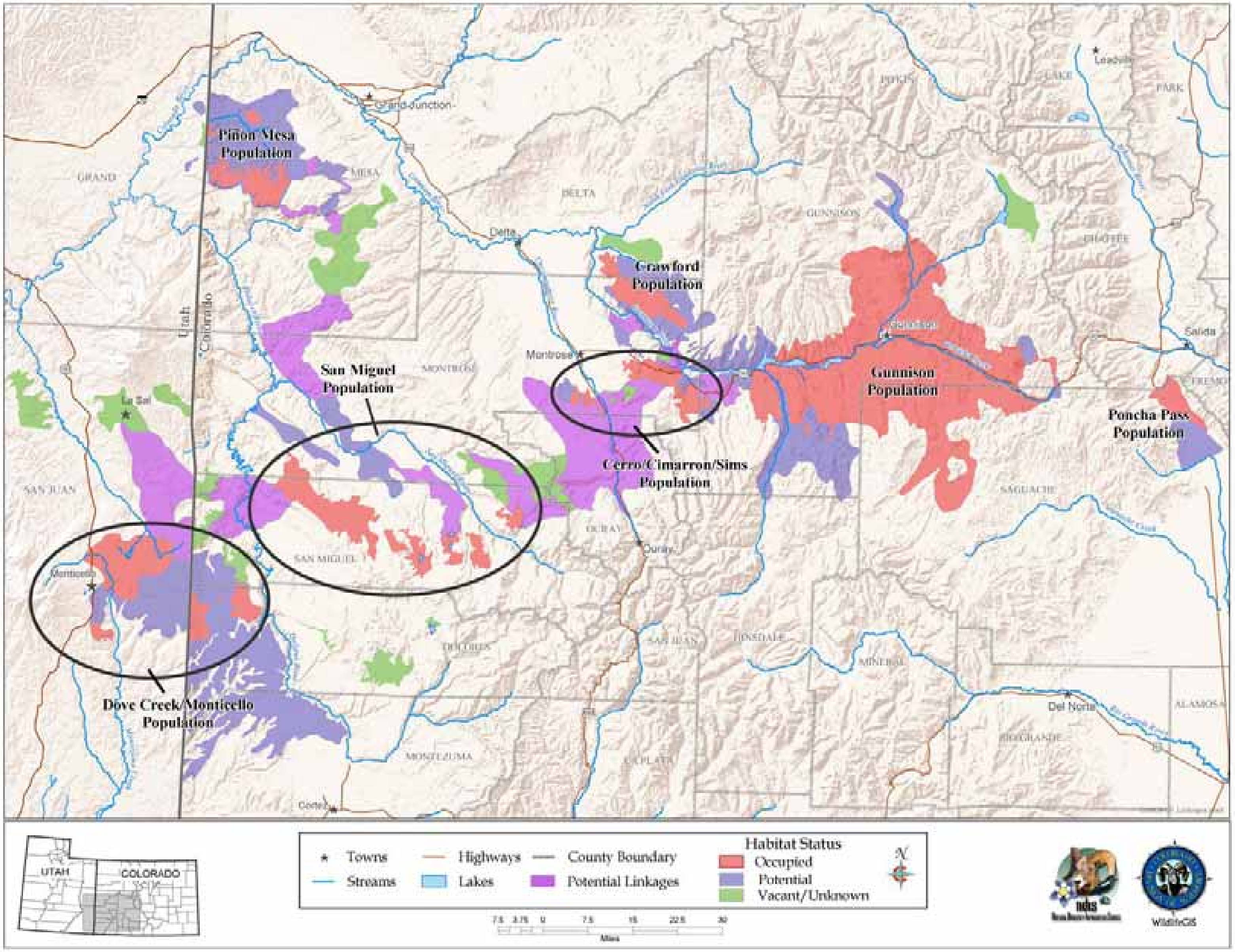


Fig. 29. Potential linkages in GUSG habitat. Discontinuities in habitat at the state border may be due to differing mapping efforts between the states and is addressed in the "Habitat Monitoring" rangewide strategy (see Objective 1, Strategy 3, pg. 221).

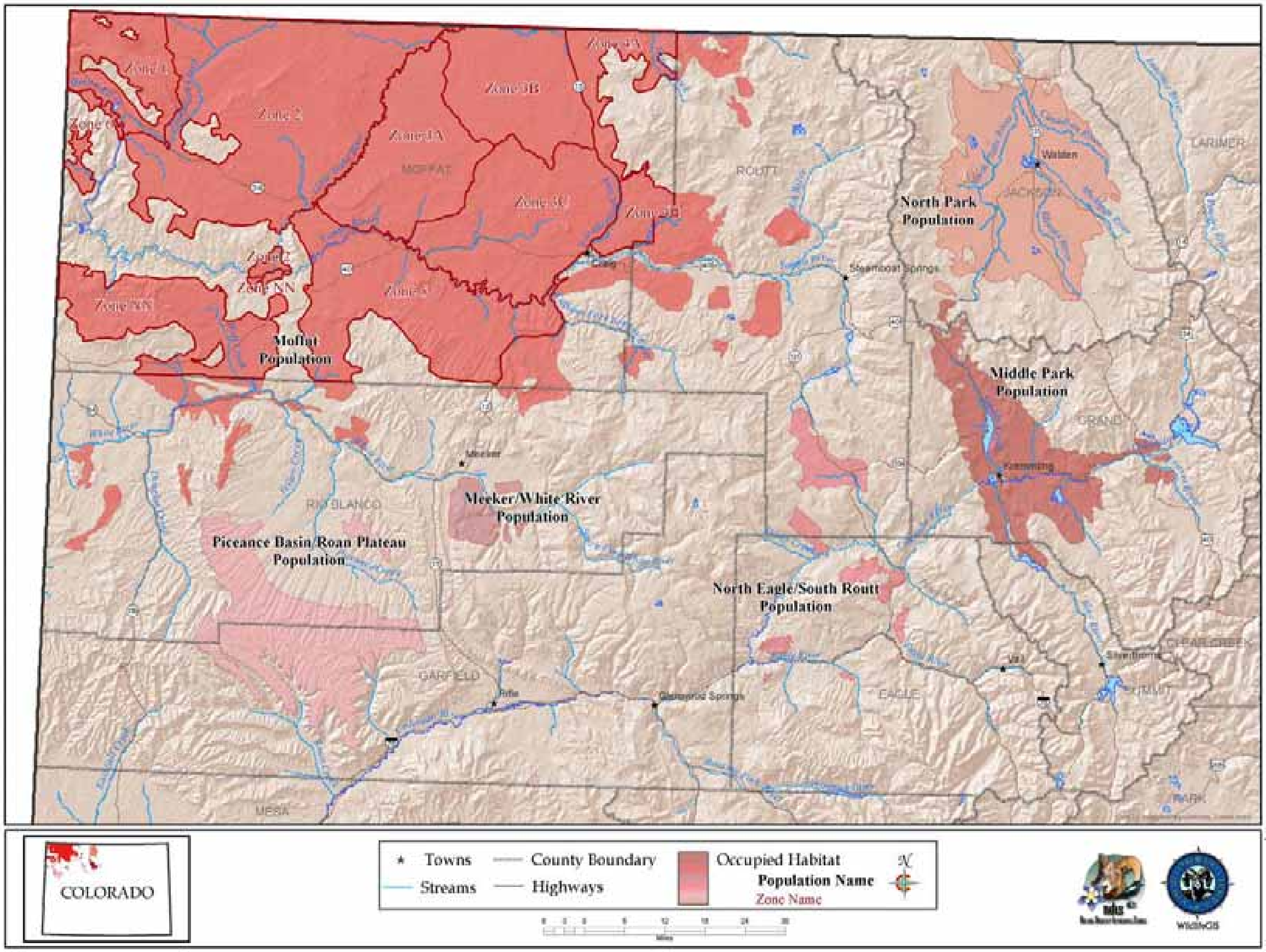


Fig. 33. Locations of GRSG populations used in analysis of sage-grouse population size and amount of available habitat.

CONSERVATION AGREEMENT

The Colorado Division of Wildlife hereby states its intent and commitment to assist with and participate in the implementation of the Gunnison Sage-grouse Rangewide Conservation Plan (RCP), prepared by the multi-agency Gunnison Sage-grouse Rangewide Plan Steering Committee. Specific commitments made hereby are as follows:

1. To provide one staff person to coordinate the implementation of this plan and represent the Division on the Gunnison Sage-grouse Rangewide Plan Steering Committee, which consists of representatives from state (Colorado and Utah) and federal agencies. Functions of the Steering Committee continue after completion of the RCP.
2. To assume lead responsibility for inventory and monitoring of Gunnison Sage-grouse in Colorado and to annually compile and report inventory and monitoring information.
3. To assume lead responsibility for the reintroduction of Gunnison Sage-grouse into formerly occupied habitats in Colorado as well as augmentation of existing small populations for purposes and by means described in the plan.
4. To implement and enforce specific State statutes (Colorado Revised Statutes, Title 33, Articles 2, 3 and 6).
5. To make recommendations to, and cooperate with, other state and federal agencies, local governments, private landowners, local work groups, and land developers to avoid, minimize, or mitigate negative impacts of development and other land uses on Gunnison Sage-grouse populations and their habitats in Colorado.
6. To make recommendations to, provide some funding for, and cooperate with, other state and federal agencies, local governments, private landowners, local work groups and other conservation organizations to conserve and enhance Gunnison Sage-grouse habitats in Colorado.
7. To continue to support and conduct research on the populations dynamics, habitat relationships, and other aspects of Gunnison Sage-grouse conservation in Colorado.
8. To continue Colorado Division of Wildlife participation and support of local work groups, as appropriate.

Performance of the commitments described above is contingent on adequate funding being made available and allocated to the Colorado Division of Wildlife. This agreement shall not prohibit the Colorado Division of Wildlife from engaging in management actions regarding Gunnison Sage-grouse beyond those described in this agreement and in the RCP. This agreement shall become effective on the date of signing by the participating party and shall remain in effect until the signatory party chooses to terminate the agreement. The agreement may be terminated by providing 90 days written notice to the Gunnison Sage-grouse Rangewide Conservation Plan Steering Committee.

Bruce L. McCloskey
Director, Colorado Division of Wildlife

5/3/05
Date:

Conservation Agreement

The U.S. Bureau of Land Management (Colorado) hereby states its intent and commitment to assist with and participate in the implementation of the ***Gunnison Sage-grouse Rangewide Conservation Plan***. This plan was prepared by an interagency steering committee and is designed to conserve and enhance populations and habitats of Gunnison Sage-Grouse (GUSG), a BLM sensitive species and FWS priority 2 candidate species. This plan is in no way meant to be construed as a Resource Management Plan Decision. All projects or management actions implemented through these guidelines will be subject to site specific environmental analysis required under the National Environmental Policy Act. Specific commitments made hereby are as follows:

1. All proposed projects or actions funded, implemented or authorized by the BLM will be analyzed with respect to impacts on Gunnison Sage-Grouse and their habitats in accordance with the guidelines set forth in this plan.

2. To implement the guidelines, conservation actions, and intent set forth in this plan within the constraints of existing laws, policies, regulations and management plans, and while considering the needs or implications to other species and multiple uses.

3. To work with private landowners, companies, organizations and other state or federal agencies to implement necessary conservation actions to enhance Gunnison Sage-Grouse habitat as outlined in this plan.

4. To protect or mitigate any Gunnison Sage-Grouse populations and suitable habitat which may be located on BLM lands from negative impacts which may be caused by other land use activities. Authority for the protection of the Gunnison Sage-Grouse and its habitat is pursuant to provisions in the BLM Policy Manual and the Federal Land Policy and Management Act.

Performance of all activities described above is contingent on adequate staff and funding being allocated to the signatory agency. This agreement shall not prohibit the signatory agency from engaging in management actions regarding Gunnison Sage-Grouse conservation beyond those described in the agreement and in the Conservation Plan. Such management action should be coordinated with the Rangewide Steering Committee (RSC) and local GUSG workgroups.

This agreement shall become effective on the date of signature by the participating agency and shall remain in effect until the signatory party chooses to terminate the agreement, or the agreement is terminated by consent of the Gunnison Sage-grouse Rangewide Steering Committee. The agreement may be terminated by providing 90 days written notice to the GUSG Rangewide Steering Committee.

Ron Wenker (signature) — 4/29/05

Ron Wenker, Colorado State Director
Bureau of Land Management, USDI

Date

Conservation Agreement

The U.S. Bureau of Land Management (Utah) hereby states its intent and commitment to assist with and participate in the implementation of the ***Gunnison Sage-grouse Rangewide Conservation Plan (RCP)***. This plan was prepared by an interagency steering committee and is designed to provide guidance that will help to conserve and enhance populations and habitats of Gunnison Sage-grouse (GUSG), a BLM- sensitive species and FWS priority 2 candidate species. The RCP is neither a Land Use Plan amendment, nor a decision-making document. All projects or management actions implemented under the RCP will be subject to site specific environmental analysis, as required under the National Environmental Policy Act. Specific commitments made BLM (Utah) are as follows:

1. Where applicable, all proposed projects or actions funded, implemented or authorized by the BLM will be analyzed with respect to potential impacts to Gunnison Sage-grouse and their habitats, and will consider the guidelines set forth in this plan.

2. Consider incorporating the guidelines and conservation measures set forth in this plan into BLM authorized or proposed actions, within the constraints of existing laws, policies, regulations, budgets and management plans; while considering the needs or implications to other species and multiple uses.

3. Work with private landowners, companies, organizations and other state or federal agencies to pursue necessary conservation actions to maintain or enhance Gunnison Sage-grouse habitat as outlined in the RCP.

4. To the extent possible, protect or mitigate Gunnison Sage-grouse populations, as well as suitable habitats located on BLM lands, from negative impacts which may be caused by other land use activities. Authority for the protection of the Gunnison Sage-grouse and its habitat is pursuant to provisions in the BLM 6840 Policy Manual and the Federal Land Policy and Management Act (FLPMA).

Performance of all activities described above is contingent upon adequate staffing and funding being allocated to the signatory agency. This agreement does not preclude the signatory agency from engaging in conservation actions for Gunnison Sage-grouse other than those described in the agreement and in the RCP. Such management action should be coordinated with the local GUSG working group and the Rangewide Steering Committee.

This agreement shall become effective on the date of signature by the participating agency and shall remain in effect until the signatory party chooses to terminate the agreement, or the agreement is terminated by consent of the Gunnison Sage-grouse Rangewide Steering Committee. The agreement may be terminated by providing 90 days written notice to the GUSG Rangewide Steering Committee.

Sally Wisely (signature) — 5/13/05

Sally Wisely, Utah State Director
Bureau of Land Management, USDI

Date

Conservation Agreement

The **National Park Service, Intermountain Region**, hereby states its intent and commitment to assist and participate in the implementation of the *Gunnison Sage-grouse Rangewide Conservation Plan* (RCP). All projects or management actions implemented in accordance with the RCP will be subject to all laws, regulations, policies and procedures in effect at the time the action is implemented. Authorities for the National Park Service to manage Gunnison Sage-grouse and their habitat, and to enter into this voluntary Conservation Agreement derive from the 1916 NPS Organic Act; the General Authorities Act of 1970; the Redwood Act of 1978; the Endangered Species Act of 1973, as amended; the Fish and Wildlife Coordination Act, as amended; and NPS Management Policies and Directors Orders. Specific commitments made hereby are as follows:

1. To undertake active management programs to inventory, monitor, restore, and maintain Gunnison Sage-grouse habitats, control detrimental non-native species, control detrimental visitor access, and re-establish populations as necessary to maintain the species and the habitats upon which they depend.

2. To cooperate with other agencies to ensure that Gunnison Sage-grouse habitat on NPS managed lands provides needed conservation benefits to the total conservation efforts being conducted by all the participating agencies.

3. To continue to participate in and support planning and implementation of conservation efforts by rangewide and local working groups, including the provision of members where appropriate.

Performance of all activities described above is contingent on adequate funds being made available and allocated to the National Park Service. This agreement is neither a fiscal nor a funds obligating document. All other parties and their respective agencies or organizations will handle their own activities and utilize their own resources in pursuing these objectives. This agreement shall not prohibit the National Park Service or the other cooperators in the plan from participating in similar activities with other public or private agencies, organizations, or private citizens. This agreement shall not prohibit the National Park Service from engaging in management actions regarding Gunnison Sage-grouse conservation beyond those described in this conservation plan. Such management actions should be coordinated with the state wildlife management agency (e.g. Colorado Division of Wildlife).

This agreement shall become effective on the date of signature by the participating parties and shall remain in effect until signatory chooses to terminate the agreement. Exceptions or amendments to this agreement may be jointly agreed to by the signatories on a case-by-case basis, where such deviations would better provide for the conservation of the species or its habitat, conflicts must be resolved, or new scientific information becomes available.

[signature] for   4/14/05

Regional Director   Date

Intermountain Region, National Park Service

CONSERVATION AGREEMENT

The USDA/Natural Resources Conservation Service hereby states its intent to assist with and participate in the implementation of the Gunnison Sage-Grouse Rangewide Conservation Plan, as prepared by the Gunnison Sage-Grouse Rangewide Steering Committee. Specific commitments are as follows:

1. To give high priority to sage grouse project applications for Farm Bill funds.
2. To cooperate with other government agencies and NGOs to conserve and enhance Gunnison sage grouse habitats in Colorado.
3. To continue NRCS participation and support of the Rangewide Steering Committee and local work groups as appropriate.

Performance of all activities described in the Plan pertaining to the NRCS is contingent on adequate funds and staff being made available and allocated to the agency. This agreement shall become effective on the date of signature by the participating parties, and shall remain in effect until the parties choose to terminate the agreement, or the agreement is terminated by consent with the Gunnison Sage-Grouse Rangewide Steering Committee.

Allen Green

ALLEN GREEN
State Conservationist
NRCS, Colorado

4/19/05
Date

Conservation Agreement

The U.S.D.A. Forest Service, Rocky Mountain Region (Forest Service), hereby states its intent and commitment to assist and participate in implementing the *Gunnison Sage-grouse Rangewide Conservation Plan (*RCP*).* All projects or management actions implemented in accordance with the RCP will be subject to all laws, regulations, policies and procedures in effect at the time the action is implemented. Authorities for the Forest Service to manage Gunnison sage-grouse habitat and to enter into this voluntary Conservation Agreement derive from the Sikes Act of 1960, as amended; the Multiple-Use Sustained-Yield Act of 1960; the Endangered Species Act (ESA) of 1973, as amended; and the National Forest Management Act of 1976. The Forest Service commits:

1. To manage, as outlined in the RCP, all Gunnison sage-grouse habitats (as mapped by the Colorado Division of Wildlife in the RCP), as a desirable objective of land management activities, consistent with the overall management direction contained within the Forest Plans on the affected national forests: Grand Mesa, Uncompahgre, and Gunnison National Forests; San Juan National Forest; Rio Grande National Forest; and the Pike-San Isabel National Forest.
2. To review and consider the information and recommendations provided by the RCP prior to making any new decision to undertake actions in Gunnison sage-grouse habitat. The RCP and other appropriate local information will be used in project design and implementation to reduce negative impacts and identify opportunities for habitat improvement.
3. To exercise authorities for maintenance of biological diversity, and the conservation and management of the Regional Forester's Sensitive Species, including the Gunnison sage-grouse, as directed by the Forest Service Manual 2630 and 2670. A "Biological Evaluation" will be prepared for each proposed Forest Service program or activity to ensure that Forest Service actions do not contribute to loss of viability of the Gunnison sage-grouse or cause this species to move toward federal listing under the Endangered Species Act.
4. To continue Forest Service participation and support of state-wide and local Gunnison sage-grouse working groups, as appropriate.
5. To coordinate management actions in Gunnison sage-grouse habitat with the Colorado Division of Wildlife.

Performance of all activities described above is contingent on adequate funds being made available and allocated to the Forest Service. This agreement is neither a fiscal nor a funds obligating document. All other parties and their respective agencies or organizations will handle their own activities and utilize their own resources in pursuing these objectives. This Agreement shall not prohibit the Forest Service or the other cooperators in the RCP from participating in similar activities with other public or private agencies, organizations, or private citizens. This Agreement shall not prohibit the Forest Service from engaging in management actions regarding Gunnison sage-grouse conservation beyond those described in this conservation plan.

This Agreement shall become effective on the date of signature and shall remain in effect until the Forest Service chooses to terminate the Agreement. Exceptions to this Agreement may be made on a case-by-case basis, where such deviations would better provide for the conservation of the species or its habitat, conflicts must be resolved, or new scientific information becomes available.

Rick D. Cables
Rick Cables, Regional Forester
Rocky Mountain Region, U.S. Forest Service

April 28, 2005
Date

Gunnison Sage-grouse Rangewide Conservation Plan

The **U.S. Fish and Wildlife Service (Service)**, hereby states its intent to assist with and participate in the implementation of the Gunnison Sage-grouse Rangewide Conservation Plan (RCP), as prepared by the interagency Rangewide Steering Committee (RSC), of which the Service is a member. Authority for the Service to enter into this agreement and participate in implementation of the RCP comes from the Endangered Species Act of 1973, as amended; the Fish and Wildlife Act of 1956; and the Fish and Wildlife Coordination Act, as amended. Signing of this agreement does not constitute a review under the Policy for Evaluating Conservation Efforts When Making Listing Decisions (PECE), nor an evaluation of the real or absolute extinction risk for the Gunnison sage-grouse. The Service's endorsement of the RCP is not an indication that it will determine, under PECE, that the RCP should be considered when the Service makes a listing determination for the Gunnison sage-grouse, nor does the existence of this RCP necessarily result in the Service determining that listing is not warranted. Specific commitments made by the Service hereby are as follows:

1. To use our authorities to review projects and recommend measures to avoid or minimize impacts to the Gunnison sage-grouse and its habitat. We will review and consider the information and recommendations in the RCP and local information during informal consultation on projects.
2. To provide technical assistance for proposed conservation actions as needed and requested, considering information and recommendations in the RCP for the actions.
3. To pursue funding opportunities through available grants or funding sources for implementation of the RCP.
4. To continue Service participation and support on the RSC and local working groups as appropriate.
5. To provide recommendations to address any issues of concern during future RCP revisions.

Performance of all activities described above is contingent on adequate funds and staff being made available and allocated. All projects or management actions implemented in accordance with the RCP will be subject to all laws, regulations, policies and procedures in effect at the time the action is implemented. This agreement is neither a fiscal nor a funds obligating document. This agreement shall not prohibit the Service from engaging in management actions regarding Gunnison sage-grouse conservation beyond those described in this agreement and in the RCP. However, such management actions should be coordinated with the RSC.

This agreement shall become effective on the last date of signature by participating parties, and shall remain in effect until the agreement is terminated by consent of the RSC. Exceptions or amendments to this agreement may be jointly agreed to by the signatories on a case-by-case basis, where such deviations would better provide for the conservation of the species or its habitat, conflicts must be resolved, or new scientific information becomes available.

Elliott Sutta | 5/9/05

for Ralph O. Morgenweck, Regional Director
Region 6, U.S. Fish and Wildlife Service

Date

CONSERVATION AGREEMENT

The Utah Division of Wildlife Resources (UDWR) hereby states its intent and commitment to assist with and participate in the implementation of the *Gunnison Sage-grouse Rangewide Conservation Plan (RCP)*, prepared by the multi-agency Gunnison Sage-grouse Rangewide Plan Steering Committee. The Gunnison Sage-grouse is listed on Utah's Sensitive Species List, under Administrative Rule R657-48 Implementation of the Wildlife Species of Concern and Habitat Designation Advisory Committee, as a Federal Candidate Species. Specific commitments made hereby are as follows:

1. To provide staff necessary to coordinate the implementation of this plan and represent the UDWR on the Gunnison Sage-grouse Rangewide Plan Steering Committee, which consists of representatives from state (Colorado and Utah) and federal agencies. Functions of the Steering Committee may continue after completion of the RCP.
2. To assume lead responsibility for inventory and monitoring of Gunnison Sage-grouse populations in Utah and to annually compile and report inventory and monitoring information.
3. To assume lead responsibility for the reintroduction of Gunnison Sage-grouse into formerly occupied habitats in Utah as well as augmentation of existing small populations for purposes and by means described in the plan.
4. To implement and enforce specific state statutes pertaining to wildlife, including Gunnison Sage-grouse, as outlined in Utah Code Title 23 and other.
5. To make recommendations to, and cooperate with, other state and federal agencies, local governments, private landowners, the San Juan County Gunnison Sage-grouse Local Working Group (SWOG), and land developers to avoid, minimize, or mitigate negative impacts of development and other land uses on Gunnison Sage-grouse populations and their habitats in Utah.
6. To make recommendations to, provide some funding for, and cooperate with, other state and federal agencies, local governments, private landowners, SWOG and conservation organizations to conserve and enhance Gunnison Sage-grouse habitats in Utah.
7. To continue to support and conduct research on the populations dynamics, habitat relationships, and other aspects of Gunnison Sage-grouse conservation in Utah.
8. To continue UDWR participation and support of the San Juan County Gunnison Sage-grouse Local Working Group as appropriate.

Performance of the commitments described above is contingent on adequate funding being made available and allocated to the UDWR. This agreement shall not prohibit the UDWR from engaging in management actions regarding Gunnison Sage-grouse beyond those described in this agreement and in the RCP.

This agreement shall become effective on the date of signing by the participating party and shall remain in effect until the signatory party chooses to terminate the agreement. The agreement may be terminated by providing 90 days written notice to the Gunnison Sage-grouse Rangewide Conservation Plan Steering Committee.

James F. Karpowitz
James F. Karpowitz
Director, Utah Division of Wildlife Resources

6/8/05
Date:

APPENDIX A

SCIENTIFIC NAMES OF ORGANISMS MENTIONED IN THE RCP

Table 1. Common and scientific names of birds and mammals referred to in the RCP.

Birds	
Common Name	**Scientific Name**
American crow	*Corvus brachyrhynchos*
American kestrel	*Falco sparverius*
Attwater's prairie chicken	*Tympanuchus cupido attwateri*
black grouse	*Tetrao tetrix*
black-billed magpie	*Pica pica*
common raven	*Corvus corax*
Cooper's hawk	*Accipiter cooperii*
eagle	*Haliaeetus* spp. and *Aquila* spp.
ferruginous hawk	*Buteo regalis*
golden eagle	*Aquila chrysaetos*
greater prairie chicken	*Tympanuchus cupido*
greater sage-grouse	*Centrocercus urophasianus*
great-horned owl	*Bubo virginianus*
Gunnison sage-grouse	*Centrocercus minimus*
gyrfalcon	*Falco rusticolus*
lesser prairie-chicken	*Tympanuchus pallidicinctus*
merlin	*Falco columbarius*
northern bobwhite	*Colinus virginianus*
northern goshawk	*Accipiter gentiles*
northern harrier	*Circus cyaneus*
ring-necked pheasant	*Phasianus colchicus*
red-tailed hawk	*Buteo jamaicensis*
sharp-tailed grouse	*Tympanuchus phasianellus*
Swainson's hawk	*Buteo swainsoni*
Mammals	
Common Name	**Scientific Name**
badger	*Taxidea taxus*
bobcat	*Felis rufus*
coyote	*Canis latrans*
elk	*Cervus elaphus*
ground squirrel	*Spermophilus* spp.
mule deer	*Odocoileus hemionus*
pronghorn antelope	*Antilocapra americana*
raccoon	*Procyon lotor*
red fox	*Vulpes vulpes*
Richardson's ground squirrel	*Spermophilus richardsonii*
striped skunk	*Mephitis mephitis*
weasel	*Mustela* spp.

Table 2. Common and scientific names of herbaceous and woody plants referred to in the RCP.

Herbaceous Plants	
Common Name	**Scientific Name**
arrowleaf balsamroot	*Balsamorhiza sagittata*
basin wildrye	*Leymus cinereus*
blue grama	*Bouteloua gracilis*
bluebunch wheatgrass	*Pseudoroegneria spicata (Agropyron spicatum)*
bluegrass	*Poa* spp.
cactus	*Opuntia* spp. *and/or Pediocactus* spp.
cheatgrass	*Bromus tecorum*
crested wheatgrass	*Agropyron cristatum*
elk sedge	*Carex garberi*
galleta grass	*Pleuraphis* spp.
Indian Paintbrush	*Castilleja* spp.
Indian ricegrass	*Achnatherum hymenoides (Oryzosis hymenoides)*
knapweed	*Centaurea* spp.
lupine	*Lupinus* spp.
mariposa lily	*Calochortus* spp.
needlegrass	*Nassella viridula and/or Hersperostipa comata*
penstemon	*Penstemon* spp.
Sand dropseed	*Sporobolus cryptandrus*
sandberg bluegrass	*Poa secunda*
squirreltail	*Elymus elymoides (Sitanion hystrix)*
thistle	*Carduus* spp.
Thurber's needlegrass	*Stipa thurberiana*
western wheatgrass	*Agropyron smithii*
wheatgrass	*Agropyron* spp.

Woody Plants	
Common Name	**Scientific Name**
antelope bitterbrush	*Purshia tridentata*
Basin big sagebrush	*Artemisia tridentata tridentata*
big sagebrush	*Artemisia tridentata*
bitterbrush	*Purshia* spp.
black sagebrush	*Artemisia nova*
chokecherry	*Prunus virginiana*
common snowberry	*Symphoticarpos* spp.
creosote	*Larrea* spp.
curl-leaf mountain mahogany	*Cercocarpus ledifolius*
Gambel oak	*Quercus gambelii*

Woody Plants	
Common Name	**Scientific Name**
greasewood	*Sarcobatus* spp.
horsebrush	*Tetradymia* spp.
juniper	*Juniperus* spp.
(little) Utah juniper	*Juniperus osteosperma*
low sagebrush	*Artemisia arbuscula*
Mormon tea	*Ephedra viridis*
mountain big sagebrush	*Artemisia tridentata vaseyana*
mountain mahogany	*Cercocarpus* spp.
mountain snowberry	*Symphoricarpos oreophilus*
oak	*Quercus* spp.
oakbrush	*Quercus gambelii*
pine	*Pinus* spp.
piñon pine	*Pinus edulis*
piñon- juniper	*Pinus edulis- Juniperus communis*
ponderosa pine	*Pinus ponderosa*
rabbitbrush	*Chrysothamnus* spp. and/or *Ericameria* spp.
rubber rabbitbrush	*Ericameria nauseosa (Chrysothamnus)*
sagebrush	*Artemisia* spp.
saltbush	*Atriplex* spp.
Saskatoon serviceberry	*Amelanchier alnifolia*
serviceberry	*Amelanchier* spp.
shadscale (saltbrush)	*Artiplex confertifolia*
silver sagebrush	*Artemisia cana*
snakeweed and broom snakeweed	*Gutierrezia sarothrae*
spiny hopsage	*Grayia spinosa*
squaw apple	*Peraphyllum ramosissimum*
squawbush	*Peraphyllum ramosissimum*
sticky rabbitbrush	*Chrysothamnus* spp.
Utah serviceberry	*Amelanchier utahensis*
winterfat	*Eurotia lanata*
Wyoming big sagebrush	*Artemisia tridentata wyomingensis*

APPENDIX B

DEFINITIONS OF ACRONYMS USED IN RCP
AND
DESCRIPTION OF "RESPONSIBLE PARTIES" LISTED IN CONSERVATION STRATEGY

Table 1. Definitions of acronyms used in RCP and responsible groups listed in the Conservation Strategy.

Acronym or Responsible Group	Definition
AIC	Akaike Information Criterion
AICc	corrected AIC
APD	application for permit to drill
APHIS	Animal and Plant Health Inspection Service (USDA)
ASAP	as soon as possible
BLM	Bureau of Land Management
BMP	best management practices
C.I.	confidence interval
CACP	Crawford Area Conservation Plan
CBSG	Conservation Breeding Specialist Group
CCAA	Candidate Conservation Agreements with Assurances
CCAA Cooperators	Includes the CDOW, USFWS, and non-federal land owners that have signed onto the Umbrella Candidate Conservation Agreement with Assurances, through a Certificate of Inclusion.
CDOW	Colorado Division of Wildlife
CMC	Colorado Mosquito Control Company
CNHP	Colorado Natural Heritage Program
COGCC	Colorado Oil and Gas Conservation Commission
County and State Health Departments	Specific county and state departments that deal with disease issues.
County Government(s)	Includes several aspects of county governments, such as land use planning, pest control agents, weed control, and county commissioners.
CRP	Conservation Reserve Program
CSA	conservation study area
CSCP	Colorado Species Conservation Partnership
CSU	Colorado State University
CVCP	Colorado Vegetation Classification Project
DCCP	Dove Creek Conservation Plan
Denver University	This refers specifically to the genetics lab at the Denver University where most of the GUSG genetic work has been conducted.
DNA	Deoxyribonucleic acid
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
FLMPA	Federal Land Management Policy Act
FRP	Federal Recovery Plan
FSA	Farm Service Agency (USDA)
FSM	Forest Service Manual

Acronym or Responsible Group	Definition
GBCP	Gunnison Basin Conservation Plan
GIS	geographic information system
GOCO	Great Outdoors Colorado
GRSG	greater sage-grouse
GUSG	Gunnison sage-grouse
Local Work Group(s)	Includes the local working groups for GUSG: Crawford, Dove Creek, Gunnison Basin, Piñon Mesa, Poncha Pass, San Miguel, and San Juan County, Utah.
LUP	Land Use Plans
MOU	Memorandum(a) of Understanding
mtDNA	mitochondrial DNA
National Wildlife Research Center	National Wildlife Research Center (USDA)
NEPA	National Environmental Policy Act
NGO	Non-governmental agencies, including local land trusts (e.g., Mesa County Land Trust, Gunnison County Agricultural land trust, San Miguel Open Space), The Nature Conservancy, and other non-profit groups.
NPS	National Park Service (USDI)
NRCS	Natural Resources Conservation Service (USDA)
NSO	no surface occupancy
O&G	oil and gas
Oil and Gas Companies	Includes all Oil and Gas Companies that currently operate or will potentially operate within the range of GUSG.
Other Research Institutions	Includes non-CDOW, UDWR research entities such as USDA, USGS, and Universities.
PECE	(Proposed) Policy for Evaluation of Conservation Efforts
PMCP	Piñon Mesa Conservation Plan
PPCP	Poncha Pass Conservation Plan
Private Landowners	non-public landowners/managers
PVA	population viability analysis
RCP	rangewide conservation plan
RFP	request for proposal
RSC	Rangewide steering committee: an interagency committee overseeing this plan and its implementation. Includes representation from: BLM, CDOW, NPS, NRCS, UDWR, USFS, USFWS.
SCD	Soil Conservation Districts
Secret Canyon Homeowners Association	A specific development area in crucial habitat for GUSG, Dove Creek subpopulation.
SERGoM v1	Spatially Explicit Regional Growth Model

Acronym or Responsible Group	Definition
SJCCP	San Juan County Conservation Plan
SMBCP	San Miguel Basin Conservation Plan
SMP	suggested management practices
STL	School Trust Lands: includes Colorado State Land Board and Utah School and Institutional Trust Lands Administration
SWA	State Wildlife Area
TBD	to be determined
UDOGM	Utah Division of Oil, Gas, and Mining
UDWR	Utah Division of Wildlife Resources
University Extensions	Includes Colorado State University and Utah State University Extensions, and potentially other University Extensions
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USFS	U. S. Forest Service (USDA)
USFWS	U. S. Fish and Wildlife Service (USDI)
USGS	U. S. Geological Survey
USU	Utah State University
Utility Companies	Includes local Rural Electric Associations, Excel Energy, and all other utility companies within the range of GUSG
WAFWA	Western Association of Fish and Wildlife Agencies
WHIP	Wildlife Habitat Incentives Program
WNV	West Nile virus
WRIS	Wildlife Resource Information System
WRP	Wetlands Reserve Program
WSC	Western State College

APPENDIX C

AVAILABLE FUNDING OPPORTUNITIES FOR GUSG HABITAT CONSERVATION

Table 1. Specific funding opportunities identified for GUSG habitat conservation.

Colorado Division of Wildlife (CDOW)						
Grant / Program	**What land is eligible?**	**Length of Agreement**	**Easements**	**Cost Share**	**Applicant obligations**	**Contact Information**
Colorado Species Conservation Partnership Program (CSCP)	Any land within the range of the Gunnison Sage-grouse, where an easement or management plan are needed to benefit sage-grouse.	Variable	one-time, up-front payment	Variable	Develop a conservation plan and comply with the terms of the easement, or develop a plan and assist with the cost, establishment, and maintenance of conservation practices.	Ken Morgan (303)291-7404 http://wildlife.state.co.us/
Habitat Partnership Program	All land is eligible where wildlife/human interactions occur.	Variable		Variable	Contact local District Wildlife Manager and develop proposal. Must be able to evaluate the success of project based on objectives.	Local District Wildlife Manager http://wildlife.state.co.us/
Cooperative Habitat Improvement Program (CHIP)	All private land for which the habitat improvement has been approved by the area habitat biologist	10 years		85%	Applicant must provide 15% of cost of habitat improvement and must ensure practice is maintained through the term of the contract.	Mike Grode (970)255-6185 http://wildlife.state.co.us/

Table 1 (con't). Specific funding opportunities identified for GUSG habitat conservation.

Natural Resources Conservation Service (NRCS)							
Grant / Program	**What land is eligible?**	**Length of Agreement**	**Rental Payments**	**Easements**	**Cost Share**	**Applicant obligations**	**Contact Information**
Conservation Reserve Program (CRP)	Highly erodible cropland that has been planted for 4 of the 6 years preceding enactment of the 2002 law. Marginal pastureland is also eligible.	10-15 years	Payment based on length of agreement		50%	Develop and follow a plan for the conversion of cropland to a less intensive use. Also, assist with the cost, establishment, and maintenance of conservation practices.	Dove Creek, Cortez, or Durango FSA or NRCS offices www.nrcs.usda.gov
Conservation Reserve Program Continuous Sign-up	Highly erodible cropland that has been planted for 4 of the 6 years preceding enactment of the 2002 law. Marginal pastureland is also eligible.	10-15 years	Payment based on length of agreement		50% to 90%	Develop and follow a plan to implement riparian buffers, wildlife habitat buffers, wetland buffers, filter strips, grass waterways, shelterbelts, living snow fences, contour grass strips, salt tolerant vegetation, or shallow water areas for wildlife. Also, assist with the cost, establishment, and maintenance of conservation practices.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] or Local FSA or NRCS office www.nrcs.usda.gov
Environmental Quality Incentives Program (EQIP)	All private land in agricultural production is eligible ; includes cropland, grassland, pastureland and non-industrial private forestland.	1-10 years	Payment based on length of agreement		up to 75%	Develop and follow an EQIP plan that describes the conservation and environmental purposes to be achieved; assist with installation costs.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] www.nrcs.usda.gov
Farm and Ranchland Protection Program (FRPP)	Private land that contains prime farmland or other unique resources and is subject to a pending easement from an eligible entity.	Perpetual		one-time, up-front payment		Continue to use the land for agricultural purposes. Develop a conservation plan and comply with the terms of the easement.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] www.nrcs.usda.gov
Grassland Reserve Program (GRP)	Private land that includes grassland, forbs, or shrubs (including rangeland and pastureland); and land that historically was dominated by grasses, forbs, and shrubs and has significant value for plants and animals.	10-30 year agreement, or perpetual	annual payment based on length of agreement	one-time, up-front payment on perpetual	up to 100%	Develop and follow a plan for the restoration and maintenance of grasslands. If necessary, assist with the cost of restoration. Can maintain agricultural use with development of a conservation plan.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] www.nrcs.usda.gov
Wetlands Reserve Program (WRP)	Most private wetlands converted to agricultural use prior to 1985 are eligible. Wetland must be restorable and suitable for wildlife benefits.	10 years, 30 years, or perpetual		one-time, up-front payment	up to 100%	Develop and follow a plan for the restoration and maintenance of the wetland. If necessary, assist with the cost of restoration. Also, must give up agriculture production rights.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] www.nrcs.usda.gov
Wildlife Habitat Incentives Program (WHIP)	All private land is eligible, unless it is currently enrolled in CRP, WRP, or a similar program	5-15 years			up to 75%	Prepare and follow a wildlife habitat development plan; assist with installation costs.	Ed Neilson[1] Chanda Pettie[2] Steve Woodis[3] www.nrcs.usda.gov

[1] For all areas in CO where Gunnison Sage-grouse occur (970-243-5068, ext. 123) [2] For Poncha Pass area (719-589-6649) [3] For Cimarron/Cerro Summit/Sims Mesa area (970-249-8407)

Table 1 (con't). Specific funding opportunities identified for GUSG habitat conservation.

U. S. Fish and Wildlife Service (USFWS)

Grant / Program	What land is eligible?	Length of Agreement	Rental Payments	Easements	Cost Share	Applicant obligations	Contact Information
Landowner Incentive Program (LIP)	All private and tribal land	Variable	Yes	Short and long term	up to 75%	Personnel from state agency will need to submit application, USF&WS will approve, and CDOW will administer grant in cooperation with the landowner.	Ken Morgan (303)291-7404 http://wildlife.state.co.us/
Intermountain West Joint Venture Partnership	Projects considered acceptable for funding include long-term protection, restoration, or enhancement of any bird habitat. Joint Venture emphasis is centered upon on-the ground conservation.	Up to 30 years		Yes	50%		David Klute – Colorado Representative (303)291-7320 www.iwjv.org
North American Wetland Conservation Act	State, private, Tribal, Federal?	Variable	No	Long-term	50%	Work with local USF&WS office, but grant is administered through USFWS Migratory Bird Office	Local Fish and Wildlife Service office or http://www.iwjv.org/
North American Wetland Conservation Act, Small Grants	State, private, Tribal, Federal	Variable	No	Long-term	50%	Work with local USF&WS office, but grant is administered through USFWS Migratory Bird Office (Up to $50K/grant)	Local Fish and Wildlife Service office or http://www.iwjv.org/
Partners for Fish and Wildlife	All private land, wetland and riparian habitat has been a primary focus along with some treatment of sagebrush.	Variable, most projects delivered in 1-3 months			75-100%	Work with FWS Biologist to develop project plan. Follow management actions for duration of wildlife extension agreement.	Rick Schnaderbeck (719)852-0124 www.coloradopartners.fws.gov
Private Stewardship Grants Program	Private land	Variable	Yes	No	Variable	The contract and plan must provide quantifiable measures to evaluate the success of the project. The grant is administered through USFWS Ecological Services.	Local Fish and Wildlife Service office http://grants.fws.gov/ (applications due 12/03 or 1/04)
Section 6 Conservation Grants	State, private, Tribal, Federal	Variable			up to 75%	Work with local USF&WS office, but grant is administered through USFWS Ecological Services	Local Fish and Wildlife Service office http://grants.fws.gov/

U. S. Fish and Wildlife Service (USFWS)							
Grant / Program	**What land is eligible?**	**Length of Agreement**	**Rental Payments**	**Easements**	**Cost Share**	**Applicant obligations**	**Contact Information**
State Wildlife Grants	State, private, Tribal, Federal	Variable	Yes	Short term and long term	75% planning, 50% implemen-tation	States, but not Tribes, must develop comprehensive wildlife management plans	Jim.Guthrie@co.state.us or Local Fish and Wildlife Service office http://grants.fws.gov/
Tribal Wildlife Grants	Tribal	Variable			100%	Up to $250,000 / tribe	Local Fish and Wildlife Service office http://grants.fws.gov/

Table 1 (con't). Specific funding opportunities identified for GUSG habitat conservation.

Utah Division of Wildlife Resources (UDWR)							
Grant / Program	**What land is eligible?**	**Length of Agreement**	**Rental Payments**	**Easements**	**Cost Share**	**Applicant obligations**	**Contact Information**
Habitat Program	All land that potentially provides habitat for wildlife.	Variable	Possible	Possible	Variable	Varies based on specific project.	www.wildlife.utah.gov
Endangered Species Mitigation Fund	All land that potentially provides habitat for those species of wildlife that are listed on the Utah Sensitive Species List or that are candidates or listed under the federal Endangered Species Act.	Variable	Possible	Possible	Variable	Varies based on specific project.	www.wildlife.utah.gov

Table 1 (con't). Specific funding opportunities identified for GUSG habitat conservation.

Non-Governmental Organizations (NGO's)							
Agency / Organization	**Grant / Program**	**What land is eligible?**	**Length of Agreement**	**Easements**	**Cost Share**	**Applicant obligations**	**Contact Information**
Great Outdoors Colorado (GOCO)	Legacy Initiative/ Open Space/ Wildlife Grants	All private and public land where state agencies, non-profit conservation organizations, local governments, or private land owners are interested in conservation and land protection.	Variable	Possible	Variable, usually requires a minimum 25% match	Personnel from local governments, non-profit land conservation organizations, CO Div. of Wildlife, and CO State Parks need to be submit proposal and manage contract.	www.goco.org (303)863-7522 info@goco.org
Mule Deer Foundation		All land that is critical to wildlife	Variable	Possible	Variable	Must go through FS, BLM or one of their corporate partners	www.muledeer.org 1-888-375-3337
Quail Unlimited		All land that potentially provides habitat for quail and (sometimes) sage grouse	Variable	Possible	Variable	Must go through FS, BLM or one of their corporate partners	www.qu.org
Rocky Mountain Elk Foundation		All land that is critical to wildlife	Variable	Possible	Variable	Must go through FS, BLM or one of their corporate partners	www.rmef.org
National Fish and Wildlife Foundation		Special grants for research on all land that potentially provides habitat for fish and wildlife.	Variable	Possible	Minimum 1:1	Non-federal partners, community-based organizations, tribes, educational institutions, and other non-profit organizations.	www.nfwf.org
National Forest Foundation		On or adjacent to National Forests or Grasslands	Variable		1:1 ratio with private	Non-federal partners, community-based organizations, tribes, educational institutions, and other non-profit organizations.	www.natlforests.org

APPENDIX D

GUSG GIS DATA:
HABITAT TYPE, LANDOWNERSHIP, EASEMENTS

Habitat Categories – All GUSG Populations

Table 1. Areas of habitat categories (see pg. 54 for definitions) in each GUSG population area.

GUSG Area	Occupied Habitat (acres)	Potentially Suitable Habitat (acres)	Vacant/Unknown Habitat (acres)
Cerro Summit – Cimarron – Sims Mesa	37,160	20,624	4,923
Crawford	35,014	62,107	18,192
Dove Creek	28,262	237,677	53,190
Gunnison Basin	592,926	157,298	22,937
Monticello, Utah	70,658	75,320	56,847
Piñon Mesa	38,890	136,414	63,807
Poncha Pass	20,415	27,875	0
San Miguel Basin	100,496	62,054	41,508
Utah (adjacent to Piñon Mesa)	0	3,788	2,233

Landownership in Each GUSG Population

This information was derived from the expert knowledge of field biologists. The "activity areas" (as defined below) were collected by having biologists use stand-up, real-time digitizing to draw on an interactive whiteboard that was connected to a GIS (Cowardin and Flenner 2003). A variety of scales was used to capture the data. CDOW GIS personnel coordinated and managed the GIS data capture sessions.

Nesting habitat is defined as areas that would include the majority of important GUSG nesting habitat. These are mapped as a 2-mile buffer zone around an active lek. Winter range represents the area known to be used by GUSG during winter. Severe winter range is defined as that part of the winter range where 90% of the individual GUSG are located when annual snowpack is at its maximum and/or temperatures are at a minimum in the 2 worst winters out of 10. The winters of 1983-84, or 1996-97 are good examples.

Table 2. Landownership data for entire Cerro Summit – Cimarron – Sims Mesa GUSG area.

Ownership	**Occupied Habitat acres (%)**	**Potentially Suitable Habitat acres (%)**	**Vacant/Unknown Habitat acres (%)**
Private	28,219 (75.9%)	16,190 (78.5)%	3,778 (76.7%)
BLM	4,853 (13.1%)	4,271 (20.7%)	1,145 (23.3%)
CDOW	4,046 (10.9%)	0	0
NPS	43 (0.1%)	163 (0.8%)	0
Lek Habitat (subset of Occupied Habitat)			
Private	275 (95.1%)		
BLM	9 (3.2%)		
CDOW	5 (1.7%)		
Nesting Habitat (subset of Occupied Habitat)			
Private	12,832 (76.7%)		
BLM	2,198 (13.1%)		
CDOW	1,704 (10.2%)		

Table 3. Landownership data in Occupied Habitat for Cerro Summit – Cimarron and Sims Mesa GUSG subpopulations.

Ownership	**Occupied Habitat acres (%)**	
	Cerro Summit – Cimarron	**Sims Mesa**
Private	25,915 (81.3%)	2,304 (43.6%)
BLM	2,165 (6.8%)	2,688 (50.8%)
CDOW	3,750 (11.8%)	296 (5.6%)
NPS	43 (0.1%)	0
TOTAL	31,873	5,288

Table 4. Landownership data for Crawford GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat acres (%)	Vacant/Unknown Habitat acres (%)
Private	8,240 (23.5%)	43,908 (70.7%)	15,901 (87.4%)
USFS	0	2,216 (3.6%)	0
BLM	22,172 (63.3%)	8,076 (13.0%)	2,292 (12.6%)
NPS	4,603 (13.2%)	7,908 (12.7%)	0
Lek Habitat (subset of Occupied Habitat)			
BLM	172 (100%)		
Nesting Habitat (subset of Occupied Habitat)			
Private	980 (6.5%)		
BLM	11,594 (77.3%)		
NPS	2,427 (16.2%)		
Winter Habitat (subset of Occupied Habitat)			
Private	2,553 (10.9%)		
BLM	18,806 (80.1%)		
NPS	2,114 (9.0%)		
Severe Winter Range (subset of Occupied Habitat and Winter Habitat)			
Private	2,553 (10.9%)		
BLM	18,808 (80.1%)		
NPS	2,113 (9.0%)		

Table 5. Landownership data for Dove Creek GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat acres (%)	Vacant/Unknown Habitat acres (%)
Private	24,538 (86.8%)	208,776 (87.8%)	18,801 (35.4%)
USFS	0	3,355 (1.4%)	6,577 (12.4%)
BLM	3,725 (13.2%)	25,486 (10.7%)	22,292 (42.2%)
CDOW	0	23 (0.0%)	0
NPS	0	39 (0.0%)	0
Colorado	0	0	5,522 (10.4%)
Lek Habitat (subset of Occupied Habitat)			
Private	900 (100%)		
Nesting Habitat (subset of Occupied Habitat)			
Private	21,317 (87.4%)		
BLM	3,079 (12.6%)		

Table 6. Landownership data for Gunnison Basin GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat acres (%)	Vacant/Unknown Habitat acres (%)
Private	182,916 (30.9%)	65,359 (41.6%)	2,274 (9.9%)
USFS	82,682 (13.9%)	18,763 (11.9%)	20,663 (90.1%)
BLM	301,354 (50.8%)	63,584 (40.4%)	0
CDOW	9,142 (1.5%)	0	0
NPS	12,411 (2.1%)	9,191 (5.8%)	0
Colorado	4,269 (0.7%)	401 (0.3%)	0
Lek Habitat (subset of Occupied Habitat)			
Private	1,275 (36.6%)		
USFS	151 (4.3%)		
BLM	1,862 (53.5%)		
CDOW	91 (2.6%)		
Colorado	97 (2.8%)		
NPS	6 (0.2%)		
Nesting Habitat (subset of Occupied Habitat)			
Private	70,412 (32.9%)		
USFS	12,743 (6.0%)		
BLM	123,146 (57.6%)		
CDOW	2,646 (1.2%)		
Colorado	1,283 (0.6%)		
NPS	3,533 (1.7%)		
Winter Habitat (subset of Occupied Habitat)			
Private	113,393 (30.7%)		
USFS	34,667 (9.4%)		
BLM	201,152 (54.5%)		
CDOW	6,984 (1.9%)		
Colorado	3,326 (0.9%)		
NPS	9,772 (2.6%)		
Severe Winter Range (subset of Occupied Habitat and Winter Habitat)			
Private	51,243 (23.6%)		
BLM	155,433 (71.5%)		
CDOW	2,645 (1.2%)		
Colorado	171 (0.1%)		
NPS	7,755 (3.6%)		

Table 7. Landownership data for Monticello, Utah GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat (acres)	Vacant/Unknown Habitat (acres)
Private	66,789 (94.5%)	73,669 (97.8%)	15,509 (27.3%)
BLM	2,885 (4.2%)	1,651 (2.2%)	36,483 (64.2%)
State of Utah	921 (1.3%)	0	1,769 (3.1%)
USFS	0	0	3,048 (5.4%)

Table 8. Landownership data for Piñon Mesa GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat (acres)	Vacant/Unknown Habitat (acres)
Private	27,295 (70.2%)	59,564 (43.7%)	3,929 (6.2%)
USFS	687 (1.8%)	572 (0.4%)	42,184 (66.1%)
BLM	10,908 (28.1%)	76,258 (55.9%)	17,695 (27.7%)
Nesting Habitat (subset of Occupied Habitat)			
Private	16,259 (85.8%)		
USFS	559 (3.0%)		
BLM	2,139 (11.3%)		
Winter Habitat (subset of Occupied Habitat)			
Private	3,877 (43.4%)		
BLM	5,054 (56.6%)		

Utah – across state border from Piñon Mesa GUSG area.			
Ownership	**Occupied Habitat acres (%)**	**Potentially Suitable Habitat (acres)**	**Vacant/Unknown Habitat (acres)**
Private	0	27 (0.7%)	621 (27.9%)
BLM	0	3,691 (97.4%)	1,611 (72.1%)
State of Utah	0	70 (1.9%)	0

Table 9. Landownership data for Poncha Pass GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat acres (%)	Vacant/Unknown Habitat acres (%)
Private	4,845 (23.7%)	11,089 (39.8%)	0
USFS	5,324 (26.1%)	187 (0.7%)	0
BLM	9,768 (47.9%)	14,993 (53.8%)	0
Colorado	478 (2.3%)	1,606 (5.8%)	0
Lek Habitat (subset of Occupied Habitat)			
Private	0.8 (2.0%)		
BLM	39.2 (98.0%)		
Winter Habitat (subset of Occupied Habitat)			
Private	300 (23.7%)		
BLM	813 (64.3%)		
Colorado	151 (12.0%)		

Table 10. Landownership data for entire San Miguel Basin GUSG area.

Ownership	Occupied Habitat acres (%)	Potentially Suitable Habitat acres (%)	Vacant/Unknown Habitat acres (%)
Private	52,423 (52.2%)	39,178 (63.1%)	29,741 (71.7%)
USFS	1,450 (1.4%)	0	11,767 (28.3%)
BLM	35,628 (35.5%)	22,546 (36.3%)	0
CDOW	9,313 (9.3%)	0	0
Colorado	1,682 (1.7%)	329 (0.5%)	0
Lek Habitat (subset of Occupied Habitat)			
Private	41 (50.6%)		
BLM	7 (8.9%)		
CDOW	33 (40.5%)		
Nesting Habitat (subset of Occupied Habitat)			
Private	20,238 (59.6%)		
USFS	181 (0.5%)		
BLM	5,498 (16.2%)		
CDOW	7,689 (22.6%)		
Colorado	379 (1.1%)		
Winter Habitat (subset of Occupied Habitat)			
Private	8,307 (41.0%)		
BLM	5,218 (25.7%)		
CDOW	6,209 (30.6%)		
Colorado	545 (2.7%)		

Table 11. Landownership data in Occupied Habitat for subpopulations in San Miguel Basin GUSG area.

Ownership	Occupied Habitat acres (%)					
	Dry Creek Basin	Hamilton Mesa	Gurley Reservoir	Miramonte	Beaver Mesa	Iron Springs
Private	18,148 (29.6)	4,059 (84.7)	6,863 (91.0)	8,866 (76.2)	8,769 (99.5)	5,717 (88.7)
USFS	0	0	334 (4.4)	746 (6.4)	0	370 (5.8)
BLM	34,959 (57.1)	202 (4.2)	191 (2.5)	234 (2.0)	42 (0.5)	0
CDOW	7,517 (12.3)	0	0	1,796 (15.4)	0	0
Colorado	641 (1.0)	529 (11.0)	156 (2.1)	0	0	356 (5.5)
TOTAL	61,265	4,790	7,544	11,642	8,811	6,443

Easements in Each GUSG Population

Table 12. Acreage of easements currently held in each GUSG area.

GUSG Population or Subpopulation	Occupied Habitat	Potentially Suitable Habitat	Vacant/ Unknown Habitat	Lek Sites[1]	Nesting Habitat[1]	Winter Range[1]	Severe Winter Range[1]
Cerro Summit – Cimarron – Sims Mesa	2,805	603	0	92	2,125	0	0
Crawford	523	936	0	0	398	209	209
Dove Creek	1,012	0	0	57	1,012	0	0
Gunnison Basin	26,145	3,884	0	703	14,865	21,162	10,774
Monticello, Utah	2,569	0	0	0	0	0	0
Piñon Mesa	7,314	13,789	0	0	1,312	145	0
Poncha Pass	0	0	0	0	0	0	0
San Miguel Basin	884	0	0	0	20	0	0

[1] This habitat category is a subset of "Occupied Habitat". Overlap may occur among easements in these seasonal categories (e.g., one easement may protect habitat that serves both as a lek site and nesting habitat)

APPENDIX E

EFFECTIVE POPULATION SIZE DISCUSSION

Genetic Effective Population Size (N_e)

In discussing minimum viable population size, geneticists refer to “genetic effective size” of populations (N_e), not the census size (N) of populations. For example, Equation 1 describes how inbreeding will occur in an ideal population. Population geneticists define an ideal population having the following characteristics: even sex ratio, non-overlapping generations, random (Poisson) variation in family size, and constant population size. GUSG populations do not fit any of the characteristics of such a genetically ideal population, and this will cause the genetic effective size of GUSG populations to be less than the census size. For example, in GUSG populations, small numbers of males are usually responsible for most of the mating at a lek. Assume for purposes of illustration that 1 male is responsible for all of the matings in a GUSG population. In this population, all of the offspring would be half-siblings, and subsequent inbreeding would be unavoidable.

Relatively simply formulae describe simple departures from the ideal population described above. For example, the lek mating system of GUGS will cause the number of breeding males to be less than the number of breeding females. If GUSG populations were ideal in all respects except sex ratio, then the genetic effective population size would be

(1) $$N_e = \frac{4N_m N_f}{N_m + N_f}$$

where N_m is the number of breeding males and N_f is the number of breeding females (Hedrick 2000).

However, estimating the genetic effective size of populations is not a simple matter of plugging terms into formulae such as Equation 1. In most cases, species depart from the idealized model described above in multiple ways, and equations that account for all of these departures are difficult to formulate. Accommodating overlapping generations is especially problematic. Furthermore, metapopulation dynamics can have a critical effect upon genetic effective population size but are difficult to resolve analytically.

One alternative to using analytical approaches for estimating genetic effective population size is to estimate the genetic effective population size (N_e) from the census size (N) of the population using N_e/N ratios obtained from similar populations or species. However, the ratio between the genetic effective size and census size of populations is determined by many aspects of a species’ biology, and N_e/N ratios vary accordingly (Frankham 1995). A review of N_e/N ratios found a mean of approximately 0.1. This means that the average genetic effective size of population is approximately 10% of the average census size.

Deciding whether GUSG populations have a higher or lower N_e/N ratio than 0.1 is difficult. The genetic effective population size of populations that fluctuate in size is strongly reduced by the generations with low sizes (Hedrick 2000) and only weakly increased by generations with large sizes. If GUSG populations do not fluctuate in size as much as the populations reviewed by Frankham (1995), then N_e/N may be higher than 0.1. For example, Frankham’s (1995) review suggests that N_e/N is approximately 0.4 for populations that do not fluctuate in size. If GUSG populations fit this criterion, 1,250 individuals would be needed to achieve an genetic effective population size of 500 individuals. On the other hand, the lek mating system of GUSG may lead to an N_e/N that is less than average. Evaluating how these processes interact is difficult to predict without research specifically attempting to estimate genetic effective population size.

There are 2 general approaches for estimating genetic effective population size. First, genetic data can be used to evaluate how much genetic drift there is in a population. Genetic drift is stronger in small populations. This method works well for estimating the genetic effective size of small populations (Fig. 1), but is much less accurate for estimating the genetic effective size of large populations. There is little genetic drift in large populations, and estimating the slight changes in heterozygosity or allele frequencies requires prohibitively large amounts of data. Demographic data can also be used. Until recently, this was done with formulae that attempted to summarize how a natural population compared to the idealized model. Now, however, the genetic effective size of natural populations can be estimated from individual-based population dynamics models (e.g., Harris and Allendorf 1989; Basset et al. 2001). Such models are difficult to parameterize, but they are also useful for examining population demographics.

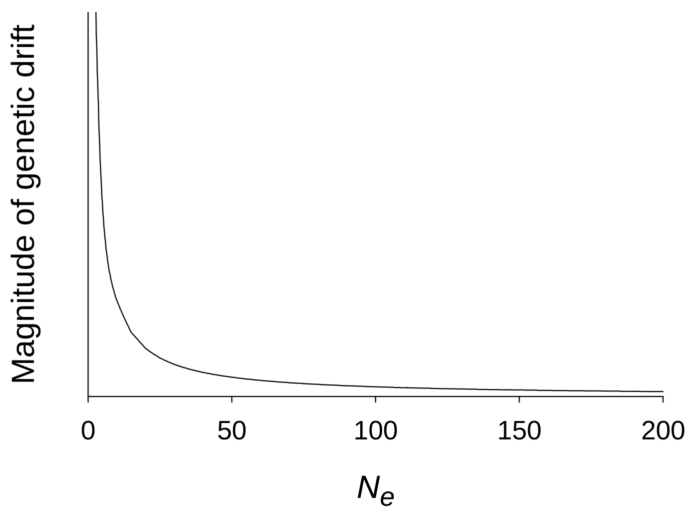


Fig. 1. The relationship between genetic effective population size (N_e) and the magnitude of genetic drift. The amount of genetic drift experienced by a population can be measured by the decline in heterozygosity, variance of allele frequencies, or amount of gametic disequilibrium, and each of these measures is related to genetic effective size in a similar way.

APPENDIX F

DETAILED DISCUSSION OF SPATIALLY EXPLICIT ANALYSIS OF ADDITIONAL HOUSING UNITS IN GUSG HABITAT

SPATIALLY EXPLICIT ANALYSIS OF ADDITIONAL HOUSING UNITS IN GUSG HABITAT

Dr. David Theobald, Natural Resource Ecology Lab, Colorado State University, developed a Spatially Explicit Regional Growth Model (SERGoM v1), designed to depict the location and density of current and projected future private land housing units across the coterminous U.S. Although the current model has not yet been published (Theobald, in review), the general procedure and rationale for a previous version of the model are described in Theobald (2003). Future growth in housing units was based on Census Bureau county-level projections for population growth. The number of housing units this growth was apportioned to was determined using the county-level average of people/household, taken from 2000 census data. Growth in housing units was allocated spatially using a formula that considered recent (1990-2000) housing growth rates for a specific location and accessibility to the nearest urban core. Assumptions of this approach are that: (1) future growth patterns will be similar to those found in the past decade; (2) people/household in the future will match that in the 2000 census data; (3) future growth is likely to occur nearby current high growth areas or “hot spots”; (4) housing units cannot occur on public land, water areas, etc.; (5) growth will be concentrated in areas closer (in terms of travel time, not just distance) to urban core areas over major roads; and (6) housing density will not decline over time (housing growth projections are additive to current housing densities).

Current and projected future housing density was classified into housing density classes, as follows:

0 = Private, no housing units
1 = >80 acres per housing unit (rural)
2 = 50-80 acres per housing unit
3 = 40-50 acres per housing unit
4 = 30-40 acres per housing unit (exurban)
5 = 20-30 acres per housing unit
6 = 10-20 acres per housing unit
7 = 1.7-10 acres per housing unit (suburban)
8 = 0.6-1.7 acres per housing unit (urban)
9 = <0.6 acres per housing unit

We applied Dr. Theobald’s model and resultant predicted housing density dataset in a GIS analysis to evaluate the potential acreage impacted by development in 2020 for each population of GUSG. We are not aware of any published work that indicates what level of housing development impacts or eliminates sage-grouse use of habitat There is likely to be little argument that the higher housing density classifications (i.e., classes 2-9) would impact sage-grouse negatively. Whether housing densities between class 0 (no housing) and class 1 (housing density greater than 1 unit per 80 acres) have negative impacts on sage-grouse may be debatable. Theobald’s original data grouped all development greater than zero, but less than or equal to 1 unit/80 acres, into 1 development class. We further refined Theobald’s data into housing density classes of 80-160, 160-320, 320-640, and >640 acres/housing unit (Table 1). Housing density is only one aspect of potential impacts; another key aspect is the spatial pattern of future housing. If houses are clustered so that the majority of a given area is undisturbed (and the cluster and associated infrastructure is not placed in an important habitat type such as a sagebrush – wet meadow interface), impacts will be much less than if housing is uniformly distributed across the area.

As a guide in determining a level of housing density (acres/unit) acceptable to sage-grouse (and above which protection would not be cost-effective), we looked at current (2000) housing densities in areas still occupied by GUSG (see Fig. 26, pg. 157). Note that impacts to GUSG populations could lag behind development (and thus, not be detected with this approach). About 860 acres of urban (<0.6 to 1.7 acres per unit) and suburban (>1.7 to 10 acres per unit) housing occur within 1.86 miles of leks. This suggests that limited development, even at these high housing densities, will not necessarily preclude sage-grouse use. Because the SERGoM v1 model was only recently released, we have not been able to conduct an intensive analysis of the housing density at which development seems to impact sage-grouse. In this initial analysis we chose 320 acres/housing unit as the threshold below which we expect impacts, and above which we do not. This is a reasonable, and perhaps conservative, density for the following reasons: (1) over 38,500 acres within 1.86 miles of leks in the Gunnison Basin have more than 1 housing unit/320 acres now (2000), yet grouse use has continued; (2) only 4 of 41 active leks have no housing units within 1.86 miles; and (3) 35 of 41 active leks have at least some area with housing densities greater than 1 unit/320 acres. This threshold was chosen keeping in mind the large amount of public (and therefore protected) habitat in the Gunnsion Basin. We do not suggest that if the large block of public land were developed at this density (1 housing unit/320 acres) that grouse would not be impacted.

We used CDOW WRIS data to define sage-grouse activity areas. In the Gunnison Basin, we estimated the acreage impacted by housing in areas identified as (1) severe winter habitat and (2) nesting/brood-rearing habitat. For this model, nesting/brood-rearing areas were identified by including all areas within 1.86 miles (3 km) of active leks, as well as brood areas mapped by local biologists (generally a 650-1,000 foot buffer along riparian areas). Winter habitat delineation was also taken from WRIS data. In the smaller GUSG populations with substantially smaller, and more fragmented available habitats, we assumed that all occupied habitat was important to GUSG. We estimated acreage impacted by housing within the entire area delineated as occupied habitat.

The intent of this analysis is to identify areas where risk of development is important, to aid agencies and work groups in habitat protection efforts. An explicit assumption in these spatially explicit models is that demand drives the location of exurban housing. If large bodies of water, protected lands or other areas unavailable for housing development exist within a block in the data, the projected density of future houses is not reduced; they simply move to other areas within the block, or to adjacent blocks. If this assumption holds when important habitats are removed from development risk by acquisition or easement, then presumably development will shift, rather than be prevented, within some spatial scale. In other words, easements and fee title acquisitions can ensure development will not occur on a particular property, but cannot ensure development will not occur within seasonal habitats used by that population, unless all important habitats where development is projected are protected. Sage-grouse will benefit if this development is shifted from sage-grouse use areas to urban areas, coniferous forest, or other areas not used by sage-grouse, or if development is dispersed, although indirect effects from population growth may still occur. If development is shifted from very important habitats such as leks, nesting, brood-rearing areas, or severe winter use areas to less important use areas, then sage-grouse will benefit, but only in the sense that they will be impacted less than they otherwise would have been.

The modeled housing density in 2000 is shown in Fig. 26 (see pg. 157), while projected housing densities (without intervention) in 2020 are shown in Fig. 27 (see pg. 158; note that white areas are the protected lands; i.e., public). Areas of growth in housing are identified in Fig. 28 (see pg. 159). Numerical estimates of acreage in each housing class modeled for 2000, projected to 2020, and increases from 2000 to 2020 by housing density class are shown for the smaller populations (Table 1) and for the Gunnison Basin (Table 2). The challenge in wisely allocating habitat protection dollars is to protect important areas where development will occur at a density that precludes use by sage-grouse, or will significantly impact grouse. At the same time there is little point in allocating resources to areas already impacted so as to preclude grouse use, or to areas where housing densities will be so low as to have negligible impact to grouse. Consequently we identified areas and acreages projected to increase from housing densities of 1 unit per 320 acres or larger to 1 unit per 320 acres or less. Examination of Table 1 indicates, for the most part, that housing outside of urban areas progresses through housing density classes, therefore the key areas are those that move from 1 unit per 320 acres or more to 1 unit per 160-320 acres, although occasionally densities may jump to the 80-160 acre/housing unit class.

The model predicting development to unsuitable housing densities seemed to perform poorly (underestimate development) outside the Gunnison Basin, where second home development or proximity to population centers or high growth areas such as Grand Junction, Montrose, or Telluride may trump local demographic growth as causes of development. Clearly we have a long-term need to develop better predictive models which take these factors into account. In the interim, we used another approach to identify habitats at greatest risk of development in the next 3-5 years. Typically, land is subdivided into smaller parcels prior to sale and development. It is these smaller (<80 acres) parcels that are probably most immediately susceptible to development to densities that would negatively impact grouse. Larger parcels may be subdivided, but this process will occur over a longer time horizon allowing time to respond. We mapped private land parcels by parcel size categories for each population (Figs. 1 - 12) as a tool to help agencies, work groups, and land trusts in assessing development risk and prioritizing habitat protection efforts for GUSG. We present an analysis of future development by population using both methods of assessing risk.

Cerro Summit – Cimarron had 477 acres projected to increase to 160-320 acres per unit, and a net loss in the 80-160 class (Table 1). Cerro Summit - Cimarron has 1,943 acres in parcels of less than 80 acres in size that are at least in part within the occupied boundary, and 1,721 acres in parcels between 80 and 160 acres in size (Fig. 1). The area of most concern is the subdivided area south of Montrose Lake. Nearby Sims Mesa had a net increase of 128 acres in the < 80 and 80-160 acres per housing unit densities, which shifted from lower density areas. Sims Mesa has about 2,344 acres in parcels less than 80 acres in size that are at least in part within the occupied boundary, most of which have already been developed (Fig. 2).

Crawford had 1,186 acres projected to increase to 160-320 acres per unit, and 247 acres projected to increase to 80-160 acres per unit. Recently acquired easements by CDOW (560 acres) were subtracted, leaving 1,590 acres. Looking at parcel sizes, Crawford has one large and one small block of subdivided parcels less than 80 acres in size (Fig. 3) and presumably at risk of development. These 2,969 acres should be the focus of habitat protection.

The Dove Creek subpopulation, and Poncha Pass populations had no areas identified to increase from 1 unit per 320-640 acres to the 160-320 or 80-160 classes. Dove Creek is largely privately owned (~85%), and perhaps because the dominant land use is crop production, a sizable portion of land parcels are less than 80 acres (Fig. 4; 4,601 acres; 17%) or 80-160 acres in size (5,095 acres; 18%, Fig. 4). Most of these parcels are not immediate development risks. Two population centers occur in this population. North and east of Dove Creek, the 2,700 acre Secret Canyon subdivision, of which about 2,000 acres occurs within occupied habitat, looms as the greatest threat (Fig. 4). Lack of access to power and water has, and likely will continue to, delay development, but even seasonal dwellings or conversion to horse pastures on parcels of 35-40 acres will be detrimental to sage-grouse. West of Dove Creek parcels are generally larger. Three parcels within the core grouse use area totaling 796 acres have been protected by CDOW with 20-year easements. Additionally, CDOW is in the final stages of fee-title acquisition of 2,354 acres in and around the core use area. The Poncha Pass population had no areas identified to increase from 1 unit per 320-640 acres to the 160-320 or 80-160 classes. Poncha Pass had 249 acres in parcel sizes less than 80 acres, and 827acres in parcel sizes from 80 to 160 acres (Fig. 5). Poncha Pass is largely publicly owned (82%; note that this percentage differs slightly from the data in Appendix D, likely due to calculation errors), and this population is too small to have major conservation benefit. Opportunities to protect or acquire privately held parcels east of Highway 285 and south of Dorsey Creek should be opportunistically explored.

Although the model indicated only 10 acres would change from no development to the 1 unit per 640 acres or more density class, and no increases to “unacceptable” housing densities in Piñon Mesa, this didn’t correspond well to our perception of development risk there. Piñon Mesa is also heavily privately owned, with 33 parcels less than 160 acres in size (Fig. 6). These parcels total about 2,000 acres, but much of the central and western portion of the occupied range is currently protected by easement or public ownership.

The model projected less than 100 acres would shift to housing densities thought to impact sage-grouse in all of the San Miguel Basin subpopulations, collectively. Potential for second home development in scenic areas like Miramonte Reservoir, Gurley Reservoir, and Iron Springs and Hamilton Mesas suggest the need for habitat protection in these areas. The San Miguel Basin population occupies six areas, each with different ownership patterns and risks of development. The Dry Creek Basin is largely (72%) publicly owned, with less than 1% of the area in small (<160) parcels (Fig. 7). Development risk is minimal, but opportunities to pursue land swaps to put heavy use areas in public (BLM) ownership should be explored. Conversely, only the periphery (~9%) of the occupied habitat for the Gurley Reservoir subpopulation is publicly owned, and about 40% of the area (3,030 acres) is made up of parcels less than 160 acres in size (Fig. 8).

The area west and south of Gurley Reservoir is already subdivided, but not yet developed. These lots are currently offered for sale, and represent an immediate conservation need. Hamilton Mesa is largely privately held, with the exception of a section (640 acres) of state school land. Parcels are generally large (Fig. 9), and threats of development are not imminent, although the location of Hamilton Mesa suggests development will occur in time. The CDOW is currently pursuing a conservation easement on Hamilton Mesa. Iron Springs Mesa is also largely privately held, with the exception of a section of school land and some Forest Service land on the northwestern periphery. About 1,800 acres are in parcels smaller than 160 acres (Fig. 10), the most significant is a subdivided tract along sheep draw on the eastern 1/3rd of the mesa, most of which is already developed. Given the isolation of Iron Springs Mesa, high real estate values, and high private ownership and extent of development, protection from further development may not be practical. The Miramonte Reservoir subpopulation is 76% private, 24% publicly held following recent CDOW acquisition of an area platted for subdivision (note that these numbers differ from those in Appendix D; those data have not yet been updated with the new CDOW property information). Parcel size is generally large (Fig. 11), but development will occur long term without protection.

Presumably the Theobald model more accurately forecasts growth in Gunnison, where at least in sagebrush areas growth in housing should be driven by population increases and not second homes. The model indicated a net loss of severe winter and nesting/brood-rearing habitat in the 160-320 acres per housing unit density, probably because these areas shifted to the 80-160 acres per housing unit and less than 80 acres per housing unit densities (Table 2). Although it may not normally be effective to spend habitat protection dollars to prevent development in the < 80 and 80-160 acres per housing unit density classes, in this case it appears that areas with very low housing densities are moving to very high density classes. Therefore we consider the acreage projected to decline from the low density classes (4,268) to be most important, assuming these were shifting to housing densities unacceptable to grouse.

Table 1. Acres within occupied GUSG range within 2000 and 2020 housing density classes, by population.

Population	**Housing Density Categories**																	
	< 80 acres/unit			**80-160 acres/unit**			**160-320 acres/unit**			**320-640 acres/unit**			**> 640 acres/unit**			**No housing**		
	2000	**2020**	**Δ[1]**	**2000**	**2020**	**Δ**	**2000**	**2020**	**Δ**	**2000**	**2020**	**Δ**	**2000**	**2020**	**Δ**	**2000**	**2020**	**Δ**
Cerro Summit – Cimarron	151	153	2	363	353	-10	442	919	477	2,398	1,894	-504	3,500	3,596	96	16,288	16,188	-100
Crawford	0	0	0	0	247	247	832	2,018	1,186	1,800	489	-1,311	800	827	27	6,600	6,607	7
Dove Creek	170	173	3	227	242	15	1,685	1,645	-40	3,097	3,058	-39	9,341	9,396	55	9,003	8,949	-54
Piñon Mesa	2	2	0	7	7	0	0	0	0	1,598	1,598	0	8,181	8,188	7	11,424	11,414	-10
Poncha Pass	326	356	30	54	5	-49	615	588	-27	121	126	5	1,899	1,907	8	1,882	1,855	-27
San Miguel Basin																		
Beaver Mesa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,561	8,561	0
Dry Creek Basin	2	2	0	0	0	0	158	165	7	682	708	26	2,077	2,100	23	15,030	15,092	62
Gurley Reservoir	0	0	0	1,722	1,731	9	729	756	27	0	0	0	3,134	3,107	-27	1,292	1,240	-52
Hamilton Mesa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,628	3,628	0
Iron Springs	0	0	0	1,276	1,302	26	0	7	7	1,837	1,855	18	2,216	2,196	-20	74	77	3
Miramonte	0	0	0	151	153	2	326	326	0	392	373	-19	1,687	1,638	-49	7,212	7,299	87
Sims Mesa	988	1,050	62	109	175	66	210	126	-84	17	0	-17	0	0	0	973	986	13
Totals	1,639	1,736	97	3,258	4,215	957	4,997	6,550	1,553	11,942	10,101	-1,841	32,835	32,955	120	81,967	81,896	-71

[1] Change in acreage in housing category indicated between 2020 and 2000.

Table 2. Acreage of seasonally important habitat (habitat within 1.86 miles [3-km] of leks, or areas identified as used by broods or during severe winters) projected to be within 2000 and 2020 housing density classes, in the Gunnison Basin.

	Housing Density Categories							
Gunnison Basin	**< 80 acres/unit**	**80-160 acres/unit**	**160-320 acres/unit**	**Totals, <320 acres/unit**	**320-640 acres/unit**	**> 640 acres/unit**	**No housing**	**Totals, >320 acres/unit**
2000 housing densities	19,212	10,991	10,846	41,049	8,131	9,756	40,426	58,313
2020 housing densities	22,980	13,454	8,707	45,141	5,732	8,020	40,293	54,045
Difference	3,768	2,463	-2,139	4,092	-2,399	-1,736	-133	-4,268

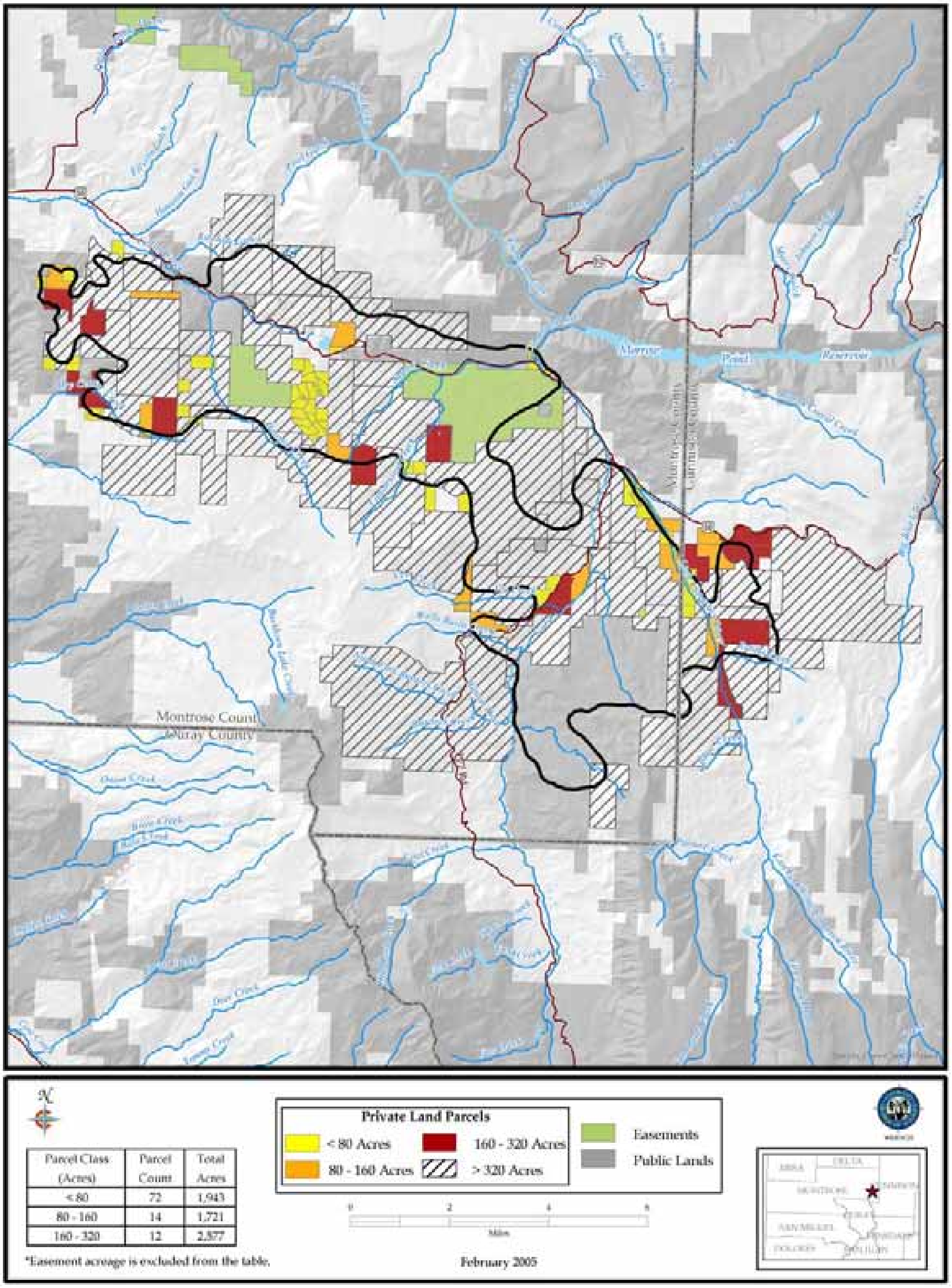


Fig. 1. Private land parcels that fall within or intersect occupied range of the Cerro Summit – Cimarron subpopulation of GUSG.

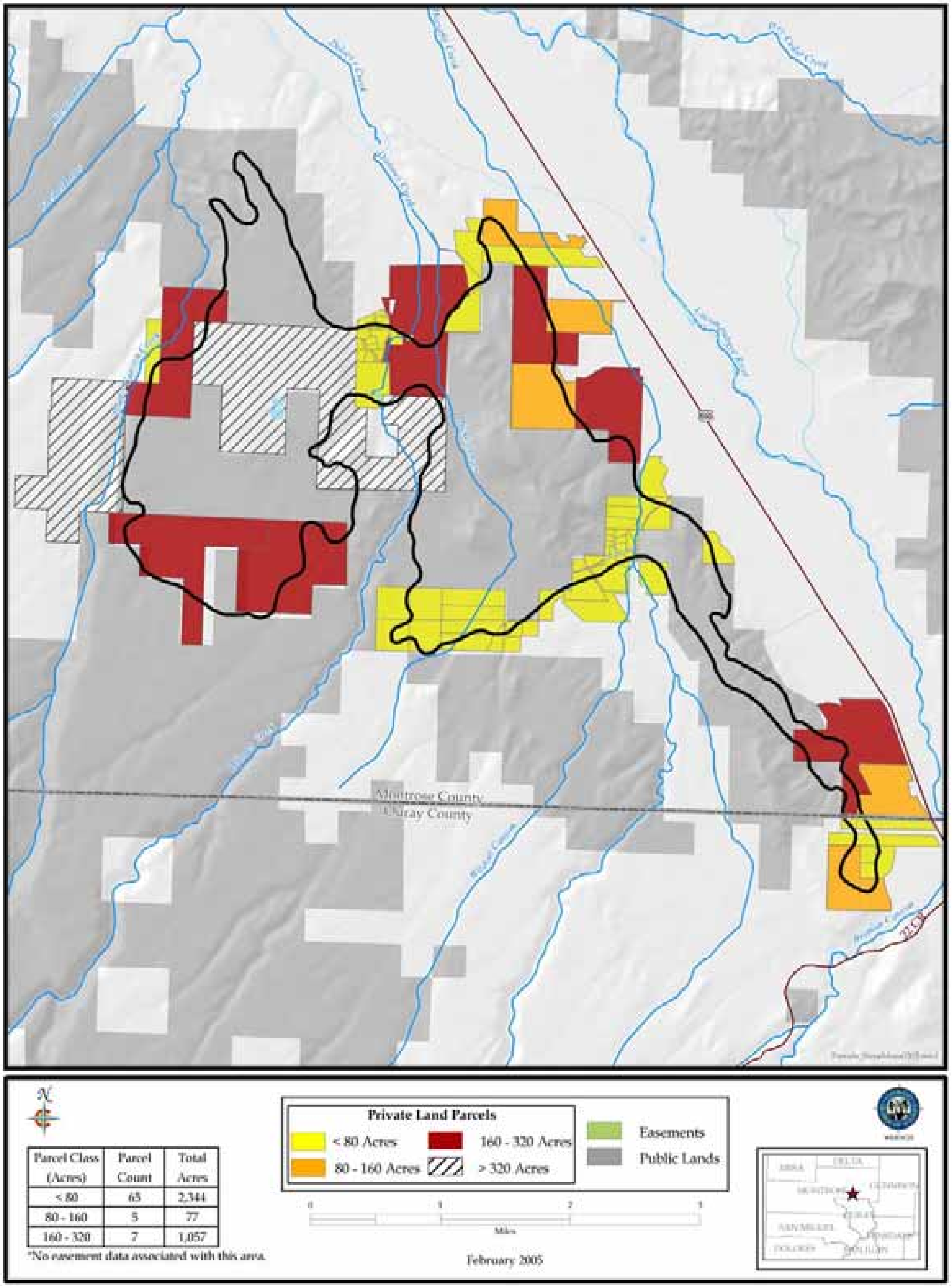


Fig. 2. Private land parcels that fall within or intersect occupied range of the Sims Mesa subpopulation of GUSG.

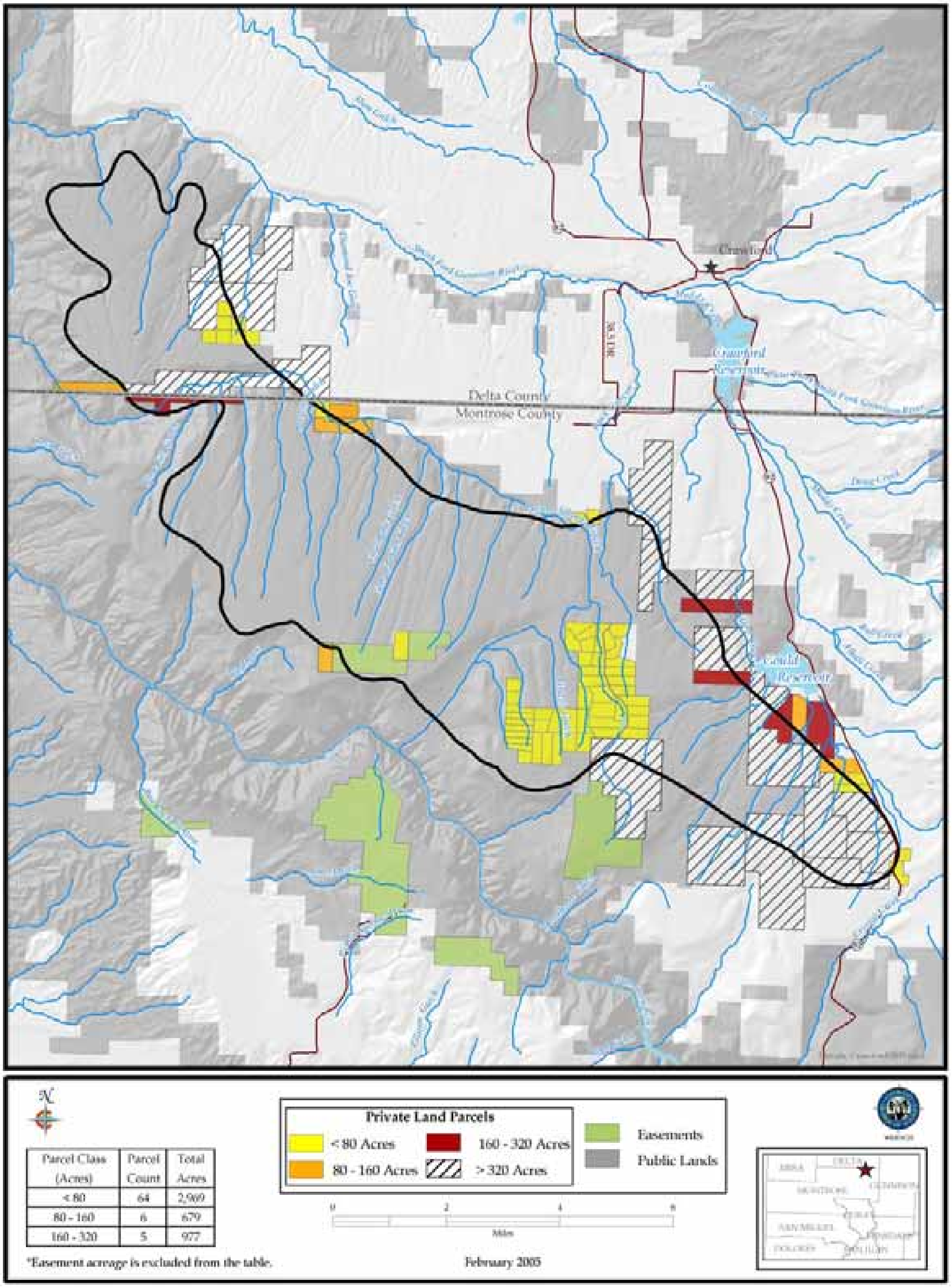
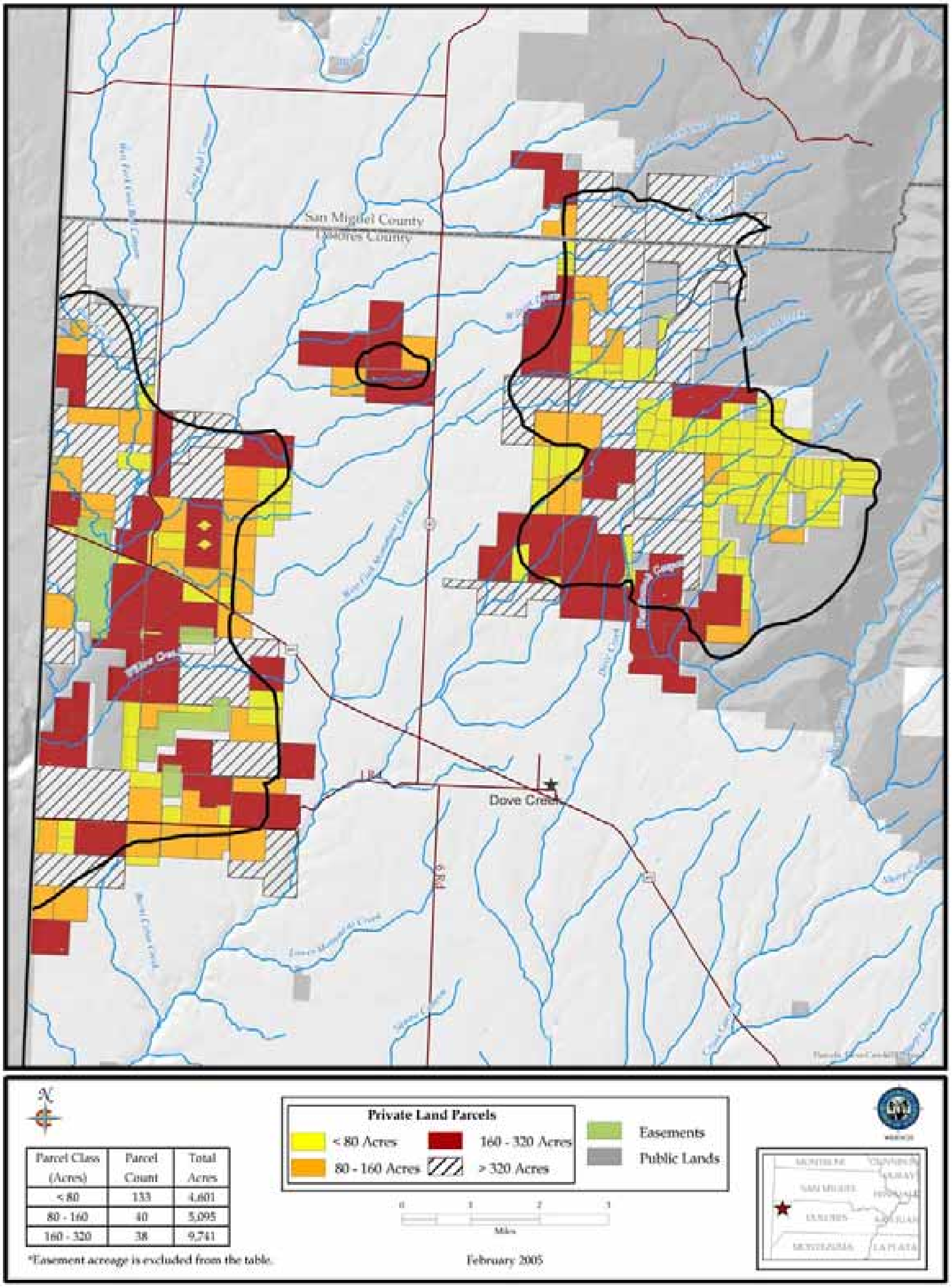


Fig. 3. Private land parcels that fall within or intersect occupied range of the Crawford population of GUSG.



Parcel Class (Acres)	Parcel Count	Total Acres
< 80	133	4,601
80 - 160	40	5,095
160 - 320	38	9,741

Fig. 4. Private land parcels that fall within or intersect occupied range of the Dove Creek subpopulation of GUSG.

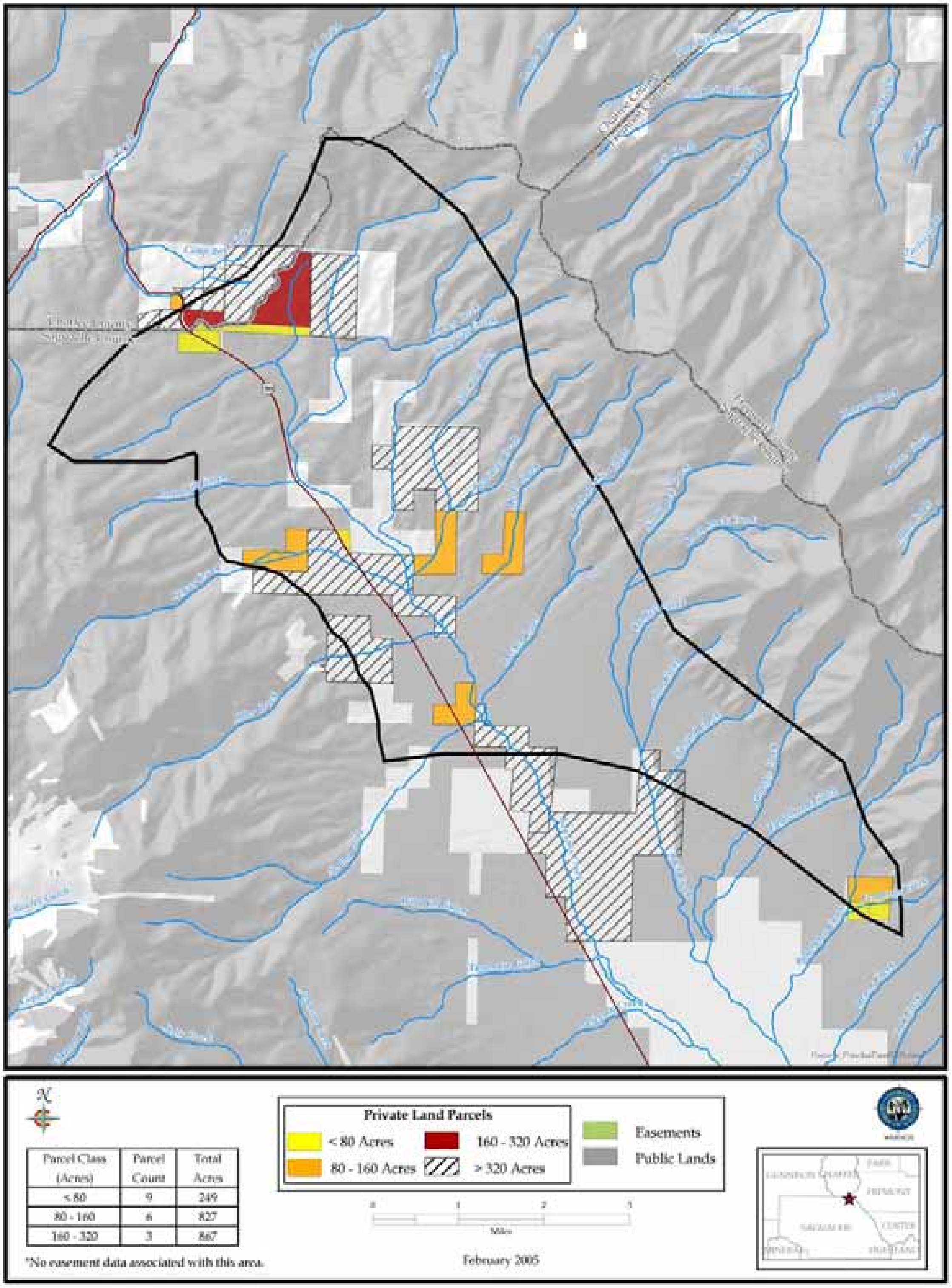


Fig. 5. Private land parcels that fall within or intersect occupied range of the Poncha Pass population of GUSG.

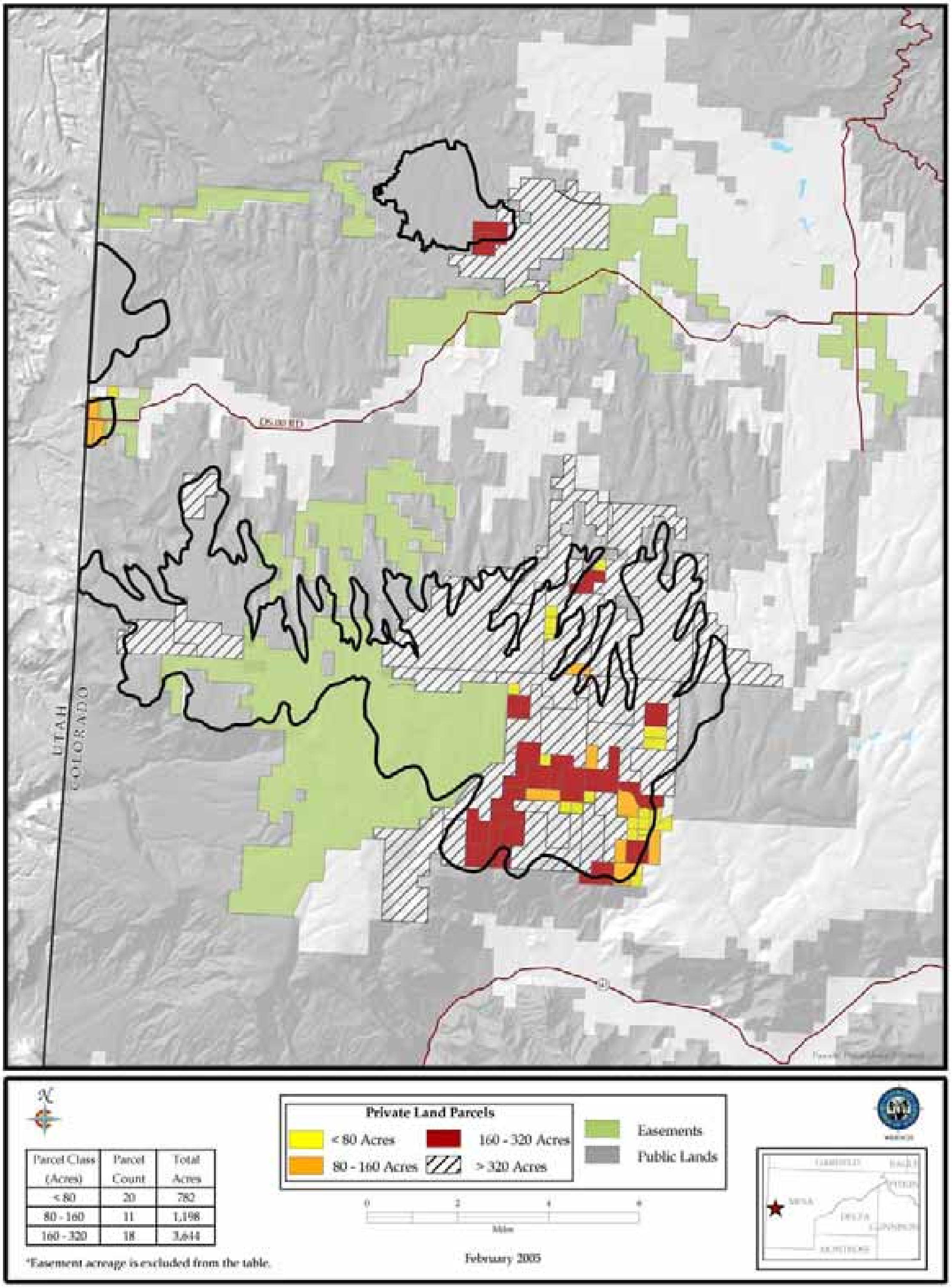


Fig. 6. Private land parcels that fall within or intersect occupied range of the Piñon Mesa population of GUSG.

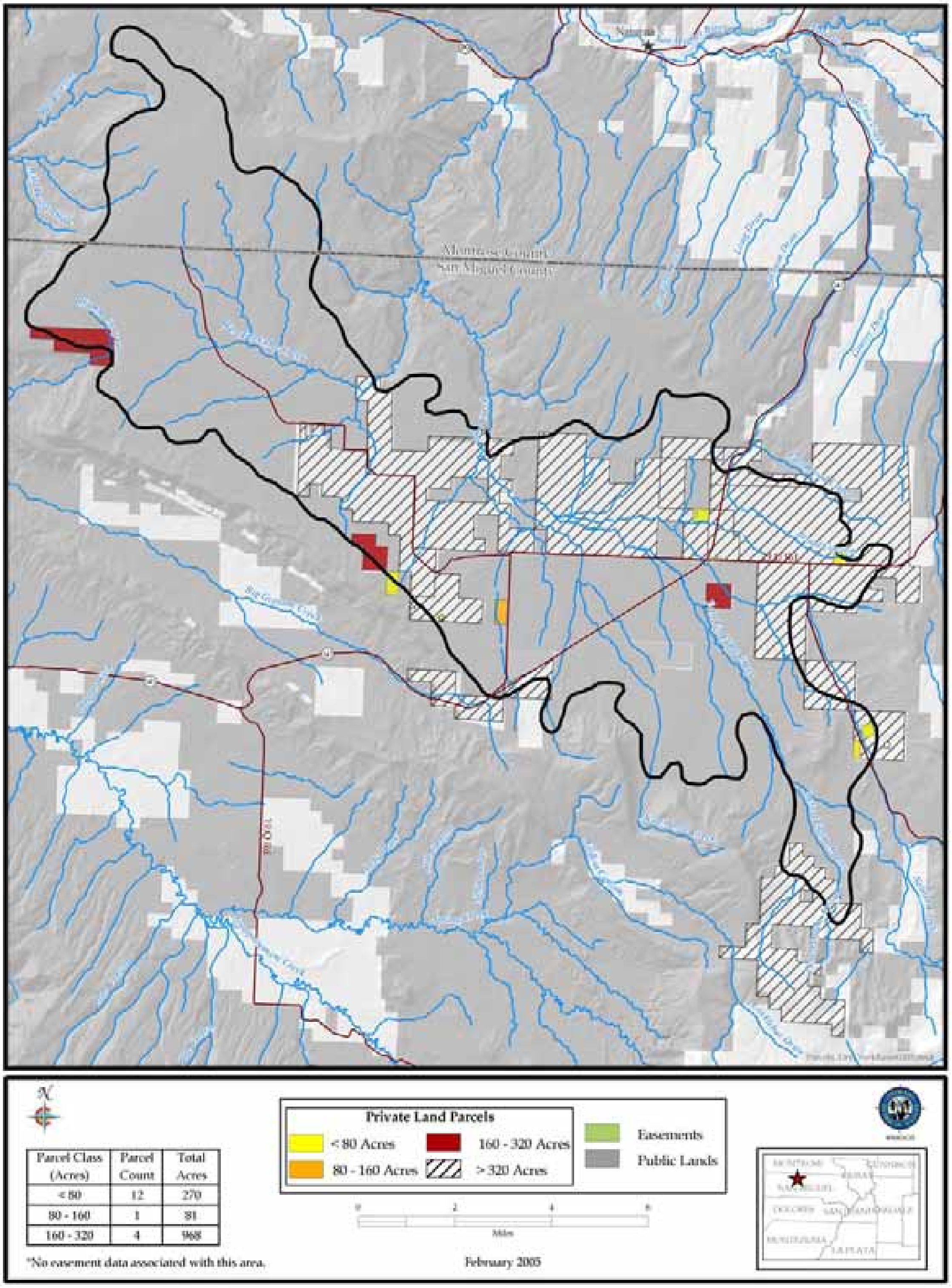


Fig. 7. Private land parcels that fall within or intersect occupied range of the Dry Creek Basin subpopulation of GUSG.

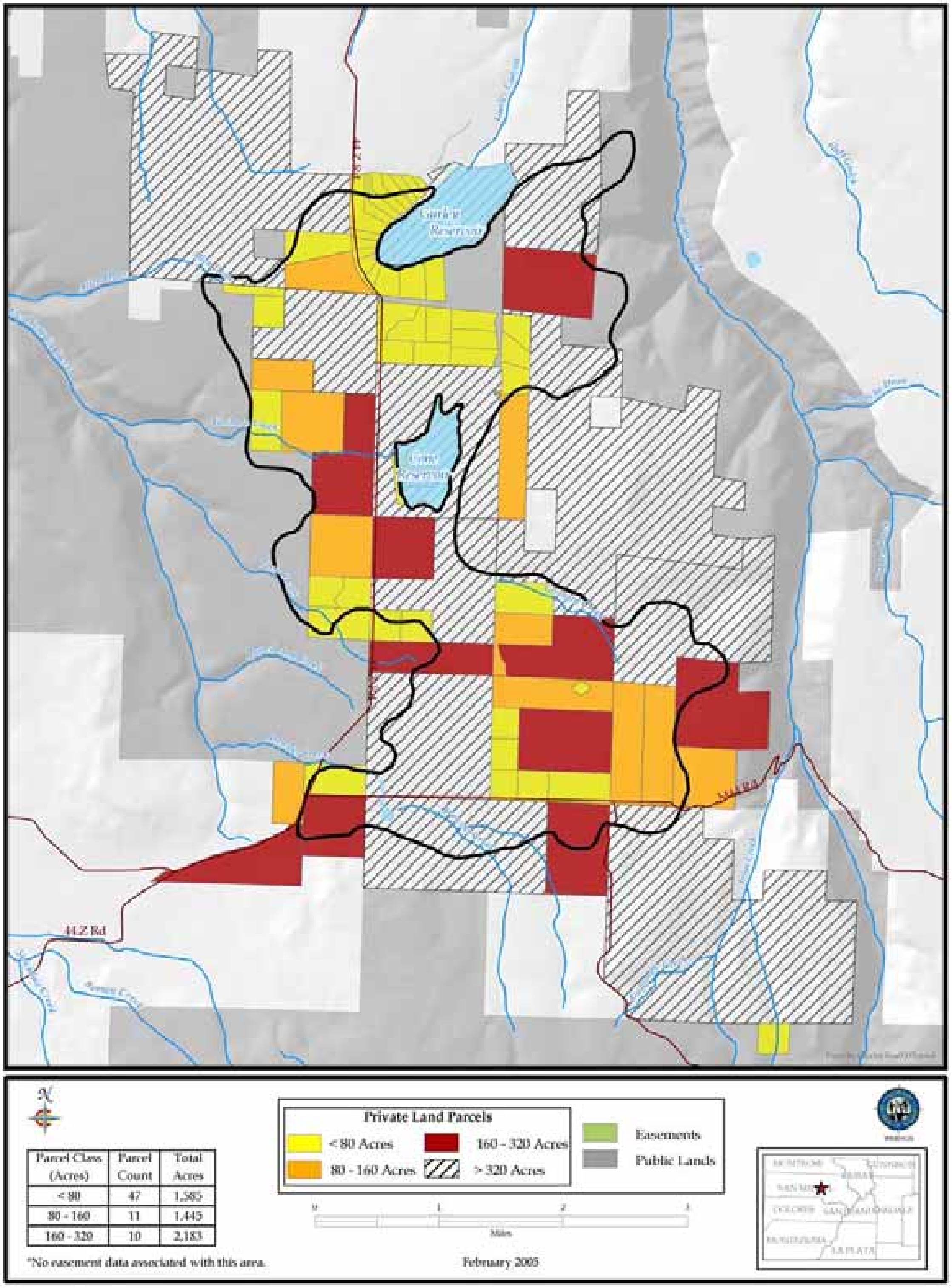


Fig. 8. Private land parcels that fall within or intersect occupied range of the Gurley Reservoir subpopulation of GUSG.

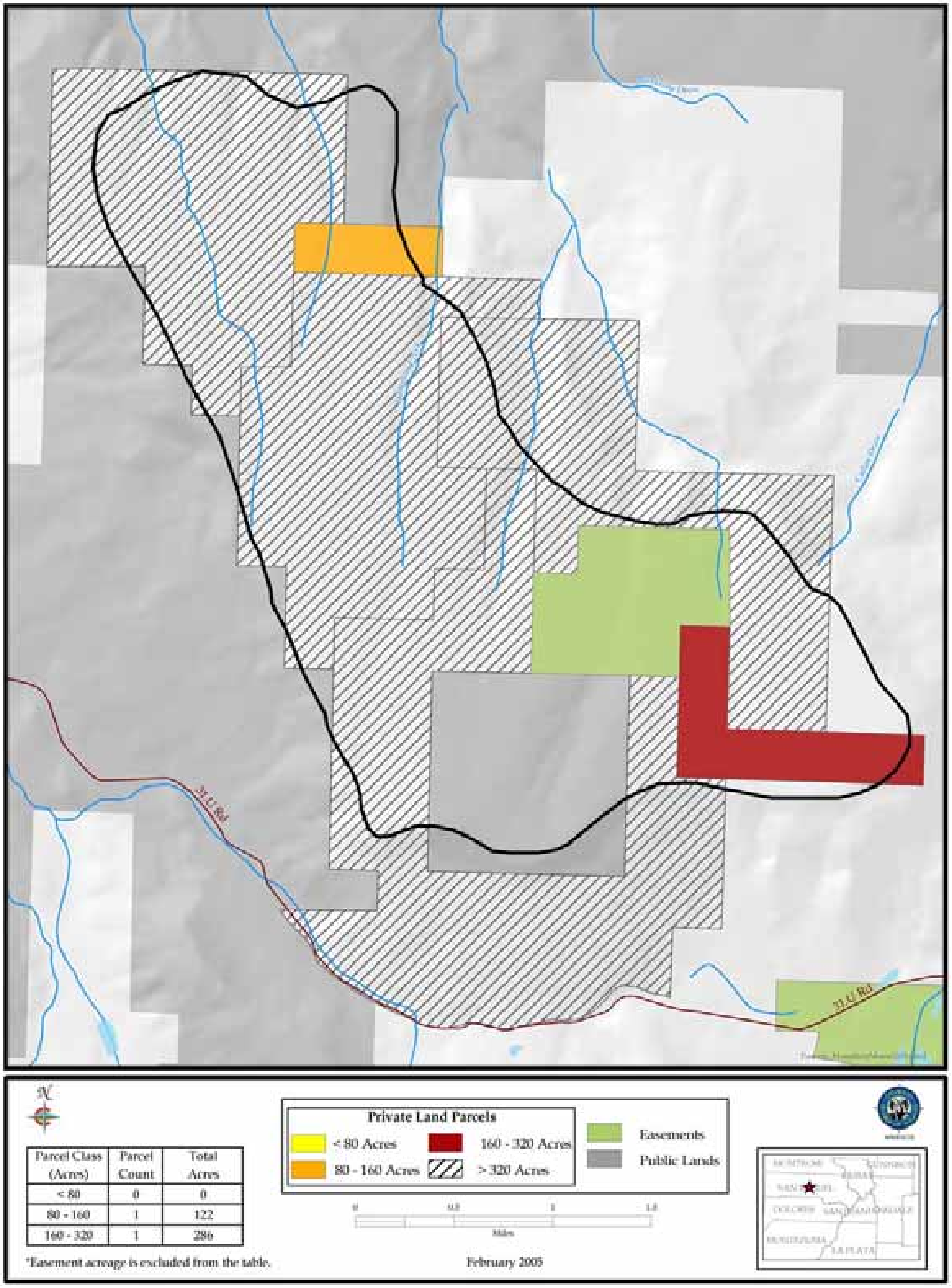


Fig. 9. Private land parcels that fall within or intersect occupied range of the Hamilton Mesa subpopulation of GUSG.

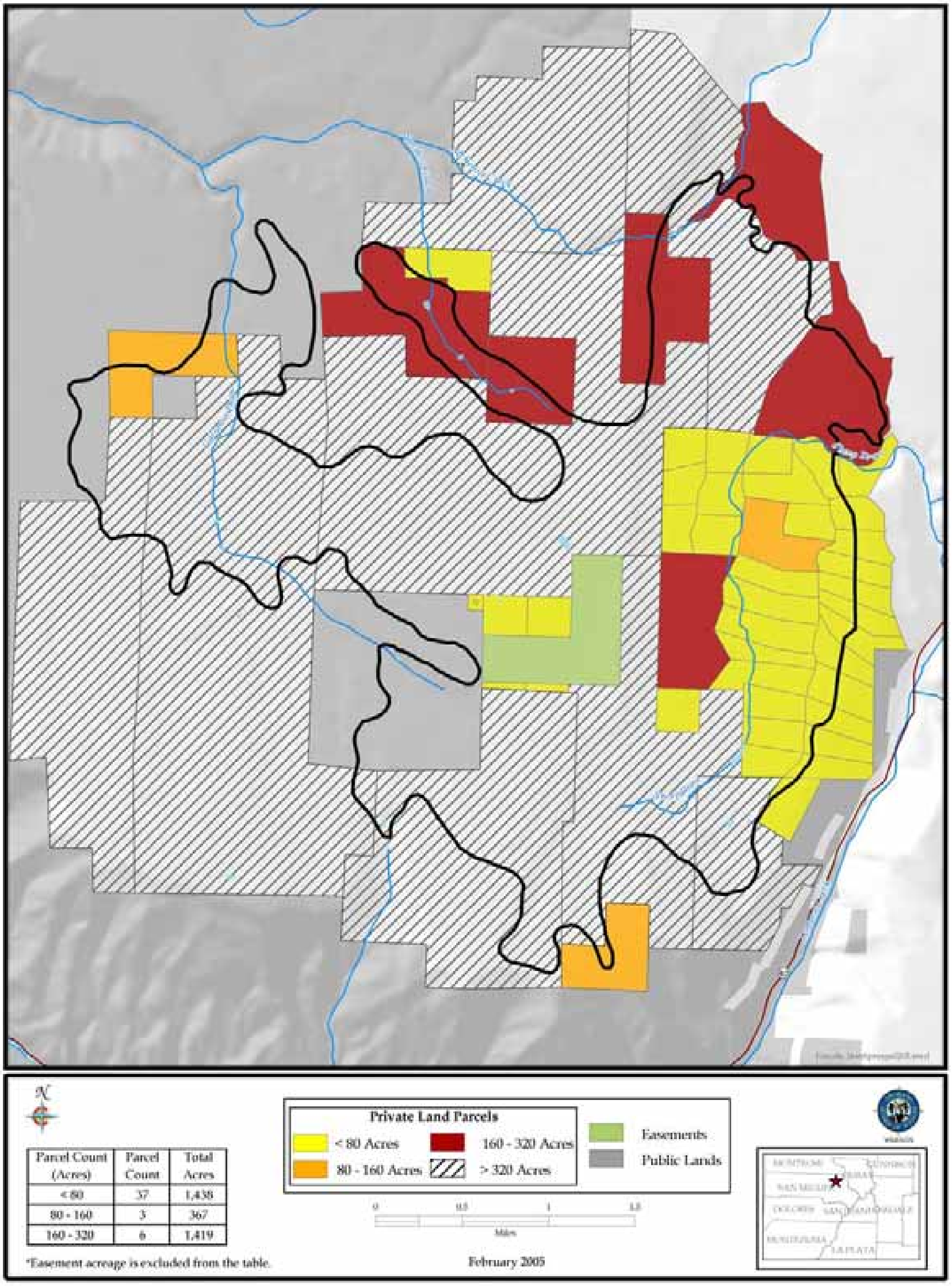
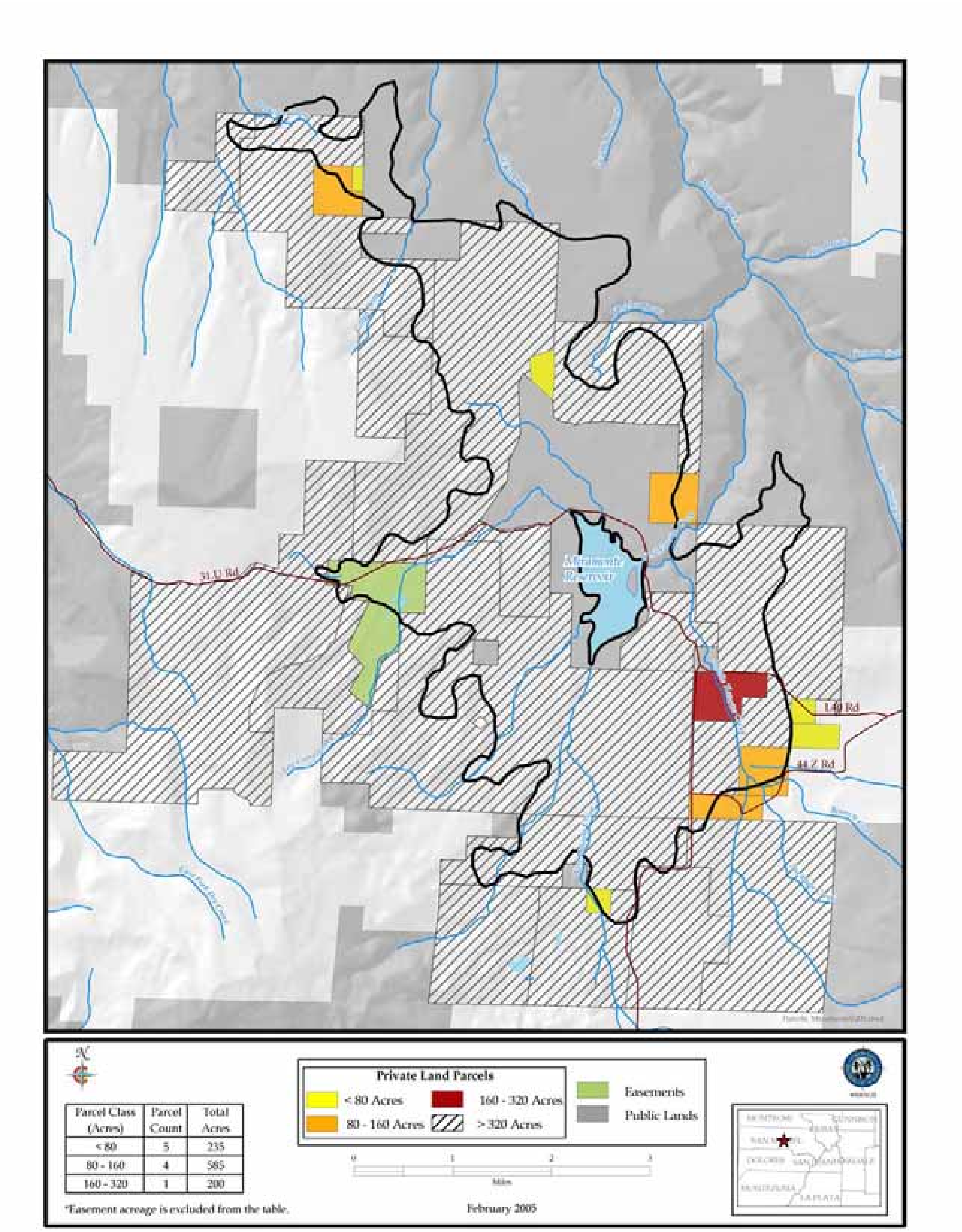


Fig. 10. Private land parcels that fall within or intersect occupied range of the Iron Springs subpopulation of GUSG.



Parcel Class (Acres)	Parcel Count	Total Acres
< 80	5	235
80 - 160	4	585
160 - 320	1	200

Fig. 11. Private land parcels that fall within or intersect occupied range of the Miramonte subpopulation of GUSG.

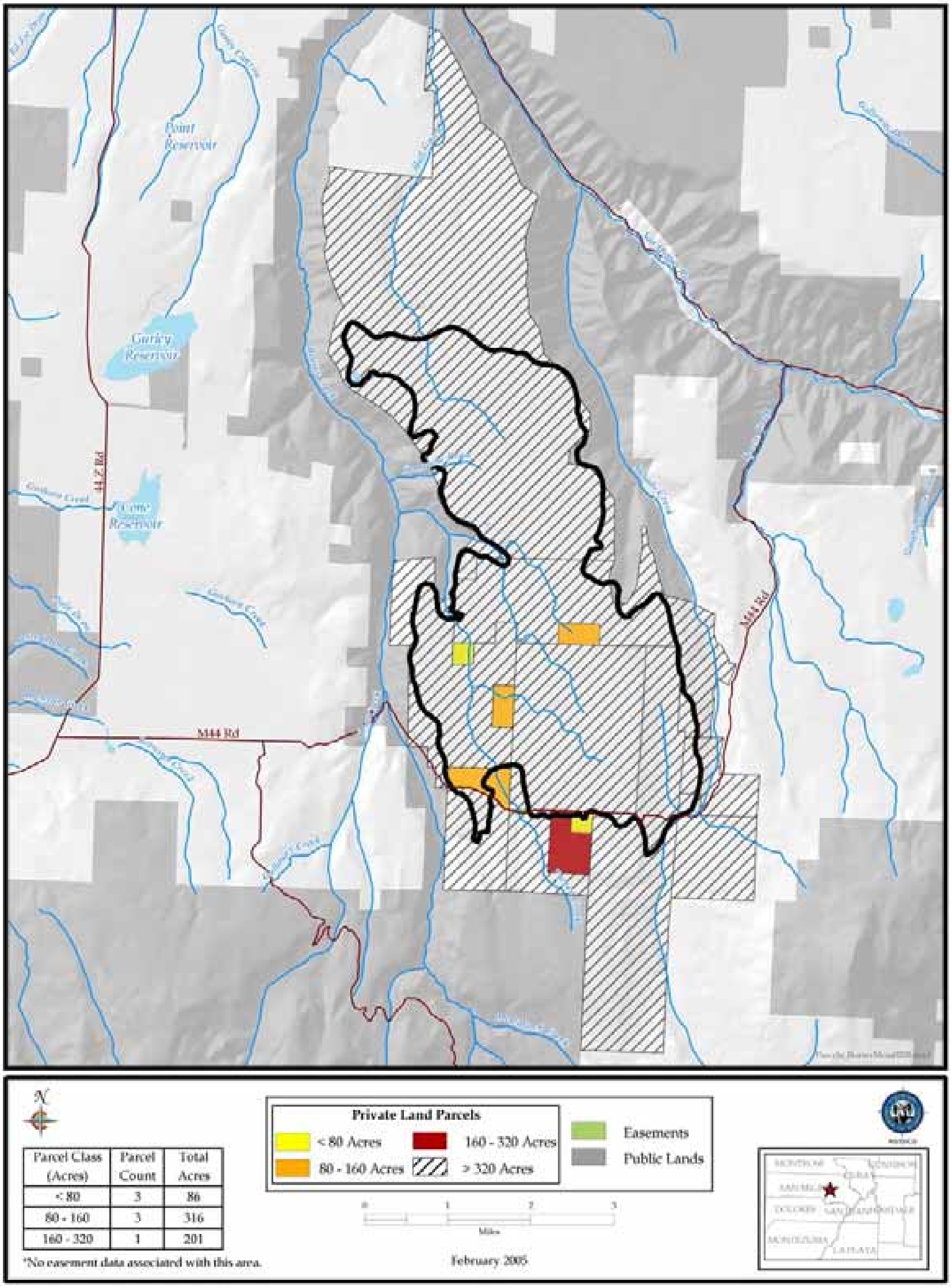


Fig. 12. Private land parcels that fall within or intersect occupied range of the Beaver Mesa subpopulation of GUSG.

APPENDIX G

REPORT ON PVA ANALYSIS FOR GUSG (Miller 2004)

Preliminary Population Viability Assessment for the Gunnison sage-grouse (*Centrocercus minimus*)

Report prepared by:

Philip S. Miller

IUCN / SSC Conservation Breeding Specialist Group

In collaboration with

Members of the Gunnison sage-grouse Rangewide Conservation Plan Science Team

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Preliminary Population Viability Assessment for the Gunnison sage-grouse (*Centrocercus minimus*)

Philip Miller, Conservation Breeding Specialist Group
and
Rangewide Conservation Plan Science Team Members

Table of Contents

Preliminary Population Viability Assessment for the Gunnison sage-grouse (*Centrocercus minimus*)

Philip Miller, Conservation Breeding Specialist Group
and
Rangewide Conservation Plan Science Team Members

Introduction

The Gunnison sage-grouse (*Centrocercus minimus*) is a newly described species that became an immediate candidate for Federal listing under the Endangered Species Act. There are perhaps 2,500-3,500 breeding individuals, about 2,500 in the Gunnison basin and another 1,000 or so spread across seven smaller populations in southwest Colorado and southeast Utah. These populations have been isolated from each other and from the main population for perhaps 50-75 years and do not seem to have unique genotypes. Detailed genetic information now exists and field researchers will have results on increased sample sizes and additional markers near the end of 2004.

The current strategy adopted by the Colorado State Department of Wildlife is to manage to conserve all of the genetic diversity currently in existence and insure that this level of diversity is maintained with a high probability for a 50-year planning horizon. The Department will manage the Gunnison Basin population as the main reservoir of genetic diversity, and the smaller populations as alternative reservoirs that contain subsets of genetic diversity. The goal across the seven smaller populations will be to retain much (hopefully all) of the genetic diversity present in the entire population, but also to ensure that a sufficiently large number of individuals exist to protect against extinction risk and loss of diversity from demographic stochasticity. This will probably require significant habitat restoration in some populations to get them above that threshold number. If they dip below that number, or appear to have lost significant genetic diversity, translocations will be effected to rescue that population.

There is interest by some in the Colorado Department of Natural Resources to establish captive breeding facilities. While a bit controversial, this option will allow for the conduct of research on improving translocation techniques and captive-rearing methodologies. If a captive breeding program is deemed beneficial, then it would be important to obtain advice from a genetic standpoint on the ideal characteristics of such a program.

Population viability analysis (PVA) can be an extremely useful tool for investigating current and future risk of wildlife population decline or extinction. In addition, the need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing populations of the Gunnison sage-grouse in its wild habitat. *VORTEX*, a simulation software package written for population viability analysis, was used here as a mechanism to study the interaction of a number of Gunnison sage-grouse life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

The *VORTEX* package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by stepping through the series of events that describe the typical life cycles of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters used as input to the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the Gunnison sage-grouse, the environmental conditions affecting the species, and possible future changes in these conditions. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Appendix 1, Lacy (2000) and Miller and Lacy (2003 [cited as Miller and Lacy 2003a in RCP Literature Cited section]).

Specifically, we were interested in using this preliminary analysis to address the following questions:

- What is our best estimate of stochastic population dynamics of this species in its current range?
- What are the primary factors that drive population growth dynamics of Gunnison sage-grouse?
- What is the predicted rate of loss of genetic diversity from isolated Gunnison sage-grouse populations, and how does the restrictive lek mating system influence this rate of loss?
- How vulnerable are small, fragmented populations of Gunnison sage-grouse to local extinction in the absence of demographic interaction with other populations?
- What might be the impacts to Gunnison sage-grouse population viability of potential habitat loss?
- How successful might augmentation be as a conservation management strategy for smaller populations of Gunnison sage-grouse?
- How many birds could be removed from a given source population such as the Gunnison Basin for augmentation of smaller populations at risk of extinction without negatively impacting the persistence of the source?

The *VORTEX* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies.

Baseline Input Parameters for Stochastic Population Viability Simulations

Much of the data discussed below are gleaned from the studies on Greater sage-grouse of Hausleitner (2003) in Moffat County, Colorado and Peterson (1980) in North Park, Colorado. Some recruitment data collected by Colorado Division of Wildlife (CDOW) in 2002 are specific to Gunnison sage-grouse. These data were collected during what was assumed to be a rather marked period of drought, so any results obtained from these data are to be interpreted accordingly.

<u>Breeding System</u>: The Gunnison sage-grouse is a polygynous lek-breeding species. In *VORTEX*, a set of adult females are therefore randomly selected each year to breed with a given male. Breeding success of adult males within a given year is often dependent on the success of that male in the previous year. This was not specifically simulated in this analysis as this aspect of the breeding biology is unlikely to have a noticeable demographic impact on future population performance.

<u>Age of First Reproduction</u>: *VORTEX* considers the age of first reproduction as the age at which the first clutch of eggs is laid, not simply the onset of sexual maturity. Female sage grouse can lay their first clutch at one year of age, while males are much more likely to be two years old before becoming

reproductively successful. Because of the very low probability of breeding success among yearling males, we elected to ignore this possibility in our models.

Age of Reproductive Senescence: In its simplest form, *VORTEX* assumes that animals can reproduce (at the normal rate) throughout their adult life. There are no real data available on senescence in sage grouse, so we made a reasonable estimate of the maximum age possible for this species as 15 years. In reality, achieving this age is highly unlikely given mortality rates (see below).

Offspring Production: Based on the depth of our knowledge of sage grouse life history, we have defined reproduction in these models as the production of newly-hatched chicks by a given female, May – June. Based on data from Greater sage-grouse in Moffat County, Colorado, it is estimated that 92% of adult females beyond the age of one year initiate nests, with 58% of those individuals being successful. Of those that were unsuccessful on their first try, 16% try to renest and they enjoy a 75% success rate. Taken together, this means that, on average, about 58% of adult grouse over the age of one year are successful breeders in a given year. About 79% of yearlings nest, and 46% of those are successful. This means that about 36% of yearling females successfully reproduce in a given year. These results were combined in an equation used within *VORTEX* to describe the relationship between the average percentage of adult females breeding each year and their age.

Reproduction data on Gunnison sage-grouse collected by Young (1994) indicated as few as 43% of adult female birds were successfully reproducing. This value was also used in the development of an alternative baseline model to investigate its impact on population dynamics.

Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully lay a clutch of eggs within a given year. Wing data from Gunnison sage-grouse populations suggests that annual variability in reproductive success among yearling females can be high (SD = 15%) and slightly lower among older birds (SD = 10%).

The maximum number of eggs per clutch has been set at 9, based on data collected by Griner (1939) in Greater sage-grouse populations in eastern Utah (such data do not yet exist for Gunnison sage-grouse).
Given that an adult female lays a clutch of eggs, the distribution of clutch size was set as follows:

Number of eggs	%
1	1.0
2	1.0
3	1.0
4	1.0
5	5.5
6	27.3
7	35.0
8	25.0
9	3.2

This distribution yields an average clutch size of 6.75 eggs. The overall population-level sex ratio among eggs is assumed to be 50%.

Density-Dependent Reproduction: *VORTEX* can model density dependence with an equation that specifies the proportion of adult females that reproduce as a function of the total population size. In addition to including a more typical reduction in breeding in high-density populations, the user can also model an Allee effect: a decrease in the proportion of females that bread at low population density due, for example, to difficulty in finding mates that are widely dispersed across the landscape.

At this time, there are no data to support density dependence in reproduction in Gunnison sage-grouse populations. Consequently, this option was not included in the models presented here.

Male Breeding Pool: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered "available" for breeding each year. Observational data suggests that as few as 10% of the adult males are actually reproducing offspring within a given population segment, and this value was used in our baseline population analysis. Other researchers think this value may be much higher, approaching as high as 33%.

Mortality: Age-sex-specific mortality rates are based on Greater sage-grouse studies in Colorado and surrounding states as specific data on Gunnison sage-grouse do not yet exist. Specifically, we needed to estimate chick mortality as mortality from hatching to October, and then adding in overwintering mortality from October to May of the following year. Early chick mortality data are based on the study in Wyoming described in June (1963), while overwintering mortality estimates come from studies conducted in Moffat County, Colorado. Yearling and adult data are derived as averages of Moffat County telemetry and North Park banding studies.

Age Class	% Mortality (SD)	
	Females	Males
0 – 1	72.0 (7.0)	72.0 (7.0)
1 – 2	23.0 (5.0)	48.0 (5.0)
2 - +	41.0 (6.0)	62.0 (6.0)

In addition, we included a catastrophic impact on chick mortality through the action of a simulated severe 3-year drought event. We assumed that such an event would occur, on average, just once in 100 years; however, when it occurred, average mortality would increase linearly from 72% in a "normal" year to 78% in drought year 1, 84% in drought year 2, and finally 90% in drought year 3. This was simulated through the use of a complex function directly within the field for chick mortality. The event is assumed to impact both males and females equally.

Mortality data collected from Gunnison sage-grouse populations in 2002 by CDOW indicated lower levels of yearling and adult survival during the period of data collection. These values are listed in the following table:

Age Class	% Mortality (SD)	
	Females	Males
0 – 1	72.0 (7.0)	72.0 (7.0)
1 – 2	39.0 (5.0)	25.0 (5.0)
2 - +	52.0 (6.0)	69.0 (6.0)

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. Because of the complete absence of information on the effects of inbreeding on the demography of Gunnison sage-grouse, the group concluded that this option should not be included in our models.

Initial Population Size: A total of eight discrete populations of Gunnison sage-grouse are thought to exist across Colorado and eastern Utah. These populations are listed below, with their estimated numbers based on spring breeding counts of males on leks and a presumed 2:1 female:male ratio.

Population	Breeding Males	Total
Gunnison Basin	1000	3000
San Miguel Basin	50	150
San Juan County, Utah	35	100
Glade Park / Piñon Mesa	25	100
Crawford	24	75
Cimarron / Cerro / Sims Mesa	6	25
Dove Creek	8	20
Poncha Pass	7	20

Because of the uncertainty in these estimates, and because of a greater interest in the more general results that can be obtained from a systematic analysis of population size and its influence on persistence in the face of random demographic fluctuations in sage grouse populations, we decided to focus instead on a set of population size classes throughout the analysis. The size classes studied were:
N_0 = 20, 25, 50, 75, 100, 150, 250, 500, 1000, 1500, 3000

Our initial baseline model was parameterized with an initial population size of 250 birds. This was chosen to represent a mid-sized population that would allow us to investigate the dynamics of population growth in the absence of significant extinction probability.

VORTEX distributes the specified initial population among age-sex classes according to a stable age distribution that is characteristic of the mortality and reproductive schedules described previously.

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across all age classes in order to return the population to the value set for K.

The estimation of a carrying capacity is a very difficult process. Our approach was to identify the largest spring breeding counts of males and compare them to the current counts. These data are shown below:

Population	**Highest Male Count in past 10 years (Year)**	**2003 Highest Male Count**
Cim/Cerro/Sims	12 (2001)	6
Dove Crk	73 (1994)	8
San Juan, UT	57 (2000)	35
San Miguel Basin	91 (1998)	50
Glade Pk	33 (2000)	25
Gunnison Basin	723 (1993)	500
Poncha	9 (2002)	7
Crawford	64 (1991)	24

Population Augmentation: An important issue for management of Gunnison sage-grouse is the feasibility of using larger populations like that in the Gunnison Basin, or perhaps a newly-established *ex situ* population, to augment smaller populations at significant risk of extinction. Specifically, the question revolves around how frequently a population must be augmented in order to minimize the risk of extinction below a given threshold. Therefore, a set of scenarios were developed that included augmentation of existing sage grouse populations with birds from an external source. Populations subject to augmentation began with 100, 200 or 300 individuals and a carrying capacity equal to twice the initial size. Calculation of gene diversity under these conditions assumes that each new bird added to the population is unrelated to all others, thereby infusing the population with two new unique alleles at the locus of analysis. Fecundity and mortality values roughly corresponding to a 0.0% long-term stochastic population growth rate among populations of intermediate size were used in all simulations (see Table 4 below). Augmentation was triggered any time the size of a population was reduced to less than 50% or 25% of the initial number of birds. The current plan calls for 40 birds (67% hens, 33% males) to be added to a given population in the fall, with 40% mortality likely to occur within a few weeks after release. Therefore, the simulations included the "effective" release of 24 birds (16 hens, 8 males) at the end of the *VORTEX* time cycle, roughly corresponding to the end of the calendar year. To assess the impact of smaller numbers of birds used for augmentation, additional models were constructed that included effective releases of 18, 12, or 6 birds (i.e., a total release of 30, 20, or 10), while maintaining the original sex ratio used for the larger augmentation simulations.

Iterations and Years of Projection: All population projections (scenarios) were simulated 500 times. Each projection extends to 100 years, with demographic information obtained at annual intervals. For our purposes, we are most interested in viewing the results of our simulations at 50 years; in this way we are able to discern the dynamics emerging from a given input dataset while reducing the uncertainty of our projections if extended out to 100 years or more. All simulations were conducted using *VORTEX* version 9.42 (March 2004).

Table 1 below summarizes the baseline input dataset upon which all subsequent *VORTEX* models are based.

Table 1. Demographic input parameters for the baseline *Vortex* Gunnison sage-grouse models. See accompanying text for more information.

Model Input Parameter	Baseline, Greater	Baseline, Gunnison
Breeding System	Polygynous	Polygynous
Age of first reproduction (♀ / ♂)	1 / 2	1 / 2
Maximum age of reproduction	15	15
Annual % adult females reproducing	36 (A = 1); 58.4 (A<1)	43
Density dependent reproduction?	No	No
Maximum clutch size	9	9
Mean clutch size†	6.75	6.75
Overall offspring sex ratio	0.5	0.5
Adult males in breeding pool	10%	10%
% annual mortality, ♀ / ♂ (SD)		
0 – 1	72.0 / 72.0 (7.0)‡	72.0 / 72.0 (7.0)‡
1 – 2	23.0 / 48.0 (5.0)	39.0 / 25.0 (5.0)
2 – +	41.0 / 62.0 (6.0)	52.0 / 69.0 (6.0)
Initial population size / carrying capacity		
	20 / 40	20 / 40
	25 / 50	25 / 50
	50 / 100	50 / 100
	75 / 150	75 / 150
	100 / 200	100 / 200
	150 / 300	150 / 300
	250 / 500	**250 / 500**
	500 / 1000	500 / 1000
	1000 / 2000	1000 / 2000
	1500 / 3000	1500 / 3000
	3000 / 6000	3000 / 6000

† Exact probability distribution of individual clutch size specified in input file.

‡ Chick mortality includes 3-year drought catastrophe that linearly increases mortality to 90%. See text for additional details.

Results of Baseline Simulations

Results reported for each modeling scenario include:

$\underline{r_s}$ (SD) – The mean rate of stochastic population growth or decline (standard deviation) demonstrated by the simulated populations, averaged across years and iterations, for all simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity.

$\underline{P(E)_{50}}$ – Probability of population extinction after 50 years, determined by the proportion of 500 iterations within that given scenario that have gone extinct within the given time frame. "Extinction" is defined in the *VORTEX* model as the lack of either sex.

$\underline{N_{50}}$ (SD) – Mean (standard deviation) population size at the end of the simulation, averaged across all simulated populations, including those that are extinct.

$\underline{GD_{50}}$ – The gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity.

Our two alternative baseline models either rely heavily on more historical Greater sage-grouse data or utilize recent data from Gunnison sage-grouse population collected during drought years. The results of these two models are shown in Table 2 and Figure 1.

Table 2. Gunnison sage-grouse PVA. Demographic output from two alternative baseline simulation models. See text for accompanying information.

Baseline Model	r_s (SD)	$P(E)_{50}$	N_{50} (SD)	GD_{50}
Greater SG	0.146 (0.229)	0.000	465 (65)	0.795
Gunnison SG (Drought)	-0.051 (0.299)	0.372	82 (122)	0.596

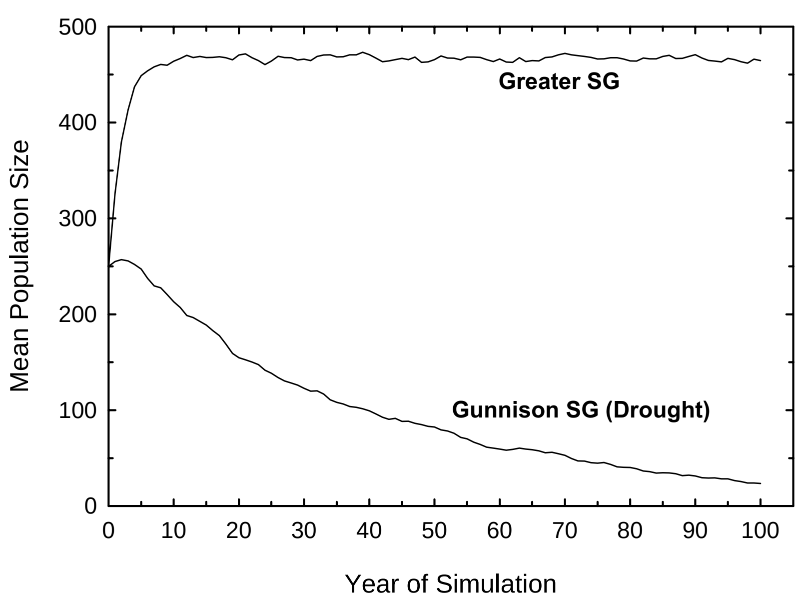


Figure 1. Projections of mean population size for two alternative baseline demographic models of Gunnison sage-grouse population dynamics. See text for accompanying information on model construction and parameterization.

Inspection of the Table and Figure point out the dramatic differences between the two datasets. When our model is based largely on demographic data from Greater sage-grouse, we see a robust population capable of increasing at an average rate of nearly 15% per year. Under these conditions, the simulated population can rapidly reach its habitat-based carrying capacity with no risk of population extinction. It is our assumption that many of these data were collected from large, healthy Greater sage-grouse populations established in optimal environments in the Axial Basin and Moffat County. Such favorable conditions will give rise to the strongly positive growth rates displayed in our model.

On the other hand, when our baseline model includes recent data from Gunnison sage-grouse populations experiencing drought conditions, we see a dramatically different picture: average growth rates drop to a 5% rate of annual decline with a probability of 37% that this population will become extinct within 50 years. Once again, members of the Science Team are mindful of the fact that the Gunnison sage-grouse – specific data were collected during a period of drought – perhaps even one as sever as the event we are simulating here – and therefore population dynamics are expected to become significantly impacted.

It is extremely unlikely that populations of Gunnison sage-grouse are currently experiencing long-term annual population growth rates as high as 15% or as low as -5%. Unfortunately, detailed data do not yet exist on long-term growth patterns of this species inside or outside Gunnison Basin. This baseline model analysis, however, is very instructive in that it provides plausible upper and lower bounds on population growth that are reasonable in the shorter-term, i.e., on the order of 5-10 years or perhaps longer.

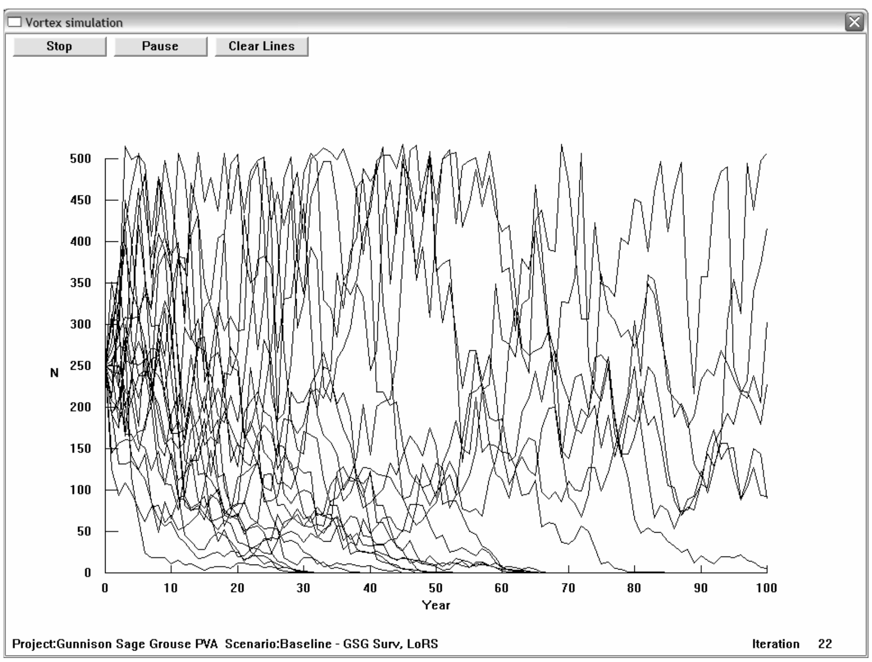


Figure 2. Plot of subset of individual iterations of Gunnison sage-grouse baseline model. Note level of variance in the model as defined by both demographic and environmental sources of stochasticity included in the *VORTEX* model. See text for accompanying details.

A review of Figure 2 also gives us an appreciation for the variability in growth rate – both within and between replicate runs of the model (iterations) – that is a defining characteristic of stochastic simulation models of wildlife demography. While we may observe a longer-term growth rate that is either positive or negative, we see significant fluctuations in population size across years. It is therefore difficult to confidently ascribe a high level of accuracy to a particular modeling scenario when the model results must be compared to a very short timeframe of detailed observation of the wild population being studied. This is indeed the case with the Gunnison sage-grouse, where longer-term trends in population size have yet to be determined with a reasonable degree of confidence. Because of this wide disparity in growth rates observed in our two baseline models, we opted to develop a larger set of models that differed in their underlying growth rates through manipulation of demographic parameters within *VORTEX*. These model will be discussed in more detail in a later section of this report.

Demographic Sensitivity Analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of Gunnison sage-grouse populations were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identify a selected set of parameters from Table 1 whose estimate we see as considerably uncertain. We then develop biologically plausible minimum and maximum values for these parameters (see Table 3).

Table 3. Uncertain input parameters and their stated ranges for use in demographic sensitivity analysis. Values in bold are those used in the baseline model using Greater sage-grouse data in the absence of Gunnison sage-grouse data. See accompanying text for more information.

		Estimate	
Model Parameter	Minimum	Midpoint	Maximum
Maximum Age	5	10	**15**
% Adult Females Reproducing	26 / 48	**36 / 58**	46 / 68
% Chick Mortality	66.0	**72.0**	78.0
% Adult Female Mortality	31.0	**41.0**	51.0
Drought Frequency (%)	**1.0**	3.0	5.0
% Males in Breeding Pool	**10**	20	33

For each of these parameters we construct two simulations, with a given parameter set at its prescribed minimum or maximum value, with all other parameters remaining at their baseline value. With the six parameters identified above, and recognizing that the aggregate set of baseline values constitute our single baseline model, the table above allows us to construct a total of 12 additional, alternative models whose performance (defined, for example, in terms of average population growth rate) can be compared to that of our starting baseline model. For this comparison, we have chosen the model relying heavily on data from Greater sage-grouse population.

For the entire suite of sensitivity analysis models, we will consider a generic population of 250 individuals and a carrying capacity of 500 individuals.

The results of the sensitivity analysis are shown in tabular form in Table 4 and graphically in Figure 3.

Table 4. Gunnison sage-grouse PVA. Output from demographic sensitivity analysis models. See text for additional information on model construction and parameterization.

Model conditions	r_s (SD)
Baseline	0.146 (0.229)
Maximum age	
5	0.124 (0.226)
10	0.146 (0.226)
Adult Females Reproducing (%)	
26 / 48	0.068 (0.233)
46 / 68	0.224 (0.223)
Chick Mortality (%)	
66	0.227 (0.215)
78	0.049 (0.248)
Adult Mortality (%)	
31	0.198 (0.220)
51	0.095 (0.230)
Drought Frequency (%)	
3	0.132 (0.238)
5	0.119 (0.250)
Males in Breeding Pool (%)	
20	0.147 (0.227)
33	0.146 (0.226)

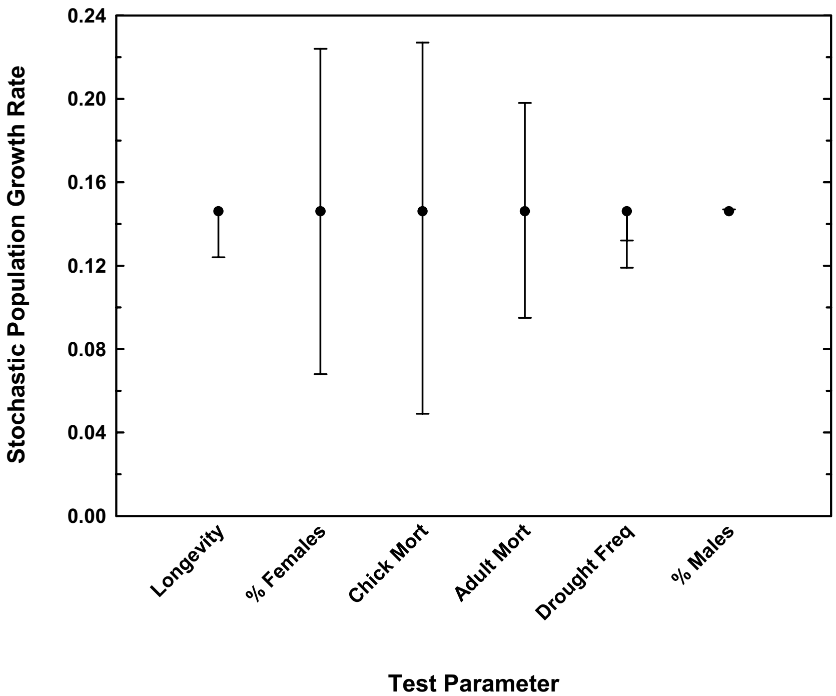


Figure 3. Demographic sensitivity analysis of a simulated Gunnison sage-grouse population. Stochastic population growth rate for a set of models in which the specific parameter is varied across a range of biologically plausible values. The baseline model growth rate of 0.146 is given by the central data point for each parameter. The general model of sage grouse population dynamics is most sensitive to uncertainty in those parameters giving the widest range in simulated population growth rates. See text for additional details.

It is clear from the analysis that our model of Gunnison sage-grouse population dynamics is most sensitive to uncertainty in adult female reproductive success (defined here as the percentage of adult females that successfully raise a clutch of eggs to hatching) and to mortality of chicks. Uncertainty in adult female mortality also leads to significant model response, but not to the level of that seen among the youngest age class. As might be expected, the longevity of sage grouse does not significantly alter the results of the analysis until this maximum age is reduced from 15 years of age down to 5 years. This is easily explained by a more detailed inspection of the results of these models, which indicates that a precious few birds actually survive beyond 10 years of age given the mortality schedule used in our baseline model. Similarly, in a purely demographic analysis we may predict that the percentage of adult males that are available for breeding is not a driving force in the growth dynamics of this model. The results presented here bear this out.

However, given the complex relationship that often exists between population genetic structure and demographic performance, we may wish to investigate in more detail the potential impact of uncertainty in lek mating structure among adult males on the retention of population genetic diversity. Figure 4 shows the rate of loss of genetic diversity over time for three different scenarios corresponding to a relatively low, medium and high degree of polygyny in simulated Gunnison sage-grouse populations.

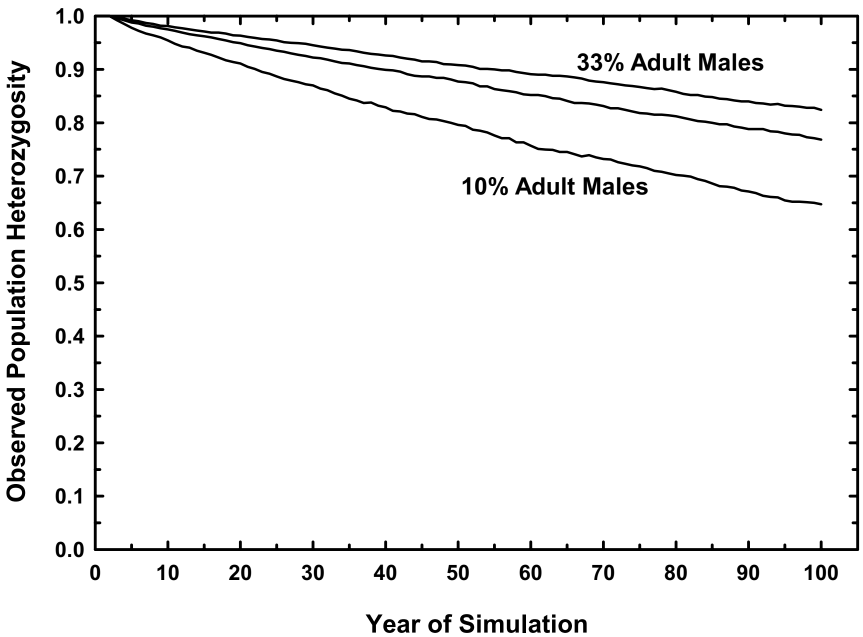
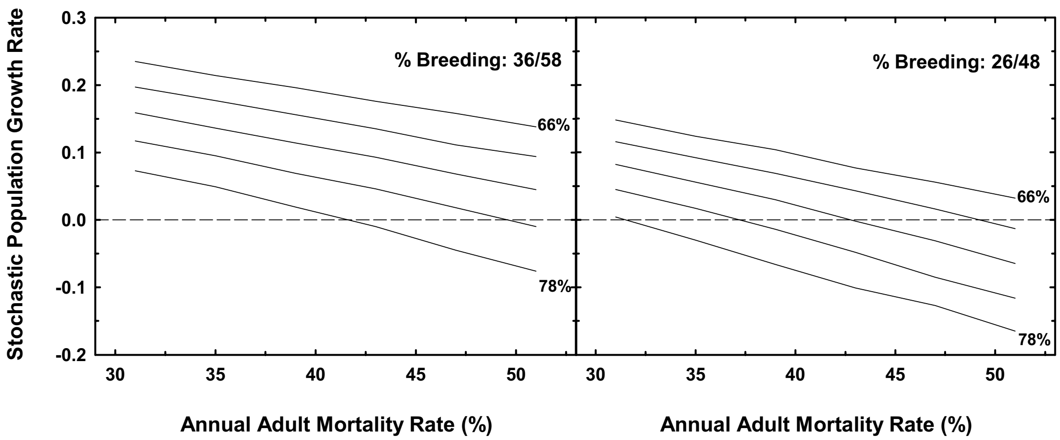


Figure 4. Projected rate of loss of genetic diversity (observed heterozygosity) in simulated populations of Gunnison sage-grouse under different expectations of degree of polygyny. Degree of polygyny is defined here as the percentage of adult males available for breeding. In this type of analysis, each individual at time 0 is assumed to be heterozygous and the plot tracks the relative rate of loss of this original diversity. See text for additional details.

Once the generalized sensitivity analysis was successfully completed, we set out to develop a set of models with the goal of identifying minimum levels of survival necessary to prevent Gunnison sage-grouse population decline. This was done in order to provide a better understanding of species population dynamics, to define a broad set of minimal conditions necessary to increase the chances of population persistence, and to gain additional insight into the magnitude of any detrimental impact of proposed major mortality factors. It is important to note that this particular analysis does not include certain stochastic elements of population dynamics, most notably the addition of the catastrophic drought event. This was intentional, as we were focused in this task on developing estimates of annual mortality that were consistent with populations that were remaining stable in size or perhaps slightly increasing. This can provide a simple benchmark to which wild population management and associated field monitoring efforts can be directed.

A total of 60 individual models were constructed that provided all possible combinations of two levels of reproductive success, five levels of chick mortality, and six levels of adult mortality. This was done in order to more effectively address the relationship between reproductive success and age-specific mortality required for population growth.

Figure 5. Gunnison sage-grouse population mortality analysis. Plots give average population growth rate (*r*) as a function of annual mortality rate of adults with individual lines corresponding to different levels of chick mortality. Two panels correspond to variable levels of adult female reproductive success (see text for additional details on the determination of success).



The results of this analysis are shown in Figure 5. It is clear that a number of combinations of chick and non-chick mortality can result in a population that is not expected to decline over time (i.e., $r > 0.0$). Inspection of these graphs lead to the following conclusions:

- As the mortality of adults increases from 31% to 51%, the maximum level of chick mortality consistent with a positive growth rate decreases. In other words, greater adult mortality results in less flexibility in allowable levels of chick mortality.
- Higher levels of reproductive success allow for higher levels of acceptable mortality. Under the conditions of lower reproductive success (right panel), many scenarios yield a negative growth rate – even under relatively favorable conditions for survival.
- A given percentage change in chick mortality results in a proportionally larger change in mean population growth rate compared to a change in adult mortality of the same magnitude. In other words, the results of our simulation models are more sensitive to chick mortality.

While it is very instructive to investigate the sensitivity of our model to uncertainty in demographic input, it is also important to recognize that detecting mortality rates to the level of precision discussed here is rather impractical at best. For example, statistical power analyses conducted on typical types of field demographic and survey data (e.g., Forcada 2000) suggest that either large sample sizes (say, in the hundreds of individuals) or long periods of observation (10 – 15 years) are necessary to detect changes in population numbers in the short term with reasonable levels of precision. Similarly, very large and detailed field studies would be required to successfully differentiate between, for example, a chick mortality rate of 75% and 78%. Consequently, the analysis presented here is typically to be used at more of a “strategic” level; when faced with the need for population management in the face of measurement uncertainty and limited institutional resources, research and/or management prioritization can be accomplished through a comparative study of sensitivity analysis data. Having said this, it is also important to note that those parameters to which a demographic model is most sensitive may **not** be the same parameters that are most directly affected by human activities and are therefore putting the population at risk. Successful conservation requires careful additional study to identify the specific risks the populations face and to develop appropriate remedial actions.

Risk Analysis I: Population Size, Stochastic Growth Rate, Extinction and Maintenance of Genetic Diversity

With our demographic sensitivity analysis complete, our next task was to investigate the relationship between the size of a Gunnison sage-grouse population, its intrinsic stochastic growth rate, and its vulnerability to extinction. Because of our inherent uncertainty in our understanding of current trends in Gunnison sage-grouse population sizes in Colorado, we elected to develop our risk analysis under a quite of scenarios that differed in their underlying growth rates. We did this so that we could provide insight into the future potential dynamics of dispersed Gunnison sage-grouse populations that may be assumed to be growing or declining at rates within the scope of this analysis. We are thereby developing a sort of "template" upon which the future of a given population may be evaluated under presumed conditions of growth and size.

We began by iteratively working on the demographic rates required to produce a population with the desired long-term stochastic growth rate. The results of this process are given in Table 5.

Table 5. Gunnison sage-grouse PVA. Demographic parameters required to achieve the desired growth rate for subsequent population size risk analysis. ♀ **:** ♂ is the female:male ratio among adults, while ♀ **:** ♂* includes yearling males (considered here as subadults). Initial population size in all simulations was 250 individuals.

	Demographic Parameter Estimate					
		Mortality				
Desired Growth Rate	**% ♀♀**	**Chick**	**Adult**	**r_s**	**♀ : ♂**	**♀ : ♂***
0.15	58.4	72.0	41.0	0.145	3.60	1.42
0.10	58.4	74.0	45.0	0.094	3.21	1.35
0.08	58.4	75.0	45.0	0.079	3.36	1.41
0.06	58.4	75.5	46.0	0.062	3.31	1.41
0.04	58.4	76.5	46.5	0.042	3.17	1.41
0.02	55.4	76.5	48.0	0.024	3.16	1.39
0.00	51.9	77.0	48.0	-0.005	3.15	1.42
-0.02	48.0	76.5	48.0	-0.018	3.28	1.45
-0.04	45.0	76.5	48.0	-0.039	3.24	1.48

With this underlying dataset in hand, we then ran simulations for each initial population size mentioned in the Input Parameters section across each growth rate scenario. This yielded a total of 99 different models [9 growth rates X 11 population sizes] to be tested for their sensitivity to extinction at 25 and 50 years.

Our goal in this analysis is to identify, for a given scenario of population growth or decline, the minimum population size necessary to minimize the risk of extinction below a defined threshold. Unfortunately for us biologists, the identification of this extinction threshold is based more on political and social factors than on anything else. The agreement upon a threshold must be done within a more participatory framework that includes a diversity of perspectives among those involved in the management and utilization of the taxon under study.

Figure 6 and Table 6 present the aggregate results of this analysis.

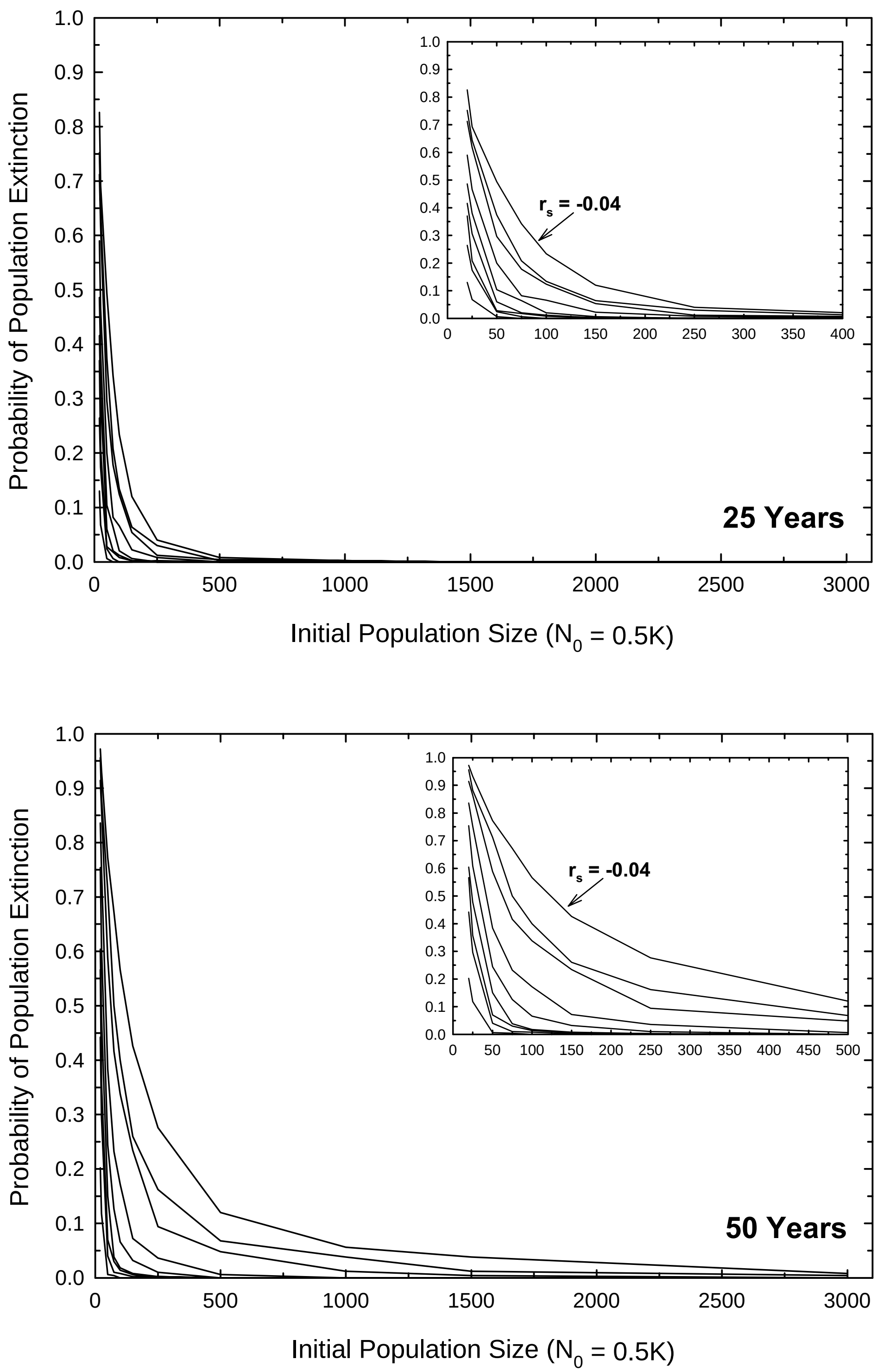


Figure 6. Gunnison sage-grouse population risk analysis. Plots show risk of extinction after 25 years (top panel) and 50 years (bottom panel) for simulated populations with specific long-term expected annual stochastic growth rates ranging from -0.04 (towards the top-right portion of each primary panel) to 0.15 (towards the bottom-left portion of each primary panel). For a given initial population size, higher growth rates lead to lower risks of extinction. Smaller inset panels magnify the results for smaller initial population sizes. See text for additional information on model construction and interpretation.

Table 6. Gunnison sage-grouse PVA. Results of population size risk analysis models under conditions of different underlying stochastic growth rates. See page 8 (RCP pg. F-11) for definitions of column headings.

r_s (Exp)	N_0	r_s (Obs) (SD)	$P(E)_{50}$	N_{50} (SD)	GD_{50}
0.150	20	0.125 (0.306)	0.202	27 (16)	0.259
	25	0.134 (0.284)	0.118	39 (17)	0.323
	50	0.143 (0.250)	0.006	92 (16)	0.432
	75	0.148 (0.235)	0.004	138 (23)	0.497
	100	0.148 (0.232)	0.000	187 (27)	0.577
	150	0.148 (0.226)	0.000	281 (37)	0.683
	250	0.147 (0.225)	0.000	472 (59)	0.800
	500	0.148 (0.226)	0.000	935 (128)	0.890
	1000	0.149 (0.228)	0.000	1871 (239)	0.921
	1500	0.149 (0.226)	0.000	2747 (358)	0.948
	3000	0.149 (0.223)	0.000	5618 (714)	0.957
0.100	20	0.067 (0.326)	0.442	17 (17)	0.243
	25	0.075 (0.306)	0.296	28 (21)	0.320
	50	0.091 (0.260)	0.040	80 (26)	0.419
	75	0.093 (0.247)	0.010	128 (32)	0.494
	100	0.096 (0.238)	0.008	171 (41)	0.576
	150	0.095 (0.234)	0.002	262 (57)	0.674
	250	0.093 (0.232)	0.002	436 (98)	0.782
	500	0.095 (0.232)	0.000	882 (182)	0.879
	1000	0.096 (0.233)	0.000	1750 (380)	0.919
	1500	0.097 (0.232)	0.000	2620 (568)	0.937
	3000	0.098 (0.232)	0.000	5185 (1083)	0.944
0.080	20	0.044 (0.337)	0.566	13 (17)	0.269
	25	0.057 (0.313)	0.358	24 (21)	0.310
	50	0.070 (0.269)	0.070	75 (31)	0.422
	75	0.075 (0.256)	0.030	118 (41)	0.491
	100	0.078 (0.247)	0.014	163 (48)	0.556
	150	0.078 (0.242)	0.006	242 (70)	0.653
	250	0.077 (0.237)	0.000	419 (106)	0.767
	500	0.077 (0.238)	0.000	845 (214)	0.874
	1000	0.075 (0.239)	0.000	1659 (431)	0.915
	1500	0.077 (0.237)	0.000	2474 (658)	0.931
	3000	0.078 (0.237)	0.000	5136 (1367)	0.940
0.060	20	0.033 (0.342)	0.604	11 (16)	0.269
	25	0.035 (0.323)	0.478	19 (21)	0.290
	50	0.054 (0.278)	0.150	65 (37)	0.401
	75	0.060 (0.261)	0.038	113 (42)	0.486
	100	0.061 (0.254)	0.018	150 (56)	0.542
	150	0.064 (0.246)	0.008	239 (76)	0.641
	250	0.064 (0.241)	0.002	404 (116)	0.751
	500	0.064 (0.240)	0.000	799 (244)	0.865
	1000	0.063 (0.242)	0.000	1594 (482)	0.908
	1500	0.063 (0.241)	0.000	2354 (730)	0.919
	3000	0.063 (0.240)	0.000	4612 (1487)	0.929
0.040	20	0.004 (0.350)	0.754	7 (13)	0.322
	25	0.017 (0.338)	0.608	13 (19)	0.292
	50	0.030 (0.292)	0.244	51 (38)	0.403
	75	0.036 (0.273)	0.126	90 (53)	0.478
	100	0.041 (0.263)	0.066	133 (65)	0.531
	150	0.042 (0.252)	0.032	202 (90)	0.623
	250	0.042 (0.249)	0.010	347 (148)	0.726
	500	0.043 (0.245)	0.000	712 (275)	0.839

r_s (Exp)	N_0	r_s (Obs) (SD)	P(E) $_{50}$	N_{50} (SD)	GD_{50}
	1000	0.043 (0.244)	0.000	1415 (539)	0.902
	1500	0.043 (0.242)	0.000	2072 (876)	0.915
	3000	0.042 (0.243)	0.000	4143 (1779)	0.922
0.020	20	-0.018 (0.361)	0.836	5 (12)	0.252
	25	-0.012 (0.347)	0.752	8 (16)	0.257
	50	0.003 (0.303)	0.384	37 (37)	0.377
	75	0.010 (0.285)	0.232	72 (56)	0.436
	100	0.015 (0.275)	0.172	98 (73)	0.489
	150	0.020 (0.262)	0.072	169 (103)	0.596
	250	0.024 (0.253)	0.036	304 (160)	0.712
	500	0.028 (0.252)	0.006	634 (314)	0.821
	1000	0.032 (0.251)	0.000	1283 (617)	0.888
	1500	0.030 (0.250)	0.000	1738 (950)	0.900
	3000	0.031 (0.250)	0.000	3467 (1854)	0.908
0.000	20	-0.047 (0.369)	0.914	2 (8)	0.274
	25	-0.046 (0.356)	0.864	4 (11)	0.311
	50	-0.029 (0.318)	0.588	21 (32)	0.368
	75	-0.022 (0.302)	0.416	39 (47)	0.434
	100	-0.019 (0.294)	0.338	61 (68)	0.489
	150	-0.013 (0.282)	0.234	108 (102)	0.559
	250	-0.004 (0.269)	0.094	198 (163)	0.664
	500	0.002 (0.261)	0.048	440 (322)	0.785
	1000	0.004 (0.259)	0.012	913 (648)	0.855
	1500	0.008 (0.257)	0.004	1383 (895)	0.891
	3000	0.007 (0.256)	0.000	2795 (1921)	0.899
-0.020	20	-0.061 (0.375)	0.956	1 (6)	0.154
	25	-0.056 (0.360)	0.882	3 (10)	0.265
	50	-0.045 (0.321)	0.712	14 (27)	0.375
	75	-0.034 (0.306)	0.500	31 (44)	0.399
	100	-0.027 (0.294)	0.400	52 (63)	0.457
	150	-0.024 (0.287)	0.260	82 (92)	0.517
	250	-0.021 (0.276)	0.162	149 (149)	0.616
	500	-0.011 (0.265)	0.068	341 (304)	0.749
	1000	-0.013 (0.262)	0.038	652 (588)	0.830
	1500	-0.007 (0.259)	0.012	1082 (919)	0.872
	3000	-0.007 (0.258)	0.048	1975 (1746)	0.884
-0.040	20	-0.089 (0.384)	0.972	0.5 (4)	0.185
	25	-0.070 (0.361)	0.932	2 (7)	0.250
	50	-0.062 (0.331)	0.772	10 (22)	0.351
	75	-0.057 (0.315)	0.672	18 (37)	0.396
	100	-0.050 (0.307)	0.566	29 (47)	0.429
	150	-0.045 (0.297)	0.426	53 (76)	0.504
	250	-0.038 (0.286)	0.276	100 (131)	0.593
	500	-0.032 (0.276)	0.120	235 (275)	0.709
	1000	-0.029 (0.268)	0.056	489 (527)	0.802
	1500	-0.026 (0.265)	0.038	747 (798)	0.841
	3000	-0.026 (0.260)	0.008	1399 (1517)	0.883

Inspection of these results lead to the following conclusions:

- Very small Gunnison sage-grouse populations are at a high risk of extinction, even when the population is expected to increase in size over the long-term ($r_s > 0.0$). For example, when the assumed long-term growth rate is 8% in a population of just 20 individuals and the carrying capacity is no more than 40 birds, the risk of extinction of this population is 37% after just 25 years, and this risk increases to nearly 57% after 50 years. These results dramatically illustrate the impact of stochastic demographic fluctuations on the viability of very small populations – a characteristic that is lost in simpler matrix-based deterministic calculations of population growth.
- The stochastic nature of population growth as simulated here results in populations often experiencing a slight decrease in population size over the duration of the simulation, even under conditions of expected positive population growth. Periodic catastrophic droughts can play a significant role in this phenomenon.
- Under assumed conditions of positive population growth (r_s just above 0.0), and if we choose an extinction threshold of 5% over 50 years, Gunnison sage-grouse populations can only be considered "secure" under this definition if they can maintain a maximum number of 500 birds (yearlings and adults). More vigorous population growth potential can, of course, reduce this required number of animals.
- If we continue to accept this definition of extinction threshold, even under the most optimistic conditions – evaluation of risk at 25 years and vigorous long-term population growth – all known Gunnison sage-grouse populations with less than 30 – 40 individuals are not viable. Over a 50-year time horizon, and even under minimal conditions of long-term population growth, populations of more than 500 individuals appear to be at low risk of extinction.

Based on this analysis, an attempt was made to fit an equation to the extinction risk data at 0.0% stochastic growth rate so that an estimate of extinction risk could be obtained for any desired population size. A slightly modified dose-response curve, used primarily in the biomedical community, was used as it seemed an appropriate descriptor of the relationship between population size and extinction risk. The modified form of the equation is

$$P(E) = \frac{1}{1 + e^{\left[B - C\left(\ln\left(N\right)\right)\right]}}$$

where B is the location parameter, C is the steepness parameter, and N is the initial population size included in the appropriate model. Results of the nonlinear regression analysis of the 25-year and 50-year extinction risk data are presented in Table 7.

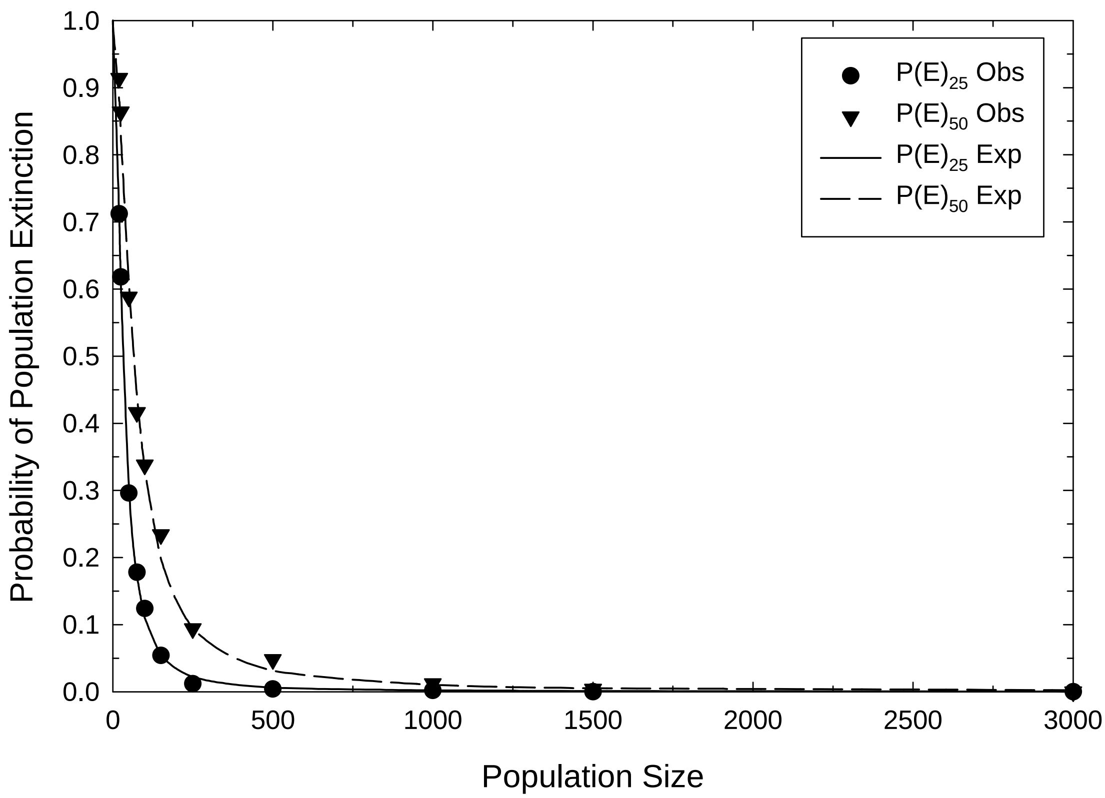
Table 7. Gunnison sage-grouse PVA. Parameter estimates for nonlinear regression analysis of extinction risk as a function of population size under conditions of approximately 0.0% stochastic population growth. See text for functional form of regression equation and additional information.

Extinction Risk Timeframe	B	C
25 Years	-6.442	-1.853

50 Years	-7.109	-1.697

The fit of this equation to the observed data is shown in Figure 7. The fit for both datasets is excellent, with mean corrected R-square for 25 and 50 years determined to be 0.999 and 0.996, respectively.

Figure 7. Observed population extinction risk probabilities (circles and inverted triangles) and predicted risk values based on nonlinear regression analysis (solid and dashed curves) for simulated Gunnison Sage Grouse populations at 25 and 50 years, respectively, under conditions of approximately 0.0% population growth. See text for function form of regression equation and additional information.



Another issue of concern with respect to Gunnison sage-grouse population conservation is the maintenance of genetic diversity within the Gunnison Basin population, particularly in light of the species' lek mating system and the small proportion of adult males that successfully breed each season. To address this issue, a series of models were run with initial population sizes of 2000, 2500 and 3000 with carrying capacity set at twice the initial size. In addition, the degree of male polygyny (defined here as the percentage of adult males available for breeding) was set at the minimum value of 10%, a medium value of 20%, and the maximum estimate of 33%.

The results of these models are shown in Table 8. Examination of the table reveals that, while the stochastic population growth rate is just above 0.0, the simulated populations decline very slightly from their initial values through the action of stochastic fluctuations in demographic parameters and occasional catastrophic reductions in population size through drought. Nevertheless, these populations remain at approximately 90% - 95% of their original values. Under these conditions, final gene diversity estimates range from 90% to 94%, with the largest value associated with the largest population size and highest degree of polygyny. However, even under these most "optimistic" conditions, the amount of genetic diversity retained within the simulated populations does not exceed 95% over the 50 years of the simulation. This threshold of gene diversity retention is crossed in just 27 years under the most strict conditions of population size and degree of polygyny, while this same threshold is crossed in 43 years when population size is large and the degree of polygyny is high.

Table 8. Gunnison sage-grouse PVA. Stochastic growth rate, final population size after 50 years, and final gene diversity (population heterozygosity) for simulated populations of different initial size and degree of polygyny. See page 8 (RCP pg. F-11) for column heading definitions. T_{95} is the timeframe within which 95% of the original population gene diversity can be retained. See text for additional details.

Population Size	% Polygyny	r_s	N_{50}	GD_{50}	T_{95}
2000	10	0.008	1909	0.8967	27
	20	0.007	1860	0.9237	33
	33	0.008	1926	0.9325	35
2500	10	0.006	2261	0.8997	28
	20	0.009	2370	0.9326	39
	33	0.007	2348	0.9372	41
3000	10	0.009	2767	0.9164	31
	20	0.010	2952	0.9301	38
	33	0.006	2738	0.9400	43

Risk Analysis II: Population Augmentation

The results for the set of population augmentation scenarios are presented in Table 9.

Inspection of these results leads to the following conclusions:

- As seen in previous analyses, the relatively larger population sizes reflect the intended growth dynamics (i.e., approaching 0.0% stochastic population growth rate) while the smaller populations, given the same demographic characteristics, display greater instability which leads to negative growth rates and higher risk of population decline or extinction.
- Under the conditions simulated here, vigilant augmentation of as few as 6 "effective" birds (corresponding to a total augmentation of 10 birds) into a small population showing basic underlying demographic stability can be very effective in rescuing it from extinction.
- Under a more conservative criterion for augmentation – i.e., a trigger corresponding to 50% of the initial population size – the number of augmentation events required to successfully reduce extinction risk does not exceed 10 times over a 50-year timeframe. Additionally, the number of events decreases as the number of birds making up the release is increased.
- Larger populations actually require a slightly *greater* number of augmentation events over the time-frame of the simulations. This may seem counter-intuitive at first glance, but may be explained rather readily by considering general Gunnison sage-grouse population dynamics and the means by which augmentation is implemented in these simulations. Based on the demographic data used as input to these models, rapid and significant declines in population size occur rather infrequently. When they do, however, the smaller populations will be bolstered in size more effectively by a given augmentation event because these additional birds will represent a larger proportion of the total recipient population. This event will therefore be more effective at pushing the recipient population above (and sometimes far

above) the augmentation trigger. In contrast, larger populations may require an additional 1-2 years of augmentation to push the total population above the threshold.

- Even under less conservative conditions for augmentation, these methods can be effective in reducing extinction risk. Moreover, since the population is allowed to decline to a smaller level before augmentation is triggered, a smaller number of events is required to achieve the same end. As expected, however, final population sizes and retained levels of gene diversity are reduced under this scenario.

Table 9. Gunnison sage-grouse PVA. Population augmentation scenarios under variable initial population sizes (N_0) and "effective" numbers of birds in the release (total number of released birds is 40% higher, with mortality assumed to occur within a few weeks of release). N* is the population size trigger for the initiation of augmentation. F_{Aug} is the average number of augmentation events that occurred during the 50-year timeframe of the simulations. See page 8 (RCP pg. F-11) for additional column heading definitions, and see text for additional details of model input.

N_0	N_{Aug}	N^*	r_s (SD)	$P(E)_{50}$	N_{50} (SD)	GD_{50}	F_{Aug}
100	0		-0.019 (0.289)	0.334	93 (63)	0.421	
200	0		-0.004 (0.269)	0.132	183 (127)	0.563	
300	0		0.000 (0.261)	0.060	268 (191)	0.656	
100	24	$0.5N_0$	0.020 (0.243)	0.000	124 (49)	0.675	2.7
200	24	$0.5N_0$	0.020 (0.236)	0.000	241 (99)	0.768	3.1
300	24	$0.5N_0$	0.019 (0.239)	0.000	359 (154)	0.820	4.0
100	18	$0.5N_0$	0.018 (0.241)	0.000	119 (50)	0.690	3.4
200	18	$0.5N_0$	0.018 (0.238)	0.000	245 (105)	0.762	3.8
300	18	$0.5N_0$	0.019 (0.242)	0.000	364 (159)	0.819	4.9
100	12	$0.5N_0$	0.017 (0.243)	0.000	116 (52)	0.666	4.4
200	12	$0.5N_0$	0.016 (0.243)	0.000	225 (106)	0.749	5.2
300	12	$0.5N_0$	0.017 (0.246)	0.000	341 (160)	0.809	5.6
100	6	$0.5N_0$	0.015 (0.252)	0.000	108 (54)	0.657	6.7
200	6	$0.5N_0$	0.012 (0.246)	0.000	213 (110)	0.735	8.1
300	6	$0.5N_0$	0.013 (0.246)	0.000	313 (169)	0.794	8.6
100	24	$0.25N_0$	0.010 (0.263)	0.000	99 (55)	0.594	1.2
200	24	$0.25N_0$	0.012 (0.246)	0.000	206 (109)	0.693	1.1
300	24	$0.25N_0$	0.010 (0.243)	0.000	294 (171)	0.766	1.6
100	18	$0.25N_0$	0.011 (0.261)	0.000	100 (57)	0.600	1.5
200	18	$0.25N_0$	0.009 (0.245)	0.000	197 (117)	0.681	1.6
300	18	$0.25N_0$	0.011 (0.242)	0.000	300 (176)	0.749	1.6
100	12	$0.25N_0$	0.010 (0.260)	0.000	96 (57)	0.601	1.8
200	12	$0.25N_0$	0.009 (0.249)	0.000	187 (117)	0.688	2.2
300	12	$0.25N_0$	0.010 (0.247)	0.000	288 (173)	0.753	2.3
100	6	$0.25N_0$	0.006 (0.263)	0.000	89 (57)	0.591	3.0
200	6	$0.25N_0$	0.009 (0.252)	0.000	184 (116)	0.685	2.9
300	6	$0.25N_0$	0.007 (0.251)	0.000	279 (184)	0.740	3.7

All in all, these simulations indicate that augmentation of smaller populations, under the conditions studied here, would be an effective means of minimizing their risk of extinction. While the total average number of observed augmentation events may be lower than original expectations, it is important to remember that a given population may require more or less of this kind of intensive management than what is described by the average population behavior. Consecutive years of augmentation may be necessary when a recipient population falls far below an identified threshold, thereby requiring an additional expenditure of resources above and beyond that which may be required by a single event or intermittent events. Additional considerations – which lie outside the bounds of biological analysis – must be considered in order to devise the most reasonable population management strategy.

Future Directions for Additional Analysis

Impacts of habitat loss
An important factor to consider when evaluating the future of Gunnison sage-grouse population persistence is the prospect of loss of habitat within the Gunnison Basin and surrounding area. Private land may be removed from use by sage grouse, leading to reduced habitat availability. There is considerable uncertainty as to the precise mode of impact of this reduced habitat. On a relatively simpler level, one may consider the loss of habitat to be reflected in a corresponding reduction in carrying capacity, K. Alternatively, a more complex perspective may involve the reduction of demographic rates as a function of habitat availability and suitability. While the former option presents its own set of complications when considering the construction of additional PVA models, the latter option is considerably more complex. The functional form of a relationship between, for example, reproductive output and habitat suitability is unknown for Gunnison sage-grouse and, for that matter, the vast majority of threatened fauna worldwide. Because of these uncertainties, we have deferred engaging in this analysis until a later date when the details of this relationship can be discussed much more thoroughly.

Impacts of disease
West Nile virus (WNV) is clearly a disease of great concern to sage grouse biologists in North America, but the data needed to rigorously evaluate its potential impact is lacking. Vortex can, by itself, simulate fairly complex disease dynamics and their impacts on wildlife population demography. However, we have chosen to delete this option from our current analyses. The Conservation Breeding Specialist Group has also developed Outbreak, a much more sophisticated simulation model of wildlife disease epidemiology, that can be of tremendous value in studying disease processes in threatened wildlife populations. Future Gunnison sage-grouse modeling efforts could be devoted to a deeper evaluation of WNV and its possible affects.

Refinement of demographic description of male reproductive success
Considerable uncertainty still surrounds our estimates of the proportion of adult males that successfully breed on a given lek. Moreover, we are not able to precisely determine the statistical description of male breeding success among a group occupying a given lek: Does each breeding male contribute the same number of offspring to the next generation, or is this distribution highly skewed towards a much smaller number of relatively highly successful males? More accurate estimates of the rate of loss of genetic diversity within a population of Gunnison sage-grouse will require a more detailed treatment of this issue.

Impacts of population genetic structure
The recent work of Sara Oyler-McCance on elucidating the genetic structure within and between Gunnison sage-grouse populations would be a valuable addition to the parameterization of genetic aspects of our evolving Vortex models. In the future, we could perhaps evaluate the impacts of reduced heterozygosity in existing isolated populations, or include a much more realistic treatment of inbreeding depression and its impacts on persistence of small isolates.

Conclusions

We may conclude our preliminary analysis of Gunnison sage-grouse population viability by returning to the original set of questions that provided the foundation for our study.

- *What is our best estimate of stochastic population dynamics of this species in its current range?*
  This is difficult to estimate. Recent demographic data suggest Gunnison sage-grouse populations are in decline. This is likely the result of a recent and ongoing drought event that depresses reproductive performance to a level that drives a population into short-term decline. This does not necessarily mean, however, that the population will remain in that state of decline when the environmental stressor is released.

- *What are the primary factors that drive population growth dynamics of Gunnison sage-grouse?*
  Based on our analysis, measure of adult female reproductive success, such as the percentage of adult females that successfully hatch chicks from a nest, and the resulting mortality of those chicks, are the primary determinants of population growth dynamics in this species. It is important to remember that such factors may not be under direct threat from anthropogenic stressors and, therefore, may not specifically require active management in a particular situation.

- *What is the predicted rate of loss of genetic diversity from isolated Gunnison sage-grouse populations, and how does the restrictive lek mating system influence this rate of loss?*
  Most Gunnison sage-grouse populations are so small that the rate of loss of genetic variation is comparatively rapid. The lek mating system characteristic of this species increases the rate of loss of variation through a dramatic reduction in the effective population size. Even under relatively optimistic conditions of population size and degree of polygyny, populations will likely retain less than 95% of their original heterozygosity over a 50-year time span.

- *How vulnerable are small, fragmented populations of Gunnison sage-grouse to local extinction in the absence of demographic interaction with other populations?*
  Because of stochastic fluctuations in demographic rates and the impact of infrequent but severe droughts, Gunnison sage-grouse populations totaling less than 50 individuals are at a serious risk of population extinction within the next 50 years (assuming some degree of consistency in environmental influences on sage grouse demography during that time). Active and intense management would likely be required to maintain these populations for any extended period of time.

- *What might be the impacts to Gunnison sage-grouse population viability of potential habitat loss in the Gunnison Basin?*
  While the precise mechanisms are as yet unknown, there is no doubt that loss of quality habitat for Gunnison sage-grouse would lead to increased extinction risk unless remedial measures are undertaken. More accurate analysis of this process will require additional efforts devoted to model construction and parameterization.

- *How successful might augmentation be as a conservation management strategy for smaller populations of Gunnison sage-grouse?*
  Augmentation can be a very effective means of dramatically minimizing the risk of population extinction. However, its success depends on careful monitoring of the recipient population both

prior to an augmentation, to verify the need for such a process, and after the event has been implemented in order to determine its short-term success in boosting population numbers.

- *How many birds could be removed from a given source population such as the Gunnison Basin for augmentation of smaller populations at risk of extinction without negatively impacting the persistence of the source?*
  It is unclear at present how the removal of birds from a larger source population in Gunnison Basin for augmentation of smaller populations elsewhere would impact the viability of the source. It is probable that eggs would be removed instead of adult birds. At the present time preliminary analyses indicate that, given this suggested method of removal and the ability of the species to re-nest following "failure" of a clutch, negative impacts to the population would be minimal. However, additional discussions on the precise nature of the removal / augmentation methodologies are required before accurate evaluation of alternative strategies can be undertaken.

Acknowledgements

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Appendix 1
Simulation Modeling and Population Viability Analysis

A model is any simplified representation of a real system. We use models in all aspects of our lives, in order to: (1) extract the important trends from complex processes, (2) permit comparison among systems, (3) facilitate analysis of causes of processes acting on the system, and (4) make predictions about the future. A complete description of a natural system, if it were possible, would often decrease our understanding relative to that provided by a good model, because there is "noise" in the system that is extraneous to the processes we wish to understand. For example, the typical representation of the growth of a wildlife population by an annual percent growth rate is a simplified mathematical model of the much more complex changes in population size. Representing population growth as an annual percent change assumes constant exponential growth, ignoring the irregular fluctuations as individuals are born or immigrate, and die or emigrate. For many purposes, such a simplified model of population growth is very useful, because it captures the essential information we might need regarding the average change in population size, and it allows us to make predictions about the future size of the population. A detailed description of the exact changes in numbers of individuals, while a true description of the population, would often be of much less value because the essential pattern would be obscured, and it would be difficult or impossible to make predictions about the future population size.

In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the standard ecological models of population change can cause population extinction, and therefore are often the primary focus of concern. In order to understand and predict the vulnerability of a wildlife population to extinction, we need to use a model which incorporates the processes which cause fluctuations in the population, as well as those which control the long-term trends in population size (Shaffer 1981). Many processes can cause fluctuations in population size: variation in the environment (such as weather, food supplies, and predation), genetic changes in the population (such as genetic drift, inbreeding, and response to natural selection), catastrophic effects (such as disease epidemics, floods, and droughts), decimation of the population or its habitats by humans, the chance results of the probabilistic events in the lives of individuals (sex determination, location of mates, breeding success, survival), and interactions among these factors (Gilpin and Soulé 1986).

Models of population dynamics which incorporate causes of fluctuations in population size in order to predict probabilities of extinction, and to help identify the processes which contribute to a population's vulnerability, are used in "Population Viability Analysis" (PVA) (Lacy 1993/4). For the purpose of predicting vulnerability to extinction, any and all population processes that impact population dynamics can be important. Much analysis of conservation issues is conducted by largely intuitive assessments by biologists with experience with the system. Assessments by experts can be quite valuable, and are often contrasted with "models" used to evaluate population vulnerability to extinction. Such a contrast is not valid, however, as *any* synthesis of facts and understanding of processes constitutes a model, even if it is a mental model within the mind of the expert and perhaps only vaguely specified to others (or even to the expert himself or herself).

A number of properties of the problem of assessing vulnerability of a population to extinction make it difficult to rely on mental or intuitive models. Numerous processes impact population dynamics, and many of the factors interact in complex ways. For example, increased fragmentation of habitat can make it more difficult to locate mates, can lead to greater mortality as individuals disperse greater distances across unsuitable habitat, and can lead to increased inbreeding which in turn can further reduce ability to attract mates and to survive. In addition, many of the processes impacting population dynamics are intrinsically probabilistic, with a random component. Sex determination, disease, predation, mate acquisition -- indeed, almost all events in the life of an individual -- are stochastic events, occurring with certain probabilities rather than with absolute certainty at any given time. The consequences of factors influencing population dynamics are often delayed for years or even generations. With a long-lived species, a population might persist for 20 to 40 years beyond the emergence of factors that ultimately cause extinction. Humans can synthesize mentally only a few factors at a time, most people have difficulty assessing probabilities intuitively, and it is difficult to consider delayed effects. Moreover, the data needed for models of population dynamics are often very uncertain. Optimal decision-making when data are uncertain is difficult, as it involves correct assessment of probabilities that the true values fall within certain ranges, adding yet another probabilistic or chance component to the evaluation of the situation.

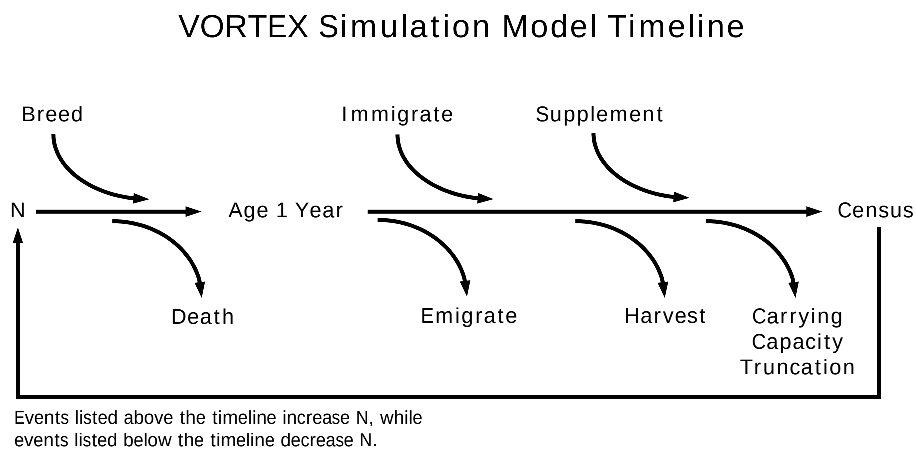
The difficulty of incorporating multiple, interacting, probabilistic processes into a model that can utilize uncertain data has prevented (to date) development of analytical models (mathematical equations developed from theory) which encompass more than a small subset of the processes known to affect wildlife population dynamics. It is possible that the mental models of some biologists are sufficiently complex to predict accurately population vulnerabilities to extinction under a range of conditions, but it is not possible to assess objectively the precision of such intuitive assessments, and it is difficult to transfer that knowledge to others who need also to evaluate the situation. Computer simulation models have increasingly been used to assist in PVA. Although rarely as elegant as models framed in analytical equations, computer simulation models can be well suited for the complex task of evaluating risks of extinction. Simulation models can include as many factors that influence population dynamics as the modeler and the user of the model want to assess. Interactions between processes can be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programs, providing output that gives both the mean expected result and the range or distribution of possible outcomes. In theory, simulation programs can be used to build models of population dynamics that include all the knowledge of the system which is available to experts. In practice, the models will be simpler, because some factors are judged unlikely to be important, and because the persons who developed the model did not have access to the full array of expert knowledge.

Although computer simulation models can be complex and confusing, they are precisely defined and all the assumptions and algorithms can be examined. Therefore, the models are objective, testable, and open to challenge and improvement. PVA models allow use of all available data on the biology of the taxon, facilitate testing of the effects of unknown or uncertain data, and expedite the comparison of the likely results of various possible management options.

PVA models also have weaknesses and limitations. A model of the population dynamics does not define the goals for conservation planning. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modeling can be used. Because the models incorporate many factors, the number of possibilities to test can seem endless, and it can be difficult to determine which of the factors that were analyzed are most important to the population dynamics. PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models probably underestimate the threats facing the population. Finally, the models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programs as needed.

The *VORTEX* Population Viability Analysis Model

For the analyses presented here, the *VORTEX* computer software (Lacy 1993a) for population viability analysis was used. *VORTEX* models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. *VORTEX*



also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified to change linearly over time, to model losses or gains in the amount or quality of habitat. Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size.

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. During the simulation, *VORTEX* monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. *VORTEX* also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

VORTEX is an *individual-based* model. That is, *VORTEX* creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime. *VORTEX* keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modeled by determining for each animal in each year of the simulation whether any of the events occur. (See figure below.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

VORTEX requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because *VORTEX* requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalized life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on *VORTEX* is available in Lacy (2000) and Miller and Lacy (2003 [cited as Miller and Lacy 2003a in RCP Literature Cited section]).

Dealing with Uncertainty

It is important to recognize that uncertainty regarding the biological parameters of a population and its consequent fate occurs at several levels and for independent reasons. Uncertainty can occur because the parameters have never been measured on the population. Uncertainty can occur because limited field data have yielded estimates with potentially large sampling error. Uncertainty can occur because independent studies have generated discordant estimates. Uncertainty can occur because environmental conditions or population status have been changing over time, and field surveys were conducted during periods which may not be representative of long-term averages. Uncertainty can occur because the environment will change in the future, so that measurements made in the past may not accurately predict future conditions.

Sensitivity testing is necessary to determine the extent to which uncertainty in input parameters results in uncertainty regarding the future fate of the pronghorn population. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population.

The above kinds of uncertainty should be distinguished from several more sources of uncertainty about the future of the population. Even if long-term average demographic rates are known with precision, variation over time caused by fluctuating environmental conditions will cause uncertainty in the fate of the population at any given time in the future. Such environmental variation should be incorporated into the model used to assess population dynamics, and will generate a range of possible outcomes (perhaps represented as a mean and standard deviation) from the model. In addition, most biological processes are inherently stochastic, having a random component. The stochastic or probabilistic nature of survival, sex determination, transmission of genes, acquisition of mates, reproduction, and other processes preclude exact determination of the future state of a population. Such demographic stochasticity should also be incorporated into a population model, because such variability both increases our uncertainty about the future and can also change the expected or mean outcome relative to that which would result if there were no such variation. Finally, there is "uncertainty" which represents the alternative actions or interventions which might be pursued as a management strategy. The likely effectiveness of such management options can be explored by testing alternative scenarios in the model of population dynamics, in much the same way that sensitivity testing is used to explore the effects of uncertain biological parameters.

Demographic Stochasticity

VORTEX models demographic stochasticity by determining the occurrence of probabilistic events such as reproduction, litter size, sex determination, and death with a pseudo-random number generator. For each life event, if the random value sampled from a specified distribution falls above the user--specified probability, the event is deemed to have occurred, thereby simulating a binomial process. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

The source code used to generate random numbers uniformly distributed between 0 and 1 was obtained from Maier (1991), based on the algorithm of Kirkpatrick and Stoll (1981). Random deviates from binomial distributions, with mean p and standard deviation s, are obtained by first determining the integral number of binomial trials, N, that would produce the value of s closest to the specified value, according to:

$$N = \frac{p(1-p)}{s^2}$$

N binomial trials are then simulated by sampling from the uniform 0-1 distribution to obtain the desired result, the frequency or proportion of successes. If the value of N determined for a desired binomial distribution is larger than 25, a normal approximation is used in place of the binomial distribution. This normal approximation must be truncated at 0 and at 1 to allow use in defining probabilities, although, with such large values of N, s is small relative to p and the truncation would be invoked only rarely. To avoid introducing bias with this truncation, the normal approximation to the binomial (when used) is truncated symmetrically around the mean. The algorithm for generating random numbers from a unit normal distribution follows Latour (1986).

Environmental Variation

VORTEX can model annual fluctuations in birth and death rates and in carrying capacity as might result from environmental variation. To model environmental variation, each demographic parameter is assigned a distribution with a mean and standard deviation that is specified by the user. Annual fluctuations in probabilities of reproduction and mortality are modeled as binomial distributions. Environmental variation in carrying capacity is modeled as a normal distribution. Environmental variation in demographic rates can be correlated among populations.

Catastrophes

Catastrophes are modeled in *VORTEX* as random events that occur with specified probabilities. A catastrophe will occur if a randomly generated number between zero and one is less than the probability of occurrence. Following a catastrophic event, the chances of survival and successful breeding for that simulated year are multiplied by severity factors. For example, forest fires might occur once in 50 years, on average, killing 25% of animals, and reducing breeding by survivors 50% for the year. Such a catastrophe would be modeled as a random event with 0.02 probability of occurrence each year, and severity factors of 0.75 for survival and 0.50 for reproduction. Catastrophes can be local (impacting populations independently), or regional (affecting sets of populations simultaneously).

Genetic Processes

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical neutral (non-selected) genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. Each offspring created during the simulation is randomly assigned one of the alleles from each parent. *VORTEX* monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. *VORTEX* also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

Inbreeding depression is modeled as a loss of viability of inbred animals during their first year. The severity of inbreeding depression is commonly measured by the number of "lethal equivalents" in a population (Morton et al. 1956). The number of lethal equivalents per diploid genome estimates the average number of lethal alleles per individual in the population if all deleterious effects of inbreeding were due entirely to recessive lethal alleles. A population in which inbreeding depression is one lethal equivalent per diploid genome may have one recessive lethal allele per individual, it may have two recessive alleles per individual, each of which confer a 50% decrease in survival, or it may have some other combination of recessive deleterious alleles which equate in effect with one lethal allele per individual.

VORTEX partitions the total effect of inbreeding (the total lethal equivalents) into an effect due to recessive lethal alleles and an effect due to loci at which there is heterozygote advantage (superior fitness of heterozygotes relative to all homozygote genotypes). To model the effects of lethal alleles, each founder starts with a unique recessive lethal allele (and a dominant non-lethal allele) at up to five modeled loci. By virtue of the deaths of individuals that are homozygous for lethal alleles, such alleles can be removed slowly by natural selection during the generations of a simulation. This diminishes the probability that inbred individuals in subsequent generations will be homozygous for a lethal allele.

Heterozygote advantage is modeled by specifying that juvenile survival is related to inbreeding

$$\ln(S) = A - BF$$

according to the logarithmic model:
in which *S* is survival, *F* is the inbreeding coefficient, *A* is the logarithm of survival in the absence of inbreeding, and *B* is the portion of the lethal equivalents per haploid genome that is due to heterozygote advantage rather than to recessive lethal alleles. Unlike the situation with fully recessive deleterious alleles, natural selection does not remove deleterious alleles at loci in which the heterozygote has higher fitness than both homozygotes, because all alleles are deleterious when homozygous and beneficial when present in heterozygous combination with other alleles. Thus, under heterozygote advantage, the impact of inbreeding on survival does not diminish during repeated generations of inbreeding.
Unfortunately, for relatively few species are data available to allow estimation of the effects of inbreeding, and the magnitude of these effects apparently varies considerably among species (Falconer 1981; Ralls et al. 1988; Lacy et al. 1992) and even among populations of the same species (Lacy et al. 1996). Even without detailed pedigree data from which to estimate the number of lethal equivalents in a population and the underlying nature of the genetic load (recessive alleles or heterozygote advantage), PVAs must make assumptions about the effects of inbreeding on the population being studied. If genetic effects are ignored, the PVA will overestimate the viability of small populations. In some cases, it might be considered appropriate to assume that an inadequately studied species would respond to inbreeding in accord with the median (3.14 lethal equivalents per diploid) reported in the survey by Ralls et al. (1988). In other cases, there might be reason to make

more optimistic assumptions (perhaps the lower quartile, 0.90 lethal equivalents), or more pessimistic assumptions (perhaps the upper quartile, 5.62 lethal equivalents). In the few species in which inbreeding depression has been studied carefully, about half of the effects of inbreeding are due recessive lethal alleles and about half of the effects are due to heterozygote advantage or other genetic mechanisms that are not diminished by natural selection during generations of inbreeding, although the proportion of the total inbreeding effect can vary substantially among populations (Lacy and Ballou 1998).

A full explanation of the genetic mechanisms of inbreeding depression is beyond the scope of this manual, and interested readers are encouraged to refer to the references cited above.

VORTEX can model monogamous or polygamous mating systems. In a monogamous system, a relative scarcity of breeding males may limit reproduction by females. In polygamous or monogamous models, the user can specify the proportion of the adult males in the breeding pool. Males are randomly reassigned to the breeding pool each year of the simulation, and all males in the breeding pool have an equal chance of siring offspring.

Deterministic Processes

VORTEX can incorporate several deterministic processes, in addition to mean age-specific birth and death rates. Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. Each animal in the population has an equal probability of being removed by this truncation. The carrying capacity can be specified to change over time, to model losses or gains in the amount or quality of habitat.

Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size. The default functional relationship between breeding and density allows entry of Allee effects (reduction in breeding at low density) and/or reduced breeding at high densities.

Populations can be supplemented or harvested for any number of years in each simulation. Harvest may be culling or removal of animals for translocation to another (unmodeled) population. The numbers of additions and removals are specified according to the age and sex of animals.

Migration Among Populations

VORTEX can model up to 50 populations, with possibly distinct population parameters. Each pairwise migration rate is specified as the probability of an individual moving from one population to another. Migration among populations can be restricted to one sex and/or a limited age cohort. Emigration from a population can be restricted to occur only when the number of animals in the population exceeds a specified proportion of the carrying capacity. Dispersal mortality can be specified as a probability of death for any migrating animal, which is in addition to age-sex specific mortality. Because of between-population migration and managed supplementation, populations can be recolonized. *VORTEX* tracks the dynamics of local extinctions and recolonizations through the simulation.

Output

VORTEX outputs: **(1)** probability of extinction at specified intervals (e.g., every 10 years during a 100 year simulation), **(2)** median time to extinction, if the population went extinct in at least 50% of the simulations, **(3)** mean time to extinction of those simulated populations that became extinct, and **(4)** mean size of, and genetic variation within, extant populations.

Standard deviations across simulations and standard errors of the mean are reported for population size and the measures of genetic variation. Under the assumption that extinction of independently replicated populations is a binomial process, the standard error of the probability of extinction is reported by *VORTEX* as:

$$SE(p) = \sqrt{\frac{p(1-p)}{n}}$$

in which the frequency of extinction was p over n simulated populations. Demographic and genetic statistics are calculated and reported for each subpopulation and for the metapopulation.

Sequence of Program Flow

(1) The seed for the random number generator is initialized with the number of seconds elapsed since the beginning of the 20th century.

(2) The user is prompted for an output file name, duration of the simulation, number of iterations, the size below which a population is considered extinct, and a large number of population parameters.

(3) The maximum allowable population size (necessary for preventing memory overflow) is calculated as:

$$K_{max} = (K + 3s)(1 + L)$$

in which K is the maximum carrying capacity (carrying capacity can be specified to change during a simulation, so the maximum carrying capacity can be greater than the initial carrying capacity), s is the annual environmental variation in the carrying capacity expressed as a standard deviation, and L is the specified maximum litter size.

(4) Memory is allocated for data arrays. If insufficient memory is available for data arrays then N_{max} is adjusted downward to the size that can be accommodated within the available memory and a warning message is given. In this case it is possible that the analysis may have to be terminated because the simulated population exceeds N_{max}. Because N_{max} is often several-fold greater than the likely maximum population size in a simulation, a warning that it has been adjusted downward because of limiting memory often will not hamper the analyses.

(5) The deterministic growth rate of the population is calculated from mean birth and death rates that have been entered. Algorithms follow cohort life-table analyses (Ricklefs 1979). Generation time and the expected stable age distribution are also calculated. Life-table calculations assume constant birth and death rates, no limitation by carrying capacity, no limitation of mates, no loss of fitness due to inbreeding depression, and that the population is at the stable age distribution. The effects of catastrophes are incorporated into the life table analysis by using birth and death rates that are weighted averages of the values in years with and without catastrophes, weighted by the probability of a catastrophe occurring or not occurring.

(6) Iterative simulation of the population proceeds via steps 7 through 26 below.

(7) The starting population is assigned an age and sex structure. The user can specify the exact age-sex structure of the starting population, or can specify an initial population size and request that the population be distributed according to the stable age distribution calculated from the life table. Individuals in the starting population are assumed to be unrelated. Thus, inbreeding can occur only in second and later generations.

(8) Two unique alleles at a hypothetical neutral genetic locus are assigned to each individual in the starting population and to each individual supplemented to the population during the simulation. *VORTEX* therefore uses an infinite alleles model of genetic variation. The subsequent fate of genetic variation is tracked by reporting the number of extant neutral alleles each year, the expected heterozygosity or gene diversity, and the observed heterozygosity. The expected heterozygosity, derived from the Hardy-Weinberg equilibrium, is given by

$$H_e = 1 - \sum \left(p_i^2 \right)$$

in which p_i is the frequency of allele *i* in the population. The observed heterozygosity is simply the proportion of the individuals in the simulated population that are heterozygous. Because of the starting assumption of two unique alleles per founder, the initial population has an observed heterozygosity of 1.0 at the hypothetical locus and only inbred animals can become homozygous. Proportional loss of heterozygosity through random genetic drift is independent of the initial heterozygosity and allele frequencies of a population (Crow and Kimura 1970), so the expected heterozygosity remaining in a simulated population is a useful metric of genetic decay for comparison across scenarios and populations. The mean observed heterozygosity reported by *VORTEX* is the mean inbreeding coefficient of the population.

(9) For each of the10 alleles at five non-neutral loci that are used to model inbreeding depression, each founder is assigned a unique lethal allele with probability equal to 0.1 x the mean number of lethal alleles per individual.

(10) Years are iterated via steps 11 through 25 below.

(11) The probabilities of females producing each possible size litter are adjusted to account for density dependence of reproduction (if any).

(12) Birth rate, survival rates, and carrying capacity for the year are adjusted to model environmental variation. Environmental variation is assumed to follow binomial distributions for birth and death rates and a normal distribution for carrying capacity, with mean rates and standard deviations specified by the user. At the outset of each year a random number is drawn from the specified binomial distribution to determine the percent of females producing litters. The distribution of litter sizes among those females that do breed is maintained constant. Another random number is drawn from a specified binomial distribution to model the environmental variation in mortality rates. If environmental variations in reproduction and mortality are chosen to be correlated, the random number used to specify mortality rates for the year is chosen to be the same percentile of its binomial distribution as was the number used to specify reproductive rate. Otherwise, a new random number is drawn to specify the deviation of age- and sex-specific mortality rates from their means. Environmental variation across years in mortality rates is always forced to be correlated among age and sex classes.

The carrying capacity (*K*) for the year is determined by first increasing or decreasing the carrying capacity at year 1 by an amount specified by the user to account for changes over time.

Environmental variation in K is then imposed by drawing a random number from a normal distribution with the specified values for mean and standard deviation.

(13) Birth rates and survival rates for the year are adjusted to model any catastrophes determined to have occurred in that year.

(14) Breeding males are selected for the year. A male of breeding age is placed into the pool of potential breeders for that year if a random number drawn for that male is less than the proportion of adult males specified to be breeding. Breeding males are selected independently each year; there is no long-term tenure of breeding males and no long-term pair bonds.

(15) For each female of breeding age, a mate is drawn at random from the pool of breeding males for that year. If the user specifies that the breeding system is monogamous, then each male can only be paired with a single female each year. Males are paired only with those females which have already been selected for breeding that year. Thus, males will not be the limiting sex unless there are insufficient males to pair with the successfully breeding females.

If the breeding system is polygynous, then a male may be selected as the mate for several females. The degree of polygyny is determined by the proportion of males in the pool of potential breeders each year.

The size of the litter produced by that pair is determined by comparing the probabilities of each potential litter size (including litter size of 0, no breeding) to a randomly drawn number. The offspring are produced and assigned a sex by comparison of a random number to the specified birth sex ratio. Offspring are assigned, at random, one allele at the hypothetical genetic locus from each parent.

(16) The genetic kinship of each new offspring to each other living animal in the population is determined. The kinship between new animal A, and another existing animal, B, is

$$f_{AB} = 0.5(f_{MB} + f_{PB})$$

in which f_{ij} is the kinship between animals i and j, M is the mother of A, and P is the father of A. The inbreeding coefficient of each animal is equal to the kinship between its parents, $F = f_{MP}$, and the kinship of an animal to itself is $f_A = 0.5(1 + F)$. (See Ballou 1983 for a detailed description of this method for calculating inbreeding coefficients.)

(17) The survival of each animal is determined by comparing a random number to the survival probability for that animal. In the absence of inbreeding depression, the survival probability is given by the age and sex-specific survival rate for that year. If a newborn individual is homozygous for a lethal allele, it is killed. Otherwise, the survival probability for individuals in their first year is multiplied by

$$e^{-b(1-\Pr[Lethals])F}$$

in which b is the number of lethal equivalents per haploid genome, and Pr[*Lethals*] is the proportion of this inbreeding effect due to lethal alleles.

(18) The age of each animal is incremented by 1.

(19) If more than one population is being modeled, migration among populations occurs stochastically with specified probabilities.

(20) If population harvest is to occur that year, the number of harvested individuals of each age and sex class are chosen at random from those available and removed. If the number to be removed do not exist for an age-sex class, *VORTEX* continues but reports that harvest was incomplete.

(21) Dead animals are removed from the computer memory to make space for future generations.

(22) If population supplementation is to occur in a particular year, new individuals of the specified age-class are created. Each immigrant is assumed to be genetically unrelated to all other individuals in the population, and it carries the number of lethal alleles that was specified for the starting population.

(23) The population growth rate is calculated as the ratio of the population size in the current year to the previous year.

(24) If the population size (N) exceeds the carrying capacity (K) for that year, additional mortality is imposed across all age and sex classes. The probability of each animal dying during this carrying capacity truncation is set to $(N - K)/N$, so that the expected population size after the additional mortality is K.

(25) Summary statistics on population size and genetic variation are tallied and reported.

(26) Final population size and genetic variation are determined for the simulation.

(27) Summary statistics on population size, genetic variation, probability of extinction, and mean population growth rate are calculated across iterations and output.

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APPENDIX H

GUSG STRUCTURAL HABITAT GUIDELINES

GUSG Structural Habitat Guidelines

Background and Data Sources

Guidelines for the maintenance of sage-grouse habitats were first provided by Braun et al. (1977). Subsequent research improved knowledge about the seasonal habitat use, movements, and migratory patterns of sage-grouse across their range. Connelly et al. (2000) built upon those findings and developed more specific habitat guidelines for the structural characteristics of the overstory and understory of sagebrush communities used by sage-grouse. Although Connelly et al. (2000) improved the 1977 recommendations, they lacked in habitat structural information specific to GUSG.

The GUSG habitat guidelines formulated for the RCP differ slightly from the Connelly et al. (2000) guidelines. As Connelly et al. (2000:275) mention, "…the judgment of local biologists and quantitative data from population and habitat monitoring are necessary to implement the guidelines correctly." This is the case in current GUSG range.

GUSG inhabit the Colorado Plateau (Fig. 3, pg. 33) where some sagebrush communities are different from those which served as a basis for the guidelines in Connelly et al. (2000). Connelly et al. (2000) reported grass and big sagebrush cover values from floristic provinces other than the Colorado Plateau, including the Wyoming Basin, Columbia Basin, Northern Great Basin, Snake River Plain, and Silver Sagebrush provinces. The Colorado Plateau is older (geologically) and has less productive soils than some of the aforementioned provinces. The moisture regime is also more characteristic of warm season grasses (summer monsoon moisture patterns) (S. B. Monsen, personal communication) rather than cool season grasses (spring and fall moisture regimes). Therefore, the herbaceous communities on the Colorado Plateau are not directly comparable to the other floristic provinces, especially when comparing herbaceous understories. Thus, the basis for some differences in the 2 sets of guidelines (Connelly et al. 2000 and RCP) are a result of local soil parent material and precipitation patterns.

In addition, much of the data used in development of the habitat structural characteristics in Connelly et al. (2000) were dominated by GRSG habitat use and movement information. Connelly et al. (2000) did use some GUSG habitat use information (Hupp 1987, Young 1994, Commons et al. 1999), but other sources of information were not used because they were located in unpublished CDOW correspondence summary reports (Woods and Braun 1995), or were new (Apa 2004). Using this more extensive data for GUSG, we have developed vegetation structure guidelines specific to the sagebrush communities within GUSG range.

In developing these habitat guidelines, we summarized *only GUSG habitat use data*. Although GRSG investigations were reviewed, no GRSG data were used in the development of these habitat guidelines. All of the known structural vegetation data collected in breeding (Young 1994, Apa 2004), summer - fall (Young 1994, Woods and Braun 1995, Commons 1997, Apa 2004), and winter (Hupp 1987) habitat were summarized. Note that Apa (2004), collected habitat data from 5 different GUSG population areas, while many of the other studies focused on Gunnison Basin.

Studies were not separated based on annual precipitation. Data reported in Apa (2004) were collected during a significant drought and variables such as grass and forb cover and height were likely lower than normal because of the lack of precipitation. Overstory shrub structural variables were less likely to be influenced by short-term drought.

Following the development of the guidelines, 1 additional GUSG vegetation dataset was used to validate the guidelines (NPS, unpublished data). In all vegetation structure categories, the mean or median reported in the NPS reports fell within the guideline ranges established in this plan.

Seasonal Habitat Definitions

Until seasonal GUSG habitats are mapped in a given population area (see "Habitat Monitoring" rangewide strategy, pg. 220, Objective 1, Strategies 7 and 8) the following definitions of seasonal habitats should be used. For additional limiting criteria, such as slope and aspect, consult with local biologists.

Breeding Habitat: sagebrush communities delineated within 4 miles (see "GUSG Disturbance Guidelines", Appendix I, for discussion) of an active strutting ground. Breeding habitat includes active strutting grounds, and nesting and early brood-rearing habitat (Connelly et al. 2000), usually in use from mid-March through late-June.

None of the studies we reviewed for GUSG breeding habitat structural guidelines divided brood-rearing habitat into early- or late-brood-rearing (Young 1994, Apa 2004), so all of the brood habitat information was included in breeding habitat. The data summary to develop the guidelines for breeding habitat was done without respect to nest success, so data from both successful and unsuccessful nests were used. Although data have been presented that suggest herbaceous vegetation might differ between successful and unsuccessful GRSG nests (Connelly et al. 2004), no consistent differences have been reported. There is, in fact, more conclusive and consistent evidence that shrub structure characteristics (i.e., horizontal and vertical cover values) differ between successful and unsuccessful nests (Connelly et al. 2004).

Summer – Fall Habitat: vegetation communities including sagebrush, agricultural fields, and wet meadows (Connelly et al. 2000) that are within 4 miles (see "GUSG Disturbance Guidelines", Appendix I, for discussion) of an active strutting ground.

For the summer - fall guidelines we used habitat use data from non-brooding females and males (Young 1994, Woods and Braun 1995, Commons 1997, Apa 2004).

Winter Habitat: sagebrush areas (Connelly et al. 2000) within currently occupied habitat that are available (i.e., not covered by snow) to sage-grouse in average winters. These areas either have sufficient shrub height to be above average snow depths, or are exposed due to topographic features (e.g., windswept ridges, south-facing slopes). Sites are typically characterized by sagebrush canopy cover > 25% and sagebrush > 12–15 inches in height (Schoenberg 1982) associated with drainages, ridges, or southwest-facing aspects having slopes < 15% (Gill 1965, Wallestad 1975, Beck 1977, Robertson 1999).

Only 1 study (Hupp 1987) reported winter habitat information and these data were collected in the Gunnison Basin.

Habitat Guideline Development

Where possible, study areas in the literature were categorized as arid or mesic. As per Connelly et al. (2000), arid and mesic sites can be determined locally using the precipitation and soil characteristics (Tisdale and Hironaka 1981, Hironaka 1983, Winward 2004, Monsen 2005). We classified data from Gunnison Basin, Dry Creek Basin, and Dove Creek (south) as arid. It is well understood that the Gunnison Basin has both mesic and arid sites, but we were not able to discern between the sites. The data from Piñon Mesa, Miramonte (in San Miguel Basin), Cerro Summit - Cimarron, Crawford, north Dove Creek, and Hamilton Mesa (in San Miguel Basin), were considered more mesic sites. Most of the data reported were in the form of means and standard errors. The mean and standard error for each structural variable were summarized by arid or mesic sites across the entire range of the GUSG. The means were bounded by the standard errors to create a variable "distribution range" and a guideline was developed using the distribution range. Numerical maximum and minimum data points were not included. The guideline range is compared with Connelly et al. (2000).

Seven overstory and understory vegetation structural characteristics guidelines for GUSG breeding and summer - fall habitats are reported: (1) sagebrush canopy cover; (2) non-sagebrush canopy cover; (3) sagebrush height; (4) grass cover; (5) forb cover; (6) grass height; and (7) forb height. Only 2 overstory vegetation structural characteristic guidelines were developed for winter habitat: (1) sagebrush canopy cover and (2) sagebrush height.

Many species of shrubs were included in the non-sagebrush canopy cover portion of the guidelines. In more arid locations, the non-sagebrush shrubs included, but are not limited to, horsebrush, rabbitbrush, bitterbrush, snakeweed, greasewood, and winterfat. In mesic locations the aforementioned shrub species can occur, but the shrub community may also include Gambel's oak, snowberry, serviceberry, and chokecherry.

None of the 6 studies we evaluated sampled vegetation structural variables in the same manner. Commons (1997) used a modification of Daubenmire (1959) and Canfield (1941) to estimate understory and overstory coverages, respectively. Understory measurements were estimated to the nearest 5%. In contrast to most of the other studies, Commons (1997) did not use the foliar intercept to estimate shrub canopy cover (%), but instead used the canopy cover estimate. The canopy cover value overestimates foliar intercept (foliar cover), which is the standard used in essentially all other sage-grouse research. No grass or forb heights were reported (Commons 1997). Hupp (1987) estimated sagebrush canopy cover using the foliar intercept. Young (1994) used a modification of Canfield (1941) to estimate shrub, forb, and grass cover, but grass and forb heights were not reported. Woods and Braun (1995) used methods similar to Commons (1997), but it is unknown whether shrub foliar or intercept cover was used to estimate canopy cover. No grass or forb heights were reported. Apa (2004) used Canfield (1941) to estimate foliar cover for non-sagebrush and sagebrush canopy cover, and Daubenmire (1959) to estimate understory coverage. Although sagebrush height was sampled in many different ways, the actual measurement (not including inflorescences) was standard across all studies. The importance of using standard monitoring protocols and techniques within GUSG range is clear, and is addressed for the future in the "Habitat Monitoring" rangewide strategy (see pg. 220).

Using the Guidelines

The vegetation structure guidelines we present (Tables 1 – 3) should be interpreted as minimum standards, and managers should strive to meet the full potential of any given site. These habitat guidelines should be considered adaptive, and interim in nature. The guidelines were developed from actual grouse use sites, but should be considered as guidance until further and more specific and quantified data are available from grouse research, or until the development of a rigorous mapping protocol. These guidelines are intended to represent a variety of landscape situations. Landscapes are diverse; some areas on the landscape will not meet these guidelines, some areas will meet the guidelines, and some areas will exceed the guidelines. As new information is collected, these guidelines, as well as the plan are meant to be adaptable.

Table 1. GUSG breeding habitat guidelines[a].

BREEDING HABITAT [b]				
Vegetation Variable	**Gunnison sage-grouse**		**Connelly et al. (2000)**	
	Arid[c]	**Mesic[c]**	**Arid**	**Mesic**
Sagebrush Canopy [d] %	15 - 25	10 – 20	15 - 25	15 – 25
Non-sagebrush Canopy [d] %	5 - 15	5 – 15	-	-
Total Shrub Canopy [d] %	20 - 40	15 – 35	-	-
Sagebrush Height cm (inches)	25 – 50 (9.8 – 19.7)	30 – 50 (11.8 – 19.7)	30 – 80 (11.8 – 31.5)	40 – 80 (15.7 – 31.5)
Grass Cover [d] %	10 - 30	20 – 40	-	-
Forb Cover [e] %	5 - 15	20 – 40	≥ 15	≥ 25
Grass Height [f] cm (inches)	10 – 15 (3.9 – 5.9)	10 – 15 (3.9 – 5.9)	> 18 (> 7.1)	> 18 (> 7.1)
Forb Height [f] cm (inches)	5 – 10 (2.0 – 3.9)	5 – 15 (2.0 – 5.9)	-	-

[a] Breeding habitat guidelines were developed using data in GUSG studies by Young (1994) and Apa (2004).
[b] Breeding habitat is defined as sagebrush communities delineated within 4 miles of a lek (see "GUSG Disturbance Guidelines", Appendix I, for discussion. Breeding habitat includes lek, nesting and early brood-rearing habitat usually from mid-March through late-June.
[c] Arid or mesic communities are as defined by Winward (2004).
[d] Canopy cover measured according to Canfield (1941) and further described by Connelly et al. (2003).
[e] Understory cover measured according to Daubenmire (1959).
[f] The tallest vertical point (droop height) where the bulk of a plant's mass occurs.

Table 2. GUSG summer - fall habitat guidelines[a]. No specific habitat guidelines have been included for riparian or wet meadow habitat used by GUSG during this period. BLM and USFS currently have riparian and/or wet meadow management guidance which is consistent with the needs of GUSG.

SUMMER - FALL HABITAT[b]				
	Gunnison sage-grouse		**Connelly et al. (2000)**	
Vegetation Variable	**Arid[c]**	**Mesic[c]**	**Arid**	**Mesic**
Sagebrush Canopy [d] (%)	5 – 15	5 – 20	10 – 25	10 – 25
Non-sagebrush Canopy [d] (%)	5 - 15	5 – 15	-	-
Total Shrub Canopy [d] (%)	10 - 30	10 – 35	-	-
Sagebrush Height cm (inches)	20 – 40 (7.9 - 15.7)	25 – 50 (9.8 – 19.7)	40 – 80 (15.7 – 31.5)	40 – 80 (15.7 – 31.5)
Grass Cover [e] (%)	10 - 25	10 – 35	-	-
Forb Cover [e] (%)	5 - 15	15 – 35	> 15	> 15
Grass Height [f] cm (inches)	10 – 15 (3.9 – 5.9)	10 – 15 (3.9 – 5.9)	variable	variable
Forb Height [f] cm (inches)	3 – 10 (1.2 - 3.9)	5 – 10 (2.0 - 5.9)	variable	variable

[a] Summer - fall habitat guidelines were developed using data in GUSG studies by Young (1994), Woods and Braun (1995), Commons (1997), and Apa (2004)
[b] Summer – fall habitat is defined as vegetation communities, including sagebrush, agricultural fields, and wet meadows (Connelly et al. 2000) that are within 4 miles (see "GUSG Disturbance Guidelines", Appendix I, for discussion) of an active strutting ground.
[c] Arid or mesic communities are as defined by Winward (2004).
[d] Canopy cover measured according to Canfield (1941) and further described by Connelly et al. (2003).
[e] Understory cover measured according to Daubenmire (1959).
[f] The tallest vertical point (droop height) where the bulk of a plant's mass occurs.

Table 3. GUSG winter habitat guidelines[a].

WINTER HABITAT[b]				
	Gunnison sage-grouse		**Connelly et al. (2000)**	
Vegetation Variable	**Arid[c]**	**Mesic[c]**	**Arid**	**Mesic**
Sagebrush Canopy[d]: %	30 – 40	-	10 – 30	10 – 30
Sagebrush Height[e]: cm (inches)	40 – 55 (15.8 – 21.7)	-	25 – 35 (9.8 – 13.8)	25 – 35 (9.8 – 13.8)

[a] Winter habitat guidelines were developed using GUSG data from Hupp (1987).
[b] Winter habitat is defined as sagebrush areas (Connelly et al. 2000) within currently occupied habitat that are available (i.e., not covered by snow) to sage-grouse in average winters.
[c] Arid or mesic communities are as defined by Winward (2004).
[d] Canopy cover measured according to Canfield (1941) and further described by Connelly et al. (2003).
[e] Measured from ground level to the tallest stem (excluding inflorescence) according to Hupp (1987).

MINIMUM STRUCTURAL VEGETATION COLLECTION GUIDELINES FOR THE GUNNISON SAGE-GROUSE

Rangewide Steering Committee

March 2007

The following protocol was designed to assess suitability of vegetation conditions for the Gunnison Sage-grouse as outlined in the Gunnison Sage-grouse Rangewide Conservation Plan (RCP) (Appendix H [Gunnison Sage-grouse Structural Habitat Guidelines]).

- This protocol is intended to provide a consistent method for measuring the minimum vegetation characteristics to evaluate site-specific suitability for Gunnison Sage-grouse as described in the RCP Structural Habitat Guidelines (Appendix H). If additional vegetation data is needed, consult the BLM Technical Reference 1734-4 or other agency technical manuals.
- This protocol can be used to evaluate current suitability of site-specific conditions, monitor changes in the suitability of site-conditions over time (other techniques will be needed for specific monitoring projects) and evaluate impacts of habitat and restoration treatments on Gunnison Sage-grouse site-suitability.
- Vegetation data must be collected during the season of use by Gunnison Sage-grouse. For breeding habitat, measurements should start around the middle to the end of May or after the first nests begin to hatch and continue through June to encompass both nesting and early-brood-rearing habitat. Summer habitat measurements should start around mid-June (after the chicks are about 4 weeks old) and continue through mid-August to encompass late-brood-rearing habitat. Winter structural habitat variables (sagebrush canopy cover and sagebrush height) may be collected at any time of the year as these variables do not change substantially on a seasonal basis.
- To ensure repeatability in data collection, all methodology should be established before beginning field work and documented for future reference. To maintain consistency in data collection, use of this protocol is recommended. If an alternate methodology is used to evaluate site suitability with regards to the RCP Structural Habitat Guidelines (Appendix H), techniques must be reported.

General Guidance

- To measure sagebrush and other shrub canopy cover, the line intercept method developed by Canfield (1941) should be used. For other canopy cover estimates use Daubenmire (1959) plots.
- Take a minimum of 1 photo per vegetation transect preferably at the starting point of the transect line. Attempt to take the photo at a height and angle that will provide a good representation of the general condition of the site.
- Frequency, density, and composition are additional types of information that could be collected but are not required by this protocol to assess Gunnison Sage-grouse with regards to the RCP Structural Habitat Guidelines (Appendix H). If this type of data is needed consult the Technical Reference 1734-4 (http://www.blm.gov/nstc/library/pdf/samplveg.pdf).

Specific Measurements

Transect Lines

- Line transects should be 30 m in length.
- Placement of transects should be done using any statistically valid design.
- Collect a UTM coordinate with a GPS unit at the start pointing of the transect line and record on the field form so that transects can be located in the future.
- Transects placement could be stratified by community types and soils.

Shrub Canopy Cover

- Measure all shrubs and trees that intersect the line transect. The sagebrush species (if it can be identified) that intersects the line should be documented; all others non-sagebrush shrubs can be lumped into one category.
- Measure the amount of live shrub canopy cover that intersects the transect line. Large spaces in the foliage cover (>5 cm) should be excluded from the canopy cover measurement so that only live shrub cover is recorded.
- Do not measure overlap of canopy of species—i.e., if two sagebrush plants overlap along the transect, the length of the transect covered from a vertical vantage point is the percent canopy cover regardless of how may individual plants makeup that coverage. Canopy cover should never exceed 100%.

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General Guidelines for Application of Daubenmire (1959)

- See Daubenmire (1959) or USDI-BLM (1996) for additional details
- Five other vegetation variables will be collected along line transects within a Daubenmire frame:
    - Sagebrush Height
    - Grass Height
    - Forb Height
    - Grass Cover
    - Forb Cover
- Collect data in 10 Daubenmire frames along each 30 m transect
- Select a consistent and statistically valid method for placement of the Daubenmire frame along each transect. Record your method on the field form so future transects can be completed in the same way.

Sagebrush Height

- Take one height measurement per sampling point (Daubenmire frame) by selecting the sagebrush closest to the lower left corner of the Daubenmire frame, based on its canopy and not its root. The closest sagebrush could be within the frame, in front of the frame, behind the frame, and on either side of the transect. Choose the sagebrush closest to the lower left corner of the frame regardless of its direction from that corner.
- Note on the data sheet whether the shrub measured is a seedling (no woody base) or a very young plant.
- Exclude seed heads (inflorescences) from height measurement of sagebrush.

- Do not re-measure the same shrub even if it is the closest sagebrush for a subsequent plot. Instead select the next nearest sagebrush within 10 meters of the plot. If there is no other sagebrush within 10 meters, do not take a height measurement for that plot.

Understory Cover

To the extent possible, plants should be identified to the species level, but training and time limitations may prevent this. The important habitat variables to be collected include:

- Grasses: break out perennial versus annual at a minimum. Identify dominant species to the extent possible in comments section of form. Identify cheat grass (e.g. *Bromus tectorum*) and other non-native species to the extent possible.
- Sedges are included in the grass category.
- Forbs: At a minimum list the number of different forb species per plot, even if you cannot identify the species. Identify species to the extent possible.
- Measure the live and residual foliar cover of grasses and forbs.

Understory Height

Height measurements are conducted to characterize the vertical and horizontal structure of the understory. Gunnison Sage-grouse select habitat based on vertical (how tall it is) and horizontal (how thick it is) structure. Both aspects contribute to a diversity of structure and provide a sense of security for birds. These aspects contribute to nest, chick and adult concealment from predation events. That is why these measurements are relatively, but not absolutely consistent.

- Measure 1 grass and 1 forb in each Daubenmire frame. The plants must be rooted in the frame, and if there are no grasses or forbs in the frame, record as not present.
- Measure height of the nearest grass and forb from the bottom left corner of the Daubenmire frame.
- Grass height only includes the current year's growth. There are no criteria or guidelines for previous year's growth (e.g. residual grass height).
- Grass height can include annual or perennial grass. It should be documented on the datasheet if annual grass (cheat grass e.g. *Bromus tectorum*) is measured. It is preferable to measure perennial grasses.
- Additional grass heights can be measured, but at a minimum grass height should be measured in the following manner:
    - Measure grass height (leaf or inflorescence) at the tallest vertical point (do not straighten up the plant, i.e. droop height) where the bulk of a plant's mass occurs. If the inflorescence of the plant does not provide visual obstruction, measure where the bulk of the mass occurs in the leafy portion of the plant at the tallest leaf height (Fig. 1). If the inflorescence provides a bulk of the mass, then the tallest portion of the inflorescence is measured (Fig. 2).
    - This protocol does not provide guidelines for every species of grass. The individual conducting the sampling will have to make a judgment for each

plot and each species along a plot. Consistency by following this protocol is key, as well as collecting an adequate number of measurements.

- The same protocol should be followed for forbs (Fig. 3 - the bulk of the mass of the plant occurs in the leafy portion and the tallest leaf height is measured; Fig. 4 - the inflorescence provides the bulk of the mass the tallest portion of the inflorescence is measured)

All cover estimates should be placed in the categories noted in Table 1. The standard Daubenmire method uses six cover classes, but the specific ranges lump too much in the 5-25% class for Gunnison Sage-grouse vegetation variables. Therefore, this category was split into 2 cover classes below.

Table 1. Cover classes for Gunnison sage-grouse habitat variable estimation.

Cover Class	Range of Coverage	Midpoint of Range
1	0-5%	2.5
2	5-15%	10
3	15-25%	20
4	25-50%	38
5	50-75%	63
6	75-100%	88

.

References:

Canfield, R.H. 1941. Application of the line interception method in sampling range vegetation. J. Forestry 39:388-394.

USDI-BLM, Interagency Technical Team. 1996. Sampling vegetation attributes. Technical Reference 1734-4, BLM/RS/ST-96/002+1730, USDI-BLM, National Science and Technology Center, Denver, CO, 172 pp.

Connelly, J.W., K.P. Reese, and M.A. Schroeder. 2003. Monitoring of greater sage-grouse habitats and populations. Station Bulletin 80, University of Idaho, Moscow, USA.

Daubenmire, Rexford. 1959. A Canopy-coverage method of vegetation analysis. Northwest Science 33:43-64.

Examples of where grass and forb heights should be taken.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

APPENDIX I

GUSG DISTURBANCE GUIDELINES

GUSG DISTURBANCE GUIDELINES

Successful implementation of these guidelines for protecting GUSG from disturbance will require the identification and delineation (e.g., mapping, ground truthing) of breeding, summer - fall, and winter habitats. All anthropogenic structures (e.g., powerlines, roads, fences) should also be identified and delineated. Available GUSG and GRSG habitat use and movement information were used to develop these guidelines. If data were not available, guidelines are consistent with Connelly et al. (2000). As new or local information becomes available through research or monitoring, these guidelines or recommended restrictions may be adjusted to more effectively manage for GUSG.

For the purpose of these guidelines, we primarily adopt the Connelly et al. (2000) definition of an active lek as a open area that has been attended by ≥ 2 male sage-grouse in ≥ 2 of the previous 5 years. However, this definition is derived mainly from observations of leks in large, stable populations and may not be appropriate for small populations with reduced numbers of males attending leks in fragmented sagebrush communities. Therefore, for the smaller GUSG populations outside of the Gunnison Basin, an active lek is defined as an open area where 1 or more sage-grouse have been observed on more than 1 occasion, engaging in courtship or breeding behavior. An area used by displaying males in the last 5 years is considered an active lek." Buffers for protection from disturbance need to be from the perimeter of the open area defining the lek, not from a center point within the lek area.

Guidelines are organized into 2 types of disturbance: (1) structures or actions that may modify GUSG habitat, or structures that may affect GUSG by potentially increasing collision risks and exposure to predation (all these structures and associated activities may also result in the second type of disturbance); and (2) human activities that may cause disturbance to GUSG themselves (i.e., anthropogenic noise or movement), especially during critical seasonal use periods. Within each type of disturbance, guidelines are organized by type of activity that might cause disturbance, and/or by seasonal habitat type. In addition to this section, review conservation strategies for particular threats (e.g., powerlines) for further guidance.

If habitat disturbances that will require habitat restoration occur, the potential community needs to be identified (Winward 2004) and a diverse seed mixture of native shrubs, grasses, and forbs should be used (Monsen 2005) for appropriate restoration (see "Habitat Enhancement" strategy, pg. 214 and "GUSG Structural Habitat Guidelines, Appendix H).

Designation of Seasonal Habitats

Unmapped Seasonal Habitats

If seasonal habitats are not mapped and field-validated, they should be designated by 2 concentric circles around active leks, the first with a radius of 0.6 miles ("Lek Habitat"), and the second with a radius of 4.0 miles (both "Non-lek Breeding Habitat" *and* "Summer – Fall Habitat) (Fig. 1). Generally, breeding habitat is considered to be sagebrush communities within the 4-mile circle. Summer-fall habitat includes sagebrush communities, wet meadows, and agricultural fields within the 4-mile circle.

The basis for the first circle, 0.6 miles from a lek (Fig. 1), is data from 5 separate studies of daytime movements of adult male GRSG during the breeding season (Carr 1967, Wallestad and Schladweiler 1974, Rothenmaier 1979, Emmons 1980, Schoenberg 1982; see pg. 28). No similar data are available for GUSG.

The second circle, 4.0 miles for non-lek breeding and summer – fall habitats (Fig. 1), is based on 3 studies of GUSG (NPS unpublished data, Young 1994, Apa 2004). Habitat use data from these studies indicate 85.2 percent of all GUSG nests and 81.3 percent of all GUSG breeding and summer-fall seasonal locations are within 4.0 miles of the lek of capture (see "GUSG Habitat Use Data", Appendix J).

Because GUSG winter habitat use data are limited, we defined winter habitat as sagebrush areas (Connelly et al. 2000) within currently occupied habitat that are available (i.e., not covered by snow) to sage-grouse in average winters (see "GUSG Structural Habitat Guidelines", Appendix H).

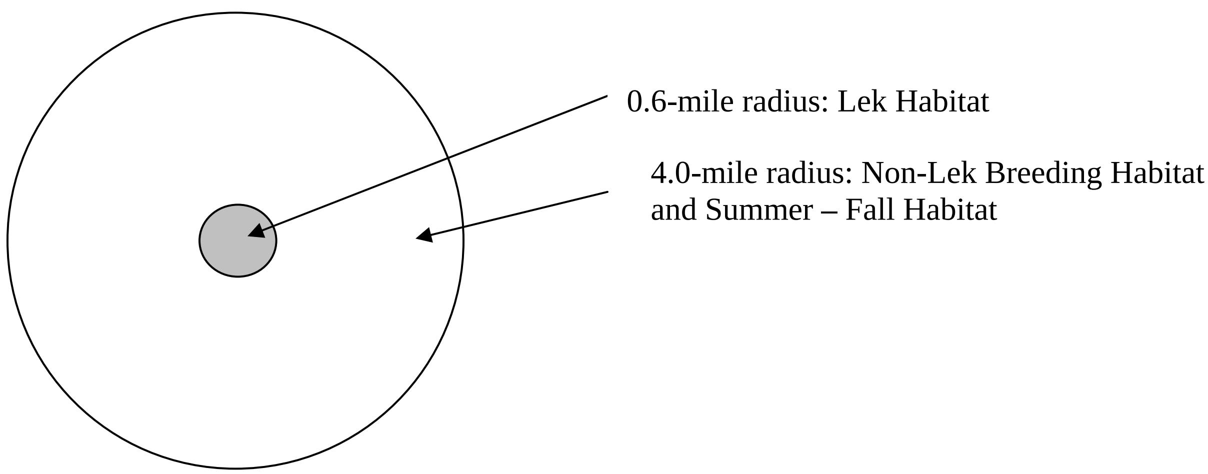


Fig. 1. Designation of GUSG seasonal habitat borders around an active lek, if seasonal habitats have not been mapped.

Within the 0.6 mile border, observe the recommendations listed under "Breeding – Lek Habitat". If a particular area is outside the 0.6 mile buffer, but within the 4.0 mile radius, the sage-grouse habitats within the circle could be considered Non-Lek Breeding, Summer – Fall, or Winter Habitat. Follow the guidelines for these other seasonal habitat categories. In general, the sagebrush stands would be considered the sage-grouse habitat within the 4.0 mile radius, but "summer-fall habitat" also would include riparian areas and agricultural fields within this circle.

Mapped Seasonal Habitats

If seasonal habitats have been mapped, the following guidance should be followed in, and relative to, the mapped habitat. If there is overlap among different seasonal mapped habitats, whichever seasonal recommendations are the most restrictive should be observed.

(1) Structures and/or Actions that May Modify GUSG Habitat, or That May Increase Mortality of GUSG

(includes fences, roads, powerlines, housing development, wind power generation, oil and gas exploration and production, sagebrush removal and/or treatment)

Fences

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- Fences should not be constructed within 0.60 miles of an active lek, if possible. Fences that will be built closer to leks, or pre-existing fence within this buffer, should be fitted with visual devices to minimize grouse collisions. Where possible, fences should be placed in areas where topographic features can be used that will deter collisions.

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- If, in the course of other activities, it is determined that fences in a particular area might be causing collision danger to GUSG, avoid constructing new fences in that area, and move, or retrofit existing fences to increase visibility and decrease possibility of GUSG collisions.

Roads

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- Local (generally, unpaved) roads should not be constructed within 0.60 miles of an active lek. If this is impractical, roads should be placed so they and the associated traffic are not in direct line-of-sight of strutting males, and should be minimally developed. Vehicles should not exceed 35 mph (adapted from Tessman et al. 2004) within 0.60 miles of an active lek on local or unpaved roads.

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- Local (generally, unpaved) roads should be excluded when possible, and when not, road length and width should be minimized to the extent possible. Vehicles should not exceed 35 mph (adapted from Tessman et al. 2004) on local or unpaved roads.

Powerlines

Consultation with local biologists (state and federal) must occur before placement of any new powerlines in all GUSG habitats, to use local knowledge and options (such as local topographic features) to minimize impacts to GUSG.

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- Powerlines should not be constructed within 0.60 miles of active leks. If this is impractical, powerlines within 0.60 miles of any active lek should be buried or retrofitted to deter raptor perching.

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- If possible, powerlines should be avoided in all other seasonal GUSG habitats. If not possible, consider burying powerlines, placing raptor perching deterrents, and avoiding sage-grouse concentrated-use areas and riparian areas.

Housing Development

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- No housing developments should occur within 0.60 miles of active leks.

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- Housing developments should be discouraged in all GUSG habitat. When this is not practical, houses should be clustered as much as possible to maintain larger areas of undisturbed habitat.

Wind Power Generation and Communication Towers

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- Wind power turbines and communication towers should not be constructed within 0.60 miles of active leks.

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- Wind power turbines and communication towers should be avoided in other GUSG seasonal habitat, if possible. If not possible, retrofit all aspects of turbines and towers to deter raptor perching, and to decrease the possibility of GUSG collisions.

Oil and Gas Exploration and Production

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- All surface-disturbing activities should be prohibited within 0.60 miles of an active lek. If not practical, any equipment should have minimal noise; compressors, vehicles, and other sources of noise should be equipped with effective mufflers or noise suppression devices. Attempts should be made to minimize continuous noise by reducing noise levels to 10 dBA or less (adapted from Tessmann et al. 2004) because most grouse vocalizations are less than 20 dBA (Dantzker et al. 1999).

Other Seasonal Habitats: (Breeding: Non-lek Habitat, Summer – Fall Habitat, or Winter Habitat)

- Surface-disturbing activities should be avoided in other GUSG seasonal habitats. If not possible, implement SMP's (see Appendix L) to minimize impacts to GUSG, and implement pertinent timing restrictions in this Appendix.
- Any necessary equipment should produce minimal noise; all compressors, vehicles, and other sources of noise should be equipped with effective mufflers or noise suppression devices. Attempts should be made to minimize continuous noise by reducing noise levels to 10 dBA or less (adapted from Tessmann et al. 2004) because most grouse vocalizations are less than 20 dBA (Dantzker et al. 1999).
- Encourage remote monitoring to minimize human disturbance.

<u>Sagebrush Removal and/or Treatment</u>

Breeding: Lek Habitat (within 0.6 miles active lek; see Fig. 1)

- Any sagebrush removal or treatment should be prohibited or limited within 0.60 miles of an active lek (Wallestad 1975), unless implemented to maintain or enhance the lek.

Breeding: Non-lek Habitat (if not mapped, then within 4.0 miles of active leks, but outside of 0.6 mile buffer; see Fig. 1)

- If seasonal habitat is uniform and not fragmented, then sagebrush loss, removal, treatments, or other surface-disturbing activities should be limited and not exceed 20-30% (Connelly et al. 2000) of the total mapped habitat. Treatments must have recovery objectives that meet the habitat objectives listed in this RCP. Treatment blocks should be small (< 50 acres), interspersed across the landscape, and irregular in shape. Treatment areas should not be distributed systematically or predictably across the landscape.
- If > 40% of the original mapped breeding habitat has been lost (Connelly et al. 2000) to other factors, all remaining habitat should be protected.

Summer – Fall Habitat (if not mapped, then within 4.0 miles of active leks; see Fig. 1)

- Maintain sagebrush communities within 0.25 miles (based on Connelly et al. 2000, Hausleitner 2003) of known summer - fall habitat (such as riparian, wet meadows, or agricultural areas). Sagebrush treatment is not discouraged but must be planned to achieve the habitat objectives outlined in the RCP.

Winter Habitat (if not mapped, then entire area within 6.0 miles of active leks; see Fig. 1)

- Any treatments should be small (<10 acres) in size and sagebrush loss, removal, treatments, or other surface-disturbing activities should not exceed 10% of the delineated winter habitat. Treatments should be irregular in shape and not distributed predictably or systematically on the landscape. Treatments in the shape of rows or strips should be avoided.

(2) Timing Restriction Recommendations for Human Disturbance in GUSG Habitat (e.g., anthropogenic noise or movement). Does not include agency-conducted research and population monitoring, or formal lek viewing sites; these activities are covered by separate guidelines.

Breeding Habitat: Lek Habitat
The following activities should be restricted as stated from mid-March through late-May (precise dates should be obtained from a local biologist).

- Any activities that could be categorized as "line of sight" or in direct view of the lek would need to follow more restrictive guidelines than situations where a topographical configuration interrupts the line of sight. Direct line of sight activities should be limited to > 300 feet from the edge of the lek. If topographical features interrupt the line of sight, the aforementioned distance can be reduced to 150 feet. Human activities that would be repetitive (occurring every day, or every other day) could be more detrimental than activities or disturbances that occur sporadically or occur equal to or less than 1 time/week.
- All activities, motorized or non-motorized, should be limited between sunset the evening before to 2 hours after sunrise the next morning (modified from Lyon and Anderson 2003, A.D. Apa, CDOW, personal communication). There should be complete exclusions from 2 hours before sunrise to 2 hours after sunrise. Any activities that create noise > 20 dBA should be severely limited (adapted from Dantzker et al. 1999).

Breeding Habitat: Non-Lek Habitat
The following activities should be restricted as stated from mid-April through June.

- Limit activities, motorized or non-motorized, when hens with broods are most active, from ½ hour before sunrise to 2 hours after sunrise, and 1 hour before sunset to sunset when hens with broods are most active.
- Activities should be confined to established roads and trails.

Summer - Fall Habitat
The following activities should be restricted as stated from July – September.

- Limit activities, if possible to established roads and trails.

Winter Habitat
The following activities should be restricted as stated during October - mid-March.

- All activities, except foot and horse traffic, should be limited to established roads and trails in areas of known winter concentration of GUSG.

APPENDIX J

GUSG HABITAT USE DATA

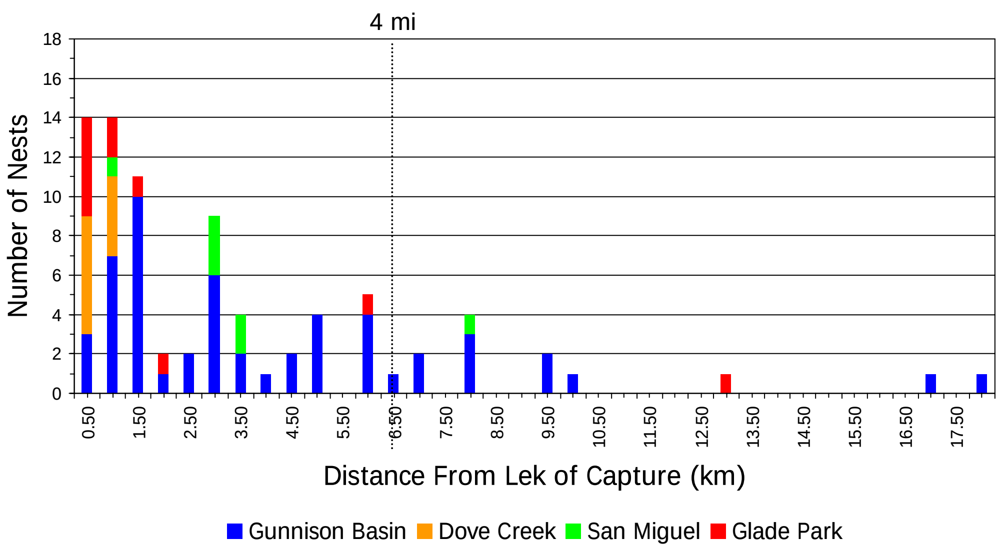
GUSG HABITAT USE DATA

This appendix illustrates GUSG habitat use data from 3 different studies (NPS unpublished data, Young 1994, Apa 2004). Apa (2004) studied GUSG in 5 population areas, and the other 2 studies focused on the Gunnison Basin (NPS unpublished data, Young 1994). Data from Young (1994) and NPS (unpublished data) are limited to nest locations only. Data from this Appendix were used to develop the "GUSG Disturbance Guidelines", Appendix I.

Nesting Habitat Use

Female Gunnison sage-grouse were captured in 3 different studies (NPS unpublished data, Young 1994, Apa 2004) and their nest locations were identified. Fig. 1 illustrates a frequency distribution of the number of nests located at differing distances from the lek of capture. A majority of females (85.2%, n = 69/81) sampled across the range of the species nested within 4 miles of the lek of capture.

Fig. 1. DISTRIBUTION OF GUNNISON SAGE-GROUSE NESTS
Rangewide (2002-2004; Apa 2004, NPS unpublished data) (n = 53)
Gunnison Basin (1990-1993; Young 1994) (n = 28)



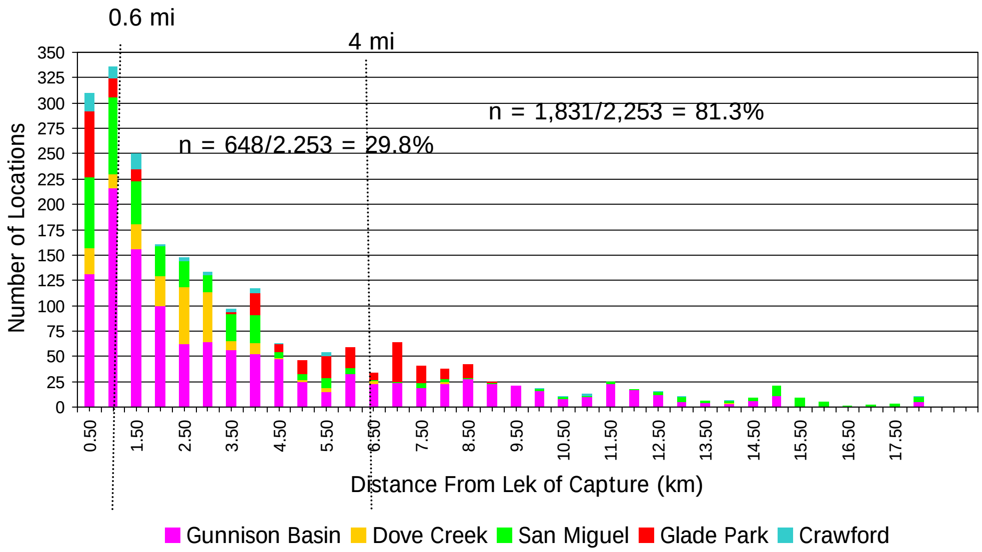
Seasonal Habitat Use

Rangewide Data

Four seasons of seasonal use data are depicted in the following figures. Breeding habitat includes not only nesting habitat, but also very early brood habitat used from 1 March – 30 June, and habitat used during this same period by males and non-brooding females. In other sections of the RCP, summer and fall habitats are combined, but for the purpose of the following figures summer and fall habitat are separated. Summer habitat includes areas used by males, non-brooding females, and brood females, from 1 July – 30 August. Fall habitat includes all of the areas used by the aforementioned grouse groups from 1 September - 28 September. Winter habitat is areas used by all age and sex classes of GUSG from 1 October – 28 February.

All seasonal habitat locations (from 5 separate GUSG populations) were summarized and graphed against distance (Fig. 2). Seasonal use data are from nest locations (NPS unpublished data, Young 1994, Apa 2004), and telemetry habitat use data (Apa 2004). From a rangewide perspective, 81.3% of all seasonal habitat locations rangewide were located within 4 miles of the lek of capture and 29.8% of the rangewide locations were found within 0.6 miles of the lek of capture.

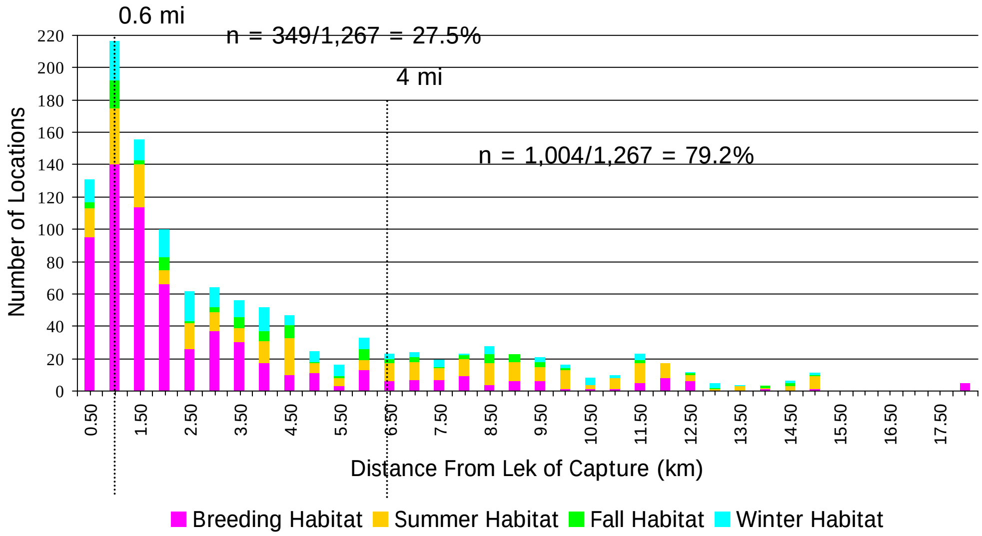
Fig. 2. RANGEWIDE DATA: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS



Gunnison Basin Data

In the Gunnison Basin, the pattern of habitat use within 4 miles of the lek of capture is similar for all seasons (breeding, summer, fall, and winter, Fig. 3). Approximately 80% of all seasonal habitat locations were found within 4 miles of the lek of capture, while 27.5% of the seasonal habitat locations were located within 0.6 miles from the lek of capture.

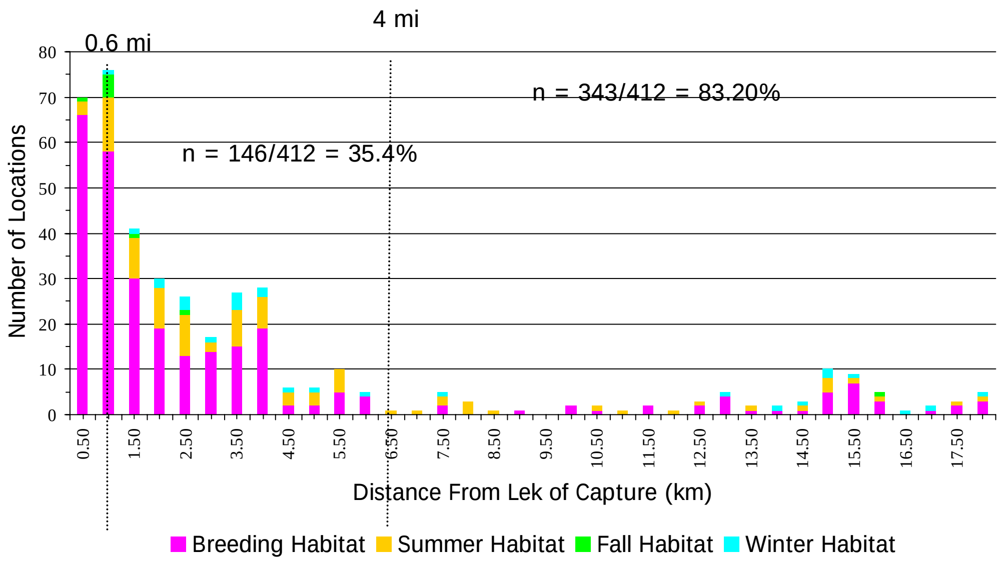
Fig. 3. GUNNISON BASIN: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS



San Miguel Basin Data

Gunnison sage-grouse in the San Miguel Basin illustrated a greater dispersion of movement patterns, although 83.2% of the seasonal habitat locations were found within 4 miles of the lek of capture (Fig. 4). Approximately 35% of all habitat use locations were located within 0.6 miles of the lek of capture.

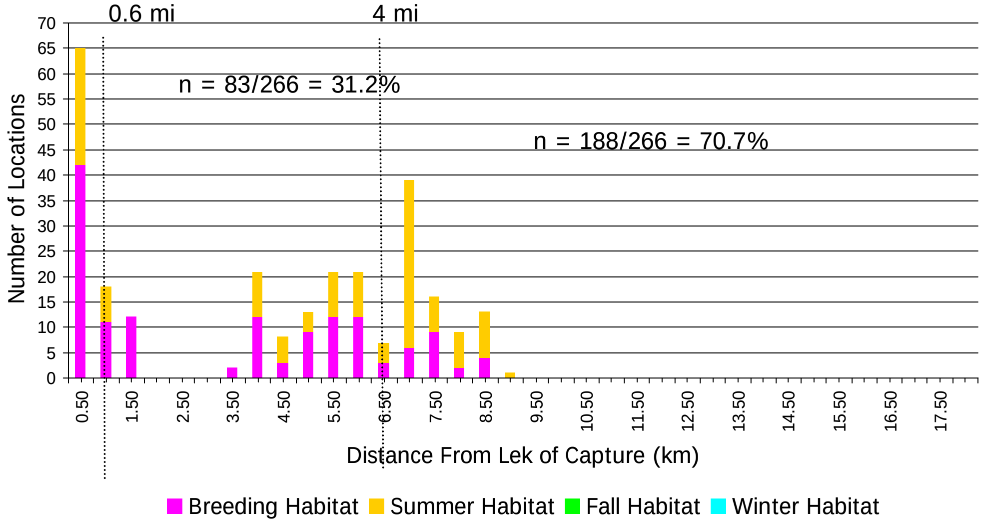
Fig. 4. SAN MIGUEL BASIN: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS
San Miguel Basin (2002-2004) (n = 42 grouse)



Glade Park / Piñon Mesa Data

Although sample sizes were lower in Glade Park/Piñon Mesa, nearly 71% of habitat use locations were found within 4 miles of the lek of capture (Fig. 5). In contrast, 31.2% of the seasonal habitat use locations were found within 0.6 miles of the lek of capture.

Fig. 5. PIÑON MESA: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS
Glade Park/Piñon Mesa (2002-2003) (n = 19 grouse)

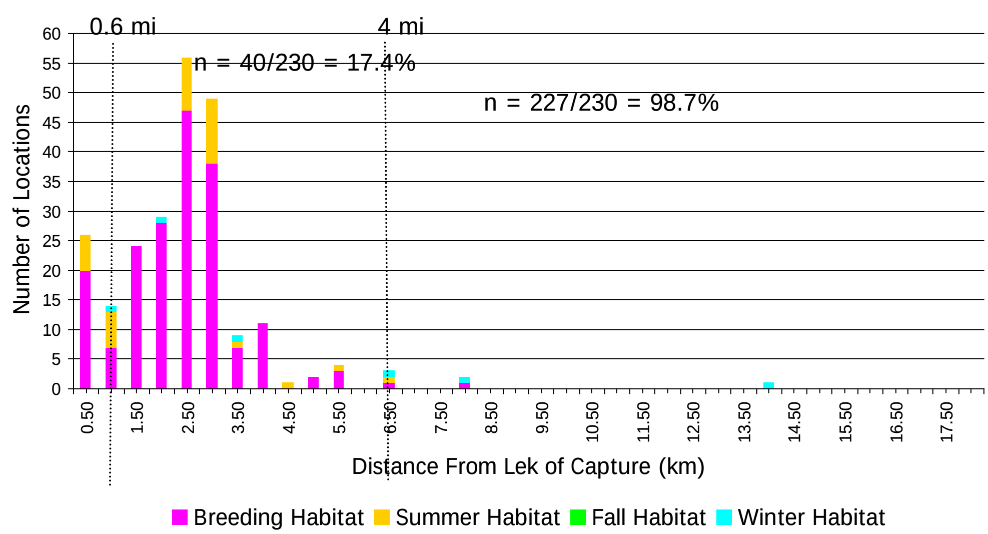


Dove Creek Data

At Dove Creek, Gunnison sage-grouse did not move as far from the lek of capture, with 98.7% of grouse locations located within 4 miles of the lek of capture (Fig. 6). Only 17.4% of seasonal habitat locations were found within 0.6 miles of the lek of capture.

Shorter distances traveled from lek of capture in the Dove Creek sub-population as compared to the other populations most likely are due to the limited and highly fragmented habitat. Sagebrush patches have progressively become smaller and fragmented, limiting available habitat and options for use by sage-grouse.

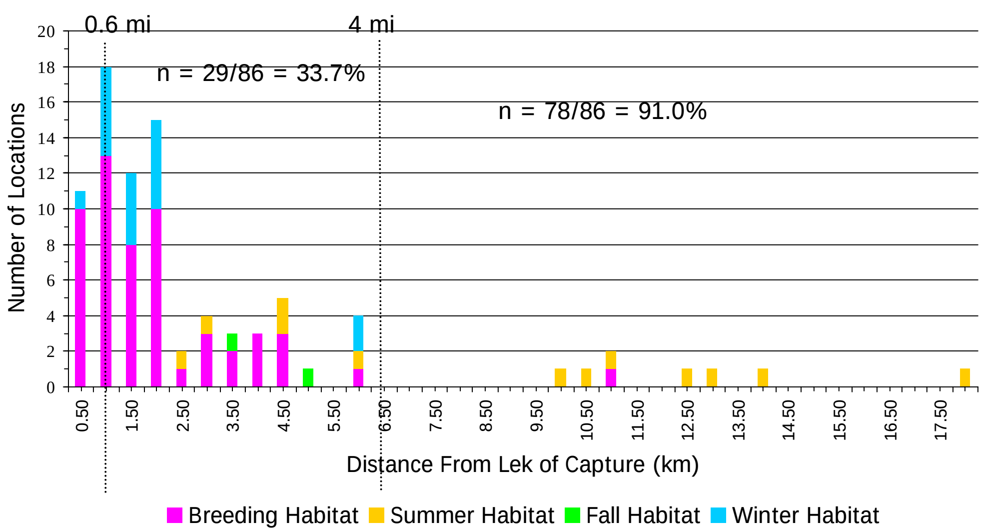
Fig. 6. DOVE CREEK: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS
Dove Creek (2002-2003) (n = 21 grouse)



Crawford Data

Gunnison sage-grouse in Crawford exhibited some longer movements to summer habitat, although 91% of seasonal habitat locations were found within 4 miles of the lek of capture (Fig. 7). Approximately 34% of locations were found within 0.6 miles of the lek of capture.

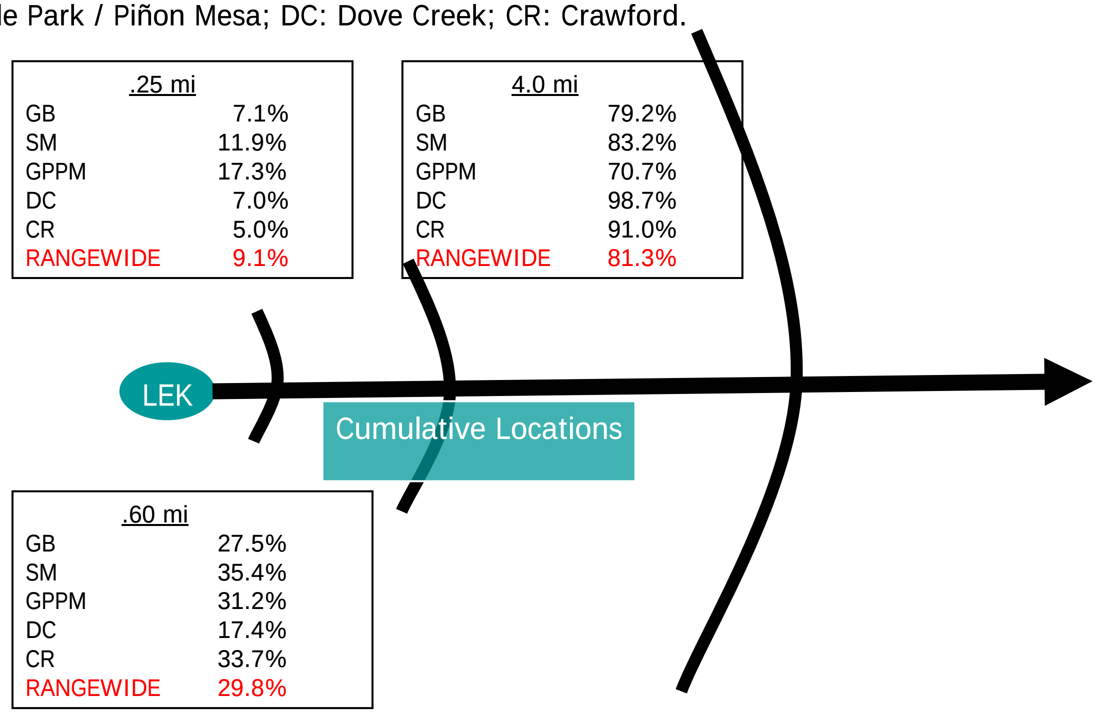
Fig. 7. CRAWFORD: DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS
Crawford (2002-2003) (n = 7 grouse)



Summary Data

Fig. 8 depicts an overall summary of GUSG locations within the following distances: 0.25 miles, 0.6 miles, and 4.0 miles. When all locations were evaluated, only 9.1% of seasonal habitat locations were found within 0.25 miles of the lek of capture.

Fig. 8. DISTRIBUTION OF GUNNISON SAGE-GROUSE SEASONAL USE LOCATIONS IN RELATION TO LEK OF CAPTURE. GB: Gunnison Basin; SM: San Miguel Basin; GPPM: Glade Park / Piñon Mesa; DC: Dove Creek; CR: Crawford.



APPENDIX K
TABLES OF CONTENT and INTRODUCTIONS FROM 2 SECTIONS IN MONSEN (2005)

Restoration Manual

For

Colorado Sagebrush and Associated Shrubland Communities

Section I. Attributes and Features of Select Grasses, Broadleaf Forbs and Selected Shrubs

By

Stephen B. Monsen

Published by
Colorado Division of Wildlife
Department of Natural Resource
6060 Broadway, Denver, CO 80216

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Introduction

Restoration of wildlife habitats is much more difficult and complicated than revegetation or enhancement of rangelands for livestock grazing or watershed protection. Recovery or reestablishment of wildlife habitats normally involves the treatment of a number of broad vegetative types. Animals are usually confined to a specific plant community, and remedial treatments often involve reestablishment of a number of plant associations. Restoring or improving any one plant or even a number of species may not be entirely satisfactory to maintain or improve the health of a particular animal population. Wildlife, particularly sage-grouse, seek and use individual species at different seasons both for cover and food (Appendix I). Sagebrush is a major part of the diet and cover for these animals, yet plant density, site location, height, and associated species significantly influence the value of the shrub. Planting or reestablishing sagebrush may not provide the age classes, plant structure, or density as required to support sage-grouse (Appendix I). Restoring the seasonal forage and cover species is difficult as a number of incidental or less common species are also required, but they are not easily established in the amounts needed.

Certain broadleaf herbs that are normally a minor part of most sagebrush communities are apparently vital to chicks and hens at particular seasons. To be effective, the plants must furnish green herbage or succulence in the spring and early summer months. To do so, these plants must occupy sites where additional moisture accumulates or exists as an understory with the shade provided by some shrubs. If the herbaceous species are not properly located in close proximity to the shrubs, their summer value is limited. Seeding to accomplish a specific arrangement of plants is difficult, as most broadleaf herbs are not easily established in combination with grasses and shrubs. Planting complexities are much more difficult when a number of plants with different life forms are being planted together.

Many sagebrush sites that require remedial treatments have been seriously altered or disrupted. In many situations the principal species have been replaced by competitive weeds, and a seed source for natural recovery is not present. In addition, many sagebrush communities occur in arid or semiarid environments. Annual and seasonal moisture is normally low and unpredictable. The lack of moisture in the spring months to support and sustain plant growth is critical to restoration. New plantings are dependent upon sufficient and continued amounts of moisture to germinate seeds and assure the uninterrupted growth of the young seedlings. Weed containment is also essential to assure young plantings can establish. Control of weedy species is often costly, and sites are frequently poorly accessible to most equipment and control measures.

Planting an assembly of native species is usually necessary to restore the desired plant communities. Presently seed of most native species is not universally available to support large projects. However, some native seed programs are being developed, particularly in Colorado that could improve this situation.

Even with these difficult restrictions, remedial treatments to improve and enhance sage-grouse habitats are feasible and possible. Many sites can be substantially improved and returned to a native assembly if appropriate site preparation treatments, seeding practices, and adapted species are used. Sufficient seed of sagebrush, and some native grasses and herbs are available for planting. Site preparation and planting methods are well understood and can be accomplished with a high degree of success if properly instigated. Many sites can be improved though proper management. Plant recovery can be expected within a reasonable time period if areas are carefully managed. Improvement of wildlife habitats will be a continuing and evolving process, but many areas can be improved with current resources.

Table of Contents

Restoration Manual

For

Colorado Sagebrush and Associated Shrubland Communities

Section II. Developing Objectives to Manage and Improve Plant Communities and Wildlife Habitats

By

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Introduction

Improvement of sage-grouse and other wildlife habitats usually involves the treatment and management of a number of associated shrubland communities. However, big sagebrush communities and other shrubland associations occupy quite different environments and climatic conditions. It is important to understand the different community associations that may occur together to effectively implement remedial treatments. Although natural recovery of disturbances is most effective and ecologically sound, this may not be possible in many situations, particularly some sagebrush, pinyon-juniper woodlands, and salt desert shrublands. Often, the vegetation in these plant associations has been so altered that few remnant plants are left to repopulate the sites. Active control measures are needed to reduce the presence of weeds and other invaders. Desirable species must be restored by introducing seed in an effective manner to assure reestablishment.

Active restoration normally involves the physical removal of competitive species, preparation of seedbeds, and seeding of desired species. Since a number of species are normally planted, it is essential to understand the principles required to restore all seeded species. Sagebrush is a major species in many projects and requires specific seedbed environments to establish. Failure to adhere to all aspects of site preparation and planting practices will result in widespread failures.

In many situations, improvement or protection of plant communities is related to wildfires and other disturbances. Many sagebrush and associated shrubland communities are subjected to fires, grazing, drought, and other influences that can create considerable change in species composition. Wildfires are particularly common and quickly reduce the presences of sagebrush and other woody species. Fires are also being promoted as a means to change the composition of many shrublands. It is important to understand the conditions that must occur to allow sites to recover, particularly to regain shrub dominance. Utilizing effective seedbed preparation and planting techniques are essential to site restoration. Planting at appropriate seasons and utilizing techniques that are more likely to be successful are critical to any restoration project. Techniques and practices must be employed that promote initial establishment of seeded species, but also facilitates the recovery and growth of residual species. Reestablishment of native communities is largely dependent upon the species that initially establish, including the recovery of surviving plants and the development of plants from intact seed banks. The manner that sites are treated significantly influences the species that become established as well as the plants than recover naturally. Remedial treatments, including management of sites to promote natural recovery, must be carefully planned and directed.

Table of Contents

APPENDIX L

SUGGESTED MANAGEMENT PRACTICES APPLICABLE FOR OIL AND GAS DEVELOPMENT, WITHIN LEASE RIGHTS

Suggested Management Practices (SMP's) Applicable for Oil and Gas Development, within Lease Rights

This is a partial list of suggested management practices that may be applied to oil and gas operations, or other surface-disturbing activities, to aid in meeting the habitat guidelines outlined in Appendix G (BLM Best Management Practices for public lands are available at http://www.blm.gov/bmp).

1. Minimize impacts on habitat through road construction standards, design and placement in all occupied and vacant/unknown sage grouse habitat. (exploration, drilling and production)
   A. Minimize construction of new roads
   B. Utilize minimum construction and maintenance standards appropriate for the operation.
   C. Minimize visual/auditory impacts by placing roads below ridgelines or along topographic features.
   D. Place roads outside of riparian areas.
   E. Conduct exploration along existing roads where possible.

2. Minimize impacts to sage grouse through road use (patterns) and seasonal restrictions. (exploration, drilling, production)
   A. Sign roads to prevent off road travel.
   B. Set seasonal closures during critical SG use periods.
   C. Encourage remote monitoring.
   D. Develop travel plan to minimize vehicular traffic.
   E. Place speed bumps, dips etc. to slow traffic as needed.
   F. Construct or maintain any roads outside of critical seasonal use periods.
   G. Encourage road rehabilitation or realignment to minimize impacts to sage grouse.
3. Overlay lease map with Gunnison sage-grouse habitat to determine vacant and occupied leases. (drilling and production)
   A. Add lease notice 'This lease may require a full development plan as determined by an interdisciplinary team.

4. Implement noise mitigation from research and/or state regulations.

5. Create an educational video about sage grouse habitat and ecology to increase awareness for oil and gas employees. (exploration, drilling, production)

6. Avoid or minimize impacts to riparian, wetland, or wet meadow habitats to limit impacts to brood rearing areas. (exploration, drilling, production)
   A. Locate equipment, facilities, and roads outside of riparian zones which may serve as late brood rearing habitat (1000 ft buffer where feasible).
   B. Drive over woody vegetation at stream crossings rather than remove it wherever possible.
   C. Bore pipeline crossings under perennial streams rather than trenching.

7. Use reclamation standards (interim and final) that are beneficial to restoring sage grouse habitat. (drilling, and production)
    A. Incorporate sagebrush, desired forbs and grass species into seed mix. Use native species wherever possible or non-natives when approved via state or federal biologists.
    B. Replace soil manually for shot holes. (exploration)
    C. rip and/or recontour and reclaim operation sites, and access roads.
    D. Retain and ‘manage’ topsoil as appropriate for reclamation.
    E. Reclaim riparian areas with native vegetation.
    F. Mimic vegetation patterns during reclamation.
    G. Develop a reclamation plan with CDOW and UDWR.
    H. Investigate opportunities to utilize suitable produced water in accordance with state water laws.

8. Prevent or minimize raptor perching on oil and gas facilities and structures in important sage grouse habitat. (drilling and production)
    A. Design power poles to prevent raptor perching.
    B. Minimize height of dry hole markers in SG habitat. (flush with ground or < 1’)

9. Components of a Comprehensive Development Plan (production)
    A. Map all road infrastructure for area to be developed.
    B. Map seasonal sage-grouse habitat within area of development.
    C. Consider cumulative habitat loss to date in determining future development opportunities.
    D. Consider topographic features when recommending areas to protect for sage-grouse.
    E. Delineate maximum wellpad spacing (e.g., “No more than 1 wellpad per 'xx' acres”) for areas when research identifies that threshold.
    F. Establish incremental development thresholds where possible (e.g. no more than 10% breeding habitat impacted over 10 year period)
    G. Coordinate planning among companies operating in the same field.
    H. Cluster development where possible to minimize impacts.
    I. Encourage alternative drilling or production methods to minimize acres of habitat directly or indirectly affected (e.g. directional drilling).
    J. Encourage remote monitoring of production sites to reduce harassment of birds during critical seasons.

10. Develop a fire response plan for oil and gas operations within sage-grouse habitat. (production)

11. Use BTI (*Bacillus thurgensis israelsis*) for mosquito control in water pits associated with oil & gas operations where appropriate. (production)
12. Implement measures to ensure water quality is maintained, and hazardous spills are minimized in sage-grouse habitat and associated riparian areas. (drilling and production)

A. Encourage use of water tanks instead of open pits.
B. Line open water pits.
C. Minimize SG contact with produced water.

13. Design well pad, storage facilities, and site locations to minimize degradation of sage-grouse habitat and visual/actual obstructions in the area. (production)
    A. Use low profile storage tanks.
    B. Paint wells to camouflage in background.

14. Minimize impacts on local watersheds & local water sources during local drilling and reclamation activities (includes minimizing surface & sub-surface water depletion impacts). (drilling and production)