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Kiger and Riddle Mountain Herd Management Areas Wild Horse Population Management Plan / Environmental Assessment

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LIST OF ACRONYMS

AAEP ..... American Association of Equine Practioners
ACEC ..... Area of Critical Environmental Concern
AHPA ..... American Horse Protection Association
AML ..... Appropriate Management Level
APHIS ..... Animal and Plant Health Inspection Service
ARMPA ..... Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment
AUM ..... Animal Unit Month
BLM ..... Bureau of Land Management
BSC ..... Biological Soil Crusts
CAWP ..... Comprehensive Animal Welfare Program
CEAA ..... Cumulative Effects Affected Area
CFR ..... Code of Federal Regulations
CMPA ..... Cooperative Management and Protection Area
COR ..... Contracting Officer's Representative
EA ..... Environmental Assessment
EIS ..... Environmental Impact Statement
FLPMA ..... Federal Land Policy and Management Act
FONSI ..... Finding of No Significant Impact
GAO ..... Government Accountability Office
GHMA ..... General Habitat Management Area
GIS ..... Geographic Information System
GRSG ..... Greater Sage-Grouse
HA ..... Herd Area
HMA ..... Herd Management Area
HMAP ..... Herd Management Area Plan
HQ ..... Headquarters Office
HSUS ..... Humane Society of the United States
IAG ..... Invasive Annual Grass
IBLA ..... Interior Board of Land Appeals
IDT ..... Interdisciplinary Team
IM ..... Instruction Memorandum
IUD ..... Intrauterine Device
LUP ..... Land Use Plan
MBTA ..... Migratory Bird Treaty Act
MD ..... Management Decisions
NAS ..... National Academy of Sciences
NEPA ..... National Environmental Policy Act
NLCS ..... National Landscape Conservation System
ODEQ ..... Oregon Department of Environmental Quality
ODFW ..... Oregon Department of Fish and Wildlife
OIG ..... Office of Inspector General
PAC ..... Priority Area of Conservation
PDF ..... Project Design Features
PHMA ..... Priority Habitat Management Area

PI ..... Project Inspector
PIM ..... Permanent Instruction Memorandum
RDF ..... Required Design Features
RFFA ..... Reasonably Foreseeable Future Actions
RMP ..... Resource Management Plan
ROD ..... Record of Decision
SOP ..... Standard Operating Procedures
SSF ..... Soil Surface Factor
SSS ..... Special Status Species
TNEB ..... Thriving Natural Ecological Balance
USFS ..... United States Forest Service
USGS ..... United States Geological Survey
VRM ..... Visual Resource Management
WFRHBA ..... Wild Free-Roaming Horses and Burros Act
WHA ..... Wild Free-Roaming Horses and Burros Act
WH&B ..... Wild Horse and Burro
WHB ..... Wild Horse and Burro
WO ..... Washington Office

KIGER AND RIDDLE MOUNTAIN HERD MANAGEMENT AREAS WILD HORSE POPULATION MANAGEMENT PLAN / ENVIRONMENTAL ASSESSMENT DOI-BLM-ORWA-B050-2020-0004-EA

1 INTRODUCTION: PURPOSE OF AND NEED FOR ACTION

1.1 Introduction

The Bureau of Land Management (BLM) Burns District has prepared this environmental assessment (EA) to disclose and analyze the environmental consequences of the Kiger and Riddle Mountain Herd Management Areas (HMA) Population Management Plan, including multiple alternatives.[1] This wild horse HMA is administered in whole by the Andrews/Steens Field Office. This EA is a site-specific analysis of the potential impacts that could result with the implementation of the proposed action or alternatives. If the BLM determines significant impacts could occur, an environmental impact statement (EIS) will be prepared for the project. If this EA determines there are no significant impacts, a decision will be issued along with a finding of no significant impact (FONSI) documenting the reasons why implementation of the selected alternative would not result in significant impact.

1.2 Background

Under the Wild Free-Roaming Horses and Burros Act of 1971, the BLM is charged with managing Kiger and Riddle Mountain HMAs in a manner that is designed to achieve and maintain a "thriving natural ecological balance." 16 U.S.C. § 1333(a). The BLM accomplishes this goal, in part, by establishing herd management areas (HMA) and Appropriate Management Levels (AMLs) for the maintenance of wild horses and burros. 43 CFR § 4710.3-1. The BLM removes excess wild horses from an HMA when the BLM determines that an overpopulation of wild horses exists and action is necessary to remove excess animals.

In general, in the past two decades, goals have also explicitly included conducting gathers and applying contraceptive treatments to achieve and maintain wild horse populations within the established AML in order to manage for healthy wild horse populations and healthy rangelands. The use of fertility controls helps reduce total wild horse population growth rates in the short term, elongates gather intervals, and reduces the number of excess horses that must be removed from the range. Other management efforts include improving the accuracy of population inventories and collecting genetic baseline data to support genetic health assessments.

Decreasing the numbers of excess wild horses on the range is consistent with findings and recommendations from the National Academy of Sciences (NAS 2013), American Association of Equine Practitioners (AAEP 2011) Government Accountability Office (GAO 2008), Office of Inspector General (OIG 2010), and current BLM policy (BLM 2010). Maintaining the population within AML under a population plan is consistent with BLM's mandate to manage for healthy rangeland resources, a thriving natural and ecological balance (TNEB), and multiple uses of BLM-managed public lands.

[1] This EA is conducted pursuant to 40 Code of Federal Regulations (CFR) parts 1500 through 1508; sections 1501.3 and 1501.5.

The Kiger (OR0010) and Riddle Mountain (OR0009) HMAs are located in Harney County, Oregon, about 2 and 12 miles east of Diamond, Oregon, and south of Highway 78 (see Appendix A: Map 1 - Vicinity and Maps 3 and 5 – Kiger and Riddle Mountain HMAs Water Developments). These HMAs are separated by approximately five miles of BLM-managed and private lands, yet the horses residing in both HMAs are known as Kiger Mustangs and managed for the same characteristics. The Kiger HMA is comprised of approximately 26,873 acres and the Riddle Mountain HMA is comprised of 28,346 acres. The Kiger HMA falls within the Smyth-Kiger and Happy Valley grazing allotments. The Riddle Mountain HMA falls within the Burnt Flat grazing allotment. The AML within the Kiger HMA is 51-82 wild horses and within Riddle Mountain HMA is 33-56 wild horses. The AMLs for both HMAs was established in the Three Rivers RMP (1992). The 1996 Riddle Mountain and Kiger Wild Horse Herd Management Area Plan (HMAP) incorporated and complies with population and habitat objectives from the Three Rivers RMP (1992). The updated 1996 HMAP maintained the AML of 33-56 wild horses for Riddle and 51-82 wild horses for Kiger (or 672 and 984 animal unit months (AUM) forage allocation respectively). The Steens Mountain Cooperative Management and Protection Area Resource Management Plan Record of Decision (Andrews/Steens RMP/ROD 2005) reaffirmed the population and habitat objectives from the Three Rivers RMP (1992).

Over the past decade, periodic drought and increasing wild horse populations have resulted in negative impacts to wild horse health and habitat conditions within the Kiger and Riddle Mountain HMAs. Based on the May 2024 simultaneous double-observer aerial surveys, the wild horse population within the Kiger HMA is estimated upwards of 508 horses in the summer of 2024 (Appendix H, BLM 2024b). The wild horse population within the Riddle Mountain HMA is estimated upwards of 284 horses in the summer of 2024 (BLM 2024b). BLM monitoring shows natural resources have been impacted by wild horses in these areas and action must be taken to preserve those resources (Appendix H, BLM 2024a).

The Kiger Mustang Area of Critical Environmental Concern (ACEC) was designated in 1992 (Federal Register, Vol. 57, No. 202, Page 47671) to protect the historic values (the relevance criteria) that are of more than local significance (importance criteria). The 1996 HMAP explains how the wild horses that exist in the Kiger Mustang ACEC (BLM 1996a) were found to be an important historic and cultural value because they exhibit Spanish Mustang characteristics. The two separate portions of the ACEC (Kiger and Riddle Mountain HMAs) provide protection for the Kiger Mustang's unique characteristics, should something happen to one of the herds. The primary management goal of the Kiger Mustang ACEC is to perpetuate and protect the dun color factor and conformation characteristics of the wild horses present in the Kiger and Riddle Mountain HMAs (Three Rivers RMP 1992). Neither the dun color factor nor the conformation characteristics that are visible in Kiger and Riddle Mountain HMAs are unique to these areas, but they are present at frequencies that make the herds unusual as a whole.

These two HMAs have similar land management objectives as they lie on the north end of Steens Mountain and have similar ecology. Kiger HMA ranges from 4,500 feet on the north end to 6,000 feet on the south end. Riddle Mountain HMA ranges from 5,000 feet to 6,750 on the south end. Both HMAs have gently rolling hills dissected by perennial streams surrounded by rimrock. Much of the rolling hills are becoming dominated by western juniper. Both HMAs have broad valleys with some open playa flats. Dominant vegetation of this area consists of low sagebrush, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass, and Thurber's needlegrass. Annual precipitation ranges from 12 to 16 inches, most of which occurs in the form of snow during the months of November through March. Occasional

spring rains are common. Temperature extremes range from 100 to -30 degrees Fahrenheit. The optimum period for plant growth is from mid-May to mid-July.

The HMAs were designated for the long-term management of wild horses in the Drewsey Management Framework Plan (BLM 1977). The Kiger HMA was originally the East Kiger and Smyth Creek HMAs, which were then combined in 1985/1986. The appropriate management level (AML) was originally set at 30 to 50 horses in the Riddle HMA and 50 to 80 in the Kiger HMA. It was adjusted upward to 33 to 56 in Riddle Mountain and 51 to 82 in Kiger through a land use plan amendment in 1986 as the result of a land exchange with the State of Oregon. The AML was reaffirmed at 672 AUMs in Riddle Mountain HMA and 984 AUMs in Kiger HMA in the Three Rivers RMP (1992). The 1992 Three Rivers RMP did not specify an AML range per HMA, but the reaffirmed AUMs are the equivalent to the high end of AML previously established. Because these HMAs lie partially (Kiger) and entirely (Riddle Mountain) in the Steens Mountain Cooperative Management and Protection Area (CMPA), the Steens Mountain CMPA RMP/ROD (August 2005) reaffirmed 672 AUMs or an AML of 33-56 for Riddle Mountain HMA and 984 AUMs or an AML of 51-82 for Kiger HMA. These AMLs were established with public participation following an in-depth analysis of resource monitoring studies.

AMLs are established to provide for the maximum number of wild horses that results in a thriving natural ecological balance (TNEB) and avoids a deterioration of the range (BLM Wild Horses and Burros Management Handbook, H-4700-1, 2010). The AML lower limit will normally be established at a number that allows the population to grow (at a baseline level of annual population growth rate that does not reflect the effects of any fertility control) to the upper limit over a 4- to 5-year period, without any interim gathers to remove excess wild horses (BLM H-4700-1). In the absence of any measures to reduce fertility, the population growth rate in many HMAs approaches 20 percent or even higher (National Research Council (NAS) Review 2013). Therefore, with a 20 percent population growth rate, starting at the low level of AML would lead to a herd size that meets or exceeds the high end of AML within 4 to 5 years.

Since 1992, both HMAs have been surveyed nine times and gathered four times to remove excess wild horses and maintain the population within AML. Results from the May 2024 simultaneous double-observer aerial survey were 284 total horses (adults and foals) for Riddle Mountain HMA and 508 total horses (adults and foals) for the Kiger HMA (Appendix H, BLM 2024b). Results of a simultaneous double-observer method aerial survey on June 15, 2017, estimated a population size at the time of the survey of 73 horses (55 adults and 18 foals) in Riddle Mountain HMA and 78 horses (63 adults and 15 foals) in Kiger HMA (Lubow 2019).

In non-drought years, both Kiger and Riddle Mountain HMAs have adequate water in the form of perennial streams and springs to support multiple uses, including livestock grazing and wild horse populations within AML. The north half of Riddle Mountain HMA dries up on drought years causing horses to range in only the southern half or move to the north onto State of Oregon managed lands to find water. Due to the elevation and location on the north end of Steens Mountain, abundant forage is generally available for wild horses within AML. Having these resources available on a regular basis allows horses to maintain good body condition, resulting in annual population growth rates at or above the average 20 percent noted by the NAS (2013). These conditions coupled with previous survey and gather data indicate an average 20 percent annual population growth rate should be used to estimate future populations in each HMA, in the absence of fertility control.

The AML for wild horses and burros across the west is 26,690. The current estimated on-range adult wild horse and burro population of animals managed by the BLM is 82,883 (68,928 horses) (as of March 1, 2023; BLM 2023a). There were nearly 61,000 wild horses and burros in BLM off-range facilities (as of March 2024; BLM 2024). Nationally, there is limited available funding and space to care for additional animals in BLM short- and long-term holding facilities. Unrestricted population growth of wild horses and burros eventually leads to overpopulation of herds and consequent detriment to the animals, health of the range, other species, and other users of the range. The BLM has been using a limited number of methods to address high population growth of wild horses and burros. Currently available options include periodic removals and the application of temporary fertility control vaccines and flexible intrauterine devices (IUDs). Reasons for wild horse and burro gathers include, but are not limited to, emergency removal of imperiled animals; court orders; public health and safety; impacts to threatened, endangered, or sensitive species (including Greater Sage-Grouse (GRSG)); private land encroachment; resource condition motivated; removal following an excess determination; catch-treat-hold-release; and implementation of research (BLM 2022a). At the time of its 2013 review, the NAS found that there were no highly effective, long lasting, easily delivered, and affordable fertility control methods available then. Therefore, since 2013 the BLM has supported research to develop and test longer-lasting fertility control methods that would reduce the number of animals that must be removed from the range as well as the number of animals that must be cared for in off-range facilities (BLM 2022b).

Kiger Mustangs have had a near 100 percent adoption rate since 1986, with 100 percent of the horses adopted following the 2011 and 2015 gathers. BLM anticipates a continued elevated adoption demand for these horses following future gathers and removals. Nevertheless, BLM would like to pursue application of fertility control vaccine to slow the population growth, reduce the number of animals that would need to be removed over time, and extend the number of years between gathers to remove excess wild horses within these HMAs.

In addition to wild horse management in the Kiger and Riddle Mountain HMAs, various management activities are ongoing in the area including, but not limited to, livestock grazing management, noxious weed treatments, road maintenance, and wildlife habitat improvement projects. The Kiger and Riddle Mountain HMAs lie within the Folly Farm/Saddle Butte and Steens GRSG Priority Areas of Conservation (PAC); are home to locally important big game species such as elk, mule deer, and pronghorn antelope; and encompass three separate livestock grazing allotments with three individual livestock grazing permits.

1.3 Purpose of and Need for Action

The purposes of the action are to:

- Manage the Kiger and Riddle Mountain wild horse populations over a ten-year timeframe so as to maintain these populations within the established AML ranges;
- Manage wild horses that have strayed outside the HMAs;
- Restore a TNEB and protect rangeland resources from deterioration associated with overpopulation; and

- Ensure multiple use on public lands in the area is consistent with the provisions of Section 1333(b) of the Wild Free-Roaming Horse and Burro Act (WFRHBA) of 1971.

The need for action is to:

- Achieve and maintain TNEB on public lands within the HMAs to ensure herd health: prevent undue or unnecessary degradation of the public lands associated with wild horse populations: and restore the multiple-use relationship on public lands consistent with the provisions of Section 1333 of the WFRHBA of 1971 (as amended), the multiple-use mandate of the Federal Land Policy and Management Act (FLPMA) of 1976, and the management directions of both the Three Rivers RMP/ROD (1992) and the Steens CMPA RMP/ROD (August 2005);
- Manage wild horses within AML over a ten-year time period[2] and in a manner that ensures rangeland health standards for upland vegetation and riparian plant communities, watershed function, and habitat quality for wildlife populations are achieved or, if not achieved, that significant progress is made toward achieving them; and
- Meet objectives to protect and manage threatened, endangered, and sensitive species (H-4700-1, 4.1.5).

1.4 Decision to be Made

The BLM authorized officer will decide which, if any, actions analyzed in the alternatives and described in Section 2 of this EA to implement in order to best meet the purpose and need of this document. The authorized officer's decision may select gather methods, numbers of horses to be gathered in the event the decision includes an excess determination, whether staged gathers will be necessary to remove excess wild horses and if so, the expected timeline, and fertility control measures and method(s). The authorized officer will also decide what project design features to apply to any selected actions to incorporate best management practices and reduce adverse environmental effects.

The authorized officer's decision would affect wild horses within the Kiger/Riddle Mountain HMAs, as well as those that have strayed outside of the HMAs' boundaries. The BLM authorized officer's decision would not set or adjust AML, nor would it adjust livestock use, as these were set or reaffirmed in the Andrews/Steens CMPA RMP/ROD (2005).

1.5 Conformance with Land Use Plans

The action alternatives are in conformance with the objectives and management actions from the Three Rivers RMP/ROD (1992) (pages 2-43 through 49) and Steens Mountain CMPA RMP/ROD (2005), (page 50) as amended by the 2015 Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment (GRSG ARMPA) and ROD, as it is specifically provided for in the management direction (MD) identified below.

[2] Under the preferred alternative (or proposed action), BLM's plan will be to achieve and maintain AML over a ten-year period through a combination of removals of excess wild horses and mare fertility control treatments to slow population growth. In the event of an excess determination pursuant to 16 U.S.C. 1333(b)(2), the BLM would begin the process of removing all excess animals as promptly as reasonably possible. It may not be feasible to remove all excess wild horses in a single gather due to limitations such as on gather efficiency, logistics, space capacity for holding removed animals, or contractor availability. In that case, BLM may issue a gather plan that contemplates a staged gather over an appropriate period of time to achieve AML. If new information or circumstances arise during this ten-year period, BLM will use its Determination of NEPA Adequacy process to identify any need for additional environmental analyses.

- Three Rivers RMP/ROD (1992) (p. 2-43):
  - Wild Horse and Burro (WHB) 1: Maintain healthy populations of wild horses within the Kiger, Palomino Buttes, Stinkingwater, and Riddle Mountain HMAs, and wild horses and burros in the Warm Springs HMA.
  - WHB 1.1: Continue to allocate the following acres and animal unit months (AUM) in active HMAs: … Kiger HMA, 26,873 ac., 984 AUMs; Riddle HMA, 28,346 ac., 672 AUMs. This is equivalent to a high AML of 138 animals combined.
  - WHB 1.2: Retain inactive status on the following herd areas (HAs): … State owned portion of Riddle Mountain. … Remove horses with approved methods if they are identified in these areas.
  - WHB 1.3: Adjust wild horse and burro population levels in accordance with the results of monitoring studies and allotment evaluations, where such adjustments are needed in order to achieve and maintain objectives for a thriving natural ecological balance and multiple-use relationships in each HA. Permanent adjustments would not be lower than the established minimum numbers in order to maintain viability. The AML would be based on the analysis of trend in range condition, utilization, actual use, and other factors that provide for the protection of the public range from deterioration.

- Steens Mountain CMPA RMP/ROD (2005) (p. RMP-50)
  - WHB: Manage and maintain healthy wild horse herds in established HMAs at AMLs to maintain a thriving natural ecological balance between wild horse populations, wildlife, livestock, vegetation resources, and other resource values. Enhance and perpetuate the special or rare and unique characteristics that distinguish the respective herds.
  - WHB 1: Designate/retain/adjust HMAs.
  - WHB 2: Designate/retain/adjust Herd Areas in inactive status.
  - WHB 3: Maintain/adjust AMLs and yearlong forage allocations for each HMA.
  - WHB 4: Maintain a thriving natural ecological balance within HMAs.
  - WHB 5: Maintain/improve year-round water sources to sustain wild horse herds.
  - WHB 6: Maintain herd viability, genetic diversity, and the genetic and physical characteristics that distinguish individual herds.

- Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment (GRSG ARMPA) (September 2015), WHB Objectives (p. 2-21):
  - Objective WHB 1: Manage wild horses and burros as components of BLM-administered lands in a manner that preserves and maintains a thriving natural ecological balance in a multiple-use relationship.
  - Objective WHB 2: Manage wild horse and burro population levels within established appropriate management levels.
  - MD WHB 1: Manage HMAs in GRSG habitat within established AML ranges to achieve and maintain GRSG habitat objectives.
  - MD WHB 3: Prioritize gathers and population growth suppression techniques in HMAs in GRSG habitat, unless removals are necessary in other areas to address higher priority environmental issues, including herd health impacts.

- MD WHB 7: Consider removals or exclusion of WHB during or immediately following emergency situations (such as fire, floods, and drought) to facilitate meeting GRSG habitat objectives where HMAs overlap with GRSG habitat.
- MD WHB 8: When conducting NEPA analysis for wild horse/burro management activities, water developments, or other rangeland improvements for wild horses, address the direct and indirect effects on GRSG populations and habitat.
- MD WHB 10: When WHB are a factor in not meeting GRSG habitat objectives or influence declining GRSG populations in priority habitat management areas (PHMA), Oregon's gather priority for consideration by the Washington Office (WO) is as follows:
  - Response to an emergency (e.g., fire, insect infestation, disease, or other events of unanticipated nature).
  - Greater Sage-Grouse habitat.
  - Maintain a thriving natural ecological balance.

The action alternatives are also consistent with the objectives, goals, and decisions related to BLM's other programs on the BLM-managed public lands within and adjacent to the HMAs (including but not limited to): livestock grazing, recreation, wildlife, special status species, and fire. It has been determined that the action alternatives would not conflict with other decisions throughout the RMP/ROD, as amended. A choice of Alternative C: Fertility Control Vaccines Only or Alternative E: No Action would not conform to the RMP/ROD because wild horse numbers would not be managed within the AML.

1.6 Relationship to Statutes, Regulations, Policies, or Other Plans[3]

Federal policies include BLM manuals, handbooks, and instruction memoranda (IM). Compliance with applicable statute, regulation, and policy includes consultation, coordination, and cooperation with Tribes, stakeholders, and interested members of the public, and completion of the applicable level of NEPA review. All Federal policies will be followed, as appropriate, even if not explicitly listed. BLM's wild horse program is governed by several IMs that address multiple facets and considerations, such as animal welfare, safety, schedules, motor vehicles/aircraft, roles and responsibilities, and media. All program-required IMs will be followed, as appropriate, even if not explicitly listed.

The proposed action and all action alternatives have been designed to conform to all applicable State, Tribal, Federal, and local land use plans (LUP), regulations, consultation requirements, and other authorities, which direct and provide the framework and official guidance for management of BLM lands within the BLM Burns District, including, but not limited to the:

- Wild Free-Roaming Horses and Burros Act (WFRHBA) of 1971 (16 U.S.C. § 1331 et seq.).
- Wild Free-Roaming Horse and Burro Management Regulations (43 CFR 4700).
- BLM Wild Horses and Burros Management Handbook (H-4700-1) (BLM 2010).
- National Environmental Policy Act (NEPA) (42 U.S.C. §§ 4321-4347, as amended).
- BLM NEPA Handbook (H-1790-1) (BLM 2008).
- Federal Land Policy and Management Act of 1976 (FLPMA), 43 U.S.C. 1701 et seq.). Public Rangelands Improvement Act (43 U.S.C. §§ 1901 et seq.) (1978).

[3] BLM's policies, including IMs, manuals, and handbooks can be accessed online at: https://www.blm.gov/policy.

- Standards for Rangeland Health and Guidelines (S&G) for Livestock Grazing Management for Public Lands Administered by the BLM in the States of Oregon and Washington (BLM 1997).
- Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment and Record of Decision (BLM 2015e).
- Migratory Bird Treaty Act (MBTA) (16 U.S.C. §§ 703-712) (1918).
- Taylor Grazing Act (43 U.S.C. §§ 315 et seq.) (1934).
- National Historic Preservation Act (16 U.S.C. §§ 470 et seq.) (1966).
- Integrated Invasive Plant Management for the Burns District Revised EA (DOI-BLM-OR-B000-2011-0041-EA) (BLM 2015a).
- Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. §§ 668-668d, as amended).
- Greater Sage-Grouse Land Use Plan Implementation Guide (2016b).
- Oregon Department of Environmental Quality (ODEQ) laws and regulations.
- Final OR/WA BLM Director's List of Special Status Species (2021b).
- Permanent Instruction Memorandum (PIM) 2021-007 – Euthanasia of Wild Horses and Burros Related to Acts of Mercy, Health or Safety (BLM 2021a).
- PIM 2021-002 – Wild Horse and Burro Comprehensive Animal Welfare Program (BLM 2021).
- PIM 2019-004 – Issuance of Wild Horse and Burro Gather Decisions (BLM 2019).
- Headquarters Office (HQ) Instruction Memorandum Manual (IM) 2022-044 – Wild Horse and Burro Gather Planning, Scheduling and Approval (BLM 2022a).
- Washington Office (WO) IM 2018-062 – Addressing Hunting, Fishing, Shooting Sports, and Big Game Habitats, and Incorporating Fish and Wildlife Conservation Plans and Information from Tribes, State Fish and Wildlife Agencies, and Other Federal Agencies in BLM NEPA Processes (BLM 2018).
- WO IM 2013-061 – Wild Horse and Burro Gathers: Internal and External Communicating and Reporting (BLM 2013c).
- WO IM 2013-060 – Wild Horse and Burro Gathers: Management by Incident Command System (BLM 2013b).
- WO IM 2013-058 – Wild Horse and Burro Gathers: Public and Media Management (BLM 2013a).
- Wild Free-Roaming Horses and Burros Management Manual (MS-4700) (BLM 2010).
- Wildlife and Fisheries Management Manual (MS-6500) (BLM 1988).
- Special Status Species Management Manual (MS-6840) (BLM 2008).
- The Foundation for Managing Cultural Resources Manual (MS-8100) (BLM 2004).
- State, local, and Tribal laws, regulations, and land use plans.Riddle Mountain and Kiger Wild Horse Herd Management Areas Plan (BLM 1996).
- Kiger Mustang Area of Critical Environmental Concern Management Plan (BLM 1996a).
- Kiger and Riddle Mountain Herd Management Area Plan Evaluation and Kiger Mustang Area of Critical Environmental Concern Review (BLM 2014).
- All other Federal laws that are relevant to this document, even if not specifically identified.

The action alternatives are consistent with overall provisions for managing resources and uses of the public land in accordance with the FLPMA of 1976. FLPMA requires that an action under consideration be in conformance with the applicable BLM land use plan(s) (43 U.S.C. 1732(a)), and be consistent with

other Federal, State, and local laws and policies to the maximum extent possible (43 U.S.C. 1712(c)(9)). The FLPMA also provides that the public lands be managed under principles of multiple use and sustained yield to protect the quality of scenic, ecological, environmental, and archeological values; to preserve and protect public lands in their natural condition; to provide feed and habitat for wildlife and livestock; and to provide for outdoor recreation (43 U.S.C. 1701(a)(8) and 1732(a)). Finally, FLPMA also stresses harmonious and coordinated management of the resources without permanent impairment of the environment (43 U.S.C. 1701(c)).

The proposed action and action alternatives (except the no action alternative) are consistent with WFRHBA regulations at 43 CFR 4700, which mandate that BLM "prevent the range from deterioration associated with overpopulation" and "remove excess wild horses in order to preserve and maintain a thriving natural ecological balance and multiple-use relationships in that area." BLM's management mandate to achieve a TNEB is not limited to removing excess animals; it also includes measures to reduce annual population growth and to allow for recovery of degraded vegetation and riparian areas impacted by the wild horse overpopulation. These objectives require a sufficient timeframe to achieve. Additionally, Federal regulations and statutory provisions state:

- 43 CFR 4700.0-6: "(a) Wild horses shall be managed as self-sustaining populations of healthy animals in balance with other uses and productive capacity of their habitat."

- 43 CFR 4710.3-1 Herd management areas: "Herd management areas shall be established for the maintenance of wild horse and burro herds. In delineating each herd management area, the authorized officer shall consider the appropriate management level for the herd, the habitat requirements of the animals, the relationships with other uses of the public and adjacent private lands, and the constraints contained in CFR 4710.4. The authorized officer shall prepare a herd management area plan, which may cover one or more herd management areas."

- 43 CFR 4710.4 Constraints on management: "Management of wild horses and burros shall be undertaken with the objective of limiting the animals' distribution to herd areas. Management shall be at the minimum level necessary to attain the objectives identified in approved land use plans and herd management area plans."

- 43 CFR 4720.1: "Upon examination of current information and a determination by the authorized officer that an excess of wild horses or burros exists, the authorized officer shall remove the excess animals immediately."

- 43 CFR 4740.1 Use of motor vehicles or aircraft:
  - "(a) Motor vehicles and aircraft may be used by the authorized officer in all phases of the administration of the Act, except that no motor vehicle or aircraft, other than helicopters, shall be used for the purpose of herding or chasing wild horses or burros for capture or destruction. All such use shall be conducted in a humane manner."
  - "(b) Before using helicopters or motor vehicles in the management of wild horses or burros, the authorized officer shall conduct a public hearing in the area where such use is to be made."

- WFRHBA 1333(b)(2)(iv) states that once the Secretary determines "…that an overpopulation exists on a given area of the public lands and that action is necessary to remove excess animals, he shall immediately remove excess animals from the range so as to achieve appropriate management levels."

- 43 U.S.C. 1901: "(4) continue the policy of protecting wild free-roaming horses and burros from capture, branding, harassment, or death, while at the same time facilitating the removal and disposal of excess wild free-roaming horses and burros which pose a threat to themselves and their habitat and to other rangeland values."

1.7 Consultation, Coordination, and Identified Issues

External scoping was conducted for the Kiger and Riddle Mountain HMAs Population Management Plan EA from January 28 through February 29, 2020. Sixty-six mailings were sent to Tribes, local and state governments, media, and members of the public. Eight unique scoping letters were received and addressed in this EA.

While many issues may arise in scoping and comments, not all issues raised warrant analysis in an EA. Issues should be analyzed if, 1) Analysis is necessary to make a reasoned choice between alternatives, or 2) The issue is associated with a significant direct, indirect, or cumulative impact (2008 NEPA Handbook, H-1790-1, p. 41).

Internal scoping conducted by the Andrews Field Office Interdisciplinary Team (IDT) identified potential resources and issues that may be impacted by implementation of the proposed action and alternatives. (BLM 2024c) The IDT also reviewed issues from the previous scoping periods related to wild horse population management plans described above, as well as from current office records, geographic information system (GIS) data, and local knowledge of resources within the HMAs.

1.7.1 Issues for Analysis

The issues below have been carried forward into Section 3 for detailed analysis.

- Wild Horses
  - What would the effects of the alternatives be on the genetic diversity, health, and the self-sustaining nature of the Kiger and Riddle Mountain HMAs' herds?
  - What would be the effects of the population growth suppression methods being considered in the alternatives on wild horse behavior?
  - What would be the direct effects of the alternatives on wild horses?
  - How would the alternatives affect wild horse and burro habitat?

- Soils and Biological Crusts
  - What would be the effects of the alternatives on soils and biological crusts?

- Upland Vegetation
  - What would be the effects of the alternatives on upland vegetation health?
  - How would the alternatives impact fine fuel loading and the risk of catastrophic[4] wildfire?

- Noxious Weeds
  - What would be the effects of the alternatives on noxious weeds?

- Wildlife
  - What would be the effects of the alternatives on GRSG and their habitat?
  - What would be the effects of the alternatives on large ungulate habitat in the HMAs?
  - What would be the effects of the alternatives on migratory birds, their habitat, and nesting sites?

- Livestock Grazing Management and Rangelands
  - What would be the effects of the alternatives on livestock grazing management and associated ranch operations?

- Social and Economic Values
  - What would be the costs associated with the various population management actions?
  - What are the anticipated costs associated with gathering wild horses?
  - What are the economic effects to other range users and the local economy?

1.7.2 Issues Considered but Eliminated from Detailed Analysis

Where resources are determined to be present but not impacted, or resources are determined not to be present, a rationale for not considering them further is provided in Appendix B.

2 DESCRIPTION OF ALTERNATIVES

This section of the EA describes the no action alternative, the proposed action, and other action alternatives, as well as alternatives that were considered but eliminated from detailed analysis. Reasonable alternatives are practical or feasible from the technical and economic standpoint and using common sense and address the purpose and need identified in Chapter 1. The proposed action and alternatives provided in this section represent a reasonable range to cover the full spectrum of alternatives that meet the purpose and need. Five alternatives are considered in detail in this EA.

- Alternative A: Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period
- Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population
- Alternative C: Fertility Control Vaccines Only
- Alternative D: Gather and Removal Only
- Alternative E: No Action - Defer Gather and Removal

[4] Catastrophic wildfires are wildfires with a perennial grass mortality, largely due to the accumulation of fine fuels in the crown of the individual plant that burns hot, resulting in mortality.

All action alternatives (A through D) were developed to respond to the identified resource issues and the purpose and need to differing degrees. Alternative E: No Action would not achieve the identified purpose and need. However, it is analyzed in this EA to provide a basis for comparison with all action alternatives, and to assess the effects of not conducting a gather. Alternative E does not conform to the WFRHBA, which requires the BLM to take action promptly to remove excess wild horses.

2.1 Actions Common to Alternatives A-D

2.1.1 Monitoring

The BLM contracting officer's representative (COR) and project inspectors (PI) assigned to the gather would be responsible for ensuring contract personnel abide by the contract specifications and the gather standard operating procedures (SOP) outlined in the Wild Horse and Burro Comprehensive Animal Welfare Program (PIM 2021-002, Comprehensive Animal Welfare Program for Wild Horses and Burro Gathers (BLM 2021)), included in this EA as Appendix C). This would apply to all action alternatives (A-D).

Ongoing monitoring of forage condition, utilization, water availability, and animal health, and aerial population surveys as required in WO IM 2010-057, Wild Horse & Burro Population Inventory and Estimation (BLM 2010b), would continue in the HMAs under all alternatives.

Genetic monitoring would also continue following gathers and/or trapping. If the results of genetic monitoring indicate that levels of genetic diversity (as measured in terms of observed heterozygosity) become unacceptably low, the BLM would consider introduction of wild horses that have appropriate phenotypes and are from HMAs in similar environments, to maintain the projected genetic diversity. The monitoring and possible translocation would follow applicable guidance from the BLM Wild Horse and Burro Herd Management Handbook, H-4700-1 (BLM 2010). This monitoring would occur under all action alternatives (A-D).

Fertility control monitoring would be conducted in accordance with Standard Operating Procedures for Population-Level Fertility Control Treatments (Appendix D). This monitoring would occur under alternatives A and C.

2.1.2 Project Design Features

The following project design features (PDF) would be used for all action alternatives (A-D).

- Timeframe for comparison of all action alternatives is 10 years. Implementation of the population management plan would begin at the time of the first gather (this would be planned to take place in 2024, pending funding from BLM headquarters office) and would continue over the next 10 years unless environmental conditions change enough to require analysis of additional management actions.
- Helicopter gather operations could take approximately 15 days to complete. Several factors such as animal condition, herd health, weather conditions, or other considerations could result in operations requiring more or less time.

- Helicopter gather operations could be scheduled any time between July 1 through February 28, and would be conducted under contract.
- Trap sites would be selected within the pastures and areas where horses are known to be frequently located, to the greatest extent possible.
- Trap sites and temporary holding facilities, made of portable panels, would be located in previously used sites or other disturbed areas whenever possible. These areas would be seeded, with a seed mix appropriate to the specific site, if bare soil exceeds more than ten square yards per location.
- Undisturbed areas identified as trap sites or holding facilities would be inventoried, prior to being used, for cultural, wildlife, and botanical resources. If cultural, wildlife, or botanical resources are encountered, these locations would not be utilized unless the trap location could be modified to avoid effects to the resources present.
- Trap sites and temporary holding facilities would be surveyed for noxious weeds prior to gather activities; any weeds found would be treated using the most appropriate methods. All gather activity sites would be monitored for at least 3 years post-gather; any weeds found would be treated using the most appropriate methods.
- All vehicles and equipment used during gather operations would be cleaned before and following implementation to guard against spreading of noxious weeds.
- Efforts would be made to keep trap and holding locations away from areas with noxious weed infestations.
- Gather sites would be noted and reported to range and weed personnel for monitoring and/or treatment of new and existing infestations.
- Maintenance may be conducted along roads accessing trap sites and holding facilities, prior to the start of gather operations, to ensure safe passage for vehicles hauling equipment and horses to and from these sites. Road maintenance would be done in accordance with BLM Burns District's road maintenance policy.
- Gather and trapping operations would be conducted in accordance with the SOPs described in the Comprehensive Animal Welfare Program (CAWP) (refer to Appendix C for PIM NO. 2021-002 (BLM 2021); Attachment 1), which establishes policy and procedures to enable safe, efficient, and successful wild horse gather operations while ensuring humane care and treatment of all animals gathered.
- An Animal and Plant Health Inspection Service (APHIS) or local veterinarian would be onsite during helicopter-drive gathers, as needed, to examine animals and make recommendations to BLM for care and treatment of the wild horses.
- Decisions to humanely euthanize animals in field situations would be made in conformance with BLM policy (WO PIM 2021-007, Euthanasia of Wild Horses and Burros Related to Acts of Mercy, Health, or Safety) (BLM 2021a).
- On all horses gathered (including horses removed and returned), data, including sex and age distribution, would be recorded. Additional information such as color, condition class (using the Henneke et al. (1983) rating system), size, individual identification, RFID chips implanted, disposition of the animal, and other information may also be recorded.
- Excess animals would be transported to an off-range corral facility via semi-truck and trailer where they would be prepared (freeze marked, microchipped, vaccinated, and dewormed) for adoption, sale (with limitations), or off-range pasture.

- Hair follicle samples would be collected to assess genetic diversity of the herd, as outlined in WO IM 2009-062 (Wild Horse and Burro Genetic Baseline Sampling) (BLM 2009a), and consistent with WHB monitoring specified in CMPA RMP/ROD (BLM 2005) Table 7. Hair follicle samples would be collected from a minimum of 25 percent of the post-gather population.
- BLM recognizes that the wild horses in these relatively small HMAs are not truly isolated populations; rather they are parts of larger metapopulations that include multiple BLM-managed (and United States Forest Service (USFS) managed) wild horse herds in Oregon, and in other states. The BLM would use the results of genetic monitoring to determine whether, and when, additional fertile wild horses from other herds should be introduced to augment levels of observed heterozygosity and to reduce the risk of negative effects of inbreeding.
- Public and media management during helicopter gather and bait trapping operations would be conducted in accordance with WO IM 2013-058 (Wild Horse and Burro Gathers: Public and Media Management (BLM 2013a). This IM establishes policy and procedures for safe and transparent visitation by the public and media at WHB gather operations, while ensuring the humane treatment of wild horses and burros.

2.2 Alternative A - Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period

Alternative A is designed to manage wild horse populations with available intensive fertility control treatments, over a ten-year period that would begin at the time of the first gather, and with wild horse removals, which would most likely include one to three excess determinations and associated gather operations during the ten-year timeframe within the Kiger and Riddle Mountain HMAs. If agency funding and logistics allow for it, implementation of the proposed action would begin in 2024. Vaccination with immunocontraceptives (see Appendix F) is the fertility control method considered under this alternative.

During the 10-year timeframe of this plan, future gathers would be scheduled once the high end of AML is surpassed, and BLM has made an excess determination pursuant to 16 U.S.C. § 1333(b)(2). The number of horses gathered, the number of excess horses removed, and the number treated with fertility control would be adjusted based upon the estimated herd size and the number of excess horses determined at the time of the gather, and on the fertility control treatment history for mares that are expected to be present in the HMAs at the time of the gather. It is assumed that the population would be managed within AML as a result of the initial gather and application of fertility control, followed by a new excess determination and associated gathers and fertility control applications every 4-5 years thereafter. In the absence of an initial gather in 2024 or consecutive years, the proposed action includes the intent that following an initial excess determination, the associated gather would achieve low AML regardless of population size. All PDFs would be the same irrespective of the number of animals gathered and removed.

After the completion of any gather and fertility control operations during this ten-year plan, at least 51 (low AML) adult wild horses would remain in the Kiger HMA. If all animals could be gathered, then the animals returned to the range would include approximately 26 mares treated with fertility control vaccine and 25 fertile studs. At least 33 (low AML) adult wild horses would remain in the Riddle Mountain HMA. Similarly, if all animals there could be gathered then approximately 17 would be mares treated with fertility control vaccine and 16 would be fertile studs. Adjustments to the actual number of

mares treated with fertility control and returned to the range would be made in response to the actual number of animals captured during a gather event, but with the goal of maintaining an average herd growth rate of 2 percent to 5 percent per year. It is more likely that some mares would not be gathered in any given gather event, in which case those mares would not be treated with any fertility control vaccine at that time.

Once the herd size in an HMA is at AML and population growth seems to be stabilized at or near the desired rate, BLM would decide as to the required frequency of new mare treatments and mare re-treatments with PZP vaccine or GonaCon-Equine vaccine in that HMA to maintain the number of horses within AML. For example, the rates of PZP vaccine and GonaCon-Equine vaccine use required to achieve population growth level goals (averaging between 2 to 5 percent per year) could be estimated based on records of how many living mares in the herd had been treated with those fertility control methods previously, the number of those treatments for each mare, and the time since last treatment for each mare.

On years in between gather activities, fertility control vaccinations could be delivered via ground-based, remote darting. Currently the available fertility control vaccines that could be delivered by dart in this project include PZP vaccine ZonaStat-H and GonaCon-Equine. The number of mares treated annually in each HMA would fluctuate depending on the number of mares darted or caught and identified for treatment, the type of fertility control vaccine being used and its expected effectiveness, and the total mare population in the HMA.

Bait/water, horseback, and helicopter-drive trapping could also be used to gather mares and apply fertility control vaccine, to reduce the population growth rates between gathers. Mares would be individually marked and/or be individually recognizable without error. Datasheets would be prepared and updated, and each individual mare's previous records would be reviewed prior to any fertility control application activity. No mare would be treated unless she had been identified as being a candidate for treatment.

Vaccine primer inoculations would be administered to selected mares. If a primer inoculation is administered in conjunction with a gather, that mare would be held for up to 60 days before receiving a booster inoculation and being returned to the HMA. Flexibility in determining which mares are selected for treatment is vital to the success of the fertility control program. Adjustments would be made if it is found that there is a severe physiological reaction by an individual mare (which would be unexpected; see summary of possible effects in Appendix F). This information would be documented in the datasheet. If timing or funding constraints arise that would limit the number of vaccine doses that could be administered, then a treatment priority would consider the existing band or herd composition, such that mares would be prioritized for vaccination if it is known that they already had one or more offspring in the herd. However, it is not a requirement of the WFRHBA, Steens Mountain CMPA RMP/ROD (2005), or the Three Rivers RMP/ROD (1992), or under any action alternatives in this EA that each mare in the herd give birth to a foal, nor is that a requirement for maintaining genetically diverse herds. Application of fertility control could take place throughout the project period. The rate and extent of fertility control applications would also partially depend on annual funding, the presence of qualified fertility control applicators, and realized annual herd growth rates.

Possible physiological, behavioral, and other effects of fertility control vaccine treatment are detailed in Appendix F but are summarized briefly here. Mares receiving any fertility control treatment must be individually identifiable, so that their treatment history is known (BLM 2010). At the demographic population level, the expected effects of fertility control vaccine applications would be to reduce the growth rate of the herds by reducing individual mare fertility rate. This would not necessarily cause a problematic loss of genetic diversity, given the apparent fact that horses in the HMAs are highly related to other wild horse herds and are part of a larger metapopulation (NAS 2013, Cothran et al. 2024, Appendix G), and given that the BLM has the potential to introduce animals from other HMAs to each of the herds if results of genetic diversity monitoring call for that. In terms of genetic diversity loss attributable to fertility control vaccine use, vaccine use should reduce the average number of foals per mare but would not necessarily prevent treated mares from giving birth to some number of foals over the course of their lifetime, either before treatment causes long-lasting infertility, or at some point after the immunological effects of treatment have worn off. At the individual level, fertility control vaccines are expected to cause an immune response that leads to reduced fertility. Other potential effects on treated and untreated wild horses are detailed in Appendix F.

If the BLM selects the proposed action alternative, the BLM aims to gather as close to 100 percent of the total wild horse population as possible and remove excess horses down to the low end of AML (51 horses for Kiger and 33 horses for Riddle). As much of the herd as possible would be gathered in order to:

1) Select horses that have desirable phenotypic characteristics (i.e., dun factor, good conformation) to return to the HMA to re-establish the low end of AML,
2) Remove excess wild horses that would be prepared for the adoption or sale program, and
3) Apply initial or booster doses of fertility control treatment to the mares that would be returned to the HMA, at rates that are appropriate to maintain the targeted average annual growth rate of 2 to 5 percent.

This would mean if horses in both HMAs were gathered under this alternative in the summer or fall of 2024, approximately 700 horses would be gathered using the helicopter-drive method, approximately 700 excess wild horses would be permanently removed from the HMAs (including any that have strayed outside the HMAs' boundaries), and horses would be returned to the HMAs to maintain 51 adult wild horses in the Kiger HMA and 33 adult wild horses in the Riddle Mountain HMA to re-establish the herd size at the low end of AML. For gathers and removals authorized for only a portion of the HMAs, the numbers would be adjusted according to the number of horses present. For future helicopter gathers following any future excess determinations under this 10-year plan, the number of horses to be gathered and the number of excess horses removed and treated with fertility control vaccine would be adjusted based upon the estimated herd size at the time of the gather and the treatment history of mares that would remain or be returned to the HMAs.

Each helicopter gather would take approximately 15 days or less. The BLM would plan to gather as soon as holding space and funding became available. The gather would be initiated following public notice on the BLM Oregon-Washington (OR/WA) Press Releases webpage. At the time of printing this EA, that webpage is: https://www.blm.gov/news/oregon-washington. No horses found outside of the HMAs would be returned to the range.

Bait/water, horseback, or helicopter-drive trapping would be conducted as needed between normal helicopter-drive gather cycles. Bait/water, horseback, and helicopter-drive trapping operations could take anywhere from one week to several months depending on the number of animals to trap, weather conditions, or other considerations. Operations would be conducted either by contract or BLM personnel. Bait/water, horseback, and helicopter-drive trapping would be used as tools to:

- Remove excess horses in areas where concentrations of wild horses are detrimental to habitat conditions or other resources within the HMAs pursuant to Section 3 of the WHA;
- Remove stray wild horses from private lands or state-owned public lands, and outside the HMAs' boundaries, pursuant to Sections 4 and 6 of the WHA;
- Selectively remove a portion of excess horses for placement in the adoption program; or
- Capture, treat, and release horses on the HMAs for application of different types of fertility control, including remote darting.

Site-specific removal criteria have not been established for the Kiger and Riddle Mountain HMAs, but 1996 Kiger/Riddle Mountain HMAP specify characteristics for horses to be retained in the herd, to perpetuate and protect the dun factor color and conformation characteristics of the wild horses present in the Kiger and Riddle Mountain HMAs. In addition to guidelines for those characteristics to be retained in the herd, animals removed from the HMAs would be chosen based on a selective removal strategy set forth in BLM Manual Section 4720.33 (BLM 2010a). Wild horses would be removed in the following order:

1) First Priority: Age Class – Four Years and Younger.
2) Second Priority: Age Class – Eleven to Nineteen Years.
3) Third Priority: Age Class Five to Ten Years.
4) Fourth Priority: Age Class Twenty Years and Older (should not be permanently removed from the HMAs unless specific exceptions prevent them from being turned back to the range. In general, this age group can survive in the HMAs, but may have relatively lower fecundity on the range and greater difficulty adapting to captivity and the stress of handling and shipping if removed).

BLM Manual Section 4720.33 (BLM 2010a) further specifies some animals that should be removed irrespective of their age class. These animals include, but are not limited to, nuisance animals and animals residing outside the HMAs or in an area of an inactive HA.

Captured wild horses would be released back into the HMAs under the following criteria.

- If a gather/removal is conducted, released horses would be selected to maintain a diverse age structure of horses at low AML (51 wild horses Kiger and 33 wild horses Riddle Mountain) and approximately a 50/50 sex ratio (26 mares and 25 studs for Kiger and 17 mares and 16 studs for Riddle).
- Released horses would be selected to maintain herd characteristics identified for these HMAs.
- Post-gather, every effort would be made to disperse released horses evenly throughout the HMAs.
- If a gather/removal is conducted, mares aged two or older would be selected to be returned to the HMAs after receiving fertility control treatment. GonaCon-Equine vaccine is the primary form

of immunocontraception that BLM Burns is currently using in the field. The specific type and method of fertility control vaccine treatment may be adjusted as advancements are made with available fertility control treatments and methods. All fertility control treatments would be administered in a manner consistent with guidelines and protocols set forth in IM 2009-090, Population-Level Fertility Control Field Trials: Herd Management Area Selection, Vaccine Application, Monitoring and Reporting Requirements (BLM 2009b), and would be in keeping with guidelines for application of GonaCon-Equine (EPA 2015) or of ZonaStat-H (EPA 2012).

During the 10-year timeframe of the proposed action, BLM anticipates that there could be the need for one to three future excess determinations and associated gathers, 4 to 5 years following an initial excess determination and associated gather. This ten-year timeframe enables BLM to refer to the results of future monitoring to determine the effectiveness of the proposed action at successfully maintaining population levels within AML in the Kiger and Riddle Mountain HMAs. During the ten-year period, helicopter gathers would be carried out under the same (or updated) SOPs as identified in the CAWP (WO IM 2021-002 (BLM 2021) Attachment 1, Comprehensive Animal Welfare Program for Wild Horses and Burro Gathers (Appendix C)), and the selective removal criteria, population control measures, release criteria, and sex ratio adjustment strategies would be applied as described in this alternative.

Management would be employed that incorporates the use of the currently most humane and effective methods of fertility control, monitors the results in terms of estimated changes to foaling rates and annual herd growth rates, and updates the level and timing of fertility control application needed to achieve herd management goals. For example, a fertility control vaccine would be used in the gather following an initial excess determination but may be substituted as advancements are made with safe but more effective and longer lasting fertility control treatments and methods. If a new vaccine type became available during the 10-year timeframe of this analysis, BLM will determine whether additional NEPA analysis is necessary prior to utilizing a new vaccine with these herds. Future determinations that "excess" horses exist within the next ten years in the HMAs would be based on the results of future population surveys and available monitoring data and would trigger future gather dates and target removal numbers for gathers. BLM will assess during the determination whether additional environmental analysis is necessary. Unless it is necessary for BLM to initiate a gather effective upon issuance or on a date established in the decision pursuant to 43 C.F.R. § 4770.3(c) (e.g., from private land, for public safety, or due to an emergency situation), a notice to the public would be published 30 days prior to any future gather.

2.3 Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population

Alternative B would follow the same gather and removal actions proposed in Alternative A, with the additional inclusion of managing a component of the wild horse population of Kiger and Riddle Mountain HMAs as non-reproducing (sterilized mares and neutered males). The intensive immunocontraceptive fertility control methods described in the Alternative A would not occur under this alternative.

Sterilizing a female horse (mare) can be accomplished by several methods, some of which are surgical and others of which are non-surgical (see Appendix F). The humane mare sterilization methods considered for use under this alternative would be limited to those that are minimally invasive,

pharmacological, or immunocontraceptive, and would not include surgical removal of the ovaries. Physical effects of surgical methods could include post-treatment healing and the possibility for complications (see Appendix F).

Minimally invasive, physical sterilization would include any physical form of sterilization that does not involve extensive incision, or removal of the ovaries. This could include any form of physical procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy. For example, one form of physical, non-surgical sterilization causes a long-term blockage of the oviduct, so that fertile eggs cannot go from the ovaries to the uterus. One form of this procedure infuses medical cyanoacrylate glue into the oviduct to cause long-term blockage (Bigolin et al. 2009). Another form involves using a laser to cause scarring of less than about 1 cm^2 at the utero-tubal junctions. Treated mares would need to be screened by a veterinarian (i.e., via transrectal ultrasonography) to ensure they are not pregnant. The procedure is transcervical, so the treated mare cannot have a fetus in the uterus at the time of treatment. The mare would be sterile, although she would continue to have estrus cycles.

Neutering is defined to be the sterilization of a male horse (stallion), either by removal of the testicles (castration, also known as gelding) or by vasectomy, where the testicles are retained but, due to severing or blocking the vas deferens or epididymis, no sperm leave the body.

Pharmacological or immunocontraceptive sterilization methods would use an as-yet undetermined drug or vaccine to cause sterilization. At this time, BLM has not yet identified a pharmacological or immunocontraceptive method to sterilize mares that has been proven to reliably and humanely sterilize wild horse mares. However, there is the possibility that future development and testing of new methods could make an injectable sterilant available for wild horse mares. Analyses of the effects of having sterile mares as a part of a wild horse herd, such as due to surgical sterilization, would likely be applicable to non-surgical methods as well. However, this method is not considered under this alternative and additional NEPA analysis would be required before such a method could be used in the Kiger and Riddle Mountain HMAs.

This alternative would include an initial action with the intent to gather 95 percent of the wild horses on the HMAs. If gather success allows for it, then the starting herd size after animals are returned to the range would be at the low end of AML (51 for Kiger HMA and 33 for Riddle Mountain HMA). Returned animals would include a non-reproducing component of 50 percent of the post-gather herd size. When at low AML, the herd population of the HMAs would be made up of approximately 84 wild horses with a minimum of 21 unsterilized (i.e., potentially fertile) mares and 21 unsterilized studs, and the remaining 42 horses being any combination of geldings or sterilized mares.

At the herd level the potential breeding animals in the herd are likely to produce enough foals to offset mortality; with approximately half the mares sterile, the average annual growth rate would be approximately half of the 20 percent background growth rate, or roughly 10 percent per year.

2.4 Alternative C: Fertility Control Vaccines Only

Alternative C would follow the same gathering and intensive fertility control actions proposed in Alternative A, but without removing any wild horses. The only action under this alternative that would directly influence the size of the wild horse herd would be application of available fertility control

vaccines. No removals would occur under this alternative. Because of wild horses' longevity, the population of the HMAs would not be reduced to within AML during the 10-year time span of this action, even though population growth rate per year would be reduced (Appendix H).

2.5 Alternative D: Gather and Removal Only

Alternative D would follow the same gather and removal actions proposed in Alternative A, but without applying any fertility control treatments. The only actions under this alternative that would directly influence the size of the wild horse herd would be to gather and remove excess horses. Even though removals would reduce herd size, after gathers the herd would be expected to increase at the background rate of approximately 20 percent per year (Appendix H).

2.6 Alternative E: No Action – Defer Gather and Removal

Under Alternative E: No Action, no gather would occur, and no additional management actions would be undertaken to control the size, fertility rate, or sex ratio of the wild horse population at this time. Based on the May 2024 simultaneous double-observer aerial survey the number of wild horses on the range indicate there will be over 792 horses associated with the Kiger and Riddle Mountain HMAs by summer 2024, with an increase of roughly 20 percent more per year expected over time. Within 4 years, wild horse numbers would be expected to increase to approximately 1,642 horses in and around the HMAs by fall 2028. Barring a catastrophic mortality event, within 10 years (fall 2034), wild horse numbers would be projected to increase to more than 3,940 horses (Appendix H), many of which would certainly be living far from the HMAs boundaries. Wild horses ranging outside the HMAs would remain in areas not designated for their management.

2.7 Alternatives Considered but Eliminated from Detailed Analysis

2.7.1 Closure of HMA to Livestock Use

This alternative was not brought forward for detailed analysis because such an action would not be in conformance with the multiple-use mandate of FLPMA (1976) and the existing Three Rivers RMP/ROD (1992) and Andrews/Steens CMPA RMP/ROD (2005), which authorize AUMs for wild horses and for permitted livestock grazing in the allotments within the Kiger and Riddle Mountain HMAs (Three Rivers RMP Appendix 9, Appendices pp. 116-118 (BLM 1992); Andrews Management Unit RMP (hereafter referred to as Andrews RMP) Appendix J, pp. J-3, J-7,and J-8 (BLM 2005a)). Livestock grazing is identified as a major use of the public land and is to be conducted in a manner that will meet multiple-use and sustained yield objectives (BLM 1992, p. 2-33). Additionally, livestock grazing management is adjusted annually based on forage and water conditions/availability within each allotment; adjustments are made to timing and duration of use and numbers of livestock. This is designed to achieve standards for rangeland health and conform to guidelines for livestock grazing management. The closure of the HMAs to livestock grazing without maintaining wild horse and burro populations within AML would be inconsistent with the WFRHBA (1971), which directs the Secretary to immediately remove excess animals. Livestock grazing can only be reduced or eliminated following the process outlined in the regulations found at 43 CFR Part 4100. This alternative would not achieve the purpose and need.

2.7.2 Complete Removal of Wild Horses from the HMAs

Complete removal of wild horses and burros from Kiger and Riddle Mountain HMAs was eliminated from detailed analysis because it would not be in conformance with the WFRHBA (1971). This alternative would, therefore, not achieve the purpose and need of this document. In addition, the Three Rivers RMP/ROD (BLM 1992) and Andrews RMP/ROD (BLM 2005a) specifically allocate AUMs and reaffirm the forage allocation (AML) for wild horse use in Kiger and Riddle Mountain HMAs on page 2-43 (Three Rivers) and page RMP-51 (Andrews). Three Rivers LUP provides a management objective to "Maintain healthy populations of wild horses within the Kiger, Palomino Buttes, Stinkingwater, and Riddle Mountain Herd Management Areas, and wild horses and burros in Warm Springs HMA" (BLM 1992, p. 2-43). The LUP does not include management direction to eliminate AML for wild horses and burros. Elimination of wild horses and closure of an HMA can only be conducted during the land use planning process or within an RMP revision or amendment; this project is neither.

2.7.3 Removal of Wild Horses from the HMAs Using Bait and Water Trapping Only

The use of bait and/or water trapping as the sole gathering method was considered and removed from detailed analysis. The use of only bait and water trapping, although effective in other HMAs with varying circumstances, would not be cost effective or practical as the primary gather method for these HMAs. Bait trapping would require an extended time to capture the proposed number of horses. Effectiveness of this type of trap is also limited to times when forage and water are not readily available outside of the trap location. Logistics of bait or water trapping 348 horses over 55,219 acres are not sustainable due to travel distances, road conditions, and nature of the topography in the HMAs. However, water or bait trapping may be used as a supplementary approach to help achieve the desired goals of Alternatives A through D. Water and bait trapping is an effective tool for specific management purposes such as removing groups of horses from an accessible concentration area. The use of only bait and water trapping was dismissed from detailed analysis because much of these HMAs have limited road access capable of handling pickups and livestock trailers. The lack of adequate road access and road conditions would make it technically infeasible to construct traps and safely transport captured wild horses from these areas of the HMAs.

2.7.4 Gather by Horseback Only

Use of horseback-drive trapping to remove excess wild horses can be effective on a small scale; but due to the large geographic size of the HMAs (55,219 acres combined), access restrictions (e.g., rough, two-track roads), topography with deep canyons, and approachability of the horses, this technique would be ineffective and impractical. Horseback-drive trapping is also labor intensive as compared to helicopter-drive trapping. Helicopter-drive trapping would require approximately 15 days to gather these HMAs vs. 2–3 months with 5 or more people during horseback-drive trapping. Horseback-drive trapping can also be dangerous to the domestic horses and riders herding the wild horses. For these reasons, this alternative is technically infeasible and was eliminated from further consideration.

2.7.5 Wild Horse Numbers Controlled by Predation or Other Natural Processes

Mountain lions are known to prey on horses, primarily foals, in a few herds (Andreasen et al. 2021, Schulman et al. 2024), but predation contributes to biologically meaningful population limitation in only

a handful of herds and is not known to do so in the Kiger HMA or Riddle Mountain HMA. Andreasen and others (2021) concluded that "At landscape scales, cougar predation is unlikely to limit the growth of feral horse populations." The 2018 estimated maximum cougar population in the Southeast Oregon Cougar Management Zone F is 985 (including all age classes), based on an estimated 2015 population of 946 (ODFW 2017). Even with high and growing cougar populations across Oregon and in the Southeast Oregon Cougar Management Zone F, there is no evidence to suggest cougars have a biologically significant effect on wild horse population growth rate in this area. Canadian biologists (Knopff et al. 2010) confirmed that wild horses were killed by cougars, but all kills were of animals less than 2 years of age. That cougar predation on large ungulate species tends to focus on animals less than 1 year old has been well-documented (Hornocker 1970, Husseman et al. 2003, Andreasen et al. 2021). Wolf predation on wild horse foals has not been documented to be common in this area. The NAS review (2013) confirms that even when cougars kill wild horses, they generally only kill foals or yearlings, and goes on to explain population size is not affected as much by foal survival as it is by adult survival (Eberhardt et al. 1982). In most managed wild horse herds, foal survival is high, with an average of over 85 percent (Ransom et al. 2016). The BLM does not make decisions on predator management but is limited to making comments and recommendations to Oregon Department of Fish and Wildlife (ODFW). In most BLM-managed herds, relying on natural predation to maintain AML has not worked in the past (as shown by current population numbers over AML), is extremely speculative, and would not meet the purpose and need for action.

Many horse herds grow at sustained high rates of 15-25 percent per year and are not a self-regulating species (NAS 2013, Ransom et al. 2016). The National Academies of Sciences report (NAS 2013) concluded that the primary way that equid populations self-limit is through increased competition for forage at higher densities, which results in smaller quantities of forage available per animal, poorer body condition, and decreased birthrate and survival. It also concluded that the effect of this would be impacts to resource and herd health that are contrary to BLM management objectives and statutory and regulatory mandates. This alternative would result in a steady increase in the wild horse populations that would continue to exceed the carrying capacity of the range resulting in a catastrophic mortality of wild horses in the HMAs, and irreparable damage to rangeland resources. Allowing horses to die of dehydration and starvation would be inhumane treatment and would be contrary to the WFRHBA, which mandates removal of excess wild horses. The damage to rangeland resources that results from excess numbers of wild horses is also contrary to the WFRHBA, which mandates the Bureau to "protect the range from the deterioration associated with overpopulation," "remove excess animals from the range to achieve appropriate management levels," and "preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area." 43 CFR 4700.0-6(a) states "Wild horses shall be managed as self- sustaining populations of healthy animals in balance with other uses and the productive capacity of their habitat." As the vegetative and water resources are over utilized and degraded to the point of no recovery as a result of wild horse overpopulation, wild horses would start showing signs of malnutrition and starvation. The weaker animals, generally the older animals and the mares and foals, would be the first to be impacted. It is likely many of these animals would die from starvation and dehydration, which could lead to a catastrophic die off. Competition between wildlife and wild horses for forage and water resources would be severe. Wild horses can be aggressive around water sources, and some other wild animals may not be able to access water. Wildlife habitat conditions would deteriorate as wild horse numbers above AML reduce herbaceous vegetative cover, damage water sources, and increase erosion, and could result in irreversible damage to the range. This alternative would not meet the purpose and need and was eliminated from further consideration.

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS

This section details the affected environment that is the baseline, existing condition, and trend of issue-related elements of the human environment (i.e., the biological, physical, social, and economic elements of the environment) that may be affected by implementing the actions proposed in each alternative discussed in Section 2. This section also includes reasonably foreseeable environmental trends and planned actions in the area, with Section 4 of the EA including a complete discussion of cumulative effects. Without this baseline data there can be no effective comparison of alternatives. The intent of this section, and Section 4, is to give enough information for the reader to compare the present with the predicted future conditions resulting from enactment of the activities proposed in each alternative, and for the decision maker to make an informed decision.

This section also details the environmental effects analysis, which identifies the known and predicted effects of the actions proposed in each alternative that are related to the issues identified in Section 2. Effects analysis includes changes to the environment that result from reasonably foreseeable future actions (RFFA) and have a reasonably close causal relationship to the proposed alternatives. The RFFAs for the Kiger and Riddle Mountain HMAs and adjacent areas are continued wild horse use, livestock grazing, weed treatments, development and road maintenance, and recreation activities.

This document is tiered to the 2005 Steens Mountain/Andrews CMPA RMP/ROD and 1992 Three Rivers RMP/ROD (BLM 1992) FEIS and the 2015 Oregon GRSG ARMPA/ROD (BLM 2015e). The environmental consequences and cumulative effects sections in the Three Rivers RMP/ROD and Andrews RMP/ROD describe potential environmental consequences to the greater environment of Three Rivers and Andrews/Steens Field Offices and are incorporated into this document by reference. The Oregon GRSG ARMPA/ROD describe potential environmental consequences to the greater environment of Oregon and are incorporated into this document by reference. This section of the EA describes the current state of the environment, which includes the effects of past actions. The environmental consequences discussions, and Section 4 of this EA, describe all expected effects including direct, indirect, and cumulative effects on resources from enacting the proposed actions.

The IDT reviewed the elements of the human environment, as required by law, regulation, Executive Order, and policy, to determine if they would be affected by any of the proposed actions or alternatives. The results are summarized in Table 1.

Table 1: Supplemental Authorities and Other Elements Potentially Affected by Action

SUPPLEMENTAL AUTHORITIES	PRESENT	AFFECTED	RATIONALE
ACECs	YES	NO	Kiger Mustang ACEC is present in Kiger and Riddle Mountain HMAs.
Air Quality	YES	NO	The planning area is outside a non-attainment area. Implementation of the proposed action would result in small, localized, and temporary areas of disturbance that would not be expected to be measurable.
Climate Change/Greenhouse Gas Emissions	YES	NO	The Nevada BLM found that Greenhouse gas emissions related to the proposed actions would be less than 124 tons, the equivalent of 27 passenger cars driven for one year. These emissions would not be expected to change the current course of climate change and so would have only a *de minimis* impact on climate impacts in Nevada (Marietta Wild Burro Range Gather Plan DOI-BLM-NV-C010-2022-0017-EA, Marietta Gather Emissions Estimate 2022). It is expected that the South Steens gather is sufficiently similar and would result in similar outcomes. Therefore, that issue is not fully analyzed, and the Marietta Wild Burro Range Gather Plan EA is incorporated by reference.
Cultural Resources	YES	NO	To prevent any impacts to cultural resources, trap sites and temporary holding facilities would be located in previously disturbed areas where a cultural specialist has determined disturbances are not likely to affect known or undetected cultural resources (Undertakings Exempted from Field Survey; Range Management Waiver #3). Additional cultural resource surveys would be conducted at trap sites or holding facilities outside existing areas of disturbance prior to their use.
Environmental Justice	NO	NO	Not present.
Fish Habitat	YES	NO	The proposed gather activities would not have an effect on fish habitat.
Floodplains	NO	NO	Not present within the Kiger and Riddle Mountain HMAs.
Livestock Grazing	YES	YES	Livestock grazing is discussed in Section 3.2 below.
Forest and Rangelands	YES	YES	Forests are not present within the Kiger and Riddle Mountain HMAs. Rangelands are discussed in Section 3.3.
Human Safety	YES	NO	Implementing the road closures identified in Section 2.2 during gather activities would eliminate the impacts to human safety created by the proposed actions.
Migratory Birds	YES	YES	Migratory birds are discussed below in Section 3.5.
Minerals	YES	NO	There are no active mining claims, leases, or mineral contracts in the project area. There would be no known impediments to administration of locatable, salable, or leasable mineral actions under any alternative.
Native American Religious Concerns	NO	NO	There are no known Native American religious concerns regarding this project.
Wildlife and Locally Important Species	YES	YES	Wildlife and Locally Important Species are discussed below in Section 3.6.
Noxious Weeds	YES	YES	Noxious weeds are discussed below in Section 3.7.
Soils and Biological Crust	YES	YES	Soils and Biological Crust are discussed below in Section 3.8.
Social and Economic Values	YES	YES	Social and Economic Values are discussed in Section 3.9 below.

SUPPLEMENTAL AUTHORITIES	PRESENT	AFFECTED	RATIONALE
Recreation	YES	NO	Impacts to recreation would be so small as to be negligible and would only occur when project work was being conducted. Recreationalists could continue to use the land as they do at this time under all alternatives.
Prime or Unique Farmlands	NO	NO	Not present within the Kiger and Riddle Mountain HMAs.
Riparian-Wetland Zones	YES	NO	There are no effects expected to riparian-wetland zones from the proposed gather operations.
Special Status Species (SSS)	YES	YES	Fauna SSS are present and are discussed below in Section 3.4. Flora SSS or critical designated habitats are not present or suspected at proposed trap sites or temporary holding facilities (2021 BLM State Directors SSS list). Areas to support gather operations, such has trap sites and temporary holding facilities, are to be located in previously disturbed areas. If trap sites or temporary holding facilities are needed on undisturbed sites to complete the proposed activities, Flora SSS surveys would be conducted, and the areas cleared prior to their use.
Visual Resource Management (VRM)	YES	NO	The location of this project is within VRM Classes I, III, and IV. Class I's objective is to preserve existing character of the landscape. Class III's objective is to partially retain the existing character of the landscape; change is allowed. The level of change to the landscape can be moderate, and activities may attract attention but should not dominate the view. Class IV's objective is to provide for management activities that require major modification of the landscape. The level of change to the characteristic landscape can be high. These activities can dominate the view and be the major focus of the viewer. However, every effort should be made to minimize the impact of these activities in both VRM Classes III and IV.
Water Quality	YES	NO	There are no effects expected to water quality from the proposed gather operations.
Waste (Hazardous or Solid)	NO	NO	Not present.
Wilderness Characteristics	NO	NO	There are no designated lands with wilderness characteristics within the Kiger and Riddle Mountain HMAs.
Wild and Scenic Rivers	NO	NO	Not present.
Wilderness and Wilderness Study Area (WSA)	YES	NO	The proposed gather would have no effect on Stonehouse WSA because of the temporary nature of the proposed action and absence of permanent ground disturbance. No wilderness is present.
Wild Horse and Burro Management	YES	YES	Discussed below in Section 3.1.

3.1 Wild Horses

3.1.1 Affected Environment – Wild Horses

The Kiger and Riddle Mountain HMAs are comprised of three allotments: the Smyth-Kiger, Happy Valley, and Burnt Flat allotments. The topography of the HMAs is generally flat to gently undulating, with a few dispersed buttes and ridges. Elevation varies from approximately 4,500 to 6,750 feet. Precipitation averages between 8 to 16 inches depending on the location within the HMAs. Most of this

precipitation comes between the months of October and March, in the form of snow, supplemented by localized thunderstorms during the summer months.

When added across the two HMAs, AML is a population range of 84–138 wild horses. The Andrews RMP/ROD (2005) allocated 132 AUMs in the Happy Valley Allotment for wild horses, 852 AUMs in the Smyth-Kiger Allotment, and 672 AUMs in the Burnt Flat Allotment for a total allocation of 1,656 AUMs. Inventory and observational data indicate wild horse use has concentrated in increasingly smaller areas throughout the spring, summer, and fall as water sources become scarce.

The combined wild horse population size is estimated to be 792 in May 2024 (508 in Kiger HMA and 284 in Riddle Mountain HMA) (Appendix H, BLM 2024b). The 2024 estimated herd sizes reflect animals that are foals or older. These values are based on a simultaneous double-observer aerial survey completed in May 2024 (Appendix H, BLM 2024b).

According to the 1996 Riddle Mountain and Kiger Wild HMAP (BLM 1996), objectives for these two HMAs are to maintain healthy wild horses with ecologically sustainable numbers that exhibit the dun factor colors and physical characteristics of Spanish mustang horses ranging in size from 13 to 15 hands and weighing between 750 and 1,000 pounds.

Since 1974, periodic gathers and removals have occurred within the HMAs in response to excessive horse populations and emergencies. Depending on reproductive rates, results of rangeland monitoring data, funding, and management considerations, horses within the HMAs have typically been gathered and removed at a four- to five-year interval, except without a major gather since 2015. Aerial inventories are typically conducted every 2–3 years for each HMA on BLM Burns District. These two HMAs were aerially surveyed in May 2024 (Appendix H, BLM 2024b). Table 2 reflects the gather history for the Kiger and Riddle Mountain HMAs.

Table 2: Kiger and Riddle Mountain HMAs - Gather History

YEAR	GATHERED	RELEASED
1982	138	6
1987	149	25
1989	59	
1999	139	21
2003	289	21
2007	190	57
2011	200	72
2015	201	39

The four essential habitat components (water, forage, cover, and space) for wild horses “must be present within the HMAs in sufficient amounts to sustain healthy wild horse and burro populations and healthy rangelands over the long term” (BLM 2010, p. 12). The key indicator of an escalating problem is a decline in the amount of forage or water available for wild horse use, which results in negative impacts to animal condition and rangeland health (BLM 2010, 4.7.1). Causal factors for these negative impacts are normally drought or animal numbers in excess of AML (BLM 2010, 4.7.1).

There are large areas of the Kiger and Riddle Mountain HMAs that remain ungrazed by both livestock and wild horses due to their distance from water sources. When adequate water is available, wild horses have been observed to be widely dispersed across the HMAs. This generally occurs annually during winter and spring months and on years of above average precipitation when water is well dispersed across the HMAs. With the severe drought the region has seen in recent years and the overpopulation of the herd, the wild horse use areas became more concentrated around the limited water sources, resulting in heavy to severe herbaceous utilization levels. Livestock, native ungulates, and other wildlife are also impacted by the limited water.

Limited resources and an overpopulation of wild horses relative to available resources can lead to competition for available resources with other users of the land (such as wildlife and permitted livestock, as summarized by Chambers and others (2017) and Crist and others (2019)). McInnis and Vavra (1987) found at least 88 percent of the mean annual diets of horses and cattle consisted of grasses; therefore, there is potential for direct competition for forage. However, dietary overlap is not sufficient evidence for exploitative competitions (Colwell and Futuyma 1971), and consequences of overlap partially depend upon availability of the resource (McInnis and Vavra 1987). Numerous studies have found that wild horses will travel 3-10 miles to and from water, though numerous factors can influence this distance (Hampson et al. 2010, Miller 1983, Pellegrini 1971, Esmaeili et al. 2021). Ganskopp (2001), Holechek and co-authors (2011), and others have found that livestock tend to spread out from water in a 2-mile radius, though there are other factors that can make it less (such as rockiness) or can increase it (such as different breeds and reproductive status). When water and forage are available together the range wild horses will travel will be smaller, and when they are not available together wild horses concentrate in areas of ample forage and travel further distances to water (Green and Green 1977, as cited in Miller 1983). Nevertheless, horses can only travel so far before their condition, or the condition of their young, is affected.

Research has also shown when wild horses must share water sources with cattle and antelope, there can be direct competition (Miller 1983, Crist et al. 2019). When resources become scarce, due to drought or overpopulation, resource concentration can create an aggregation of animals where direct contact between competing species is more common, increasing the likelihood of interference behavior (Valeix et al. 2007, Atwood et al. 2011, Gooch et al. 2017). Wild horses have been found to be typically dominant in their social interactions with native Great Basin ungulates, due to their large size and often aggressive behavior (Gooch et al. 2017, Hall et al. 2016, Perry et al. 2015, Berger 1986). In a study of interactions with desert bighorn sheep (*Ovis canadensis nelsoni*), domestic horses were experimentally placed near water sources, which resulted in no direct aggression; however, the mere presence of horses resulted in a 76 percent decline in bighorn use of waterholes at those locations (Ostermann-Kelm et al. 2008, Gooch et al. 2017). Gooch and others (2017) investigated the interference competition between pronghorn antelope and wild horses at water sources within the Great Basin, particularly the Sheldon National Wildlife Refuge (NWR). They found that nearly half of the pronghorn/horse interactions observed were negative and resulted in pronghorn being excluded from the water source as a result of horse activity (Gooch et al. 2017). They did not measure the consequences of these interactions on pronghorn antelope water consumption and fitness. About 40 percent of horse/pronghorn antelope interactions resulted in pronghorn antelope exclusion from water. There is a biological cost for these pronghorn/horse interactions that is likely associated with energy expended fleeing the water source and the lost opportunity to water (Frid and Dill 2002, Gooch et al. 2017). These effects could have

detrimental impacts on pronghorn fitness and population dynamics, particularly when surface water availability is limited and monopolized by horses (Gooch et al. 2017). Further review of wild horse interactions with the environment is included in Appendix F.

With the current estimated wild horse populations in the HMAs, interference competition and the indirect consequences are more likely to occur and impact other species sharing the HMAs. As the wild horse population continues to grow well above the AML, there is cause for concern regarding the potential for degradation of rangeland resources in typical home ranges surrounding the limited reliable water sources. Unlike managed livestock grazing, wild horse grazing occurs year-round. If there are ample, well-distributed resources then there is little to no concern for resource degradation. However, when resources are limited and habitat use is concentrated into a small number of areas, desirable key forage species receive heavier levels of use during the growing season. This type of use is acceptable if it occurs only on a periodic basis, but not throughout the year. Repetitive use during the growing season that prevents key forage species from completing their growth and reproductive cycles (such as what was seen in the previous drought years) tends to reduce plant vigor as plant reserves are spent on repeated regrowth.

3.1.2 Environmental Consequences – Wild Horses

The cumulative effect analysis areas (CEAA) for wild horses are the HMAs' boundaries for all action alternatives, which provide adequate resources for the wild horse population when within AML. Alternative E: No Action and Alternative C: No Gather would have a CEAA for wild horses of an estimated ten miles outside the HMAs' boundaries in all directions. This area was chosen because AML is currently exceeded and horses may have strayed outside HMA boundaries. If no action is taken to maintain populations within AML, horses will seek areas outside of the HMAs in search of feed and water.

3.1.2.1 Effects Common to All Alternatives

For over 40 years, various impacts to wild horses as a result of gather activities have been observed. Under the actions proposed, effects to wild horses would be both direct and indirect to individual horses and the Kiger and Riddle Mountain populations as a whole. Gather methods and procedures have been identified and refined to minimize stress and impacts to wild horses during gather implementation. There is policy in place for gathers (both helicopter and bait/water) to enable efficient and successful gather operations while ensuring humane care and treatment of the animals gathered (PIM 2021-002 (BLM 2021), Appendix C). This policy includes standard operating procedures such as time of year and temperature ranges for helicopter gathers to reduce physical stress while horses are being herded toward a trap; maximum distances to herd horses based on climatic conditions, topography, and condition of horses; and handling procedures once the animals are in the trap.

Acute gather-related mortality averages about 0.5 percent (Government Accountability Office (GAO) 2008, GAO-09-77; Scasta 2020), which is considered very low compared to the acute mortality rates that other agencies and researchers cause when trapping and handling wild animals (Scasta 2020). Additionally, an average of about 0.7 percent of the captured animals are humanely euthanized in accordance with BLM policy IM 2021-007 (BLM 2021a) due to pre-existing conditions (GAO 2008, GAO-09-77; Scasta 2020). These data affirm that use of helicopters and motorized vehicles has proven

to be a safe, humane, effective, and practical means for the gather and removal of excess wild horses (and burros) from public lands. BLM Manual 4720.41 prohibits the capture of wild horses by using a helicopter during the foaling period (generally March 1 to June 30), which is defined as 6 weeks on either side of the expected peak of the foaling period.

Impacts due to gathers have been analyzed in many previous documents. To see this analysis, refer to Kiger and Riddle Mountain Herd Management Areas Wild Horse Gather Environmental Assessment (DOI-BLM-OR-B050-2011-0006-EA) (BLM 2011a). Additional consideration of these effects is included in the literature review in Appendix F.

3.1.2.2 Alternative A: Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period

Alternative A would result in the wild horse population in the Kiger and Riddle Mountain HMAs remaining within AML, which is expected to foster a TNEB on those lands. Maintaining horse herd levels at densities that are proportionate to available natural resources is an important element of the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992). The effects of climate change may include prolonged and more frequent drought conditions, and maintaining wild horse herds at levels within AML should help BLM managers to ensure that adequate water and forage resources are available for the wild horses living in these HMAs, into the future, as well as providing for multiple uses as allowed by FLPMA.

Gathering every 4 to 5 years allows BLM to collect deoxyribonucleic acid (DNA) samples on hair follicles as an essential part of monitoring the genetic diversity of the herd. Genetic sampling of hair samples makes use of scheduled gather activities; genetic diversity monitoring via fecal collection is possible but is logistically difficult and expensive (Schoenecker et al. 2021). The BLM can make appropriate changes when the results of genetic diversity monitoring (as measured in terms of observed heterozygosity) indicate changes would be necessary. For example, introducing new animals to the herd in the event that observed heterozygosity becomes undesirably low is a management action that could happen under this or any of the action alternatives. A consistent gather cycle also enables the maintenance and improvement of desirable physical traits within the herd.

BLM's Use of Contraception in Wild Horse Management

Fertility control vaccines (also known as immunocontraceptives) meet BLM requirements for safety to mares and the environment (EPA 2009, 2012). Because they work by causing an immune response in treated animals, there is no risk of hormones or toxins being taken into the food chain when a treated mare dies. At this time, the BLM and other land managers have mainly used three fertility control vaccine formulations for fertility control of wild horse mares on the range: ZonaStat-H, PZP-22, and GonaCon-Equine. As other formulations become available, they may be applied in the future. The BLM has begun to use soft, flexible, Y-shaped silicone intrauterine devices (IUD) for mares in some other HMAs (e.g., DOI-BLM-WY-D040-2020-0005-EA (BLM 2020)). Flexible IUDs are not expected to be a main method of fertility control in this herd, but effects of IUD use are analyzed in this EA for comparison.

In any vaccine, the antigen is the stimulant to which the body responds by making antigen-specific antibodies. Those antibodies then signal to the body that a foreign molecule is present, initiating an immune response that removes the molecule or cell. Adjuvants are additional substances that are included in vaccines to elevate the level of immune response. Adjuvants help to incite recruitment of lymphocytes and other immune cells, which foster a long-lasting immune response that is specific to the antigen.

Liquid emulsion vaccines can be injected by hand or remotely administered in the field using a pneumatic dart (Roelle and Ransom 2009, Rutberg et al. 2017, McCann et al. 2017). Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 meters or closer (BLM 2010). Booster doses can be safely administered by hand or by dart.

Expanding the use of population growth suppression to slow population growth rates and reduce the number of animals removed from the range and sent to off-range pastures is a BLM priority. The WFRHBA of 1971 specifically provides for contraception and sterilization (section 3.b.1). No finding of excess animals is required for BLM to pursue contraception in wild horses or wild burros. Population modeling (Gross 2000, Bartholow 2004, deSeve and Boyles-Griffin 2013, Folt et al. 2023a, 2023b) confirms the commonsense conclusion that the higher the fraction of contracepted mares, generally the lower the growth rate. Schulman and others (2024) demonstrated that a shorter duration of effect requires larger fractions of mares need to be frequently treated to maintain a 'fertility control index' large enough to reduce herd-level growth rates. This is one reason that the BLM has historically sought to use humane, longer-lasting fertility control methods. For example, it is easier to achieve the 60-90 percent rate of effectively treated mares if the method used does not require treatment every year. Horses are long-lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods of time (i.e., 10 or more years), fertility control methods such as immunocontraceptive vaccines alone are not very effective at reducing population growth rates to the point where births equal deaths in a herd. All fertility control methods in wild animals are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al. 2015). Contraception by itself does not remove excess horses from an HMA's population, so if a wild horse population is in excess of AML, then contraception alone would result in some continuing environmental effects of wild horse overpopulation. Successful contraception reduces future reproduction. Limiting future population increases of wild horses could limit increases in environmental damage from higher densities of wild horses.

Successful contraception would be expected to reduce the frequency of horse gather activities on the environment, as well as wild horse management costs to taxpayers. Bartholow (2007) concluded that the application of 2- or 3-year contraceptives to wild mares could reduce operational costs in a project area by 12–20 percent, or up to 30 percent in carefully planned population management programs. He also concluded that contraceptive treatment would likely reduce the number of horses that must be removed in total, with associated cost reductions in the number of adoptions and total holding costs. If applying contraception to horses requires capturing and handling horses, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs. Selectively applying contraception to older animals and returning them to the HMAs could reduce long-term holding costs for such horses, which

are difficult to adopt, and could reduce the compensatory reproduction that often follows removals (Kirkpatrick and Turner 1991).

Although contraceptive treatments are associated with a number of potential physiological, behavioral, demographic, and genetic effects detailed below and in Appendix F, those concerns do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott and Oli 2013). In principle, it is possible that mares treated repeatedly with fertility control vaccines may not return to fertility before they die (Nuñez et al. 2017). For the purposes of this analysis, though, it is believed that such long-lasting effects are not expected to be common and would not be expected to cause a sterile, non-reproducing component of the herd in the same sense as purposeful sterilization considered under Alternative B.

It is a BLM policy requirement for animals treated with fertility control to be readily identifiable, either via freeze marks or in a record system that can identify horses by unique coloration, so that their treatment history is easily recognized (BLM 2010). Markings would always be useful in helping to determine the approximate fraction of fertility control treated mares, or geldings, in a herd and could provide additional insight regarding gather efficiency. BLM has instituted the CAWP to reduce the sources of handling stress in captured animals (BLM PIM 2021-002. Handling may include freeze-marking for the purpose of identifying an individual. Some level of transient stress is likely to result in newly captured horses that have not been previously marked. Under past management practices, captured horses experienced increased, transient stress levels from handling (Ashley and Holcombe 2001). It is difficult to compare the level of temporary stress with long-term stress that can result from food and water limitation on the range (Creel et al. 2013), which could occur in the absence of herd management. Most horses recover from the stress of capture and handling quickly once released back to the range.

Under the proposed action, the BLM would return to the HMAs as needed to re-apply available fertility control vaccines, such as PZP vaccines (i.e., ZonaStat-H) and GonaCon-Equine, and initiate new treatments in order to maintain contraceptive effectiveness in controlling population growth rates. Once the population is at AML and population growth seems to be stabilized, BLM could use population planning software (such as PopEquus (Folt et al. 2023a, 2023b)) to determine the required frequency of re-treating mares with the available fertility control vaccine.

The effects of PZP antigen vaccines, GnRH (GonaCon) vaccines, and IUDs have been previously discussed in other NEPA analyses for wild horse management; a current literature review with a more complete discussion of the potential effects from each approach to fertility control is also attached in Appendix F (that review includes methods that are not included in any action alternative here, for the sake of providing an informed comparison).

Population Management Impacts

The proposed action would achieve and maintain wild horse numbers within AML during the ten-year timeframe of the alternative using available fertility control vaccines and removals, when wild horses are found to be in excess of the high end of AML and would use fertility control vaccine application to help maintain an average population growth rate of 2 percent to 5 percent per year. Keeping the herd within AML would reduce the risk of horses experiencing periods of diminished available forage and/or

water (e.g., during drought). Having a plan in place allows BLM staff to monitor and take appropriate action when needed before emergency situations arise. Using adaptive management that involves incorporating the use of the currently most humane and effective proven methods of fertility control and monitoring the outcomes in terms of foaling rates and annual population growth rates should allow BLM to extend the number of years between gather cycles (BLM 2022a), while continuing to maintain numbers within AML and providing for a TNEB. Successful management of many species often relies on actions that involve intensive handling of individuals (Ashley and Holcombe 2001). Nevertheless, extending a gather cycle based upon a slowing of the population growth would reduce the frequency of potentially stressful events, such as gathers.

The objectives set forth in the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992) to maintain or improve upland health and forage and water resources would most likely be achieved under this alternative because it combines the best tools and actions to maintain wild horse populations within AML and, therefore, would achieve a TNEB.

3.1.2.3 Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population

As with Alternative A, Alternative B would result in the numbers of wild horses in the HMAs being maintained within AML. This is expected to foster a TNEB and long-term maintenance of high-quality wild horse habitat, resulting in healthy wild horse individuals and herds. By including some non-reproducing (sterilized) animals in the herd, this alternative reflects a recommendation made in the WHB Handbook (BLM 2010) Section 4.5.3, which states "During gather or herd management area planning, the authorized officer should consider a range of alternatives to reduce population growth rates and extend the gather cycle for all wild horse herds with annual growth rates greater than or equal to 5 percent. Alternatives may include but are not limited to: …management of selected HMAs for non-reproducing wild horses."

Sterile wild horses (whether geldings or sterilized mares) would continue to have the legal protections of the WFRHBA, and it is not expected that sterilization would change their free-roaming behavior. Analysis of effects in this section of the EA is limited to an overview of the effects of neutering of males, and of the minimally invasive forms of mare sterilization. See Appendix F for a more complete literature review of the effects of these methods. The review in Appendix F also includes an analysis and literature review of surgical ovariectomy methods of mare sterilization, for comparative purposes. However, ovariectomy would not be used under this or any alternative considered in this EA.

Effects of Sterilization, Including Spaying and Gelding

Various forms of fertility control can be used in wild horses and wild burros, with the goals of maintaining herds at or near AML, reducing fertility rates, and reducing the frequency of gathers and removals. The WFRHBA of 1971 specifically provides for the use of contraception and sterilization (16 U.S.C. 1333(3)(b)(1)). Fertility control measures have been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used in combination with gathers, to reduce horse population size (Bartholow 2004, de Seve and Boyles-Griffin 2013, Fonner and Bohara 2017). Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000) or permanent, such as with sterilization methods that may include sterilizing mares and gelding stallions.

In the context of BLM wild horse management, sterilization is expected to be successful to the extent that it reduces the number of reproducing females. By definition, sterilizing a given female is 100 percent effective as a fertility control method for that female. Gelding males may be effective in one of two ways. First, neutered males may continue to guard fertile females, preventing the females from breeding with fertile males, which may reduce female fertility rates (Garrott and Siniff 1992). Or second, if neutered males are included in a herd that has a high male-to-female sex ratio, then the neutered males may comprise some of the animals within the AML of that herd, which would effectively reduce the number of breeding females in the herd. Although these and other fertility control treatments may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, those impacts are generally minor and transient (other than the sterility itself), do not prevent overall maintenance of a self-sustaining population, and do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott and Oli 2013).

Peer-reviewed scientific literature (see Appendix F) details the expected impacts of sterilization methods on wild horses. No finding of excess animals is required for BLM to pursue sterilization in wild horses, but NEPA analysis has been required. On the whole, the identified impacts at the herd level are generally transient. The principal impact to individuals treated is sterility, which is the intended outcome. Sterilization that affects individual horses does not prevent BLM from ensuring that there will be self-sustaining populations of wild horses in any single HMA, complexes of HMAs, and at regional scales of multiple HMAs and complexes. Under the WFRHBA of 1971, BLM is charged with maintaining self-sustaining populations of wild horses. The NAS (2013) encouraged BLM to manage wild horses at the spatial scale of "metapopulations" – that is, across multiple HMAs and complexes in a region. In fact, many HMAs have historical and ongoing genetic and demographic connections with other HMAs (NAS 2013, Appendix F), and BLM routinely[5] moves animals from one HMA to another to improve local herd traits and maintain adequate genetic diversity.

Discussions about herds that are 'non-reproducing' in whole or in part are in the context of this 'metapopulation' structure, where self-sustaining herds are not necessarily at the scale of single HMAs. The current definition of what constitutes a self-sustaining herd (i.e., includes the larger set of HMAs that have past or ongoing demographic and genetic connections), as is recommended by the NAS 2013 report, is clear in allowing single HMAs to be managed as non-reproducing in whole or in part while still allowing for a self-sustaining population of wild horses at the broader spatial scale. Wild horses are not an endangered species (USFWS 2015), nor are they rare. Over 70,000 adult wild horses roamed BLM lands as of March 1, 2021, and those numbers do not include approximately 10,000 wild horses and burros on US Forest Service lands, and at least 100,000 free-roaming horses on tribal lands in the Western United States (Schoenecker et al. 2021).

All fertility control methods affect the behavior and physiology of treated animals (NAS 2013) and are associated with potential risks and benefits including: effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al. 2015). Contraception methods alone do not remove excess horses from an HMA's population, so one or more gathers are usually needed in order to bring the herd down to a level close to AML. Horses are long-

[5] This movement of animals would continue under all alternatives.

lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods (10 or more years), mare sterilization and gelding alone would not be very effective at reducing population growth rates to the point where births equal deaths in a herd. However, even modest levels of fertility control activities can reduce the frequency of horse gather activities. Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000), such as with sterilization. Because sterilizing animals requires capturing and handling, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs.

Surgical sterilization techniques, while not reversible, may control horse reproduction without the kind of additional handling or darting that can be needed to administer contraceptive vaccines. In this sense, sterilization surgeries can be used to achieve herd management objectives with a relative minimum level of animal handling and management over the long term. The WFRHBA indicates that management should be at the minimum level necessary to achieve management objectives (CFR 4710.4), and if gelding some fraction of a managed population can reduce population growth rates by replacing breeding mares, it then follows that sterilizing a portion of mares and/or stallions can lead to a reduced number of handling occasions and removals of excess horses from the range, which is consistent with legal guidelines. Other fertility control options that may be temporarily effective on male horses, such as the injection of GonaCon-Equine immunocontraceptive vaccine, apparently require multiple handling occasions to achieve longer-term male infertility. Similarly, some formulations of PZP immunocontraception that are currently available for use in female wild horses and burros require handling or darting every year (though longer-term effects may result after 4 or more treatments) (Nuñez et al. 2017). Any management activities that require multiple capture operations to treat a given individual would be more intrusive for wild horses and potentially less sustainable than the proposed sterilization that requires only one handling occasion.

Most horses recover from the stress of capture and handling quickly once released back to the range, and none are expected to suffer serious long-term effects from gelding or minimally invasive mare sterilization, other than the direct consequence of becoming infertile.

Observations of the long-term outcomes of sterilization could be recorded during routine resource monitoring work, but use of sterilization in the Kiger and Riddle Mountain HMAs would not necessarily be part of any scientific research. Such observations could include (but not be limited to) band size, social interactions with other geldings and harem bands, distribution within their habitat, forage utilization, and activities around key water sources. Periodic population inventories and future gather statistics could provide additional anecdotal information.

Gelding Males

Castration (the surgical removal of the testicles, also called gelding or neutering) is a surgical procedure for horse sterilization that has been used for millennia. Vasectomy involves severing or blocking the vas deferens or epididymis, to prevent sperm from being ejaculated. The procedures are straight forward and have a relatively low complication rate. As noted in the review of scientific literature (Appendix F), the expected effects of gelding and vasectomy are well understood overall, even though there is some

degree of uncertainty about the exact quantitative outcomes for any given individual (as is true for any natural system).

Including gelded males in herd management would not be new for BLM and Federal land management. Geldings have been released on BLM lands as a part of herd management in the Barren Valley Complex in Oregon (BLM 2011), the Challis HMA in Idaho (BLM 2012a), and the Conger HMA in Utah (BLM 2016). Vasectomized males and geldings were also included in US Fish and Wildlife (USFWS) Service management plans for the Sheldon National Wildlife Refuge that relied on sterilization and removals (Collins and Kasbohm 2016). Taking into consideration the literature available at the time, the NAS 2013 report concluded that vasectomy was one of the three most promising methods for WHB fertility control. BLM is not pursuing the chemical vasectomy method. The NAS (2013) panel noted that, even though chemical vasectomy had been used in dogs and cats up to that time, "There are no published reports on chemical vasectomy in horses..." and that, "Only surgical vasectomy has been studied in horses, so side effects of the chemical agent are unknown." The only known use of chemical vasectomy in horses was subsequently published by Scully and others (2015) and was part of a study cited in Collins and Kasbohm (2016). Scully and others (2015) found that the chemical vasectomy method was not effective.

Collins and Kasbohm (2016) suggested that there was a reduced mare fertility rate due to inclusion of some sterile males in a free-roaming horse herd with both surgically sterilized mares and vasectomized horses. Statistically significant reductions in mare fertility rates were only observed in the first year after geldings were introduced to a herd in Utah (King et al. 2022). Garrott and Siniff (1992) concluded from their modeling that male sterilization would effectively cause there to be zero population growth (the point where births roughly equal deaths) only if a large proportion of males (i.e., >85 percent) could be sterilized. At Conger HMA a fraction of geldings that were returned to the range with their social band did continue to live with females, apparently excluding fertile stallions, for at least 2 years (King et al. 2022).

Direct Effects of Gelding

No animals that appear to be distressed, injured, or in poor health or condition would be selected for gelding. Stallions would not typically be gelded within 72 hours of capture. The surgery would be performed by a veterinarian using general anesthesia and appropriate surgical techniques. The final determination of which specific animals would be gelded would be based on the professional opinion of the attending veterinarian in consultation with the authorized officer (see the SOPs for gelding in the Antelope/Triple B Complexes Gather Plan EA, DOI-BLM-NV-E030-2017-0010-EA, BLM 2017).

Though sterilizing males is a common surgical procedure, especially gelding, some level of minor complications after surgery may be expected (Getman 2009), and it is not always possible to predict when postoperative complications will occur. Fortunately, the most common complications are almost always self-limiting, resolving with time and exercise. Individual impacts to the stallions during and following the gelding process should be minimal. Complications may include, but are not limited to, minor bleeding, swelling, inflammation, edema, infection, peritonitis, hydrocele, penile damage, excessive hemorrhage, and eventration (Schumacher 1996, Searle et al. 1999, Getman 2009). A small amount of bleeding is normal and generally subsides quickly, within 2-4 hours following the procedure. Some degree of swelling is normal, including swelling of the prepuce and scrotum, usually peaking

between 3-6 days after surgery (Searle et al. 1999). Older horses are reported to be at greater risk of post-operative edema, but daily exercise can prevent premature closure of the incision and prevent fluid buildup (Getman 2009). For intact stallions, testosterone levels appear to vary as a function of age, season, and harem size (Khalil et al. 1998). It is expected that testosterone levels will decline over time after castration. Testosterone levels should not change due to vasectomy. Vasectomized stallions should retain their previous levels of libido. Domestic geldings had a significant prolactin response to sexual stimulation but lacked the cortisol response present in stallions (Colborn et al. 1991). Although libido and the ability to ejaculate tends to be gradually lost after castration (Thompson et al. 1980), some geldings continue to mount mares and intromit (Rios and Houpt 1995, Schumacher 2006).

Indirect Effects of Gelding

Other than the short-term outcomes of surgery, gelding is not expected to reduce males' survival rates. Castration is thought to increase survival as males are released from the cost of reproduction (Jewell 1997). Moreover, it is unlikely that a reduced testosterone level will compromise gelding survival in the wild, considering that wild mares survive with low levels of testosterone. Consistent with geldings not expending as much energy in attempts to obtain or defend a harem, it is expected that wild geldings may have a better body condition than fertile stallions. In contrast, some vasectomized males may continue to defend or compete for harems in the way that fertile males do, so those individuals are not expected to experience an increase in health or body condition due to surgery. The question of whether or not a given gelded male would or would not attempt to maintain a harem is not germane to population-level management. It is worth noting, though, that the BLM is not required to manage populations of wild horses in a manner that ensures that any given individual maintains its social standing within any given harem or band. Gelding a subset of stallions would not prevent other fertile stallions and mares from continuing with the typical range of social behaviors for sexually active adults.

The effect of castration on aggression in horses has not often been quantified, though results from the Conger HMA suggest that the frequency of agonistic behaviors in recently gelded males was not significantly different from that of fertile stallions (King et al. 2022). Stallion-like behavior in domestic horse geldings is relatively common (Smith 1974, Schumacher 1996), being shown in 20-33 percent of cases whether the horse was castrated pre- or post-puberty (Line et al. 1985, Rios and Houpt 1995, Schumacher 2006).

The likely effects of castration on geldings' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King and Gurnell 2005). By comparison, bachelor groups tend to be more transient and can potentially use areas of good forage further from water sources, as they are not constrained by the needs of lactating mares and foals in a group. The number of observations of gelded "wild stallion behavior" are still too few to make general predictions about whether a particular gelded individual will behave like a harem stallion, a bachelor, or form a group with other geldings that may forage and water differently from fertile wild horses. However, results from the Conger HMA indicate that gelded wild horses had habitat use and movement patterns that were comparable to those of fertile stallions (King et al. 2022).

Sterilizing wild horses does not change their status as wild horses under the WFRHBA. In terms of whether geldings will continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that geldings would continue to roam unhindered once they are returned to the range. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a gelded animal would still be expected to have a number of internal reasons for moving across a landscape and, therefore, exhibiting free-roaming behavior.

Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that gelding wild horses will cause them to lose their free-roaming nature. It is worth noting that individual choices in wild horse group membership, home range, and habitat use are not protected under the WFRHBA. BLM acknowledges that geldings may exhibit some behavioral differences after surgery, compared to intact stallions, but those differences are not expected to remove the geldings' rebellious and feisty nature, nor their defiance of man. While it may be that a gelded horse could have a different set of behavioral priorities than an intact stallion, the expectation is that geldings will choose to act upon their behavioral priorities in an unhindered way, just as is the case for an intact stallion. In this sense, a gelded male would be just as much 'wild' as defined by the WFRHBA as any intact stallion, even if his patterns of movement differ from those of an intact stallion. Results from the Conger study herd indicate that geldings' movement patterns were not qualitatively different from those of fertile stallions, when controlling for social status as bachelor or harem stallion (King et al. 2022). Congress specified that sterilization is an acceptable management action (16 U.S.C. 1333(b)(1)). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild, free-roaming horse (16 U.S.C. 1333(2)(C)(d)). Several academics have offered their opinions about whether gelding a given stallion would lead to that individual effectively losing its status as a wild horse (Rutberg 2011, Kirkpatrick 2012, Nock 2017). Those opinions are based on a semantic and subjective definition of 'wild,' while BLM must adhere to the legal definition of what constitutes a wild horse, based on the WFRHBA. Those individuals have not conducted any studies that would test the speculative opinion that gelding wild stallions would cause them to become docile. BLM is not obliged to base management decisions on such opinions, which do not meet the BLM's principle and practice to "[u]se the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al. 2015).

There is additional information on potential effects of neutering horses in Appendix F.

Mare Sterilization

Herd-level birth rate (i.e., foals per female) is expected to decline in direct proportion to the fraction of sterilized mares in the herd because sterilized mares cannot become pregnant. Sterilizing mares has already been shown to be an effective part of free-roaming horse management that reduced herd growth rates on Federal lands (Collins and Kasbohm 2016).

The mare sterilization methods whose effects are analyzed here are limited to minimally invasive physical sterilization, and pharmacological or immunocontraceptive sterilization. A more detailed analysis of mare sterilization, which includes inferences that can be made from analysis of surgical ovariectomy methods, is included in Appendix F. The anticipated effects of any mare sterilization method could be both physical and behavioral.

Effects of Mare Sterilization on Pregnancy and Foals

The minimally invasive sterilization techniques noted above require a trans-cervical technique, so those mares would have been screened for pregnancy ahead of time, and no pregnant mares would be treated. If a mare treated with these methods were to become pregnant (i.e., because scarring of the oviduct or oviduct papilla did not permanently block eggs from reaching the uterus) then it is expected that pregnancies and foal development would proceed normally throughout the duration of the pregnancy as the ovaries and reproductive system would still be functional.

Direct Effects of Mare Sterilization

Minimally invasive sterilization methods are expected to have only minor and transient physical effects on treated mares, other than the blockage of the oviduct and prevention of pregnancy. In the case of surgical grade cyanoacrylate use to cause oviduct occlusion, some scarring of the oviduct is the desired result, but that effect is localized and not anticipated to cause long-term discomfort. Similarly, laser ablation of the oviduct papilla is expected to cause scarring on a very small portion of uterine tissue (the papilla and a few square millimeters of tissue nearby), and to not cause long-term discomfort. The attending veterinarian would be responsible to provide appropriate analgesics for any animal treated, to alleviate short-term discomfort. Mortality due to either form of minimally invasive sterilization method described here is not expected to take place.

Behavioral Effects of Mare Sterilization

Behavioral effects of mare sterilization can be inferred from studies in which mares were sterilized by other methods, and in which ovarian function continued despite contraception being effective. No fertility control method exists that does not affect physiology or behavior of a mare (NAS 2013). Any action taken to alter the reproductive capacity of an individual has the potential to affect hormone production and therefore behavioral interactions and ultimately population dynamics in unforeseen ways (Ransom et al. 2014). The health and behavioral effects of sterilizing wild horse mares that live with other fertile and infertile wild horses has not been well documented, but the literature review in Appendix F indicates potential likely behaviors.

Horses are anovulatory (do not ovulate/express estrous behavior) during the short days of late fall and early winter, beginning to ovulate as days lengthen and then cycling roughly every 21 days during the warmer months, with about 5 days of estrus (Asa et al. 1979, Crowell-Davis 2007). Estrus in mares is shown by increased frequency of proceptive behaviors: approaching and following the stallion, urinating, presenting the rear end, clitoral winking, and raising the tail towards the stallion (Asa et al. 1979, Crowell-Davis 2007). In most mammal species other than primates, estrus behavior is not shown during the anovulatory period, and reproductive behavior is considered extinguished following removal of the ovaries (Hart and Eckstein 1997). However, mares may continue to demonstrate estrus behavior during the anovulatory period (Asa et al. 1980). Mares continue to show reproductive behavior following ovariectomy due to non-endocrine support of estrus behavior, specifically steroids from the adrenal cortex. Continuation of this behavior during the non-breeding season has the function of maintaining social cohesion within a horse group (Asa et al. 1980, Asa et al. 1984, NAS 2013). This

may be a unique response of the horse (Bertin et al. 2013), as ovariectomy usually greatly reduces female sexual behavior in companion animals (Hart and Eckstein 1997).

The likely effects of sterilization on mares' social interactions and group membership can be inferred from available literature, even though wild horses have rarely been sterilized and released back into the wild, resulting in relatively few studies that have investigated their behavior in free-roaming populations. Wild horses are instinctually herd bound, and this behavior is expected to continue. Overall, the BLM anticipates that some or all mares treated with minimally invasive sterilization would continue to exhibit estrus behavior, which could foster band cohesion. This outcome would be consistent with research that demonstrated continuing estrus behavior in ovariectomized mares, comparable to the levels seen in the anovulatory (non-breeding) season in intact mares (Asa et al. 1980). Insofar as minimally invasive mare sterilization techniques considered here would not remove the ovaries, it is likely that the behavior of such treated mares may be comparable to the behavior of mares treated with PZP vaccine; that is, the continuation of estrus behavior at roughly 21-day cyclicity throughout the breeding season. As noted by the NAS (2013) report, the ideal fertility control method would not eliminate sexual behavior or change social structure substantially, and it appears that the various forms of mare sterilization noted here would most likely allow for the continuation of such behaviors. The complexity of social behaviors among free-roaming horses is not entirely centered on reproductive receptivity, and fertility control treatments that suppress fertility may not cause substantial changes to social behavior (Ransom et al. 2014, Collins and Kasbohm 2016). BLM expects that wild horse harem structures would continue to exist under the proposed action because fertile mares, stallions, and their foals would continue to be components of the herd. It is not expected that sterilizing a subset of mares would significantly change the social structure or herd demographics (age and sex ratios) of fertile wild horses.

'Foal stealing,' where a near-term pregnant mare steals a neonate foal from a weaker mare, is unlikely to be a common behavioral result of including sterilized mares in a wild horse herd. McDonnell (2012) noted that "foal stealing is rarely observed in horses, except under crowded conditions and synchronization of foaling," such as in horse feed lots. Those conditions are not likely in the wild, where pregnant mares will be widely distributed across the landscape, and where the expectation is that parturition dates would be distributed across the normal foaling season.

Indirect Effects of Mare Sterilization

The free-roaming behavior of wild horses is not anticipated to be affected by mare sterilization, as the definition of free-roaming is the ability to move without restriction by fences or other barriers within an HMA (BLM 2010), and there are no permanent physical barriers being proposed.

Because mares treated with minimally-invasive sterilization methods may accrue greater fat reserves than those that are pregnant or nursing foals; they may attain higher body condition scores and survive longer – as has been observed in mares treated with immunocontraceptive vaccines. In wild horses, contracepted mares tend to be in better body condition than mares that are pregnant or that are nursing foals (Nuñez et al. 2010); the same improvement in body condition is likely to take place in sterilized mares.

The likely effects of sterilization on mares' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the

habitat and varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King and Gurnell 2005). It is unlikely that sterilized mares will change their spatial use patterns, but not having energetic constraints of lactation may mean they can spend more time away from water sources and increase their home range size. Lactating mares need to drink every day, but during the winter when snow can fulfill water needs or when not lactating, horses can traverse a wider area (Feist and McCullough 1976, Salter 1979). During multiple aerial surveys in years following the mare ovariectomy study at the Sheldon NWR, it was documented that all treated individuals appeared to maintain group associations, no groups consisted only of treated females, and none of the solitary animals observed were treated females (Collins and Kasbohm 2016). These results would be consistent with the conclusion that movement patterns and distances moved by sterile mares may be essentially unchanged.

Sterilizing wild horses does not change their status as wild horses under the WFRHBA . In terms of whether sterilized mares would continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that sterilized mares would continue to roam unhindered. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a sterilized animal would still be expected to have a number of internal reasons for moving across a landscape and, therefore, exhibiting 'free roaming' behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that sterilizing wild horses will cause them to lose their free-roaming nature.

In this sense, a sterilized wild mare would be just as much 'wild' as defined by the WFRHBA as any fertile wild mare, even if her patterns of movement differ slightly. Congress specified that sterilization is an acceptable management action (16 U.S.C. 1333(b)(1)). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 U.S.C. 1333(2)(C)(d)). Any opinions based on a semantic and subjective definition of what constitutes a 'wild' horse are not legally binding for BLM, which must adhere to the legal definition of what constitutes a wild free-roaming horse, based on the WFRHBA (as amended). BLM is not obliged to base management decisions on personal opinions, which do not meet the BLM's principle and practice to "use the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al. 2015).

Sterilization is not expected to reduce mare survival rates on public rangelands. Individuals receiving fertility control often have reduced mortality and increased longevity due to being released from the costs of reproduction (Kirkpatrick and Turner 2008). The long-term survival rate of sterile wild mares at the Sheldon NWR appeared to be the same as that of untreated mares (Collins and Kasbohm 2016); recapture rates for released mares were similar for treated mares and untreated mares.

There is further analysis of potential effects of mare sterilization in Appendix F.

Genetic Effects of Mare Sterilization and Gelding

Sterilized females and gelded males are unable to contribute to the genetic diversity of the herd. BLM is not obligated to ensure that any given individual in a herd has the chance to sire or give birth to a foal and pass on genetic material. Management practices in the BLM Wild Horses and Burros Management Handbook (BLM 2010) include measures to increase population genetic diversity in reproducing herds

where monitoring reveals a cause for concern about low levels of observed heterozygosity. These measures include increasing the sex ratio to a greater percentage of fertile males than fertile females (and thereby increasing the number of males siring foals) and bringing new animals into a herd from elsewhere.

Under Alternative B, the HMAs would retain at least half of each herd as potentially breeding. In reproducing herds with high levels of genetic diversity, which will be monitored for loss of genetic diversity, and into which additional animals can be introduced should there be indication of need, sterilizing some mares and/or gelding some stallions is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. The NAS report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. Introducing 1-2 fertile animals every generation (about every 10 years) is a standard management technique that can alleviate potential inbreeding concerns (BLM 2010).

In these HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Although those results are specific to mares, some inferences about potential effects of stallion sterilization may also be made from their results. Roelle and Oyler-McCance (2015) showed that the risk of the loss of genetic heterozygosity is extremely low except in cases where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5 percent per year), and very large fractions of the population are permanently sterilized. The starting level of genetic diversity in Kiger and Riddle Mountain HMAs is relatively high, and the fraction of sterile animals in this case would not be more than 50 percent. Roelle and Oyler-McCance (2015) concluded that nothing in their results indicates wild horse managers should steer away from permanent contraceptive techniques, as long as results are monitored, and adjustments are made if necessary. Therefore, the use of permanent contraceptive techniques coupled with continued herd monitoring would remain in compliance with the WFRHBA, the WHB Handbook (2010), Andrews RMP/ROD (2005), and Three Rivers RMP (1992).

3.1.2.4 Alternative C: Fertility Control Vaccines Only

Under this alternative, wild horse population size would remain well over AML, and there would be a higher density of wild horses across the HMAs, increasing competition for resources and habitat among horses, and with other species. Exceeding population size beyond the established AMLs would be expected to decrease forage quantity and quality and put wild horse health at risk. The overpopulation of wild horses would increase the potential for individual animals or the herd to be affected by climatic fluctuations causing drought and reductions in available forage. This would lead to an increased probability for the need for emergency gathers and decrease success of the herd over the long term.

The objectives set forth in the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992) would become more difficult to achieve under this alternative as solely using fertility treatment to slow population growth in wild horses would take much longer than in Alternative A. It is not expected to be

logistically possible that a high enough fraction of the mares in the HMAs could be treated, with a great enough frequency, to cause the herd to decline. Even if efforts to vaccinate the majority of mares in the HMAs were somehow successful, the long lifespan of wild horses is expected to cause the population to continue to grow in proportion to the fraction of mares still breeding in any given year, and to not diminish to any great extent due to mortality for at least a 10-year duration. This means that although fertility control could slow reproduction rates, it would not be successful in causing herd sizes to attain AML. The effects on the animals' required habitat, and on their behaviors, would be expected to reflect a high degree of competition between individuals for limited resources. Horse herd sizes over AML can also be considered in light of expected effects of climate change. Severe drought conditions may worsen and become more frequent. High herd densities using limited water supplies could reasonably be expected to exacerbate behavioral conflict at water sources, and to cause even greater levels of habitat degradation because of excessive habitat use near those water sources.

Effects of fertility control via vaccine would be as described under Alternative A.

3.1.2.5 Alternative D: Gather and Removal Only

Under this alternative, effects to wild horses and to the habitats they rely on would be comparable to Alternative A, with the exception of the use of fertility treatment. With no fertility treatment applied, wild horse numbers are expected to increase by approximately 20 percent annually (NAS 2013, Ransom et al. 2016). Therefore, after initial gather population would be 84 horses (low AML), and within 4 years it would be expected that herd size would be approximately 174 animals, exceeding the high AML of 138. While gathers would be similar to Alternative A, it is expected that under this alternative, the population would exceed AML faster, requiring more frequent gathers.

Insofar as a higher number of animals is expected to be removed under Alternative D than under Alternative A, it is expected that the loss of observed heterozygosity could occur at a greater rate under Alternative D (Gross 2000). The alternative would omit fertility control treatment and would result in a higher number of breeding mares compared to Alternative A. Consistent gathers with genetic monitoring and translocation of horses from other HMAs to boost genetic diversity, when necessary, would continue under this alternative. This aspect of monitoring and managing genetic diversity would be the same as under Alternative A.

The objectives set forth in the AMU RMP/ROD (2005) and Three Rivers RMP/ROD (1992) would become more difficult to achieve under this alternative as fertility treatment to slow population growth in wild horses would not be applied. Gathers would occur as described under Alternative A.

3.1.2.6 Alternative E: No Action

The BLM has observed impacts from wild horses on upland use areas within the HMAs with current horse numbers. Taking no action to reduce horse numbers or apply fertility control would only exacerbate the problem. Not only would horses cause increasing levels of competition for forage and water with wildlife and livestock, but amongst themselves as well. Wild horses usually occupy home ranges (undefended, nonexclusive areas), however, when resources are limited, mutual avoidance occurs but can intensify into increased aggression for territory (defended, exclusive areas). In a wild horse behavior study in Grand Canyon, Berger (1976) summarized home ranges for all bands decreased in size

in successive warm months, probably due to increased ambient temperature and drought, resulting in greater utilization of spring areas that led to increased interband confrontation and agonistic display. Miller and Denniston (1979) reported that even females participated along with male group mates when threatening another group of horses at water. Increased occurrences of aggressive activities, caused by a lack of necessary resources, and the consequent acute injuries or effects to the health and wellbeing of wild horses would not follow BLM's objective of managing for a TNEB within an HMA. The co-occurring effects of climate change and high herd densities (over AML) noted under Alternative C would also be expected under the no action alternative, but to a greater degree as no fertility treatments would occur under this alternative.

Non-achievement of the objectives in the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992), specifically the upland and forage and water resources objectives, would be realized more rapidly under the no action alternative as compared to the other alternatives, which aim to maintain wild horse populations within AML. If no action were taken to reduce the population size, initially there would be no effect to wild horses and forage/water availability. Livestock would be moved from the pasture if adequate forage and water were not available for wild horses present. However, as the population grows, there would be increased competition for forage, water, and home ranges, which would result in bands modifying social behavior and increased risk to herd health as forage quantity and quality become more limited.

3.2 Livestock Grazing Management

3.2.1 Affected Environment – Livestock Grazing

The Kiger HMA encompasses two BLM grazing allotments, Smyth-Kiger (#05331) and Happy Valley (#05309) allotments. The BLM allocated forage for livestock (animal unit months (AUM[6])), most recently, in the Andrews RMP/ROD (2005). The Smyth-Kiger Allotment is 30,057 acres and has a permitted season of use of April 1 through October 31, with one permittee authorized to use a total of 2,295 AUMs.

The Happy Valley Allotment is 19,362 acres and has a season of use of April 1 through October 15, with two permittees authorized to use a total of 2,107 AUMs.

The Riddle Mountain HMA encompasses one BLM grazing allotment, Burnt Flat (#05604) Allotment. The BLM allocated forage for livestock (3,866 AUMs), most recently, in the Andrews RMP/ROD (2005). The Burnt Flat Allotment is 34,962 total acres with 29,154 acres as public lands, 5,414 acres as private, and 394 as State-managed lands. There are a total of 4 pastures in the allotment: Louie Hughes 2,303 acres at 89 percent public land, Oriana Flat 30,024 acres at 87 percent public land, Big Sage 632 acres at 76 percent public land, and a private pasture with 2,003 acres with 23 percent public land. The permitted season of use is from April 1 through October 30, with one permittee grazing authorization #3602280 authorized to use a total of 3,866 AUMs.

Table 3 summarizes information about livestock grazing and its relationship to wild horse management within the Kiger and Riddle Mountain HMAs.

[6] An AUM is the amount of forage needed to sustain one cow, five sheep, or five goats for one month.

Table 3: Livestock Use Information

Allotment	Total Allotment Acres	% of Allotment in HMA	Number of Permittees in Allotment	Number of Authorized Livestock in Allotment	Authorized Season of Use	Authorized Livestock AUMs in Allotment
Smyth-Kiger	30,057 (22,706 PD[7]; 7,351 PVT)	100%	1	326 Cattle	4/1–10/31	2,295
Happy Valley	19,362 (16,763 PD; 2,569 PVT)	100%	2	324 Cattle	4/1-10/15	2,107
Burnt Flat	34,962 (29,154 PD; 5,414 PVT)	100%	1	552 Cattle	4/1-10/30	3,866

Table 4 summarizes information about livestock grazing actual use in comparison to wild horse actual use from 2015-2023.

Table 4: Livestock Permitted Use Information

Permittee	Allotment	Allocated AUMs
3600166	Smyth-Kiger	2,295
3601953	Happy Valley	485
3601943	Happy Valley	1,622
3602280	Burnt Flat	3,866

[7] PD stands for public domain and identifies public managed acres; PVT stands for privately owned acres within the allotment.

Table 5: Livestock Actual Use and Wild Horse estimated Use Information

Year	Allotment	Permittee	Permitted Livestock Actual Use AUMs	Total Livestock AUMs	Wild horse Population (Kiger/Riddle combined)	Wild horse AUMs
2023	Smyth-Kiger	3600166	2,024	6,094	456	5,472
	Happy Valley	3601953	420			
	Happy Valley	3601943	1,407			
	Burnt Flat	3602280	2,243			
2022	Smyth-Kiger	3600166	2,422	9,315	380	4,560
	Happy Valley	3601953	514			
	Happy Valley	3601943	1,719			
	Burnt Flat	3602280	4,660			
2021	Smyth-Kiger	3600166	2,064	3,611	316	3,792
	Happy Valley	3601953	356			
	Happy Valley	3601943	1,191			
	Burnt Flat	3602280	N/A			
2020	Smyth-Kiger	3600166	2,686	8,791	263	3,156
	Happy Valley	3601953	383			
	Happy Valley	3601943	1,271			
	Burnt Flat	3602280	4,451			
2019	Smyth-Kiger	3600166	2,587	9,430	219	2,628
	Happy Valley	3601953	581			
	Happy Valley	3601943	1,753			
	Burnt Flat	3602280	4,509			
2018	Smyth-Kiger	3600166	2,779	6,207	182	2,184
	Happy Valley	3601953	442			
	Happy Valley	3601943	1,204			
	Burnt Flat	3602280	1,782			
2017	Smyth-Kiger	3600166	1,506	7,088	151	1,812
	Happy Valley	3601953	465			
	Happy Valley	3601943	1,641			
	Burnt Flat	3602280	3,476			
2016	Smyth-Kiger	3600166	1,689	5,883		
	Happy Valley	3601953	460			
	Happy Valley	3601943	1,634			
	Burnt Flat	3602280	2,100			
2015	Smyth-Kiger	3600166	2,313	7,073		
	Happy Valley	3601953	439			
	Happy Valley	3601943	1,753			
	Burnt Flat	3602280	2,532			

Analysis of actual use data has shown that 6 of the last 9 years livestock use has been reduced to benefit the over-population of wild horses. Utilization has not been consistently recorded above allowable use levels; however, it has been noted that there are areas of consistent, concentrated, and repeated higher levels of use in areas where horses and cattle overlap. Upland trend sites (Pace 180 data (BLM 2024a)) show sites are losing deep-rooted perennial bunch grasses that in turn could be replaced with annual grasses thus reducing available perennial forage. Rangeland Analysis Platform (RAP) data from 2015 to 2023 for the Kiger HMA shows for cover that perennial and annual grass and forb cover are decreasing as bare ground and shrub cover are increasing (BLM 2024a). For Annual Biomass annual grasses are decreasing due to the annual grass treatments that have occurred recently in this area. Perennial grass decreasing during drought years and slight increase on non-drought years. RAP data from 2015-2023 for the Riddle Mountain HMA shows for cover that annual forbs and grasses are static trend and perennial forbs and grasses are increasing (BLM 2024a). Bare ground is increasing, which could lead to the invasion of annual species. Shrub cover appears to be a static trend (BLM 2024a).

3.2.2 Environmental Consequences – Livestock Grazing Management

3.2.2.1 Effects Common to All Alternatives

The current overpopulation of wild horses is continuing to contribute to areas of heavy vegetation utilization and trailing and trampling damage and is preventing the BLM from managing for rangeland health and a TNEB and multiple-use relationships on the public lands in the area. Utilization across both allotments has not exceeded allowable levels consistently; however, areas where concentrated and repeated use occur have seen higher levels of use. Livestock use has been adjusted to accommodate these issues, cattle have been moved away from high use areas when possible, and adjustments in use patterns and grazing timing have been attempted to accommodate horse use in low water years (leading to fewer water sources and thus greater concentrations).

Livestock grazing would be expected to continue to occur in a manner consistent with grazing permits' terms and conditions. Utilization of the available vegetation (forage) would also be expected to continue at similar levels (up to 50 percent on native range and up to 60 percent on non-native seedings). In some years, this may result in livestock being removed from the area prior to utilizing all of the permitted AUMs allocated to that use in the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992).

3.2.2.2 Effects Common to Action Alternatives A, B, and D

Direct impacts to livestock and management practices from activity associated with gathering, including disturbance resulting from moving horses with a helicopter, would be minimal.

Removal of horses to within AML in the HMAs would reduce the combined impacts of both livestock and wild horses on the available forage and water resources. This benefit would decrease as wild horse numbers increased until the next gather. Indirect impacts would include an increase in the quality and quantity of the available forage in the short term. Over the longer-term, improved vegetation resources would lead to a thriving natural ecological condition.

3.2.2.3 Alternative A: Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period

This alternative would result in a slower increase in wild horse population than with the other alternatives. This would allow wild horse use to remain within their allocated AUMs for a longer period, increasing the availability of forage for livestock up to their full permitted use dependent on annual rangeland conditions. The ability to continue gathers, as needed, over the next 10 years would decrease the risk of wild horse numbers interfering with the ability of livestock to utilize permitted AUMs while also maintaining a thriving natural ecological balance by maintaining livestock and wild horse use at allocated levels.

3.2.2.4 Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population

Under this alternative, the effects would be similar to those under Alternative A. Under this alternative, by reducing the breeding population, wild horse numbers would increase at a slightly lower rate, resulting in the need for fewer gathers in the long term and fewer animals receiving fertility control treatments. This would result in keeping the wild horse populations within AML and would decrease the risk of wild horse numbers interfering with the ability of livestock to utilize permitted AUMs while also maintaining a thriving natural ecological balance by maintaining livestock and wild horse use at allocated levels.

3.2.2.5 Alternative C: Fertility Control Vaccines Only

Under this alternative, the effects would be similar to the no action alternative with the exception of slightly lower long-term wild horse populations. Under this alternative, without the initial gather, wild horse reproduction rates would be gradually decreased. As horse numbers naturally decreased through attrition, the grazing impacts due to wild horses would decrease, but horse numbers would not attain AML in the next decade. This would increase the likelihood that livestock use may have to be reduced due to wild horse populations exceeding the high end of AML and the associated forage competition.

3.2.2.6 Alternative D: Gather and Removal Only

Under this alternative, the effects would initially be the same as in Alternative A. Without the use of fertility control, the population would continue to increase by approximately 20 percent per year resulting in numbers above high AML in approximately 4-5 years from the initial gather. Under this alternative, without any fertility treatment, wild horse numbers would increase at a quicker rate, resulting in the need for more gathers in the long term or increasing the likelihood that livestock use may have to be reduced prior to future gathers due to wild horse populations exceeding the high end of AML and the associated forage competition.

3.2.2.7 Alternative E: No Action

Utilization of native perennial forage species by authorized livestock has been directly affected due to the current excess of wild horses above the AML. Wild horse numbers above the AML result in wild horses utilizing more AUMs than they were allocated in the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992). In order to meet annual utilization targets and allow for management that

would meet or make progress towards land health standards in the future, permitted livestock grazing would likely be reduced below full permitted use, as wild horse numbers continue to exceed AML. Apparent heavy to severe utilization is occurring in areas used by livestock, wild horses, and wildlife, specifically around water sources, as indicated by field observations. These areas are currently receiving heavy use even when livestock are not present. The indirect effects of the No Action - Defer Gather and Removal Alternative would be continued damage to the range as would be seen in S&Gs not being achieved in the future; continued competition between livestock, wild horses, and wildlife for the available forage and water; reduced quantity and quality of forage and water; and undue hardship on the livestock operators who would continue to be unable to fully use the forage they are authorized.

3.3 Upland Vegetation

3.3.1 Affected Environment – Upland Vegetation

Shrub steppe vegetation communities in the area result from cold winters and hot, dry summers. Historically, the project area supported a wide variety of sagebrush/perennial grassland cover types. Stands of bluebunch wheatgrass (*Pseudorogneria spicata*) occupy many north-facing slopes. Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) stands are common, generally associated with bluebunch wheatgrass, Thurber's needlegrass (*Stipa thurburiana*), Indian rice grass (*Achnatherum hymenoides*), needle and thread (*Stipa comata*), basin wildrye *(Leymus cinereus*), bottlebrush squirreltail (*Elymus elymoides*), and Sandberg bluegrass (*Poa secunda*). Pockets of low sagebrush (*Artemisia arbuscula*), primarily associated with Sandberg bluegrass and bluebunch wheatgrass, are common on ridgetops and lower production ecological sites. Both gray rabbitbrush (*Ericameria nauseosa*) and green rabbitbrush (*Chrysothamnus viscidiflorus*), and broom snakeweed (*Guterrizea sarothrae*), are scattered throughout the area. Forbs on areas in mid- to late seral conditions include, but are not limited to, hermit milkvetch (*Astragalus erimiticus*), Pursh's milkvetch (*Astragalus purshii*), Hood's phlox (*Phlox hoodii*), and showy penstemon (*Penstemon speciosus*).

Large wildfires (100,000 acres and larger) in the past 15 years in Harney County and Southeast Oregon (Miller Homestead 2012, Holloway 2012, and Buzzard 2014) ultimately consumed over 1,000,000 acres of southeast Oregon rangelands, HMAs, and wildlife habitat. Wildfire season is variable from year to year but, in general, for this area it is from mid-June through the end of August. Moderate grazing has been scientifically shown to result in reduced risk of catastrophic wildfire (Davies et al. 2021). While most studies have been completed using livestock grazing, the factors that are impacting the risk of catastrophic wildfire is the removal of fine fuels, which can be done by many species, including wild horses. Grazing studies have found that grazing in any season increased fuel moisture by reducing the amount of dead (cured) fuels in the bunchgrasses, therefore increasing the live:dead material ratio (Davies et al. 2015; Davies et al. 2016b, Davies et al. 2016c, Davies et al. 2017). In studies where complete grazing exclusion has occurred, results have found that the accumulation of fine fuels may increase fire risk, potential fire severity, and post-fire annual grass invasion in some situations (Davies et al. 2009). Davies and others (2021) found additional strong evidence that moderate "grazing before fire can determine postfire plant community dynamics in fire-prone Artemisia communities at risk of exotic annual grass invasion."

While studies have shown that grazing can help reduce the risk of wildfire, most studies mention that while grazing can help reduce the risk of catastrophic wildfires, grazing in specific time periods offer the most benefits. Schmelzer et al. (2014) also found that "prescribed fall grazing can reduce cheatgrass fuel loads in the Great Basin." Diamond et al. 2009 found that while fire spread in areas grazed, islands of unburned vegetation remained; these islands are important for the recovery of systems after fire. In moderately grazed areas, shrub density was found to be four times greater than in the ungrazed areas in the first growing season following fire, "providing strong evidence that fire-induced mortality was substantially greater in ungrazed areas" (Davies et al. 2021). They found that "dormant-season moderate pre-fire grazing helped maintain perennial vegetation dominance in sagebrush communities at risk of conversion to exotic annual grasslands. In contrast, in ungrazed areas, exotic annual grasses increased substantially post fire" because "greater reductions in dominant perennial vegetation after fire in ungrazed areas likely increased resources for B. tectorum; hence, its biomass was approximately twice as great in ungrazed compared with grazed areas" (Davies et al. 2021). Consistent fall use of cheatgrass by livestock has been shown to disrupt safe sites for seed germination in standing dead cheatgrass biomass and reduce cheatgrass seed banks by half when compared to an ungrazed control (Perryman et al. 2020). Due to the variability of cheatgrass production, grazing it, whether for the objective of providing livestock forage or for the objective of using livestock grazing as a tool to reduce fine fuels, requires flexibility in numbers, timing, or both. Wyoming big sagebrush plant communities with minimal cheatgrass and an understory dominated by perennial bunchgrasses are resilient to repeated winter grazing applied at 40 percent and 60 percent utilization (Davies et al. 2016b). Davies and others (2024) concluded that "Strategically applied grazing can modify fuels and plant community composition to achieve desired social-ecological outcomes such as reduced invasion, decreased fire probability and spread, reduced fire suppression cost, and prevention of ecological transformation postfire. This does not discount that heavy, repeated growing season grazing can have severe negative ecological consequences in sagebrush systems (Daubenmire, 1970; Griffith, 1902; Mack, 1981; Stewart & Hull, 1949). However, strategic grazing, applied with careful attention to the timing, duration, frequency, and intensity of use needed to meet vegetation objectives, has the potential to limit the detrimental impacts of invasive annual grasses, promote native species in introduced grasslands, and encourage shrub recovery."

Grazing at specific times, in combination with growing season rest provides an opportunity for bunchgrasses to complete their lifecycles without grazing stress and is an important factor in grazing rotations in which pastures are grazed during the graze or critical growth period. Moderate grazing levels paired with periodic growing season rest have been shown to maintain or improve bunchgrass communities. While livestock, with proper grazing management can be managed to control the specific locations and timing of grazing, promoting vigor and abundance of perennial bunchgrasses while removing fine fuels and decreasing risk of catastrophic wildfire, wild horses cannot be managed at that level. The WFRHBA states that "All management activities shall be at the minimal feasible level…wherein such lands are located in order to protect the natural ecological balance" (Public Law 92-195, as amended). The BLM does not feel that intensive management that moves wild horses to different pastures multiple times of year on a regular basis would meet the "minimal feasible level" bar from the WFRHBA. Using horses to manage fine fuels in a way that would reduce fuel loading while maintaining a thriving natural ecological balance, would require the gathering and relocating of wild horses into different pastures within the HMAs multiple times a year. In addition, the Wild Horses and Burros Management Handbook (H-4700-1) states that "Activities are carried out with the objective of maintaining free-roaming behavior and at the minimum feasible level of management necessary" and defines the minimal feasible level of management as "The minimum number of habitat or population

management tools or actions necessary to attain the objectives identified in approved LUPs and HMAPs for a HMA or HMA complex" (BLM 2010). As BLM can use livestock to address fine fuel accumulation, with minimal impact to wild horses through the closing of gates only when livestock are present, the BLM believes using intensive grazing management of wild horses is not necessary or appropriate as it would increase the number of gathers needed, increasing stress and risk of injury or mortality to wild horses. In addition, limiting horse movement to a specific pasture within the HMA at a specific time would be contrary to the requirement that the free-roaming behavior of wild horses is maintained (BLM 2010). The maintenance of wild horses within AML, while utilizing intensive livestock grazing management would continue to address fine fuel loading while maintaining a thriving natural ecological balance.

A variety of noxious weeds and invasive annual plants of varying significance are scattered throughout the HMAs. Refer to Section 3.7 Invasive Plants and Noxious Weeds for a description.

Noxious species are a threat to the area because (1) they are easily moved about by various means including wind, water, human activities, livestock, wildlife, and wild horses, (2) they are often very difficult to remove or eradicate in rangeland situations, and (3) they may entirely replace native plants including special status species (SSS).

In areas where wild horses and livestock congregate (generally waterholes), as well as on trailing routes, vegetation is heavily utilized with some areas having all vegetation removed. Desired perennials are weakened by overgrazing, which allows cheatgrass and medusahead to increase. Cheatgrass is becoming more predominant within the HMAs, especially along horse trailing routes and at waterholes. Typically, as grazing pressure increases, so does cheatgrass.

High wild horse utilization may be contributing to conversion of native plant communities to invasive annual grass monocultures that serve little to no ecological purpose on the landscape.

3.3.2 Environmental Consequences – Upland Vegetation

3.3.2.1 Effects Common to Alternatives A, B, and D

Due to the hoof action and vehicle use around trap sites, upland vegetation is often trampled and/or uprooted. However, to minimize these effects, the proposed trap sites would be located in areas previously used as trap sites, or those that have been disturbed in the past. The trap sites would be approximately 0.5 acre in size, which would have a minimal effect on total upland vegetation in the HMAs. However, keeping gather sites in previously used areas or areas previously disturbed would minimize or reduce potential new effects to upland vegetation since vegetation has already been impacted.

Reducing wild horse numbers to AML would reduce the potential for repeated heavy annual utilization levels in wild horse use areas. Reductions in wild horse numbers would result in decreased demand for forage, thus providing opportunity for some plants in use areas to have a full growing season of no to slight use in order to restore vigor and complete a reproductive cycle. Removal of excess horses would allow native vegetation to improve in areas where it has received continuous moderate to heavy growing season use in the recent past. Annual utilization of herbaceous plants during the growing season is

widely known to reduce plant vigor, reproduction, and productivity. Maintaining horses within AML would allow wild horses to remove some fine fuels without requiring intensive management to maintain a thriving natural ecological balance, which would, in conjunction with more intensively managed livestock grazing, would reduce fine fuel loading across the HMA, reducing the risk of a catastrophic wildfire with high perennial grass mortality.

3.3.2.2 Alternative A: Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period

Applying the fertility vaccine would slow down the reproductive rate of the wild horses, reduce the grazing pressure over a longer period, disperse wild horse use areas, and give native vegetation a greater chance to recover and reproduce after grazing. Fewer wild horses would result in utilization of vegetation being moderate and less and increase the potential for any individual plant to receive growing season rest, which has been found to be effective in maintaining and improving rangelands. Healthy, diverse, and productive plant communities promote improved resiliency, reducing the threat of noxious and invasive weed establishment and spread.

3.3.2.3 Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population

Under this alternative, the environmental consequences on upland vegetation would be similar to Alternative A, although the growth rate would not be reduced as much due to less aggressive fertility control applications. Vegetation would be negatively impacted by increased horse numbers sooner than under Alternative A, which would limit or decrease native vegetative recovery rates post gather.

3.3.2.4 Alternative C: Fertility Control Vaccines Only

Under this alternative, environmental consequences would be similar to the no action alternative (Alternative E), with the exception of a reduced growth rate under this alternative as a result of applying fertility treatment. Over time the numbers would be expected to increase at a slower rate as compared to the no action alternative, but not decrease enough to reach AML. As wild horse numbers would not be expected to decrease enough to reach AML, it is expected that wild horses would continue grazing vegetation, which would remove fine fuels, decreasing risk of catastrophic wildfire. However, with numbers that are continuously above AML, there is an increased potential that perennial bunchgrasses would be grazed heavily during the growing season annually. This would result in bunch grasses having reduced vigor, increasing the risk of annual grass invasion which would increase risk of catastrophic wildfire, and would not promote a thriving natural ecological balance in the long-term.

3.3.2.5 Alternative D: Gather and Removal Only

The environmental consequences on upland vegetation would be the same as Alternative A as long as a regular gather cycle were followed. However, if a regular gather cycle were not followed, increases in horse numbers would adversely affect upland vegetation with impacts resembling current conditions.

3.3.2.6 Alternative E: No Action–- Defer Gather and Removal

Under the no action alternative, wild horse populations greater than the AML would not be removed. The increased number of wild horses on the range would further increase the amount of utilization on native vegetation and decrease the amount of available forage. Over time land health standards would not be achieved, with the continued increase in wild horse utilization and the associated disturbance expected to be the causal factors.

Taking no action to maintain the wild horse population within AML is expected to reduce the vigor and resiliency of perennial grasses in the HMAs as utilization levels increase, thereby increasing the potential for annual grass invasion and expansion. Annual grass communities lack the plant community structure, root occupancy of the soil profile, and ability to provide the amount and distribution of plant litter that native perennial communities provide. Annual grass communities, as compared to the potential and capability of native perennial communities, lack the ability to protect the soil surface from raindrop impact, do not provide detention of overland flow, and do not provide maintenance of infiltration and permeability or protect the soil surface from erosion (BLM 1997). The loss of native vegetation would lead to soil loss due to exposure to wind and water erosion and would expose previously native plant communities' areas to noxious and invasive weed invasion. Increases in erosion directly influence the potential to achieve Land Health Standards 1 – Uplands and 3 – Ecological Processes. Additionally, if native, perennial vegetation is degraded, the potential for the expansion of invasive annual grasses could occur, leading to increased fire activity within the HMAs and further degradation of the site and its ability to function or maintain current grazing of domestic livestock, wild horses, and wildlife.

Under this alternative, wild horse numbers would continue to increase. Wild horses would continue grazing vegetation, with a higher intensity as populations increase. While this grazing would remove a higher amount of fine fuels then under any other alternative, which could decrease risk of catastrophic wildfire, it would also increase the risk of annual grass invasion, increasing the risk of catastrophic wildfire. If annual grasses become dominant on the site, a wildfire would be increasingly catastrophic, decreasing the ability of the site to recover from wildfire. Therefore, it is not expected that this alternative would promote a thriving natural ecological balance in the long-term.

3.4 Special Status Species and Habitat

3.4.1 Affected Environment – Special Status Species and Habitat

No federally listed threatened or endangered species are known or suspected to occur within the HMAs.

The BLM sensitive fauna species within the Kiger and Riddle Mountain HMAs include Greater Sage-Grouse (GRSG) and grasshopper sparrow. The species mentioned in this section are sagebrush obligates or associated with sagebrush steppe ecosystems. As such, GRSG will serve as a focal species. The focal species concept provides a link between single- and multi-species methods of wildlife conservation and management (Mills 2007). Focal species serve as a set of species that define the characteristics of different spatial and compositional landscape attributes necessary for functional and healthy ecosystems (Lambeck 1997, Caro and O'Doherty 1999). In short, because they are sagebrush obligates, GRSG function as surrogates for sagebrush communities and associated vertebrates (Rowland et al. 2006). Conserving GRSG habitat also benefits other wildlife species, particularly sagebrush-obligate bird

species (Hanser and Knick 2011, Donnelly et al. 2017), small mammals (Rowland et al. 2006), and big game (Copeland et al. 2014). Potential project impacts for many wildlife species would be similar to those anticipated for sage-grouse.

The Greater Sage-Grouse Conservation Assessment and Strategy for Oregon (Hagen 2011) contains guidelines for wild horse management as it relates to sagebrush habitat management (p. 104), and it states, "[t]he management goals for wild horses are to manage them as components of the public lands in a manner that preserves and maintains a thriving natural ecological balance in a multiple-use relationship. Wild horses are managed in HMAs that involve 2.8 million acres of public land, primarily in Southeastern OR." The Oregon Sage-Grouse Action Plan (Sage-Grouse Conservation Partnership 2015), adopted through Governor Kate Brown's Executive Order (EO 15-18), further builds upon the foundational work of the strategy. The recommended conservation actions for wild horses from the action plan include:

- Action FRE-1) Develop, implement, and enforce adequate regulatory mechanisms that ensure that free-roaming horse and burro populations do not exceed AMLs in HMAs, particularly those that overlap with sage-grouse Priority Areas of Conservation (PAC).
- Action FRE-1-2) Prioritize funding for free-roaming horse gathers in PACs that exceed AML unless removals are necessary in other areas to prevent catastrophic environmental impacts.
- Action FRE-1-4) Use permanent sterilization as a method to suppress population growth rates.

In addition, the Oregon Greater Sage-Grouse Approved Resource Management Plan Amendment (GRSG ARMPA) (BLM 2015e) outlines the following objectives for wild horse and burro management:

1) Manage wild horses and burros as components of BLM-administered lands in a manner that preserves and maintains a thriving natural ecological balance in a multiple-use relationship.
2) Manage wild horse and burro population levels within established appropriate management levels (AML).
3) Complete assessments of Greater Sage-[g]rouse habitat indicators for HMAs containing PHMA and GHMA.[8]

There are two GRSG occupied or pending leks in the project area, one is adjacent to the HMAs, and one is within the HMAs. Within Kiger and Riddle Mountain HMAs, approximately 92 percent (27,788 acres) and .45 percent (1,467 acres) respectively, is designated as general habitat management area (GHMA). Priority habitat management area (PHMA) occurs within approximately 95 percent (29,896 acres) of the Riddle HMA and .07 percent (2,064 acres) within the Kiger HMA. Fifty-two percent (15,760 acres) of the Kiger and 90 percent (29,524 acres) of the Riddle HMA are within 4-miles of an occupied or pending lek. Females exhibit strong fidelity to both leks and nesting areas (Fischer et al. 1993) with approximately 80 percent of GRSG females nesting within four miles of a lek (Hagen 2011). Optimal nesting habitat provides adequate sagebrush and residual grass cover to provide both hiding and thermal cover (Hagen et al. 2005, Anthony et al. 2021) as well as a healthy herbaceous understory of

[8] Priority habitat management area (PHMA): BLM-administered lands identified as having the highest value to maintaining sustainable GRSG populations. These areas include breeding, late brood-rearing, winter concentration areas, and migration or connectivity corridors. General habitat management area (GHMA): BLM-administered lands where some special management will apply to sustain GRSG populations; areas of occupied seasonal or year-round habitat outside of PHMA.

grasses and forbs that provides important nutrition for both pre-breeding adult females and broods (Hagen 2007).

All three seasonal habitats occur within the Kiger and Riddle Mountain HMAs. All three seasonal use areas overlap to cover 100 percent (32,625 acres) of the Riddle HMA. Within the Kiger HMA, 98 percent (29,500 acres) occurring in breeding habitat, 66 percent (20,071 acres) designated as summer brood-rearing habitat, and 100 percent (30,158 acres) occurring in winter habitat (INR 2016[9], Henderson 2019). Not all areas within 4 miles of the occupied or pending leks are modelled as spring or nesting habitat as naturally occurring ecological site limitations do not support or provide sagebrush or other sage-grouse habitat requirements.

3.4.2 Environmental Consequences – Special Status Species and Habitat

3.4.2.1 Effects Common to All Alternatives

Under all alternatives wild horses would continue to graze within the HMAs. The sagebrush plant communities within the HMAs that support sage-grouse are very complex and successionally dynamic, making it difficult to form large-scale conclusions about the impacts of grazing on sage-grouse populations (Crawford et al. 2004). Grazing effects are not distributed evenly because historic practices, management plans and agreements, and animal behavior all lead to differential use of the range (Manier et al. 2013). However, research suggests it is possible for grazing to be managed in a way that promotes forage quality for sage-grouse since grazing may result in increased forb presence (Vavra 2005). Impacts to riparian vegetation per individual wild horse can exceed impacts per individual domestic cow (Kaweck et al. 2018, Burdick et al. 2021).

3.4.2.2 Effects Common to Action Alternatives A, B, and D

Sage-grouse could be temporarily disturbed or displaced by the helicopter or by placement of traps if sage-grouse are still present in the area; however, the general helicopter gather period would be outside the breeding and nesting period. Impacts would be short term (<2 weeks) and sage-grouse would return to regular use of the area after the disturbance has passed.

In these alternatives, sage-grouse would have the same level of resources available as are currently present within the HMAs, or greater. Because of the known damage that overpopulated wild horse and burro herds can cause in rangeland ecosystems, the presence of wild horses and burros is considered a threat to Greater Sage-Grouse habitat quality, particularly in the bird species' western range (Beever and Aldridge 2011, USFWS 2013). Under alternatives A, B, and D horse numbers would be reduced to AML reducing the occurrence of large areas of uniform utilization at heavy intensities on a year-round basis. This would have expected beneficial effects for GRSG. The presence of wild horses is associated with a reduced degree of Greater Sage-Grouse lekking behavior (Muñoz et al. 2020). Moreover, increasing densities of wild horses, measured as a percentage above AML, are associated with decreasing Greater Sage-Grouse population sizes, measured by lek counts (Coates et al. 2021). Utilization is not expected to exceed 50 percent. Anderson and McCuistion (2008) found grazing management (including horses), when upland birds are present, should be flexible, but limited to a light

[9] These data layers represent seasonal habitat for the greater sage-grouse. They are based on species distribution models, linking known locations for greater sage-grouse at different times of year to an array of environmental variables describing climate, topography, and vegetation condition.

to moderate use (30 percent to 50 percent utilization). They concluded light to moderate use can increase forb quality and quantity since it can delay the maturation of forbs, extending availability throughout the growing season. Adams and others (2004) suggest that light to moderate grazing encourages the height and cover of sagebrush and other native species during nesting seasons, and light grazing is used to create patches in the vegetation, increasing the herbage of species preferred by sage-grouse, especially during nest and brood rearing. Moderate levels of use are generally considered compatible with maintaining perennial bunchgrass, with the level of sustainable use depending on a number of environmental factors (Hagen 2011).

Under these alternatives, herbaceous cover is expected to increase, which will benefit the sage-grouse by providing improved thermal cover and protection from predators. This could improve survivability over time. Areas within the HMAs near water sources would continue to be affected by concentrated grazing uses. Portions of the HMAs away from existing waterholes would have non-grazed or lightly grazed areas, which would be expected to provide more suitable nesting sites for sage-grouse due to more residual grass cover. This would be expected to be highest in areas outside of the current use area during drought years and lowest in these areas during wet years since in those years it would be expected that all water sources would have water and attract livestock and wild horses while dispersing their use. Residual grass cover provides horizontal screening at nest sites, in addition to screening from shrubs, which is believed to reduce predation. Maintaining wild horse numbers within AML would aid BLM land managers in their ability to provide quality sage-grouse habitat in the quantities needed for their survival and the growth of populations. These alternatives would maintain achievement of, or promote progress toward achieving, Land Health Standard 5 with the goal of providing habitats that support healthy, productive, and diverse populations and communities of native plants and animals (including special status species and species of local importance) appropriate to soil, climate, and landform. These alternatives would not contribute to the decline of remaining sagebrush habitat for sage-grouse or the reduction of sage-grouse populations.

Fertility control actions would not be likely to impact SSS except as the changes in reproduction would impact upland vegetation by reducing the horse herd annual growth rate.

3.4.2.3 Alternative C: Fertility Control Vaccines Only and Alternative E: No Action - Defer Gather and Removal

Under these alternatives, wild horse numbers would continue to increase, resulting in greater use of the area and reduction of residual grasses that provide hiding cover for sage-grouse nests. Utilization studies in the HMAs are currently showing only localized moderate to heavy (41-60 percent to 61-80 percent) use areas around water sources and wild horse home ranges. These alternatives would likely expand those moderate to heavy use areas with an indefinite increase in wild horse numbers. In addition to the work by Muñoz and others (2020) and Coates and others (2021) that directly implicates high wild horse density with negative effects on GRSG behaviors and demographic rates, findings from France and others (2008) suggest cattle initially concentrate grazing on plants between shrubs and begin foraging on perennial grasses beneath shrubs as interspace plants are depleted. It can be assumed wild horse use would mimic cattle use of perennial grasses as the more easily accessible plants would be grazed first. France and others (2008) found cattle use of understory perennial grass was minimal until standing crop utilization reached about 40 percent, although this utilization level would likely vary depending on sagebrush density, sagebrush arrangement (e.g., patchy vs. uniform distribution), bunchgrass structure,

and accompanying forage production levels. As utilization levels increase across the HMAs with increased wild horse numbers it is expected that horizontal screening cover of sage-grouse nests would decline. An increase in wild horse numbers would also decrease the likelihood that individual perennial plants could receive a full growing season of rest from wild horse use. When perennial plants lack adequate growing season rest periods where they are able to complete a full reproductive cycle, the plant community composition, age class distribution, and productivity of healthy habitats is negatively affected, thus influencing the ability to achieve Land Health Standard 5 for Native, Threatened and Endangered (T&E), and Locally Important Species. Increases in wild horse numbers further beyond AML could also lead to direct competition between wild horses and sage-grouse for food sources during critical stages of the sage-grouse lifecycle (nesting and brood rearing), with less available resources for sage-grouse due to overutilization of the area by wild horses. These alternatives would be expected to result in lower habitat quality for sage-grouse and contribute to the further reduction of sage-grouse habitat and population numbers.

3.5 Migratory Birds

3.5.1 Affected Environment – Migratory Birds

The sagebrush steppe present within the HMAs supports several species of sagebrush obligate and facultative migratory birds, including sage thrasher (*Oreoscoptes montanus*), sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), and loggerhead shrike (*Lanius ludovicianus*). Other species commonly occurring in sagebrush habitat in the area include mountain bluebird (*Sialia currucoides*), vesper sparrow (*Pooecetes gramineus*), horned lark (*Eremophila alpestris*), and western meadowlark (*Sturnella neglecta*). Raptors found in or near the project area include golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*Buteo regalis*), American kestrel (*Falco sparverius*), and prairie falcon (*Falco mexicanus*). Species listed by the US Fish and Wildlife Service as Birds of Conservation Concern (USFWS 2021) that occur in the HMAs are golden eagle, ferruginous hawk, long-billed curlew, sage thrasher, Brewer's sparrow, and sage sparrow.

3.5.2 Environmental Consequences – Migratory Birds

Past and present actions affecting the area include road and fence construction, water developments, livestock and wild horse grazing, and recreation. These actions and events can have mixed effects on migratory birds and their habitat depending on the species. Livestock and wild horse grazing are the most widespread and long-term actions occurring within the HMAs and are managed and monitored to facilitate sustainable multiple use, including maintenance of migratory bird habitat.

3.5.2.1 Effects Common to Action Alternatives A, B, and D

Bird nest survival may be lower in areas with wild horses (Zalba and Cozzani 2004), and bird populations have recovered substantially after livestock and/or wild horses have been removed (Earnst et al. 2005, Earnst et al. 2012, Batchelor et al. 2015). Under these alternatives, herbaceous cover is expected to increase, which will benefit migratory birds by providing improved nesting and hiding cover, protection from predators, and forage (especially for ground nesting bird species). Maintaining wild horse numbers within AML would aid BLM land managers in their ability to provide quality migratory bird habitat in the quantities needed for migratory bird survival and possible growth of

populations. These alternatives would maintain achievement of, or promote progress toward achieving, Land Health Standard 5 with the goal of providing habitats that support healthy, productive, and diverse populations and communities of native plants and animals. These alternatives would not contribute to the decline of sagebrush habitat for sagebrush obligate species.

Some migratory birds could be temporarily disturbed or displaced by the helicopter or by placement of traps. However, the general helicopter gather period would be outside the breeding and nesting period for most birds. Impacts would be short term (<2 weeks) and many species of migratory birds would return to regular use of the areas after the disturbance has passed. Reduction of wild horse numbers to AML would reduce utilization of forage and water resources by wild horses, reducing competition for these resources and allowing for maintenance or improvement of habitat conditions for migratory bird species.

3.5.2.2 Alternative C: Fertility Control Vaccines Only and Alternative E: No Action - Defer Gather and Removal

Under these alternatives, wild horse numbers would continue to increase, resulting in greater use of the area and reduced residual grasses that provide food, hiding cover, and nesting habitat for migratory birds. An increase in wild horse numbers would also decrease the likelihood that individual perennial plants could receive a full growing season of rest from wild horse use. When perennial plants lack adequate growing season rest periods where they are able to complete a full reproductive cycle, the plant community composition, age class distribution, and productivity of healthy habitats is negatively affected thus influencing the ability to achieve Land Health Standard 5 for Native, T&E, and Locally Important Species. Increases in wild horse numbers further beyond AML would also lead to direct competition between wild horses and migratory birds for food and water sources during critical stages of their lifecycle (nesting and brood rearing), with less available resources due to overutilization of the area by wild horses. These alternatives could, and are expected to, result in lower habitat quality for migratory birds and contribute to the further reduction of migratory bird habitat.

3.6 Wildlife and Locally Important Species

3.6.1 Affected Environment – Wildlife and Locally Important Species

A variety of wildlife, other than migratory birds and SSS, including small mammals (black-tailed jackrabbit, cottontails, ground squirrels, pocket gophers, deer mouse, bobcat, yellow-bellied marmot, wood rats, voles, chipmunks, and bats), cougars, coyotes, amphibians, and reptiles common to southeast Oregon, can be found throughout the HMAs. Pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*) use the HMAs to varying extents yearlong.

Wild horses present throughout the HMAs may exclude other wildlife use from water sources, especially in late summer when water sources are limited. Miller (1983) found that when antelope could get to water while being no closer than 3 meters from a wild horse or cow, they were able to water; otherwise, they would only circle the waterhole, leave, and return later to try again. Grazing by wild horses can have severe impacts on water source quality, aquatic ecosystems, and riparian communities as well (Beever and Brussard 2000, Barnett 2002, Nordquist 2011, USFWS 2008, Earnst et al. 2012, USFWS 2012, Kaweck et al. 2018), sometimes excluding native ungulates from water sources

(Ostermann-Kelm et al. 2008, USFWS 2008, Perry et al. 2015, Hall et al. 2016, Gooch et al. 2017, Hall et al. 2018). Additional review of potential effects of wild horses on wildlife generally is included in Appendix F.

3.6.2 Environmental Consequences – Wildlife and Locally Important Species

3.6.2.1 Effects Common to Alternatives A, B, and D

Some wildlife could be temporarily disturbed or displaced by the helicopter or by placement of traps. Impacts would be short term (<2 weeks) and many species of wildlife would return to regular use of the areas after the disturbance has passed. Reduction of wild horse numbers to AML would reduce utilization of forage and water resources by wild horses, reducing competition for these resources and allowing for improvement of habitat conditions for wildlife species. A recent study in the Murderers Creek HMA concluded that mule deer avoid habitat also occupied by wild horses (Platte and Torland 2024), so mule deer usage might be expected to increase marginally if wild horse density is kept at AML. Reduced competition for vegetation would result in plants being able to be healthy and vigorous.

3.6.2.2 Alternative C: Fertility Control Vaccines Only and Alternative E: No Action - Defer Gather and Removal

Over time the wild horse population would continue to increase, using more resources and leaving fewer forage species for wildlife to graze upon. Of the big game species present, pronghorn and elk would most likely be more affected by competition for forage with wild horses than mule deer. On an annual basis, dietary overlap between wild horses and pronghorn averaged 16 percent and ranged from 7-26 percent (McInnis and Vavra 1987). Elk would have a similar dietary overlap with wild horses (Scasta et al. 2016). A study by Hansen and others (1977) found that mule deer food habits appear to be complementary rather than conflicting with diets of wild horses. The no action alternative and the subsequent increase in wild horse numbers would also cause increased competition, between wild horses and some wildlife, for water. As wild horse numbers increase, they may exclude wildlife from using water sources, especially in late summer when water sources are limited, and horse concentrations are high around the remaining water sources. Both mule deer and pronghorn used water sources less often where wild horse activity was high (Hall et al. 2018). As wild horse numbers increase, wildlife numbers in the HMAs could decrease due to lack of forage base support and accessible water sources.

3.7 Invasive Plants and Noxious Weeds

3.7.1 Affected Environment – Invasive Plants and Noxious Weeds

Invasive plants are non-native and aggressive with the potential to cause significant damage to ecosystems and/or cause significant economic loss. Noxious weeds are a subset of invasive weed species that are listed by county or state as injurious to public health, agriculture, recreation, wildlife, or any public or private property and have a legal classification as noxious. Unlisted invasives include a suite of annual mustard species, chenopods (e.g., Russian thistle), and other nuisance annual species. The most troublesome and problematic of the species are invasive annual grasses, collectively referred to as IAGs.

The last intensive survey of the Kiger and Riddle Mountain HMAs was conducted in 2013. Survey, treatment, and monitoring efforts are ongoing and focused on vectors of spread, namely roadways and past ground disturbances such as fire. However, wild horses are also known to spread viable seeds of invasive plants such as cheatgrass (i.e, Loydi and Zalba 2009, King et al. 2019). Based on existing GIS data, Tables 6 and 7 show invasive plant species and noxious weeds, number of sites, estimated acres of infestation, and general location within each HMA. IAGs (cheatgrass, medusahead, Japanese brome, and ventenata) are not well represented in existing GIS data or mapped with traditional survey methods often due to landscape scale infestation size, though remote sensing technologies can provide a useful tool in identifying these areas.

Table 6: Kiger HMA Invasive Plants and Noxious Weeds

Common Name ***Scientific Name***	**# of Sites**	**Acres***	**General Location**
Bull Thistle *Cirsium vulgare*	236	930.6	Scattered throughout HMA
Canada Thistle *Cirsium arvense*	682	199.0	Scattered throughout HMA
Diffuse Knapweed *Centaurea diffusa*	1	123.6	Near Rock Creek Reservoir
Field Bindweed *Convolvulus arvensis*	3	0.2	Kiger Mustang Viewing and the Smyth Ranch Roads
Mediterranean Sage *Salvia aethiopis*	3	1.5	Kiger Mustang Viewing Road south of previous trap location
Medusahead *Taeniatherum caput-medusa*	56	1,751.9	Scattered throughout HMA
Perennial Pepperweed *Lepidium latifolium*	3	23.5	Diamond Grade Spur and Kiger Mustang Viewing Roads
Russian Knapweed *Centaurea repens*	1	trace	Kiger Mustang Viewing Road
Scotch Thistle *Onopordum acanthium*	92	175.0	Scattered throughout HMA
Spotted Knapweed *Centaurea stoebe*	1	trace	Ross Cabin Road near Rock Creek Reservoir
Whitetop *Cardaia draba*	26	392.4	Roads in HMA
Ventenata *Ventenata dubia*	2	0.8	Kiger Mustang Viewing and West Kiger Rim Roads

*Values rounded to nearest tenth of acre. Values less than 0.10 acre are trace.

Table 7: Riddle HMA Invasive Plants and Noxious Weeds

Common Name *Scientific Name*	# of Sites	Acres*	General Location
Bull Thistle *Cirsium vulgare*	26	281.3	Predominately along the South Virginia Valley and Anderson Mountain Roads in the NW portion of HMA
Canada Thistle *Cirsium arvense*	214	2.7	Predominately along the South Virginia Valley and Anderson Mountain Roads in the NW portion of HMA
Field Bindweed *Convolvulus arvensis*	1	trace	Edge of HMA on Anderson Mountain Road
Medusahead *Taeniatherum caput-medusa*	12	149.3	South Virginia Valley Road
Scotch Thistle *Onopordum acanthium*	15	0.1	Predominately along the Anderson Mountain Road in the NW portion HMA
Whitetop *Cadaria draba*	1	0.1	South Virginia Valley Road
Ventenata *Ventenata dubia*	1	512.3	Close proximity to previously used trap areas

*Values rounded to nearest tenth of acre. Values less than 0.10 acre are trace.

The Kiger Creek Fire (1996) and Smyth Creek Fire (2011) are the primary fire scars located in the center of the Kiger HMA covering approximately 6,430 acres. Several other small fires and portions of larger fires cross into the HMA boundary or are located along its edges, typically less than 1,000 acres in size. Within the Riddle Mountain HMA several small fires or larger fires that cross into the HMA boundary are located mostly along the southeast portion of the HMA in drainages and range in size from a few hundred to approximately 1,500 acres spanning the timeframe from 1996 to 2020. In both HMAs fire scars show a higher percentage of annual grass cover compared to unburned areas (ORC 2016a). Additionally, according to threat-based model data (ORC 2016b) and areas vulnerable to medusahead invasion data (BLM 2015a), several thousand more acres are susceptible to IAG infestation.

Treatments consist of both ground-based and aerial. Ground-based tend to be small-scale spot applications targeting broadleaf weeds (tables above), while aerial treatments are largescale broadcast applications targeting IAGs. From 2012 to 2023, approximately 20,577 acres in Riddle HMA and 18,842 acres in Kiger HMA have been aerially treated with herbicide for IAGs.

As wild horse numbers increase, intense grazing at higher utilization levels removes desirable vegetation and increases rate of spread and dominance in areas infested with IAGs. Annual species provide little to no competition against invasion by noxious species, especially knapweeds, thistles, and perennial mustards, such as whitetop. With the exception of whitetop and perennial pepperweed (spread by non-pappus seeds and root fragments), the seeds of these weed species have a pappus, which allows for wind transport into vulnerable areas, or in the case of Mediterannean sage are capable of breaking off and tumbling in the wind. Vegetation communities dominated by IAGs become more easily invaded by noxious weed seed sources (i.e., diffuse and spotted knapweed, Mediterranean sage, and whitetop) as well as are more susceptible to wildland fires (D'Antonio 1992).

3.7.2 Environmental Consequences – Invasive Plants and Noxious Weeds

3.7.2.1 Affects Common to All Alternatives

Areas of high wild horse concentration are subject to heavy grazing. This disturbance opens up more niches for noxious weed and IAG establishment and spread. By maintaining horse numbers at or below AML, the opportunities for noxious weed and IAG spread would be reduced. Limiting vehicle travel to existing roadways and timing gather events to avoid times of high spread potential (seed shatter, muddy conditions, etc.) as much as possible, combined with aggressive weed treatment during the year pre-gather, and avoiding noxious weed and IAG infested areas when selecting trap sites, would limit the potential of noxious weed and invasive plant spread during gathering operations. Gather sites would be noted, monitored by the staff, and weed sightings reported to district weed personnel for treatment and monitoring. Gather related monitoring and treatment of noxious weeds are described in the Project Design Features section 2.1.2.

3.7.2.2 Effects Common to Action Alternatives A, B, and D

By reducing horse populations and managing within AML, vegetation in areas of wild horse usage within the HMAs would be less heavily grazed, allowing the desirable vegetation to be more vigorous and competitive, and providing less opportunity for new weed infestations. The fertility treatment may lengthen the time before horse numbers return to high AML, which would allow the vegetation a longer time period in which to recover.

If the gather activities follow the listed SOPs and project design features, including thoughtful selection of timing of gathers (which can minimize likelihood of weed spread), then the gather activities themselves would not increase the opportunities for increased noxious weed introduction and spread. Trap sites would be disturbed and would need to be monitored at least 3 years post-gather. Any weeds found would be treated in a timely manner using the most appropriate methods.

3.7.2.3 Alternative C: Fertility Control Vaccines Only and Alternative E: No Action - Defer Gather and Removal

The continuing increase in wild horse numbers above the AML would lead to areas of higher horse concentrations causing more negative impacts to the vegetation due to overgrazing. This opens up more niches for noxious weeds to establish and spread. Areas of wild horse concentration and consequent heavy use typically are highest near water sources. Heavier use around already disturbed areas such as waterholes and congregation areas would lead to increased disturbance and, consequently, increases in noxious weed and/or IAG establishment. Given medusahead's ability to spread to new sites and alarming expansion of existing sites, it and other IAGs are a special concern in these over-used areas.

3.8 Soils and Biological Crusts

3.8.1 Affected Environment – Soils and Biological Crusts

3.8.1.1 Soils

There are seven soil associations found within the HMAs: Ninemile-Westbutte-Carryback, Welch silt loam, Duff-Clamp Complex, Hackwood-Bacon Camp Complex, Fletcher-Rock Outcrop Complex, Swalesilver silt loam, and Fletcher-Sagehen Complex.

Soil erosion has the greatest impact around water developments where soils are most exposed to the elements. Because water developments are placed in areas where they are mostly flat, or level on the landscape, water erosion would not have as great an impact as wind erosion. Additionally, because trails are relatively narrow, and wind through vegetation, especially farther from water developments, livestock and wild horse trails are not a primary source for water or wind erosion.

Wild horses can impact soils by reducing soil cover temporarily (annual utilization of grass) or longer term (if repeated, overgrazing kills perennial grass), making soils more susceptible to erosion from wind, rain, and overland flow. Livestock can also compact soils in congregation areas, reducing soil productivity as well as increasing potential erosion. Lai and Kumar (2020) found that while moderate grazing increases soil compaction and soil alkalinity, and reduces soil organic carbon and total nitrogen, these impacts were significantly lower than under heavy grazing. They also found that heavy grazing is much more likely to result in overgrazing than moderate grazing, and that heavy grazing would have more detrimental impacts on soil quality than moderate grazing (Lai and Kumar 2020). Their study found that moderate grazing did not influence most of the 15 tracked soil properties (Lai and Kumar 2020). Soil texture also plays a role on grazing impacts, with sandier soils showing less change in soil porosity and water circulation due to trampling (Lai and Kumar 2020). Loams tend to have a higher proportion of sand and silt, and less clay. Temperature and precipitation also play a complex role in grazing effects to soils (Lai and Kumar 2020). Overall, Lai and Kumar (2020) concluded that heavy grazing had "more detrimental impacts on soil quality than moderate and light grazing" and that "global grazing intensities did not significantly impact most of the 15 soil properties, and the grazing impacts on the 15 soil properties had no significant change over the last two decades." Recovery processes (e.g., earthworm activity and frost heaving) may be sufficient to limit compaction by livestock in many upland systems (Thurow et al. 1988). On desert grasslands, increasing grass cover can result in a long-term reduction in compaction layers and an increase in water infiltration (Castellano and Valone 2007).

3.8.1.2 Biological Soil Crusts

Biological soil crusts (BSC) can be viewed from functional, structural, and compositional perspectives. They function as living mulch by retaining soil moisture and discouraging annual weed growth. They reduce wind and water erosion, fix atmospheric nitrogen, and contribute to soil organic matter (Eldridge and Greene 1994). Biological soil crusts in North America are diverse and are most evident in arid and semi-arid ecoregions (BLM 2001). Total crust cover is inversely related to vascular plant cover, as less plant cover results in more surface available for colonization and growth of crustal organisms. Thus, when all crust types are combined (cyanobacterial, moss, lichen), cover is greatest at lower elevation inland sites (less than 1,000 m; 3,280 feet) compared to mid-elevation sites (1,000 to 2,500 m; 3,280 to

8,202 feet) (Hansen et al. 1999). However, relative lichen and moss cover increases with elevation and effective precipitation until vascular plant cover precludes their growth. The elevation of the project area ranges from 4,400 to 6,200 feet, making it mid-elevation for BSCs. In the great basin, when present, BSCs such as soil lichens are located in the interspaces while mosses are more commonly found under shrubs or trees (BLM 2001).

BSCs form in open spaces between plants and can help stabilize soil and fix carbon and nitrogen. BSCs are slow growing, and how BSCs interact with other environmental factors is not well understood due to complex interactions that are difficult to separate in scientific studies. This results in limited success of practices to conserve and restore BSCs (Bowker 2007, Young et al. 2019). Ponzetti and McCune (2001) found that "[t]he soil chemistry gradient is by far the strongest explanatory factor for the compositional differences among research sites" and "[o]ther important factors include average annual temperatures, elevation, and shrub cover." They also conclude that therefore, "the compositional effects of grazing were overwhelmed by the stronger soil chemistry and climate gradients" (Ponzetti and McCune 2001). Their study did find that when comparing grazed vs. non-grazed transects that grazed sites had "slightly lower mean species richness" under conditions of light to moderate grazing and that BSCs may be more sensitive to impacts from grazing than vascular plants such as bunchgrasses (Ponzetti and McCune 2001). BSCs can be damaged by hoof action (trampling) from wild horse grazing (as well as native wildlife and livestock), wildfire, drill seeding, and off-trail recreation activities like hiking, horseback riding, mountain biking, and motorized use, all of which have occurred to some degree in the project area. Livestock and wild horse grazing, and associated hoof impact, can result in patchy disturbance to BSCs, with different levels of intensity, depending upon factors such as water and supplement placement, fence placement, and livestock forage preference; vegetation composition and fuel loading can also result in fire patchiness (Fuhlendorf et al. 2009). Any reduction in BSCs may increase the potential for erosion and soil loss, though the direct relationship is variable depending on the site and other characteristics (Ponzetti and McCune 2001). This disturbance would only occur in areas where BSCs are currently present.

Specific identification of BSCs at the species level is often not practical for fieldwork. The use of some basic morphological groups simplifies the situation. Morphological groups are also useful because they are representative of the ecological function of the organisms (BLM TR-1730-2, 2001, p. 6). Using a classification scheme proposed in 1994 we can divide microbiota such as biological soil crusts into three groups based on their physical location in relation to the soil: hypermorphic (above ground), perimorphic (at ground), and cryptomorphic (below ground). The morphological groups are: 1. Cyanobacteria - Perimorphic/cryptomorphic, 2. Algae - Perimorphic/cryptomorphic, 3. Micro-fungi - Cryptomorphic/perimorphic, 4. Short moss (under10mm) – Hypermorphic, 5. Tall moss (over 10mm) – Hypermorphic, 6. Liverwort – Hypermorphic, 7. Crustose lichen – Perimorphic, 8. Gelatinous lichen – Perimorphic, 9. Squamulose lichen – Perimorphic, 10. Foliose lichen – Perimorphic, and 11. Fruticose lichen – Perimorphic.

Soil surface microtopography and aggregate stability are important contributions from BSCs as they increase the residence time of moisture and reduce erosional processes. The influence of BSCs on infiltration rates and hydraulic conductivity varies greatly; generally speaking, infiltration rates increase in pinnacled crusts and decrease in flat crust microtopography. The northern Great Basin has a rolling BSC microtopography and the infiltration rates are probably intermediate compared to flat or pinnacled

crustal systems. Factors influencing distribution of BSCs (BLM TR-1730-2, 2001) include, but are not limited to, elevation, soils and topography, percent rock cover, timing of precipitation, and disturbance.

In many areas of these HMAs, range assessments found few areas of existing BSC. Historical disturbance including historic improper grazing, cultivation, and fire likely reduced BSCs. Studies, specifically Davies and Bates (2010), found that BSCs do not appear to constitute a large portion of cover in either mountain or Wyoming big sagebrush plant communities in the northern Great Basin; these plant communities make up the majority of the landscape within the HMAs. Muscha and Hild (2006) studied BSCs in grazed and ungrazed Wyoming sagebrush steppe and found mosses decreased with grazing, but there was no difference in lichens inside the enclosures (32-45 years of no grazing) versus outside. Davies and others (2016) found that areas grazed pre-fire had more BSCs post-fire than areas not grazed, likely because fire was more severe in ungrazed areas (due to accumulated plant material) and cheatgrass increased in those areas post-fire, both of which negatively influence BSCs. Root and others (2020) found that where livestock reduced BSCs, more annual grasses were found. However, O'Connor and Germino (2020) found that Root and others' (2020) conclusion neglected to consider the effects of wildfire on the study plots in recent decades. Concostrina-Zubiri and others (2016) found that mean lichen cover did not show changes with increased grazing; however, species richness differed along disturbance gradients, with more richness in less disturbed areas. Loss has been shown to occur with increased stocking rates; however, most livestock travel two-three miles from any water source and horses will travel even farther, but the majority of their use is located around water sources. While overgrazing can impact BSCs, overgrazing (higher than the 50 percent limit) is localized around water developments and average utilization across a pasture should remain below the 50 percent utilization threshold on native perennial grasses (which is more difficult to manage with increased wild horse numbers compared to livestock grazing). This would be expected to minimize potential loss of diversity.

Grazing management in the three allotments within the Kiger and Riddle Mountain HMAs is designed to prevent overgrazing by livestock by applying utilization thresholds and responses. The target utilization levels for key forage plant species of no more than 50 percent utilization on key native upland perennial species and 60 percent utilization on desirable nonnative species, such as crested wheatgrass, would limit negative effects of hoof action while matching the prescription for positive effects related to fire. As wild horses are present year-round, use/utilization is not able to be altered or adjusted through active management like livestock grazing and thus wild horses pose a greater threat to the BSCs that may be located within the HMAs.

3.8.2 Environmental Consequences – Soils and Biological Crusts

Actions proposed in this EA that could negatively affect BSCs are hoof action from wild horses, and actions associated with construction and removal of the equipment at the gather site(s).

3.8.2.1 Effects Common to Alternatives A, B, and D

Wild horses, much like livestock, tend to congregate around areas where resources are plentiful, such as water sources. When horse numbers increase, so do the impacts to soils and biological soil crusts. Soil loss and compaction would be expected to increase in those areas near water sources where horses are

forced to concentrate. Lower populations of wild horses would result in less hoof traffic, thereby decreasing negative impacts to soil and BSCs.

Soil would be displaced and/or disturbed on two acres at each trap site, in the construction of the trap, use of the access routes, and in the round-up and loading of the wild horses. The area of severe surface disturbance is normally less than 2,000 square feet. Minimal surface wind and water erosion is expected on these areas during the vegetative rehabilitation period (approximately 1 to 3 years). Overall, impacts would be localized and short-term.

3.8.2.2 Alternative C: Fertility Control Vaccines Only and Alternative E: No Action - Defer Gather and Removal

Under these alternatives, wild horse numbers would increase at a rate of approximately 11 percent and 20 percent, per year, with no gathering to the lowest AML. Increases in horse numbers would lead to excessive overgrazing, which would expose soils to wind and water erosion and remove biological soil crusts from the HMAs. Larger areas around water resources and in use areas would become compacted as wild horse numbers increase. Increased loss of BSCs across the HMAs would occur as wild horses utilize more of the area looking for resources as they become scarce.

3.9 Social and Economic Values

3.9.1 Affected Environment – Social and Economic Values

As stated in an Office of Inspector General report (2010), fiercely competing interests and highly charged differences of opinion currently exist between BLM and private individuals and organizations concerning the need for wild horse gathers, the methods used to gather, and whether horses are treated humanely by BLM and its contractors during and after the gathers. Scoping comments received on previous NEPA documents proposing wild horse population management activities have included a wide range of both support and opposition to various methods of population management.

Many of these commenters derive benefit from the presence of these wild horse herds by actively participating in recreation to view the horses. Some individuals believe that any type of gathering and holding of wild horses is inhumane, or not in keeping with the intentions of the WFRHBA. Others value the existence of wild horses without actually encountering them. This value represents a non-use or passive value commonly referred to as existence value. Existence values reflect the willingness to pay to simply know these resources exist.

Conversely, a separate group of individuals may or may not support the existence of wild horses on public land yet express concern about wild horse numbers and the adverse impacts on other resources. These “other resources” include, but are not limited to, the economic impacts that could result from increased wild horse numbers such as reduced livestock grazing opportunities; the impacts to wildlife, biodiversity resources, and rangeland ecosystem functions; as well as the resultant decline in hunting opportunities.

For the purposes of this analysis, it is important to recognize the number of wild horses the BLM manages across the United States, and the total estimated number of free-roaming horses in the United

States, in order to fully understand the effects analysis area of social and economic costs of the decisions to be made for the Kiger and Riddle Mountain HMAs. Table 8 displays the numbers of horses estimated on the range and in off-range corrals and off-range pasture holding facilities. The national total of high AML across all HMAs is 26,770 horses and burros.

Table 8: Number of Wild Horses and Burros BLM Manages Nationally, On and Off the Range.

Location	Horses	Burros	Total
On the Range BLM managed wild horses and burros (Estimate as of March 1, 2023. Does not include 20% increase for the 2023 foal crop).	68,928	13,955	82,883
Off the Range BLM managed wild horses and burros (BLM facilities and long-term holding as of March 2023).	59,045	2,781	61,826
		Total	**144,709**

Numbers comparable to those in Table 8 led the Office of Inspector General of the U.S. Department of the Interior (2016) to state at the time that, "BLM does not have a strategic plan in place to manage the wild horse and burro populations. The consistent on-range population growth drives the constant need for additional off-range holding and increased spending. If no plan is in place to control the on-range population source, the off-range holding, and financial need will continue in this unsustainable pattern." Since that time, the BLM has provided reports to Congress indicating strategies to bring national populations down to AML, and to maintain them at that level. In fiscal year (FY) 2023, $109 million (69 percent of the WHB Program expenses) were allocated to off-range holding costs (BLM 2024).

Some of the costs associated with certain activities, included in the range of alternatives, are listed below. Not all activities are included in the list as it is extremely difficult to put a numerical value on such things as vegetative resource damage or decreased recreational opportunities, yet there is certainly a social and economic value associated with their improvement, maintenance, or loss. Quantifiable costs of such things as holding, gathering, and fertility treatment include, but are not limited to:

- Holding horses at Oregon's Wild Horse Corral Facility costs approximately $5 per day per horse.
- Long-term holding costs average about $2.01 per day per horse. Unadopted animals receive an estimated 25 years of care, which adds up to approximately $46,000 per horse for the remainder of their life.
- Helicopter-drive gather operations are currently costing around $600 per horse gathered.
- Bait/water and horseback-drive trap gathers are currently averaging $1,100 per horse trapped in Oregon.
- Field darting applications cost approximately $1,000 per mare treated.
- GonaCon-Equine fertility treatment costs approximately $50 per dose.
- ZonaStat-H fertility treatment costs approximately $30 per dose.
- PZP-22 fertility treatment costs approximately $500 per dose.
- The costs of GonaCon-Equine, ZonaStat-H, and PZP-22 listed above include the drug costs only, not the cost of capturing the mare to be treated.
- Gelding of stallions costs approximately $60 per horse. This includes the castration surgery only.
- Mare sterilization costs approximately $300-$1,000 per horse depending on the sterilization method used (including surgical and nonsurgical methods).

3.9.2 Environmental Consequences – Social and Economic Values

3.9.2.1 Effects Common to Alternatives A, B, and D

For the purposes of this analysis, the cumulative effects analysis area (CEAA) for social and economic values is the extent of Harney County. Past actions such as wild horse gathers to maintain AML have influenced the existing environment within the CEAA. Present actions associated with the HMAs have the potential to improve rangeland health and increase forage production for wildlife, wild horses, and livestock, thereby maintaining or possibly increasing economic opportunities and fostering more desirable recreation opportunities (e.g., wild horse viewing and photography) with associated economic benefits to the local economy. The decision to manage rangeland resources properly should lead toward improvements in range condition and aid in the sustainability of ecosystem function and ranching operations. In addition to sustaining livestock operations, rangeland improvement could also bring about increased sustainability for wild horse management, further improving the local economy and supporting a well-established, local, rural-oriented social fabric. Gathering and maintaining AML is expected not to provide measurable negative impacts to social and economic values in Harney County.

3.9.2.2 Alternative A: Remove Excess Wild Horses and Implement Intensive Fertility Control Management over a Ten-Year Period

Comments received from the public for BLM gathers over the past few years have emphasized the desire that BLM increase the use of fertility control in order to reduce the number of wild horses to be removed from the range or maintained in long-term holding facilities. Alternative A includes the use of available fertility control in those mares that would be released back into the HMAs to help maintain the wild horses within AML with fewer necessary removals in the future.

Costs associated with the proposed gather and implementation of the fertility control would be incurred under the proposed action. There would also be costs associated with both off-range corral and off-range pasture holding facilities incurred once the gather is completed, but the percentages that would be adopted or sent to long-term holding are dependent upon specific horses gathered. The magnitude of these costs is uncertain as are any long-term costs of maintaining wild horses either within AML on the range or in holding facilities. An approximate calculation of cost savings of implementing the intensive fertility control project ranges anywhere from an estimated $100,000 to $500,000 per year, depending on many variables and complexities within the HMAs, such as through reduced gather schedules.

The proposed actions encompass a ten-year timeframe that would include one to two additional gathers following the initial gather, as needed, which would bring horse numbers down to low AML. The possibility of one to two gathers is based upon the typical 20 percent per year herd growth rate observed across most HMAs, and projections of when populations would normally reach high AML. However, the cost and frequency of gathers could decrease if more effective fertility control treatments become available for use on BLM wild horses.

Under the proposed action, wild horses would be gathered to the low end of AML. Over time the vegetation and hydrologic resources in the area would be allowed to recover due to the reduced amounts of utilization and forage competition between wild horses, livestock, and wildlife. Tourists drawn to the area to observe wild horses would still have that opportunity. Livestock permittees would be able to

continue grazing their cattle, at permitted levels, in these areas further securing the possibility of economic benefits (e.g., income) for those permittees. This would contribute to the local economies through taxes, the purchase of supplies, and other contributions to the local communities.

Habitat quality for wildlife, livestock, and wild horses would be maintained or improved with management of wild horse populations within AML. When horse numbers are kept within AML, BLM is able to manage for a TNEB. This means wild horses would have enough forage to maintain a healthy body condition throughout the year while vegetation would remain healthy and vigorous. BLM's understanding is that wild horses and public rangelands in good health are what the public wants to see, no matter if they are opposed to or proponents of gathers.

Maintaining wild horse populations within AML and contributing to a TNEB for the 10-year period of Alternative A would allow the rangeland improvement goals associated with the Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992) to be more readily achieved. Managing wild horse populations in the HMAs ensures security for a sustainable livestock grazing operation.

3.9.2.3 Alternative B: Gather and Removal Including a Non-reproducing Portion of the Population

Under this alternative, impacts would be very similar to Alternative A. The only difference would be a slightly lower reproduction rate due to a smaller breeding population. This alternative would ensure that in the ten-year timeframe of this analysis there would be fewer gathers required as compared to Alternative A. Under this alternative the public perception of BLM's management of wild horses would be similar to Alternative A. Effects to past, present, and reasonably foreseeable actions would be the same under this alternative as those previously described.

3.9.2.4 Alternative C: Fertility Control Vaccines Only

Under this alternative, impacts due to fertility control application would be very similar to Alternative A. The only difference would be a more gradual reduction in reproduction rates and population decreases. The ultimate level of herd growth would depend on the rates of mares treated, as a fraction of the total number of mares in the herd, and on natural attrition. In the ten-year timeframe of this analysis, this alternative would most likely result in the wild horse populations within the HMAs not achieving the goal of AML. Under this alternative the public confidence in BLM's ability to manage wild horses at AML would likely decline.

3.9.2.5 Alternative D: Gather and Removal Only

The BLM, a number of non-governmental organizations, and sectors of the public support some sort of fertility treatment applied for the management of wild horse numbers within AML, and possibly to decrease the frequency of wild horse gathers. Under this alternative, with no application of fertility control, the status quo of approximately 20 percent annual herd growth would continue. In the ten-year timeframe of this analysis, this alternative would likely lead to three more gathers required, as nothing beyond gathering wild horses would be done to slow the population growth. Under this alternative, the public confidence in BLM's ability to manage wild horses at AML would likely decline if no efforts were made to solve the current issues with growing wild horse populations.

3.9.2.6 Alternative E: No Action - Defer Gather and Removal

Under the no action alternative there would be no initial monetary cost to the agency in terms of direct wild horse related actions, as no gather would be conducted, and no fertility treatments would be applied to slow wild horse population growth. If wild horse numbers are left unchecked, over the next 4 years, numbers would likely increase to about 722 adult horses in Kiger and Riddle Mountain HMAs; this value is about 859 percent of low AML. Competition for forage would become evident between wild horses, livestock, and likely wildlife. It is anticipated that at this point range conditions would be deteriorating enough to create a situation where livestock active preference would be reduced accordingly to prevent further degradation to range conditions under authority of 43 CFR Ch. II, Subpart 4110.3 Changes in grazing preference (2006). Livestock permittees would likely have to find feed elsewhere, probably at the private land lease rate, which is significantly higher than the BLM AUM rate, or sell their cattle. BLM's rate per AUM in 2023 is $1.35, while the private land lease rate is considered to be roughly $25 per AUM in Harney County. The Andrews RMP/ROD (2005) and Three Rivers RMP/ROD (1992) decisions for the livestock grazing permits would be ineffective toward the sustainability of the livestock operation if livestock were not turned out on the allotments due to AUMs being utilized by wild horses. A livestock operation in Harney County that is not sustainable economically would further burden the struggling economy of Harney County.

At 5-6 times the high AML, it is assumed, the body condition score of the wild horses would decrease as forage competition increased and water availability decreased. If horse numbers become too high and drought conditions persist, emergency situations arise where BLM must take extreme measures to save wild horses. Generally, these extreme measures include hauling water, gathering in the heat of summer to prevent water starvation, and even euthanizing horses too weak to survive. Wild horse-based tourism to the county and perhaps adoptability of these animals may decline if the herds in the area acquire a reputation for being of unhealthy body condition.

Should a gather take place in the future, there would be a higher cost to remove wild horses as there would need to be more horses removed from the HMAs and an expected higher number of wild horses sent to off-range pasture holding facilities.

4 CUMULATIVE EFFECTS

The NEPA regulations define cumulative impacts as impacts on the environment that result from the incremental impact of an alternative when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such actions (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The cumulative impacts study area for the purposes of evaluating cumulative impacts within and adjacent to the project area is the HMA and wildlife habitat adjacent to the HMA.

According to the 1994 BLM Guidelines for Assessing and Documenting Cumulative Impacts, the cumulative analysis should be focused on those issues and resource values identified during scoping that are of major importance. Accordingly, the issues of major importance to be analyzed are maintaining land health and proper management of wild horses.

4.1 Past Actions

In 1971 Congress passed the WFRHBA, which placed wild and free-roaming horses and burros, that were not claimed for individual ownership, under the protection of the Secretaries of Interior and Agriculture. In 1976, the FLPMA gave the Secretary the authority to use motorized equipment in the capture of wild, free-roaming horses, as well as continued authority to inventory the public lands. In 1978, the Public Range Improvement Act (PRIA) was passed, which amended the WFRHBA to provide additional directives for BLM's management of wild, free-roaming horses on public lands.

Past actions include establishment of wild horse HMAs and establishment of AML for wild horses, wild horse gathers, vegetation treatment, livestock grazing, wildfires, and recreational activities throughout the area. Some of these activities have increased infestations of invasive plants, noxious weeds, and pests and their associated treatments.

In 1992, the BLM issued the Three Rivers RMP/ROD. In 2005, the BLM signed Andrews RMP/ROD. Currently, management of HMAs and wild horse population is guided by the Three Rivers RMP/ROD (1992) and Andrews RMP/ROD (2005). The AML range for the BLM Burns District is 411–764 wild horses and burros, with an additional 198–390 wild horses and burros in a HMA that is shared with the BLM Vale District. The LUPs analyzed impacts of management's direction for grazing and wild horses, as updated through Bureau policies, Rangeland Program direction, and Wild Horse Program direction. It also reaffirmed boundaries and AMLs for the BLM Burns District's HMAs to ensure sufficient habitat for wild horses and achieve a TNEB and rangeland health.

Adjustments in livestock season of use, livestock numbers, and grazing systems were made through the allotment evaluation/multiple use decision process. In addition, temporary closures to livestock grazing in areas burned by wildfires, or due to extreme drought conditions, have previously been implemented to improve range condition.

4.2 Present Actions

Program goals have expanded beyond establishing a "thriving natural ecological balance" by setting AMLs for individual herds to include achieving and maintaining healthy and stable populations and controlling population growth rates.

Though authorized by the WFRHBA, current appropriations and policy prohibit the destruction of healthy animals that are removed or deemed to be excess. Only sick, lame, or dangerous animals can be euthanized (BLM 2021a, PIM 2021-007), and destruction of healthy animals is not used as a population control method. The WFRHBA allows the limited sale of excess wild horses that are over 10 years in age or have been offered unsuccessfully for adoption three times. As with adoptions, wild horse sales require the purchaser to agree not to slaughter or otherwise turn the purchased horse into commercial products, or to knowingly sell the animal to a second purchaser who would do the same. The BLM is adding additional off-range pastures in the Midwest and West to care for excess wild horses for which there is no adoption or sale demand. Most animals not immediately adopted or sold have been transported to long-term grassland pastures in the Midwest. Approximately 61,000 excess wild horses and burros are being maintained within BLM's off-range facilities (BLM 2024, WHB Program).

The actions that have influenced today's Kiger and Riddle Mountain HMA wild horse population are primarily wild horse gathers, which have resulted in the capture and removal of approximately 813 wild horses in the Kiger and Riddle Mountain HMAs since 1996.

Within the proposed gather area cattle grazing occurs on a yearly basis. Wildlife use by large ungulates such as elk, deer, and antelope is also common in the project area.

The focus of wild horse management has also expanded to place more emphasis on achieving rangeland health as measured against the land health standards. Adjustments to numbers, season of use, grazing season, and allowable use are based on evaluating achievement of or making progress toward achieving the standards.

The Greater Sage-Grouse Conservation Assessment and Strategy for Oregon (Hagen 2011), The Oregon Sage-Grouse Action Plan (Sage-Grouse Conservation Partnership 2015), and the Oregon GRSG ARMPA (BLM 2015e) contain guidelines and actions for wild horse management as it relates to maintaining or enhancing Greater Sage-Grouse habitat. The plans emphasize appropriate wild horse management throughout the BLM Burns District.

4.3 Reasonably Foreseeable Future Actions

The BLM would continue to conduct monitoring to assess progress toward meeting land health standards. Wild horses would continue to be a component of the public lands, managed within its multiple-use mission.

While there is no anticipation for amendments to WFRHBA, any amendments may change the management of wild horses on the public lands. However, it is not possible to foresee what such changes may entail, and the BLM will follow the will of the US Congress in this regard if such changes are enacted.

If the BLM and USFS can achieve AML on a national basis, the timing of gathers should become more predictable due to facility space. Improved population growth suppression (PGS) may also become more readily available as a management tool, with treatments that last for a longer duration; this would reduce the need to remove as many wild horses and possibly extend the time between gathers. The combination of these factors could result in an increase in stability of gather schedules and longer periods of time between gathers and help resolve issues leading to the overpopulation of wild horses in the proposed gather area.

The proposed gather area contains a variety of resources and supports a variety of uses. Any alternative course of wild horse management has the opportunity to affect and be affected by other authorized activities ongoing in and adjacent to the area. Future activities that could be expected to contribute to the cumulative impacts of implementing the proposed action include: future wild horse gathers, continuing livestock grazing in the allotments within the area, mineral exploration, solar energy development, juniper treatments, vegetation treatments, rangeland development maintenance and construction, road maintenance, new or continuing infestations of invasive plants, noxious weeds, and pests and their associated treatments, recreation activities, and continued native wildlife populations. The significance

of cumulative effects based on past, present, proposed, and reasonably foreseeable future actions is determined based on context and intensity.

The Greater Sage-Grouse Conservation Assessment and Strategy for Oregon (Hagen 2011), The Oregon Sage-Grouse Action Plan (Sage-Grouse Conservation Partnership 2015), and the Oregon GRSG ARMPA (BLM 2015e) will continue to guide wild horse management as it relates to maintaining or enhancing Greater Sage-Grouse habitat. The plans emphasize appropriate wild horse management throughout the BLM Burns District in the future.

4.4 Summary of Past, Present, and Reasonably Foreseeable Future Actions

4.4.1 Effects Common to Alternatives A, B, and D

The cumulative effects associated with the capture and removal of excess wild horses include gather-related mortality of less than 1 percent of the captured animals; about 5 percent per year associated with transportation, off-range corrals, adoption, or sale with limitations; and about 8 percent per year associated with off-range pastures (Government Accountability Office 2008, GAO-09-77, p. 49). This compares with natural mortality on the range ranging from about 5–8 percent per year or less for foals (animals under age 1), about 5 percent per year or less for horses ages 1–15, and 5–100 percent for animals aged 16 and older (Ransom et al. 2016). In situations where forage and/or water are limited, mortality rates increase, with the greatest impact to young foals, nursing mares, and older horses.

While humane euthanasia and sale, without limitation, of healthy horses for which there is no adoption demand is authorized under the WFRHBA, Congress has prohibited the use of appropriated funds for this purpose many times since 1987, including such a limitation in the use of FY2024 appropriated funds.

The other cumulative effects that would be expected when incrementally adding any of these alternatives would include continued improvement of upland vegetation conditions, which would in turn benefit permitted livestock, native wildlife, and the wild horse population as forage (habitat) quality and quantity is improved over the current level. Benefits from a reduced wild horse population would include fewer animals competing for limited forage and water resources.

Cumulatively, there should be more stable wild horse populations, healthier rangelands, healthier wild horses, and fewer multiple-use conflicts in the area over the short and long term. Over the next 15–20 years, continuing to manage wild horses within the established AML range would achieve a TNEB and multiple-use relationship on public lands in the area.

4.4.2 Impacts of Alternative C and Alternative E

Under Alternative C and the no action alternative, the wild horse population would continue to exceed the low end of AML, exceeding it by approximately fifteen to twenty-one times in eleven years. Under both alternatives, wild horse movement outside the HMAs would be expected as greater numbers of horses search for food and water for survival, thus impacting larger areas of public lands. Heavy to severe utilization of the available forage would be expected, and the water available for use could become increasingly limited. Eventually, ecological plant communities would be damaged to the extent

that they are no longer sustainable, and the wild horse population would be expected to crash, but not before causing extensive and long-lasting ecological damage (NAS 2013).

Emergency removals could be expected under these alternatives in order to prevent individual animals from suffering or death as a result of insufficient forage and water. During emergency conditions, competition for the available forage and water increases. This competition generally impacts the oldest and youngest horses as well as lactating mares first. These groups would experience substantial weight loss and diminished health, which could lead to their prolonged suffering and eventual death. If emergency actions are not taken, the overall population could be affected by severely skewed sex ratios towards stallions as they are generally the strongest and healthiest portion of the population. An altered age structure would also be expected, with decreased numbers of very young animals.

Cumulative effects would result in foregoing the opportunity to improve land health and to properly manage wild horses in balance with the available forage and water and other multiple uses. Attainment of site-specific vegetation management objectives and standards for rangeland health would not be achieved. AML would not be achieved and the opportunity to collect the scientific data necessary to re-evaluate AML levels, in relationship to land health standards, would be foregone.

5 CONSULTATION AND COORDINATION

5.1 Agencies and Individuals Consulted

BLM Oregon/Washington Policy (BLM 2015b, IM 2015-037, ePlanning Phase 1 Implementation Minimum Standards for Oregon and Washington) guides BLM Burns District to use ePlanning to post NEPA documents; therefore, this EA and all related information are posted on the ePlanning site. A notice of availability of the EA and request for comment has been mailed to 86 interested individuals, groups, and agencies (and emailed to 5 more) for a 30-day public comment period on April 26, 2024. This comment period was extended to May 28, 2024, to provide two additional days to submit comments based upon the federal holiday weekend. Four hundred and fourteen public comment form letters were received along with 18 unique public comments including one from ODFW, which stated that it was in favor of keeping wild horses within AML.

Individuals that wish to read documents that are cited in this EA may access them at the BLM Burns District Office during business hours.

5.2 Interdisciplinary Team

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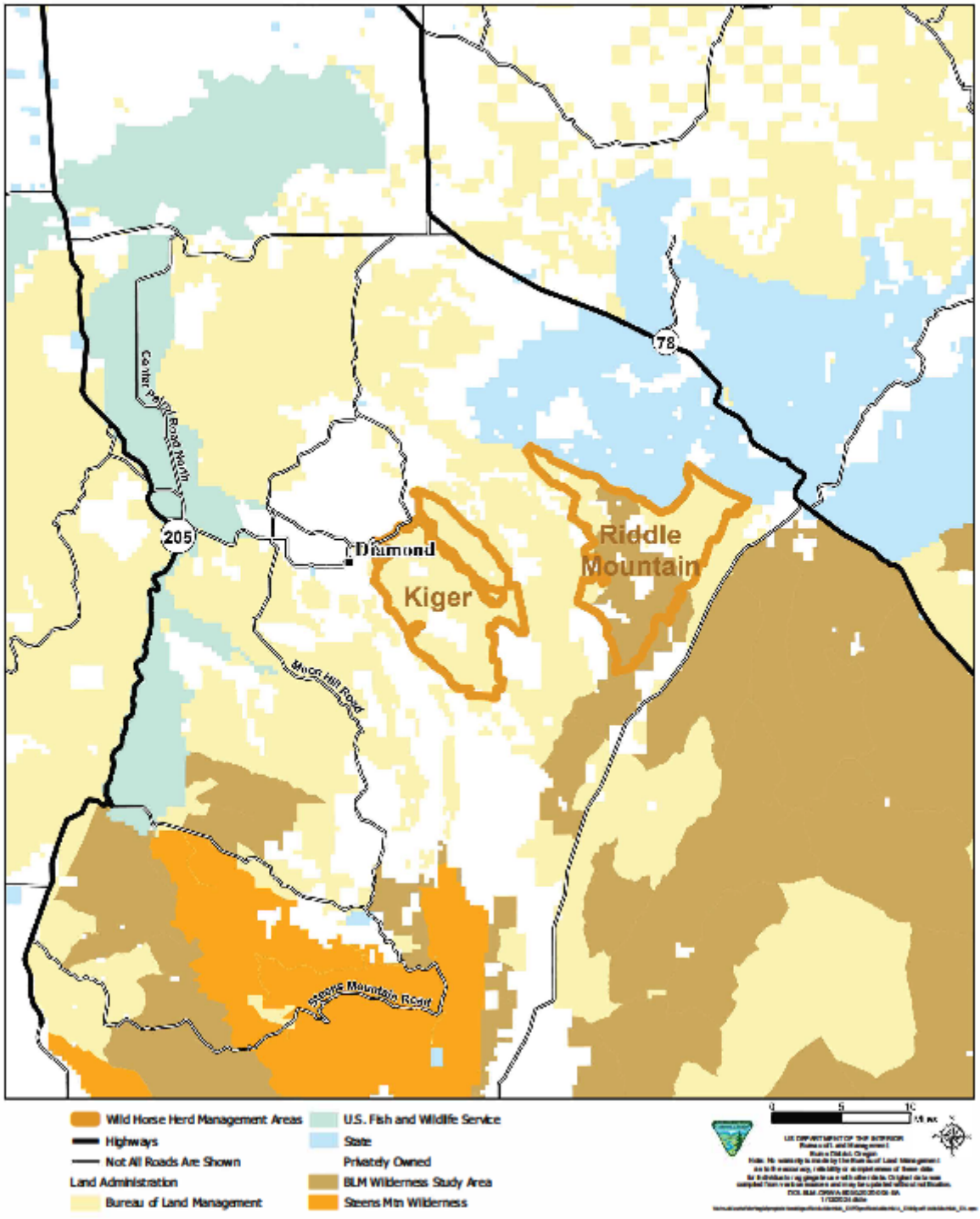
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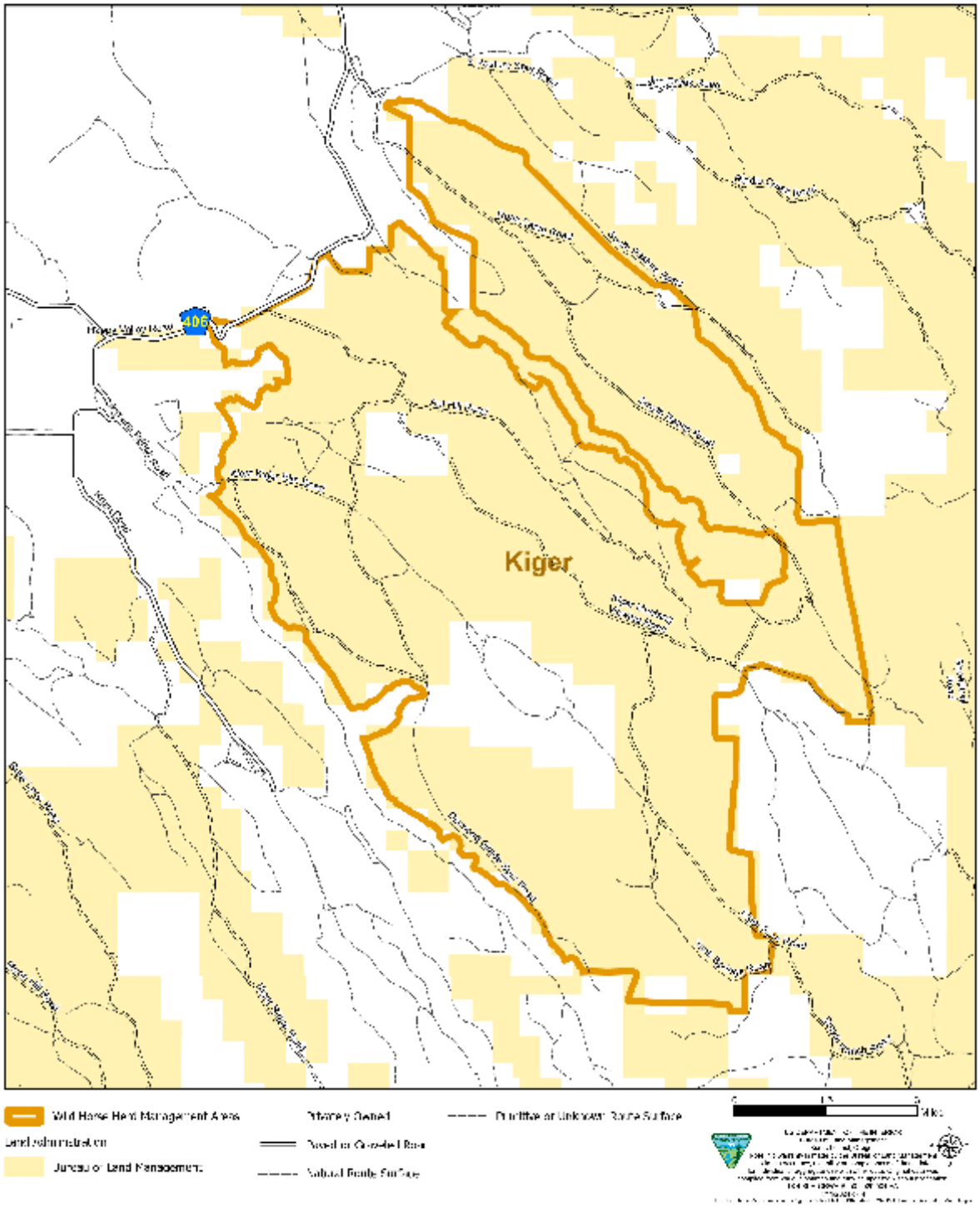
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APPENDIX A: MAPS

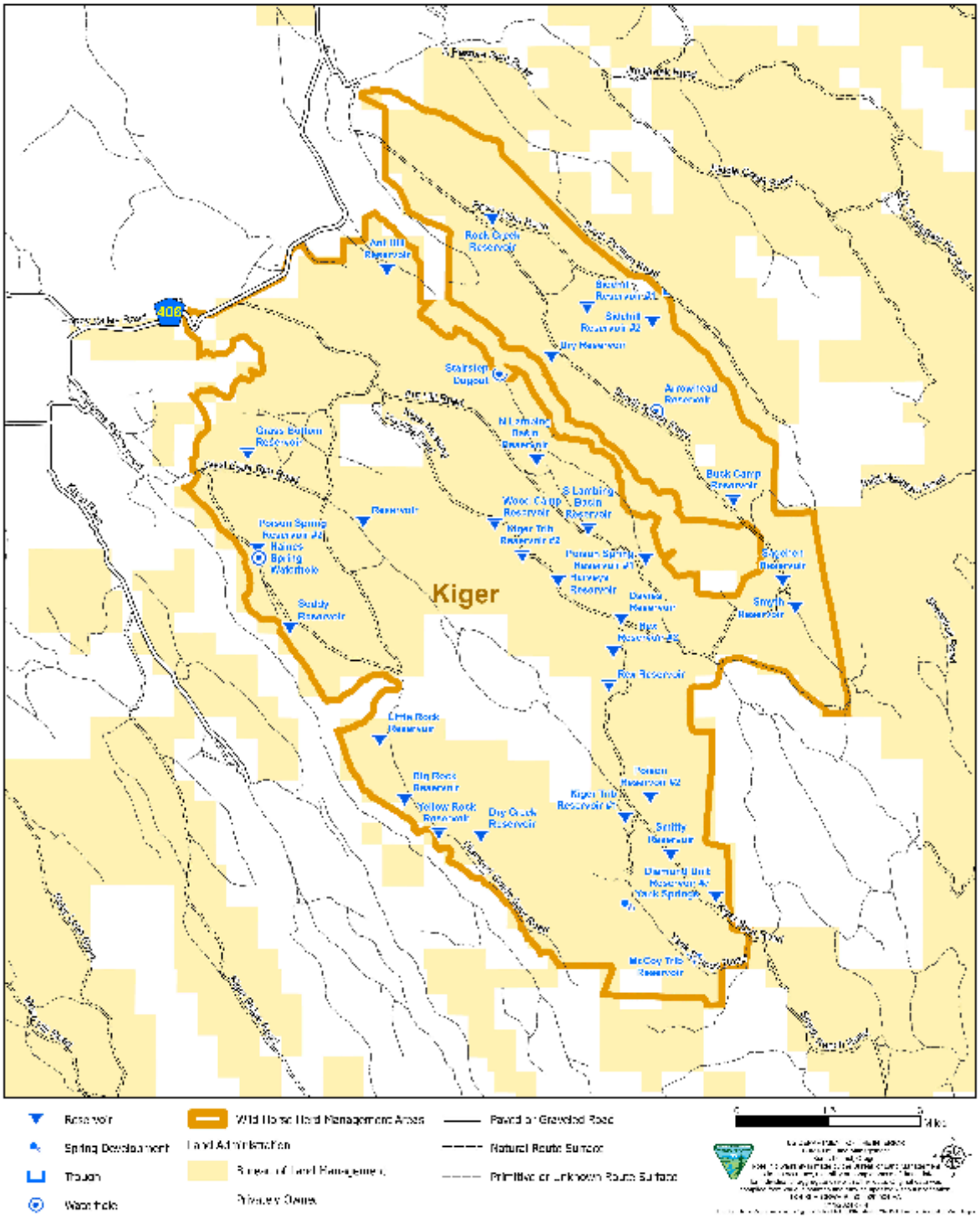
Map 1 Vicinity Map
Kiger and Riddle Mountain Herd Management Area
DOI-BLM-ORWA-B050-2020-0004-EA



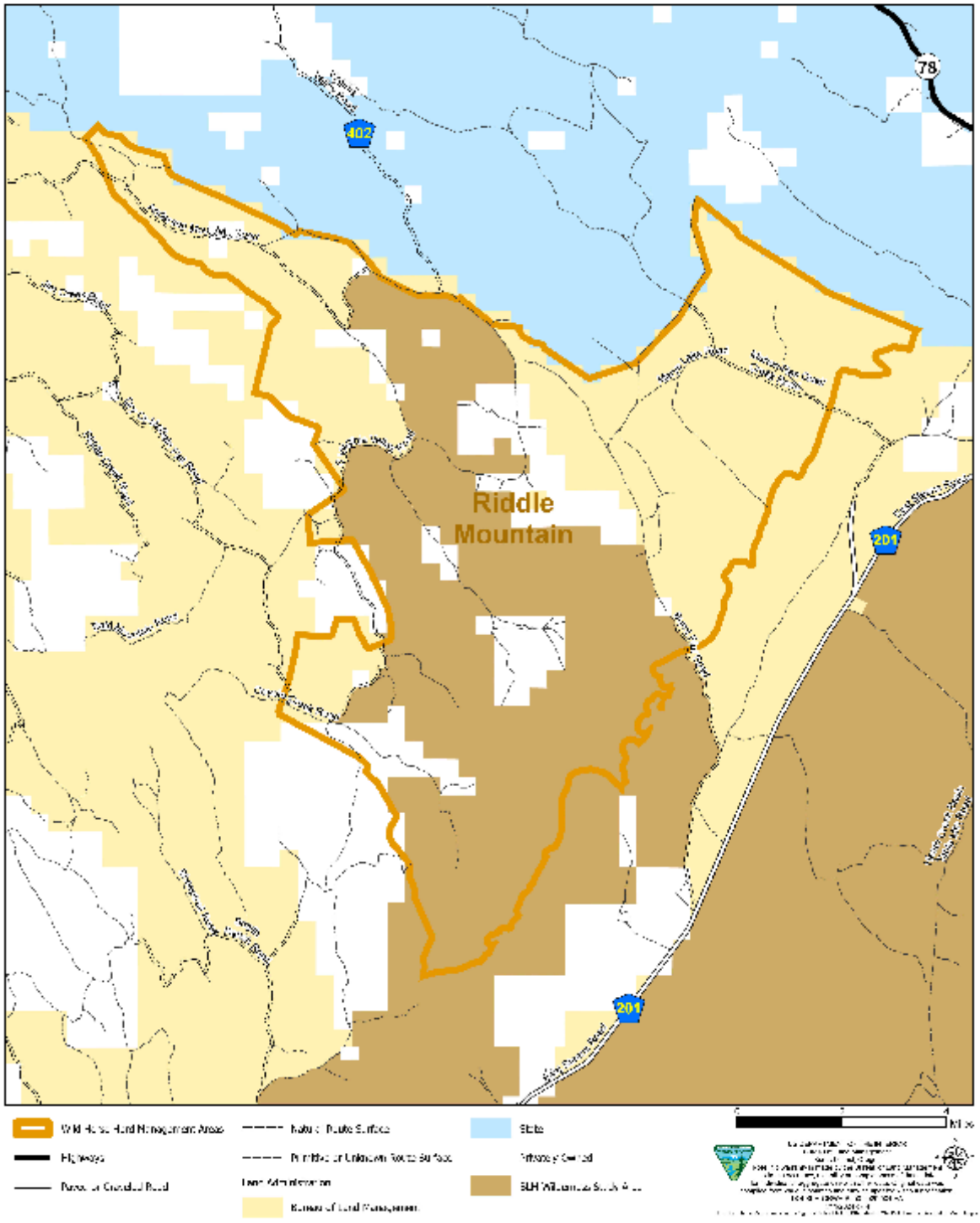
Map 2
Kiger Herd Management Area
DOI-BLM-ORWA-B050-2020-0004-EA



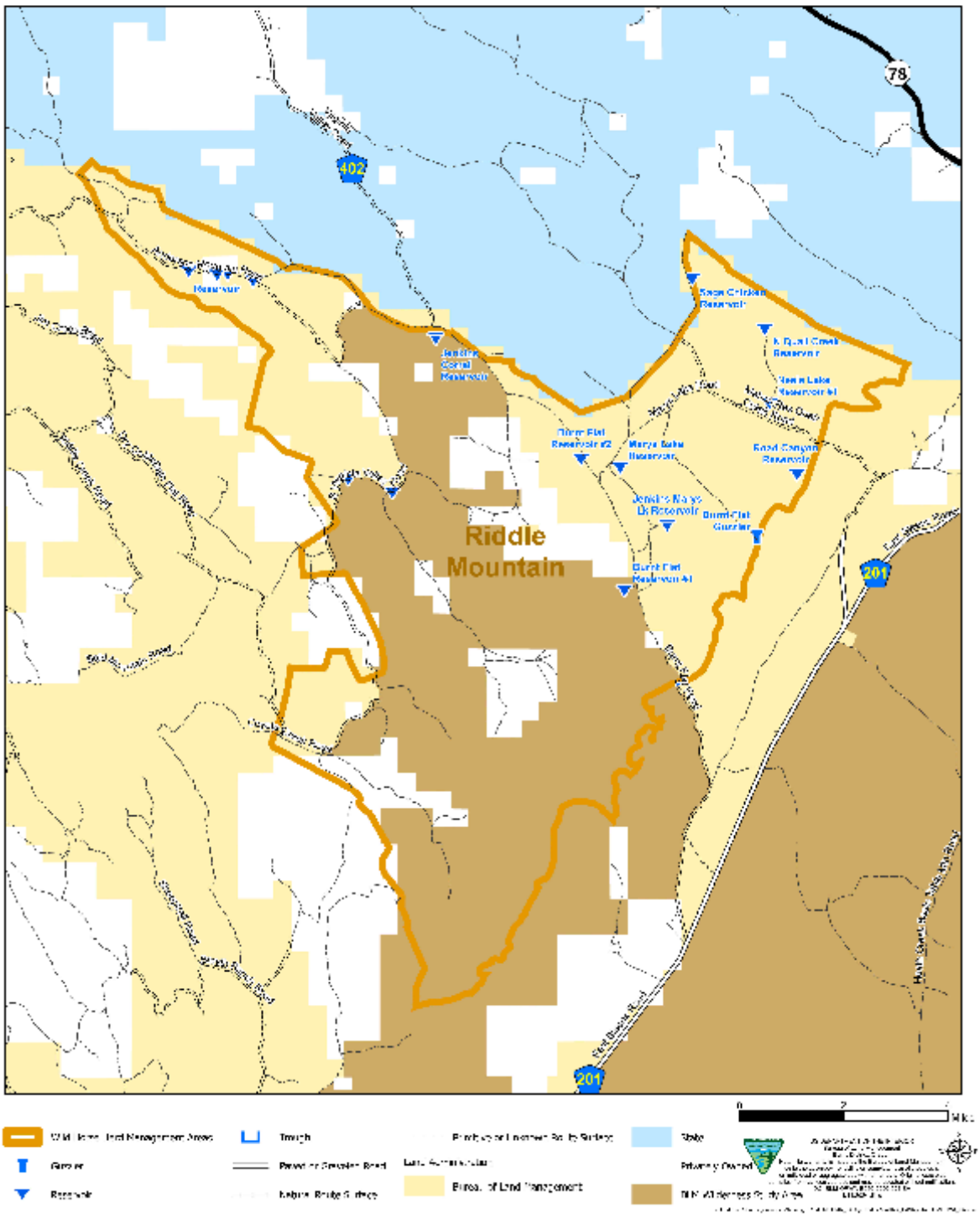
Map 3
Kiger Herd Management Area Water Developments
DOI-BLM-ORWA-B050-2020-0004-EA



Map 4
Riddle Mountain Herd Management Area
DOI-BLM-ORWA-B050-2020-0004-EA



Map 5
Riddle Mountain Herd Management Area Water Developments
DOI-BLM-ORWA-B050-2020-0004-EA



APPENDIX B: ISSUES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

The following issues were raised by the public or BLM during scoping and internal reviews for similar projects. These issues have been considered but eliminated from detailed analysis because they are outside the scope of this analysis or do not relate to how the proposed action or alternatives respond to the purpose and need:

- Develop alternatives that do not require the use of the fertility drug PZP-22.
  Response: Use of fertility control vaccine PZP-22 is being analyzed and is considered as one method of fertility control vaccine, for the purpose of limiting the fertility rates of wild horse mares within the HMAs. The effects of PZP-22 on wild horses has been analyzed and can be found in Appendix F.

- The EA should contain a detailed analysis of the effects of the proposed action on the genetic composition.
  Response: See Sections 2.1, 2.2, and 2.3 in the EA, which considers the development of positive, meaningful removal/retention criteria. See Appendix G for Riddle Mountain and Kiger HMAs Genetic Information.

- Discuss the option of gathering every two years, doing a gate cut, and only removing the horses that are one and two years old.
  Response: This is outside the scope of the document and does not meet the purpose and need for action due to removing the one- and two-year-old population would not lower the horse numbers to within AML. Also removing the one- and two-year-olds every two years would greatly skew the herds age classes and older horses would eventually die out leaving no horses left in the HMA.

- In the 1996 Riddle Mountain/Kiger Management Plan, obstacles to the horses' success were identified; juniper encroachment, fences, natural and prescribed burns, and limited water. Many of these issues have been at least partially addressed, but we would like to see alternatives which assure these specific improvements will be completed and future habitat enhancement projects will be a substantive part of management strategies.
  Response: This comment is out of the scope and does not fit the purpose and need for action and will not be discussed further in this document.

- Lands with Wilderness Characteristics
  What would be the effects of the alternatives on lands with wilderness characteristics?
  Response: There are no designated lands with wilderness characteristics within the Kiger/Riddle Mountain HMAs. In addition, there have been no changes in land condition or road status since the previous determination that would require the determination to be updated. Therefore, lands with wilderness characteristics are not considered within this document.

- Recreation
  What would be the effects of the alternatives on recreation activities?
  Response: The actions proposed within this EA would only have a localized, temporary impact on recreation and only if gathers were a selected action. During gathers, recreation opportunities would be limited within the HMAs, but they would be allowed to resume following gather operations. Due to this, impacts to recreation are not further considered within the document.

- Riparian Zones, Wetlands, Water Quality, Fish and Special Status Species (SSS)
  What would be the effects of the alternatives on water quality and riparian conditions within the HMAs and on adjacent private land?
  Response: Trap sites and/or holding facilities would not be located within wetlands or riparian zones and would not have an effect on water quality or fish habitat within the Kiger or Riddle Mountain HMAs. While wild horses can contribute to the conditions of riparian areas and water quality, this issue was not analyzed in detail because there would be no measurable difference in impacts from any of the action alternatives. The high concentrations of horses under the no action alternative and the fertility control vaccines only alternative would result in more areas of disturbance in riparian areas throughout the HMAs, especially near areas where horses congregate. Because there would be no measurable difference between these alternatives, this issue will not be analyzed in detail.

- Cultural Resources, American Indian Traditional Practices
  What would be the effect of the wild horse and burro population management plan alternatives on cultural resources?
  Response: There are no known Tribal traditional practices that occur within the Kiger or Riddle Mountain HMAs that would be impacted by any of the alternatives. Any activities that may occur within the HMAs would be temporarily limited during any selected gather activities but would resume immediately afterwards. In addition, sites to be used for actions analyzed within the EA would be surveyed for cultural resources prior to their use, and if resources are found, that site would not be used. Therefore, there would be no impacts to cultural resources within the EA area, and they are not further considered within this EA.

- How would the number of wild horses influence cultural resources within these HMAs?

  The no action alternative would result in greater numbers of horses over the next 10 years. Increasing the horse herd would expand congregation areas and produce additional congregation areas that are not evidenced under the current grazing regime. Congregation areas could expand under the no action alternative and grazing effects in what are currently considered “generalized” grazing areas and additional archaeological sites could be affected.

  For the purpose of this analysis, the effects of the proposed actions, which seek to reduce the number of animals within the HMAs, would be nearly the same for all three proposals. The proposed actions would eliminate or minimize additional effects to archaeological sites within 200 feet of any man-made or natural water source. Archaeological sites within “generalized” grazing areas would remain unaffected. Therefore, they are not further considered within this EA.

- How would the location of trap sites affect cultural resources in these HMAs?

  The proposed action and other ongoing and RFFAs would not lead to cumulative effects to cultural resources because horse traps would be localized, or the sites would be completely avoided per incorporated project design features. Potential direct and cumulative effects to cultural resources would be mitigated through project-specific cultural resource inventory and mitigation measures prior to any project implementation. Therefore, this issue is not further considered within this EA.

- How would the number of wild horses influence the conditions of riparian areas and water quality in these HMAs?

  Within the Kiger and Riddle HMAs there are a total of five perennial streams: Swamp Creek, Frog Creek, Smyth Creek, Yank Creek, and Squaw Creek, numerous springs and several wetlands and playas that may hold water throughout parts of the year. These five perennial streams are approximately a total of 16 miles in length within both HMAs. A combination of photo trend monitoring, Multiple Indicator Monitoring (MIM), proper functioning condition (PFC), and water quality monitoring has been conducted throughout the Kiger and Riddle HMAs on the perennial streams listed above.

  While wild horses can contribute to the conditions of riparian areas and water quality, this issue was not analyzed in detail because there would be no measurable difference in impacts from any of the action alternatives. The high concentrations of horses under the no action alternative and the fertility control vaccines only alternative would result in more areas of disturbance in riparian areas throughout the HMAs, especially near areas where horses congregate. Areas of disturbance are more susceptible to declining conditions in riparian vegetation, water quality, bank stability, fish habitat, and overall stream health. Heavy disturbance and grazing within these riparian areas weaken the riparian plant community, causing a decline in bank stabilization that leads to more erosion and decreased water quality. Healthy riparian vegetation, increased stream bank stability, and water quality are essential for the livelihood of fish and macroinvertebrates, and the overall health of the riparian area and the larger watershed.

  Under the three gather alternatives, excess wild horses would be removed to similar levels (within AML), and this reduction would result in reduced damage to riparian areas. Maintenance of AML over a ten-year timeframe is the only way to protect stream condition and riparian areas for all action alternatives since horses are present year-round in these areas. This reduced damage to riparian areas and improved stream condition is estimated to be the same across the three gather alternatives, and therefore, the resulting reduction in riparian and stream damage is anticipated to be the same. Because there would be no measurable difference between these alternatives, this issue will not be analyzed in detail.

- How would the number of wild horses influence Greater Sage-grouse and their habitat?

  Greater Sage-Grouse (sage-grouse) are present in both HMAs. There are 14 leks across the HMAs and habitat has been designated as priority habitat management area (PHMA), general

habitat management area (GHMA), and a priority area for conservation (PAC) named Folly Farm/Saddle Butte. Sage-grouse habitat in both HMAs is utilized year-round and sagebrush habitat condition is vital in providing breeding, brood rearing, and winter habitats. Habitats that require adequate grass and forb cover are breeding (nesting) and brood rearing. These two herbaceous functional groups are critical in nest and chick survival because they provide hiding cover and food. However, these plants are also the main forage for wild horses and livestock.

Wild horses and livestock readily feed on perennial bunch grasses and some forbs and can be detrimental to sage-grouse survival if utilization of these plants becomes heavy to severe. This use is mitigated for livestock by pasture rotations and maintaining authorized animal unit months (AUM). Wild horses are not managed as livestock and the primary means of minimizing impacts to sage-grouse habitat is to maintain AML. On-the-ground monitoring of vegetation plots and utilization indicate that keeping wild horses at AML is in balance with the habitat and impacts are minimal to sage-grouse, but concentration areas can become a concern especially as wild horse number exceed AML. This example is evident in Wood Camp Pasture in the Kiger HMA where wild horses have concentrated in large numbers and use on herbaceous plants is heavy to severe. Fortunately, this negative impact to sage-grouse habitat is more than 1 mile from the nearest lek. The probable high concentrations of horses under the no action alternative would result in the degradation of sage-grouse habitat and the mortality of nests and chicks. If sage-grouse can no longer successfully reproduce this population would likely be lost.

Under the action alternatives, excess wild horses would be removed to similar levels (within AML) and maintaining AML would result in reduced impacts to sage-grouse habitat. Maintenance of AML over a ten-year timeframe coupled with established PDFs would minimize the potential for detrimental impacts to the sage-grouse population of this area across all action alternatives. This reduced habitat disturbance is estimated to be the same across all action alternatives, and therefore, the resulting maintenance or improvement of sage-grouse habitat is anticipated to be the same. Because there would be no measurable difference between the action alternatives, this issue will not be analyzed in detail.

- How would the location of trap sites and activities associate with gather operations effect Greater sage-grouse?

  Although trap locations can create temporary (2-4 days) activities disruptive to sage-grouse, Section 2.1 of this EA describes the Management Actions Common to Action Alternatives, which include multiple project design features (PDF) (specifically, under 2.1.2, the PDFs regarding trap sites and gather time within seasonal habitat) will not impair the life-cycle or behavioral needs of sage-grouse. Because of these PDFs, the creation and use of wild horse trap locations is not expected to have a measurable effect on sage-grouse and, thus, will not be discussed further in this document.

- How would the number of wild horses influence livestock grazing management within these HMAs?

  There are many similarities between livestock use and wild horse use. However, livestock use in the HMAs is managed to provide periodic growing season rest to desirable forage species to help

maintain or achieve a healthy, functioning landscape. This is achieved through management of timing, duration, and intensity of livestock use. These tools are not available for wild horse management. One result is horses will spend much of the year in their preferred area causing grazing pressure year-round.

The no action alternative would result in a greater number of horses over the next ten years. This action would reduce the amount of available forage for permittees. Heavy utilization is occurring in areas used by livestock, wild horses, and wildlife, specifically around water sources. The indirect effects of the no action alternative would be damage to the forage resources, which would likely lead to land health standards not being achieved in the future. The no action alternative would lead to competition between livestock, wild horses, and wildlife for the available forage and water; reduced quantity and quality of forage and water; and undue hardship on the livestock operators who would continue to be unable to fully use the forage they are authorized, possibly leading to the operators having to reduce livestock numbers.

Gather activities could result in direct effects by disturbing and dispersing the livestock present for a period of 5 to 7 days. Trapping activities would be scheduled in coordination with the rangeland management specialist to avoid conflicts with the authorized grazing rotations. Any removal of wild horses would result in some level of reduced competition between the species for available forage and water. Indirect effects would include an increase in the quality and quantity of the available forage for the remainder of the grazing year. This benefit would decrease as wild horse numbers increased until the next gather. Because there would be no measurable difference between the action alternatives, this issue will not be analyzed in detail.

- How would the number of wild horses influence lands with wilderness characteristics and wilderness study areas in the HMAs?

  The Stonehouse Wilderness Study Area (WSA) is within the Riddle Mountain HMA and contains 21,325 acres of BLM land (Wilderness Study Report 1991, BLM 1991). The objective is to manage existing WSAs so as not to impair their suitability for preservation as wilderness. (Andrews/Steens CMPA RMP/ROD, August 2005). WSAs are managed in accordance with BLM's Manual 6330 (BLM 2012). WSAs will continue to be managed under the WSA Manual until designated as wilderness by Congress or released from WSA status.

  While wild horses can contribute to the management of WSAs, this issue was not analyzed in detail because there would be no measurable difference in impacts from any of the action alternatives. The high concentrations of horses under the no action alternative would result in more areas of disturbance throughout the WSA; especially near areas where horses congregate. High wild horse populations, areas of disturbance, and heavy grazing would deteriorate the WSA's naturalness, solitude, primitive and unconfined recreation, and special features. These criteria are highly considered in developing the WSAs.

  Under the action alternatives, excess wild horses would be removed to similar levels (within AML) and this reduction would result in reduced disturbance throughout the WSA while continuing to preserve wilderness values. Because there would be no measurable difference between the action alternatives, this issue will not be analyzed in detail.

- How would the location of trap sites affect lands with wilderness characteristics and wilderness study areas in the HMAs?

  The Stonehouse WSA is within the Riddle Mountain HMA and contains 21,325 acres of BLM land (Wilderness Study Report 1991, BLM 1991). WSA goal is to manage WSAs so as not to impair their suitability for preservation as wilderness. The objective is to manage existing WSAs so as not to impair their suitability for preservation as wilderness. (Andrews/Steens CMPA RMP/ROD, August 2005). WSAs are managed in accordance with BLM's Manual 6330 (BLM 2012). WSAs will continue to be managed under the WSA Manual until designated as wilderness by Congress or released from WSA status.

  The 2012 BLM Manual 6330, Management of Wilderness Study Areas, provides for wild horse and burro populations to be "Managed at appropriate management levels so as to not exceed the productive capacity of the habitat (as determined by available science and monitoring activities), to ensure a thriving natural ecological balance, and to prevent impairment of wilderness characteristics, watershed function, and ecological processes. The BLM should limit population growth or remove excess animals as necessary to prevent the impairment of the WSA" (BLM Manual 6330, Chapter 1.6.D.10.a).

  The manual also allows for "Temporary traps [to be] located within WSAs for the effective removal of animals in excess of the appropriate management level established for the herd area," when practical alternatives do not exist…. Also, "Vehicles necessary for set-up and take-down of traps and for transporting excess wild horses and burros away from the area may be driven off of existing primitive routes or boundary roads on a route specified through the NEPA analysis" (BLM Manual 6330, Chapter 1.6.D.10.c).

  To conform with BLM Manual 6330, "at the completion of the gather [or bait/water trapping], all facilities must be removed, the route used for trap access closed to motor vehicles until it is restored to the original condition, and any new access route and trap area rehabilitated so that the route is no longer visible to subsequent motor vehicle operators" (Chapter 1.6.D.10.c).

  Under the action alternatives, excess wild horses would be removed to similar levels (within AML) and this reduction would result in reduced disturbance throughout the WSA while continuing to preserve wilderness values. The use of temporary traps within the WSA is within the appropriate management practices and because there would be no measurable difference between the action alternatives, this issue will not be analyzed in detail.

APPENDIX C: PIM 2021-002 ATTACHMENT – COMPREHENSIVE ANIMAL WELFARE PROGRAM FOR WILD HORSE AND BURRO GATHERS

STANDARDS

Developed by

The Bureau of Land Management
Wild Horse and Burro Program

in collaboration with

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WELFARE ASSESSMENT STANDARDS FOR GATHERS

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STANDARDS

Standard Definitions

Major Standard: Impacts the health or welfare of WH&Bs. Relates to an alterable equipment or facility standard or procedure. Appropriate wording is "must," "unacceptable," "prohibited."

Minor Standard: unlikely to affect WH&Bs health or welfare or involves an uncontrollable situation. Appropriate wording is "should."

Lead COR = Lead Contracting Officer's Representative

COR = Contracting Officer's Representative

PI = Project Inspector

WH&Bs = Wild horses and burros

I. FACILITY DESIGN

A. Trap Site and Temporary Holding Facility

1. The trap site and temporary holding facility must be constructed of stout materials and must be maintained in proper working condition, including gates that swing freely and latch or tie easily. (**major**)
2. The trap site should be moved close to WH&B locations whenever possible to minimize the distance the animals need to travel. (minor)
3. If jute is hung on the fence posts of an existing wire fence in the trap wing, the wire should be either be rolled up or let down for the entire length of the jute in such a way that minimizes the possibility of entanglement by WH&Bs unless otherwise approved by the Lead COR/COR/PI. (minor)
4. Fence panels in pens and alleys must be not less than 6 feet high for horses, 5 feet high for burros, and the bottom rail must not be more than 12 inches from ground level. (**major**)

5. The temporary holding facility must have a sufficient number of pens available to sort WH&Bs according to gender, age, number, temperament, or physical condition. (**major)**)
    a. All pens must be assembled with capability for expansion. (**major**)
    b. Alternate pens must be made available for the following: (**major**)
        1) WH&Bs that are weak or debilitated
        2) Mares/jennies with dependent foals
    c. WH&Bs in pens at the temporary holding facility should be maintained at a proper stocking density such that when at rest all WH&Bs occupy no more than half the pen area. (minor)
6. An appropriate chute designed for restraining WH&Bs must be available for necessary procedures at the temporary holding facility. This does not apply to bait trapping operations unless directed by the Lead COR/COR/PI. (**major**)
7. There must be no holes, gaps or openings, protruding surfaces, or sharp edges present in fence panels or other structures that may cause escape or possible injury. (**major**)
8. Padding must be installed on the overhead bars of all gates and chutes used in single file alleys. (**major**)
9. Hinged, self-latching gates must be used in all pens and alleys except for entry gates into the trap, which may be secured with tie ropes. (**major**)
10. Finger gates (one-way funnel gates) used in bait trapping must be constructed of materials approved by the Lead COR/COR/PI. Finger gates must not be constructed of materials that have sharp ends that may cause injuries to WH&Bs, such as T-posts, sharpened willows, etc. (**major**)
11. Water must be provided at a minimum rate of ten gallons per 1000-pound animal per day, adjusted accordingly for larger or smaller horses, burros and foals, and environmental conditions, with each trough placed in a separate location of the pen (i.e., troughs at opposite ends of the pen). Water must be refilled at least every morning and evening. (**major**)
12. The design of pens at the trap site and temporary holding facility should be constructed with rounded corners. (minor)

13. All gates and panels in the animal holding and handling pens and alleys of the trap site must be covered with materials such as plywood, snow fence, tarps, burlap, etc. approximately 48" in height to provide a visual barrier for the animals. All materials must be secured in place. (**major**)

    These guidelines apply:

    a. For exterior fences, material covering panels and gates must extend from the top of the panel or gate toward the ground. (**major)**
    b. For alleys and small internal handling pens, material covering panels and gates should extend from no more than 12 inches below the top of the panel or gate toward the ground to facilitate visibility of animals and the use of flags and paddles during sorting. (minor)
    c. The initial capture pen may be left uncovered as necessary to encourage animals to enter the first pen of the trap. (minor)

14. Non-essential personnel and equipment must be located to minimize disturbance of WH&Bs. (**major**)
15. Trash, debris, and reflective or noisy objects should be eliminated from the trap site and temporary holding facility. (minor)

B. Loading and Unloading Areas

1. Facilities in areas for loading and unloading WH&Bs at the trap site or temporary holding facility must be maintained in a safe and proper working condition, including gates that swing freely and latch or tie easily. (**major**)
2. The side panels of the loading chute must be a minimum of 6 feet high and fully covered with materials such as plywood or metal without holes that may cause injury. (**major**)
3. There must be no holes, gaps or openings, protruding surfaces, or sharp edges present in fence panels or other structures that may cause escape or possible injury. (**major**)
4. All gates and doors must open and close easily and latch securely. (**major**)

5. Loading and unloading ramps must have a non-slip surface and be maintained in a safe and proper working condition to prevent slips and falls. Examples of non-slip flooring would include, but not be limited to, rubber mats, sand, shavings, and steel reinforcement rods built into ramp. There must be no holes in the flooring or items that can cause an animal to trip. (**major)**
6. Trailers must be properly aligned with loading and unloading chutes and panels such that no gaps exist between the chute/panel and floor or sides of the trailer creating a situation where a WH&B could injure itself. (**major**)
7. Stock trailers should be positioned for loading or unloading such that there is no more than 12" clearance between the ground and floor of the trailer for burros and 18" for horses. (minor)

II. CAPTURE TECHNIQUE

A. Capture Techniques

1. WH&Bs gathered on a routine basis for removal or return to range must be captured by the following approved procedures under direction of the Lead COR/COR/PI. (**major**)
   a. Helicopter
   b. Bait trapping
2. WH&Bs must not be captured by snares or net gunning. (**major**)
3. Chemical immobilization must only be used for capture under exceptional circumstances and under the direct supervision of an on-site veterinarian experienced with the technique. (**major**)

B. Helicopter-Drive Trapping

1. The helicopter must be operated using pressure and release methods to herd the animals in a desired direction and should not repeatedly evoke erratic behavior in the WH&Bs causing injury or exhaustion. Animals must not be pursued to a point of exhaustion; the on-site veterinarian must examine WH&Bs for signs of exhaustion. (**major**)

2. The rate of movement and distance the animals travel must not exceed limitations set by the Lead COR/COR/PI who will consider terrain, physical barriers, access limitations, weather, condition of the animals, urgency of the operation (animals facing drought, starvation, fire, etc.) and other factors. (**major)**
    a. WH&Bs that are weak or debilitated must be identified by BLM staff or the contractors. Appropriate gather and handling methods should be used according to the direction of the Lead COR/COR/PI. (**major**)
    b. The appropriate herding distance and rate of movement must be determined on a case-by-case basis considering the weakest or smallest animal in the group (e.g., foals, pregnant mares, or horses that are weakened by body condition, age, or poor health) and the range and environmental conditions present. (**major**)
    c. Rate of movement and distance travelled must not result in exhaustion at the trap site, with the exception of animals requiring capture that have an existing severely compromised condition prior to gather. Where compromised animals cannot be left on the range or where doing so would only serve to prolong their suffering, euthanasia will be performed in accordance with BLM policy. (**major**)
3. WH&Bs must not be pursued repeatedly by the helicopter such that the rate of movement and distance travelled exceeds the limitation set by the Lead COR/COR/PI. Abandoning the pursuit or alternative capture methods may be considered by the Lead COR/COR/PI in these cases. (**major**)
4. When WH&Bs are herded through a fence line en route to the trap, the Lead COR/COR/PI must be notified by the contractor. The Lead COR/COR/PI must determine the appropriate width of the opening that the fence is let down to allow for safe passage through the opening. The Lead COR/COR/PI must decide if existing fence lines require marking to increase visibility to WH&Bs. (**major**)
5. The helicopter must not come into physical contact with any WH&B. The physical contact of any WH&B by helicopter must be documented by Lead COR/COR/PI along with the circumstances. (**major**)
6. WH&Bs may escape or evade the gather site while being moved by the helicopter. If there are mare/dependent foal pairs in a group being brought to a trap and half of an identified pair is thought to have evaded capture, multiple attempts by helicopter may

be used to bring the missing half of the pair to the trap or to facilitate capture by roping. In these instances, animal condition and fatigue must be evaluated by the Lead COR/COR/PI or on-site veterinarian on a case-by-case basis to determine the number of attempts that can be made to capture an animal. (**major**)

7. Horse captures must not be conducted when ambient temperature at the trap site is below 10ºF or above 95ºF without approval of the Lead COR/COR/PI. Burro captures must not be conducted when ambient temperature is below 10ºF or above 100ºF without approval of the Lead COR/COR/PI. The Lead COR/COR/PI will not approve captures when the ambient temperature exceeds 105 ºF. (**major**)

C. Roping

1. The roping of any WH&B must be approved prior to the procedure by the Lead COR/COR/PI. (**major**).
2. The roping of any WH&B must be documented by the Lead COR/COR/PI along with the circumstances. WH&Bs may be roped under circumstances which include but are not limited to the following: reunite a mare or jenny and her dependent foal; capture nuisance, injured or sick WH&Bs or those that require euthanasia; environmental reasons such as deep snow or traps that cannot be set up due to location or environmentally sensitive designation; and public and animal safety or legal mandates for removal. (**major**)
3. Ropers should dally the rope to their saddle horn such that animals can be brought to a stop as slowly as possible and must not tie the rope hard and fast to the saddle so as to intentionally jerk animals off their feet. (**major**)
4. WH&Bs that are roped and tied down in recumbency must be continuously observed and monitored by an attendant at a maximum of 100 feet from the animal. (**major**)
5. WH&Bs that are roped and tied down in recumbency must be untied within 30 minutes. (**major**)
6. If the animal is tied down within the wings of the trap, helicopter-drive trapping within the wings will cease until the tied-down animal is removed. (**major**)
7. Sleds, slide boards, or slip sheets must be placed underneath the animal's body to move and/or load recumbent WH&Bs. (**major**)

8. Halters and ropes tied to a WH&B may be used to roll, turn, position or load a recumbent animal, but a WH&B must not be dragged across the ground by a halter or rope attached to its body while in a recumbent position. **(major)**
9. Animals captured by roping must be evaluated by the on-site/on-call veterinarian within four hours after capture, marked for identification at the trap site, and be re-evaluated periodically as deemed necessary by the on-site/on-call veterinarian. (**major**)

D. Bait Trapping

1. WH&Bs may be lured into a temporary trap using bait (feed, mineral supplement, water) or sexual attractants (mares/jennies in heat) with the following requirements:
   a. The period of time water sources other than in the trap site are inaccessible must not adversely affect the wellbeing of WH&Bs, wildlife or livestock, as determined by the Lead COR/COR/PI. (**major**)
   b. Unattended traps must not be left unobserved for more than 12 hours. (**major**)
   c. Mares/jennies and their dependent foals must not be separated unless for safe transport. (**major**)
   d. WH&Bs held for more than 12 hours must be provided with accessible clean water at a minimum rate of ten gallons per 1000-pound animal per day, adjusted accordingly for larger or smaller horses, burros and foals and environmental conditions. (**major**)
   e. WH&Bs held for more than 12 hours must be provided good quality hay at a minimum rate of 20 pounds per 1000-pound adult animal per day, adjusted accordingly for larger or smaller horses, burros and foals. (**major**)
      1) Hay must not contain poisonous weeds, debris, or toxic substances. (**major**)
      2) Hay placement must allow all WH&Bs to eat simultaneously. (**major**)

III. WILD HORSE AND BURRO CARE

A. Veterinarian

1. On-site veterinary support must be provided for all helicopter gathers and on-site or on-call support must be provided for bait trapping. (**major**)

2. Veterinary support must be under the direction of the Lead COR/COR/PI. The on-site/on-call veterinarian will provide consultation on matters related to WH&B health, handling, welfare, and euthanasia at the request of the Lead COR/COR/PI. All decisions regarding medical treatment or euthanasia will be made by the on-site Lead COR/COR/PI. **(major)**

B. Care

1. Feeding and Watering
    a. Adult WH&Bs held in traps or temporary holding pens for longer than 12 hours must be fed every morning and evening with water available at all times other than when animals are being sorted or worked. (**major)**
    b. Water must be provided at a minimum rate of ten gallons per 1000-pound animal per day, adjusted accordingly for larger or smaller horses, burros and foals, and environmental conditions, with each trough placed in a separate location of the pen (i.e., troughs at opposite ends of the pen). (**major**)
    c. Good quality hay must be fed at a minimum rate of 20 pounds per 1000 pound adult animal per day, adjusted accordingly for larger or smaller horses, burros and foals. (**major**)
        i. Hay must not contain poisonous weeds or toxic substances. (**majo**r)
        ii. Hay placement must allow all WH&Bs to eat simultaneously. (**major**)
    d. When water or feed deprivation conditions exist on the range prior to the gather, the Lead COR/COR/PI should adjust the watering and feeding arrangements in consultation with the onsite veterinarian as necessary to provide for the needs of the animals. (minor)

2. Dust abatement
    a. Dust abatement by spraying the ground with water must be employed when necessary at the trap site and temporary holding facility. (**major**)

3. Trap Site
    a. Dependent foals or weak/debilitated animals must be separated from other WH&Bs at the trap site to avoid injuries during transportation to the temporary holding facility. Separation of dependent foals from mares must not exceed four hours unless the Lead COR/COR/PI authorizes a longer time or a decision is made to wean the foals. (**major**)
4. Temporary Holding Facility
    a. All WH&Bs in confinement must be observed at least once daily to identify sick or injured WH&Bs and ensure adequate food and water. (**major**)
    b. Foals must be reunited with their mares/jennies at the temporary holding facility within four hours of capture unless the Lead COR/COR/PI authorizes a longer time or foals are old enough to be weaned during the gather. (**major**)
    c. Non-ambulatory WH&Bs must be located in a pen separate from the general population and must be examined by the BLM horse specialist and/or on-call or on-site veterinarian as soon as possible, no more than four hours after recumbency is observed. Unless otherwise directed by a veterinarian, hay and water must be accessible to an animal within six hours after recumbency. (**major**)
    d. Alternate pens must be made available for the following: (**major**)
        1) WH&Bs that are weak or debilitated
        2) Mares/jennies with dependent foals
    e. Aggressive WH&Bs causing serious injury to other animals should be identified and relocated into alternate pens when possible. (minor)
    f. WH&Bs in pens at the temporary holding facility should be maintained at a proper stocking density such that when at rest all WH&Bs occupy no more than half the pen area. (minor)

C. Biosecurity

1. Health records for all saddle and pilot horses used on WH&B gathers must be provided to the Lead COR/COR/PI prior to joining a gather, including: (**major**)
   a. Certificate of Veterinary Inspection (Health Certificate, within 30 days).
   b. Proof of:
      1) A negative test for equine infectious anemia (Coggins or EIA ELISA test) within 12 months.
      2) Vaccination for tetanus, eastern and western equine encephalomyelitis, West Nile virus, equine herpes virus, influenza, *Streptococcus equi*, and rabies within 12 months.
2. Saddle horses, pilot horses and mares used for bait trapping lures must not be removed from the gather operation (such as for an equestrian event) and allowed to return unless they have been observed to be free from signs of infectious disease for a period of at least three weeks and a new Certificate of Veterinary Examination is obtained after three weeks and prior to returning to the gather. (**major**)
3. WH&Bs, saddle horses, and pilot horses showing signs of infectious disease must be examined by the on-site/on-call veterinarian. (**major**)
   a. Any saddle or pilot horses showing signs of infectious disease (fever, nasal discharge, or illness) must be removed from service and isolated from other animals on the gather until such time as the horse is free from signs of infectious disease and approved by the on-site/on-call veterinarian to return to the gather. (**major**)
   b. Groups of WH&Bs showing signs of infectious disease should not be mixed with groups of healthy WH&Bs at the temporary holding facility, or during transport. (minor)
4. Horses not involved with gather operations should remain at least 300 yards from WH&Bs, saddle horses, and pilot horses being actively used on a gather. (minor)

IV. HANDLING

A. Willful Acts of Abuse

1. Hitting, kicking, striking, or beating any WH&B in an abusive manner is prohibited. (**major**)
2. Dragging a recumbent WH&B without a sled, slide board or slip sheet is prohibited. Ropes used for moving the recumbent animal must be attached to the sled, slide board or slip sheet unless being loaded as specified in Section II. C. 8. (**major**)
3. There should be no deliberate driving of WH&Bs into other animals, closed gates, panels, or other equipment. (minor)
4. There should be no deliberate slamming of gates and doors on WH&Bs. (minor)
5. There should be no excessive noise (e.g., constant yelling) or sudden activity causing WH&Bs to become unnecessarily flighty, disturbed or agitated. (minor)

B. General Handling

1. All sorting, loading or unloading of WH&Bs during gathers must be performed during daylight hours except when unforeseen circumstances develop and the Lead COR/CO/PI approves the use of supplemental light. (**major**)
2. WH&Bs should be handled to enter runways or chutes in a forward direction. (minor)
3. WH&Bs should not remain in single-file alleyways, runways, or chutes longer than 30 minutes. (minor)
4. Equipment except for helicopters should be operated and located in a manner to minimize flighty behavior. (minor)

C. Handling Aids

1. Handling aids such as flags and shaker paddles must be the primary tools for driving and moving WH&Bs during handling and transport procedures. Contact of the flag or paddle end of primary handling aids with a WH&B is allowed. Ropes looped around the hindquarters may be used from horseback or on foot to assist in moving an animal forward or during loading. (**major**)

2. Electric prods must not be used routinely as a driving aid or handling tool. Electric prods may be used in limited circumstances only if the following guidelines are followed:
    a. Electric prods must only be a commercially available make and model that uses DC battery power and batteries should be fully charged at all times. (**major**)
    b. The electric prod device must never be disguised or concealed. (**major**)
    c. Electric prods must only be used after three attempts using other handling aids (flag, shaker paddle, voice or body position) have been tried unsuccessfully to move the WH&Bs. (**major**)
    d. Electric prods must only be picked up when intended to deliver a stimulus; these devices must not be constantly carried by the handlers. (**major**)
    e. Space in front of an animal must be available to move the WH&B forward prior to application of the electric prod. (**major**)
    f. Electric prods must never be applied to the face, genitals, anus, or underside of the tail of a WH&B. (**major**)
    g. Electric prods must not be applied to any one WH&B more than three times during a procedure (e.g., sorting, loading) except in extreme cases with approval of the Lead COR/COR/PI. Each exception must be approved at the time by the Lead COR/COR/PI. (**majo**r)
    h. Any electric prod use that may be necessary must be documented daily by the Lead COR/COR/PI including time of day, circumstances, handler, location (trap site or temporary holding facility), and any injuries (to WH&B or human). (**major**)

V. TRANSPORTATION

A. General

1. All sorting, loading, or unloading of WH&Bs during gathers must be performed during daylight hours except when unforeseen circumstances develop and the Lead COR/CO/PI approves the use of supplemental light. (**major**)

2. WH&Bs identified for removal should be shipped from the temporary holding facility to a BLM facility within 48 hours. (minor)
    a. Shipping delays for animals that are being held for release to range or potential on-site adoption must be approved by the Lead COR/COR/PI. (**major**)
3. Shipping should occur in the following order of priority; 1) debilitated animals, 2) pairs, 3) weanlings, 4) dry mares and 5) studs. (minor)
4. Planned transport time to the BLM preparation facility from the trap site or temporary holding facility must not exceed 10 hours. (**major**)
5. WH&Bs should not wait in stock trailers and/or semi-trailers at a standstill for more than a combined period of three hours during the entire journey. (minor)

B. Vehicles

1. Straight-deck trailers and stock trailers must be used for transporting WH&Bs. (**major**)
    a. Two-tiered or double deck trailers are prohibited. (**major**)
    b. Transport vehicles for WH&Bs must have a covered roof or overhead bars containing them such that WH&Bs cannot escape. (**major**)
2. WH&Bs must have adequate headroom during loading and unloading and must be able to maintain a normal posture with all four feet on the floor during transport without contacting the roof or overhead bars. (**major**)
3. The width and height of all gates and doors must allow WH&Bs to move through freely. (**major**)
4. All gates and doors must open and close easily and be able to be secured in a closed position. (**major**)
5. The rear door(s) of the trailers must be capable of opening the full width of the trailer. (**major**)
6. Loading and unloading ramps must have a non-slip surface and be maintained in proper working condition to prevent slips and falls. (**major**)

7. Transport vehicles more than 18 feet and less than 40 feet in length must have a minimum of one partition gate providing two compartments; transport vehicles 40 feet or longer must have at least two partition gates to provide a minimum of three compartments. (**major**)
8. All partitions and panels inside of trailers must be free of sharp edges or holes that could cause injury to WH&Bs. (**major**)
9. The inner lining of all trailers must be strong enough to withstand failure by kicking that would lead to injuries. (**major**)
10. Partition gates in transport vehicles should be used to distribute the load into compartments during travel. (minor)
11. Surfaces and floors of trailers must be cleaned of dirt, manure and other organic matter prior to the beginning of a gather. (**major**)

C. Care of WH&Bs during Transport Procedures

1. WH&Bs that are loaded and transported from the temporary holding facility to the BLM preparation facility must be fit to endure travel. (**major**)
    a. WH&Bs that are non-ambulatory, blind in both eyes, or severely injured must not be loaded and shipped unless it is to receive immediate veterinary care or euthanasia. (**major**)
    b. WH&Bs that are weak or debilitated must not be transported without approval of the Lead COR/COR/PI in consultation with the on-site veterinarian. Appropriate actions for their care during transport must be taken according to direction of the Lead COR/COR/PI. (**major**)
2. WH&Bs should be sorted prior to transport to ensure compatibility and minimize aggressive behavior that may cause injury. (minor)
3. Trailers must be loaded using the minimum space allowance in all compartments as follows: (**major**)
    a. 12 square feet per adult horse.
    b. 6.0 square feet per dependent horse foal.
    c. 8.0 square feet per adult burro.
    d. 4.0 square feet per dependent burro foal.

4. The Lead COR/COR/PI in consultation with the receiving Facility Manager must document any WH&B that is recumbent or dead upon arrival at the destination. (**major**)
    a. Non-ambulatory or recumbent WH&Bs must be evaluated on the trailer and either euthanized or removed from the trailers using a sled, slide board or slip sheet. (**major**)
5. Saddle horses must not be transported in the same compartment with WH&Bs. (**major**)

VI. EUTHANASIA OR DEATH

A. Euthanasia Procedure during Gather Operations

1. An authorized, properly trained, and experienced person as well as a firearm appropriate for the circumstances must be available at all times during gather operations. When the travel time between the trap site and temporary holding facility exceeds one hour or if radio or cellular communication is not reliable, provisions for euthanasia must be in place at both the trap site and temporary holding facility during the gather operation. (**major**)
2. Euthanasia must be performed according to American Veterinary Medical Association euthanasia guidelines (2013) using methods of gunshot or injection of an approved euthanasia agent. (**major**)
3. The decision to euthanize and method of euthanasia must be directed by the Authorized Officer or their Authorized Representative(s) that include but are not limited to the Lead COR/COR/PI who must be on site and may consult with the on-site/on-call veterinarian. (**major**)
4. Photos needed to document an animal's condition should be taken prior to the animal being euthanized. No photos of animals that have been euthanized should be taken. An exception is when a veterinarian or the Lead COR/COR/PI may want to document certain findings discovered during a postmortem examination or necropsy. (minor)
5. Any WH&B that dies or is euthanized must be documented by the Lead COR/COR/PI including time of day, circumstances, euthanasia method, location, a

description of the age, gender, and color of the animal and the reason the animal was euthanized. (**major**)

6. The on-site/on-call veterinarian should review the history and conduct a postmortem physical examination of any WH&B that dies or is euthanized during the gather operation. A necropsy should be performed whenever feasible if the cause of death is unknown. (minor)

B. Carcass Disposal

1. The Lead COR/COR/PI must ensure that appropriate equipment is available for the timely disposal of carcasses when necessary on the range, at the trap site, and temporary holding facility. (**major**)
2. Disposal of carcasses must be in accordance with state and local laws. (**major**)
3. WH&Bs euthanized with a barbiturate euthanasia agent must be buried or otherwise disposed of properly. (**major**)
4. Carcasses left on the range should not be placed in washes or riparian areas where future runoff may carry debris into ponds or waterways. Trenches or holes for buried animals should be dug so the bottom of the hole is at least 6 feet above the water table and 4-6 feet of level earth covers the top of the carcass with additional dirt mounded on top where possible. (minor)

CAWP

REQUIRED DOCUMENTATION AND RESPONSIBILITIES OF LEAD COR/COR/PI

Required Documentation

Section	Documentation
II.B.5	Helicopter contact with any WH&B.
II.C.2	Roping of any WH&B.
III.B.3.a and III.B.4.b	Reason for allowing longer than four hours to reunite foals with mares/jennies. Does not apply if foals are being weaned.
III.C.1	Health status of all saddle and pilot horses.
IV.C.2.h	All uses of electric prod.
V.C.4	Any WH&B that is recumbent or dead upon arrival at destination following transport.
VI.A.5	Any WH&B that dies or is euthanized during gather operation.

Responsibilities

Section	Responsibility
I.A.10	Approve materials used in construction of finger gates in bait trapping
II.A.1	Direct gather procedures using approved gather technique.
II.B.2	Determine rate of movement and distance limitations for WH&B helicopter gather.
II.B.2.a	Direct appropriate gather/handling methods for weak or debilitated WH&B.
II.B.3	Determine whether to abandon pursuit or use other capture method in order to avoid repeated pursuit of WH&B.
II.B.4	Determine width and need for visibility marking when using opening in fence en route to trap.
II.B.6	Determine number of attempts that can be made to capture the missing half of a mare/foal pair that has become separated.
II.B.7	Determine whether to proceed with gather when ambient temperature is outside the range of 10°F to 95°F for horses or 10°F to 100°F for burros.
II.C.1	Approve roping of any WH&B.
II.D.1 .a	Determine period of time that water outside a bait trap is inaccessible such that wellbeing of WH&Bs, wildlife, or livestock is not adversely affected.
III.A.2	Direct and consult with on-site/on-call veterinarian on any matters related to WH&B health, handling, welfare and euthanasia.

III.B.1.e	Adjust feed/water as necessary, in consultation with onsite/on call veterinarian, to provide for needs of animals when water or feed deprivation conditions exist on range.
III.B.4.c	Determine provision of water and hay to non-ambulatory animals.
IV.C.2.g	Approve use of electric prod more than three times, for exceptional cases only.
V.A.1	Approve sorting, loading, or unloading at night with use of supplemental light.
V.A.2 .a	Approve shipping delays of greater than 48 hours from temporary holding facility to BLM facility.
V.C.1.b	Approve of transport and care during transport for weak or debilitated WH&B.
VI.A.3	Direct decision regarding euthanasia and method of euthanasia for any WH&B; may consult with on-site/on-call veterinarian.
VI.B.1	Ensure that appropriate equipment is available for carcass disposal.

APPENDIX D: STANDARD OPERATING PROCEDURES FOR POPULATION-LEVEL FERTILITY CONTROL TREATMENTS

SOPs Common to all Vaccine Types:

Identification

- Animals intended for treatment must be clearly, individually identifiable to allow for positive identification during subsequent management activities. For captured animals, marking for identification may be accomplished by marking each individual with a freeze mark on the hip and/or neck and a microchip in the nuchal ligament. In some cases, identification may be accomplished based by cataloguing markings that make animals uniquely identifiable. Such animals may be photographed using a telephoto lens and high-quality digital camera as a record of treated individuals.

Safety

- Safety for both humans and animals is the primary consideration in all elements of fertility control vaccine use. Administration of any vaccine must follow all safety guidance and label guidelines on applicable Environmental Protection Agency (EPA) labeling.

Injection Site

- For hand injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right side, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone): this is the hip/upper gluteal area. For dart-based injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right thigh areas (lower gluteal/biceps femoralis).

Monitoring and Tracking of Treatments

1. Estimation of population size and growth rates (in most cases, using aerial surveys) should be conducted periodically after treatments.
2. Population growth rates of some herds selected for intensive monitoring may be estimated every year post-treatment using aerial surveys. If, during routine herd management area (HMA) field monitoring (on-the-ground), data describing adult to foal ratios can be collected, these data should also be shared with HQ-261.
3. Field applicators should record all pertinent data relating to identification of treated animals (including photographs if animals are not freeze-marked) and date of treatment, lot number(s) of the vaccine, quantity of vaccine issued, the quantity used, the date of vaccination, disposition of any unused vaccine, the date disposed, the number of treated mares by HMA, field office, and State along with the microchip numbers and freeze-mark(s) applied by HMA and date. A summary narrative and data sheets will be forwarded to HQ-261 annually (Reno, Nevada). A copy of the form and data sheets and any photos taken should be maintained at the field office.

4. HQ-261 will maintain records sent from field offices on the quantity of PZP issued, the quantity used, disposition of any unused PZP, the number of treated mares by HMA, field office, and State along with the freeze-mark(s) applied by HMA and date.

SOPs for One-year Liquid PZP Vaccine (ZonaStat-H)

- ZonaStat-H vaccine (Science and Conservation Center (SCC), Billings, MT) would be administered through hand injection or darting by trained BLM personnel or collaborating partners only. At present, the only PZP vaccine for dart-based delivery in BLM-managed wild horses or burros is ZonaStat-H. For any darting operation, the designated personnel must have successfully completed a nationally recognized wildlife darting course and have documented and successful experience darting wildlife under field conditions.
- Until the day of its use, ZonaStat-H must be kept frozen.
- Animals that have never been treated with a PZP vaccine would receive 0.5 cc of PZP vaccine emulsified with 0.5 cc of Freund's Modified Adjuvant (FMA). Animals identified for re-treatment receive 0.5 cc of the PZP vaccine emulsified with 0.5 cc of Freund's Incomplete Adjuvant (FIA).

Administering ZonaStat-H by Hand Injection

- Hand injection of liquid PZP vaccine would be by intramuscular injection into the gluteal muscles while the animal is restrained in a working chute. The vaccine would be injected into the left hind quarters of the animal, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone).
- For hand injection, delivery of the vaccine would be by intramuscular injection into the left or right buttocks and thigh muscles (gluteals, biceps femoris) while the animal is standing still.

Application of ZonaStat-H via Darting

- Only designated darters would prepare the emulsion. Vaccine-adjuvant emulsion would be loaded into darts at the darting site and delivered by means of a projector gun.
- No attempt to dart should be taken when other persons are within a 100-m radius of the target animal. The Dan Inject gun should not be used at ranges in excess of 30 m while the Pneu-Dart gun should not be used over 50 m.
- No attempts would be taken in high wind (greater than 15 mph) or when the animal is standing at an angle where the dart could miss the target area and hit the flank or rib cage. The ideal is when the dart would strike the skin of the animal at a 90° angle.
- If a loaded dart is not used within two hours of the time of loading, the contents would be transferred to a new dart before attempting another animal. If the dart is not used before the end of the day, it would be stored under refrigeration and the contents transferred to another dart the next day, for a maximum of one transfer (discard contents if not used on the second day). Refrigerated darts would not be used in the field.
- A darting team should include two people. The second person is responsible for locating fired darts. The second person should also be responsible for identifying the animal and keeping onlookers at a safe distance.
- To the extent possible, all darting would be carried out in a discrete manner. However, if darting is to be done within view of non-participants or members of the public, an explanation

of the nature of the project would be carried out either immediately before or after the darting.

- Attempts will be made to recover all darts. To the extent possible, all darts that are discharged and drop from the target animal at the darting site would be recovered before another darting occurs. In exceptional situations, the site of a lost dart may be noted and marked, and recovery efforts made at a later time. All discharged darts would be examined after recovery in order to determine if the charge fired and the plunger fully expelled the vaccine. Personnel conducting darting operations should be equipped with a two-way radio or cell phone to provide a communications link with a project veterinarian for advice and/or assistance. In the event of a veterinary emergency, darting personnel would immediately contact the project veterinarian, providing all available information concerning the nature and location of the incident.
- In the event that a dart strikes a bone or imbeds in soft tissue and does not dislodge, the darter would follow the affected animal until the dart falls out or the animal can no longer be found. The darter would be responsible for daily observation of the animal until the situation is resolved.

SOPs for Application of PZP-22 Pelleted Vaccine

- PZP-22 pelleted vaccine treatment would be administered only by trained BLM personnel or designated partners.
- A treatment of PZP-22 is comprised of two separate injections: (1) a liquid dose of PZP vaccine (equivalent to one dose of ZonaStat-H) is administered using an 18-gauge needle primarily by hand injection; (2) the pellets are preloaded into a 14-gauge needle. For animals constrained in a working chute, these are delivered using a modified syringe and jabstick to inject the pellets into the gluteal muscles of the animals being returned to the range. The pellets are intended to release PZP over time.
- Until the day of its use, the liquid portion of PZP-22 must be kept frozen.
- At this time, delivery of PZP-22 treatment would only be by intramuscular injection into the gluteal muscles while the animal is restrained in a working chute. The primer would consist of 0.5 cc of liquid PZP emulsified with 0.5 cc of adjuvant. Animals that have never been treated with a PZP vaccine would receive 0.5 cc of PZP vaccine emulsified with 0.5 cc of Freund's Modified Adjuvant (FMA). Animals identified for re-treatment receive 0.5 cc of the PZP vaccine emulsified with 0.5 cc of Freund's Incomplete Adjuvant (FIA). The syringe with PZP vaccine pellets would be loaded into the jabstick for the second injection. With each injection, the liquid or pellets would be injected into the left hind quarters of the animal, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone).
- In the future, the PZP-22 treatment may be administered remotely using an approved long range darting protocol and delivery system if and when BLM has determined that the technology has been proven safe and effective for use.

SOPs for GonaCon-Equine Vaccine Treatments

- GonaCon-Equine vaccine (USDA Pocatello Storage Depot, Pocatello, ID; Spay First!, Inc., Oklahoma City, OK) is distributed as preloaded doses (2 ml) in labeled syringes. Upon receipt, the vaccine should be kept refrigerated (4° C) until use. Do not freeze GonaCon-Equine. The vaccine has a 6-month shelf-life from the time of production, and the expiration date will be noted on each syringe that is provided.
- For initial and booster treatments, mares would ideally receive 2.0 ml of GonaCon-Equine.

Administering GonaCon Vaccine by Hand Injection

- Experience has demonstrated that only 1.8 ml of vaccine can typically be loaded into 2 cc darts, and this dose has proven successful. Calculations below reflect a 1.8 ml dose.
- For hand-injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right side, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone): this is the hip/upper gluteal area.
- A booster vaccine may be administered after the first injection to improve efficacy of the product over subsequent years.

Application of GonaCon-Equine via Darting

- General practice guidelines for darting operations, as noted above for dart-delivery of ZonaStat-H, should be followed for dart-delivery of GonaCon-Equine.
- Wearing latex gloves, the applicator numbers darts, and loads numbered darts with vaccine by attaching a loading needle (7.62 cm; provided by dart manufacturer) to the syringe containing vaccine and placing the needle into the cannula of the dart to the fullest depth possible. Slowly depress the syringe plunger and begin filling the dart. Periodically, tap the dart on a hard surface to dislodge air bubbles trapped within the vaccine. Due to the viscous nature of the fluid, air entrapment typically results in a maximum of approximately 1.8 ml of vaccine being loaded in the dart. The dart is filled to max once a small amount of the vaccine can be seen at the tri-ports.
- Important! Do not load and refrigerate darts the night before application. When exposed to moisture and condensation, the edges of gel barbs soften, begin to dissolve, and will not hold the dart in the muscle tissue long enough for full injection of the vaccine. The dart needs to remain in the muscle tissue for a minimum of 1 minute to achieve dependable full injection. Sharp gel barbs are critical.
- Darts should be weighed to the nearest hundredth gram by electronic scale when empty, when loaded with vaccine, and after discharge, to ensure that 90% (1.62 ml) of the vaccine has been injected. GonaCon weighs 0.95 grams/ml, so animals should receive 1.54 grams of vaccine to be considered treated. Animals receiving <50% should be darted with another full dose; those receiving >50% but <90% should receive a half dose (1 ml). All darts should be weighed to verify a combination of ≥1.62 ml has been administered. Therefore, every effort should be made to recover darts after they have fallen from animals.
- Although infrequent, dart injections can result in partial injections of the vaccine, and shots are missed. As a precaution, it is recommended that extra doses of the vaccine be ordered to accommodate failed delivery (which may be as high as ~15%). To determine the amount of vaccine delivered, the dart must be weighed before loading, and before and after delivery in the field. The scale should be sensitive to 0.01 grams or less, and accurate to 0.05 g or less.
- For best results, darts with a gel barb should be used. (i.e., 2 cc Pneu-Dart brand darts configured with Slow-inject technology, 3.81 cm long 14 ga. tri-port needles, and gel collars positioned 1.27 cm ahead of the ferrule). One can expect updates in optimal dart configuration, pending results of research and field applications.
- Darts (configured specifically as described above) can be loaded in the field and stored in a cooler prior to application. Darts loaded, but not used can be maintained in dry conditions at

about 4° C and used the next day, but do not store in any refrigerator or container likely to cause condensation, which can compromise the gel barbs.

SOPs for Insertion of Y-shaped Silicone IUD for Feral Horses

- Background: Mares must be open. A veterinarian must determine pregnancy status via palpation or ultrasound. Ultrasound should be used as necessary to confirm open status of mares down to at least 14 days for those that have recently been with stallions. For mares segregated from stallions, this determination may be made at an earlier time when mares are identified as candidates for treatment, or immediately prior to IUD insertion. Pregnant mares should not receive an IUD.

  Preparation: IUDs must be clean and sterile. Sterilize IUDs with a low-temperature sterilization system, such as Sterrad.

- The introducer is two PVC pipes. The exterior pipe is a 29-inch length of one-half-inch diameter pipe, sanded smooth at one end, then heat-treated to smooth its curvature further (Fig. 1). The IUD will be placed into this smoothed end of the exterior pipe. The interior pipe is a 29 ½ inches long, one-quarter-inch riser tube (of the kind used to connect water lines to sinks), with one end slightly flared out to fit more snugly inside the exterior pipe (Fig. 1), and a plastic stopper attached to the other end (Fig. 2).

Figure 1. Interior and exterior pipes (unassembled), showing the ends that go into the mare.

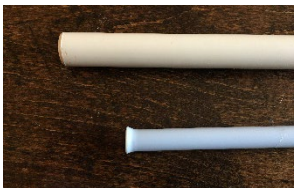


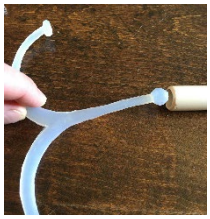
Figure 2. Interior pipe shown within exterior pipe. After the introducer is 4" beyond the os, the stopper is pushed forward (outside the mare), causing the IUD to be pushed out from the exterior pipe.



- Introducers should be sterilized in Benz-all cold sterilant, or similar. Do not use iodine-based sterilant solution. A suitable container for sterilant can be a large diameter (i.e., 2") PVC pipe with one end sealed and one end removable.

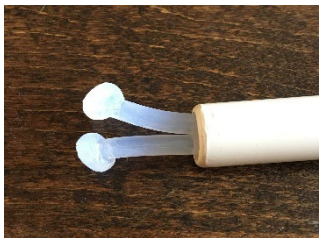
- Prepare the IUD: Lubricate with sterile veterinary lube and insert into the introducer. The central stem of the IUD goes in first (Fig. 3).

Figure 3. Insert the stem end of the IUD into the exterior pipe.



- Fold the two 'legs' of the IUD, and push the IUD further into the introducer, until just the bulbous ends are showing (Fig. 4).

Figure 4. Insert the IUD until just the tips of the 'legs' are showing.



- Restraint and Medication: The mare should be restrained in a padded squeeze chute to provide access to the rear end of the animal, but with a solid lower back door, or thick wood panel, for veterinarian safety.

- Only a veterinarian shall oversee this procedure and insert IUDs. Some practitioners may choose to provide sedation. If so, when the mare's head starts to droop, it may be advisable to tie the tail up to prevent risk of the animal sitting down on the veterinarian's arm (i.e., double half hitch, then tie tail to the bar above the animal). Some practitioners may choose to provide a dose of long-acting progesterone to aid in IUD retention. (Example dosage: 5ml of BioRelease LA Progesterone 300 mg/mL (BET labs, Lexington KY), *or* long-acting Altrenogest). No other intrauterine treatments of any kind should be administered at the time of IUD insertion.

  Insertion Procedure:

  - Prep clean the perineal area.
  - Lubricate the veterinarian's sleeved arm and the Introducer+IUD.
  - Carry the introducer (IUD-end-first) into the vagina.
  - Dilate the cervix and gently move the tip of the introducer past the cervix.
  - Advance the end of the 1/2" PVC pipe about 4 inches past the internal os of the cervix.
  - Hold the exterior pipe in place, but push the stopper of the interior pipe forward, causing the IUD to be pushed out of the exterior pipe, into the uterus.
  - Placing a finger into the cervical lumen just as the introducer tube is removed from the external os allows the veterinarian to know that the IUD is left in the uterus, and not dragged back into or past the cervix.
  - Remove the introducer from the animal, untie the tail.

- Mares that have received an IUD should be observed closely for signs of discharge or discomfort for 24 hours following insertion after which they may be released back to the range.

APPENDIX E: GENETICS INFORMATION

Genetic samples were taken for the purpose of monitoring genetic diversity following the 2009, 2011, and 2015 gathers in Kiger and Riddle Mountain HMAs. Analysis of the 2009, 2011, and 2015 hair samples was completed by E. Gus Cothran from Texas A&M University in 2010, 2012, and 2016.

Despite the title of Cothran's 2010 report (which might suggest it is limited to Kiger HMA), this was an analysis of samples collected in 2009 from 12 Kiger HMA horses and 13 Riddle Mountain HMA. These samples indicated that genetic variability (Table A) within both herds was near the average for a wild horse herd, with observed heterozygosity of 0.729 in the Kiger samples and 0.724 in the Riddle Mountain samples. The Kiger and Riddle Mountain samples clustered most closely to each other, in a dendrogram of Oregon wild horse herd similarity, but Cothran concluded that the herd ancestry was primarily North American, with some component that was likely of Spanish heritage as well. At the time, Cothran did not recommend any management actions but did recommend ongoing regular monitoring of genetic diversity continue.

Genetics analysis for the samples collected in 2011 was completed by using hair samples collected from 40 horses from Kiger HMA (Cothran 2012a). These samples indicated that genetic variability within Kiger herd in general is near average for a wild horse herd. Observed heterozygosity was 0.671 (Table A), which is near normal to the recorded mean for wild horse herds. Based on the average degree of genetic variation within the herd, Cothran noted that there was no need for any genetic action, however recommended periodic future monitoring and possible exchange of horses between neighboring herds if warranted.

Genetics analysis for the samples collected in 2015 was completed by using hair samples collected from 56 horses from Kiger HMA (Cothran 2016a). These samples indicated that genetic variability within Kiger herd is on the high side but there is a high percentage of variation that is at risk for a wild horse herd. Observed heterozygosity was 0.722 (Table A), which is higher than the recorded mean for wild horse herds. Based on the high degree of genetic variation within the herd, Cothran noted that there was no need for any genetic action, however recommended monitoring the herd closely due to high proportion of rare alleles.

Genetics analysis for the samples collected in 2011 was completed by using hair samples collected from 21 horses from Riddle Mountain HMA (Cothran 2012b). These samples indicated that genetic variability within Riddle Mountain herd is lower than the average for wild horses but not critically so for a wild horse herd. Observed heterozygosity was 0.679 (Table A), which is lower than the recorded mean for wild horse herds. Based on the average degree of genetic variation within the herd, Cothran noted that current variability levels are high enough that no action is needed at this point, but the herd should be monitored closely due to the trend for loss of variability.

Genetics analysis for the samples collected in 2015 was completed by using hair samples collected from 29 horses from Riddle Mountain HMA (Cothran 2016b). These samples indicated that genetic variability within Riddle Mountain herd could be considered mixed for a wild horse herd. Observed heterozygosity was 0.724 (Table A), which is higher than the recorded mean for wild horse herds. Based on the average degree of genetic variation within the herd, Cothran noted that variability levels are low enough that there should be some concern. The herd should be monitored to check for evidence of inbreeding and possible exchange of horses between neighboring herds if warranted.

Because of history, context, and genetic relatedness, wild horses that live in the Kiger and Riddle Mountain HMAs should not be considered as a truly isolated population (NAS 2013). Rather, managed herds of wild horses should be considered as components of interacting metapopulations, connected by interchange of

individuals and genes over time, due to both natural and human-facilitated movements. These animals are part of part of a larger metapopulation (NAS 2013) that has demographic and genetic connections with other federally-managed herds in Oregon and beyond. Wild horse herds in the larger metapopulation have a background of diverse domestic breed heritage, probably caused by natural and intentional movements of animals between herds. Under the action alternatives, hair samples would be collected during gathers to assess the genetic diversity of the herds at the time of the gathers. Analysis would determine whether management is maintaining acceptable genetic diversity (and avoiding excessive risk of inbreeding depression). Under all action alternatives, fertile wild horse introductions could augment observed heterozygosity, which is a measure of genetic diversity. The result of introductions should be to reduce the risk of inbreeding-related health effects. Introducing a small number of fertile animals every generation (about every 8-10 years) is a standard wild horse management technique that can alleviate potential inbreeding concerns.

Specific empirical evidence also indicates that the Kiger HMA herd and Riddle Mountain HMA herd are also closely related to a large number of other Forest Service and Bureau of Land Management-managed herds. The 'fixation index,' (Fst) is a measure of genetic differentiation, in this case as estimated by the pattern of microsatellite allelic diversity analyzed by Dr. Cothran's laboratory. Low values of Fst indicate that a given pair of sampled herds has a shared genetic background. The lower the Fst value, the more genetically similar are the two sampled herds. Values of Fst of 0.10 or lower indicate 'very little differentiation' and values of 0.05 or lower indicate 'virtually no differentiation' (Frankham et al. 2010). Only if values are above about 0.15 are any two sampled subpopulations considered to have evidence of 'elevated differentiation' (Frankham et al. 2010). In the NAS (2013) report, Fst values were analyzed for the samples from Kiger HMA and Riddle Mountain HMA that were available before the 2013 report. Pairwise Fst values for Kiger HMA were less than 0.05 with 77 other sample sets. Pairwise Fst values for the Riddle Mountain HMA samples were less than 0.05 with 69 other sample sets. These results suggest that the Kiger HMA herd and Riddle Mountain HMA herd are extremely similar to a very large number of other federally-managed herds in the western United States, and support the interpretation that the Murderers Creek HMA wild horses are components in a highly connected metapopulation that includes many wild horse herds. In a recent preprint analysis, Cothran and others (2024) used 2009, 2011, and 2015 samples from Kiger HMA and 2003, 2009, 2011, and 2015 samples from Riddle Mountain HMA in an updated analysis of wild horse herd genetic connectivity, and found that the pattern of microsatellite allele frequencies placed samples from these HMAs near the center of a principal components analysis distribution; this also indicates very high similarity to a large number of other wild horse herds.

Table A is a summary of the genetic diversity analysis reports within the HMAs. The observed heterozygosity (Ho) is a measure of how much diversity is found, on average, within individual animals in a wild horse herd and is insensitive to sample size, although the larger the sample, the more robust the estimate. Ho values below the mean for wild horse populations are an indication that the wild horse herd may have diversity issues. Herds with Ho values that are one standard deviation below the mean are considered at critical risk. The Fis is the estimated inbreeding level (ratio of 1-Ho/He). Fis levels greater than 0.25 are considered the critical level and suggestive of an inbreeding problem. The key to remember is that BLM is not managing for genotype and that there are no rare genetic variants present. We are managing for horse characteristics (phenotypes noted in the area of critical environmental concern (ACEC)) and to maintain adequate variability.

Table A: Genetic Variability Measures Comparison.
Results of genetic monitoring from the 2009, 2011, and 2015 samples from Kiger and Riddle Mountain HMAs including observed heterozygosity (Ho), the effective number of alleles (Ae), and the estimated inbreeding level (Fis). For comparison, the mean and standard deviation (SD) values for wild horse herds are also shown.

	H_o	A_e	F_{is}
2009 Kiger HMA Samples	0.729	3.39	-0.06
2011 Kiger HMA Samples	0.671	3.54	0.034
2015 Kiger HMA Samples	0.722	3.710	-0.021
2009 Riddle Mountain HMA Samples	0.724	3.41	-0.07
2011 Riddle Mountain HMA Samples	0.679	3.21	-0.034
2015 Riddle Mountain HMA Samples	0.724	3.410	-0.094
Wild Horse mean	0.716 SD=0.056	3.866 SD=0.657	-0.012 SD=0.071

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APPENDIX F: SCIENTIFIC LITERATURE REVIEW

This appendix includes scientific literature reviews addressing six topics: effects of gathers, effects of wild horses and burros on rangeland ecosystems, effects of fertility control vaccines and sex ratio manipulations, effects of sterilization, effects of intrauterine devices (IUD), and effects of radio collars and radio tail tags.

Effects of Gathers on Wild Horses and Burros

Gathering any wild animals into pens has the potential to cause impacts to individual animals. There is also the potential for impacts to individual horses and burros during transportation, short-term holding, and long-term holding that take place after a gather. However, BLM follows guidelines to minimize those impacts and ensure humane animal care and high standards of welfare. The following literature review summarizes the limited number of scientific papers and government reports that have examined the effects of gathers and holding on wild horses and burros.

Two early papers, by Hansen and Mosley (2000) and Ashley and Holcomb (2001) examined limited effects of gathers, including behavioral effects and effects on foaling rates. Hansen and Mosley (2000) observed BLM gathers in Idaho and Wyoming. They monitored wild horse behaviors before and after a gather event, and compared the behavioral and reproductive outcomes for animals that were gathered by helicopter against those outcomes for animals that were not. This comparison led to the conclusion that gather activities used at that time had no effect on observed wild horse foraging or social behaviors, in terms of time spent resting, feeding, vigilant, traveling, or engaged in agonistic encounters (Hansen and Mosley 2000). Similarly, the authors did not find any statistically significant difference in foaling rates in the year after the gather in comparisons between horses that were captured, those that were chased by a helicopter but evaded capture, or those that were not chased by a helicopter. The authors concluded that the gathers had no deleterious effects on behavior or reproduction. Ashley and Holcomb (2001) conducted observations of reproductive rates at Garfield Flat HMA in Nevada, where horses were gathered in 1993 and 1997, and compared those observations at Granite Range HMA in Nevada, where there was no gather. The authors found that the two gathers had a short-term effect on foaling rates; pregnant mares that were gathered had lower foaling rates than pregnant mares that were not gathered. The authors suggested that BLM make changes to the gather methods used at that time, to minimize the length of time that pregnant mares are held prior to their release back to the range. Since the publications by Hansen and Mosley (2000) and by Ashley and Holcomb (2001), BLM did make changes to reduce the stress that gathered animals, including pregnant females, may experience as a result of gather and removal activities; these measures have been formalized as policy in the Wild Horse and Burro Comprehensive Animal Welfare Program (BLM IM 2021-002). That policy also covers care of animals in corrals, where measures to ensure wild horse and burro health and welfare include oversight by attending veterinarians.

A thorough review of gather practices and their effects on wild horses and burros can be found in a 2008 report from the Government Accounting Office (GAO). The report found that the BLM had controls in place to help ensure the humane treatment of wild horses and burros (GAO 2008). The controls included standard operating procedures (SOP) for gather operations, inspections, and data collection to monitor animal welfare. These procedures led to humane treatment during gathers, and in short-term and long-term holding facilities. The report found that cumulative effects associated with the capture and removal of excess wild horses include gather-related mortality averaged only about 0.5 percent and approximately 0.7 percent of the captured animals, on average, are humanely euthanized due to pre-existing conditions (such as lameness or club feet) in accordance with BLM policy. Scasta (2020) found the same overall mortality rate (1.2 percent) for BLM wild horse and burro (WHB) gathers in 2010-2019, with a mortality rate of 0.25 percent caused

directly by the gather, and a mortality rate of 0.94 percent attributable to euthanasia of animals with pre-existing conditions such as blindness or club-footedness. Scasta (2020) summarized mortality rates from 70 BLM WHB gathers across nine states, from 2010-2019. Records for 28,821 horses and 2,005 burros came from helicopter and bait/water trapping. For wild burro bait/water trapping, mortality rates were 0.05 percent due to acute injury caused by the gather process, and death for burros with pre-existing conditions was 0.2 percent (Scasta 2020). For wild horse bait/water trapping, mortality rates were 0.3 percent due to acute injury, and the mortality rate due to pre-existing conditions was 1.4 percent (Scasta 2020). For wild horses gathered with the help of helicopters, mortality rates were only slightly lower than for bait/water trapping, with 0.3 percent due to acute causes, and 0.8 percent due to pre-existing conditions (Scasta 2020). Scasta (2020) noted that for other wildlife species capture operations, mortality rates above 2 percent are considered unacceptable and that, by that measure, BLM WHB "…welfare is being optimized to a level acceptable across other animal handling disciplines." In a separate analysis of 2010-2019 BLM wild horse gathers, Scasta and others (2021) concluded that fewer than 20 percent of wild horse deaths at gathers were attributable to acute causes, with the great majority being euthanasia of animals with pre-existing, chronic conditions.

King and others (2023) studied the fate of wild horse foals, as part of a broader 2016-2020 study on the effects of having some geldings in with breeding herds (King et al. 2022). In two HMAs in Utah that were intensively monitored for 4 years, about 5 percent of foals died in their first year of life, and about 2.5 percent of foals younger than 70 days old that became separated from their mothers (dams) survived and joined other social bands. BLM gather activities were not associated with any statistical increase in foal mortality, foal separation from their dams, or infanticide. King and others (2023) concluded that, "…separation of offspring may be more common than previously considered, and that this is a natural event that does not necessarily result in mortality. … the separation of young foals from their dams was not a result of human disturbance or handling, resulting in the conclusion that foals even as young as 2 months old have a good chance of survival if separated from their dam or orphaned, as long as other social groups remain on the range that they can join."

The GAO report (2008) noted the precautions that BLM takes before gather operations, including screening potential gather sites for environmental and safety concerns, approving facility plans to ensure that there are no hazards to the animals there, and limiting the speeds that animals travel to trap sites. BLM used SOPs for short-term holding facilities (e.g., corrals) that included procedures to minimize excitement of the animals to prevent injury, separating horses by age, sex, and size, regular observation of the animals, and recording information about the animals in a BLM database. The GAO reported that BLM had regular inspections of short-term holding facilities and the animals in there, ensuring that the corral equipment is up to code and that animals are treated with appropriate veterinary care (including that hooves are trimmed adequately to prevent injury). Mortality was found to be about 5 percent per year associated with transportation, short-term holding, and adoption or sale with limitations. The GAO noted that BLM also had controls in place to ensure humane care at long-term holding facilities (i.e., pastures). BLM staff monitor the number of animals, the pasture conditions, winter feeding, and animal health. Veterinarians from the USDA Animal and Plant Health Inspection Service inspect long-term facilities annually, including a full count of animals, with written reports. Contract veterinarians provide animal care at long-term facilities, when needed. Weekly counts provide an incentive for contractors that operate long-term holding facilities to maintain animal health (GAO 2008). Mortality at long-term holding was found to be about 8 percent per year, on average (GAO 2008). The mortality rates at short-term and long-term holding facilities are comparable to the natural annual mortality rate on the range of about 16 percent per year for foals (animals under age 1), about 5-10 percent per year for horses ages 1-10 years, and about 10-25 percent for animals aged 10-20 years (Ransom et al. 2016).

In 2010, the American Association of Equine Practitioners (AAEP 2011) was invited by the BLM to visit the BLM operations and facilities, spend time on WHB gathers, and evaluate the management of the wild equids. The AAEP Task Force evaluated horses in the BLM Wild Horse and Burro Program through several visits to wild horse gathers, and short- and long-term holding facilities. The task force was specifically asked to "review animal care and handling within the Wild Horse and Burro Program, and make whatever recommendations, if any, the Association feels may be indicated, and if possible, issue a public statement regarding the care and welfare of animals under BLM management." In their report (AAEP 2011), the task force concluded "that the care, handling and management practices utilized by the agency are appropriate for this population of horses and generally support the safety, health status and welfare of the animals."

In June 2010, BLM invited independent observers organized by American Horse Protection Association (AHPA) to observe BLM gathers and document their findings. AHPA engaged four independent credentialed professionals who are academia-based equine veterinarians or equine specialists. Each observer served on a team of two and was tasked specifically to observe the care and handling of the animals for a 3-4-day period during the gather process and submit their findings to AHPA. An Evaluation Checklist was provided to each of the observers that included four sections: Gather Activities; Horse Handling During Gather; Horse Description; and Temporary Holding Facility. The independent group visited three separate gather operations and found that "BLM and contractors are responsible and concerned about the welfare of the horses before, during and after the gather process" and that "gentle and knowledgeable, used acceptable methods for moving horses… demonstrated the ability to review, assess and adapt procedures to ensure the care and well-being of the animals" (Greene et al. 2011).

BLM commissioned the Natural Resources Council of the National Academies of Sciences (NAS) to conduct an independent, technical evaluation of the science, methodology, and technical decision-making approaches of the BLM Wild Horse and Burro Management Program. Among the conclusions of their 2013 report, NAS (2013) concluded that wild horse populations grow at 15-20 percent a year, and that predation will not typically control population growth rates of free-ranging horses. The report (NAS 2013) also noted that, because there are human-created barriers to dispersal and movement (such as fences and highways) and not enough substantial predator pressure to actually cause herds to decrease, maintaining a herd within an appropriate management level (AML) requires removing animals in roundups, also known as gathers, and may require management actions that limit population growth rates. The report (NAS 2013) examined a number of population growth suppression techniques, including the use of sterilization, fertility control vaccines, and sex ratio manipulation.

The effects of gathers as part of free-roaming horse management have also been documented on National Park Service Lands. Since the 1980s, managers at Theodore Roosevelt National Park have used periodic gathers, removals, and auctions to maintain the free-roaming horse herd size at a carrying capacity level of 50 to 90 horses (Amberg et al. 2014). In practical terms, this carrying capacity is equivalent to an AML. Horse herd sizes at those levels were determined to allow for maintenance of certain sensitive forage plant species. Gathers every 3-5 years did not prevent the herd from self-sustaining. The herd continues to grow, to the point that the NPS now uses gathers and removals along with temporary fertility control methods in its free-roaming horse management (Amberg et al. 2014).

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Effects of Wild Horses and Burros on Rangeland Ecosystems

The presence of wild horses and wild burros can have substantial effects on rangeland ecosystems, and on the capacity for habitat restoration efforts to achieve landscape conservation and restoration goals. While wild horses and burros may have some beneficial ecological effects, such benefits are outweighed by ecological damage they cause when herds are at levels greater than supportable by allocated, available natural resources (i.e., when herds are greater than AML).

In the biological sense, all free-roaming horses and burros in North America are feral, meaning that they are descendants of domesticated animals brought to the Americas by European colonists. Available evidence has indicated that horses went extinct in the Americas by the end of the Pleistocene, about 10,000 years ago (Webb 1984, MacFadden 2005), though DNA samples from permafrost suggest their extinction from Alaska could possibly have been as recent as about 6,000 years ago (Murchie et al. 2021). Burros evolved in Eurasia (Geigl et al. 2016). After domesticated horses were introduced to the Americas, their geographic distribution was facilitated by Native Americans and colonizing Europeans (Taylor et al. 2023a, 2023b). The published literature refers to free-roaming horses and burros as either feral or wild. In the ecological context the terms are interchangeable, but the terms 'wild horse' and 'wild burro' are associated with a specific legal status. The legal status of federally recognized wild horses and burros stems entirely from the WFRHBA of 1971 and is not dependent on whether the animals are or are not considered 'native' to the particular lands of the western USA where they are managed by the BLM and US Forest Service. Whether or not those animals were continuously present throughout the Holocene period in the 10 states where they are currently managed does not appear to influence the magnitude or direction of their ecological effects (Lundgren et al. 2024), but those effects are by no measure benign with respect to less well-known plant and animal species, many of which have far more limited geographic distributions.

The following literature review on the effects of wild horses and burros on rangeland ecosystems draws on scientific studies of feral horses and burros, some of which also have wild horse or wild burro legal status. Parts of this review draw heavily on Parts 1 and 2 of the "Science framework for conservation and restoration of the sagebrush biome" interagency report (Chambers et al. 2017, Crist et al. 2019).

Because of the known damage that overpopulated wild horse and burro herds can cause in rangeland ecosystems, the presence of wild horses and burros is considered a threat to Greater Sage-Grouse habitat quality, particularly in the bird species' western range (Beever and Aldridge 2011, USFWS 2013). In addition, free-roaming equids have been shown to occupy habitat preferred by both pronghorn and greater sage-grouse increasing direct competition for scarce resources such as reliable water sites and indirect impacts resulting from reduced availability of perennial grass which provided forage for pronghorn and hiding cover for both sage-grouse nests and broods (Hennig et al, 2023). Wild horse population sizes on Federal lands have more than doubled in the five years since the USFWS report (2013) was published (BLM 2018). On lands administered by the BLM, there were over 82,000 BLM-administered wild horses and burros as of March 1, 2022, which does not include foals born in 2020. Lands with wild horses and burros are managed for multiple uses; scientific studies designed to separate those effects of wild horses and burros, which are summarized below, point to conclusions that landscapes with greater wild horse and burro abundance will tend to have lower resilience to disturbance and lower resistance to invasive plants than similar landscapes with herds at or below target AML levels.

In contrast to managed livestock grazing, neither the seasonal timing nor the intensity of wild horse and burro grazing can be managed, except through efforts to manage their numbers and distribution. Wild horses live on the range year-round, they roam freely, and wild horse populations have the potential to grow 15-20

percent per year (Wolfe 1980, Eberhardt et al. 1982, Garrott et al. 1991, Dawson 2005, Roelle et al. 2010, Scorolli et al. 2010). Although this annual growth rate may be lower in some areas where mountain lions can take foals (Turner and Morrison 2001, Turner 2015), horses tend to favor use of more open habitats (Schoenecker 2016) that are dominated by grasses and shrubs and where ambush is less likely. Wild horses may compete for forage with elk, mule deer, other wild ungulates, and managed livestock (Smith . 1986a, Scasta et al. 2016, Platte and Torland 2024).

As a result of the potential for wild horse populations to grow rapidly, impacts from wild horses on water, soil, vegetation, and native wildlife resources (Davies and Boyd 2019) can increase exponentially unless there is active management to limit their population sizes. For the majority of wild horse herds, there is little overall evidence that population growth is significantly affected by predation (NAS 2013), although wild horse and burro herd growth rates may be somewhat reduced by predation in some localized areas, particularly where individual cougars specialize on horse or burro predation (Turner and Morrison 2001, Roelle et al. 2010, Mesler and Jones 2021). Andreasen and others (2021) and Iacono (2023) found that the level of specializing on young horse varies across individual mountain lions (*Puma concolor*). This specialization seems more prevalent where horses are at very high densities and native ungulates are at very low densities (Andreasen et al. 2021). The greatest rate of predation on horses, by mountain lions, was in the Virginia Range, where the state of Nevada manages a herd of feral horses that is not federally protected. Where lion predation on horses was common, Andreasen and others (2021) found that female lions preyed on horses year-round, but 13 percent or fewer of horses killed by lions were adults. Andreasen and others (2021) concluded that, “at landscape scales, cougar predation is unlikely to limit the growth of feral horse populations.” Mesler and Jones (2021) also documented that some mountain lions have a far higher prevalence of wild burro in their diet than others, though their sample size was relatively lower than Andreasen and others (2021) or Iacono (2023). Similarly, Lundgren and others (2022) documented that mountain lions kill feral burros in Death Valley National Park. Lundgren and others (2022) advocated for not eliminating wild equids from landscapes, but that is not a consideration on HMAs, where the BLM aims to have herd sizes of wild horses and burros that are at or above the low level of AML. BLM does not have the legal authority to regulate or manage mountain lion populations, and it is not clear whether there are any mountain lions in the Kiger and Riddle Mountain HMAs that specialize on horse predation. Andreasen and others (2021) concluded that “At landscape scales, cougar predation is unlikely to limit the growth of feral horse populations.” In a study of Mexican wolf predation in an area of Arizona with free-roaming horses, horses were not part of the documented wolf diet (Smith et al. 2023). Given the recent history of consistent growth in the Kiger and Riddle Mountain HMAs wild horse herds, as documented by repeated aerial survey, the inference that predation does not limit local wild horse herd growth rates apparently applies.

The USFWS (2008), Beever and Aldridge (2011), and Chambers and others (2017) summarize much of the literature that quantifies direct ecosystem effects of wild horse presence. Beever and Aldridge (2011) present a conceptual model that illustrates the effects of wild horses on sagebrush ecosystems. In the Great Basin, areas without wild horses had greater shrub cover, plant cover, species richness, native plant cover, and overall plant biomass, and less cover percentage of grazing-tolerant, unpalatable, and invasive plant species, including cheatgrass, compared to areas with horses (Smith 1986b, Beever et al. 2008, Davies et al. 2014, Zeigenfuss et al. 2014, Boyd et al. 2017). There were also measurable increases in soil penetration resistance and erosion, decreases in ant mound and granivorous small mammal densities, and changes in reptile communities (Beever et al. 2003, Beever and Brussard 2004,

Beever and Herrick 2006, Ostermann-Kelm et al. 2009). Intensive grazing by horses and other ungulates can damage biological crusts (Belnap et al. 2001). In contrast to domestic livestock grazing, where post-fire grazing rest and deferment can foster recovery, wild horse grazing occurs year-round. These effects imply

that horse presence can have broad effects on ecosystem function that could influence conservation and restoration actions.

Many studies corroborate the general conclusion that wild horses can lead to biologically significant changes in rangeland ecosystems, particularly when their populations are overabundant relative to water and forage resources, and other wildlife living on the landscape (Eldridge et al. 2020). The presence of wild horses is associated with a reduced degree of Greater Sage-Grouse lekking behavior (Muñoz et al. 2020). Moreover, increasing densities of wild horses, measured as a percentage above AML, are associated with decreasing Greater Sage-Grouse population sizes, measured by lek counts (Coates et al. 2021). Horses are primarily grazers (Hanley and Hanley 1982), but shrubs—including sagebrush—can represent a large part of a horse's diet, at least in summer in the Great Basin (Nordquist 2011). Horses may crop grazed plants closer to the ground than bovids because horses have agile lips and top and bottom teeth (Chapter 21 in McNew et al. 2023). Free-ranging equids have a high affinity for habitats that are close to water (Esmaeili et al. 2021, Karish et al. 2023), which appears to be stronger than for like-sized ruminants (Esmaeili et al. 2021). Grazing by wild horses can have severe impacts on water source quality, aquatic ecosystems, and riparian communities as well (Beever and Brussard 2000, Barnett 2002, Nordquist 2011, USFWS 2008, Earnst et al. 2012, USFWS 2012, Kaweck et al. 2018), sometimes excluding native ungulates from water sources (Ostermann-Kelm et al. 2008, USFWS 2008, Perry et al. 2015, Hall et al. 2016, Gooch et al. 2017, Hall et al. 2018). Impacts to riparian vegetation per individual wild horse can exceed impacts per individual domestic cow (Kaweck et al. 2018, Burdick et al. 2021). Bird nest survival may be lower in areas with wild horses (Zalba and Cozzani 2004), and bird populations have recovered substantially after livestock and/or wild horses have been removed (Earnst et al. 2005, Earnst et al. 2012, Batchelor et al. 2015). Wild horses can spread nonnative plant species, including cheatgrass, and may limit the effectiveness of habitat restoration projects (Beever et al. 2003, Couvreur et al. 2004, Jessop and Anderson 2007, Loydi and Zalba 2009). Riparian and wildlife habitat improvement projects intended to increase the availability of grasses, forbs, riparian habitats, and water will likely attract and be subject to heavy grazing and trampling by wild horses that live in the vicinity of the project. Even after domestic livestock are removed, continued wild horse grazing can cause ongoing detrimental ecosystem effects (USFWS 2008, Davies et al. 2014), which may require several decades for recovery (e.g., Anderson and Inouye 2001).

Wild horses and burros may have ecologically beneficial effects, especially when herd sizes are low relative to available natural resources, but those ecological benefits do not typically outweigh damage caused when herd sizes are high, relative to available natural resources. Under some conditions, there may not be observable competition with other ungulate species for water (e.g., Meeker 1979), but recent studies that used remote cameras have found wild horses excluding native wildlife from water sources under conditions of relative water scarcity (Perry et al. 2015, Hall et al. 2016, Hall et al. 2018). Compared to landscapes where large herbivores such as horses and burros are completely absent, the presence of some large herbivores can cause local-scale ecological disturbances that may increase local species diversity (Trepel et al. 2024); this is consistent with the intermediate disturbance hypothesis (e.g., Wilkinson 1999), which also predicts that excessive disturbance leads to reduced species diversity. Wild burros (and, less frequently, wild horses) have been observed digging 'wells'; such digging may improve habitat conditions for some vertebrate species and, in one site, may improve tree seedling survival (Lundgren et al. 2021). This behavior has been observed in intermittent stream beds where subsurface water is within 2 meters of the surface (Lundgren et al. 2021). The BLM is not aware of published studies that document wild horses or burros in the western United States causing similar or widespread habitat amelioration on drier upland habitats such as sagebrush, grasslands, or pinyon-juniper woodlands. Lundgren and others (2021) suggested that, due to well-digging in ephemeral streambeds, wild burros (and horses) could be considered 'ecosystem engineers'; a term for species that modify resource availability for other species (Jones et al. 1994). Rubin and others

(2021) and Bleich and others (2021) responded by pointing out that ecological benefits from wild horse and burro presence must be weighed against ecological damage they can cause, especially at high densities. Burro density appears to be negatively correlated with endangered desert tortoise presence, which implies that burros should be considered along with other known environmental factors that can degrade tortoise habitat and demographic rates (Berry et al. 2020).

In HMAs where wild horse and burro biomass is very large relative to the biomass of native ungulates (Boyce and McLoughlin 2021), they should probably also be considered 'dominant species' (Power and Mills 1995) whose ecological influences result from their prevalence on the landscape. Wild horse densities could be maintained at high levels in part because artificial selection for early or extended reproduction may mean that wild horse population dynamics are not constrained in the same way as large herbivores that were never domesticated (Boyce and McLoughlin 2021). Another potentially positive ecological effect of wild horses and burros is that they, like all large herbivores, redistribute organic matter and nutrients in dung piles (King and Gurnell 2006), which could disperse and improve germination of undigested seeds. This could be beneficial if the animals spread viable native plant seeds (Downer 2022) but could have negative consequences if the animals spread viable seeds of invasive plants such as cheatgrass (Loydi and Zalba 2009, King et al. 2019). Increased wild horse and burro density would be expected to increase the spatial extent and frequency of seed dispersal, whether the seeds distributed are desirable or undesirable. As is true of herbivory by any grazing animals, light grazing can increase rates of nutrient cycling (Manley et al. 1995) and foster compensatory growth in grazed plants, which may stimulate root growth (Osterheld and McNaughton 1991, Schuman et al. 1999) and, potentially, an increase in carbon sequestration in the soil (Derner and Schuman 2007, He et al. 2011). In Spain, Segarra and others (2023) noted that an area lightly to moderately grazed by donkeys had lower net productivity but higher plant biodiversity than ungrazed pastures where trees were encroaching. However, when grazer density is high relative to available forage resources—as can be the case when wild horse and burro densities exceed AML—then overgrazing by any species can lead to long-term reductions in plant productivity, including decreased root biomass (Herbel 1982, Williams et al. 1968) and potential reduction of stored carbon in soil horizons. Ecological processes associated with large herbivore carcass decomposition can contribute to higher insect and microbial diversity and localized nutrient flux to soils and plants, with effects that may last for several years (Newsome and Barton 2023). Degraded ecosystems may not have the capacity to use and recycle the ecological benefits of decomposing carcasses to the same level as healthy, diverse, resilient ecosystems (Newsome and Barton 2023).

Recognizing the potential beneficial effects of low-density wild horse and burro herds, but also recognizing the totality of available published studies documented ecological effects of wild horse and burro herds, especially when above AML (as noted elsewhere), it is prudent to conclude that horse and burro herd sizes above AML may cause levels of disturbance that reduce landscapes' capacity for resilience in the face of further disturbance, such as is posed by extreme weather events and other consequences of climate change.

Most analyses of wild horse effects have contrasted areas with wild horses to areas without, which is a study design that should control for effects of other grazers, but historical or ongoing effects of livestock grazing may be difficult to separate from horse effects in some cases (Davies et al. 2014). Analyses have generally not included horse density as a continuous covariate; therefore, ecosystem effects have not been quantified as a linear function of increasing wild horse density. One exception is an analysis of satellite imagery confirming that varied levels of free-roaming horse biomass were negatively correlated with average plant biomass growth (Ziegenfuss et al. 2014).

Horses require access to large amounts of water; an individual can drink an average of 7.4 gallons of water per day (Groenendyk et al. 1988). Despite a general preference for habitats near water (e.g., Crane et al. 1997), wild horses will routinely commute long distances (e.g., 10+ miles per day) between water sources and palatable vegetation (Hampson et al. 2010).

Wild burros can also substantially affect riparian habitats (e.g., Tiller 1997) and native wildlife (e.g., Seegmiller and Ohmart 1981), and have grazing and trampling impacts that are similar to wild horses (Carothers et al. 1976, Hanley and Brady 1977, Douglas and Hurst 1993). Where wild burros and Greater Sage-Grouse co-occur, burros' year-round use of low-elevation habitats may lead to a high degree of overlap between burros and Greater Sage-Grouse (Beever and Aldridge 2011).

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Effects of Fertility Control Treatments and Sex Ratio Manipulations in Wild Horse and Burro Management

Various forms of fertility control can be used in wild horses and wild burros, with the goals of maintaining herds at or near AML, reducing fertility rates, and reducing the frequency of gathers and removals. The WFRHBA of 1971 specifically provides for contraception and sterilization (16 U.S.C. 1333 section 3.b.1). Although sex ratio manipulation is not expected to directly reduce individual fertility, it is included in discussions of fertility control treatments here because it can be a form of population growth suppression. Fertility control measures have been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used in combination with gathers, to reduce horse population size (Bartholow 2004, de Seve and Boyles-Griffin 2013, Fonner and Bohara 2017). Although fertility control treatments may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, those impacts are generally minor and transient, do not prevent overall maintenance of a self-sustaining population, and do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott and Oli 2013).

The percentage of effectively contracepted mares in the herd could vary over time, depending on the number of mares that are treated in different years, the formulation of vaccine that is used, and the expected duration of vaccine effectiveness. After the initial gather, the BLM could use a population modeling software such as PopEquus (Folt et al. 2023a, 2023b) to help inform expectations about how many animals in future gathers or actions should be removed, or mares treated, in order to achieve herd management goals. Herd management projections and specific decisions about the number of mares to be treated in the future would be informed by the best available information at the time, based on the results of records of past treatments and on herd monitoring results. However, logistical constraints associated with gather scheduling (for vaccine hand-injection) and animal approachability (for dart-based vaccine treatments) are such that it is unlikely that the fraction of mares that are effectively contracepted in any given year would ever exceed 75 percent. Because of high foal and adult survival rates (Ransom et al. 2016), the likely result is that the herd will always have a positive growth rate over time.

An extensive body of peer-reviewed scientific literature details the impacts of fertility control methods on wild horses and burros. No finding of excess animals is required for BLM to pursue contraception in wild horses or wild burros, but NEPA analysis has been required, as there are possible effects to individuals and groups of wild horses and burros. This review focuses on peer-reviewed scientific literature. The summary that follows first examines effects of fertility control vaccine use in mares, then of sex ratio manipulation. This review does not examine effects of spaying and neutering and does not include an analysis of oocyte growth factor vaccine formulations. Cited studies are generally limited to those involving horses and burros, except where including studies on other species helps in making inferences about physiological or behavioral questions not yet addressed in horses or burros specifically. Burros (donkeys) are a distinct species from horses; however, they are both of the family *Equidae*. While there are notable differences between the species in their anatomy, diet, behaviors, and metabolism (Burden and Thiemann 2015), the essential endocrine controls of the hypothalamic-pituitary-gonadal axis and the function of the zona

pellucida in fertility are the same. While most studies reviewed are based on results from horses, burros are similar enough in their reproductive physiology and immunology (Turini et al. 2021) that expected effects of immunocontraception are comparable.

On the whole, the identified impacts of fertility control methods are generally transient—other than the contraceptive effects that are the purpose of treatment—and affect primarily the individuals treated. Fertility control that affects individual horses and burros does not prevent BLM from ensuring that there will be self-sustaining populations of wild horses and burros in single herd management areas (HMAs), in complexes of HMAs, and at regional scales of multiple HMAs and complexes. Under the WFRHBA of 1971, BLM is charged with maintaining self-reproducing populations of wild horses and burros. The National Academies of Sciences (2013) encouraged BLM to manage wild horses and burros at the spatial scale of "metapopulations" – that is, across multiple HMAs and complexes in a region. In fact, many HMAs have historical and ongoing genetic and demographic connections with other HMAs, and BLM routinely moves animals from one to another to improve local herd traits and maintain high genetic diversity. The NAS report (2013) includes information (pairwise genetic fixation index values for sampled WHB herds) confirming that WHB in the vast majority of HMAs are genetically similar to animals in multiple other HMAs.

All fertility control methods affect the behavior and physiology of treated animals (NAS 2013), and are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al. 2015). Contraception alone does not remove excess horses from an HMA's population, so one or more gathers are usually needed in order to bring the herd down to a level close to AML. Because population growth rates depend partly on the frequency that females give birth (i.e., the foaling rate), the use of fertility control vaccination to reduce growth rates is more effective when a herd is relatively close to AML. Population modeling (Gross 2000, deSeve and Boyles-Griffin 2013, Folt et al. 2023a, 2023b) confirms the common sense conclusion that the higher the fraction of contracepted mares, generally the lower the growth rate. Schulman and others (2024) demonstrated that a shorter duration of effect requires larger fractions of mares need to be frequently treated to maintain a 'fertility control index' large enough to reduce herd-level growth rates. This is one reason that the BLM has historically sought to use humane, longer-lasting fertility control methods. For example, it is easier to achieve the 60-90 percent rate of effectively treated mares if the method used does not require treatment every year. Horses are long-lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods of (i.e., 10 or more years), fertility control methods such as immunocontraceptive vaccines and sex ratio manipulation are not very effective at reducing population growth rates to the point where births equal deaths in a herd. However, even more modest fertility control activities can reduce the frequency of horse gather activities, and costs to taxpayers. Bartholow (2007) concluded that the application of 2-year or 3-year contraceptives to wild mares could reduce operational costs in a project area by 12-20 percent, or up to 30 percent in carefully planned population management programs.

Population monitoring as noted in the EA will be useful to guide BLM in achieving and maintaining the population at AML over the duration of the proposed action. To determine desired fertility control vaccine application rates in these herds, the BLM could use a population modeling software such as PopEquus (Folt et al. 2023a, 2023b) to help assess how many animals at that time should be removed or mares treated in order to achieve herd management goals and update its herd management projections in the future, based on the results of local, contemporaneous herd monitoring. Because applying contraception to horses often requires capturing and handling, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs. Dart-based fertility control applications would entail no capture cost, but administration costs will

vary in relation to approachability. Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000).

In the context of BLM wild horse and burro management, fertility control vaccines and sex ratio manipulation rely on reducing the number of reproducing females. Taking into consideration available literature on the subject, the National Academies of Sciences concluded in their 2013 report that forms of fertility control vaccines were two of the three 'most promising' available methods for contraception in wild horses and burros (NAS 2013). That report also noted that sex ratio manipulations where herds have approximately 60 percent males and 40 percent females can expect lower annual growth rates, simply as a result of having a lower number of reproducing females.

It is not realistic to rely on wild horse and burro herds to limit their own population size or growth rates in the western United States. Predators such as mountain lions tend to not fully prevent free-roaming population growth, even in locations where relatively high numbers of foals die per year, such as in the Virginia Range of Nevada (Schulman et al. 2024). Wild horses and burros are long-lived species with documented survival rates that can exceed 95 percent (Ransom et al. 2016) and they do not self-regulate their population (NAS 2013). The National Academies of Sciences report (NAS 2013) concluded that the primary way that equid populations self-limit is through increased competition for forage at higher densities, which results in smaller quantities of forage available per animal, poorer body condition, and decreased natality and survival. It also concluded that the effect of this would be impacts to resource and herd health that are contrary to BLM management objectives and statutory and regulatory mandates. In the absence of management actions to limit the herd size, wild horse and burro populations would be expected to increase to a point where forage and/or water resources are depleted resulting in the irreversible loss of native vegetation, a loss of wildlife habitat (including riparian habitat), and eventually the potential for periodic large-scale die-offs of the wild horses and burros themselves (NAS 2013). In a detailed demographic study of a growing population of Przewalski horses in Hungary, Kerekes and others (2021) did observe slight reductions in foaling rates at high population sizes, but not nearly enough to prevent the population from continuing to grow at high annual rates, except during a winter die-off event when a quarter of the herd died. As such, there is a continuing need for active wild horse and burro herd management, such as through removals and fertility control.

Fertility Control Vaccines

Fertility control vaccines (also known as immunocontraceptives) meet BLM requirements for safety to mares and the environment (EPA 2009a, 2012). Because they work by causing an immune response in treated animals, there is no risk of hormones or toxins being taken into the food chain when a treated mare dies. The BLM and other land managers have mainly used three fertility control vaccine formulations for fertility control of wild horse mares on the range: ZonaStat-H, PZP-22, and GonaCon-Equine. As other formulations become available, they may be applied in the future.

In any vaccine, the antigen is the stimulant to which the body responds by making antigen-specific antibodies. Those antibodies then signal to the body that a foreign molecule is present, initiating an immune response that removes the molecule or cell. Adjuvants are additional substances that are included in vaccines to elevate the level of immune response. Adjuvants help to incite recruitment of lymphocytes and other immune cells that foster a long-lasting immune response that is specific to the antigen.

Liquid emulsion vaccines can be injected by hand or remotely administered in the field using a pneumatic dart (Roelle and Ransom 2009, Rutberg et al. 2017, McCann et al. 2017) in cases where mares are relatively

approachable. Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 meters (BLM 2010). Booster doses can be safely administered by hand or by dart. Even with repeated booster treatments of the vaccines, it is expected that most mares would eventually return to fertility, though some individual mares treated repeatedly may remain infertile. Once the herd size in the project area is at AML and population growth seems to be stabilized at desired levels, BLM can make adaptive determinations as to the required frequency of new and booster fertility control vaccine treatments. Updated planning may be further informed by repeating the use of wild horse population projection modeling, such as PopEquus (Folt et al. 2023a, 2023b).

The BLM has guidelines for fertility control vaccine application, with respect to selection of herds (BLM IM 2009-090). Herds selected for fertility control vaccine use should have background annual growth rates over 5 percent, have a herd size over 50 animals, and have a target rate of treatment of between 50 percent and 90 percent of female wild horses or burros. Treated mares should be identifiable via a visible freeze brand or individual color markings, so that their vaccination history can be known. Individuals that are handled can also be identified by means of uniquely numbered RFID chip, placed in the nuchal ligament (BLM IM 2023-028). Follow-up population surveys should be used to determine the realized annual growth rate in herds treated with fertility control vaccines.

The BLM's potential application of PZP ZonaStat-H vaccine booster doses 2 weeks or more after an initial dose, and GonaCon-Equine booster doses 30 or more days after an initial dose, is consistent with use specifications on the product labels (EPA 2012, 2013). Temporarily holding animals or use of dart-based delivery to provide a booster dose do not require further study for justification. The Environmental Protection Agency regulates the use of fertility control agents such as the PZP vaccine ZonaStat-H or the GnRH vaccine GonaCon-Equine in wild horses and burros; even though these are regulated by the EPA as pesticides, their purpose is to reduce fertility of treated individuals and effects outside of the reproductive system are minimal. These vaccines are registered with the EPA and are not experimental. The EPA-required product label associated with the registration for ZonaStat-H is cited in the EA as EPA (2012). That label states that "For maximum efficacy, ZonaStat-H is administered as an initial priming dose followed by a booster dose at least two weeks later." The EPA-required product label associated with the registration for GonaCon-Equine is cited in the EA as EPA (2013). That label states that "If longer contraceptive effect is desired, a second vaccination may be given 30 or more days after the first injection or during the following year with no known adverse health effects to the vaccinated animal."

The explicit intention of BLM's potential use of fertility control vaccines, such as PZP ZonaStat-H or GonaCon-Equine, is to reduce the fertility rate of treated individual mares for one or more years and, therefore, to reduce the herd-level annual growth rates. This outcome would be consistent with the purpose and need identified in the EA, and consistent with authorities in the WFRHBA. The BLM acknowledges that there is a range of possible duration of contraceptive effects (noted below). It is even possible that some fertility control vaccine-treated mares may not reproduce again before they die. The 2013 EPA label for GonaCon-Equine states that, "there is a chance some vaccinated females will become permanently sterile." Precise probabilistic estimates of the return time to fertility for individual mares are not required for the BLM to ensure that these methods are humane, safe, and effective, and that herd management goals of achieving and maintaining the AML are met.

Vaccine Formulations: Porcine Zona Pellucida (PZP)

PZP vaccines have been used on dozens of wild and free-roaming horse herds by the National Park Service,

US Forest Service, Bureau of Land Management, and Native American tribes, and PZP vaccine use is approved for free-ranging wild and feral horse herds in the United States (EPA 2012). PZP vaccine use can reduce or eliminate the need for gathers and removals, if very high fractions of mares are treated over a very long time period (Turner et al. 1997). PZP vaccines have been used extensively in wild horses (NAS 2013), and in wild and feral burros (Turner et al. 1996, French et al. 2017, French et al. 2020, Kahler and Boyles-Griffin 2022). PZP vaccine formulations are produced as ZonaStat-H, an EPA-registered commercial product (EPA 2012, SCC 2015), as PZP-22, which is a formulation of PZP in polymer pellets that can lead to a longer immune response (Turner et al. 2002b, Rutberg et al. 2017, Grams et al. 2022), and as Spayvac, where the PZP protein is enveloped in liposomes (Killian et al. 2008, Roelle et al. 2017, Bechert and Fraker 2018, Bechert et al. 2022). 'Native' PZP proteins can be purified from pig ovaries (Liu et al. 1989). Recombinant ZP proteins may be produced with molecular techniques (Gupta and Minhas 2017, Joonè et al. 2017a, Nolan et al. 2018a).

When advisories on the product label (EPA 2015) are followed, the product is safe for users and the environment (EPA 2012). In keeping with the EPA registration for ZonaStat-H (EPA 2012; reg. no. 86833-1), certification through the Science and Conservation Center in Billings, Montana is required to apply that vaccine to equids.

For maximum effectiveness, PZP vaccine is administered within the December to February timeframe. When applying ZonaStat-H, first the primer with modified Freund's Complete Adjuvant is given and then the booster with Freund's Incomplete Adjuvant is given 2–6 weeks later. Preferably, the timing of the booster dose is at least 1–2 weeks prior to the onset of breeding activity. Following the initial 2 inoculations, only annual boosters are required. For the PZP-22 formulation, each released mare would receive a single dose of the two-year PZP contraceptive vaccine at the same time as a dose of the liquid PZP vaccine with modified Freund's Complete Adjuvant. The pellets are applied to the mare with a large gauge needle and jab-stick into the hip. PZP-22 pellets have been successfully delivered via darting (Rutberg et al. 2017, Carey et al. 2019), and could be delivered in that way to approachable mares in Kiger and Riddle Mountain herds.

Vaccine Formulations: Gonadotropin Releasing Hormone (GnRH)

GonaCon (which is produced under the trade name GonaCon-Equine for use in wild and feral horses and burros) is approved for use by authorized Federal, State, Tribal, public, and private personnel for application to free-ranging wild horse and burro herds in the United States (EPA 2013, 2015). GonaCon has been used on free-roaming horses in Theodore Roosevelt National Park and on wild horses administered by BLM. GonaCon has been produced by USDA-APHIS (Fort Collins, Colorado) in several different formulations, the history of which is reviewed by Miller and others (2013). GonaCon vaccines present the recipient with hundreds of copies of GnRH as peptides on the surface of a linked protein that is naturally antigenic because it comes from invertebrate hemocyanin (Miller et al. 2013). Early GonaCon formulations linked many copies of GnRH to a protein from the keyhole limpet (GonaCon-KHL), but more recently produced formulations where the GnRH antigen is linked to a protein from the blue mussel (GonaCon-B) proved less expensive and more effective (Miller et al. 2008). GonaCon-Equine is in the category of GonaCon-B vaccines.

As with other contraceptives applied to wild horses, the long-term goal of GonaCon-Equine use is to reduce or eliminate the need for gathers and removals (NAS 2013). GonaCon-Equine contraceptive vaccine is an EPA-approved vaccine for mitigating population growth (EPA, 2009a) that is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and is produced in a USDA-APHIS laboratory.

GonaCon-Equine is a pharmaceutical-grade vaccine, including aseptic manufacturing technique to deliver a sterile vaccine product (Miller et al. 2013). If stored at 4° Celcius, the shelf life is 6 months (Miller et al. 2013).

Miller and others (2013) reviewed the vaccine environmental safety and toxicity. When advisories on the product label (EPA 2015) are followed, the product is safe for users and the environment (EPA 2009b). The EPA waived a number of tests prior to registering the vaccine, because GonaCon was deemed to pose low risks to the environment, so long as the product label is followed (Wang-Cahill et al. 2022).

GonaCon-Equine can safely be reapplied as necessary to control the population growth rate; booster dose effects may lead to increased effectiveness of contraception, which is generally the intent. Even after booster treatment of GonaCon-Equine, it is expected that most, if not all, mares would return to fertility at some point. Although the exact timing for the return to fertility in mares boosted more than once with GonaCon-Equine has not been quantified, a prolonged return to fertility would be consistent with the desired effect of using GonaCon (i.e., effective contraception).

The adjuvant used in GonaCon, Adjuvac, generally leads to a milder reaction than Freund's Complete Adjuvant (Powers et al. 2011). Adjuvac contains a small number of killed *Mycobacterium avium* cells (Miller et al. 2008, Miller et al. 2013). The antigen and adjuvant are emulsified in mineral oil, such that they are not all presented to the immune system right after injection. It is thought that the mineral oil emulsion leads to a 'depot effect' that is associated with slow or sustained release of the antigen, and a resulting longer-lasting immune response (Miller et al. 2013). Miller and others (2008, 2013) have speculated that, in cases where memory-B leukocytes are protected in immune complexes in the lymphatic system, it can lead to years of immune response. Increased doses of vaccine may lead to stronger immune reactions, but only to a certain point; when Yoder and Miller (2010) tested varying doses of GonaCon in prairie dogs, antibody responses to the 200µg and 400µg doses were equal to each other but were both higher than in response to a 100µg dose.

Direct Effects: PZP Vaccines

The historically accepted hypothesis explaining PZP vaccine effectiveness posits that when injected as an antigen in vaccines, PZP causes the mare's immune system to produce antibodies that are specific to zona pellucida proteins on the surface of that mare's eggs. The antibodies bind to the mare's egg's surface proteins (Liu et al. 1989), and effectively block sperm binding and fertilization (Zoo Montana, 2000). Because treated mares do not become pregnant but other ovarian functions remain generally unchanged, PZP can cause a mare to continue having regular estrus cycles throughout the breeding season. More recent observations support a complementary hypothesis, which posits that PZP vaccination causes reductions in ovary size and function (Mask et al. 2015, Joonè et al. 2017b, Joonè et al. 2017c, Nolan et al. 2018b and 2018c, French et al. 2020). PZP vaccines do not appear to interact with other organ systems, as antibodies specific to PZP protein do not crossreact with tissues outside of the reproductive system (Barber and Fayrer-Hosken 2000).

Research has demonstrated that contraceptive efficacy of an injected liquid PZP vaccine, such as ZonaStat-H, is approximately 90 percent or more for mares or burros treated twice in the first year (Turner and Kirkpatrick 2002a, Turner et al. 2008, French et al. 2020). In the PopEquus projection model (Folt et al. 2023a, 2023b), a primer and booster dose of PZP ZonaStat-H treatment is modeled as having 95 percent and 19 percent reductions on reproduction one and two years after the first two doses, respectively. The same effect is modeled for a third dose, but a higher effectiveness of 95 percent, 72 percent, 58 percent, and 30

percent fertility reductions is modeled for one, two, three, and four years, respectively, after receiving a fourth dose. The highest success for fertility control has been reported when the vaccine has been applied November through February. High contraceptive rates of 90 percent or more can be maintained in horses that are given a booster dose annually (Kirkpatrick et al. 1992). Approximately 60 percent to 85 percent of mares are successfully contracepted for one year when treated simultaneously with a liquid primer and PZP-22 pellets (Rutberg et al. 2017, Carey et al. 2019, Grams et al. 2022). Application of PZP for fertility control would reduce fertility in a large percentage of mares for at least one year (Ransom et al. 2011). The contraceptive result for a single application of the liquid PZP vaccine primer dose along with PZP vaccine pellets (PZP-22), based on winter applications, can be expected to fall in the approximate efficacy ranges as follows (based on figure 2 in Rutberg et al. 2017). Below, the approximate efficacy used in PopEquus (Folt et al. 2023a, 2023b) modeling for PZP-22 effects is based on available studies and is measured as the relative decrease in foaling rate for treated mares, compared to control mares:

Year 1	Year 2	Year 3
0 (developing fetuses come to term)	~33-72%	~20-40%

If mares that have been treated with PZP-22 vaccine pellets subsequently receive a booster dose of either the liquid PZP vaccine or the PZP-22 vaccine pellets, the subsequent contraceptive effect is apparently more pronounced and long-lasting. The approximate efficacies following a booster dose can be expected to be in the following ranges (based on figure 3 in Rutberg et al. 2017, and used in Folt et al. 2023a, 2023b).

Year 1	Year 2	Year 3	Year 4
0 (developing fetuses come to term)	~68-85%	~70-75%	~60-72%

The fraction of mares treated in a herd can have a large effect on the realized change in growth rate due to PZP contraception, with an extremely high portion of mares required over many years to be treated to totally prevent population-level growth (e.g., Turner and Kirkpatrick 2002a, Grams et al. 2022, Schulman et al. 2024). Gather efficiency does not usually exceed 85 percent via helicopter, and may be less with bait and water trapping, so there will almost always be a portion of the female population uncaptured that is not treated in any given year. Additionally, a small number of mares may not respond to the fertility control vaccine, but instead will continue to foal normally (BLM 2023).

Direct Effects: GnRH Vaccines

GonaCon-Equine is one of several vaccines that have been engineered to create an immune response to the gonadotropin releasing hormone peptide (GnRH). GnRH is a small peptide that plays an important role in signaling the production of other hormones involved in reproduction in both sexes. When combined with an adjuvant, a GnRH vaccine stimulates a persistent immune response resulting in prolonged antibody production against GnRH, the carrier protein, and the adjuvant (Miller et al. 2008). The most direct result of successful GnRH vaccination is that it has the effect of decreasing the level of GnRH signaling in the body, as evidenced by a drop in luteinizing hormone levels, and a cessation of ovulation.

GnRH is highly conserved across mammalian taxa, so some inferences about the mechanism and effects of GonaCon-Equine in horses can be made from studies that used different anti-GnRH vaccines, in horses and other taxa. Other commercially available anti-GnRH vaccines include: Improvac (Imboden et al. 2006, Botha et al. 2008, Janett et al. 2009, Schulman et al. 2013, Dalmau et al. 2015, Nolan et al. 2018c), made in South Africa; Equity (Elhay et al. 2007), made in Australia; Improvest, for use in swine (Bohrer et al. 2014); Repro-BLOC (Boedeker et al. 2012); and Bopriva, for use in cows (Balet et al. 2014). Of these, GonaCon-

Equine, Improvac, and Equity are specifically intended for horses. Other anti-GnRH vaccine formulations have also been tested, but did not become trademarked products (e.g., Goodloe 1991, Dalin et al. 2002, Stout et al. 2003, Donovan et al. 2013, Schaut et al. 2018, Yao et al. 2018). The effectiveness and side-effects of these various anti-GnRH vaccines may not be the same as would be expected from GonaCon-Equine use in horses. Results could differ as a result of differences in the preparation of the GnRH antigen, and the choice of adjuvant used to stimulate the immune response. For some formulations of anti-GnRH vaccines, a booster dose is required to elicit a contraceptive response, though GonaCon can cause short-term contraception in a fraction of treated animals from one dose (Powers et al. 2011, Gionfriddo et al. 2011a, Baker et al. 2013, Miller et al. 2013).

GonaCon can provide multiple years of infertility in several wild ungulate species, including horses (Killian et al. 2008, Gray et al. 2010a). The lack of estrus cycling that results from successful GonaCon vaccination has been compared to the typical winter period of anoestrus in open mares. As anti-GnRH antibodies decline over time, concentrations of available endogenous GnRH increase and treated animals usually regain fertility (Powers et al. 2011). In the PopEquus projection model (Folt et al. 2023a, 2023b), a single dose of GonaCon-Equine treatment is modeled as having 37 percent and 29 percent reductions on reproduction one and two years; as with the PZP ZonaStat-H vaccine, GonaCon is not expected to reduce the foaling rate for existing pregnancies. The PopEquus model (Folt et al. 2023a, 2023b) models fertility reductions of 100 percent, 85 percent, and 50 percent respectively for years 1, 2–4, and 5–7 after two or more doses. Unpublished results indicate that BLM-managed wild horses that were treated with a primer dose, held for 30 days, and treated with a booster dose before being returned to the range foaled at normal rates in the first season after treatment, but then had contraceptive effectiveness of approximately 85 percent. Those results are based on observations in three HMAs. Mares were initially treated in September 2020 (Sulphur and Swasey HMAs) or January 2021 (Eagle HMA), held until they received a booster dose of GonaCon-Equine, then released. Some mares were radio-collared (Schoenecker et al. 2020) or radio-tail-tagged (King et al. 2022) before release. After release, mares were monitored visually at least once per month to document any foaling and to confirm that radio collars were not causing any negative effects to the mares. Because of the timing of vaccination, it is not expected that there would have been any reduction in foaling in 2021, as GonaCon-Equine is not expected to influence the fetus of any mares that were pregnant at the time of vaccination. For these mares, 2022 was the first year when the GonaCon-Equine could have had a contraceptive effect; 8 of the 59 treated mares (~14%) were observed to have a foal. The second year of potentially observable contraceptive effect was 2023, and approximately 30 percent of mares were observed to have foals in 2023.

Baker and others (2018) showed that mares that receive only one dose of GonaCon-Equine tend to return to fertility within 3 years. Baker and others (2018, 2023) have also shown that mares treated twice with GonaCon-Equine tend to return to fertility over time, with an increasing number of mares returning to fertility the longer the time since the second dose. The specific method of injection and the time between the first and second dose appear to influence the effectiveness. Two hand-injected doses 4 years apart caused 100 percent infertility for a year, but that had dropped to 80 percent by year 6. Two darted injections separated by 6 months, 1 year, or 2 years appear less effective: within 3-4 years after two darted injections, only between about 55 percent to 75 percent of mares were infertile. When two hand-injections were only separated by 30 days, approximately 85 percent of treated mares were infertile for 1 year (BLM 2022); this is more effective than one dose, but less effective than when the doses are separated by 4 years. This 30-day timing is becoming a relatively common treatment schedule and is consistent with the EPA label for this vaccine (EPA 2013).

As is true for PZP vaccine treatments, the fraction of mares treated in a herd can have a large effect on the

realized change in growth rate. Due to high wild horse survival rates, in any given year, a very high fraction of mares (i.e., ~75 percent) must be effectively contracepted (i.e., the fertility control vaccine prevents fertility in that year) to cause overall herd-level growth rates to be anywhere close to zero. The fraction of contracepted mares at any given time has also been called the 'fertility control index' (Grams et al. 2022, Schulman et al. 2024). As part of its adaptive management in decisions about how many mares to treat with fertility control vaccine in any given year of the 10-year duration of this action, the BLM would use results of monitoring to make inferences about the number of mares present and the expected fraction of those that may be effectively contracepted, based on their treatment histories.

Females that are successfully contracepted by GnRH vaccination enter a state similar to anestrus, have a lack of or incomplete follicle maturation, and no ovarian cycling (Botha et al. 2008, Nolan et al. 2018c). A leading hypothesis is that anti-GnRH antibodies bind GnRH in the hypothalamus – pituitary 'portal vessels,' preventing GnRH from binding to GnRH-specific binding sites on gonadotroph cells in the pituitary, thereby limiting the production of gonadotropin hormones, particularly luteinizing hormone (LH) and, to a lesser degree, follicle-stimulating hormone (FSH) (Powers et al. 2011, NAS 2013). This reduction in LH (and FSH), and a corresponding lack of ovulation, has been measured in response to treatment with anti-GnRH vaccines (Boedeker et al. 2012, Garza et al. 1986).

Females successfully treated with anti-GnRH vaccines have reduced progesterone levels (Garza et al. 1986, Stout et al. 2003, Imboden et al. 2006, Elhay et al. 2007, Botha et al. 2008, Killian et al. 2008, Miller et al. 2008, Schulman et al. 2013, Balet et al. 2014, Dalmau et al. 2015) and β-17 estradiol levels (Elhay et al. 2007), but no great decrease in estrogen levels (Balet et al. 2014). Reductions in progesterone do not occur immediately after the primer dose but can take several weeks or months to develop (Elhay et al. 2007, Botha et al. 2008, Schulman et al. 2013, Dalmau et al. 2015). This indicates that ovulation is not occurring and corpora lutea, formed from post-ovulation follicular tissue, are not being established.

Antibody titer measurements are proximate measures of the antibody concentration in the blood specific to a given antigen. Anti-GnRH titers generally correlate with a suppressed reproduction system (Gionfriddo et al. 2011a, Powers et al. 2011). Various studies have attempted to identify a relationship between anti-GnRH titer levels and infertility, but that relationship has not been universally predictable or consistent. The time length that titer levels stay high appears to correlate with the length of suppressed reproduction (Dalin et al. 2002, Levy et al. 2011, Donovan et al. 2013, Powers et al. 2011). For example, Goodloe (1991) noted that mares did produce elevated titers and had suppressed follicular development for 11-13 weeks after treatment, but that all treated mares ovulated after the titer levels declined. Similarly, Elhay and others (2007) found that high initial titers correlated with longer-lasting ovarian and behavioral anoestrus. However, Powers and others (2011) did not identify a threshold level of titer that was consistently indicative of suppressed reproduction despite seeing a strong correlation between antibody concentration and infertility, nor did Schulman and others (2013) find a clear relationship between titer levels and mare acyclicity.

In many cases, young animals appear to have higher immune responses and stronger contraceptive effects of anti-GnRH vaccines than older animals (Brown et al. 1994, Curtis et al. 2002, Stout et al. 2003, Schulman et al. 2013). Vaccinating with GonaCon at too young an age, though, may prevent effectiveness; Gionfriddo and others (2011a) observed weak effects in 3–4-month-old fawns. It has not been possible to predict with precision which individuals of a given age class will have long-lasting immune responses to the GonaCon vaccine. Gray (2009a) noted that mares in poor body condition tended to have lower contraceptive efficacy in response to GonaCon-B. Miller and others (2013) suggested that higher parasite loads might have explained a lower immune response in free-roaming horses than had been observed in a captive trial. At this

time, it is unclear what the quantitative relationship is between various factors and the resulting contraceptive efficacy, but average efficacy rates have been reported in studies such as Baker and others (2023).

Several studies have monitored animal health after immunization against GnRH. GonaCon treated mares did not have any measurable difference in uterine edema (Killian et al. 2006, 2008). Powers and others (2011, 2014) noted no differences in blood chemistry except a mildly elevated fibrinogen level in some GonaCon treated elk. In that study, one sham-treated elk and one GonaCon treated elk each developed leukocytosis, suggesting that there may have been a causal link between the adjuvant and the effect. Curtis and others (2008) found persistent granulomas at GonaCon-KHL injection sites three years after injection, and reduced ovary weights in treated females. Yoder and Miller (2010) found no difference in blood chemistry between GonaCon treated and control prairie dogs. One of 15 GonaCon treated cats died without explanation, and with no determination about cause of death possible based on necropsy or histology (Levy et al. 2011). Other anti-GnRH vaccine formulations have led to no detectable adverse effects (in elephants; Boedeker et al. 2012), though Imboden and others (2006) speculated that young, treated animals might conceivably have impaired hypothalamic or pituitary function.

Kirkpatrick and others (2011) raised concerns that anti-GnRH vaccines could lead to adverse effects in other organ systems outside the reproductive system. GnRH receptors have been identified in tissues outside of the pituitary system, including in the testes and placenta (Khodr and Siler-Khodr 1980), ovary (Hsueh and Erickson 1979), bladder (Coit et al. 2009), heart (Dong et al. 2011), and central nervous system, so it is plausible that reductions in circulating GnRH levels could inhibit physiological processes in those organ systems. Kirkpatrick and others (2011) noted elevated cardiological risks to human patients taking GnRH agonists (such as leuprolide), but the National Academy of Sciences (2013) concluded that the mechanism and results of GnRH agonists would be expected to be different from that of anti-GnRH antibodies; the former flood GnRH receptors, while the latter deprive receptors of GnRH.

Return to Fertility and Effects on Ovaries: PZP Vaccines

In most cases, PZP contraception appears to be temporary and most treated mares return to fertility over time (Kirkpatrick and Turner 2002) unless they receive additional vaccine treatments. The return to fertility associated with a reduced immune response to the fertility control vaccine antigen has been called ‘reversibility,’ but the timing of the return to fertility is not under direct human control in the same sense that a narcotic drug can be reversed by application of naloxone, for example. The ZonaStat-H formulation of the vaccine tends to confer only one year of efficacy per dose. Some studies have found that a PZP vaccine in long-lasting pellets (PZP-22) can confer multiple years of contraception (Turner et al. 2007), particularly when boostered with subsequent PZP vaccination (Rutberg et al. 2017). Other trial data, though, indicate that the pelleted vaccine may only be effective for one year (J. Turner, University of Toledo, Personal Communication to BLM) (Turner 2017).

The purpose of applying PZP vaccine treatment is to prevent mares or jennies from conceiving foals, but BLM acknowledges that long-term infertility could be a result for some number of individual wild horses receiving PZP vaccinations. The effect of the PZP vaccine treatments is an immune response, but if it happens that multiple PZP vaccine treatments cause a mare to not regain fertility before death, some would interpret that course of immunocontraceptive treatment to have caused sterility. The rate of long-term or permanent sterility following vaccinations with PZP is hard to predict for individual horses, but that outcome appears to increase in likelihood as the number of doses increases (Kirkpatrick and Turner 2002). This form of vaccine-induced long-term infertility or sterility for mares treated consecutively in each of 5–7 years was

observed by Nuñez and others (2010, 2017). In a graduate thesis, Knight (2014) suggested that repeated treatment with as few as three to four years of PZP treatment may lead to longer-term sterility, and that sterility may result from PZP treatment before puberty. Repeated treatment with PZP led to long-term infertility in Przewalski's horses receiving as few as one PZP booster dose (Feh 2012). However, even if some number of mares become sterile as a result of PZP treatment, that potential result would be consistent with the contraceptive purpose that motivates BLM's potential use of the vaccine, and with Congressional guidance that condones such treatment in the management of wild horses and burros, in WFRHBA section 1333(b).

In some number of individual mares and jennies, PZP vaccination may cause direct effects on ovaries (Gray and Cameron 2010b, Joonè et al. 2017b, Joonè et al. 2017c, Joonè et al. 2017d, Nolan et al. 2018b, French et al. 2020). Joonè and others (2017a) noted that effects on ovaries in mares treated with one primer dose and booster dose were temporary. Joonè and others (2017c) and Nolan and others (2018b) documented decreased anti-Mullerian hormone (AMH) levels in mares treated with native or recombinant PZP vaccines; AMH levels are thought to be an indicator of ovarian function. French and others (2020) documented fewer visible follicles and reduced uterine horn diameter in PZP treated jennies; 25 percent of treated burros returned to fertility during that study. Bechert and others (2013) found that ovarian function was affected by the SpayVac PZP vaccination, but that there were no effects on other organ systems. Mask and others (2015) demonstrated that equine antibodies that resulted from SpayVac immunization could bind to oocytes, ZP proteins, follicular tissues, and ovarian tissues. It is possible that result is specific to the immune response to SpayVac, which may have lower PZP purity than ZonaStat or PZP-22 (Hall et al. 2016). However, in studies with native ZP proteins and recombinant ZP proteins, Joonè and others (2017a) found transient effects on ovaries after PZP vaccination in some treated mares; normal estrus cycling had resumed 10 months after the last treatment. SpayVac is a patented formulation of PZP in liposomes that led to multiple years of infertility in some breeding trials (Killian et al. 2008, Roelle et al. 2017, Bechert and Fraker 2018), but unacceptably poor efficacy in a subsequent trial (Kane 2018). Kirkpatrick and others (1992) noted effects on horse ovaries after three years of treatment with PZP. Observations at Assateague Island National Seashore indicated that the more times a mare is consecutively treated, the longer the time lag before fertility returns, but that even mares treated 7 consecutive years did eventually return to ovulation (Kirkpatrick and Turner 2002). Other studies have reported that continued PZP vaccine applications may result in decreased estrogen levels (Kirkpatrick et al. 1992) but that decrease was not biologically significant, as ovulation remained similar between treated and untreated mares (Powell and Monfort 2001). Skinner et al. (1984) raised concerns about PZP effects on ovaries, based on their study in laboratory rabbits, as did Kaur and Prabha (2014), though neither paper was a study of PZP effects in equids. Bagavant and others (2002) demonstrated T-cell clusters on ovaries, but no loss of ovarian function after ZP protein immunization in macaques.

Return to Fertility and Effects on Ovaries: GnRH Vaccines

As with PZP vaccines, mares that are treated with GonaCon-Equine vaccine can be expected to return to fertility when the immune response to the antigen declines; in the colloquial usage of the term, this also makes GonaCon-Equine a 'reversible' treatment, even though the return to fertility is not under direct human control in the same sense that a narcotic drug can be 'reversed' by application of naloxone, for example. The NAS (2013) review pointed out that single doses of GonaCon-Equine do not lead to high rates of initial effectiveness, or long duration. Initial effectiveness of one dose of GonaCon-Equine vaccine appears to be lower than for a combined primer plus booster dose of the PZP vaccine Zonastat-H (Kirkpatrick et al. 2011), and the initial effect of a single GonaCon dose can be limited to as little as one breeding season; a relatively low fraction of mares that receive only one dose of GonaCon-Equine may be contracepted in the first year after treatment. However, preliminary results on the effects of boostered doses of GonaCon-Equine indicate

that a booster dose in horses can increase the strength and duration of immune response—this can result in high contraceptive efficacy and longer-lasting effects (Baker et al. 2017, 2018) than the one-year effect that is generally expected from a single booster of Zonastat-H.

Too few studies have reported on the various formulations of anti-GnRH vaccines to make generalizations about differences between products, but GonaCon formulations were consistently good at causing loss of fertility in a statistically significant fraction of treated mares for at least one year (Killian et al. 2009, Gray et al. 2010a, Baker et al. 2013, 2017, 2018). With few exceptions (e.g., Goodloe 1991), anti-GnRH treated mares gave birth to fewer foals in the first season when there would be an expected contraceptive effect (Botha et al. 2008, Killian et al. 2009, Gray et al. 2010a, Baker et al. 2013, 2018). Goodloe (1991) used an anti-GnRH-KHL vaccine with a triple adjuvant, in some cases attempting to deliver the vaccine to horses with a hollow-tipped 'biobullet,' but concluded that the vaccine was not an effective immunocontraceptive in that study.

Not all mares should be expected to respond to the GonaCon-Equine vaccine; some number should be expected to continue to become pregnant and give birth to foals. In studies where mares were exposed to stallions, the fraction of treated mares that are effectively contracepted in the year after anti-GnRH vaccination varied from study to study, ranging from ~50 percent (Baker et al. 2017), to 61 percent (Gray et al. 2010a), to ~90 percent (Killian et al. 2006, 2008, 2009). Miller and others (2013) noted lower effectiveness in free-ranging mares (Gray et al. 2010a) than captive mares (Killian et al. 2009). Some of these rates are lower than the high rate of effectiveness typically reported for the first year after PZP vaccine treatment (Kirkpatrick et al. 2011). In the one study that tested for a difference, darts and hand-injected GonaCon doses were equally effective in terms of short-term fertility outcome (McCann et al. 2017). After treatment with GonaCon-Equine vaccine, some mares may return to fertility faster than others (Thompson et al. 2022).

In studies where mares were not exposed to stallions, the duration of effectiveness also varied. A primer and booster dose of Equity led to anoestrus for at least 3 months (Elhay et al. 2007). A primer and booster dose of Improvac also led to loss of ovarian cycling for all mares in the short term (Imboden et al. 2006, Nolan et al. 2018c). It is worth repeating that those vaccines do not have the same formulation as GonaCon.

Results from horses (Baker et al. 2017, 2018, 2023) and other species (Curtis et al. 2002) suggest that providing a booster dose of GonaCon-Equine will increase the fraction of temporarily infertile animals to higher levels than would a single vaccine dose alone.

Longer-term infertility has been observed in some mares treated with anti-GnRH vaccines, including GonaCon-Equine. In a single-dose mare captive trial with an initial year effectiveness of 94 percent, Killian and others (2008) noted infertility rates of 64 percent, 57 percent, and 43 percent in treated mares during the following three years, while control mares in those years had infertility rates of 25 percent, 12 percent, and 0 percent in those years. GonaCon effectiveness in free-roaming populations was lower, with infertility rates consistently near 60 percent for three years after a single dose in one study (Gray et al. 2010a) and annual infertility rates decreasing over time from 55 percent to 30 percent to 0 percent in another study with one dose (Baker et al. 2017, 2018). Similarly, gradually increasing fertility rates were observed after single dose treatment with GonaCon in elk (Powers et al. 2011) and deer (Gionfriddo et al. 2011a); these results are consistent with the expectation that the contraceptive effect of GonaCon in mammals results from the immune response, and that return to fertility increases as that immune response wanes.

Baker and others (2017, 2018) observed a return to fertility over 4 years in mares treated once with

GonaCon, but then noted extremely low fertility rates of 0 percent and 16 percent in the two years after the same mares were given a booster dose four years after the primer dose. Four of nine mares treated with primer and booster doses of Improvac did not return to ovulation within 2 years of the primer dose (Imboden et al. 2006), though one should probably not make conclusions about the long-term effects of GonaCon-Equine based on results from Improvac. In 2023, Baker and others reported that mares treated with two doses of GonaCon-Equine returned to fertility at different rates and timing, depending on the length of time between the primer and booster dose. The longer the time between primer and booster, generally the longer-lasting was the contraceptive effect. For mares re-treated 4 years after the first dose, 29 percent had returned to fertility within 6 years after the second dose. For mares re-treated 2 years after the first dose, 36 percent had returned to fertility within 4 years of the second dose. For mares retreated 1 year, or 6 months after their first dose, 57 percent, and 46 percent of mares, respectively, had returned to fertility within 3 years. Results for the timing of return to fertility among mares treated twice with GonaCon-Equine vaccine is consistent with immune response being the cause of contraception, and that those contraceptive effects wane as the immune response declines over time (Baker et al. 2023).

It is difficult to predict which females will exhibit strong or long-term immune responses to anti-GnRH vaccines (Killian et al. 2006, Miller et al. 2008, Levy et al. 2011). A number of factors may influence responses to vaccination, including age, body condition, nutrition, prior immune responses, and genetics (Cooper and Herbert 2001, Curtis et al. 2002, Powers et al. 2011, Thompson et al. 2022). One apparent trend is that animals that are treated at a younger age, especially before puberty, may have stronger and longer-lasting responses (Brown et al. 1994, Curtis et al. 2002, Stout et al. 2003, Schulman et al. 2013). It is plausible that giving GonaCon-Equine to prepubertal mares will lead to long-lasting infertility, but no published data are available. Under the selective removal criteria of the proposed action (EA section 2.2), prepubertal mares would not typically be returned to the range; such young animals also tend to be highly adoptable.

To date, short-term evaluation of anti-GnRH vaccines shows contraception appears to be temporary, and a result of an immune response that can wane over time. Killian and others noted long-term effects of GonaCon in some captive mares (2009). However, Baker and others (2017) observed horses treated with GonaCon-B return to fertility after they were treated with a single primer dose; after four years, the fertility rate was indistinguishable between treated and control mares. It appears that a single dose of GonaCon results in temporary infertility lasting a short time (i.e., usually less than 2 years). Baker and others (2023) noted the possibility that some mares treated twice with GonaCon-Equine vaccine could remain contracepted for over 6 years, or even until they die; the latter outcome would presumably depend on the animal's age when treated, with older animals more likely to die before regaining fertility simply because their lifespan may not be long enough for the immune reaction to wane and cause a resumption of fertility. If long-term treatment resulted in such a long duration of immune response that a mare remained infertile until death, that type of permanent infertility would be consistent with the desired effect of using GonaCon (e.g., effective contraception), and with section 1333(b) of the WFRHBA.

Other anti-GnRH vaccines also have had temporary effects in mares. Elhay and others (2007) noted a return to ovary functioning over the course of 34 weeks for 10 of 16 mares treated with Equity. That study ended at 34 weeks, so it is not clear when the other six mares would have returned to fertility. Donovan and others (2013) found that half of mares treated with an anti-GnRH vaccine intended for dogs had returned to fertility after 40 weeks, at which point the study ended. In a study of mares treated with a primer and booster dose of Improvac, 47 of 51 treated mares had returned to ovarian cyclicity within 2 years; younger mares appeared to have longer-lasting effects than older mares (Schulman et al. 2013). Joonè and others (2017cc) analyzed samples from the Schulman and others (2013) study, and found no significant decrease in anti-Mullerian

hormone (AMH) levels in mares treated with GnRH vaccine. AMH levels are thought to be an indicator of ovarian function, so results from Joonè and others (2017c) support the general view that the anoestrus resulting from GnRH vaccination is physiologically similar to typical winter anoestrus. In a small study with a non-commercial anti-GnRH vaccine (Stout et al. 2003), three of seven treated mares had returned to cyclicity within 8 weeks after delivery of the primer dose, while four others were still suppressed for 12 or more weeks. In elk, Powers and others (2011) noted that contraception after one dose of GonaCon was temporary. In white-tailed deer, single doses of GonaCon appeared to confer two years of contraception (Miller et al. 2000). Ten of 30 domestic cows treated became pregnant within 30 weeks after the first dose of Bopriva (Balet et al. 2014).

Long-term infertility could result from multiple doses of GonaCon-Equine vaccine. As is the case for PZP vaccines (noted above), it is possible that some fraction of mares treated with multiple doses of GonaCon-Equine could be prevented from having any more foals before they die—this outcome would depend on the age when the mare is treated, duration of the mare's immune response, and the mare's longevity. All available evidence supports the conclusion that the effect of GonaCon-Equine vaccine treatments is to cause an immune response, and that when that immune response wanes a mare is expected to return to fertility. As noted above, Baker and others (2023) demonstrated increasing rates of return to fertility over time, after a second dose of GonaCon-Equine was administered. But if it happens that GonaCon-Equine vaccine treatments cause a mare or jenny to not return to fertility before death, some would interpret that course of immunocontraceptive treatment to have caused sterility. If some fraction of mares treated with GonaCon-Equine were to become sterile, though, that result would be consistent with the contraceptive purpose that motivates BLM's potential use of the vaccine, and with Congressional guidance that condones such treatment in the management of wild horses and burros, in WFRHBA section 1333(b).

In summary, based on the above results related to fertility effects of GonaCon and other anti-GnRH vaccines, application of a single dose of GonaCon-Equine to gathered or remotely darted wild horses could be expected to prevent pregnancy in perhaps 30 percent to 60 percent of mares for one year. Some smaller number of wild mares should be expected to have persistent contraception for a second year, and less still for a third year. Applying one booster dose of GonaCon to previously treated mares may lead to four or more years with relatively high rates (80+ percent) of additional infertility expected (Baker et al. 2018, 2023), with the potential for additional infertility until the immune response to the vaccine wears off. The duration of effect after a second dose would appear to depend on the length of time between first and second dose, with longer-lasting effects if that time span is 4 years than if it is 1 year or less (Baker et al. 2023). Given that GonaCon-Equine is formulated as a highly immunogenic, long-lasting vaccine, it is reasonable to hypothesize that additional boosters would increase the effectiveness and duration of the vaccine.

GonaCon-Equine only affects the fertility of treated animals; untreated animals will still be expected to give birth. Even under favorable circumstances for population growth suppression, gather efficiency might not exceed 85 percent via helicopter, and may be less with bait and water trapping. Similarly, not all animals may be approachable for darting. The uncaptured or undarted portion of the female population would still be expected to have normally high fertility rates in any given year, though those rates could go up slightly if contraception in other mares increases forage and water availability.

Changes in hormones associated with anti-GnRH vaccination lead to measurable changes in ovarian structure and function. The volume of ovaries reduced in response to treatment (Garza et al. 1986, Dalin et al. 2002, Imboden et al. 2006, Elhay et al. 2007, Botha et al. 2008, Gionfriddo 2011a, Dalmau et al. 2015). Treatment with an anti-GnRH vaccine changes follicle development (Garza et al. 1986, Stout et al. 2003, Imboden et al. 2006, Elhay et al. 2007, Donovan et al. 2013, Powers et al. 2011, Balet et al. 2014), with the

result that ovulation does not occur. A related result is that the ovaries can exhibit less activity and cycle with less regularity or not at all in anti-GnRH vaccine treated females (Goodloe 1991, Dalin et al. 2002, Imboden et al. 2006, Elhay et al. 2007, Powers et al. 2011, Donovan et al. 2013). In studies where the vaccine required a booster, hormonal and associated results were generally observed within several weeks after delivery of the booster dose.

Effects on Existing Pregnancies, Foals, and Birth Phenology: PZP Vaccines

Although fetuses are not explicitly protected under the WFRHBA of 1971, as amended, it is prudent to analyze the potential effects of fertility control vaccines on developing fetuses and foals. Any impacts identified in the literature have been found to be transient, and do not influence the future reproductive capacity of offspring born to treated females.

If a mare is already pregnant, the PZP vaccine has not been shown to affect normal development of the fetus or foal, or the hormonal health of the mare with relation to pregnancy (Kirkpatrick and Turner 2003). Studies on Assateague Island (Kirkpatrick and Turner 2002) showed that once female offspring born to mares treated with PZP during pregnancy eventually breed, they produce healthy, viable foals. It is possible that there may be transitory effects on foals born to mares or jennies treated with PZP. For example, in mice, Sacco and others (1981) found that antibodies specific to PZP can pass from mother mouse to pup via the placenta or colostrum, but that did not apparently cause any innate immune response in the offspring: the level of those antibodies was undetectable by 116 days after birth. There was no indication in that study that the fertility or ovarian function of those mouse pups was compromised, nor is BLM aware of any such results in horses or burros. Unsubstantiated, speculative connections between PZP treatment and 'foal stealing' have not been published in a peer-reviewed study and thus cannot be verified. 'Foal stealing,' where a near-term pregnant mare steals a neonate foal from a weaker mare, is unlikely to be a common behavioral result of including spayed mares in a wild horse herd. McDonnell (2012) noted that "foal stealing is rarely observed in horses, except under crowded conditions and synchronization of foaling," such as in horse feed lots. Those conditions are not likely in the wild, where pregnant mares will be widely distributed across the landscape, and where the expectation is that parturition dates would be distributed across the normal foaling season. Similarly, although Nettles (1997) noted reported stillbirths after PZP treatments in cynomolgus monkeys, those results have not been observed in equids despite extensive use in horses and burros.

On-range observations from 20 years of application to wild horses indicate that PZP application in wild mares does not generally cause mares to give birth to foals out of season or late in the year (Kirkpatrick and Turner 2003). Research by Nuñez and others (2010) showed that a small number of mares that had previously been treated with PZP foaled later than untreated mares and expressed the concern that this late foaling "may" impact foal survivorship and decrease band stability, or that higher levels of attention from stallions on PZP-treated mares might harm those mares. However, that paper provided no evidence that such impacts on foal survival or mare well-being actually occurred. Rubenstein (1981) called attention to a number of unique ecological features of horse herds on Atlantic barrier islands, such as where Nuñez and others made observations, which calls into question whether inferences drawn from island herds can be applied to western wild horse herds. Ransom and others (2013), though, did identify a potential shift in reproductive timing as a possible drawback to prolonged treatment with PZP, stating that treated mares foaled on average 31 days later than non-treated mares. Results from Ransom and others (2013), however, showed that over 81 percent of the documented births in that study were between March 1 and June 21, within the normal peak spring foaling season. Ransom and others (2013) pointedly advised that managers should consider carefully before using fertility control vaccines in small refugia or rare species. Wild horses

and burros managed by BLM do not generally occur in isolated refugia, nor are they at all rare species. The US Fish and Wildlife Service denied a petition to list wild horses as endangered (USFWS 2015). Moreover, any effect of shifting birth phenology was not observed uniformly: in two of three PZP-treated wild horse populations studied by Ransom and others (2013), foaling season of treated mares extended three weeks and 3.5 months, respectively, beyond that of untreated mares. In the other population, the treated mares foaled within the same time period as the untreated mares. Furthermore, Ransom and others (2013) found no negative impacts on foal survival even with an extended birthing season. If there are shifts in birth phenology, though, it is reasonable to assume that some negative effects on foal survival for a small number of foals might result from particularly severe weather events (Nuñez 2018).

Effects on Existing Pregnancies, Foals, and Birth Phenology: GnRH Vaccines

Although fetuses are not explicitly protected under the WFRHBA of 1971, as amended, it is prudent to analyze the potential effects of fertility control vaccines on developing fetuses and foals. Any impacts identified in the literature have been found to be transient, and do not influence the future reproductive capacity of offspring born to treated females.

GonaCon and other anti-GnRH vaccines can be injected while a female is pregnant (Miller et al. 2000, Powers et al. 2011, Baker et al. 2013)—in such a case, a successfully contracepted mare will be expected to give birth during the following foaling season, but to be infertile during the same year's breeding season. Thus, a mare injected in November of 2018 would not show the contraceptive effect (i.e., no new foal) until spring of 2020.

GonaCon had no apparent effect on pregnancies in progress, foaling success, or the health of offspring, in horses that were immunized in October (Baker et al. 2013), elk immunized 80–100 days into gestation (Powers et al. 2011, 20144), or deer immunized in February (Miller et al. 2000). Kirkpatrick and others (2011) noted that anti-GnRH immunization is not expected to cause hormonal changes that would lead to abortion in the horse, but this may not be true for the first 6 weeks of pregnancy (NAS 2013). Curtis and others (2002) noted that GonaCon-KHL treated white tailed deer had lower twinning rates than controls, but speculated that the difference could be due to poorer sperm quality late in the breeding season, when the treated does became pregnant. Goodloe (1991) found no difference in foal production between treated and control animals.

Offspring of anti-GnRH vaccine treated mothers could exhibit an immune response to GnRH (Khodr and Siler-Khodr 1980), as antibodies from the mother could pass to the offspring through the placenta or colostrum. In the most extensive study of long-term effects of GonaCon immunization on offspring, Powers and others (2012) monitored 15 elk fawns born to GonaCon treated cows. Of those, 5 had low titers at birth and 10 had high titer levels at birth. All 15 were of normal weight at birth, and developed normal endocrine profiles, hypothalamic GnRH content, pituitary gonadotropin content, gonad structure, and gametogenesis. All the females became pregnant in their second reproductive season, as is typical. All males showed normal development of secondary sexual characteristics. Powers and others (2012) concluded that suppressing GnRH in the neonatal period did not alter long-term reproductive function in either male or female offspring. Miller and others (2013) report elevated anti-GnRH antibody titers in fawns born to treated white tailed deer, but those dropped to normal levels in 11 of 12 of those fawns, which came into breeding condition; the remaining fawn was infertile for three years.

Direct effects on foal survival are equivocal in the literature. Goodloe (1991) reported lower foal survival for a small sample of foals born to anti-GnRH treated mares but did not assess other possible explanatory

factors such as mare social status, age, body condition, or habitat (NAS 2013). Gray and others (2010a) found no difference in sex ratio, parturition phenology, or foal survival in foals born to free-roaming mares treated with GonaCon.

There is little empirical information available to evaluate the effects of GnRH vaccination on foaling phenology, but those effects are likely to be similar to those for PZP vaccine treated mares in which the effects of the vaccine wear off. It is possible that immunocontracepted mares returning to fertility late in the breeding season could give birth to foals at a time that is out of the normal range (Nuñez et al. 2010, Ransom et al. 2013). Curtis and others (2002) did observe a slightly later fawning date for GonaCon treated deer in the second year after treatment, when some does regained fertility late in the breeding season. In anti-GnRH vaccine trials in free-roaming horses, there were no published differences in mean date of foal production (Goodloe 1991, Gray et al. 2010a). Baker and others (2023) reported a wider range of foaling dates in mares treated with GonaCon-Equine vaccine than in untreated mares, but the differences in foaling date were not associated with any difference in foal survival rates. Because of the concern that contraception could lead to shifts in the timing of parturitions for some treated animals, Ransom and others (2013) advised that managers should consider carefully before using PZP immunocontraception in small refugia or rare species; the same considerations could be advised for use of GonaCon, but wild horses and burros in most areas do not generally occur in isolated refugia, they are not a rare species at the regional, national, or international level, and genetically they represent descendants of domestic livestock with most populations containing few if any unique alleles (NAS 2013). Moreover, in PZP-treated horses that did have some degree of parturition date shift, Ransom and others (2013) found no negative impacts on foal survival even with an extended birthing season; however, this may be more related to stochastic, inclement weather events than extended foaling seasons. If there were to be a shift in foaling date for some treated mares, the effect on foal survival may depend on weather severity and local conditions; for example, Ransom and others (2013) did not find consistent effects across study sites.

Effects of Marking and Injection

Standard practices require that immunocontraceptive-treated animals be readily identifiable, either via brand marks or unique coloration (BLM 2010). Some level of transient stress is likely to result in newly captured mares that do not have markings associated with previous fertility control treatments. It is difficult to compare that level of temporary stress with the long-term stress that can result from food and water limitation on the range (e.g., Creel et al. 2013).

Handling may include freeze-marking and/or RFID chipping, for the purpose of identifying that mare and identifying that mare's vaccine treatment history. Under past management practices, captured mares experienced increased stress levels from handling (Ashley and Holcombe 2001), but BLM has instituted guidelines to reduce the sources of handling stress in captured animals (BLM 2021).

Most mares recover from the stress of capture and handling quickly once released back to the range, and none are expected to suffer serious long-term effects from the fertility control injections, other than the direct consequence of becoming temporarily infertile. Injection site reactions associated with fertility control treatments are possible in treated mares and jennies (Roelle and Ransom 2009, Bechert et al. 2013, French et al. 2017, Baker et al. 2018, French et al. 2020), but swelling or local reactions at the injection site are expected to be minor in nature. Roelle and Ransom (2009) found that the most time-efficient method for applying PZP is by hand-delivered injection of 2-year pellets when horses are gathered. They observed only two instances of swelling from that technique. French and others (2020) observed localized swelling, transient lameness in PZP vaccine-treated burros, and sterile abscesses in 87 percent of those treated jennies.

Whether injection is by hand or via darting, GonaCon-Equine is associated with some degree of inflammation, swelling, and the potential for abscesses at the injection site (Baker et al. 2013). Swelling or local reactions at the injection site are generally expected to be minor in nature, but some may develop into draining abscesses. Use of remotely delivered vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached. The dart-delivered PZP formulation produced injection-site reactions of varying intensity, though none of the observed reactions appeared debilitating to the animals (Roelle and Ransom 2009), but that was not observed with dart-delivered GonaCon (McCann et al. 2017). Joonè and others (2017a) found that injection site reactions had healed in most mares within 3 months after the booster dose, and that they did not affect movement or cause fever.

Long-lasting nodules observed did not appear to change any animal's range of movement or locomotor patterns and in most cases did not appear to differ in magnitude from naturally occurring injuries or scars. Mares treated with one formulation of GnRH-KHL vaccine developed pyogenic abscesses (Goodloe 1991). Miller and others (2008) noted that the water and oil emulsion in GonaCon will often cause cysts, granulomas, or sterile abscesses at injection sites; in some cases, a sterile abscess may develop into a draining abscess. In elk treated with GonaCon, Powers and others (2011) noted up to 35 percent of treated elk had an abscess form, despite the injection sites first being clipped and swabbed with alcohol. Even in studies where swelling and visible abscesses followed GonaCon immunization, the longer-term nodules observed did not appear to change any animal's range of movement or locomotor patterns (Powers et al. 2014, Baker et al. 2017, 2018). The result that other formulations of anti-GnRH vaccine may be associated with less notable injection site reactions in horses may indicate that the adjuvant formulation in GonaCon leads a single dose to cause a stronger immune reaction than the adjuvants used in other anti-GnRH vaccines. Despite that, a booster dose of GonaCon-Equine appears to be more effective than a primer dose alone (Baker et al. 2017). Horses injected in the hip with Improvac showed only transient reactions that disappeared within 6 days in one study (Botha et al. 2008), but stiffness and swelling that lasted 5 days were noted in another study where horses received Improvac in the neck (Imboden et al. 2006). Equity led to transient reactions that resolved within a week in some treated animals (Elhay et al. 2007). Donovan and others noted no reactions to the canine anti-GnRH vaccine (2013). In cows treated with Bopriva there was a mildly elevated body temperature and mild swelling at injection sites that subsided within 2 weeks (Balet et al. 2014).

Indirect Effects: PZP Vaccines

One expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health (Turner and Kirkpatrick 2002a). Many treated mares would not experience the biological stress of reproduction, foaling, and lactation as frequently as untreated mares. The observable measure of improved health is higher body condition scores (Nuñez et al. 2010). After a treated mare returns to fertility, that mare's future foals would be expected to be healthier overall and would benefit from improved nutritional quality in the mare's milk. This is particularly to be expected if there is an improvement in rangeland forage quality at the same time, due to reduced wild horse population size. Past application of fertility control has shown that mares' overall health and body condition remains improved even after fertility resumes. PZP treatment may increase mare survival rates, leading to longer potential lifespan (Turner and Kirkpatrick 2002a, Ransom et al. 2014a) that may be as much as 5–10 years (NPS 2008). To the extent that this happens, changes in lifespan and decreased foaling rates could combine to cause changes in overall age structure in a treated herd (Turner and Kirkpatrick 2002a, Roelle et al. 2010), with a greater prevalence of older mares in the herd (Gross 2000, NPS 2008). Observations of mares treated in past gathers showed that many of the treated mares were larger than, maintained higher body condition than, and had larger healthy foals than untreated mares (BLM, anecdotal observations).

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called a 'rebound effect.' Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick and Turner 1991). If repeated contraceptive treatment leads to a prolonged contraceptive effect, then that may minimize or delay the hypothesized rebound effect. Selectively applying contraception to older animals and returning them to the range could reduce long-term holding costs for such horses, which are difficult to adopt, and may reduce the compensatory reproduction that often follows removals (Kirkpatrick and Turner 1991).Because successful fertility control in a given herd reduces foaling rates and population growth rates, another indirect effect should be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. Contraception may change a herd's age structure, with a relative increase in the fraction of older animals in the herd (NPS 2008). Reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to off-range holding corrals or pastures for long-term holding.

A principal motivation for use of contraceptive vaccines or sex ratio manipulation is to reduce population growth rates and maintain herd sizes at AML. Where successful, this should allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse and burro habitat quality, and the well-being of animals living on the range. As the population nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses and burros, there should also be less trailing and concentrated use of water sources. Lower population density should lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Among mares in the herd that remain fertile, a higher level of physical health and future reproductive success would be expected in areas where lower horse and burro population sizes lead to increases in water and forage resources. While it is conceivable that widespread and continued treatment with fertility control vaccines could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present is treated in almost every year.

Indirect Effects: GnRH Vaccines

As noted above to PZP vaccines, an expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health. Body condition of anti-GnRH-treated females was equal to or better than that of control females in published studies. Ransom and others (2014b) observed no difference in mean body condition between GonaCon-B treated mares and controls. Goodloe (1991) found that GnRH-KHL treated mares had higher survival rates than untreated controls. Baker and others (2023) noted higher body condition scores in GonaCon-Equine vaccine treated mares than in untreated mares. In other species, treated deer had better body condition than controls (Gionfriddo et al. 2011b), treated cats gained more weight than controls (Levy et al. 2011), as did treated young female pigs (Bohrer et al. 2014).

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called by some a 'rebound effect.' Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick and Turner 1991). If repeated contraceptive

treatment leads to a prolonged contraceptive effect, then that may minimize or delay the hypothesized rebound effect. Selectively applying contraception to older animals and returning them to the range could

reduce long-term holding costs for such horses, which are difficult to adopt, and could negate the compensatory reproduction that can follow removals (Kirkpatrick and Turner 1991).

Because successful fertility control would reduce foaling rates and population growth rates, another indirect effect would be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. Contraception would be expected to lead to a relative increase in the fraction of older animals in the herd. Reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to off-range holding corrals or pastures for long-term holding. Among mares in the herd that remain fertile, a high level of physical health and future reproductive success would be expected because reduced population sizes should lead to more availability of water and forage resources per capita.

Reduced population growth rates and smaller population sizes could also allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse habitat quality. As the local horse abundance nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available to wild horses and wildlife throughout the area. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses across the range, there should also be less trailing and concentrated use of water sources. Lower population density would be expected to lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Should GonaCon-Equine treatment, including booster doses, continue into the future, with treatments given on a schedule to maintain a lowered level of fertility in the herd, the chronic cycle of overpopulation and large gathers and removals might no longer occur, but instead a consistent abundance of wild horses could be maintained, resulting in continued improvement of overall habitat conditions and animal health. While it is conceivable that widespread and continued treatment with GonaCon-Equine could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present is treated with primer and booster doses, and perhaps repeated booster doses.

Behavioral Effects: PZP Vaccines

Behavioral differences, compared to mares that are fertile, should be considered as potential results of successful contraception. The NAS report (2013) noted that all forms of fertility suppression have effects on mare behavior, mostly because of the lack of pregnancy and foaling, and concluded that fertility control vaccines were among the most promising fertility control methods for wild horses and burros. The resulting impacts may be seen as neutral in the sense that a wide range of natural behaviors is already observable in untreated wild horses, or mildly adverse in the sense that effects are expected to be transient and to not affect all treated animals.

PZP vaccine-treated mares may continue estrus cycles throughout the breeding season. Ransom and Cade (2009) delineated wild horse behaviors. Ransom and others (2010) found no differences in how PZP-treated and untreated mares allocated their time between feeding, resting, travel, maintenance, and most social behaviors in three populations of wild horses, which is consistent with Powell's (1999) findings in another population. Likewise, body condition of PZP-treated and control mares did not differ between treatment

groups in Ransom and others' (2010) study. Nuñez and others (2010) found that PZP-treated mares had higher body condition than control mares in another population, presumably because energy expenditure was reduced by the absence of pregnancy and lactation. Knight (2014) found that PZP-treated mares had better body condition, lived longer, and switched harems more frequently, while mares that foaled spent more time concentrating on grazing and lactation and had lower overall body condition.

In two studies involving a total of four wild horse populations, both Nuñez and others (2009) and Ransom and others (2010) found that PZP vaccine treated mares were involved in reproductive interactions with stallions more often than control mares, which is not surprising given the evidence that PZP-treated females of other mammal species can regularly demonstrate estrus behavior while contracepted (Shumake and Killian 1997, Heilmann et al. 1998, Curtis et al. 2002, Duncan et al. 2017). There was no evidence, though, that mare welfare was affected by the increased level of herding by stallions noted in Ransom and others (2010). Later analysis by Nuñez and others (2017) noted no difference in mare reproductive behavior as a function of contraception history.

Ransom and others (2010) found that control mares were herded by stallions more frequently than PZP-treated mares, and Nuñez and others (2009, 2014, 2017) and Nuñez (2018) found that PZP-treated mares exhibited higher infidelity to their band stallion during the non-breeding season than control mares. Madosky and others (2010) and Knight (2014) found this infidelity was also evident during the breeding season in the same population that Nuñez and others (2009, 2010, 2014, 2017, 2018) studied. Nuñez and others (2014, 2017, 2018) concluded that PZP-treated mares changing bands more frequently than control mares could lead to band instability. Nuñez and others (2009), though, cautioned against generalizing from that island population to other herds. Also, despite any potential changes in band infidelity due to PZP vaccination, horses continued to live in social groups with dominant stallions and one or more mares. Nuñez and others (2014) found elevated levels of fecal cortisol, a marker of physiological stress, in mares that changed bands. The research is inconclusive as to whether all the mares' movements between bands were related to the PZP treatments themselves or the fact that the mares were not nursing a foal and did not demonstrate any long-term negative consequence of the transiently elevated cortisol levels. In separate work in a long-term study of semi-feral Konik ponies, Jaworska and others (2020) showed that neither infanticide nor feticide resulted for mares and their foals after a change in dominant stallion. Nuñez and others (2014) wrote that these effects "…may be of limited concern when population reduction is an urgent priority." Nuñez (2018) and Jones and others (2019, 2020) noted that band stallions of mares that have received PZP treatment can exhibit changes in behavior and physiology. Nuñez (2018) cautioned that PZP use may limit the ability of mares to return to fertility, but also noted that, "such aggressive treatments may be necessary when rapid reductions in animal numbers are of paramount importance…If the primary management goal is to reduce population size, it is unlikely (and perhaps less important) that managers achieve a balance between population control and the maintenance of more typical feral horse behavior and physiology."

In contrast to transient stresses, Creel and others (2013) highlight that variation in population density is one of the most well-established causal factors of chronic activation of the hypothalamic-pituitary-adrenal axis, which mediates stress hormones; high population densities and competition for resources can cause chronic stress. Creel and others (2013) also state that "…there is little consistent evidence for a negative association between elevated baseline glucocorticoids and fitness." Band fidelity is not an aspect of wild horse biology that is specifically protected by the WFRHBA of 1971. It is also notable that Ransom and others (2014b) found higher group fidelity after a herd had been gathered and treated with a contraceptive vaccine; in that case, the researchers postulated that higher fidelity may have been facilitated by the decreased competition for forage after excess horses were removed among. At the population level, available research does not provide evidence of the loss of harem structure any herds treated with PZP. No biologically significant

negative impacts on the overall animals or populations overall, long-term welfare or well-being have been established in these studies.

The National Research Council (NAS 2013) found that harem changing was not likely to result in serious adverse effects for treated mares: "The studies on Shackleford Banks (Nuñez et al. 2009; Madosky et al. 2010) suggest that there is an interaction between pregnancy and social cohesion. The importance of harem stability to mare well-being is not clear, but considering the relatively large number of free-ranging mares that have been treated with liquid PZP in a variety of ecological settings, the likelihood of serious adverse effects seem low."

Nuñez and others (2010) stated that not all populations will respond similarly to PZP treatment. Differences in habitat, resource availability, and demography among conspecific populations will undoubtedly affect their physiological and behavioral responses to PZP contraception and may be considered. Kirkpatrick and others (2010) concluded that: "the larger question is, even if subtle alterations in behavior may occur, this is still far better than the alternative," and that the "…other victory for horses is that every mare prevented from being removed, by virtue of contraception, is a mare that will only be delaying her reproduction rather than being eliminated permanently from the range. This preserves herd genetics, while gathers and adoption do not."

The NAS report (2013) provides a comprehensive review of the literature on the behavioral effects of contraception that puts research up to that date by Nuñez and others (2009, 2010) into the broader context of all of the available scientific literature, and cautions, based on its extensive review of the literature that: ". . . in no case can the committee conclude from the published research that the behavior differences observed are due to a particular compound rather than to the fact that treated animals had no offspring during the study. That must be borne in mind particularly in interpreting long-term impacts of contraception (e.g., repeated years of reproductive "failure" due to contraception)."

Behavioral Effects: GnRH Vaccines

The result that GonaCon treated mares may have suppressed estrous cycles throughout the breeding season can lead treated mares to behave in ways that are functionally similar to pregnant mares. Where it is successful in mares, GonaCon and other anti-GnRH vaccines are expected to induce fewer estrous cycles when compared to non-pregnant control mares. This has been observed in many studies (Garza et al. 1986, Curtis et al. 2002, Dalin et al. 2002, Killian et al. 2006, Dalmau et al. 2015). Females treated with GonaCon had fewer estrous cycles than control or PZP-treated mares (Killian et al. 2006) or deer (Curtis et al. 2002). Thus, any concerns about PZP treated mares receiving more courting and breeding behaviors from stallions (Nuñez et al. 2009, Ransom et al. 2010) are not generally expected to be a concern for mares treated with anti-GnRH vaccines (Botha et al. 2008).

Ransom and others (2014b) and Baker and others (2018) found that GonaCon treated mares had similar rates of reproductive behaviors that were similar to those of pregnant mares. Among other potential causes, the reduction in progesterone levels in treated females may lead to a reduction in behaviors associated with reproduction. Despite this, some females treated with GonaCon or other anti-GnRH vaccines did continue to exhibit reproductive behaviors, albeit at irregular intervals and durations (Dalin et al. 2002, Stout et al. 2003, Imboden et al. 2006), which is a result that is similar to spayed (ovariectomized) mares (Asa et al. 1980b). Gray (2009a) and Baker and others (2018) found no difference in sexual behaviors in mares treated with GonaCon and untreated mares. In a sense, the hormonal state of and the behaviors of GonaCon-Equine vaccine treated animals is generally comparable to when they are pregnant, but Baker and others (2023)

noted that GonaCon-Equine treated mares actually do still "…show periodic estrous behaviors throughout the normal breeding season suggesting that vaccination only partially suppresses the hormones responsible for stimulating reproductive behavior, although concentrations are likely insufficient to induce ovulation." Mares treated with GonaCon-Equine do not leave their bands any more often than untreated mares. In fact, Ransom and others (2014b) actually found increased levels of band fidelity after treatment with GonaCon-Equine. Baker and others (2018) reported that GonaCon-Equine treated mares received slightly more harem-social behaviors from stallions than untreated mares, but that most of those social behaviors were allo-grooming. When progesterone levels are low, small changes in estradiol concentration can foster reproductive estrous behaviors (Imboden et al. 2006). Owners of anti-GnRH vaccine treated mares reported a reduced number of estrous-related behaviors under saddle (Donovan et al. 2013). Treated mares may refrain from reproductive behavior even after ovaries return to cyclicity (Elhay et al. 2007). Studies in elk found that GonaCon treated cows had equal levels of precopulatory behaviors as controls (Powers et al. 2011), though bull elk paid more attention to treated cows late in the breeding season, after control cows were already pregnant (Powers et al. 2011).

Stallion herding of mares and harem switching by mares are two behaviors related to reproduction that might change as a result of contraception. Ransom and others (2014b) observed a 50 percent decrease in herding behavior by stallions after the free-roaming horse population at Theodore Roosevelt National Park was reduced via a gather, and mares there were treated with GonaCon-B. The increased harem tending behaviors by stallions were directed to both treated and control mores. It is difficult to separate any effect of GonaCon in this study from changes in horse density and forage following horse removals.

With respect to treatment with GonaCon or other anti-GnRH vaccines, it is probably less likely that treated mares will switch harems at higher rates than untreated animals, because treated mares are similar to pregnant mares in their behaviors (Ransom et al. 2014b). Indeed, Gray (2009a) found no difference in band fidelity in a free-roaming population of horses with GonaCon treated mares, despite differences in foal production between treated and untreated mares. Ransom and others (2014b) actually found increased levels of band fidelity after treatment, though this may have been partially a result of changes in overall horse density and forage availability.

Gray (2009a) and Ransom and others (2014b) monitored non-reproductive behaviors in GonaCon treated populations of free-roaming horses. Gray (2009a) found no difference between treated and untreated mares in terms of activity budget, sexual behavior, proximity of mares to stallions, or aggression. Ransom and others (2014b) found only minimal differences between treated and untreated mare time budgets, but those differences were consistent with differences in the metabolic demands of pregnancy and lactation in untreated mares, as opposed to non-pregnant treated mares.

Genetic Effects of Fertility Control Vaccines

In HMAs where large numbers of wild horses have recent and/or an ongoing influx of breeding animals from other areas with wild or feral horses, contraception is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright 1931) or by introducing new potential breeding animals (Mills and Allendorf 1996). The NAS report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and

human-facilitated movements. Introducing 1-2 mares every generation (about every 10 years) is a standard management technique that can alleviated potential inbreeding concerns (BLM 2010).

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM, such that most alleles that are present in any given mare are likely to already be well represented in that mare's siblings, cousins, and more distant relatives. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NAS 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from domestic breeds. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al. 2006). In a relatively small population with empirically documented individual genotypes, Zimmerman and others (2023) used projections to determine that adequate genetic diversity should be maintained despite immunocontraception and planned periodic gathers. Based on a population model, Gross (2000) found that a strategy to preferentially treat young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals, or a strategy with periodic gathers and removals.

Even if it is the case that repeated treatment with a fertility control vaccine may lead to prolonged infertility, or even sterility in some mares, most HMAs have only a low risk of loss of genetic diversity if logistically realistic rates of contraception are applied to mares. Wild horses in most herd management areas are descendants of a diverse range of ancestors coming from many breeds of domestic horses. As such, the existing genetic diversity in the majority of HMAs does not contain unique or historically unusual genetic markers. Past interchange between HMAs, either through natural dispersal or through assisted migration (i.e., human movement of horses) means that many HMAs are effectively indistinguishable and interchangeable in terms of their genetic composition (i.e., see the table of Fst vales *in* NAS 2013). Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Their results show that the risk of the loss of genetic heterozygosity is extremely low except in cases where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5 percent per year), and very large fractions of the female population are permanently sterilized.

It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual herd management area or complex. Also, there is no Bureau-wide policy that requires BLM to allow each female in a herd to reproduce before treatment with contraceptives.

Fertility Control Vaccines and the Evolution of Immune Response

One concern that has been raised with regards to genetic diversity is that treatment with immunocontraceptives could possibly lead to an evolutionary increase in the frequency of individuals whose genetic composition fosters weak immune responses (Cooper and Larson 2006, Ransom et al. 2014a). Based on principles of population genetics, likely application rates in wild horse and burro metapopulations, and on currently available knowledge, it appears unlikely that BLM's application of fertility control vaccines would

cause biologically significant, population-level evolutionary changes in the capacity to mount healthy immune responses, for reasons noted below.

In well-monitored wild horse herds that have been treated with PZP vaccine for many years, there have been a small number of mares that are 'non-responders' – that is, they continue to be fertile despite multiple treatments with ZonaStat-H PZP vaccine (i.e., BLM 2023). To the extent that this outcome may be partly attributable to genes, then for such 'non-responder' genes to spread widely in the population, both heritability and the selection coefficient must be high. Many factors influence the strength of a vaccinated individual's immune response, potentially including genetics, but also nutrition, body condition, and prior immune responses to pathogens or other antigens (Powers et al. 2011). The premise of the concern (Cooper and Larson 2006, Ransom et al. 2014a) is based on an assumption that lack of immune response to any given fertility control vaccine is a highly heritable trait, that the great majority of mares in a population would be treated with immunocontraceptives, that treated 'non-responder' mares would give birth to a far greater number of foals than other treated mares, and that the result would be an increasing frequency of the poor immune response associated trait over time in a population of vaccine-treated animals. Cooper and Herbert (2001) reviewed the topic, in the context of concerns about the long-term effectiveness of immunocontraceptives as a control agent for exotic eutherian species in Australia. They argue that imunocontraception could be a strong selective pressure, and that selecting for reproduction in individuals with poor immune response could lead to a general decline in immune function in populations where such evolution takes place. Other authors have also speculated that differences in antibody titer responses could be partially due to genetic differences between animals (Curtis et al. 2002, Herbert and Trigg 2005). However, Magiafoglou and others (2003) clarify that if the variation in immune response is due to environmental factors (i.e., body condition, social rank) and not due to genetic factors, then there will be no expected effect of the immune phenotype on future generations. It is possible that general health, as measured by body condition, can have a causal role in determining immune response, with animals in poor condition demonstrating poor immune reactions (NAS 2013).

Correlations between physical factors and immune response would not preclude, though, that there could also be a heritable response to immunocontraception. In studies not directly related to immunocontraception, immune response has been shown to be heritable (Kean et al. 1994, Sarker et al. 1999). Predictions about the long-term, population-level evolutionary response to immunocontraceptive treatments have been largely speculative up to this point, with outcomes likely to depend on several factors, including: the strength of the genetic predisposition to not respond to the fertility control vaccine; the heritability of that gene or genes; the initial prevalence of that gene or genes; the number of mares treated with a primer dose of the vaccine (which generally has a short-acting effect); the number of mares treated with one or more booster doses of the vaccine; and the actual size of the genetically-interacting metapopulation of horses within which the vaccine treatment takes place.

One recent study attempted to quantify the heritability of a decreased response to fertility control vaccine-induced duration of infertility and the pattern of single nucleotide polymorphisms (SNPs) in the genomes of feral mares in Theodore Roosevelt National Park. SNPs can be associated with DNA variants in nearby coding regions, due to linkage. Fifty-three mares were treated with the GonaCon-Equine immunocontraception vaccine, and 25 were not. Almost all of the GonaCon treated mares became infertile for at least one year. The researchers found a correlation between a more rapid return to fertility and several SNPs. The SNPs that were correlated with a more rapid return to fertility are not known to be located in coding regions of genes that influence immune response, but based on the location of those SNPs the researchers suggested that there may be an association with genes that may influence immune response. The researchers estimated that the heritability for genetic effects on the duration of GonaCon effectiveness in

feral horse mares was $h^2 = 0.27$ (SE = 0.23). They characterized this level of heritability as 'moderate.' There are several reasons to expect that in any single managed herd of wild horses, there would be the potential for only a relatively low strength of selection promoting the genes identified in the paper. Almost all of those treated mares became infertile for some time, even though certain SNPs were correlated with a marginally faster return to fertility. The fact that immunocontraception with GonaCon still reduced fertility in treated mares is indicative of a weaker selection potential than if treated mares with those SNPs had remained entirely fertile. These reasons include the only 'moderate' levels of heritability identified by Thompson and others (2022), the expectation that mares treated multiple times should experience additional duration of effect after each dose, the likelihood that an essentially random selection of mares in the herd would not be treated at all with an immunocontraceptive, the possible non-genetic causes that treated mares may return to fertility, and the large genetic effective population size of wild horse metapopulations that is characterized across multiple HMAs and complexes. The results from Thompson and others (2022) would not be expected substantively to change expectations about the effects of potentially heritable immune responses to immuncontraceptive vaccines. Thompson and others (2022) based their results on mares that were treated twice with GonaCon-Equine. While some treated mares may carry genes that marginally decrease vaccine effectiveness and cause them to return to fertility faster, there may also be other treated mares who do not carry those genes but experience poor vaccine response due to environmental or other causes. Of course, any mares that are not treated with immunocontraceptives would be expected to contribute more foals to the herd than treated mares, and the choice of which mares happen to be treated or not be treated would be essentially random with respect to the SNPs identified. In their conclusions, Thompson and others (2022) suggest that wild horse managers should not rely solely on immunocontraceptive methods for herd management; in the three HMAs under consideration in this EA, gathers and immunocontraception are both considered for use in the proposed action. Therefore, the continued presence of untreated and other reproducing mares is likely to reduce any risk of long-term evolutionary reduction in immune function in these herds.

Although a few, generally isolated, feral horse populations have been treated with high fractions of mares receiving PZP immunocontraception for long-term population control (e.g., Assateague Island National Park and Pryor Mountains Herd Management Area), the BLM is unaware of any studies that tested for changes in immune competence in those areas.

Sex Ratio Manipulation

Skewing the sex ratio of a herd so that there are more males than females is an established BLM management technique for reducing population growth rates. As part of a wild horse and burro gather process, the number of animals returned to the range may include more males, the number removed from the range may include more females, or both. By reducing the proportion of breeding females in a population (as a fraction of the total number of animals present), the technique leads to fewer foals being born, relative to the total herd size.

Sex ratio can vary in local populations of wild horses, with many having approximately equal numbers of males and females, some having more females, and some more males. Basic principles of wildlife demography posit that for populations where there is no major influence of any sex-biased immigration or emigration, the realized sex ratio is expected to be a result of sex ratios at birth and sex-specific survival rates at different ages.

Across many herds of federally-managed wild horses and feral horses, there can be substantial variation in the sex ratio at birth. Ransom and others (2016) summarized information about sex ratio at birth across all

wild equid species, in a meta-analysis of demographic studies that were available up to that time. Across all wild equid species, Ransom and others (2016) documented a sex ratio at birth that was slightly skewed toward males on average, with 1.1 male foals born for every 1 female foal. However, the 95 percent confidence interval for that ratio across wild equid populations was from 0.93:1 to 1.29:1. The actual value of sex ratio at birth can vary from herd to herd and over time and appears to be influenced by environmental conditions. Ransom and others (2016) cited studies indicating that female equids tend to give birth to female foals at higher rates when they are living in conditions with inadequate natural resources, when they are in relatively poorer body condition (Cameron et al. 1999), or when they give birth for the first time at very young ages. When free-roaming mares were experiencing improving body condition, they tended to give birth to male foals at high rates (Cameron and Linklater 2007), consistent with predictions of the Trivers-Willard hypothesis that mares in better condition will tend to invest more effort into the sex with higher variance in reproductive success.

The following is not an exhaustive review of all available studies that document adult sex ratio in wild or free-roaming horses, but a conclusion that can be drawn from across many studies is that there is a range of observed sex ratios; there is no single typical sex ratio typical in either unmanaged or managed herds. In a comprehensive 1973-1987 study of 74 management areas that did not have any fertility control applications, Garrott (1991) documented that over half had male to female ratios that were very close to 50:50 (not statistically different from equal numbers of males and females). Among the others, many herds did have more females than males. Over 84 percent of those areas had male to female parity in horses under 1 year old (Garrott 1991). Survival of foals appears to be, on average, equal between male and female foals. In herds without fertility control, Garrott (1991) concluded that young adult male horses had lower survival than young female horses, but that older adult male horses had higher survival than older adult female horses.

The realized overall sex ratio in any given wild horse or burro herd will also be influenced by age-specific and sex-specific survival rates. Mare fertility control application in wild horses increases adult mare survival (Turner and Kirkpatrick 2002a, Ransom et al. 2014a). This is expected to cause an increase in adult females over time in a herd that has been treated with mare fertility control. During 1993-2007, wild horses in the Pryor Mountains were studied intensively; during that time adult sex ratio varied in the range from 44 percent to 55 percent male. The contemporary Pryor Mountain herd sex ratio is an example of where long use of fertility control vaccine has likely affected the sex ratio, which is ~57 percent female. However, this is largely driven by high mare longevity in the 20+ year-old age class (20 mares vs. only 2 studs), that is most likely caused by those mares having relatively few foals. Discounting that age class, the sex ratio at Pryor Mountains herd is ~52 percent female (BLM 2023). Before helicopter gathers or fertility control treatments began at Sheldon National Wildlife Refuge, the sex ratio of adults (3 years old or older) was 55 percent male (424 stallions to 353 mares; Collins and Kasbahm 2016). On an Atlantic barrier island in Georgia, Goodloe and others (2000) documented overall adult sex ratio that was 62 percent male. On Sable Island (Canada) where resources are limited and there is relatively high post-natal mare mortality, sex ratios have been over 60 percent male (Regan et al. 2020).

In BLM management actions that include it, sex ratio is typically adjusted so that up to 60 percent of the horses are male. In the absence of other fertility control treatments, this 60:40 sex ratio can temporarily reduce population growth rates from approximately 20 percent to approximately 15 percent (Bartholow 2004). While such a decrease in growth rate may not appear to be large or long-lasting, the net result can be fewer foals being born, at least for a few years – this can extend the time between gathers, and reduce impacts on-range, and costs off-range. Any impacts of sex ratio manipulation are expected to be temporary because the sex ratio of wild horse and burro foals at birth is approximately equal between males and

females (NAS 2013), and it is common for female foals to reproduce by their second year (NAS 2013). Thus, within a few years after a gather and selective removal that leads to more males than females, the sex ratio of reproducing wild horses and burros will be returning toward a 50:50 ratio.

Having a larger number of males than females is expected to lead to several demographic and behavioral changes as noted in the NAS report (2013), including the following. Having more fertile males than females should not alter the fecundity of individual fertile females. Wild mares may be distributed in a larger number of smaller harems (as documented by Regan et al. 2020). Singer and Schoenecker (2000) found that increases in the number of males on Pryor Mountain Wild Horse Range Herd Management Area lowered the breeding male age but did not alter the birth rate among females. If females are distributed among a larger number of smaller harems, it is expected that genetic effective population size (Ne) should increase relative to a herd of the same number of mares, but with 50:50 sex ratio. Competition and aggression between males may cause a decline in male body condition. Female foraging may be somewhat disrupted by elevated male-male aggression. With a greater number of males available to choose from, females may have opportunities to select more genetically fit sires. There would also be an increase to the genetic effective population size because more stallions would be breeding and existing females would be distributed among many more small harems. This last beneficial impact is one reason that skewing the sex ratio to favor males is listed in the BLM Wild Horse and Burro Management Handbook (BLM 2010) as a method to consider in herds where there may be concern about the loss of genetic diversity; having more males fosters a greater retention of genetic diversity.

Changes in which stallions mate with mares are a natural part of the wild horse behavioral repertoire. Berger (1983) reported forced copulations after band stallion changes, but these were not related to sex ratio per se, considering that the sex ratio in the populations he studied were approximately 43 percent male (Grange et al. 2009). Kirkpatrick and Turner (1991) looked for but did not find any forced copulation or induced abortions after stallion changes in wild horse bands. Infanticide is a natural behavior that has been observed in wild equids (Feh and Munkhtuya 2008, Gray 2009), but there are no published accounts of infanticide rates increasing as a result of having a skewed sex ratio in wild horse or wild burro herds. Any comment that implies such an impact would be speculative.

The BLM Wild Horse and Burro Management Handbook (BLM 2010) discusses this method. The handbook acknowledges that there may be some behavioral impacts of having more males than females. The handbook includes guidelines for when the method should be applied, specifying that this method should be considered where the low end of the AML is 150 animals or greater, and with the result that males comprise 60-70 percent of the herd. Having more than 70 percent males may result in unacceptable impacts in terms of elevated male-male aggression. In NEPA analyses, BLM has chosen to follow these guidelines in some cases, for example:

- In the 2015 Cold Springs HMA Population Management Plan EA (DOI-BLM-V040-2015-022), the low end of AML was 75. Under the preferred alternative, 37 mares and 38 stallions would remain on the HMA. This is well below the 150 head threshold noted above.
- In the 2017 Hog Creek HMA Population Management Plan EA (DOI-BLM-ORWA-V000-2017-0026-EA, BLM 2017c), BLM clearly identified that maintaining a 50:50 sex ratio was appropriate because the herd size at the low end of AML was only 30 animals.

It is relatively straightforward to speed the return of skewed sex ratios back to a 50:50 ratio. The BLM Wild Horse and Burro Management Handbook (BLM 2010) specifies that, if post-treatment monitoring reveals

negative impacts to breeding harems due to sex ratio manipulation, then mitigation measures could include removing males, not introducing additional males, or releasing a larger proportion of females during the next gather.

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Effects of Female Sterilization and Male Neutering

Various forms of fertility control can be used in wild horses and wild burros, with the goals of maintaining herds at or near AML, reducing fertility rates, and reducing the frequency of gathers and removals. The WFRHBA of 1971 specifically provides for contraception and sterilization (16 U.S.C. 1333 section 3.b.1). Fertility control measures have been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used in combination with gathers, to reduce horse population size (Bartholow 2004, de Seve and Boyles-Griffin 2013, Fonner and Bohara 2017). Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000), such as with sterilization methods. Sterilizing a female horse (mare) or burro (jenny) can be accomplished by several methods, some of which are minimally invasive, and others of which are surgical. In this review, 'spaying' is defined to be surgical sterilization, usually accomplished by removal of the ovaries, but other surgical methods such as tubal ligation that lead to sterility may also be considered by some to be a form of spaying. Minimally invasive, physical forms of sterilization, such as trans-cervical methods that occlude the oviduct, are not labeled as spaying in this review, but may have similar physiological outcomes as surgical methods that leave the ovaries intact. In this review, 'neutering' is defined to be the sterilization of a male horse (stallion) or burro (jack), either by removal of the testicles (castration, also known as gelding) or by vasectomy, where the testicles are retained but no sperm leave the body by severing or blocking the vas deferens or epididymis.

In the context of BLM wild horse and burro management, sterilization is expected to be successful to the extent that it reduces the number of reproducing females. By definition, sterilizing a given female is 100 percent effective as a fertility control method for that female. Neutering males may be effective in one of two ways. First, neutered males may continue to guard fertile females, preventing the females from breeding with fertile males. Second, if neutered males are included in a herd that has a high male-to-female sex ratio, then the neutered males may comprise some of the animals within the appropriate management level (AML) of that herd, which would effectively reduce the number of females in the herd. Although these and other fertility control treatments may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, those impacts are generally minor and transient, do not prevent overall maintenance of a self-sustaining population, and do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott and Oli 2013).

Peer-reviewed scientific literature details the expected impacts of sterilization methods on wild horses and burros. No finding of excess animals is required for BLM to pursue sterilization in wild horses or wild burros, but NEPA analysis has been required. This review focuses on peer-reviewed scientific literature. The summary that follows first examines effects of female sterilization, then neuter use in males. This review does not examine effects of fertility control vaccines. Cited studies are generally limited to those involving horses and burros, except where including studies on other species helps in making inferences about physiological or behavioral questions not exhaustively addressed in horses or burros specifically. While

there are notable differences between the species in their anatomy, diet, behaviors, and metabolism (Burden and Thiemann 2015), the essential endocrine controls of the hypothalamic-pituitary-gonadal axis and the function of the zona pellucida in fertility are the same. While most studies reviewed are based on results from horses, burros are similar enough in their reproductive physiology and immunology (Turini et al. 2021) that expected effects of immunocontraception are comparable.

On the whole, the identified impacts at the herd level are generally transient. The principal impact to individuals treated is sterility, which is the intended outcome. Sterilization that affects individual horses and burros does not prevent BLM from ensuring that there will be self-sustaining populations of wild horses and burros in single HMAs, in complexes of HMAs, and at regional scales of multiple HMAs and complexes. Under the WFRHBA of 1971, BLM is charged with maintaining self-reproducing populations of wild horses and burros. The WFRHBA makes clear that BLM is not explicitly charged with ensuring the fertility of any given individual wild horse or burro. The National Academies of Sciences (2013) encouraged BLM to manage wild horses and burros at the spatial scale of "metapopulations" – that is, across multiple HMAs and complexes in a region. In fact, many HMAs have historical and ongoing genetic and demographic connections with other HMAs, and BLM routinely moves animals from one to another to improve local herd traits and maintain high genetic diversity.

Discussions about herds that include some 'non-reproducing' individuals, or even those that are entirely non-reproducing, should be considered in the context of this 'metapopulation' structure, where the 'self-sustaining' nature of herds is not necessarily to be measured at the scale of single HMAs. So long as the definition of what constitutes a self-sustaining herd includes the larger set of HMAs that have past or ongoing demographic and genetic connections – as is recommended by the NAS 2013 report – it is clear that particular HMAs can be managed as non-reproducing in whole or in part while still allowing for a self-sustaining population of wild horses or burros at the broader spatial scale. Wild horses are not an endangered species (USFWS 2015), nor are they rare. Over 64,000 adult wild horses and over 17,000 adult wild burros roamed BLM lands as of March 1, 2022, and those numbers do not include at least 9,000 wild horses and burros (WHB) on US Forest Service lands, nor at least 100,000 feral horses on tribal lands in the Western United States (Schoenecker et al. 2021).

All fertility control methods affect the behavior and physiology of treated animals (NAS 2013), and are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al. 2015). Contraception methods alone do not remove excess horses from an HMA's population, so one or more gathers are usually needed in order to bring the herd down to a level close to AML. Horses are long-lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods (i.e., 10 or more years), spaying and neutering are not very effective at reducing population growth rates to the point where births equal deaths in a herd. However, even modest levels of fertility control activities can reduce the frequency of horse gather activities, and costs to taxpayers. Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000), such as with sterilization. Because sterilizing animals requires capturing and handling, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs.

Effects of Handling and Marking

Sterilization techniques, while not reversible, may control horse reproduction without the kind of additional handling or darting that can be needed to administer contraceptive vaccines. In this sense, sterilization can be

used to achieve herd management objectives with a relative minimum level of animal handling and management over the long term. The WFRHBA (as amended) indicates that management should be at the minimum level necessary to achieve management objectives (CFR 4710.4), and if sterilizing mares or neutering some stallions can lead to a reduced number of handling occasions and removals of excess horses from the range, then that is consistent with legal guidelines. Other fertility control options that may be temporarily effective on male horses, such as the injection of GonaCon-Equine immunocontraceptive vaccine, apparently require multiple handling occasions to achieve longer-term male infertility. Similarly, some formulations of PZP immunocontraception that are currently available for use in female wild horses and burros require handling or darting every year (though longer-term effects may result after 4 or more treatments; Nuñez et al. 2017). By some measures, any management activities that require multiple capture operations to treat a given individual could be seen as more intrusive for wild horses and potentially less sustainable than an activity that requires only one handling occasion.

It is prudent for sterilized animals to be readily identifiable, either via freeze brand marks or unique coloration, and uniquely numbered RFID chips inserted in the nuchal ligament, so that their treatment history is easily recognized (e.g., BLM 2010). Markings may also be useful into the future to determine the approximate fraction of geldings in a herd and could provide additional insights about gather efficiency. BLM has instituted capture and animal welfare program guidelines to reduce the sources of handling stress in captured animals (BLM 2021). Handling may include freeze-marking for the purpose of identifying an individual. Some level of transient stress is likely to result in newly captured horses that are not previously marked. Under past management practices, captured horses experienced increased, transient stress levels from handling (Ashley and Holcombe 2001). It is difficult to compare that level of temporary stress with long-term stress that can result from food and water limitation on the range (e.g., Creel et al. 2013), which could occur in the absence of herd management.

Most horses recover from the stress of capture and handling quickly once released back to the range, and none are expected to suffer serious long-term effects from gelding, other than the direct consequence of becoming infertile.

Observations of the long-term outcomes of sterilization may be recorded during routine resource monitoring work. Such observations could include but not be limited to band size, social interactions with other geldings and harem bands, distribution within their habitat, forage utilization, and activities around key water sources. Periodic population inventories and future gather statistics could provide additional anecdotal information.

Neutering Males

Whether or not stallion sterilization methods are considered in any of the action alternatives in this EA, they are included here for comparison and for the sake of completeness in the review. Castration (the surgical removal of the testicles, also called gelding or neutering) is a surgical procedure for horse sterilization that has been used for millennia. Vasectomy involves severing or blocking the vas deferens or epididymis, to prevent sperm from being ejaculated. The procedures are fairly straight forward and have a relatively low complication rate. As noted in the review of scientific literature that follows, the expected effects of gelding and vasectomy are well understood overall, even though there is some degree of uncertainty about the exact quantitative outcomes for any given individual (as is true for any natural system).

Including a portion of neutered males in a herd can lead to a reduced population-level per-capita growth rate if they cause a marginal decrease in female fertility or if the neutered males take some of the places that would otherwise be occupied by fertile females. By having a skewed sex ratio with fewer females than males

(fertile stallions plus neutered males), the result will be that there will be a lower number of breeding females in the population. Including neutered males in herd management is not new for BLM and Federal land management. Geldings have been released on BLM lands as a part of herd management in the Barren Valley Complex in Oregon (BLM 2011), the Challis HMA in Idaho (BLM 2012a), and the Conger HMA in Utah (BLM 2016). Vasectomized males and geldings were also included in US Fish and Wildlife Service management plans for the Sheldon National Wildlife Refuge that relied on sterilization and removals (Collins and Kasbohm 2016). Taking into consideration the literature available at the time, the National Academies of Sciences concluded in their 2013 report that a form of vasectomy was one of the three most promising methods for WHB fertility control (NAS 2013). However, BLM is not pursuing the chemical vasectomy method. The NAS panel noted that, even though chemical vasectomy had been used in dogs and cats up to that time, "There are no published reports on chemical vasectomy in horses..." and that, "Only surgical vasectomy has been studied in horses, so side effects of the chemical agent are unknown." The only known use of chemical vasectomy in horses was published by Scully and others (2015); this was part of a study cited in the EA (Collins and Kasbohm 2016). They injected chlorhexidine into the stallions' epididymis. That is the same chemical agent as had been used to chemically vasectomize dogs. Scully and others (2015) found that the chemical vasectomy method failed to prevent fertile sperm from being located in the vas deferens seminal fluid. Stallions treated with the chemical vasectomy method still had viable sperm and were still potentially as fertile as untreated 'control' stallions in that study. Thus, the method was not effective.

Nelson (1980) and Garrott and Siniff (1992) modeled potential efficacy of male-oriented contraception as a population management tool, and both studies agreed that while slowing growth, sterilizing only dominant males (i.e., harem-holding stallions) would result in only marginal reduction in female fertility rates. Eagle and others (1993) and Asa (1999) tested this hypothesis on HMAs where dominant males were vasectomized. Their findings agreed with modeling results from previous studies, and they also concluded that sterilizing only dominant males would not provide the desired reduction in female fertility and overall population growth rate, assuming that the numbers of fertile females is not changed. While bands with vasectomized harem stallions tended to have fewer foals, breeding by bachelors and subordinate stallions meant that population growth still occurred – female fertility was not dramatically reduced. Collins and Kasbohm (2016) demonstrated that there was a reduced fertility rate in a feral horse herd with both spayed and vasectomized horses – some geldings were also present in that herd. Statistically significant reductions in mare fertility rates were only observed in the first year after geldings were introduced to a herd in Utah (King et al. 2022). Garrott and Siniff (1992) concluded from their modeling that male sterilization would effectively cause there to be zero population growth (the point where births roughly equal deaths) only if a large proportion of males (i.e., >85 percent) could be sterilized. In cases where the goal of harem stallion sterilization is to reduce population growth rates, success appears to be dependent on a stable group structure, as strong bonds between a stallion and mares reduce the probability of a mare mating an extra-group stallion (Nelson 1980, Garrott and Siniff 1992, Eagle et al. 1993, Asa 1999). At Conger HMA a fraction of geldings that were returned to the range with their social band did continue to live with females, apparently excluding fertile stallions, for at least 2 years (King et al. 2022).

Despite these studies, neutered males can be used to reduce overall growth rates in a management strategy that does not rely on any expectation that geldings will retain harems or lead to a reduction in per-female fertility rates. The primary goal of including neutered males in a herd need not necessarily be to reduce female fertility (although that may be one result). Rather, by including some neutered males in a herd that also has fertile mares and stallions, the neutered males would take some of the spaces toward AML that would otherwise be taken by fertile females. If the total number of horses is constant but neutered males are included in the herd, this can reduce the number of fertile mares, therefore, reducing the absolute number of

foals produced. Put another way, if neutered males occupy spaces toward AML that would otherwise be filled by fertile mares, that will reduce growth rates merely by the fact of causing there to be a lower starting number of fertile mares.

Direct Effects of Neutering

No animals which appear to be distressed, injured, or in poor health or condition would be selected for gelding. Stallions would not typically be neutered within 72 hours of capture. The surgery would be performed by a veterinarian using general anesthesia and appropriate surgical techniques. The final determination of which specific animals would be gelded would be based on the professional opinion of the attending veterinarian in consultation with the authorized officer (i.e., see the SOPs for neutering in the Antelope/Triple B Complexes Gather Plan EA, DOI-BLM-NV-E030-2017-0010-EA, BLM 2017).

Though neutering males is a common surgical procedure, especially gelding, some level of minor complications after surgery may be expected (Getman 2009), and it is not always possible to predict when postoperative complications would occur. Fortunately, the most common complications are almost always self-limiting, resolving with time and exercise. Individual impacts to the stallions during and following the gelding process should be minimal and would mostly involve localized swelling and bleeding. Complications may include, but are not limited to: minor bleeding, swelling, inflammation, edema, infection, peritonitis, hydrocele, penile damage, excessive hemorrhage, and eventration (Schumacher 1996, Searle et al. 1999, Getman 2009). A small amount of bleeding is normal and generally subsides quickly, within 2-4 hours following the procedure. Some degree of swelling is normal, including swelling of the prepuce and scrotum, usually peaking between 3-6 days after surgery (Searle et al. 1999). Swelling should be minimized through the daily movements (exercise) of the horse during travel to and from foraging and watering areas. Most cases of minor swelling should be back to normal within 5-7 days, more serious cases of moderate to severe swelling are also self-limiting and are expected to resolve with exercise after 1 to 2 weeks. Older horses are reported to be at greater risk of post-operative edema, but daily exercise can prevent premature closure of the incision, and prevent fluid buildup (Getman 2009). In some cases, a hydrocele (accumulation of sterile fluid) may develop over months or years (Searle et al. 1999). Serious complications (eventration, anesthetic reaction, injuries during handling, etc.) that result in euthanasia or mortality during and following surgery are rare (e.g., eventration rate of 0.2 percent to 2.6 percent noted in Getman 2009, but eventration rate of 4.8 percent noted in Shoemaker et al. 2004a) and vary according to the population of horses being treated (Getman 2009). Normally one would expect serious complications in less than 5 percent of horses operated under general anesthesia, but in some populations these rates have been as high as 12 percent (Shoemaker 2004a). Serious complications are generally noted within 3 or 4 hours of surgery but may occur any time within the first week following surgery (Searle et al. 1999). If they occur, they would be treated with surgical intervention when possible, or with euthanasia when there is a poor prognosis for recovery. There was no observed mortality in geldings at the Conger HMA study, and geldings retained good body condition (King et al. 2022). Vasectomized stallions may remain fertile for up to 6 weeks after surgery, so it is optimal if that treatment occurs well in advance of the season of mare fertility starting in the spring (NAS 2013). The NAS report (2013) suggested that chemical vasectomy, which has been developed for dogs and cats, may be appropriate for wild horses and burros.

For intact stallions, testosterone levels appear to vary as a function of age, season, and harem size (Khalil et al. 1998). It is expected that testosterone levels will decline over time after castration. Testosterone levels should not change due to vasectomy. Vasectomized stallions should retain their previous levels of libido. Domestic geldings had a significant prolactin response to sexual stimulation, but lacked the cortisol response present in stallions (Colborn et al. 1991). Although libido and the ability to ejaculate tends to be gradually

lost after castration (Thompson et al. 1980), some geldings continue to mount mares and intromit (Rios and Houpt 1995, Schumacher 2006).

Indirect Effects of Neutering

Other than the short-term outcomes of surgery, neutering is not expected to reduce males' survival rates. Castration is actually thought to increase survival as males are released from the cost of reproduction (Jewell 1997). In Soay sheep castrates survived longer than rams in the same cohort (Jewell 1997), and Misaki horse geldings lived longer than intact males (Kaseda et al. 1997, Khalil and Murakami 1999). Moreover, it is unlikely that a reduced testosterone level will compromise gelding survival in the wild, considering that wild mares survive with low levels of testosterone. Consistent with geldings not expending as much energy toward attempts to obtain or defend a harem, it is expected that wild geldings may have a better body condition than wild, fertile stallions. King and others (2022) noted that geldings maintained good body condition in the wild. In contrast, vasectomized males may continue to defend or compete for harems in the way that fertile males do, so they are not expected to experience an increase in health or body condition due to surgery.

Depending on whether an HMA is non-reproducing in whole or in part, reproductive stallions may or may not still be a component of the population's age and sex structure. The question of whether or not a given neutered male would or would not attempt to maintain a harem in the long run is not germane to population-level management. It is worth noting, though, that the BLM is not required to manage populations of wild horses in a manner that ensures that any given individual maintains its social standing within any given harem or band. Neutering a subset of stallions would not prevent other fertile stallions and mares from continuing with the typical range of social behaviors for sexually active adults. For fertility control strategies where gelding is intended to reduce growth rates by virtue of sterile males defending harems, the NAS (2013) suggested that the effectiveness of gelding on overall reproductive rates may depend on the pre-castration social roles of those animals. Having a post-gather herd with some neutered males and a lower fraction of fertile mares necessarily reduces the absolute number of foals born per year, compared to a herd that includes more fertile mares. An additional benefit is that geldings that would otherwise be permanently removed from the range (for adoption, sale, or other disposition) may be released back onto the range where they can engage in free-roaming behaviors.

Behavioral Effects of Neutering

Feral horses typically form bands composed of an adult male with 1 to 3 adult females and their immature offspring (Feist and McCullough 1976, Berger 1986, Roelle et al. 2010). In many populations subordinate 'satellite' stallions have been observed associating with the band, although the function of these males continues to be debated (see Feh 1999, and Linklater and Cameron 2000). Juvenile offspring of both sexes leave the band at sexual maturity (normally around two or three years of age (Berger 1986)), but adult females may remain with the same band over a span of years. Group stability and cohesion is maintained through positive social interactions and agonistic behaviors among all members, and herding and reproductive behaviors from the stallion (Ransom and Cade 2009). Group movements and consortship of a stallion with mares is advertised to other males through the group stallion marking dung piles as they are encountered, and over-marking mare eliminations as they occur (King and Gurnell 2006). Burro jacks tend to not have as stable of relations with jennies and foals, as compared to what is most often seen in horses; wild burro social structure is more typically of a fission-fusion type nature (King 2016).

In horses, males play a variety of roles during their lives (Deniston 1979): after dispersal from their natal band they generally live as bachelors with other young males, before associating with mares and developing their own breeding group as a harem stallion or satellite stallion. In any population of horses not all males will achieve harem stallion status, so all males do not have an equal chance of breeding (Asa 1999). Stallion behavior is thought to be related to androgen levels, with breeding stallions having higher androgen concentrations than bachelors (Angle et al. 1979, Chaudhuri and Ginsberg 1990, Khalil et al. 1998). A bachelor with low libido had lower levels of androgens, and two-year-old bachelors had higher testosterone levels than two-year-olds with undescended testicles who remained with their natal band (Angle et al. 1979). Vasectomized males continue to attempt to defend or gain breeding access to females. It is generally expected that vasectomized WHB will continue to behave like fertile males, given that the only physiological change in their condition is a lack of sperm in their ejaculate. If a vasectomized stallion retains a harem, the females in the harem will continue to cycle until they are fertilized by another stallion, or until the end of the breeding season. As a result, the vasectomized stallion may be involved in more aggressive behaviors to other males through the entire breeding season (Asa 1999), which may divert time from foraging and cause him to be in poorer body condition going into winter. Ultimately, this may lead to the stallion losing control of a given harem. A feral horse herd with high numbers of vasectomized stallions retained typical harem social structure (Collins and Kasbohm 2016). Again it is worth noting that the BLM is not required to manage populations of wild horses in a manner that ensures that any given individual maintains its social standing within any given harem or band.

Neutering males by gelding adult male horses is expected to result in reduced testosterone production, which is expected to directly influence reproductive behaviors (NAS 2013). However, testosterone levels alone are not a predictor of masculine behavior (Line et al. 1985, Schumacher 2006). In domestic geldings, 20-30 percent continued to show stallion-like behavior, whether castrated pre- or post-puberty (Line et al. 1985). Gelding of domestic horses most commonly takes place before or shortly after sexual maturity, and age-at-gelding can affect the degree to which stallion-like behavior is expressed later in life. In intact stallions, testosterone levels peak increase up to an age of ~4-6 years, and can be higher in harem stallions than bachelors (Khalil et al. 1998). It is assumed that free roaming wild horse geldings would generally exhibit reduced aggression toward other horses, and reduced reproductive behaviors (NAS 2013). In a herd that included some geldings and some fertile stallions, there were few behavioral differences between those groups, other than that geldings engaged in more affiliative and less marking and reproductive behaviors (King et al. 2022). The behavior of wild horse geldings in the presence of intact stallions has not otherwise been well documented, but the literature review below can be used to make reasonable inferences about their likely behaviors.

Despite livestock being managed by neutering males for millennia, there was relatively little published research on castrates' behaviors (Hart and Jones 1975) until recently. Stallion behaviors in wild or pasture settings are better documented than gelding behaviors, but inferences about how the behaviors of geldings will change, how quickly any change will occur after surgery, or what effect gelding an adult stallion and releasing him back into a wild horse population will have on his behavior and that of the wider population may be surmised from the existing literature. There was a BLM-supported study in Utah focused on the individual and population-level effects of including some geldings in a free-roaming horse population (BLM 2016, King et al. 2022). Additional inferences about likely behavioral outcomes of gelding can be made based on available literature.

The effect of castration on aggression in horses has not often been quantified. One report has noted that high levels of aggression continued to be observed in domestic horse geldings who also exhibited sexual behaviors (Rios and Houpt 1995). Stallion-like behavior in domestic horse geldings is relatively common

(Smith 1974, Schumacher 1996), being shown in 20-33 percent of cases whether the horse was castrated pre- or post-puberty (Line et al. 1985, Rios and Houpt 1995, Schumacher 2006). While some of these cases may be due to cryptorchidism or incomplete surgery, it appears that horses are less dependent on hormones than other mechanisms for the maintenance of sexual behaviors (Smith 1974). Domestic geldings exhibiting masculine behavior had no difference in testosterone concentrations than other geldings (Line et al. 1985, Schumacher 2006), and in some instances the behavior appeared context dependent (Borsberry 1980, Pearce 1980).

Dogs and cats are commonly neutered, and it is also common for them to continue to exhibit reproductive behaviors several years after castration (Dunbar 1975). Dogs, ferrets, hamsters, and marmosets continued to show sexually motivated behaviors after castration, regardless of whether they had previous experience or not, although in beagles and ferrets there was a reduction in motivation post-operatively (Hart 1968, Dunbar 1975, Dixson 1993, Costantini et al. 2007, Vinke et al. 2008). Ungulates continued to show reproductive behaviors after castration, with goats continuing to respond to females even a year later, although mating time and the ejaculatory response was reduced (Hart and Jones 1975).

The likely effects of castration on geldings' social interactions and group membership can be inferred from available literature. In a pasture study of domestic horses, Van Dierendonck and others (1995) found that social rank among geldings was directly correlated to the age at which the horse was castrated, suggesting that social experiences prior to sterilization may influence behavior afterward. Of the two geldings present in a study of semi-feral horses in England, one was dominant over the mares whereas a younger gelding was subordinate to older mares; stallions were only present in this population during a short breeding season (Tyler 1972). A study of domestic geldings in Iceland held in a large pasture with mares and sub-adults of both sexes, but no mature stallions, found that geldings and sub-adults formed associations amongst each other that included interactions such as allo-grooming and play, and were defined by close proximity (Sigurjónsdóttir et al. 2003). These geldings and sub-adults tended to remain in a separate group from mares with foals, similar to castrated Soay sheep rams (*Ovis aries*) behaving like bachelors and grouping together, or remaining in their mother's group (Jewell 1997). In Japan, Kaseda and others (1997) reported that young males dispersing from their natal harem and geldings moved to a different area than stallions and mares during the non-breeding season. Although the situation in Japan may be the equivalent of a bachelor group in natural populations, in Iceland this division between mares and the rest of the horses in the herd contradicts the dynamics typically observed in a population containing mature stallions. Sigurjónsdóttir and others (2003) also noted that in the absence of a stallion, allo-grooming between adult females increased drastically. Other findings included increased social interaction among yearlings, display of stallion-like behaviors such as mounting by the adult females, and decreased association between females and their yearling offspring (Sigurjónsdóttir et al. 2003). In the same population in Iceland the presence of geldings did not appear to affect the social behavior of mares (Van Dierendonck et al. 2009) or negatively influence parturition, mare-foal bonding, or subsequent maternal activities (Van Dierendonck et al. 2004). Additionally, the welfare of broodmares and their foals was not affected by the presence of geldings in the herd (Van Dierendonck et al. 2004). These findings are important because treated geldings will be returned to the range in the presence of pregnant mares and mares with foals of the year.

The likely effects of castration on geldings' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King and Gurnell 2005). By comparison, bachelor groups tend to be more transient, and can potentially use areas of good forage further from water sources, as they are not constrained by the needs of lactating mares in a group. The number of observations of gelded wild stallion behavior are

still too few to make general predictions about whether a particular gelded stallion individual will behave like a harem stallion, a bachelor, or form a group with geldings that may forage and water differently from fertile wild horses.

Sterilizing wild horses does not change their status as wild horses under the WFRHBA (as amended). In terms of whether geldings will continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that geldings would continue to roam unhindered once they are returned to the range. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a gelded animal would still be expected to have a number of internal reasons for moving across a landscape and, therefore, exhibiting 'free-roaming' behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that gelding wild horses will cause them to lose their free-roaming nature. It is worth noting that individual choices in wild horse group membership, home range, and habitat use are not protected under the WFRHBA. BLM acknowledges that geldings may exhibit some behavioral differences after surgery, compared to intact stallions, but those differences are not be expected to remove the geldings' rebellious and feisty nature, or their defiance of man. While it may be that a gelded horse could have a different set of behavioral priorities than an intact stallion, the expectation is that geldings will choose to act upon their behavioral priorities in an unhindered way, just as is the case for an intact stallion. In this sense, a gelded male would be just as much 'wild' as defined by the WFRHBA as any intact stallion, even if his patterns of movement differ from those of an intact stallion. Unpublished USGS results from the Conger study herd indicate that geldings' movement patterns were not qualitatively different from those of fertile stallions, when controlling for social status as bachelor or harem stallion. Congress specified that sterilization is an acceptable management action (16 U.S.C. §1333.b.1). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 U.S.C. §1333.2.C.d). Several academics have offered their opinions about whether gelding a given stallion would lead to that individual effectively losing its status as a wild horse (Rutberg 2011, Kirkpatrick 2012, Nock 2017). Those opinions are based on a semantic and subjective definition of 'wild,' while BLM must adhere to the legal definition of what constitutes a wild horse, based on the WFRHBA (as amended). Those individuals have not conducted any studies that would test the speculative opinion that gelding wild stallions will cause them to become docile. BLM is not obliged to base management decisions on such opinions, which do not meet the BLM's principle and practice to "Use the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al. 2015).

Mare Sterilization

Sterilizing mares has already been shown to be an effective part of feral horse management that reduced herd growth rates on Federal lands (Collins and Kasbohm 2016). Herd-level birth rate is expected to decline in direct proportion to the fraction of spayed mares in the herd because spayed mares cannot become pregnant. A number of methods are available, with potentially differing effects.

Current Methods of Sterilization

This literature review of mare sterilization impacts focuses on 4 methods: pharmacological or immunocontraceptive methods, minimally invasive physical sterilization, ovariectomy via colpotomy, and ovariectomy via flank laparoscopy. The range of anticipated effects may be both physical and behavioral. Whether or not surgical mare sterilization methods are considered in any of the action alternatives in this EA, they are included here for comparison and for the sake of completeness in the review.

Pharmacological or immunocontraceptive sterilization methods would use a drug or vaccine to cause sterilization. BLM has not yet identified a pharmacological or immunocontraceptive method to sterilize mares that has been proven to reliably and humanely sterilize wild horse mares. However, there is the possibility that current or future development and testing of new methods could make an injectable sterilant available for wild horse mares. An oocyte growth factor OGF vaccine is currently under testing, for its ability to cause long-term infertility or, potentially, sterility (BLM 2020, Bruemmer et al. 2023). Mares that received 5 or more doses of ZonaStat-H vaccine have been shown to have reduced ovarian function, and to be effectively infertile for life (Nuñez et al. 2017), and it is conceivable that the contraceptive effects of repeated treatment with GonaCon-Equine may last longer than a mare's lifespan, depending on the mare's age at treatment and the number of doses received (Baker et al. 2018). While the physiological effects of various potential methods may differ, the herd-level effects of having sterile mares as a part of a wild horse herd would be expected to be similar for minimally invasive and surgical methods. Salient differences in individual breeding behavior that result from either retaining functioning ovaries, or having no or reduced ovarian function, are discussed below.

Minimally Invasive Mare Sterilization Procedures

Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000), such as with spaying and neutering. For the purposes of this EA, 'minimally invasive sterilization' is defined to be the minimally invasive sterilization of a female horse (mare) by physical means. The physical means considered here include forms of oviduct blockage; for the purposes of this analysis, these are considered minimally invasive insofar as no incisions are required. Unlike in dog and cat spaying, these minimally invasive forms of mare sterilization do not entail removal of the ovaries or uterus. Only healthy mares in BCS score of 3 or greater would be considered.

The specific minimally invasive sterilization procedures could include any form of procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy, but that does not entail incision by scalpel. The two transcervical procedures analyzed below are physical, minimally invasive sterilization methods that cause long-term blockage of the oviduct, so that fertile eggs cannot go from the ovaries to the uterus. A detailed analysis of those methods and their expected effects is included in Appendix D.

As is the case for IUDs, candidate mares for minimally invasive sterilization procedure treatment would need to be screened by a veterinarian to ensure they are not pregnant, because any transcervical procedures can cause a pregnancy to terminate. If palpation or ultrasound indicate that the mare is pregnant, then that mare would not be considered for the minimally invasive sterilization procedure.

One form of minimally invasive oviduct blockage procedure, "endoscopic oviduct ablation," infuses medical-grade N-butyl cyanoacrylate glue into the oviduct (Bigolin et al. 2009). In the procedure, the veterinarian passes an endoscope through the cervix, to visualize the interior of the uterus. Treated mares would stand in a padded, hydraulic chute. Banamine may be administered intravenously prior to the procedure to minimize transient colic (abdominal cramping) following the procedure. Ketamine may be added on an as needed basis for additional standing chemical restraint. Fecal material is removed from the rectum, the tail is wrapped and suspended, the perineal and vaginal areas are cleansed. A sterilized, flexible endoscope would be placed into the vaginal vault and advanced through the cervix in an atraumatic manner. A veterinary team is required to manipulate and operate the endoscope monitor, insert and hold the endoscope, manipulate and position the fine-tipped catheter into the oviduct, and infuse the fluid into the oviduct. The uterus would be partially inflated with filtered room air to visualize the oviduct papilla located at the proximal end of the uterine horn. A sterile catheter is guided to each uterotubal junction (which is the

entrance to the oviduct), and medical-grade glue (N-butyl cyanoacrylate) is introduced to the oviduct, where it causes blockage. After the procedure, the uterus could be infused with an antibiotic and saline to minimize the potential for infection secondary to any unintended bacterial contamination. The mares are monitored initially for 10 minutes and observed by a veterinarian twice per day for 10-14 days, but no further pain management is expected to be needed. Any mare showing signs of postoperative complications would receive treatment as indicated by a veterinarian. The total duration of the procedure per mare is expected to be less than 30 minutes. A pilot project used this approach in six domestic mares and has shown that after three years of breeding by a fertile stallion, all six mares remained infertile (Dr. I. Liu, University of California (UC) Davis Emeritus Professor, personal communication to BLM) (Liu 2018). After receiving support from the California legislature (California Legislature 2019), researchers used a similar method in burros but with electrocauterization of the utero-tubular junction; a five-person team completed the procedure in 20-30 minutes total (Dr. E. Davis, UC Davis, 2021 personal communication to BLM). Another form of minimally invasive oviduct blockage procedure, "endoscopic laser ablation of the oviduct papilla," is similar to the procedure described above, except that the oviducts are blocked via heating from a laser to ablate the oviduct papilla. The diode laser is expected to immediately "seal" the oviduct opening and the resulting inflammatory reaction is expected to result in additional scar tissue formation, forming a barrier to the passage of eggs from the ovary to the uterus. Local anesthesia could be dripped directly onto each oviduct papilla to minimize any discomfort. This method has been used successfully in Georgia (Edwards et al. 2021).

Neither of these minimally invasive procedures damages the ovaries. The mare would be sterile, although the mare would continue to have estrus cycles. Because of the retention of estrus cycles, it is expected that behavioral outcomes of either method would be similar to those observed for PZP vaccine treated mares. Namely, mares would continue with hormonal cycles and associated breeding behaviors during the typical breeding season.

If the minimally invasive sterilization techniques are either of the two noted above, then mares chosen for the minimally invasive sterilization procedure could include adult females and immature females estimated to be older than 8 months. Immature females could be included because there are no concerns regarding space for instruments, as an endoscope and associated instruments used along with the endoscope are the only tools used, and only open (non-pregnant) females would receive the procedure.

Minimally invasive, physical sterilization procedure could include any physical form of sterilization that does not involve removal of the ovaries and entails only minimal or no incisions. Such procedures could include any form of physical procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy. For example, in endoscopic oviduct ablation, minimally invasive sterilization causes a long-term blockage of the oviduct by infusion of a surgical-grade glue into the oviducts, so that fertile eggs cannot go from the ovaries to the uterus (Bigolin et al. 2009). Or, in endoscopic laser ablation of the oviduct papilla, scarring caused by heat applied at the uterotubal junction prevents eggs from reaching the uterus (Edwards et al. 2021). These two procedures use trans-cervical endoscopy, so any treated mares would first need to have been screened by a veterinarian (e.g., using trans-rectal ultrasonography) to ensure they are not pregnant. Endoscopic approaches also require temporary insufflation of the uterus, to allow the veterinarian to fully visualize the internal structures. The result of such minimally invasive procedures that prevent pregnancy but do not harm the ovaries is that the mare would be sterile, although the mare would continue to have estrus cycles.

Ovariectomy via colpotomy is a surgical technique in which there is no external incision, reducing susceptibility to infection. Ovariectomy via colpotomy, has been an established veterinary technique since

1903 (Loesch and Rodgerson 2003, NAS 2013). Spaying via colpotomy has the advantage of not leaving any external wound that could become infected. For this reason, it has been identified as a good choice for sterilization of feral or wild mares (Rowland et al. 2018). The procedure has a relatively low complication rate, although post-surgical mortality and morbidity are possible, as with any surgery. For this reason, ovariectomy via colpotomy has been identified as a good choice for feral or wild horses (Rowland et al. 2018). Ovariectomy via colpotomy is a relatively short surgery, with a relatively quick expected recovery time. In 1903, Williams first described a vaginal approach, or colpotomy, using an ecraseur to ovariectomize mares (Loesch and Rodgerson 2003). The ovariectomy via colpotomy procedure has been conducted for over 100 years, normally on open (non-pregnant), domestic mares. It is expected that the surgeon should be able to access ovaries with ease in mares that are in the early- or mid-stage of pregnancy. The anticipated risks associated with the pregnancy are described below. When wild horses are gathered or trapped for fertility control treatment there would likely be mares in various stages of gestation. Removal of the ovaries is permanent and 100 percent effective, however the procedure is not without risk.

Ovariectomy via flank laparoscopy (Lee and Hendrickson 2008, Devick et al. 2018, Easley et al. 2018) is commonly used in domestic horses for application in mares due to its minimal invasiveness and full observation of the operative field. Ovariectomy via flank laparoscopy was seen as the lowest risk method considered by a panel of expert reviewers convened by USGS (Bowen 2015). In a review of unilateral and bilateral laparoscopic ovariectomy on 157 mares, Röcken and others (2011) found that 10.8 percent of mares had minor post-surgical complications, and recorded no mortality. Mortality due to this type of surgery, or post-surgical complications, is not expected, but is a possibility. In two studies, ovariectomy by laparoscopy or endoscope-assisted colpotomy did not cause mares to lose weight, and there was no need for rescue analgesia following surgery (Pader et al. 2011, Bertin et al. 2013). This surgical approach entails three small incisions on the animal's flank, through which three cannulae (tubes) allow entry of narrow devices to enter the body cavity: these are the insufflator, endoscope, and surgical instrument. The surgical procedure involves the use of narrow instruments introduced into the abdomen via cannulae for the purpose of transecting or sealing (Easley 2018) the ovarian pedicle, but the insufflation should allow the veterinarian to navigate inside the abdomen without damaging other internal organs. The insufflator blows air into the cavity to increase the operating space between organs, and the endoscope provides a video feed to visualize the operation of the surgical instrument. This procedure can require a relatively long duration of surgery but tends to lead to the lowest post-operative rates of complications. Flank laparoscopy may leave three small (<5 cm) visible scars on one side of the horse's flank, but even in performance horses these scars are considered minimal. It is expected that the tissues and musculature under the skin at the site of the incisions in the flank will heal quickly, leaving no long-lasting effects on horse health. Monitoring for up to two weeks at the facility where surgeries take place will allow for veterinary inspection of wound healing. The ovaries may be dropped into the abdomen, but this is not expected to cause any health problem; it is usually done in ovariectomies in cattle (e.g., the Willis Dropped Ovary Technique) and Shoemaker and others (2004b) found no problems with revascularization or necrosis in a study of young horses using this method.

Effects of Sterilization on Pregnancy and Foal

The physical, behavioral, and herd-level effects of immunocontraceptives have been addressed elsewhere in this review. In the case of repeated PZP vaccine or GonaCon applications that cause infertility through the duration of a given mare's life, the effects of that form of treatment have been discussed previously; neither vaccine appears to disrupt pregnancy or foal development. OGF vaccine effects on fetal development are unknown, as no pregnant mares have been injected with this vaccine to date; use on pregnant mares may be limited until further information is available.

Transcervical, minimally invasive sterilization methods are not suitable for pregnant mares, because disruption of the cervix may lead to termination of the pregnancy. Therefore, any mares under consideration for such methods must first be screened for pregnancy, such as via transrectal ultrasound.

The average mare gestation period ranges from 335 to 340 days (Evans et al. 1977, p. 373). There are few peer reviewed studies documenting the effects of surgical ovariectomy on the success of pregnancy in a mare. A National Research Council of the National Academies of Sciences (NAS) committee that reviewed research proposals in 2015 explained, "The mare's ovaries and their production of progesterone are required during the first 70 days of pregnancy to maintain the pregnancy" (NAS 2015). In female mammals, less progesterone is produced when ovaries are removed, but production does not cease (Webley and Johnson 1982). In 1977, Evans and others stated that by 200 days, the secretion of progesterone by the corpora lutea is insignificant because removal of the ovaries does not result in abortion (p. 376). "If this procedure were performed in the first 120 days of pregnancy, the fetus would be resorbed or aborted by the mother. If performed after 120 days, the pregnancy should be maintained. The effect of ovary removal on a pregnancy at 90–120 days of gestation is unpredictable because it is during this stage of gestation that the transition from corpus luteum to placental support typically occurs" (NAS 2015). In 1979, Holtan and others evaluated the effects of bilateral ovariectomy at selected times between 25 and 210 days of gestation on 50 mature pony mares. Their results show that abortion (resorption) of the conceptus (fetus) occurred in all 14 mares ovariectomized before day 50 of gestation, that pregnancy was maintained in 11 of 20 mares after ovariectomy between days 50 and 70, and that pregnancy was not interrupted in any of 12 mares ovariectomized on days 140 to 210. Those results are similar to the suggestions of the NAS committee (2015). For those pregnancies that are maintained following an ovariectomy procedure, likely those past approximately 120 days, the development of the foal is not expected to be affected. However, because this procedure is not commonly conducted on pregnant mares the rate of complications to the fetus has not yet been quantified. There is the possibility that entry to the abdominal cavity could cause premature births related to inflammation. However, after five months the placenta should hormonally support the pregnancy regardless of the presence or absence of ovaries. Gestation length was similar between ovariectomized and control mares (Holtan et al. 1979).

Direct Effects of Sterilization

The direct effects of immunocontraceptive PZP vaccines and GonaCon-Equine have been discussed previously. In cases where PZP vaccines have been administered enough times to cause effective sterility, the mechanism of action may be related to long-term reduction in ovarian activity (Nolan et al. 2018c). The direct effects of OGF vaccine treatment were discussed by BLM (2020) and may include an injection site reaction that is comparable to that of GonaCon-Equine; a brief period of heightened inflammation and mild fever that is characteristic of a successful immune response; development of an immune response against GDF9 and BMP15, with related reductions in the concentration of those proteins; and a reduction in estrus activity.

The direct effects of successful minimally invasive mare sterilization procedures are sterility, for example through occlusion of the oviduct with surgical glue and associated tissue damage, or creation of scar tissue in part of the oviduct. Hysteroscopy is a common procedure in humans (WebMD 2014). Because such minimally invasive procedures do not involve major incisions or removal of ovaries, there is no risk of hemorrhage, failure of sutures, or prolonged discomfort. There is the potential for mild, transient colic (abnormal cramping) after the procedure due to temporary inflation and expansion of the uterus. Use of analgesics prior to any procedure should minimize this incidence. Side effects of minimally invasive sterilization procedures may include mild discomfort in the short term, for example at the location where the oviduct is blocked. For

example, if surgical grade glue is placed in the oviduct or if a laser is used to ablate the oviduct papilla, that may cause transient irritation. For this reason, systemic and/or topical analgesics are generally provided before or during the procedure. An NAS review of the endoscopic laser ablation of the oviduct papilla technique concluded that the method is relatively non-invasive, with a relatively low risk of complications (NAS 2015); the expected severe complication rate for the laser ablation procedure may be lower than 1 percent. Ablation of the oviduct via cyanoacrylate glue has been performed successfully in mares at UC Davis, and laser ablation of the oviduct papilla has been performed successfully in burros and horses, in California and Georgia. In addition, other transcervical endoscopic procedures (including the use of a laser diode) are not uncommon in mares (Blikslager et al. 1993, Griffin and Bennet 2002, Ley et al. 2002, Brinsko 2014).

Between 2009 and 2011, the Sheldon NWR in Nevada conducted ovariectomy via colpotomy surgeries (August through October) on 114 feral mares and released them back to the range with a mixture of sterilized stallions and untreated mares and stallions (Collins and Kasbohm 2016). Gestational stage was not recorded, but a majority of the mares were pregnant (Gail Collins, US Fish and Wildlife Service (USFWS), pers. comm. (pers. comm. found in Bowen 2015). Only a small number of mares were very close to full term. Those mares with late term pregnancies did not receive surgery as the veterinarian could not get good access to the ovaries due to the position of the foal (Gail Collins, USFWS, pers. comm., see Bowen 2015). After holding the mares for an average of 8 days after surgery for observation, they were returned to the range with other treated and untreated mares and stallions (Collins and Kasbohm 2016). During holding the only complications were observed within 2 days of surgery. The observed mortality rate for ovariectomized mares following the procedure was less than 2 percent (Collins and Kasbohm 2016, Pielstick pers. comm. (pers. comm. found in Bowen 2015)). During the Sheldon NWR ovariectomy study, mares generally walked out of the chute and started to eat; some would raise their tail and act as if they were defecating; however, in most mares one could not notice signs of discomfort (Bowen 2015). In their discussion of ovariectomy via colpotomy, McKinnon and Vasey (2007) considered the procedure safe and efficacious in many instances, able to be performed expediently by personnel experienced with examination of the female reproductive tract, and associated with a complication rate that is similar to or less than male castration. Nevertheless, all surgery is associated with some risk. Loesch and others (2003) list the following potential risks with colpotomy: pain and discomfort; injuries to the cervix, bladder, or a segment of bowel; delayed vaginal healing; eventration of the bowel; incisional site hematoma; intraabdominal adhesions to the vagina; and chronic lumbar or bilateral hind limb pain. Most horses, however, tolerate ovariectomy via colpotomy with very few complications, including feral horses (Collins and Kasbohm 2016). Evisceration is also a possibility, but these complications are considered rare (Prado and Schumacher 2017). Mortality due to surgery or post-surgical complications is not anticipated, but it is a possibility and, therefore, every effort would be made to mitigate risks.

In September 2015, the BLM solicited the USGS to convene a panel of veterinary experts to assess the relative merits and drawbacks of several surgical ovariectomy techniques that are commonly used in domestic horses for potential application in wild horses. A table summarizing the various methods was sent to the BLM (Bowen 2015) and provides a concise comparison of several methods. Of these, ovariectomy via colpotomy was found to be relatively safe when practiced by an experienced surgeon and was associated with the shortest duration of potential complications after the operation. The panel discussed the potential for evisceration through the vaginal incision with this procedure. In marked contrast to a suggestion by the NAS report (2013), this panel of veterinarians identified evisceration as not being a probable risk associated with ovariectomy via colpotomy and “none of the panel participants had had this occur nor had heard of it actually occurring” (Bowen 2015).

Most ovariectomy surgeries on mares have low morbidity[10] and, with the help of medications, pain and discomfort can be mitigated. Pain management is an important aspect of any ovariectomy (Rowland et al. 2018); according to surgical protocols that would be used, a long-lasting direct anesthetic would be applied to the ovarian pedicle, and systemic analgesics in the form of butorphanol and flunixin meglumine would be administered, as is compatible with accepted animal husbandry practices. In a study of the effects of bilateral ovariectomy via colpotomy on 23 mares, Hooper and others (1993) reported that postoperative problems were minimal (1 in 23, or 4 percent). Hooper and others (1993) noted that four other mares were reported by owners as having some problems after surgery, but that evidence as to the role the surgery played in those subsequent problems was inconclusive. In contrast Röcken and others (2011) noted a morbidity of 10.8 percent for mares that were ovariectomized via a flank laparoscopy. "Although 5 mares in our study had problems (repeated colic in 2 mares, signs of lumbar pain in 1 mare, signs of bilateral hind limb pain in 1 mare, and clinical signs of peritonitis in 1 mare) after surgery, evidence is inconclusive in each as to the role played by surgery" (Hooper et al. 1993). A recent study showed a 2.5 percent complication rate where one mare of 39 showed signs of moderate colic after laparoscopic ovariectomy (Devick et al. 2018).

Behavioral Effects of Mare Sterilization

All fertility control methods affect physiology or behavior of a mare (NAS 2013). Any action taken to alter the reproductive capacity of an individual has the potential to affect hormone production and therefore behavioral interactions and ultimately population dynamics in unforeseen ways (Ransom et al. 2014bb). The health and behavioral effects of sterilizing wild horse mares that live with other fertile and infertile wild horses has not been well documented, but the literature review below can be used to make reasonable inferences about their likely behaviors.

The behavioral effects of PZP vaccines and GonaCon-Equine have been discussed previously. For the OGF vaccine, a paired immune reaction to two proteins (GDF9 and BMP15) can prevent the completion of oocyte development, with the result being that successfully treated mares do not exhibit estrus cycles (Bruemmer et al. 2023). As a result, the behavioral and herd-level effects of OGF vaccine treatment are expected to be similar to those documented for GonaCon-Equine; namely, a reduced incidence of breeding behaviors, but a continuation of affiliative behaviors within the social band (see previous discussion of effects of GonaCon-Equine).

Horses are anovulatory (do not ovulate/express estrous behavior) during the short days of late fall and early winter, beginning to ovulate as days lengthen and then cycling roughly every 21 days during the warmer months, with about 5 days of estrus (Asa et al. 1979, Crowell-Davis 2007). Estrus in mares is shown by increased frequency of proceptive behaviors: approaching and following the stallion, urinating, presenting the rear end, clitoral winking, and raising the tail towards the stallion (Asa et al. 1979, Crowell-Davis 2007). In most mammal species, other than primates, estrus behavior is not shown during the anovulatory period, and reproductive behavior is considered extinguished following spaying (Hart and Eckstein 1997). However mares may continue to demonstrate estrus behavior during the anovulatory period (Asa et al. 1980b).

The behavioral effects of minimally invasive mare sterilization methods that cause no change in ovarian functionality would be expected to be similar to those observed in mares treated with a small number of doses of PZP vaccine (i.e., those in which ovarian functionality is not impaired). Those behavioral outcomes are discussed previously, but include a continuation of estrus cycling, and associated proceptive and breeding behaviors, including copulation. As a result of the expectation that the minimally invasive procedures

[10] Morbidity is defined as the frequency of the appearance of complications following a surgical procedure or other treatment. In contrast, mortality is defined as an outcome of death due to the procedure.

would have similar behavioral effects as treatment with PZP, BLM does not anticipate any need to study the behavioral effects of minimally invasive mare sterilization, in which functional ovaries are retained. Sterile mares with functional ovaries would be expected to continue to engage in breeding activities, although they would not become pregnant. There is the possibility that such mares may change social bands at a greater rate than fertile mares (e.g., Nuñez et al. 2017).

Ovariectomized mares may continue to exhibit estrous behavior (Scott and Kunze 1977, Kamm and Hendrickson 2007, Crabtree 2016), with one study finding that 30 percent of mares showed estrus signs at least once after surgery (Roessner et al. 2015) and only 60 percent of ovariectomized mares cease estrous behavior following surgery (Loesch and Rodgerson 2003). Mares continue to show reproductive behavior following ovariectomy due to non-endocrine support of estrus behavior, specifically steroids from the adrenal cortex. Continuation of this behavior during the non-breeding season has the function of maintaining social cohesion within a horse group (Asa et al. 1980b, Asa et al. 1984, NAS 2013). This may be a unique response of the horse (Bertin et al. 2013), as spaying usually greatly reduces female sexual behavior in companion animals (Hart and Eckstein 1997). In six ponies, mean monthly plasma luteinizing hormone[11] levels in ovariectomized mares were similar to intact mares during the anestrous season, and during the breeding season were similar to levels in intact mares at mid-estrus (Garcia and Ginther 1976).

The likely effects of spaying on mares' social interactions and group membership can be inferred from available literature, even though wild horses have rarely been spayed and released back into the wild, resulting in few studies that have investigated their behavior in free-roaming populations. Wild horses and burros are instinctually herd-bound and this behavior is expected to continue. Overall the BLM anticipates that some spayed mares may continue to exhibit estrus behavior that could foster band cohesion. If free-ranging ovariectomized mares show estrous behavior and occasionally allow copulation, interest of the stallion may be maintained, which could foster band cohesion (NAS 2013). This last statement could be validated by the observations of group associations on the Sheldon NWR where feral mares were ovariectomized via colpotomy and released back on to the range with untreated horses of both sexes (Collins and Kasbohm 2016). No data were collected on inter- or intra-band behavior (e.g., estrous display, increased tending by stallions, etc.); during multiple aerial surveys in years following treatment, all treated individuals appeared to maintain group associations, and there were no groups consisting only of treated males or only of treated females (Collins and Kasbohm 2016). In addition, of solitary animals documented during surveys, there were no observations of solitary treated females (Collins and Kasbohm 2016). These data help support the expectation that ovariectomized mares would not lose interest in or be cast out of the social dynamics of a wild horse herd. As noted by the NAS (2013), the ideal fertility control method would not eliminate sexual behavior or change social structure substantially.

A study conducted for 15 days in January 1978 (Asa et al. 1980a), compared the sexual behavior in ovariectomized and seasonally anovulatory (intact) pony mares and found that there were no statistical differences between the two conditions for any measure of proceptivity or copulatory behavior, or days in estrous. This may explain why treated mares at Sheldon NWR continued to be accepted into harem bands; they may have been acting the same as a non-pregnant mare. Five to ten percent of pregnant mares exhibit estrous behavior (Crowell-Davis 2007). Although the physiological cause of this phenomenon is not fully understood (Crowell-Davis 2007), it is thought to be a bonding mechanism that assists in the maintenance of stable social groups of horses year-round (Ransom et al. 2014b). The complexity of social behaviors among free-roaming horses is not entirely centered on reproductive receptivity, and fertility control treatments that

[11] Luteinizing hormone (LH) is a glycoprotein hormone produced in the pituitary gland. In females, a sharp rise of LH triggers ovulation and development of the corpus luteum. LH concentrations can be measured in blood plasma.

suppress the reproductive system and reproductive behaviors should contribute to minimal changes to social behavior (Ransom et al. 2014b, Collins and Kasbohm 2016).

The BLM expects that wild horse harem structures would continue to exist under the proposed action because fertile mares, stallions, and their foals would continue to be a component of the herd. It is not expected that spaying a subset of mares would significantly change the social structure or herd demographics (age and sex ratios) of fertile wild horses.

'Foal stealing,' where a near-term pregnant mare steals a neonate foal from a weaker mare, is unlikely to be a common behavioral result of including sterilized mares in a wild horse herd, no matter the method of sterilization. McDonnell (2012) noted that "foal stealing is rarely observed in horses, except under crowded conditions and synchronization of foaling," such as in horse feed lots. Those conditions are not likely in the wild, where pregnant mares will be widely distributed across the landscape, and where the expectation is that parturition dates would be distributed across the normal foaling season.

Indirect Effects of Mare Sterilization

The free-roaming behavior of wild horses is not anticipated to be affected by mare sterilization, as the definition of free-roaming is the ability to move without restriction by fences or other barriers within an HMA (BLM 2010), and there are no permanent physical barriers being proposed.

In domestic animals, sterilization is often associated with weight gain and associated increase in body fat (Fettman et al. 1997, Becket et al. 2002, Jeusette et al. 2006, Belsito et al. 2009, Reichler 2009, Camara et al. 2014). Spayed cats had a decrease in fasting metabolic rate, and spayed dogs had a decreased daily energy requirement, but both had increased appetite (O'Farrell and Peachey 1990, Hart and Eckstein 1997, Fettman et al. 1997, Jeusette et al. 2004). In wild horses, contracepted mares tend to be in better body condition than mares that are pregnant or that are nursing foals (Nuñez et al. 2010); the same improvement in body condition is likely to take place in spayed mares. In horses, surgical sterilization through ovariectomy has the potential to increase risk of equine metabolic syndrome (leading to obesity and laminitis), but both blood glucose and insulin levels were similar in mares before and after ovariectomy over the short term (Bertin et al. 2013). In wild horses the quality and quantity of forage, and frequent exercise, is unlikely to be sufficient to promote over-eating and obesity.

Coit and others (2009) demonstrated that spayed dogs have elevated levels of LH-receptor and GnRH-receptor mRNA in the bladder tissue, and lower contractile strength of muscles. They noted that urinary incontinence occurs at elevated levels in spayed dogs and in post-menopausal women. Thus, it is reasonable to suppose that some ovariectomized mares could also suffer from elevated levels of urinary incontinence.

Sterilization had no effect on movements and space use of feral cats or brushtail possums (Ramsey 2007, Guttilla and Stapp 2010), or greyhound racing performance (Payne 2013). Rice field rats (*Rattus argentiventer*) tend to have a smaller home range in the breeding season, as they remain close to their litters to protect and nurse them. When surgically sterilized, rice field rats had larger home ranges and moved further from their burrows than hormonally sterilized or fertile rats (Jacob et al. 20088). Spayed possums and foxes (*Vulpes vulpes*) had a similar core range area after spay surgery compared to before, and were no more likely to shift their range than intact females (Saunders et al. 2002, Ramsey 2007).

The likely effects of sterilization on mares' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and

varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King and Gurnell 2005). It is unlikely that sterilized mares will change their spatial ecology, but not having constraints of gestation and lactation may mean they can spend more time away from water sources and increase their home range size. Lactating mares need to drink every day, but during the winter when snow can fulfill water needs or when not lactating, horses can traverse a wider area (Feist and McCullough 1976, Salter 1979). During multiple aerial surveys in years following the mare ovariectomy study at the Sheldon NWR, it was documented that all treated individuals appeared to maintain group associations, no groups consisted only of treated females, and none of the solitary animals observed were treated females (Collins and Kasbohm 2016). Given that treated females maintained group associations, this indicates that their movement patterns and distances may be unchanged.

Sterilizing wild horses does not change their status as wild horses under the WFRHBA (as amended). In terms of whether sterile mares would continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that sterile mares would continue to roam unhindered. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a sterilized animal would still be expected to have a number of internal reasons for moving across a landscape and, therefore, exhibiting 'free-roaming' behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that spaying wild horses will cause them to lose their free-roaming nature.

In this sense, a sterilized wild mare would be just as much 'wild' as defined by the WFRHBA as any fertile wild mare, even if that mare's patterns of movement did differ slightly. Congress specified that sterilization is an acceptable management action (16 U.S.C. §1333.b.1). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 U.S.C. §1333.2.C.d). As noted in the discussion of neutering, any opinions based on a semantic and subjective definition of what constitutes a 'wild' horse are not legally binding for BLM, which must adhere to the legal definition of what constitutes a wild free-roaming horse[12], based on the WFRHBA (as amended). The BLM is not obliged to base management decisions on personal opinions, which do not meet the BLM's principle and practice to "Use the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al. 2015).

Sterilization is not expected to reduce mare survival rates on public rangelands. Individuals receiving fertility control often have reduced mortality and *increased* longevity due to being released from the costs of reproduction (Kirkpatrick and Turner 2008). Similar to contraception studies, in other wildlife species a common trend has been higher survival of sterilized females (Twigg et al. 2000, Saunders et al. 2002, Ramsey 2005, Jacob et al. 2008, Seidler and Gese 2012). Observations from the Sheldon NWR provide some insight into long-term effects of ovariectomy on feral horse survival rates. The sterilized mares in Sheldon NWR were returned to the range along with untreated mares. Between 2007 and 2014, mares were captured, a portion treated, and then recaptured. There was a minimum of 1 year between treatment and recapture; some mares were recaptured a year later and some were recaptured several years later. The long-term survival rate of treated wild mares appears to be the same as that of untreated mares (Collins and Kasbohm 2016). Recapture rates for released mares were similar for treated mares and untreated mares.

[12] "Wild free-roaming horses and burros" means all unbranded and unclaimed horses and burros on public lands of the United States.

Effects on Bone Histology

There is no known mechanism by which bone development would change in mares treated with pharmacological or immunological sterilization methods, or with minimally invasive sterilization methods. The BLM knows of no scientific, peer-reviewed literature that documents bone density loss in mares following ovariectomy. A concern has been raised in an opinion article (Nock 2013) that ovary removal in mares could lead to bone density loss. That opinion article was not peer reviewed nor was it based on research in wild or domestic horses, so it does not meet the BLM's standard for "best available science" on which to base decisions (Kitchell et al. 2015). Hypotheses that are forwarded in Nock (2013) appear to be based on analogies from modern humans leading sedentary lives. Post-menopausal women appear to have a greater chance of developing osteoporosis (Scholz-Ahrens et al. 1996), but BLM is not aware of any research examining bone loss in horses following ovariectomy. Bone loss in humans has been linked to reduced circulating estrogen. There have been conflicting results when researchers have attempted to test for an effect of reduced estrogen on animal bone loss rates in animal models; all experiments have been on laboratory animals, rather than free-ranging wild animals. While some studies found changes in bone cell activity after ovariectomy leading to decreased bone strength (Jerome et al. 1997, Baldock et al. 1998, Huang et al. 2002, Sigrist et al. 2007), others found that changes were moderate and transient or minimal (Scholz-Ahrens et al. 1996, Lundon et al. 1994, Zhang et al. 2007), and even returned to normal after 4 months (Sigrist et al. 2007).

Consistent and strenuous use of bones, for instance using jaw bones by eating hard feed, or using leg bones by travelling large distances, may limit the negative effects of estrogen deficiency on micro-architecture (Mavropoulos et al. 2014). The effect of exercise on bone strength in animals has been known for many years and has been shown experimentally (Rubin et al. 2001). Dr. Simon Turner, Professor Emeritus of the Small Ruminant Comparative Orthopaedic Laboratory at Colorado State University, conducted extensive bone density studies on ovariectomized sheep, as a model for human osteoporosis. During these studies, he did observe bone density loss on ovariectomized sheep, but those sheep were confined in captive conditions, fed twice a day, had shelter from inclement weather, and had very little distance to travel to get food and water (Simon Turner, Colorado State University Emeritus, written comm., 2015). Dr. Turner indicated that an estrogen deficiency (no ovaries) could potentially affect a horse's bone metabolism, just as it does in sheep and human females when they lead a sedentary lifestyle, but indicated that the constant weight bearing exercise, coupled with high exposure to sunlight ensuring high vitamin D levels, are expected to prevent bone density loss Ho).

Home range size of horses in the wild has been described as 4.2 to 30.2 square miles (Green and Green 1977) and 28.1 to 117 square miles (Miller 1983). A study of distances travelled by feral horses in "outback" Australia shows horses travelling between 5 and 17.5 miles per 24-hour period (Hampson et al. 2010a), and travelling about 11 miles a day even in a very large paddock (Hampson et al. 2010b). Thus extensive movement patterns of wild horses are expected to help prevent bone loss. The expected daily movement distance would be far greater in the context of larger pastures typical of BLM long-term holding facilities in off-range pastures. A horse would have to stay on stall rest for years after removal of the ovaries in order to develop osteoporosis (Simon Turner, Colorado State University Emeritus, written comm., 2015), and that condition does not apply to any wild horses turned back to the range or any wild horses that go into off-range pastures.

Genetic Effects of Mare Sterilization and Neutering

It is true that spayed females and neutered males are unable to contribute to the genetic diversity of the herd. The BLM is not obligated to ensure that any given individual in a herd has the chance to sire a foal and pass on genetic material. Management practices in the BLM Wild Horse and Burro Management Handbook (2010) include measures to increase population genetic diversity in reproducing herds where monitoring reveals a cause for concern about low levels of observed heterozygosity. These measures include increasing the sex ratio to a greater percentage of fertile males than fertile females (and thereby increasing the number of males siring foals), and bringing new animals into a herd from elsewhere.

In a hypothetical herd that is managed to be entirely non-reproducing, it would not be a concern to maintain genetic diversity because the management goal would be that animals in such a herd would not breed.

In reproducing herds where large numbers of wild horses have recent and/or an ongoing influx of breeding animals from other areas with wild or feral horses, spaying and neutering is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright 1931) or by introducing new potential breeding animals (Mills and Allendorf 1996). The NAS report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual herd management area or complex. Also, there is no Bureau-wide policy that requires BLM to allow each female in a herd to reproduce before treatment with contraceptives. Introducing 1-2 mares every generation (about every 10 years) is a standard management technique that can alleviated potential inbreeding concerns (BLM 2010). The NAS report (2013) recommended that managed herds of wild horses would be better viewed as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements.

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM. As a result, most alleles that are present in any given mare are likely to already be well represented in that mare's siblings, cousins, and more distant relatives on the HMA. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NAS 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from domestic breeds. The NAS report (2013) includes information (pairwise genetic 'fixation index' values for sampled WHB herds) confirming that WHB in the vast majority of HMAs are genetically similar to animals in multiple other HMAs. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al. 2006). Based on a population model, Gross (2000) found that a strategy to preferentially treat young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals, or a strategy with periodic gathers and removals.

Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low

starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Although those results are specific to mares, some inferences about potential effects of stallion sterilization may also be made from their results. Roelle and Oyler-McCance (2015) showed that the risk of the loss of genetic heterozygosity is extremely low except in cases where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5 percent per year), and very large fractions of the population are permanently sterilized. Given that 94 of 102 wild horse herds sampled for genetic diversity did not meet a threshold for concern (NAS 2013), the starting level of genetic diversity in most wild-horse herds is relatively high.

In a breeding herd where more than 85 percent of males in a population are sterile, there could be genetic consequences of reduced heterozygosity and increased inbreeding coefficients, as it would potentially allow a very small group of males to dominate the breeding (e.g., Saltz et al. 2000). Such genetic consequences could be mitigated by natural movements or human-facilitated translocations (BLM 2010). Garrott and Siniff's (1992) model predicts that gelding 50-80 percent of mature males in the population would result in reduced, but not halted, mare fertility rates. However, neutering males tends to have short-lived effects, because within a few years after any male sterilization treatment, a number of fertile male colts would become sexually mature stallions who could contribute genetically to the herd.

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Intrauterine Devices (IUDs)

Based on promising results from published, peer-reviewed studies in domestic mares, BLM has begun to use IUDs to control fertility as a wild horse and burro fertility control method on the range. The initial management use was in mares from the Swasey HMA, in Utah. The BLM has supported and continues to support research into the development and testing of effective and safe IUDs for use in wild horse mares (Baldrighi et al. 2017, Holyoak et al. 2021). However, existing literature on the use of IUDs in horses allows for inferences about expected effects of any management alternatives that might include use of IUDs and supports the apparent safety and efficacy of some types of IUDs for use in horses. Overall, as with other methods of population growth suppression, use of IUDs and other fertility control measures are expected to help reduce population growth rates, extend the time interval between gathers, and reduce the total number of excess animals that will need to be removed from the range.

The 2013 National Academies of Sciences (NAS) report considered IUDs and suggested that research should test whether IUDs cause uterine inflammation and should also test how well IUDs stay in mares that live and breed with fertile stallions. Since that report, a recent study by Holyoak and others (2021) indicates that a flexible, inert, y-shaped, medical-grade silicone IUD design prevented pregnancies in all the domestic mares that retained the device, even when exposed to fertile stallions. Domestic mares in that study lived in large pastures, mating with fertile stallions. Biweekly ultrasound examinations showed that IUDs stayed in 75 percent of treated mares over the course of two breeding seasons. The IUDs were then removed so the researchers could monitor the mares' return to fertility. In that study, uterine health, as measured in terms of inflammation, was not seriously affected by the IUDs, and most mares became pregnant within months after IUD removal. The overall results are consistent with results from an earlier study (Daels and Hughes 1995), which used O-shaped silicone IUDs. Similarly, a flexible IUD with three components connected by magnetic force (the 'iUPOD') was retained over 90 days in mares living and breeding with a fertile stallion; after IUD removal, the majority of mares became pregnant in the following breeding season (Hoopes et al. 2021).

IUDs are considered a temporary fertility control method that does not generally cause future sterility (Daels and Hughes 1995). Use of IUDs is an effective fertility control method in women, and IUDs have historically been used in livestock management, including in domestic horses. Insertion of an IUD can be a very rapid procedure, but it does require the mare to be temporarily restrained, such as in a squeeze chute. IUDs in mares may cause physiological effects including discomfort, infection, perforation of the uterus if the IUD is hard and angular, endometritis, uterine edema (Killian et al. 2008), and pyometra (Klabnik-Bradford et al. 2013). In women, deaths attributable to IUD use may be as low as 1.06 per million (Daels and Hughes 1995). The effects of IUD use on genetic diversity in a given herd should be comparable to those of other temporary fertility control methods; use should reduce the fraction of mares breeding at any one time but does not necessarily preclude treated mares from breeding in the future, as they survive and regain fertility.

The exact mechanism by which IUDs prevent pregnancy is uncertain, but may be related to persistent, low-grade uterine inflammation (Daels and Hughes 1995, Gradil et al. 2021, Hoopes et al. 2021), Turner and others (2015) suggested that the presence of an IUD in the uterus may, like a pregnancy, prevent the mare from coming back into estrus. However, some domestic mares did exhibit repeated estrus cycles during the time when they had IUDs (Killian et al. 2008, Gradil et al. 2019, Lyman et al. 2021, Hoopes et al. 2021). The main cause for an IUD to not be effective at contraception is its failure to stay in the uterus (Daels and Hughes 1995, NAS 2013). As a result, one of the major challenges to using IUDs to control fertility in mares

on the range is preventing the IUD from being dislodged or otherwise ejected over the course of daily activities, which could include, at times, frequent breeding.

At this time, it is thought that any IUD inserted into a pregnant mare may cause the pregnancy to terminate, which may also cause the IUD to be expelled. For that reason, it is expected that IUDs would only be inserted in non-pregnant (open) mares. Wild mares receiving IUDs would be checked for pregnancy by a veterinarian prior to insertion of an IUD. This can be accomplished by transrectal palpation and/or ultrasound performed by a veterinarian. Pregnant mares would not receive an IUD. Only a veterinarian would apply IUDs in any BLM management action. The IUD is inserted into the uterus using a thin, tubular applicator similar to a shielded culture tube, and would be inserted in a manner similar to that routinely used to obtain uterine cultures in domestic mares. If a mare has a zygote or very small, early phase embryo, it is possible that it will fail to be detected in screening, and may develop further, but without causing the expulsion of the IUD. Wild mares with IUDs would be individually marked and identified, so that they can be monitored occasionally and examined, if necessary, in the future, consistent with other BLM management activities.

Using metallic or glass marbles as IUDs may prevent pregnancy in horses (Nie et al. 2003) but can pose health risks to domestic mares (Turner et al. 2015, Freeman and Lyle 2015). Marbles may break into shards (Turner et al. 2015), and uterine irritation that results from marble IUDs may cause chronic, intermittent colic (Freeman and Lyle 2015). Metallic IUDs may cause severe infection (Klabnik-Bradford et al. 2013). In domestic ponies, Killian and others (2008) explored the use of three different IUD configurations, including a silastic polymer O-ring with copper clamps, and the "380 Copper T" and "GyneFix" IUDs designed for women. The longest retention time for the three IUD models was seen in the "T" device, which stayed in the uterus of several mares for 3-5 years. Reported contraception rates for IUD-treated mares were 80 percent, 29 percent, 14 percent, and 0 percent in years 1-4, respectively. They surmised that pregnancy resulted after the IUD fell out of the uterus. Killian and others (2008) reported high levels of progesterone in non-pregnant, IUD-treated ponies.

Soft or flexible IUDs may cause relatively less discomfort than hard IUDs (Daels and Hughes 1995). Daels and Hughes (1995) tested the use of a flexible O-ring IUD, made of silastic, surgical-grade polymer, measuring 40 mm in diameter; in five of six breeding domestic mares tested, the IUD was reported to have stayed in the mare for at least 10 months. In mares with IUDs, Daels and Hughes (1995) reported some level of uterine irritation but surmised that the level of irritation was not enough to interfere with a return to fertility after IUD removal.

More recently, several types of soft or flexible IUDs have been tested for use in breeding mares. When researchers attempted to replicate the O-ring study (Daels and Hughes 1995) in an USGS/Oklahoma State University (OSU) study with breeding domestic mares, using various configurations of silicone O-ring IUDs, the IUDs fell out at unacceptably high rates over time scales of less than 2 months (Baldrighi et al. 2017, Lyman et al. 2021). Subsequently, the USGS/OSU researchers tested a Y-shaped IUD to determine retention rates and assess effects on uterine health; retention rates were greater than 75 percent for an 18-month period, and mares returned to good uterine health and reproductive capacity after removal of the IUDs (Holyoak et al. 2021). These Y-shaped silicone IUDs are considered a pesticide device by the EPA, in that they work by physical means (EPA 2020). It is possible that some individual mares may become permanently infertile as a result of IUD use, even after IUD removal or expulsion; however, available evidence indicates that flexible IUDs should be considered a reversible fertility control method for most mares. The University of Massachusetts has developed a magnetic IUD that has been effective at prolonging estrus and preventing pregnancy in domestic mares (Gradil et al. 2019, Joonè et al. 2021, Gradil et al. 2021,

Hoopes et al. 2021). After insertion in the uterus, the three subunits of the device are held together by magnetic forces as a flexible triangle. A metal detector can be used to determine whether the device is still present in the mare. In an early trial, two sizes of those magnetic IUDs fell out of breeding domestic mares at high rates (Holyoak et al. 2021), but more recent trials have shown that the magnetic IUD was retained even in the presence of breeding with a fertile stallion (Hoopes et al. 2021). The magnetic IUD was used in two trials where mares were exposed to stallions, and in one where mares were artificially inseminated; in all cases, the IUDs were reported to stay in the mares without any pregnancy (Joonè et al. 2021, Gradil et al. 2021, Hoopes et al. 2021).

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Effects of and SOPs for Use of GPS Telemetry for Wild Horses and Burros

The purpose of this document is to describe methods that would be used for fitting GPS radio collars on wild horse mares and wild burro jennies, or GPS tail tags on wild horses, and describe the expected possible effects for mares and jennies wearing radio collars. This document does not include methods for restraint, care, and maintenance of animals during gathers, while in captivity, or for any other handling procedures beyond those needed for fitting a radio collar.

It is now common to use radio collars fitted with VHF transmitters, GPS recorders, or satellite transmitters to obtain and record data on animal movement and other activities. Therefore, use of this technology can assist in collection of more detailed information for monitoring. Understanding the daily life of the focal species can lead to improvements in animal behavior and ecological knowledge (King 2013). While most radio collars are considered to be minimally invasive, they can impose some cost on the animal carrying them. Thus, guidelines have been developed for a weight ratio (a collar should not exceed 5 percent of the animal's body weight) and best practice in their use (Sikes et al. 2011). Collars have the potential to cause injury to the animal wearing them, but when the collar is fitted correctly and monitored regularly it can provide invaluable data without any measurable impact on the collared or tagged animal.

Telemetry collars have been used extensively on carnivores (Germain et al. 2008, Creel and Christianson 2009, Hunter et al. 2010, Broekhuis et al. 2013), rodents (Koprowski et al. 2007), and some ungulates (Johnson et al. 2000, Creel et al. 2005, Ito et al. 2005, Allred et al. 2013, Buuveibaatar et al. 2013, Latombe et al. 2013). However, in the time period until approximately 2010 they were not as commonly used on equids (but see Hennig et al. 2020). Several studies have used this method to examine habitat use, movements, and behavior of zebra (Fischhoff et al. 2007, Sundaresan et al. 2007, Brooks and Harris 2008) and Asiatic wild asses (Kaczensky et al. 2006, 2008, 2011; Giotto et al. 2015). Before 2010, fewer published studies had used telemetry collars on feral equids (Committee on Wild Horse and Burro Research 1991, Asa 1999, Goodloe et al. 2000, Hampson et al. 2010), and additional studies on feral equids have become available to document their safety and use, as noted below.

Some studies have been conducted on wild horse and burro use of vegetation and habitat, based on methods that do not record animal locations directly (e.g., Beever and Brussard 2000). It can be beneficial to resource managers to have a more detailed understanding of local wild equid seasonal habitat use and movements on

public lands. Due to the scale of some herd management areas (HMA) or complexes of HMAs, it can be logistically challenging to collect unbiased habitat use data via direct visual observation. Using GPS and VHF collars for marking and locating individuals can provide fine-scale monitoring data about where wild animals spend their time and how they use their habitat, based on locations that are recorded throughout the day and night.

From March 2015 through March 2016, researchers at the U.S. Geological Survey (USGS) conducted a year-long preliminary study on captive wild horses and burro jennies to determine proper fit and wear of radio collars (Schoenecker et al. 2020). The condition of wild horses wearing radio collars was compared to non-collared controls and documented with photographs. In addition, the behavior of both collared individuals and controls was recorded for one hour daily, in order to quantify any impact of the collar on their behavior and health. At the end of the study period (March 2016) the collars were removed (Schoenecker et al. 2020).

Radio collars consist of an ~2-inch-wide strap/belt made of soft pliable plastic-like material (Figure 1). Some collars are oval shaped with adjustments on both sides of the collar, and others are teardrop shaped with adjustments at the top of the collar so it can be fitted to different neck sizes. This is the most optimal shape for the neck of equids. Attached to the belt of the collar is a battery pack and transmitter module. These may either be combined in the same unit or placed at the top and bottom of the collar to counterbalance each other. The size of the battery is determined by the amount of power needed, both in terms of length of deployment, and how much data will be recorded by the collar. The type of transmitter used will depend on the monitoring goals, but all principles stated here for collar fitting and use apply regardless of communication systems used.

Radio collars used on BLM-managed wild horses or burros would include two pathways to cause the collar to fall off the animal. Collar drop-off happens when a mechanical device releases, so that the loop of the collar is no longer continuous. First, every collar would have a programmed drop-off date of, for example, 2-3 years after the fitting date. The precise duration until the timed drop-off will depend on the battery life; programmed drop-off date would be before the end of the expected battery life. Second, every radio collar would include a manually triggerable drop-off option. A user with the appropriate UHF signaling device can send a signal to the collar, causing it to drop off. To ensure that the radio collar is not causing any physical injuries, the BLM would aim for every radio-collared horse or burro to be located and visually observed at least once every 4-6 weeks, by a BLM employee or trained person from a designated cooperating agency or organization. In the event that there is any concern about physical damage caused by a collar, the BLM employee or BLM cooperating group's observer would cause the collar to drop off, with the UHF signal.

Collars can be placed on horses' or burros' necks when they are in a padded squeeze chute. It takes between 7 and 12 minutes to properly fit a collar on the animal. The transmitter should be functioning and turned on before the collar is fitted, then checked to ensure that the VHF signal is working correctly before the animal is released. GPS tags can be braided into wild horse tails and held in place with low temperature curing epoxy (Schoenecker et al. 2020, King and Schoenecker 2022).

Fitting of the Collar or Tag

Details on radio collar fitting in horses are in Schoenecker and others (2020). Fitting a collar requires an understanding of the neck circumference and shape; that is, when the head of the animal is raised the collar should be tight, and when the head is down grazing the collar will become looser (Figures 2, 3). The collar should rest just behind the ears of the equid and be tight enough so it does not slip down the neck, yet loose

enough that it does not interfere with movement when the neck is flexed. The collar must fit snugly to minimize rubbing. USGS researchers used 0-1 finger spacing (of an average sized adult human) between collar and neck, depending on the season the collar is deployed to give consideration to the potential for weight gain. Other studies (e.g., Committee on Wild Horse and Burro Research 1991) have had problems with the fitting of collars due to animals gaining weight in spring, or losing weight in winter, causing collars to become too tight or too loose. In the USGS study, researchers did notice collars were looser or tighter at different times during the year, but it did not affect the behavior of collared mares or jennies, or cause sores or wounds on mares or jennies. Whenever collars are deployed, they should be fitted by experienced personnel who can attach the collar quickly but proficiently to minimize handling stress on the animal.

No effects are expected from the tags; however, it is possible that they may form an irritation to individuals should vegetation get tangled in the tail. In this case it is expected that the tag would ultimately rip out of the hair (leaving no injury) as the horse rubs it. Details on tag fitting in horses are in Schoenecker and others (2020).

Impacts of the Use of Radio Collars

Based on numerous studies that have used modern radio collars with remote releases and tags to monitor wild ungulates and equids in particular, these devices have minimal effects on the animals wearing them. The impact of radio collars and tags is very minimal and tends to last only as long as the animal has the collar or tag. From March 2015 through March 2016, researchers at the USGS conducted a preliminary study on captive wild horses and burro jennies to determine proper fit and wear of radio collars (Schoenecker et al. 2020). The condition of wild horses and burros wearing radio collars was compared to non-collared controls and documented with photographs. In addition, both collared individuals and controls were observed for 80 minutes each week for 14 weeks in order to quantify any impact of the collar on their behavior and health. At the end of the study period (March 2016) the collars were removed. Preliminary analyses indicate that mares and jennies had almost no impact in terms of rubbing or wear from radio collars and behavior of collared and uncollared mares did not differ (Schoenecker et al. 2020). The same authors also examined effects of a braid-in tail tag, which also had no negative impacts, but which cannot be used on burros because their tails are relatively hairless, compared to horses (King and Schoenecker 2022). If new data are published from more recent studies, the procedures for use of collars and tail tags may be updated accordingly. The BLM has supported other ecological studies in which wild mares and jennies living on-range were radio collared with similar collars and were monitored for health and any effects of collars via monthly welfare checks. Such collars, with the timed and remotely triggerable drop-off mechanisms, have been used in Adobe Town, Conger, Eagle, Frisco, Swasey, and Sulphur HMAs (mares) and in Sinbad HMA and Lake Pleasant HMA (jennies). The timed and remote-release drop off mechanisms have proven safe for use; the same authors who urged researchers to report any problems with equid radio collars in Hennig and others (2020) have not reported such problems in their subsequent papers (Hennig et al. 2018, Esmaileh et al. 2021, Hennig et al. 2021, Hennig et al. 2022, King et al. 2022), nor did Karish and others (2023).

There are some possible effects from the use of collars. On rare occasions, a collar over an ear has been observed, and this seems more common on collared stallions (Schoenecker et al. 2020). On stallions, radio collars may cause sores (Schoenecker et al. 2020), though Popova and others (2023) did not report any health concerns in collared stallions. No stallions or jack burros would be collared in any of the action alternatives in this EA. Also, collars may be fitted too tightly, or a horse or burro may grow, tightening the collar. If neck abrasions or sores caused by a collar are observed and have not healed within 4 weeks of when observed, the collar's remote release would be deployed, or the horse or burro would be captured as soon as possible to remove the collar. If these situations are observed, the triggerable remote-release

function would be deployed remotely. If that remote release failed, the collar would be removed after capturing the animal through approved methods in the proposed action. Although collars may cause fur matting and minor hair loss (Schoenecker et al. 2020), notable neck abrasions or sores on mares or jennies have not been reported in papers about studies where equids have been collared (e.g., Collins et al. 2014, Hennig et al. 2018, Esmaeili et al. 2021, Hennig et al. 2021, Hennig et al. 2022, King et al. 2022).

The use of collar and tag technology in monitoring may help with understanding how free- roaming horses move across the HMAs and use increasingly scarce resources. Applying this technology in free-roaming horses and burros could provide the opportunity to better monitor resource use, individual foaling rates, habitat preference, home range and movement patterns. Such information may or may not be useful in informing future management decisions.

Figure 1. Two collar designs to use on wild horses and burros; one is teardrop shaped, and the other is oval shaped from Collins and others (2014).





Figure 2. Burro jenny fitted with a radio collar in the USGS study (Schoenecker et al. 2020) showing appropriate placement of collars higher on the neck, behind ears.



Figure 3. Wild horse mares fitted with radio collars in the USGS study (Schoenecker et al. 2020) showing head up and head down and demonstrating appropriate placement of collars higher on the neck just behind the ears.





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APPENDIX G: GENETIC ANALYSIS

Genetic Analysis of the Riddle Mountain
and Hog Creek, OR feral horse herds.

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May 13, 2004

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The following is a report of the genetic analysis of the Riddle Mountain and Hog Creek, OR feral horse herds.

METHODS

A total of 28 blood samples (14 from each herd) were received by the Univ. of Kentucky on November 7, 2003. Seventeen genetic marker systems were analyzed. Seven systems were red blood cell alloantigen loci (the *A, C, D, K, P, Q* and *U)* horse blood groups tested by standard serological methods of aggulutination and compliment mediated hemolysis. The other 10 systems were biochemical polymorphisms detected by electrophoretic techniques. These systems were Albumin *(ALB)*, Alpha-1-beta Glycoprotein *(A1B)*, Serum Cholinesterase *(ES)*, Vitamin D Binding Protein *(GC)*, Glucose Phosphate Isomerase *(GPI)*, Alpha Hemoglobin *(HB)*, Phosphoglucomutase *PGM)*, Phosphogluconate Dehydrogenase *(PGD)*, Protease Inhibitor *(PI)*, and Transferrin *(TRF)*. In addition to the above genetic systems, DNA was extracted from the blood samples and tested for variation at 12 microsatellite (mSat) systems. These were *ATH4, AHT5, ASB2, ASB17, ASB23, HMS3, HMS6, HMS7, HTG4, HTG10, LEX3,* and *VHL20.* These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual and is based upon biochemical loci only; expected heterozygosity *(He)* which is the predicted number of heterozygous loci based upon gene frequencies and was calculated for biochemical loci and all marker systems *(Het)*; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV);* and estimated inbreeding

level *(Fis)* which is calculated as 1-*Ho-He*. These same measures were calculated for the mSat data.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies for the blood group and biochemical markers are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Riddle and Hog Creek horse herds. Also shown in Table 2 are values for other Oregon feral horse populations plus values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 54 herds) and mean values for domestic breeds (based upon 118 domestic horse populations) also are shown.

Mean genetic similarity of the Riddle and Hog Creek herds to domestic horse breed types are shown in Table 3. Table 4 shows the genetic similarity matrix for comparison of Oregon feral populations to each other. A dendrogram of relationship of the Riddle and Hog Creek herds to a standard set of domestic breeds shown in Figure 1. Figure 2 shows the relationships among the Oregon feral herds.

Genetic variants. Only one variant was observed in the Riddle herd that was not seen in the 1993 analysis (the *Abc* marker) and this was observed in just one individual. However, there were 17 variants observed in 1993 not seen in 2003. This is mainly due to the small sample size

for 2003 and it is not possible to determine if variants have been lost. Of the 57 variants seen in 2003, 10 (17.5%) were at low frequency and are at risk of loss.

No unusual variants were observed in the Hog Creek herd. The total number of variants is low but this may be due to the small sample size. 16% of the variants were at low frequency and thus, at risk of loss.

Genetic variability. Genetic variation in the Riddle herd is high. There does appear to be a reduction in variation in the herd from 1993 to 2003 and this does not appear to simply be due to the difference in sample size. All measures are lower in 2003 and *Ho* and *Ae* are fairly independent of sample size. The pattern of variation suggests population bottleneck effects. This is a reasonable assumption considering the low population size of the herd.

Genetic variation in the Hog Creek herd is above the mean for feral horse populations. Total heterozygosity is especially high and allelic diversity is relatively high considering the total number of variants (*TNV*). *Ho* is greater than *He*. This also may represent a bottleneck effect in this herd as the population size is small.

Genetic similarity. Mean *S* for this sample of the Riddle herd to domestic breeds is low due to the small sample size. A clearer picture of similarity of this herd is shown in the RML tree (Figure 1) which is based upon the 1993 data. The Riddle herd groups on the outside of the cluster of light racing and riding breeds. Based upon markers present it is likely that there is some Quarter Horse in the background of this herd. Other North American saddle horse breeds could well be in the ancestry of the group as well. There are markers with associations to Spanish breeds in this herd but these markers can be found in some North American saddle breeds as well.

The Hog Creek herd does not show a clear pattern of relationship to any breed group based upon the RML tree. Highest mean *S* was with North American Gaited breeds and New World Iberian breeds but there is some indication of "cold blood" (draft horse or pony) association as well. This group probably is of widely mixed breed origins with recent loss of variation due to small population size.

The Riddle herd shows greatest similarity to the Kiger herd as expected. The Hog Creek herd has its highest similarity to the Paisley Desert and Beaty Butte herds which are geographically distant. However, the sample size for the Hog Creek herd is low enough that there is not a high confidence in these similarity values or the placement of the herd in Figure 2.

Summary. The Riddle herd has high genetic variability although there appears to have been a decline in variation over the past 10 years. Current *Ho* shows a reduction of about 2.4% of the 1993 *Ho*. This is a fairly rapid loss of heterozygosity and may be due to a population bottleneck. The herd appears to be mainly of North American saddle stock origins. The Hog Creek herd also has relatively good variation levels. Allelic diversity is high based upon the small sample size and likely is due to a widely mixed breed origin of the herd.

RECOMMENDATIONS

No immediate action is needed for the Riddle Mountain herd because variability levels are high. However, the rate of loss of variation is a potential concern. This is clearly associated with the population size and possible past gather activity. The level of variation is high enough that variation should not fall to critically low levels for some time. However, the AML is low enough that it is possible that deleterious recessive genes could become common enough to show an effect despite high variability levels. The herd should be monitored for possible physical defects or lowered fecundity.

The Hog Creek herd also would not appear to be at immediate risk due to high variability. However, the AML for this herd also is small so what was stated above for the Riddle herd would apply here as well.

Table 1. Allele frequencies of genetic variants observed in the RIDDLE HERD OR feral horse herd.

System	Allele	Frequency
Tf	D	.465
	F2	.214
	H2	.071
	R	.250
A1B	K	.893
	S	.107
Es	F	.107
	G	.036
	I	.643
	L	.071
	S	.036
	R	.107
Al	A	.429
	B	.571
Gc	F	.929
	S	.071
PGD	F	.857
	S	.143
PGM	F	.107
	S	.893
GPI	F	.036
	I	.928
	S	.036
Hb	BI	.643
	BII	.357
Ai	I	.071
	J	.036
	L	.179
	N	.321
	P	.143
	S	.071
	T	.036
	U	.143
A	adf	.887
	b	.071
	bc	.036
	-	.006
C	a	.622
	-	.378
D	ad	.119
	d	.116
	dk	.179
	dghm	.157
	deo	.179
	bcm	.107
	cgm	.143
K	-	1.000
P	ac	.177
	ad	.177
	b	.076
	-	.570
Q	abc	.345
	b	.055
	c	.588
	-	.012

U	a	.537
		.463

Table 1. Allele frequencies of genetic variants observed in the RIDDLE HERD (1993) feral horse herd.

System	Allele	Frequency
Tf	D	.371
	F1	.005
	F2	.181
	H1	.014
	H2	.162
	O	.043
	R	.224
A1B	F	.038
	K	.867
	S	.095
Es	F	.133
	G	.067
	I	.628
	S	.029
	R	.143
Al	A	.362
	I	.005
	B	.633
Gc	F	.938
	S	.062
PGD	D	.019
	F	.743
	S	.238
PGM	F	.143
	S	.857
GPI	F	.029
	I	.933
	S	.038
Hb	AII	.062
	BI	.543
	BII	.395
Pi	G	.010
	H	.010
	I	.024
	J	.048
	K	.052
	L	.242
	L2	.010
	N	.242
	P	.162
	S	.081
	T	.014
	U	.105
A	adf	.560
	adg	.077
	b	.083
	-	.280
C	a	.661
	-	.339
	ad	.059
	d	.114
	dk	.201
	dghm	.143
	deo	.125
	dek	.011

	dfk	.019
	bcm	.190
	cgm	.045
	cegi	.093
K	a	.005
	-	.995
P	ac	.239
	ad	.157
	b	.170
	bd	.005
	d	.008
	-	.421
Q	abc	.244
	b	.188
	c	.124
	-	.444
U	a	.406
	-	.594

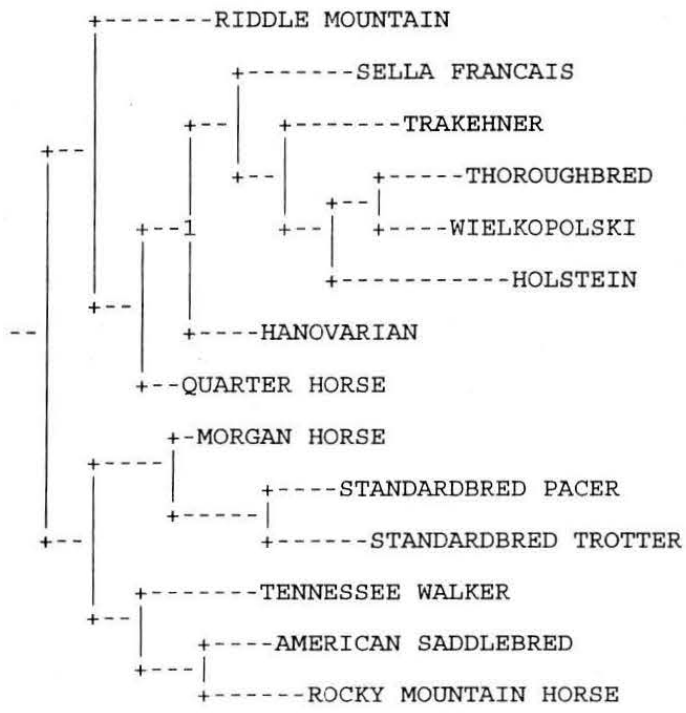
Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Het*	*Ae*	*TNV*
Riddle Mtn. 2003	14	0.421	0.388	-0.086	0.414	2.400	57
Hog Creek	14	0.386	0.373	-0.057	0.436	2.296	50
Sheepshead	61	0.307	0.336	0.087	0.408	2.239	66
Warm Springs	56	0.387	0.373	-0.038	0.456	2.702	68
Paisley Desert	90	0.353	0.395	0.105	0.444	2.597	69
Alvord Tule Springs	20	0.320	0.377	0.151	0.383	2.083	56
Coyote lake	73	0.358	0.381	0.061	0.400	2.111	63
Jackies Butte	31	0.297	0.308	0.036	0.361	2.343	57
Murderer's Creek	17	0.429	0.447	0.040	0.432	2.183	47
Riddle Mtn. 1993	105	0.432	0.428	-0.011	0.475	2.781	73
Kiger	154	0.409	0.415	0.013	0.465	2.650	77
Feral Horse Mean	54	0.360	0.351	-0.035	0.385	2.218	53.5
Standard Deviation		0.051	0.053	0.118	0.067	0.339	12.5
Domestic Horse Mean	118	0.371	0.365	-0.014	0.414	2.398	65.4
Standard Deviation		0.049	0.043	0.065	0.039	0.253	11.1

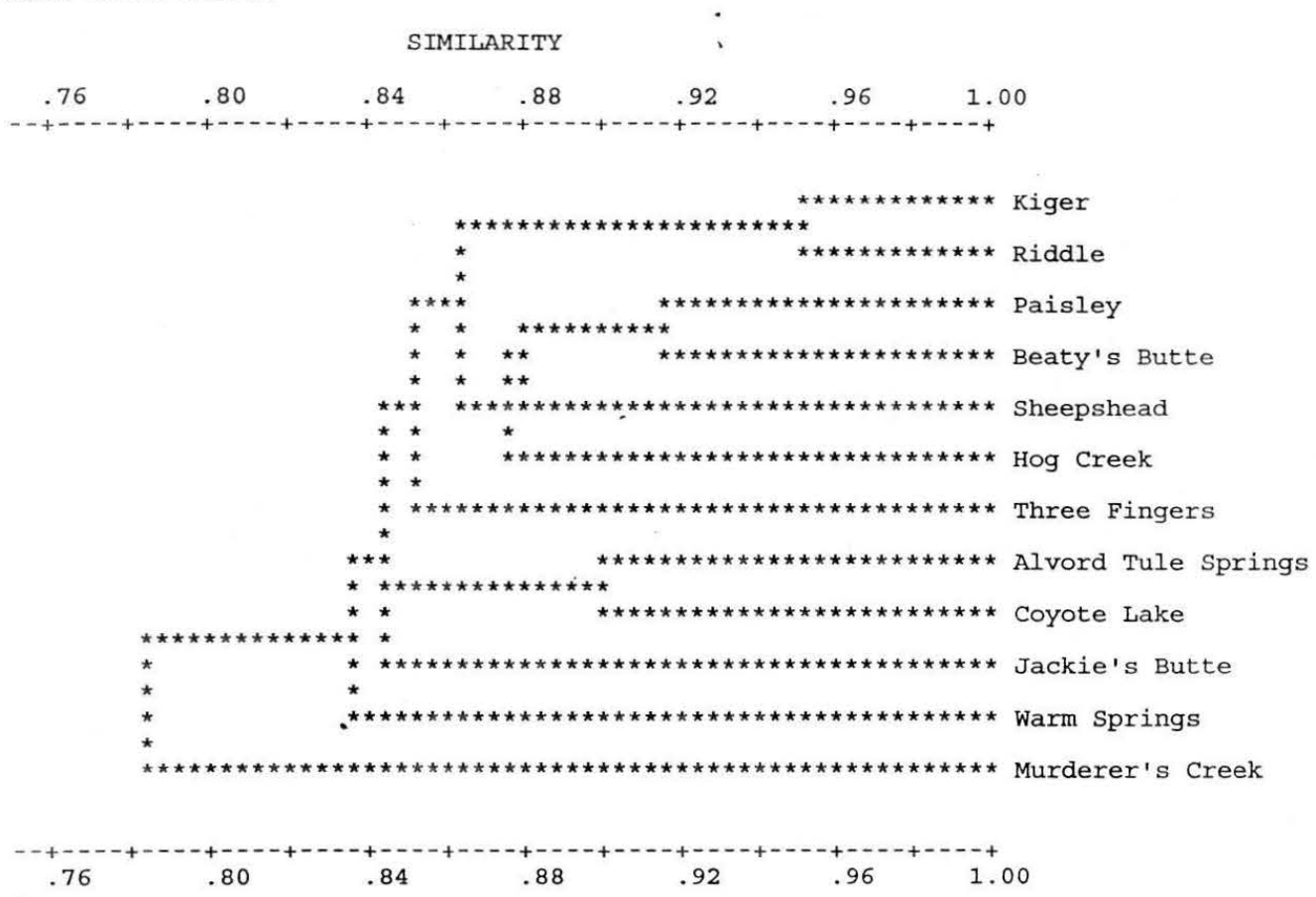
Table 3. Rogers' genetic similarity of the Riddle Mtn./Hog Creek OR feral horse herds to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.809/.817	0.018/.033	0.786/.761	0.845/.861
Oriental and Arabian Breeds	0.824/.827	0.028/.026	0.772/.779	0.849/.869
Old World Iberian Breeds	0.826/.832	0.024/.033	0.776/.760	0.864/.864
New World Iberian Breeds	0.827/.843	0.028/.032	0.775/.800	0.855/.878
North American Gaited Breeds	0.818/.846	0.026/.022	0.773/.807	0.845/.871
Heavy Draft Breeds	0.773/.829	0.035/.040	0.686/.745	0.810/.883
True Pony Breeds	0.769/.823	0.028/.032	0.735/.762	0.826/.884

Figure 1. Partial RML tree of genetic similarity of the Riddle Mountain herd to selected domestic breeds.



'igure 2. Dendrogram of genetic similarity among Oregon
eral horse herds.



Appendix 1. Blood group and biochemical data for individual horses of the Riddle Mountain OR feral horse herd.

| | | Biochemical Systems | | |

Appendix 2. DNA data for the Riddle Mountain OR feral horse herd.

		Microsatellite Loci														
		VHL20	HTG4	AHT4	HMS7	H	AHT5	HMS6	ASB2	HTG10	HTG7	HMS3	HMS2	ASB17	ASB23	LEX33	LEX3
ID																	
03-11581	rd51	JL	KM	HJ	LL	**	JK	MP	OQ	QR	**	MM	**	RR	JK	LR	NN
03-11582	rd51	LO	MP	JJ	LM	**	KN	PP	MQ	KO	**	MM	**	IN	KK	KR	LL
03-11583	rd51	LN	MP	JJ	LO	**	KO	MP	MQ	KM	**	NP	**	II	KS	OQ	LL
03-11584	rd51	NN	MM	JK	LM	**	NO	MP	NQ	MM	**	NP	**	IR	KS	RR	LL
03-11585	rd51	LQ	KK	JK	LO	**	KQ	MP	MQ	KR	**	IN	**	IM	KS	KO	LO
03-11586	rd51	MP	MM	JJ	KL	**	JQ	LM	OQ	OR	**	IP	**	IR	KS	LO	LL
03-11587	rd51	PQ	MM	HJ	KL	**	KK	MM	NO	OR	**	PP	**	IR	JK	OR	LL
03-11588	rd51	JM	PP	JO	NN	**	JK	MM	MQ	OP	**	MP	**	MN	IK	KL	KN
03-11589	rd51	LP	KM	JJ	LL	**	MQ	NP	MM	KP	**	IP	**	NR	KK	LO	FF
03-11590	rd51	NO	KP	JO	LN	**	IN	PP	MN	MO	**	MP	**	IN	JS	KL	FL
03-11591	rd51	NO	MP	HJ	LM	**	IN	PP	MQ	OO	**	MP	**	IR	KS	KK	LL
03-11592	rd51	NP	PP	JJ	LN	**	LN	OP	MQ	OO	**	NP	**	MR	UU	KL	LM
03-11593	rd51	NQ	LM	JJ	LM	**	KN	MP	MN	KO	**	MR	**	IM	KS	QR	LM
03-11594	rd51	LN	KK	HJ	KM	**	NN	PP	QQ	OR	**	NO	**	IN	IS	KQ	KN

Genetic Analysis of the Kiger HMA, OR

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September 10, 2010

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The following is a report of the genetic analysis of the Kiger HMA, OR.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels will be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation will be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type so similarity is based upon the total data set.

METHODS

A total of 12 samples the Kiger HMA and 13 from the Riddle HMA were received by Texas A&M University, Equine Genetics Lab on May 22, 2009. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He)*, which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker

system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Tables 1a and 1b. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Kiger and Riddle HMAs. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Kiger and Riddle HMAs to domestic horse breed types are shown in Tables 3a and 3b, respectively. A dendrogram of relationship of the Kiger HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 63 variants were seen in the Kiger HMA herd while 65 were found in the Riddle HMA. This is below the mean for feral herds and well below the mean for domestic breeds, however, sample sizes are small. Other measures of allelic diversity also are less than average values for both of these herds which indicates that sample size is not the sole

cause of the low TNV values. The percentage of alleles at risk of future loss is slightly above average for both herds.

Genetic Variation: Genetic variation, as indicated by *Ho*, in both the Kiger HMA and Riddle HMA is slightly above the feral mean. The Kiger *Ho* is higher than that of Riddle but not significantly. Both herds have *He* values that are lower than the average and considerably below *Ho*. This may be an indication of a recent bottleneck.

Genetic Similarity: Overall similarity of the Kiger HMA herd to domestic breeds was about average for feral herds. Highest mean genetic similarity of the Kiger HMA herd was with the Oriental breeds followed by the Old World Iberian breeds. Overall similarity of the Riddle HMA herd to domestic breeds was lower than seen for the Kiger. Highest mean genetic similarity of the Riddle herd was with the Old World Iberian breeds followed by the Oriental breeds. As seen in Fig. 1, the Kiger and Riddle herds cluster closely with each other but fall outside the main cluster of the riding type horses and between that group and the draft and pony breeds. In comparison to other Oregon herds, the Kiger and Riddle herds again are very similar to each other but do not necessarily show close similarity to geographically close herds (Figure 2).

SUMMARY

Genetic variability of both the Kiger and Riddle herds is basically right at the mean level for feral populations when all measures are considered. The values related to allelic diversity are below the average as is *He* while *Ho* is higher than the mean. Genetic similarity results suggest a herd with mixed ancestry that likely includes some Spanish heritage, although earlier blood typing analysis suggested that the ancestry is primarily is North American. There is a possibility that this herd has seen a recent loss of population size based upon the differences in observed and

expected heterozygosity values. In comparison to the variability based upon blood typing, the Kiger herd has lost variability because blood typing estimates of heterozygosity and allelic diversity were well above the feral horse mean. The Kiger and Riddle herds show great similarity to each other both in variation levels and actual genetic similarity which is not unexpected.

RECOMMENDATIONS

Current variability levels for both herds are at a level where the herds should be closely monitored although there is no action that is needed at this point. Genetic variation should be checked again in about five years to see if there is a continued decrease in variation as appears to have occurred.

Table 1a. Allele frequencies of genetic variants observed in Kiger HMA feral horse herd.

VHL20

I	J	K	L	M	N	O	P	Q	R	S
0.083	0.000	0.000	0.083	0.208	0.500	0.042	0.042	0.042	0.000	0.000

HTG4

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.125	0.125	0.667	0.000	0.000	0.083	0.000	0.000

AHT4

H	I	J	K	L	M	N	O	P	Q	R
0.167	0.042	0.417	0.083	0.000	0.000	0.000	0.292	0.000	0.000	0.000

HMS7

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.042	0.625	0.208	0.125	0.000	0.000	0.000	0.000

AHT5

I	J	K	L	M	N	O	P	Q	R
0.000	0.250	0.208	0.042	0.125	0.292	0.000	0.000	0.083	0.000

HMS6

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.000	0.250	0.042	0.333	0.375	0.000	0.000

ASB2

B	I	J	K	L	M	N	O	P	Q	R
0.000	0.042	0.000	0.125	0.000	0.125	0.292	0.000	0.000	0.417	0.000

HTG10

H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.375	0.125	0.042	0.000	0.250	0.042	0.083	0.083	0.000	0.000

HMS3

H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.083	0.000	0.000	0.000	0.250	0.333	0.000	0.333	0.000	0.000	0.000

ASB17

D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.125	0.000	0.000	0.083	0.000	0.000	0.000	0.250	0.042	0.000	0.000	0.000	0.500	0.000	0.000

ASB23

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.042	0.375	0.375	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.042	0.000	0.000

LEX33

F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.292	0.125	0.042	0.000	0.083	0.000	0.208	0.250	0.000	0.000

Table 1b. Allele frequencies of genetic variants observed in Riddle HMA feral horse herd.

VHL20

I	J	K	L	M	N	O	P	Q	R	S
0.000	0.038	0.000	0.154	0.077	0.385	0.154	0.115	0.077	0.000	0.000

HTG4

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.192	0.077	0.615	0.000	0.000	0.115	0.000	0.000

AHT4

H	I	J	K	L	M	N	O	P	Q	R
0.231	0.000	0.692	0.038	0.000	0.000	0.000	0.038	0.000	0.000	0.000

HMS7

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.115	0.654	0.154	0.038	0.038	0.000	0.000	0.000

AHT5

I	J	K	L	M	N	O	P	Q	R
0.077	0.115	0.308	0.000	0.077	0.269	0.077	0.000	0.077	0.000

HMS6

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.038	0.269	0.038	0.077	0.577	0.000	0.000

ASB2

B	I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.038	0.000	0.231	0.231	0.115	0.000	0.385	0.000

HTG10

H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.231	0.000	0.115	0.000	0.423	0.038	0.038	0.154	0.000	0.000

HMS3

H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.115	0.000	0.000	0.000	0.385	0.154	0.038	0.231	0.000	0.077	0.000

ASB17

D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.038	0.000	0.000	0.423	0.000	0.000	0.000	0.077	0.154	0.000	0.000	0.000	0.308	0.000	0.000

ASB23

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.038	0.154	0.423	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.269	0.000	0.077	0.000

LEX33

F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.308	0.154	0.000	0.000	0.231	0.000	0.115	0.192	0.000	0.000

Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
KIGER HERD OR	**12**	**0.729**	**0.688**	**-0.060**	**3.39**	**63**	**5.25**	**15**	**0.238**
RIDDLE HERD OR	**13**	**0.724**	**0.677**	**-0.070**	**3.41**	**65**	**5.42**	**14**	**0.215**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0

Table 3a. Rogers' genetic similarity of the Kiger HMA feral horse herd to major groups of domestic horses.

	Mean S	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.738	0.016	0.713	0.752
Oriental and Arabian Breeds	0.757	0.018	0.724	0.777
Old World Iberian Breeds	0.739	0.023	0.716	0.773
New World Iberian Breeds	0.716	0.040	0.647	0.781
North American Gaited Breeds	0.736	0.020	0.697	0.752
Heavy Draft Breeds	0.675	0.036	0.630	0.730
True Pony Breeds	0.684	0.029	0.646	0.724

Table 3b. Rogers' genetic similarity of the Riddle HMA feral horse herd to major groups of domestic horses.

	Mean S	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.729	0.024	0.700	0.757
Oriental and Arabian Breeds	0.731	0.019	0.703	0.757
Old World Iberian Breeds	0.736	0.022	0.715	0.770
New World Iberian Breeds	0.709	0.036	0.654	0.760
North American Gaited Breeds	0.711	0.024	0.681	0.736
Heavy Draft Breeds	0.658	0.044	0.605	0.706
True Pony Breeds	0.672	0.030	0.638	0.719

Figure 1. Partial RML tree of genetic similarity to domestic horse breeds.

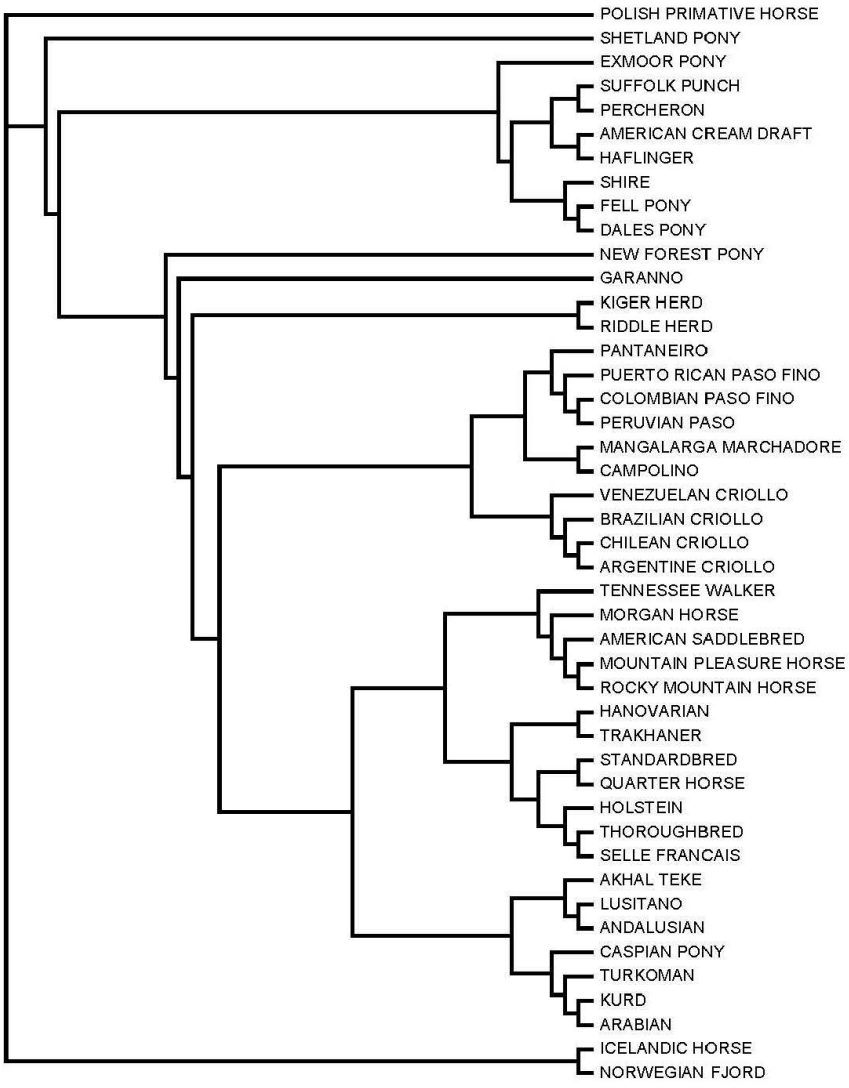
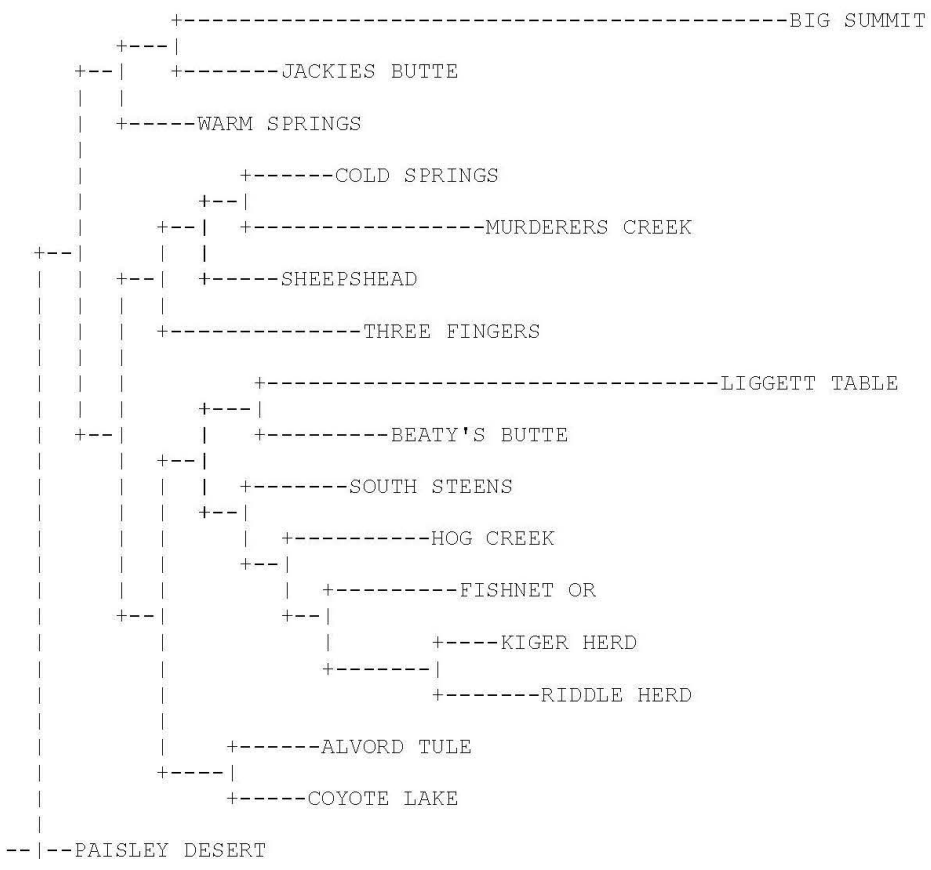


Figure 2. Genetic similarity tree of Oregon populations.



Appendix 1a. DNA data for the Kiger HMA, OR herd.

AID	AHT4	AHT5	ASB17	ASB2	ASB23	HMS3	HMS6	HMS7	HTG10	HTG4	LEX3	LEX33	VHL20
40578	JK	MN	FR	NQ	KS	NP	PP	LM	LO	LM	NN	KK	NO
40579	JJ	JK	RR	NQ	JK	NP	OO	LL	KO	MM	LL	QR	MN
40580	JO	NN	MM	QQ	KS	MP	MP	LL	KM	MM	FF	QR	MN
40581	OO	MN	NR	IK	LT	NN	OP	MN	LR	KL	FN	LQ	IM
40582	HJ	JM	FM	MN	JS	NP	PP	MM	KO	MP	NN	KR	NN
40583	JJ	JQ	RR	MN	JK	IM	MN	LL	KQ	KM	FO	KO	LQ
40584	IK	LN	FI	NQ	JK	PP	OP	LN	LO	MM	MM	KL	NN
40585	JO	KK	MR	QQ	JK	MN	MM	LM	OR	LM	LN	LR	LM
40586	HO	JN	MR	KQ	JK	MP	OP	KL	KK	MM	FM	QR	NN
40587	HJ	JK	IR	KN	JJ	MN	OO	LL	KK	MM	LM	QR	NN
40588	OO	JK	MR	QQ	IK	MP	MP	LN	OP	MP	NP	KO	MP
40602	HJ	NQ	RR	MN	JK	IN	MO	LL	KQ	KM	FF	KM	IN

Appendix 1b. DNA data for the Riddle HMA, OR herd.

AID	AHT4	AHT5	ASB17	ASB2	ASB23	HMS3	HMS6	HMS7	HTG10	HTG4	LEX3	LEX33	VHL20
40589	HJ	JK	RR	OQ	JK	MM	MP	LL	QR	KM	NN	LR	JL
40590	JJ	JM	FI	QQ	KS	MN	PP	LL	MO	LM	MM	KQ	NO
40591	JJ	KN	IN	MQ	KK	MM	PP	LM	KO	MP	LL	KR	LO
40592	JO	IN	IN	MN	JS	MP	PP	LN	MO	KP	FL	KL	NO
40593	JJ	KQ	IR	OQ	KS	IP	LM	KL	OR	MM	LL	LO	MP
40594	HJ	KK	IR	NO	JK	PP	MM	KL	OR	MM	LL	OR	PQ
40595	HJ	IN	IR	MQ	KS	MP	PP	LM	OO	MP	LL	KK	NO
40596	HJ	NN	IN	QQ	IS	NO	PP	KM	OR	KK	KN	KQ	LN
40597	JK	JN	MR	KN	LU	IM	MO	LO	KK	MM	MM	KK	NN
40598	JJ	KO	IR	NQ	SU	MN	MP	LL	KO	MM	LM	OO	NN
40599	JJ	MQ	NR	MM	KK	IP	NP	LL	KP	KM	FF	LO	LP
40600	HH	KO	II	NQ	JK	NR	OP	LL	MO	MM	FM	OR	MN
40601	JJ	KN	IM	MN	KS	MR	MP	LM	KO	LM	LM	QR	NQ

Genetic Analysis of the Kiger HMA, OR010

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The following is a report of the genetic analysis of the Kiger HMA, OR010.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels will be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation will be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type so similarity is based upon the total data set.

METHODS

A total of 40 samples were received by Texas A&M University, Equine Genetics Lab on November 15, 2011. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He),* which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the

number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Kiger HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Kiger HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Kiger HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 70 variants were seen in the Kiger HMA herd which is just below the mean for feral herds and below the mean for domestic breeds. Of these, 17 had frequencies below 0.05 which is about average for the percentage of variants at risk of future loss. Allelic diversity as represented by *Ae* and *MNA* is slightly below the average for feral herds.

Genetic Variation: Observed heterozygosity in the Kiger HMA herd from 2011 is well below the feral mean while *He* is only slightly lower than average. *Ho* is lower than *He*.

Differences such as this can indicate recent inbreeding through a reduction in population size, within the past few generations, but this not possible to confirm by DNA data alone. Heterozygosity and other variability values calculated from the Kiger HMA in 2009 were significantly higher than just three years later which shows that there is something greatly different in the herd now. Sample size from 2009 was just above half what the 2011 number was but sample size alone would not cause what is being seen as lower values are usually associated with lower sample size. Horses tested in 2002 had *Ho* levels very similar but slightly higher than did those from 2009. The 2002 horses were one that had been adopted and were part of the Kiger Mestino Registry.

Genetic Similarity: Overall similarity of the Kiger HMA herd to domestic breeds was about average for feral herds. Highest mean genetic similarity of the Kiger HMA herd was with Old World Iberian breeds, followed closely by the Oriental and Arabian breeds. As seen in Fig. 1, the Kiger HMA herd clusters with the South American Pantaniero breed in the branch with the main Old World Iberian breeds and Oriental breeds. These results indicate a herd with mixed origins with no clear indication of primary breed type but there does appear to be some Spanish blood based upon the 2011 sample. Evidence of Spanish influence has not been as apparent as it now is but there has been some suggestion of Spanish heritage with past testing including blood typing. As with most trees involving feral herds, the tree is somewhat distorted.

SUMMARY

Genetic variability of this herd in general is near average however, heterozygosity is considerably lower than horses sampled from this HMA in 2009. The picture for allelic diversity is not so clear because the 2009 sample was only 12 animals and allelic numbers are strongly associated with sample size. In comparison the horses typed in 2002, allelic numbers are

reduced even though sample size is higher in 2011. The proportion of rare alleles is lower in 2011 which is suggestive of loss of allelic diversity. The data suggests that this herd has seen a recent loss of population size which would increase the risk to genetic diversity. Genetic similarity results suggest a herd with mixed ancestry and some Spanish heritage.

RECOMMENDATIONS

Current variability levels are high enough that no action is needed at this point but the herd should be monitored closely due to the trend for loss of variability. This is especially true if it is known that the herd size has seen a recent decline. Populations that consist of less than 100 individuals are at high risk of loss of variability and this can occur rapidly at low population numbers. It should be noted that the Riddle Mountain herd is genetically very close to the Kiger herd but different enough that exchange of a few individuals of these herds could restore variability levels.

Table 1. Allele frequencies of genetic variants observed in Kiger HMA feral horse herd.

VHL20															
I	J	K	L	M	N	O	P	Q	R	S					
0.125	0.013	0.000	0.138	0.200	0.348	0.063	0.038	0.075	0.000	0.000					
HTG4															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.100	0.125	0.687	0.038	0.000	0.050	0.000	0.000						
AHT4															
H	I	J	K	L	M	N	O	P	Q	R					
0.100	0.025	0.587	0.188	0.000	0.000	0.025	0.075	0.000	0.000	0.000					
HMS7															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.025	0.462	0.300	0.150	0.063	0.000	0.000	0.000						
AHT5															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.150	0.250	0.025	0.075	0.325	0.162	0.000	0.013	0.000						
HMS6															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.000	0.000	0.237	0.087	0.213	0.463	0.000	0.000						
ASB2															
B	I	J	K	L	M	N	O	P	Q	R					
0.000	0.013	0.000	0.050	0.000	0.200	0.250	0.038	0.000	0.449	0.000					
HTG10															
H	I	J	K	L	M	N	O	P	Q	R	S	T			
0.000	0.000	0.000	0.225	0.063	0.100	0.000	0.337	0.087	0.038	0.125	0.025	0.000			
HMS3															
H	I	J	K	L	M	N	O	P	Q	R	S				
0.000	0.125	0.000	0.000	0.000	0.200	0.150	0.000	0.462	0.000	0.063	0.000				
ASB17															
D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.050	0.000	0.000	0.188	0.000	0.000	0.000	0.200	0.075	0.000	0.000	0.000	0.487	0.000	0.000
ASB2															
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.000	0.350	0.449	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.013	0.000	0.000
LEX33															
F	G	K	L	M	N	O	P	Q	R	S	T				
0.300	0.000	0.138	0.112	0.213	0.150	0.087	0.000	0.000	0.000	0.000	0.000				

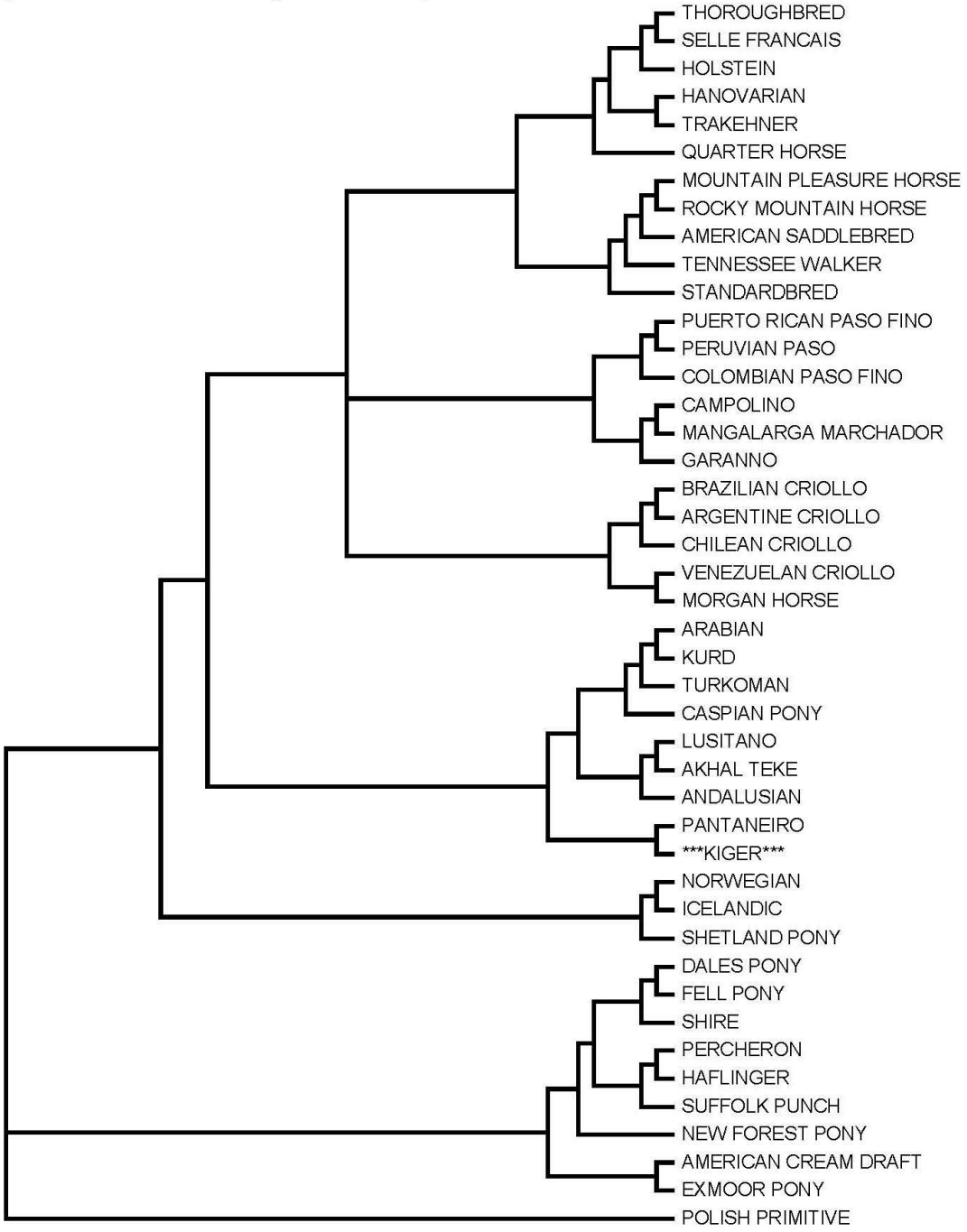
Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
KIGER OR 2011	**40**	**0.671**	**0.695**	**0.034**	**3.54**	**70**	**5.83**	**17**	**0.243**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table 3. Rogers' genetic similarity of the Kiger HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.738	0.017	0.715	0.755
Oriental and Arabian Breeds	0.742	0.020	0.710	0.767
Old World Iberian Breeds	0.743	0.021	0.722	0.778
New World Iberian Breeds	0.731	0.037	0.674	0.786
North American Gaited Breeds	0.734	0.023	0.702	0.764
Heavy Draft Breeds	0.670	0.035	0.623	0.714
True Pony Breeds	0.681	0.026	0.649	0.712

Figure 1. Partial RML tree of genetic similarity to domestic horse breeds.



Appendix 1. DNA data for the Kiger HMA, OR herd.

AID	VHL20	HTG4	AHT4	HMS7	AHT5	HMS6	ASB2	HTG10	HMS3	ASB17	ASB23	LEX3	LEX33
56661	IL	KM	HJ	LO	KK	PP	NN	MR	NP	RR	JJ	FF	LO
56662	MN	MM	JO	LL	NN	MP	QQ	KM	MP	MM	KS	FF	QR
56663	NN	MM	KK	LM	MN	PP	NQ	OO	PP	IR	JS	MN	KK
56664	IM	MM	JJ	LN	NN	MO	OQ	KR	PP	IM	SS	FL	OR
56665	NN	MM	HK	LM	JO	PP	KQ	KM	PP	RR	JL	FM	OR
56666	MN	KM	HJ	LM	JO	NP	MN	KM	IP	IR	KK	FO	OR
56667	IN	MM	JK	LN	NN	OP	OQ	OR	PR	IR	JS	LM	LO
56668	MN	MM	JJ	LM	JO	NP	MN	KO	IP	IR	KK	FO	KR
56669	MQ	MM	JJ	LN	JK	MM	MM	KO	IP	RR	JK	FK	LO
56670	MO	LM	IJ	LM	KN	OP	QQ	KO	PP	FM	JS	FF	OR
56671	LN	MM	JK	LM	KN	NP	NQ	MP	IN	IR	KK	FL	OR
56672	NO	LM	KK	LM	LM	PP	QQ	LO	NP	IR	KS	MN	KL
56673	LQ	KM	JJ	LL	JQ	MN	MN	KQ	IM	RR	JK	FO	KO
56674	LL	MM	JJ	LO	KO	MP	NQ	PR	MP	NR	JK	FL	LL
56675	NN	MP	HJ	MM	JM	PP	MN	KO	NP	FM	JS	NN	KR
56676	IM	KL	OO	MN	MN	OP	IK	LR	NN	NR	LT	FN	LQ
56677	NN	MM	IK	LN	LN	OP	NQ	LO	PP	FI	JK	MM	KL
56678	II	KP	NN	LL	JK	OP	MM	SS	IP	NN	JL	FN	KK
56679	NN	MM	JJ	MN	KN	MO	QQ	MO	NP	NR	JK	MN	QR
56680	NN	MM	HK	KL	NN	PP	KQ	LP	MP	MM	JJ	FF	KQ
56681	MP	MN	JJ	LM	OO	OP	NN	KO	MP	IR	KK	OO	QR
56682	MO	LL	JK	LM	MO	PP	KQ	OO	MN	RR	JK	NN	KL
56683	LQ	MM	JJ	LO	KO	MP	MN	KP	MP	MR	JS	LL	KL
56684	NP	LM	JJ	MM	NO	OO	NQ	OO	NP	NR	KK	MM	QQ
56685	LM	MM	JK	LL	KO	MM	MQ	KR	PR	MR	JK	KK	LO
56686	IQ	MM	JJ	LM	JK	MO	MQ	OR	PR	MR	JJ	KK	OO
56687	MN	KM	HJ	LN	KO	MO	MQ	KO	PR	MR	JK	KK	LR
56688	JM	MM	HJ	LN	KO	MN	MM	KO	PP	MR	KK	KK	OQ
56689	LQ	MM	JJ	LM	KN	NP	MQ	PQ	IM	IR	KS	LL	KO
56690	NN	LM	JK	LL	KN	MO	QQ	OP	MP	II	JK	MM	QR
56691	IO	MN	JJ	MN	NN	OP	QQ	OR	MP	RR	JK	MM	KL
56693	MN	MM	JO	LM	NN	MO	QQ	KO	MP	MR	KK	FM	QQ
56695	IQ	KM	JJ	LO	JK	NP	NN	QR	IN	RR	JK	FO	LO
56696	NN	LM	JK	KM	MN	PP	MQ	KL	NP	IR	KK	FN	KQ
56697	MN	MP	JJ	LM	JN	PP	NQ	KO	MN	FM	JS	FN	KQ
56698	MP	KL	HJ	LM	JO	PP	NN	MO	IP	RR	KK	FM	QR
56699	IL	LM	KO	LN	KK	MM	QQ	KR	MP	RR	JK	KN	LR
56700	MN	MM	KO	LN	NN	OP	OQ	MO	PR	IM	JS	FM	OR
56701	LL	MP	JJ	NO	KK	MM	QQ	OP	MM	MR	JK	KL	LQ
56702	NO	MN	JJ	MM	JN	OP	NQ	OO	IM	IR	KK	MO	KR

Genetic Analysis of the Riddle Mountain HMA, OR009

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March 29, 2012

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The following is a report of the genetic analysis of the Riddle Mountain HMA, OR009.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels will be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation will be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type so similarity is based upon the total data set.

METHODS

A total of 21 samples were received by Texas A&M University, Equine Genetics Lab on November 15, 2011. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He),* which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the

number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Riddle Mountain HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Riddle Mountain HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Riddle Mountain HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 66 variants were seen in the Riddle Mountain HMA herd which is below the mean for feral herds and well below the mean for domestic breeds. Of these, 21 had frequencies below 0.05 which is a high percentage of variants at risk of future loss. Allelic diversity as represented by *Ae* is low for feral herds as is *MNA*.

Genetic Variation: Observed heterozygosity in the Riddle Mountain HMA herd is well below the feral mean as is *He*. *Ho* is a slightly higher than *He*. Differences such as this can indicate a recent reduction in population size, within the past few generations, but this not possible to confirm by DNA data alone. In comparison to horses sampled in 2009, heterozygosity levels have declined considerably while *Ae* is slightly reduced (despite a much smaller sample size in 2009) and the proportion of rare alleles has increased. This all indicates a loss of diversity.

Genetic Similarity: Overall similarity of the Riddle Mountain HMA herd to domestic breeds was about average for feral herds. Highest mean genetic similarity of the Riddle Mountain HMA herd was with the Old World Iberian breeds followed closely by the Light Racing and Riding breeds then the Oriental and Arabian breeds. As seen in Fig. 1, however, the Riddle Mountain HMA herd clusters a pony breed on the branch that has some Old World Iberian breeds and Oriental breeds. These results indicate a herd with mixed origins with no clear indication of primary breed type. As with most trees involving feral herds, the tree is somewhat distorted.

SUMMARY

Genetic variability of this herd is lower than the feral average but not critically so. However, in comparison, the horses from this herd tested in 2003 and 2009 (both years had small sample sizes) had greater diversity levels than in 2011. All evidence points to a recent reduction in population size that has led to a reduction in genetic variability. Genetic similarity results suggest a herd with mixed ancestry with some Spanish influence possible.

RECOMMENDATIONS

Current variability levels are high enough that no action is needed at this point but the herd should be monitored closely due to the trend for loss of variability. This is especially true if it is known that the herd size has seen a recent decline. Populations that consist of less than 100 individuals are at high risk of loss of variability and this can occur rapidly at low population numbers. It should be noted that the Riddle Mountain herd is genetically very close to the Kiger herd but different enough that exchange of a few individuals among these herds could restore variability levels.

Table 1. Allele frequencies of genetic variants observed in Riddle Mountain HMA feral horse herd.

VHL20															
I	J	K	L	M	N	O	P	Q	R	S					
0.025	0.025	0.000	0.275	0.150	0.275	0.175	0.050	0.025	0.000	0.000					
HTG4															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.175	0.025	0.625	0.000	0.000	0.175	0.000	0.000						
AHT4															
H	I	J	K	L	M	N	O	P	Q	R					
0.175	0.000	0.750	0.025	0.000	0.000	0.000	0.050	0.000	0.000	0.000					
HMS7															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.075	0.650	0.250	0.025	0.000	0.000	0.000	0.000						
AHT5															
I	J	K	L	M	N	O	P	Q	R						
0.050	0.100	0.325	0.000	0.050	0.375	0.025	0.000	0.075	0.000						
HMS6															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.000	0.025	0.275	0.050	0.100	0.550	0.000	0.000						
ASB2															
B	I	J	K	L	M	N	O	P	Q	R					
0.000	0.000	0.000	0.100	0.000	0.175	0.200	0.150	0.000	0.375	0.000					
HTG10															
H	I	J	K	L	M	N	O	P	Q	R	S	T			
0.000	0.000	0.000	0.250	0.000	0.075	0.000	0.475	0.025	0.050	0.125	0.000	0.000			
HMS3															
H	I	J	K	L	M	N	O	P	Q	R	S				
0.000	0.175	0.000	0.000	0.000	0.400	0.150	0.050	0.175	0.000	0.050	0.000				
ASB17															
D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.025	0.000	0.000	0.350	0.000	0.000	0.000	0.100	0.250	0.000	0.000	0.000	0.275	0.000	0.000
ASB2															
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.025	0.125	0.575	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.025	0.025	0.000
LEX33															
F	G	K	L	M	N	O	P	Q	R	S	T				
0.125	0.000	0.075	0.350	0.300	0.150	0.000	0.000	0.000	0.000	0.000	0.000				

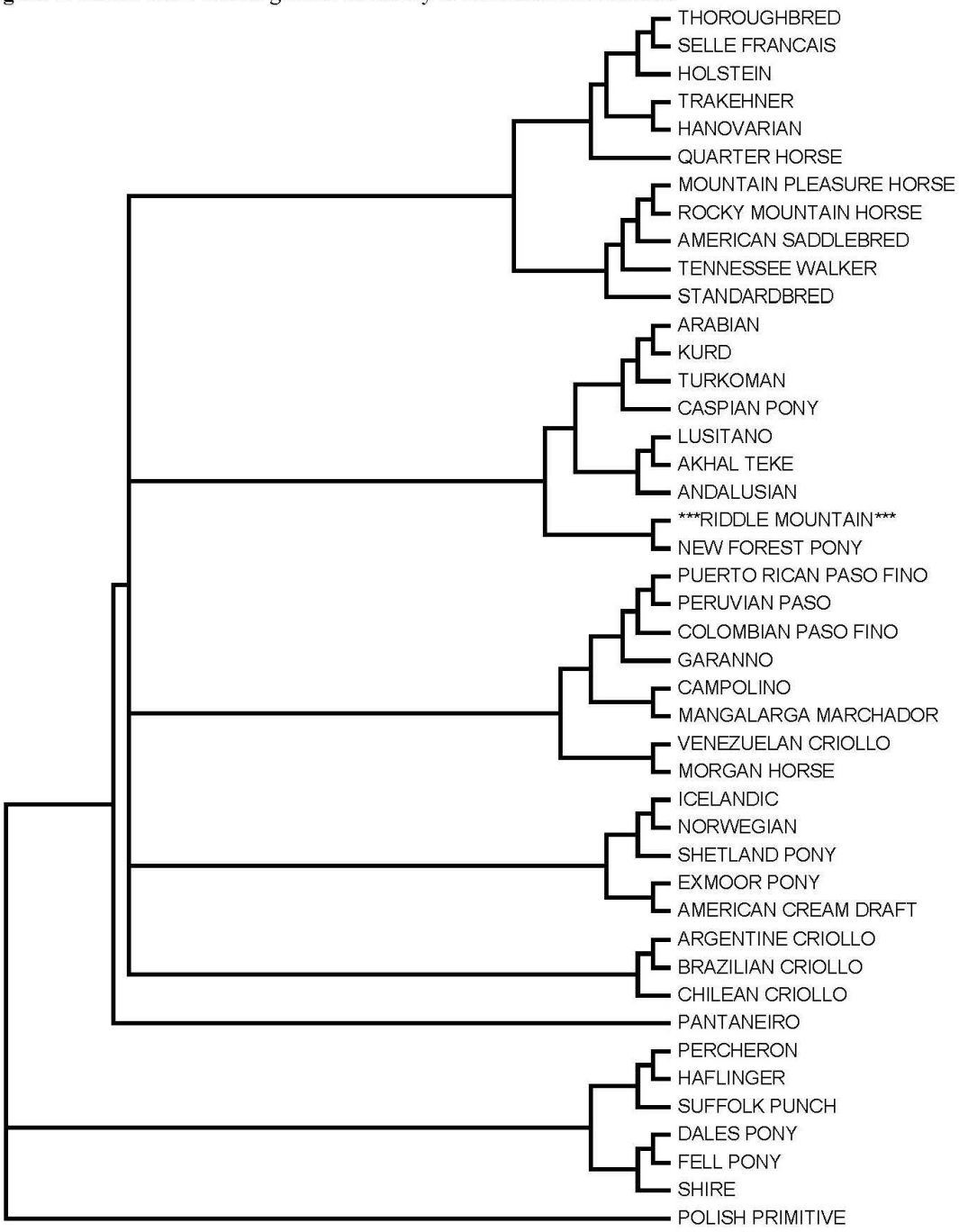
Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
RIDDLE MTN OR	**21**	**0.679**	**0.657**	**-0.034**	**3.21**	**66**	**5.50**	**21**	**0.318**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table 3. Rogers' genetic similarity of the Riddle Mountain HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.723	0.021	0.691	0.748
Oriental and Arabian Breeds	0.715	0.018	0.692	0.740
Old World Iberian Breeds	0.728	0.021	0.707	0.759
New World Iberian Breeds	0.702	0.033	0.651	0.741
North American Gaited Breeds	0.704	0.030	0.669	0.734
Heavy Draft Breeds	0.632	0.046	0.582	0.685
True Pony Breeds	0.644	0.028	0.614	0.680

Figure 1. Partial RML tree of genetic similarity to domestic horse breeds.



Appendix 1. DNA data for the Riddle Mountain HMA, OR herd.

AID	VHL20	HTG4	AHT4	HMS7	AHT5	HMS6	ASB2	HTG10	HMS3	ASB17	ASB23	LEX3	LEX33
56718	NO	MP	JK	LM	JK	MP	KM	KK	MM	MN	KL	LM	KK
56719	LN	MM	JJ	LL	JN	MP	NQ	KK	IM	IR	KL	LM	KK
56720	JL	MM	HJ	LL	JK	MP	MN	OQ	MN	IR	JK	NN	LR
56721	MP	MM	JJ	KL	KQ	LM	OQ	OR	IP	IR	KS	LL	LO
56722	LO	MP	JJ	LM	KN	PP	MQ	KO	MM	IN	KK	LL	KR
56723	NO	MP	HJ	LM	IN	PP	MQ	OO	MP	IR	KS	LL	KK
56724	LN	KK	HJ	KM	NN	PP	QQ	OR	NO	IN	IS	KN	KQ
56725	MN	MM	JJ	LL	KK	MP	NO	KO	NN	RR	KU	MN	LO
56726	LM	MP	HJ	LL	KN	OP	QQ	KO	MR	IN	JK	FL	OR
56727	NO	KP	JO	LN	IN	PP	MN	MO	MP	IN	JS	FL	KL
56728	MN	MM	HH	LL	KO	OP	NQ	MO	NR	II	JK	FM	OR
56729	IN	MM	JO	LM	NN	MO	KK	KR	IP	MR	LT	MM	KR
56730	JL	MM	HJ	LL	JK	MP	MN	OQ	MN	IR	JK	NN	LR
56731	NO	LM	JJ	LL	JM	PP	QQ	MO	MN	FI	KS	MM	KQ
56732	LN	KP	JJ	LM	NN	PP	MN	OO	MP	NN	KS	FF	KR
56733	LO	KP	HJ	LM	KN	MP	OQ	OQ	MP	IR	JK	LL	KR
56734	LQ	KM	JJ	LM	MN	NP	MQ	OO	IM	IN	KK	MM	KO
56735	LM	KM	JJ	LM	KN	MP	OQ	OR	IO	MN	KK	KK	KQ
56736	LM	MM	JJ	LL	KK	MO	KO	KR	IM	MR	KK	NN	QQ
56737	NO	MM	JJ	LM	KN	MP	NQ	KO	MM	IN	KK	MM	KQ
56738	LP	MM	JJ	KL	QQ	MN	NO	OP	IP	RR	KK	LL	LO

Genetic Analysis of the Kiger HMA, OR010

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February 20, 2016

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The following is a report of the genetic analysis of the Kiger HMA, OR010.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels will be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation will be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type so similarity is based upon the total data set.

METHODS

A total of 56 samples were received by Texas A&M University, Equine Genetics Lab on October 1, 2015. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He),* which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the

number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Kiger HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Kiger HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Kiger HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 80 variants were seen in the Kiger HMA herd which is above the mean for feral herds and slightly below the mean for domestic breeds. Of these, 24 had frequencies below 0.05 which is a high percentage of variants at risk of future loss. Allelic diversity as represented by *Ae* is somewhat below average for feral herds while *MNA* is greater than the mean.

Genetic Variation: Observed heterozygosity in the Kiger HMA herd is well above the feral mean while He is only slightly lower than average. *Ho* is a good bit higher than *He.* Differences such as this can indicate a recent reduction in population size, within the past few generations, but this not possible to confirm by DNA data alone.

Genetic Similarity: Overall similarity of the Kiger HMA herd to domestic breeds was about average for feral herds. Highest mean genetic similarity of the Kiger HMA herd was with the Oriental and Arabian breeds with the Old World Iberian group having almost the same mean *S* value. As seen in Fig. 1, however, the Kiger HMA herd clusters with the Brazilian Pantaniero breed between the Old World Iberian breeds and those from South America. This is similar to what was observed in 2011 where the Kiger herd paired with the Pantaniero but was not as close to the other South American breeds. These results indicate a herd with mixed origins but there does appear to be a stronger association with Spanish breeds than has been seen in recent years. As with most trees involving feral herds, the tree is somewhat distorted. In comparison to other feral herds from Oregon the Kiger herd is most like the Riddle Mountain herd which is geographically nearby.

SUMMARY

Genetic variability of this herd in general is on the high side but there is a high percentage of variation that is at risk. There is a possibility that this herd has seen a recent loss of population size which would increase the risk to genetic diversity. Genetic similarity results suggest a herd with mixed ancestry but with a clear Spanish component.

RECOMMENDATIONS

Current variability levels are high enough that no action is needed at this point but the herd should be monitored closely due to the high proportion of rare alleles. This is especially true if it is known that the herd size has seen a recent decline.

Table 1. Allele frequencies of genetic variants observed in Kiger HMA feral horse herd.

VHL20															
I	J	K	L	M	N	O	P	Q	R	S					
0.063	0.054	0.000	0.143	0.179	0.330	0.089	0.045	0.098	0.000	0.000					
HTG4															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.054	0.170	0.643	0.054	0.000	0.080	0.000	0.000						
AHT4															
H	I	J	K	L	M	N	O	P	Q	R					
0.098	0.027	0.670	0.143	0.000	0.000	0.018	0.045	0.000	0.000	0.000					
HMS7															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.018	0.027	0.527	0.205	0.143	0.080	0.000	0.000	0.000						
AHT5															
I	J	K	L	M	N	O	P	Q	R						
0.009	0.161	0.330	0.063	0.036	0.295	0.098	0.000	0.009	0.000						
HMS6															
I	J	K	L	M	N	O	P	Q	R						
0.000	0.000	0.018	0.009	0.241	0.036	0.214	0.482	0.000	0.000						
ASB2															
B	I	J	K	L	M	N	O	P	Q	R					
0.000	0.027	0.000	0.107	0.000	0.170	0.268	0.107	0.000	0.321	0.000					
HTG10															
H	I	J	K	L	M	N	O	P	Q	R	S	T			
0.000	0.000	0.000	0.295	0.027	0.107	0.018	0.348	0.027	0.063	0.107	0.009	0.000			
HMS3															
H	I	J	K	L	M	N	O	P	Q	R	S				
0.000	0.161	0.000	0.000	0.000	0.241	0.152	0.009	0.375	0.000	0.063	0.000				
ASB17															
D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.071	0.000	0.000	0.116	0.000	0.000	0.000	0.295	0.036	0.036	0.000	0.000	0.429	0.018	0.000
ASB23															
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.071	0.295	0.357	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000
LEX33															
F	G	K	L	M	N	O	P	Q	R	S	T				
0.000	0.009	0.179	0.170	0.009	0.000	0.205	0.000	0.170	0.250	0.000	0.009				

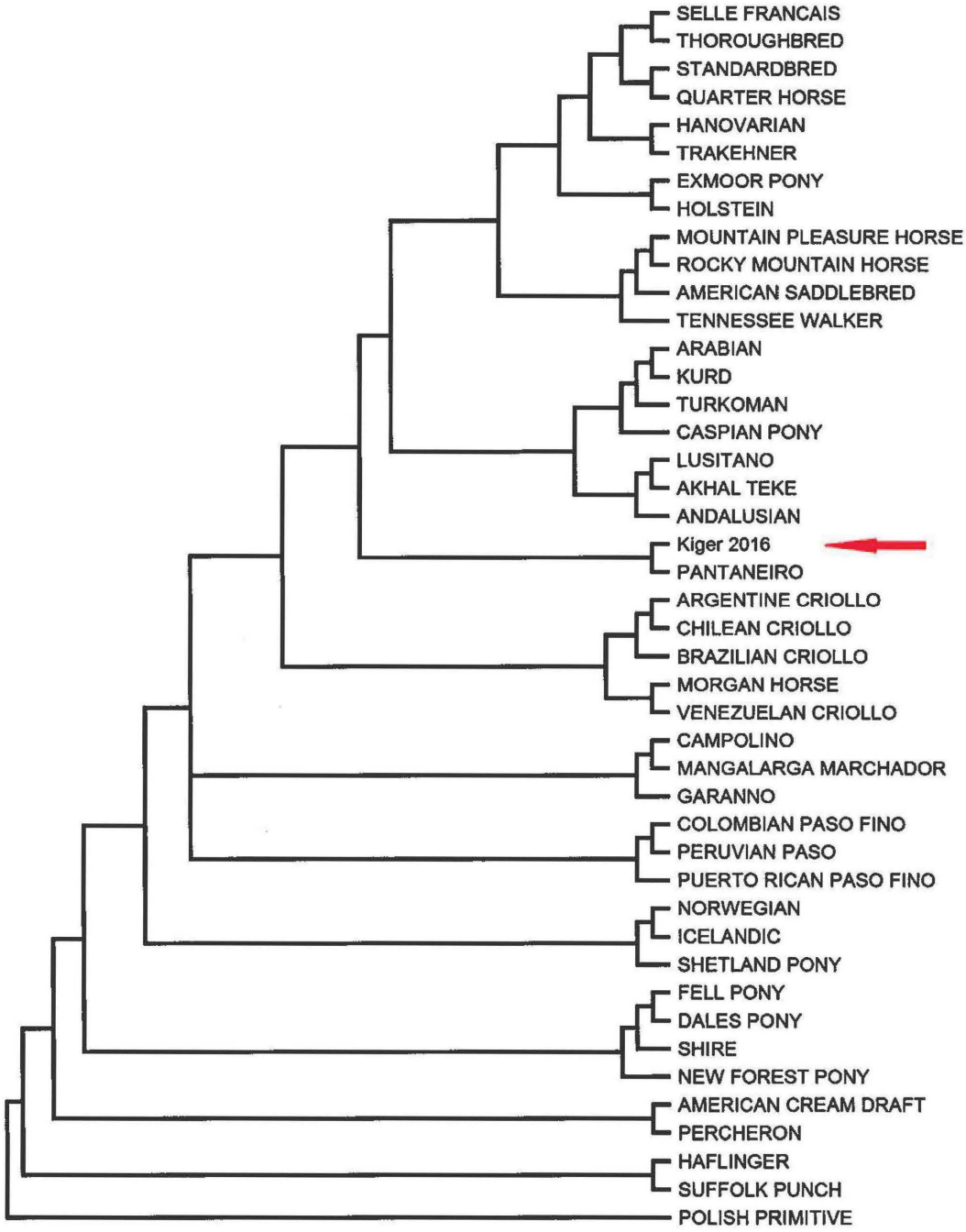
Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
Kiger Herd OR	**56**	**0.722**	**0.707**	**-0.021**	**3.710**	**80**	**6.667**	**24**	**0.300**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table 3. Rogers' genetic similarity of the Kiger HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	**0.752**	**0.019**	**0.728**	**0.777**
Oriental and Arabian Breeds	**0.759**	**0.023**	**0.724**	**0.790**
Old World Iberian Breeds	**0.758**	**0.019**	**0.738**	**0.791**
New World Iberian Breeds	**0.744**	**0.036**	**0.686**	**0.800**
North American Gaited Breeds	**0.744**	**0.019**	**0.714**	**0.765**
Heavy Draft Breeds	**0.685**	**0.044**	**0.624**	**0.742**
True Pony Breeds	**0.701**	**0.029**	**0.665**	**0.742**

Figure 1. Partial RML tree of genetic similarity to domestic horse breeds.



Appendix 1. DNA data for the Kiger HMA, OR herd.

AID	VHL20	HTG4	AHT4	HMS7	AHT5	HMS6	ASB2	HTG10	HMS3	ASB17	ASB23	LEX33	LEX3
86033	MN	LM	JJ	LN	NO	PP	KQ	KO	IM	MR	JL	KR	FF
86034	MO	MP	JJ	LO	KM	MP	MO	KK	MP	MR	KK	KL	MM
86035	MQ	LL	JJ	JL	JK	MP	OO	KO	MP	MO	IK	LQ	HH
86036	NP	MN	JK	MN	NO	OP	NO	KO	PP	MR	KK	OQ	FF
86037	LQ	KM	JK	LM	NQ	PP	NQ	KM	NN	MR	KS	OO	NN
86038	NO	MM	JK	MN	NN	OP	OO	OO	MR	IR	KS	LR	LL
86039	LP	MM	JJ	KL	KK	MM	KQ	OR	II	IM	KK	OQ	LL
86040	LN	MM	JJ	LL	JK	PP	MN	OQ	MN	RR	KK	LO	MM
86041	JN	KM	HN	LO	IO	MP	KQ	OR	IP	OR	IS	QQ	NN
86042	LO	MM	JJ	LL	KN	MP	OQ	OR	MP	MR	KK	KQ	LL
86043	LL	KM	JJ	LM	KN	OP	OQ	OR	IN	NR	KS	QQ	NN
86044	NN	LM	JJ	LL	KN	MP	MQ	OQ	MP	MR	JK	KO	NN
86045	LN	MM	JO	LN	KN	NP	NQ	MP	IR	IR	JK	OR	FF
86046	JQ	MM	JJ	LN	JK	MP	MQ	OO	IP	RR	JK	LQ	KK
86047	NN	MP	HO	LM	JN	PP	MQ	KK	NP	FM	SS	RR	NN
86048	JM	MP	JJ	LL	KK	OP	NQ	KO	MR	IN	JJ	LO	LL
86049	MQ	LM	IJ	LL	KN	OP	NQ	KO	IP	FM	SS	OR	FF
86050	LN	MM	JJ	MO	KO	MP	MN	PQ	IM	NR	JS	LQ	FF
86051	IL	LM	JK	NO	KO	MP	MN	MO	NN	RR	JK	OR	FF
86052	IM	LM	HO	LM	KK	MP	NQ	MR	MP	MR	JJ	OR	LL
86053	IN	KP	JK	MM	JN	MP	MN	KO	NP	MR	JS	KR	MN
86054	JM	MM	HJ	LL	JJ	KP	KM	OO	OP	RS	IL	LO	FI
86055	MN	MN	JJ	LM	NO	MO	QQ	MO	MN	MR	KK	KR	FN
86056	MM	LM	JJ	LN	KN	MP	OQ	KO	MP	MM	KS	LR	MN
86057	IM	LM	HJ	MO	KK	MP	NQ	OR	MP	RR	JK	LO	FL
86058	LN	MM	HN	KL	JL	LM	KO	KM	PP	MR	LL	LQ	FL
86059	MQ	MN	JJ	LL	KN	MO	KN	KQ	IM	MR	JK	KO	FM
86060	NP	MP	HJ	LL	LO	MO	IQ	KN	PP	FR	IL	GQ	FH
86061	MN	MM	IJ	LN	NN	OP	KN	KL	IP	FR	JK	LR	FM
86062	NQ	MM	JK	MN	KM	MP	NN	KK	PP	MM	JS	KR	MN
86063	LO	MM	JK	LL	KL	PP	NQ	OO	PR	FM	KS	KO	MN
86064	LM	MM	JK	LL	KN	NP	MQ	MP	PP	MR	KS	OO	FF
86065	NQ	LM	IJ	JK	JN	OP	IO	MO	IP	OO	II	LQ	HN
86066	IN	MM	JJ	LL	KN	MO	MN	KO	MN	IM	KS	MR	LM
86067	LQ	MM	JJ	LO	JK	PP	MM	OR	MP	MR	JJ	KQ	KL
86068	NN	MM	JJ	MN	NN	OP	KN	OR	IP	IM	JL	KK	FN
86069	JM	MP	HJ	LM	JJ	KM	MQ	OS	IP	RS	IS	LO	NN
86070	NP	MM	HJ	LL	JL	MO	IK	KN	PP	NR	IL	QT	HH
86071	NN	LM	JK	LM	NN	OP	NN	OR	PR	II	JS	KR	FN
86072	JN	MM	HJ	LL	JK	PP	MN	KQ	MN	IR	KK	LR	NN
86073	NO	MN	JJ	MM	KO	OO	NQ	MO	MN	RR	KK	KR	MN
86074	NQ	KP	JK	MM	JN	PP	NN	KK	NN	FR	JS	OR	MN
86075	MO	LM	JJ	LN	KL	OP	QQ	OR	NR	MR	JJ	RR	FF
86076	MN	MM	JJ	LL	JK	NP	MN	KL	IP	IM	JK	KR	LO
86077	IL	LM	JJ	LO	KK	MP	NQ	MR	MN	RR	JJ	LO	FN
86078	MP	LL	JO	LN	KN	MO	OQ	KK	MP	RR	KS	LR	FN
86079	NN	MN	JJ	MN	KN	OP	QQ	KM	IM	MR	JK	RR	FN
86080	MN	MM	JJ	LO	KK	OP	MQ	KR	IM	MM	JS	LR	FL
86081	OQ	NP	JJ	MO	MN	OP	KM	KO	PP	RR	JK	KQ	MM
86082	IL	MM	JK	LM	NN	MM	MN	KQ	PP	RR	KS	QR	FM
86083	MN	LM	JK	LN	NO	PP	KN	KO	MR	IM	JJ	KK	NN
86084	OQ	KM	JJ	LL	KO	MN	KN	KQ	IP	RR	KS	OQ	FF
86085	NO	LM	JK	MN	LO	PP	QQ	OO	MN	MR	JK	LR	FM
86086	NN	LM	KO	LN	JN	OP	QQ	MO	MP	MM	JJ	OR	FM
86087	LN	LP	HJ	LL	JN	OP	QQ	KO	MM	II	KS	OQ	FF
86088	NO	MM	KK	LL	LM	OP	NQ	LO	PP	FF	KS	KK	MN

Genetic Analysis of the Riddle HMA, OR

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February 20, 2016

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The following is a report of the genetic analysis of the Riddle HMA, OR.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels will be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation will be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type so similarity is based upon the total data set.

METHODS

A total of 29 samples were received by Texas A&M University, Equine Genetics Lab on October 01, 2015. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He),* which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the

number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Riddle HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Riddle HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Riddle HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 65 variants were seen in the Riddle HMA herd which is below the mean for feral herds and well below the mean for domestic breeds. Of these, 14 had frequencies below 0.05. This percentage of variants at risk of future loss is below average and indicates little risk of loss of allelic diversity over the short term. Allelic diversity as represented by *Ae* also is below the average for feral herds as is *MNA*.

Genetic Variation: Genetic variation, as indicated by heterozygosity, in the Riddle HMA herd is slightly above the feral mean, and higher than might be expected based upon the allelic diversity. *Ho* is higher than *He*. This result could represent a recent loss of population size but this is not clear based upon DNA information alone.

Genetic Similarity: Overall similarity of the Riddle HMA herd to domestic breeds was low for feral herds. This is likely due to the low allelic diversity. Highest mean genetic similarity of the Riddle HMA herd was with both groups of Iberian breeds but, again, the values are quite low. As seen in Fig. 1, the Riddle HMA herd fits within a cluster of draft breeds and pairs with an English pony breed. However, in this branch also is the Brazilian breed the Pantaneiro which is the breed that fits most closely to the Kiger HMA horses. This could be due to the close relationship of the Riddle and Kiger herds. As with most trees involving feral herds, the tree is somewhat distorted as demonstrated by the branch with the Riddle herd. There is some evidence for Spanish relationship but the low similarity values and clearly distorted dendrogram make evaluation of this association difficult to interpret. In comparison to neighboring HMAs, the Riddle Mountains herd is most like the Kiger herd as indicated above.

SUMMARY

Genetic variability of this herd could be considered mixed. The values related to allelic diversity are low while heterozygosity is about average. This pattern has existed in the herd since 2003 but although allelic diversity values in 2003 were similar to those in 2015, there has been a trend for heterozygosity to decrease over this time as well. Genetic similarity results suggest a herd with mixed ancestry that may include some Spanish background but over all is not that close to any domestic group and shows mixed results. There is a possibility that this herd has seen a recent loss of population size and genetic diversity.

RECOMMENDATIONS

Current variability levels are low enough that there should be some concern. The herd should be monitored to check for evidence of inbreeding. The current genetic data does not indicate that inbreeding is a concern at this time but the diversity levels are trending in a direction that may lead to a need for action in the next few years. The potential to exchange horses among neighboring HMAs lessen the potential impact of the small AML is exchanges are allowed.

Table 1. Allele frequencies of genetic variants observed in Riddle HMA feral horse herd.

VHL20										
I	J	K	L	M	N	O	P	Q	R	S
0.052	0.103	0.000	0.259	0.086	0.241	0.121	0.086	0.052	0.000	0.000

HTG4									
I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.155	0.052	0.638	0.017	0.000	0.138	0.000	0.000

AHT4										
H	I	J	K	L	M	N	O	P	Q	R
0.069	0.000	0.690	0.190	0.000	0.000	0.017	0.034	0.000	0.000	0.000

HMS7									
I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.621	0.121	0.121	0.138	0.000	0.000	0.000

AHT5									
I	J	K	L	M	N	O	P	Q	R
0.034	0.052	0.448	0.000	0.034	0.328	0.069	0.000	0.034	0.000

HMS6									
I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.000	0.190	0.086	0.121	0.603	0.000	0.000

ASB2										
B	I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.052	0.000	0.259	0.207	0.172	0.000	0.310	0.000

HTG10												
H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.224	0.000	0.069	0.000	0.379	0.103	0.069	0.138	0.017	0.000

HMS3											
H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.172	0.000	0.000	0.000	0.397	0.121	0.000	0.293	0.000	0.017	0.000

ASB17															
D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.000	0.345	0.000	0.000	0.000	0.190	0.207	0.000	0.000	0.000	0.241	0.017	0.000

ASB23															
G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.000	0.362	0.500	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.103	0.000	0.017	0.000

LEX33											
F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.362	0.190	0.000	0.000	0.190	0.000	0.121	0.138	0.000	0.000

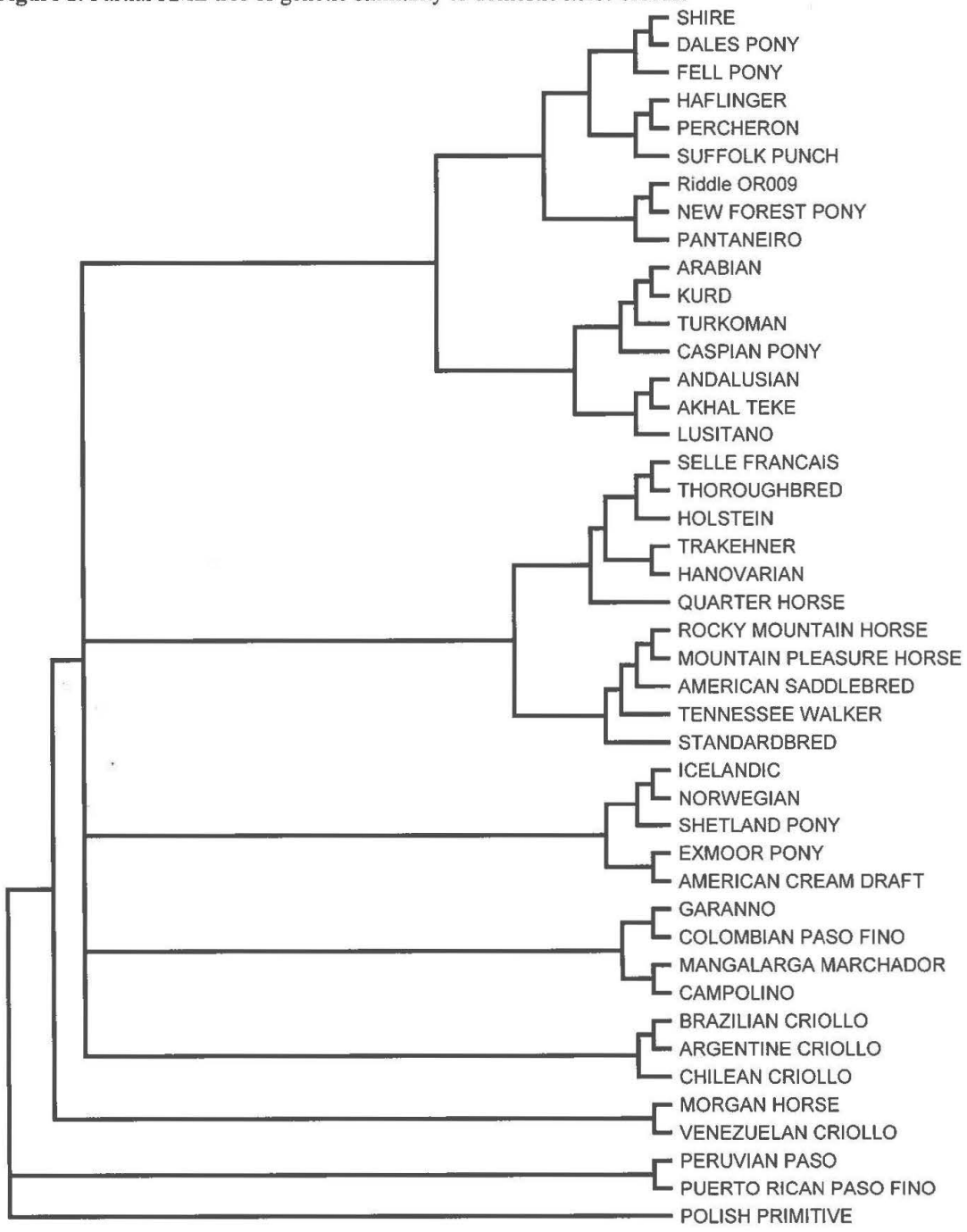
Table 2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
Riddle Mountain OR 009	**29**	**0.724**	**0.677**	**-0.094**	**3.410**	**65**	**5.420**	**14**	**1.167**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table 3. Rogers' genetic similarity of the Riddle HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	**0.576**	**0.019**	**0.551**	**0.599**
Oriental and Arabian Breeds	**0.583**	**0.019**	**0.560**	**0.602**
Old World Iberian Breeds	**0.588**	**0.013**	**0.576**	**0.610**
New World Iberian Breeds	**0.588**	**0.014**	**0.563**	**0.605**
North American Gaited Breeds	**0.578**	**0.019**	**0.541**	**0.600**
Heavy Draft Breeds	**0.591**	**0.036**	**0.527**	**0.632**
True Pony Breeds	**0.590**	**0.016**	**0.566**	**0.605**

Figure 1. Partial RML tree of genetic similarity to domestic horse breeds.



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Appendix 1. DNA data for the Riddle HMA, OR herd.

AID	VHL20	HTG4	AHT4	HMS7	AHT5	HMS6	ASB2	HTG10	HMS3	ASB17	ASB23	LEX33	LEX3
86004	MO	MM	JJ	LL	JN	PP	MQ	KO	MP	NR	KK	RR	FL
86005	JP	MP	JJ	LO	KN	PP	OO	OR	IP	MR	KS	LQ	KK
86006	LQ	KM	JK	LO	KK	MP	OQ	RR	MN	MS	SS	OO	LM
86007	IL	NP	JJ	LN	KN	OP	QQ	OR	MP	IR	KK	KK	LM
86008	LM	MM	HK	LL	KK	PP	OQ	KP	NP	IR	JJ	LR	MM
86009	LN	MM	JK	NO	IK	MN	MO	OR	IM	IM	JS	KO	MM
86010	NQ	MM	JK	LM	KN	MP	NQ	OQ	IP	MR	JJ	KQ	MN
86011	LM	MM	HJ	LM	KK	PP	MQ	KM	MN	II	JK	OR	LM
86012	LN	MM	HJ	LL	NO	OP	NQ	MO	MR	II	KK	OR	LM
86013	JN	KM	JJ	LL	KN	MP	MO	OP	MP	MR	JK	KL	KK
86014	LN	MM	JJ	LN	KO	OP	MN	MO	IM	IM	JK	KO	FL
86015	NO	MM	JK	LL	MN	PP	NQ	OO	MP	IR	JK	KK	MM
86016	LN	KL	JJ	LL	KN	MN	MN	PQ	MM	IN	JK	KL	KK
86017	LO	MP	JJ	LM	KN	PP	MQ	KO	MM	IN	KK	KR	LL
86018	PQ	KP	JK	LO	NQ	PP	OQ	OR	IP	IR	KS	OQ	LL
86019	LP	MP	JK	LO	NO	PP	NO	OP	NP	NR	JK	LQ	KK
86020	LN	KM	JJ	MN	KQ	NP	NQ	OR	II	IM	KS	LO	MM
86021	JL	LM	HJ	LL	KN	MM	MN	KO	NP	IR	JK	QR	MM
86022	LN	MP	JJ	LM	KN	OP	QQ	KO	MP	IN	JK	KQ	MM
86023	IP	LM	JO	NO	KN	MO	KM	KO	NP	NR	JK	KO	MM
86024	NN	KM	JO	LN	IK	NP	MN	OQ	IM	IM	JK	KO	FF
86025	IM	KM	KN	LO	KO	OP	MN	PS	NP	NN	JK	KL	NN
86026	NO	MP	JK	LL	JN	MP	KQ	KK	IM	IM	KU	KK	MM
86027	JP	MM	JJ	LL	JM	NP	NQ	KK	MP	MR	JJ	LQ	MM
86028	LO	MM	JJ	LN	KN	OP	QQ	OO	MP	IR	KK	KR	MM
86029	NO	MP	JK	MO	KN	MP	KM	KK	IM	MN	KL	KK	MM
86030	JJ	KK	JJ	LL	KK	MP	MO	QR	MM	NR	JJ	LL	FN
86031	NO	MM	JK	LL	NN	PP	MN	OO	MP	IN	JK	KK	LN
86032	LM	MM	JJ	LM	KK	PP	MO	MP	MP	IN	KK	LO	MM

APPENDIX H: POPEQUUS MODELING OF THE ALTERNATIVES.**

PopEquus (1.0.1) Advanced Tool - Simulation Report

27 March 2024 15:32:02

Population inputs

You used the *PopEquus* Advanced Tool to simulate a horse population that started with 224 horses, had a population sex ratio where 0.5 of the population is female, was censused at a time that foals were present (No), had a mean annual population growth rate of 20 percent per year, and a capture probability during management (e.g., helicopter gather) of 1. You assumed that the target population size range for the population (i.e., Appropriate Management Level) was 51-82 horses, that removals aimed for a target population size of 51, and that if the population decreased to beneath 30 horses that it would be at high risk of local extirpation. In summary:

- Population size: 224
- Female proportion of population: 0.5
- Foals included in population size? No
- Population growth rate (% increase per year): 20
- Capture proportion during gathers: 1
- Appropriate management level (minimum): 51
- Appropriate management level (maximum): 82
- Target population size: 51
- Persistence threshold (i.e., minimum number of individuals): 30

Simulation inputs

You simulated populations over a 10-year projection interval, and you performed 30 replicate projections.

- Projection interval (years): 10
- Number of simulation replicates: 30

Management alternatives

You simulated 6 management alternatives using the tool: **Mare sterilization and GonaCon, No management, Removal (year 1) and GonaCon (darting), Removals, Removals and GonaCon, Removals and mare sterilization.**

The following settings were specified for management actions:

Gather options

- Short-term holding costs ($ per day): 7.61

Removal options

- Removal years: 1, 5, 9
- Reactive removals: Yes
- Minimum gather interval (years) for a reactive removal: 5
- Selective removals: Yes
- Male proportion of population returned after a removal: 0.5
- Maximum number removed from the population per year: 1500

- Number of years to project holding population: 25
- Long-term holding costs ($ per day): 2.02
- Proportion of horses adopted per year: 0.69
- Net adoption cost to agency ($ per horse): 1775
- Breeding reduction (%) of removed females in captivity the first year after removal: 25

GonaCon options

- Treatment years: 1, 5, 9
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Treatment cost per shot ($): 50
- Hold to give booster treatment: Yes
- Days in holding until booster: 60

Mare sterilization options

- Treatment years: 1, 5, 9
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 50
- Treatment cost ($): 500
- Post-treatment monitoring (days): 14

Darting options

- Treatment years: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
- Proportion of the female population (%) that can be darted in a year: 50
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females that can be darted in a year: 100
- Are individuals darted twice to receive a booster in their first year? (Only applies to 'GonaCon (darting)'.) No
- Darting cost ($) per shot: 250

Results

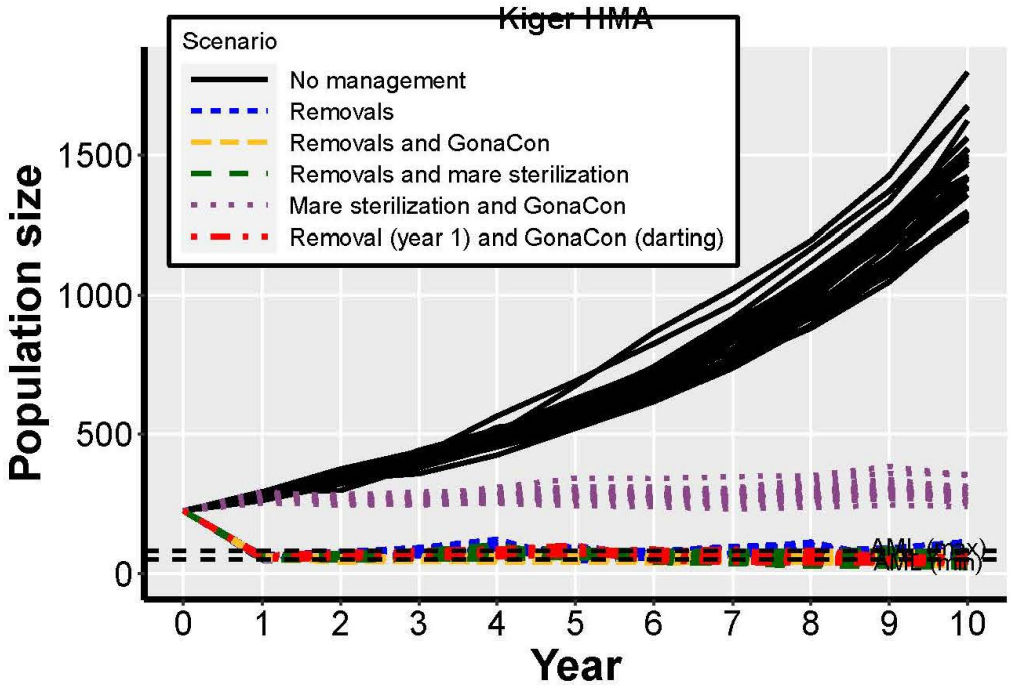
Simulation outcomes can be summarized with a table(s) describing mean values among replicates for relevant metrics. Metrics include: population size in the final year of the projection interval ('Final population size'), average population size across all years ('Mean population size'), proportion of replicates that ended within the AML (i.e., the likelihood that an alternative yielded AML in the final year; 'AML probability'), proportion of replicates that ended above the persistence threshold ('Persistence probability'), total number of horses gathered ('Number gathered'), total number of horses removed ('Number removed'), total number of horses treated ('Number treated'), cost of management in the Herd Management Area (HMA) in millions of USD ['On-range cost ($ million)'], and total cost of management, including costs incurred at the HMA and in holding facilities ['Total cost ($ million)']. Values in parentheses are 95% confidence intervals.

Alternative	Final population size	Overall mean population size	AML probability
No management	1467 (1274-1708)	686 (622-780)	0.00
Removals	73 (57-111)	89 (84-95)	0.87
Removals and GonaCon	54 (34-73)	72 (61-82)	0.60
Removals and mare sterilization	60 (30-83)	80 (70-87)	0.53
Mare sterilization and GonaCon	288 (248-354)	276 (254-307)	0.00
Removal (year 1) and GonaCon (darting)	51 (38-64)	78 (70-84)	0.53

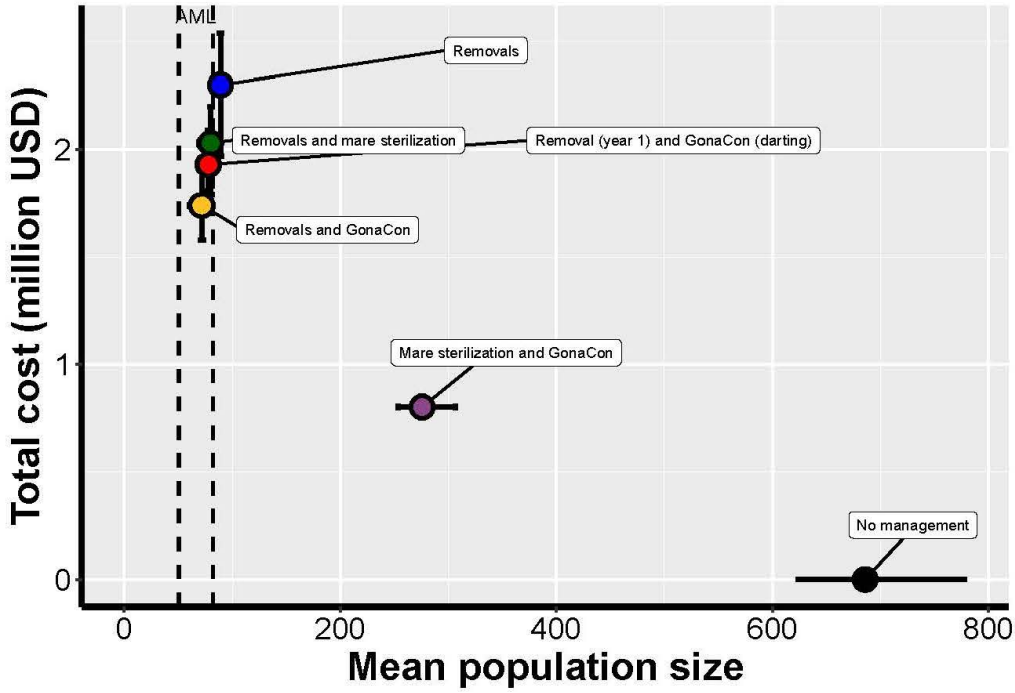
Alternative	Persistence probability	Number gathered	Number removed	Number treated
No management	1.00	0 (0-0)	0 (0-0)	0 (0-0)
Removals	1.00	411 (325-444)	271 (229-302)	0 (0-0)
Removals and GonaCon	0.97	343 (313-394)	183 (182-192)	72 (57-87)
Removals and mare sterilization	0.97	436 (361-474)	222 (200-254)	24 (20-29)
Mare sterilization and GonaCon	1.00	790 (729-864)	0 (0-0)	286 (265-309)
Removal (year 1) and GonaCon (darting)	1.00	314 (308-327)	221 (214-235)	119 (85-147)

Alternative	On-range cost ($ million)	Off-range cost ($ million)	Total cost ($ million)
No management	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
Removals	0.40 (0.31-0.43)	1.90 (1.66-2.12)	2.30 (1.97-2.54)
Removals and GonaCon	0.36 (0.32-0.42)	1.38 (1.23-1.56)	1.74 (1.58-1.93)
Removals and mare sterilization	0.45 (0.37-0.49)	1.58 (1.38-1.77)	2.03 (1.79-2.20)
Mare sterilization and GonaCon	0.80 (0.75-0.85)	0.00 (0.00-0.00)	0.80 (0.75-0.85)
Removal (year 1) and GonaCon (darting)	0.32 (0.31-0.34)	1.61 (1.49-1.77)	1.93 (1.81-2.09)

A graph of population size through time can be used to visualize effects of management alternatives on population size. Different colored lines indicate management alternatives simulated by the user; for each alternative, individual lines are different simulation replicates, that vary due to random chance. Dashed horizontal black lines indicate the minimum and maximum target population size range (i.e., AML).



Individuals might be interested in identifying a management alternative(s) that achieves the reduction or maintenance of a population within the target population size range (i.e., AML) while also incurring lower direct costs relative to other options. We can visualize the relationship between predicted population size and direct costs of management by graphing the overall mean population size (number of horses) on the x-axis and total cost of management (millions of USD) on the y-axis predicted by each alternative. Points are mean predictions among replicates and are colored by scenario (as in in the first graph); horizontal and vertical lines from points represent 95% confidence intervals in predicted population size and cost, respectively, for each scenario. While this graph does not account for all factors that might be important during management decisions, the graph provides a useful illustration of the trade-off between predicted population size and total direct cost of management resulting from the simulated alternatives.



Summary

The alternative that yielded the smallest average population size was:

```
## [1] "Removals and GonaCon"
```

The alternative that incurred the lowest direct costs 'on range' (other than 'no management') over the next 10 years was:

```
## [1] "Removal (year 1) and GonaCon (darting)"
```

The alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range' (other than 'no management') over the next 35 years was:

```
## [1] "Mare sterilization and GonaCon"
```

Among the alternatives that achieved population size within Appropriate Management Levels, the alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range':

```
## [1] "Removals and GonaCon"
```

Note: results from the simulations may not be the sole basis for a management decision. The model does not explicitly account for or consider multiple uses on public lands, local land use planning considerations, ecological costs of horses on ecosystems, or other important values. The results presented here reflect considerations related to population size, amount of management, and fiscal costs of management that were estimated, given the input parameters and alternatives specified.

PopEquus (1.0.1) Advanced Tool - Simulation Report

27 March 2024 15:24:52

Population inputs

You used the *PopEquus* Advanced Tool to simulate a horse population that started with 198 horses, had a population sex ratio where 0.5 of the population is female, was censused at a time that foals were present (No), had a mean annual population growth rate of 20 percent per year, and a capture probability during management (e.g., helicopter gather) of 0.75. You assumed that the target population size range for the population (i.e., Appropriate Management Level) was 33-56 horses, that removals aimed for a target population size of 33, and that if the population decreased to beneath 30 horses that it would be at high risk of local extirpation. In summary:

- Population size: 198
- Female proportion of population: 0.5
- Foals included in population size? No
- Population growth rate (% increase per year): 20
- Capture proportion during gathers: 0.75
- Appropriate management level (minimum): 33
- Appropriate management level (maximum): 56
- Target population size: 33
- Persistence threshold (i.e., minimum number of individuals): 30

Simulation inputs

You simulated populations over a 10-year projection interval, and you performed 30 replicate projections.

- Projection interval (years): 10
- Number of simulation replicates: 30

Management alternatives

You simulated 6 management alternatives using the tool: **Mare sterilization and GonaCon, No management, Removal (year 1) and GonaCon (darting), Removals, Removals and GonaCon, Removals and mare sterilization.**

The following settings were specified for management actions:

Gather options

- Short-term holding costs ($ per day): 7.61

Removal options

- Removal years: 1, 5, 9
- Reactive removals: Yes
- Minimum gather interval (years) for a reactive removal: 5
- Selective removals: Yes
- Male proportion of population returned after a removal: 0.5
- Maximum number removed from the population per year: 1500

- Number of years to project holding population: 25
- Long-term holding costs ($ per day): 2.02
- Proportion of horses adopted per year: 0.69
- Net adoption cost to agency ($ per horse): 1775
- Breeding reduction (%) of removed females in captivity the first year after removal: 25

GonaCon options

- Treatment years: 1, 5, 9
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Treatment cost per shot ($): 50
- Hold to give booster treatment: Yes
- Days in holding until booster: 60

Mare sterilization options

- Treatment years: 1, 5, 9
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 50
- Treatment cost ($): 500
- Post-treatment monitoring (days): 14

Darting options

- Treatment years: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
- Proportion of the female population (%) that can be darted in a year: 50
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females that can be darted in a year: 100
- Are individuals darted twice to receive a booster in their first year? (Only applies to 'GonaCon (darting)'.) No
- Darting cost ($) per shot: 250

Results

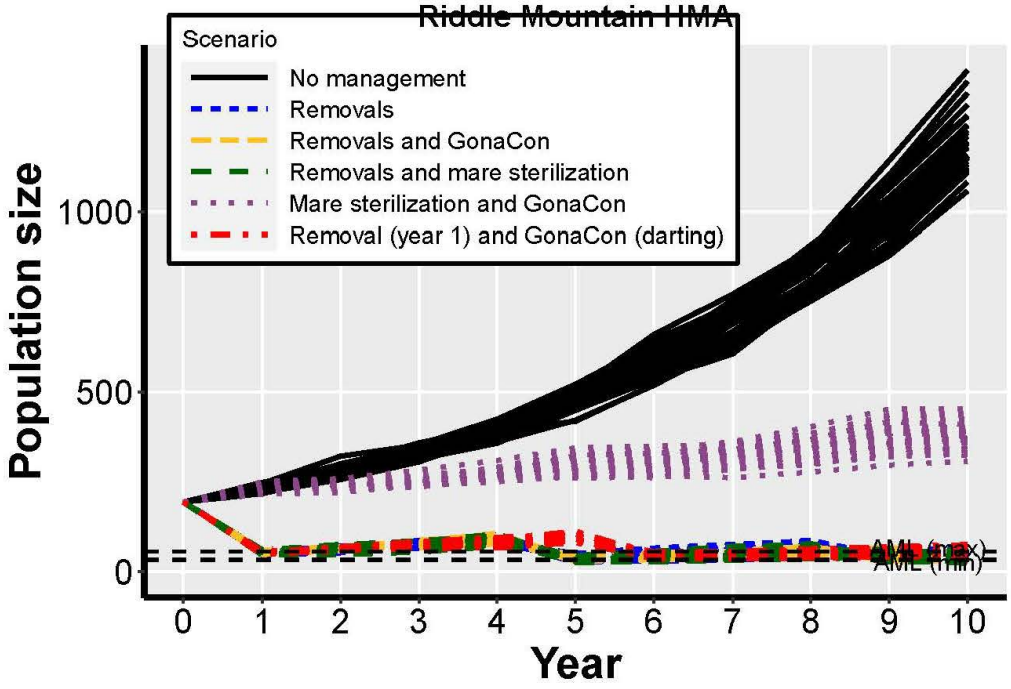
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Alternative	Final population size	Overall mean population size	AML probability
No management	1193 (1076-1372)	563 (521-613)	0.00
Removals	45 (32-67)	69 (64-74)	0.77
Removals and GonaCon	36 (27-53)	68 (65-70)	0.60
Removals and mare sterilization	39 (25-60)	67 (61-73)	0.57
Mare sterilization and GonaCon	379 (319-445)	293 (263-325)	0.00
Removal (year 1) and GonaCon (darting)	59 (45-75)	74 (67-83)	0.43

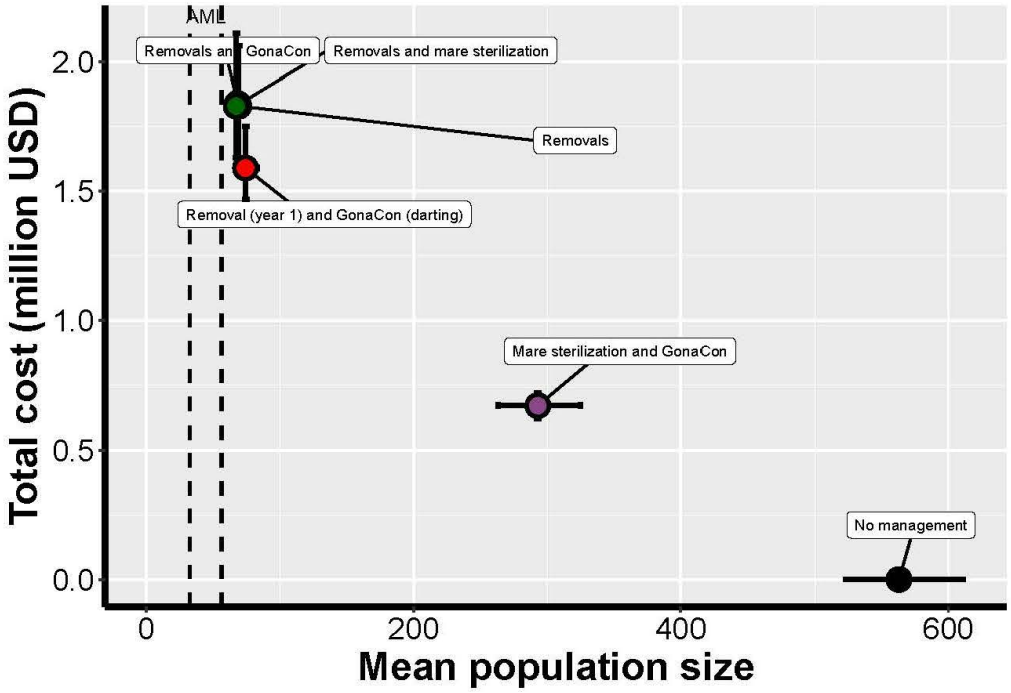
Alternative	Persistence probability	Number gathered	Number removed	Number treated
No management	1.00	0 (0-0)	0 (0-0)	0 (0-0)
Removals	0.97	269 (216-290)	242 (207-260)	0 (0-0)
Removals and GonaCon	0.70	286 (263-322)	241 (213-256)	17 (9-26)
Removals and mare sterilization	0.80	283 (255-324)	239 (207-259)	4 (1-8)
Mare sterilization and GonaCon	1.00	623 (571-683)	0 (0-0)	234 (215-253)
Removal (year 1) and GonaCon (darting)	1.00	232 (222-244)	209 (201-219)	91 (68-110)

Alternative	On-range cost ($ million)	Off-range cost ($ million)	Total cost ($ million)
No management	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
Removals	0.28 (0.22-0.31)	1.55 (1.36-1.76)	1.83 (1.58-2.06)
Removals and GonaCon	0.31 (0.29-0.36)	1.53 (1.40-1.65)	1.84 (1.69-1.98)
Removals and mare sterilization	0.30 (0.27-0.35)	1.52 (1.35-1.80)	1.83 (1.63-2.11)
Mare sterilization and GonaCon	0.67 (0.62-0.72)	0.00 (0.00-0.00)	0.67 (0.62-0.72)
Removal (year 1) and GonaCon (darting)	0.26 (0.25-0.27)	1.33 (1.21-1.48)	1.59 (1.47-1.75)

A graph of population size through time can be used to visualize effects of management alternatives on population size. Different colored lines indicate management alternatives simulated by the user; for each alternative, individual lines are different simulation replicates, that vary due to random chance. Dashed horizontal black lines indicate the minimum and maximum target population size range (i.e., AML).



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Summary

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The alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range' (other than 'no management') over the next 35 years was:

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Among the alternatives that achieved population size within Appropriate Management Levels, the alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range':

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APPENDIX I: STATISTICAL ANALYSIS FOR 2024 SURVEY

M E M O R A N D U M

To: Kylie Caraher (BLM)
CC: Donald Rotell, Richard Knox, Emily Lent, Paul Griffin, Scott Fluer, Paul McGuire (BLM)
From: Michelle Crabb (BLM) WHB Program Population Biologist
Date: 07/10/2024
RE: Statistical analysis for 2024 survey of horse abundance in Kiger, Riddle Mountain, and South Steens HMAs, OR

Summary Table

Survey Areas and Dates	Start date	End date	Area name	Area ID
	5/8/2024	5/8/2024	Kiger HMA	OR0010
	5/8/2024	5/8/2024	Riddle Mountain HMA	OR0009
	5/9/2024	5/9/2024	South Steens HMA	OR0003
Type of Survey	Simultaneous double-observer			
Aviation Details	Pilot: Rob Grubb, APEX Helicopters, Helicopter: AS350B3, #N544AS			
Agency Personnel	Observers: Rick Knox, Kylie Caraher, Michelle Crabb (BLM) Helicopter manager: Robert Smith, Paul Weil (BLM)			

Summary Narrative

In May 2024 Bureau of Land Management (BLM) personnel conducted simultaneous double-observer aerial surveys of the wild horse populations in the Kiger, Riddle Mountain, and South Steens herd management areas (HMAs; Figure 1). Surveys were conducted using methods recommended by BLM policy (BLM 2010) and a recent National Academy of Sciences review (NRC 2013) with detailed field methods described in Griffin et al. (2020). These data were analyzed using methods in Ekernas and Lubow (2019) to estimate sighting probabilities for horses, with sighting probabilities then used to correct the raw counts for systematic biases (undercounts) that are known to occur in aerial surveys (Lubow and Ransom 2016), and to provide confidence intervals (which are measures of uncertainty) associated with the abundance estimates. Estimated abundance in and near the HMAs are listed in Table 1, below.

Table 1. Estimated abundance (Estimate No. Horses) is for the number of horses in the surveyed areas at the time of survey. 90% confidence intervals are shown in terms of the lower limit (LCL) and upper limit (UCL). The coefficient of variation (CV) is a measure of precision; it is the standard error as a percentage of the estimated population. Number of horses seen (No. Horses Seen) leads to the estimated percentage of horses that were present in the surveyed area, but that were not recorded by any observer (Estimated % Missed). The estimated number of horses associated with each HMA but located outside the HMA's boundaries (Est. No. horses Outside HMA) is already included in the total estimate for each HMA.

Area	Age Class	Estimated No. Horses	LCL[a]	UCL	Std Err	CV	No. Horses Seen	Estimated % Missed	Estimated No. Groups	Estimated Group Size	Foals Per 100 Adults[b]	Est. No. Horses Outside HMA
Kiger HMA	Total	508	419	827	168.2	33.1%	419	17.5%	13	39.1	13.4	19
	Foals	60	49	101	22.4	37.4%	49					
	Adults	448	370	725	145.9	32.6%	370					
Riddle Mt. HMA	Total	284	276	330	30.7	10.8%	276	2.8%	8	35.5	17.8	14
	Foals	43	42	50	4.4	10.2%	42					
	Adults	241	234	281	26.3	10.9%	234					
South Steens HMA	Total	945	887	1045	45.3	4.8%	885	6.3%	123	7.7	21.1	0
	Foals	165	155	179	7.5	4.6%	155					
	Adults	781	732	865	38.5	4.9%	730					
Survey Total	Total	1,737	1,580	2,145	198.3	11.4%	1,580	9.0%	144	12.1	18.2	33
	Foals	268	246	321	27.2	10.2%	246					
	Adults	1,470	1,334	1,823	171.4	11.7%	1,334					

[a] The lower 90% confidence limit is based on bootstrap simulation results or the number of horses seen, whichever is higher.

[b] The estimated ratio of foals to adults reflects what was observed during this May survey and does not represent the full cohort of foals for this year.

Abundance Results

The estimated total horse abundance within the surveyed area is reported in Table 1. Observers recorded 134 horse groups, of which 107 horse groups had data recorded properly 'on protocol' and that could be used to compute statistical estimates of sighting probability. Of the 134 groups seen, 133 observations used to calculate the abundance estimate. Any horse groups that were seen on two separate occasions (i.e., double counted), or that were identified as domestic and privately owned, were not used to calculate abundance; however, such groups can be used to parameterize sighting probability if they were recorded on protocol. Coefficient of variation (Table 1) values of less than 10% indicate high precision resulting from high detection probabilities; values between 10-20% indicate medium precision resulting from lower detection probabilities; and values greater than 20% indicate low precision resulting from very low detection probabilities.

The mean estimated size of detected horse groups, after correcting for missed groups, was 12.1 horses/group across the surveyed area, with a median of 7.0 horses/group. There were an estimated 18.2 foals per 100 adult horses at the time of these surveys (Table 1). Surveys flown before July are unlikely to include all foals born this year, while surveys flown during or after July would not include foals that were born this year but died before the survey.

Sighting Probability Results

The combined front observers saw 84.1% of the horse groups (78.4% of the horses) seen by any observer, whereas the back seat observers saw 71% of all horse groups (73.7% of horses) seen (Table 2). At least one observer (front or back) missed 44.9% of horse groups seen by the other. These results demonstrate that simple raw counts do not fully reflect the true abundance without statistical corrections for missed groups, made possible by the double observer method and reported here. Direct counts from aerial surveys underestimate true abundance because some animals are missed by all observers; this analysis corrects for that bias (Lubow and Ransom 2016). The analysis method used for the surveyed areas was based on simultaneous double-observer data collected during these surveys.

The sample size of observations following protocol was 107 horse groups. Survey datasets with sample size less than 20 groups cannot be analyzed using these methods; sample sizes of 20 to 40 groups are considered low and have high risk of containing unmodeled heterogeneity in sighting probability; sample sizes of 41-100 groups are moderate and can estimate effects of many but likely not all potential sightability covariates; and sample sizes >100 groups are large and can account for most sightability covariates.

All models used in the double-observer analysis contained an estimated intercept common to all observers. Informed by *a priori* reasoning, preliminary analyses, showing overwhelming support, I also included an additional parameter in all models for effects of observations by front-seat observers on the pilot's side and back-seat observers. I evaluated, 6 possible effects on sighting probability by fitting models for all possible combinations with and without these effects, resulting in 128 alternative models. The 6 effects examined were: (1) group size; (2) distance from the flight path; (3) percent vegetation cover; (4) group activity; (5) moderate/complex background environment; (6) highlighting conditions. Due to minimal support during preliminary analyses, I did not include effects on detection probability of: (1) percent snow cover; or (2) percent vegetation squared. I did not consider effects on detection probability of rugged topography and vegetation composition due to

insufficient variation in the values of these covariates. Covariates and their relative effect on sighting probability are shown in Table 3.

There was moderate support for an effect of group activity (73.2% of AICc model weight), moderate/complex background environment (41.2%), and weak support for an effect of individual backseat observers (31.8%), group size (30.9%), distance from the transect (29.3%), and high lighting conditions (25.5%). As expected, visibility was higher for groups that were moving, and lower for horse groups that were further from the transect, in vegetation cover, on a moderate/complex background, and on the pilot side. Visibility conditions were lower or groups in high lighting conditions, perhaps because of shadows in vegetated areas. Surprisingly, overall group size had a negative relationship with sighting probability, although there was only weak support, and the overall effect was minimal (Table 3). Covariates and their relative effect on sighting probability are shown in Table 3.

Groups that were recorded on the centerline, directly under the aircraft, were not available to backseat observers. For these groups, backseat observers' sighting probability was therefore set to 0. Sighting probability for groups visible on both sides of the aircraft was computed based on the assumption that both backseat observers could have independently seen them, thereby increasing total detection probability for these groups relative to groups available to only one side of the helicopter.

Estimated overall sighting probabilities, $\hat{p}$, for the combined observers ranged across horse groups from 0.66-0.99. Sighting probability was <0.9 for 31 (23%), and <0.8 for 10 (7%) of observed groups. In aggregate across all observed groups, the overall "correction factor" that was added on to the total number of wild horses *seen* was 9.9%. That is to say: 1,580 horses were seen, and adding another 9.9% of that number seen equals the total estimate of 1,737 horses (Table 1). A different but mathematically equivalent interpretation is listed in Table 1 in the "Estimated % Missed" column, which shows that, overall, 9.0% of the horses that were estimated to be present during the survey were *never seen* by any of the observers during the survey (Table 1).

Assumptions and Caveats

Results from this double observer analysis are a conservative estimate of abundance. True abundance values are likely to be higher, not lower, than abundance estimates in Table 1 because of several potential sources of bias listed below. Results should always be interpreted with a clear understanding of the assumptions and implications.

1. The results obtained from these surveys are estimates of the horses present in the surveyed area at the time of the survey and should not be used to make inferences beyond this context. Abundance values reported here may vary from the annual March 1 population estimates for the HMA; aerial survey data are just one component of all the available information that BLM uses to make March 1 population estimates. Aerial surveys only provide information about the area surveyed at the time of the survey, and do not account for births, deaths, movements, or any management removals that may have taken place afterwards.

2. Simultaneous double-observer analyses cannot account for undocumented animal movement between, within, or outside of the surveyed area. Fences and topographic barriers can provide deterrents to animal movement, but even these barriers may not present continuous, unbroken, or impenetrable barriers. It is possible that the surveys did not extend as far beyond a boundary as

horses might move. Consequently, there is the possibility that temporary emigration from the surveyed area may have contributed to some animals that are normally resident having not being present at the time of survey. In principle, if the level of such movement were high, then the number of animals found within the survey area at another time could differ substantially. If there were any wild horses that are part of a local herd but were outside the surveyed areas, then Table 1 underestimates true abundance.

3. The validity of the analysis rests on the assumption that all groups of animals are flown over once during a survey period, and thus have exactly one chance to be counted by the front and back seat observers, or that groups flown over more than once are identified and considered only once in the analysis. Animal movements during a survey can potentially bias results if those movements result in unintentional over- or under-counting of horses. Groups counted more than once would constitute 'double counting,' which would lead to estimates that are biased higher than the true number of groups present. Groups that were never available to be seen (for example due to temporary emigration out of the study area or undetected movement from an unsurveyed area to an already-surveyed area) can lead to estimates that are negatively biased compared to the true abundance. Survey SOPs (Griffin et al. 2020) call for observers to identify and record 'marker' animals (with unusual coloration) on paper, and variation in group sizes helps reduce the risk of double counting during aerial surveys. Observers are also to take photographs of many observed groups and use those photos after landing to identify any groups that might have been inadvertently recorded twice. Unfortunately, there is no effective way to correct for the converse problem of horses fleeing and thus never having the opportunity for being detected. Because observers can account for horse movements leading to double counting, but cannot account for movement causing horses to never be observed, animal movements can contribute to the estimated abundance (Table 1) potentially being lower than true abundance.

4. The simultaneous double-observer method assumes that all horse groups with identical sighting covariate values have equal sighting probability. If there is additional variability in sighting probability not accounted for in the sighting models, such heterogeneity could lead to a negative bias (underestimate) of abundance. In other words, under most conditions the double-observer method underestimates abundance.

5. The analysis assumes that the number of animals in each group is counted accurately. Standard Operating Procedures (Griffin et al. 2020) specify that all groups with more than 20 animals are photographed and photos scrutinized after the flight to correct counts. Smaller groups, particularly ones with poor sighting conditions such as heavy tree cover, could also be undercounted. Any such undercounting would lead to biased estimates of abundance.

Evaluation of Survey and Recommendations

It appears that survey protocols were followed well and with enough consistency among flights to enable useful pooling of data for more precise estimates of sighting probability. Observers appear to have been well trained, and visibility conditions were good or very good for the 2-day survey.

The survey covered all parts of the Kiger, Riddle Mountain, and South Steens HMAs, OR, and extended beyond the boundaries of the HMAs in a number of places, particularly to the northeast of Riddle Mountain and in the gap between Kiger and Riddle Mountain HMAs, and to the northeast of South Steens (Figure 1). There are no obvious natural deterrents to horse movements that would

contain them within the boundaries of the survey area, except for the large steep drop off on the southeastern edge of Riddle Mountain HMA, and the steep canyon to the northeast of the South Steens HMA boundary. Fencing where present, and terrain features are not impenetrable barrier to horse movement. Consequently, it is difficult to be sure there were no additional horses outside of the HMA in areas not surveyed and results should be understood to represent the horses present only in the area surveyed, which may not represent all horses that occasionally occupy this area. Nevertheless, careful consideration should be given to where horses were located near the edge of the area surveyed when planning whether to extend the survey area further in future surveys to ensure covering all areas potentially occupied by horses associated with the HMA, or to confirm that the current survey boundaries do cover the full extent of horses' range in this area.

Table 2. Tally of raw counts of horses and horse groups by observer (front, back, and both) for combined data from Kiger, Riddle Mountain, and South Steens HMAs surveyed in May 2024.

Observer	Groups seen[a] (raw count)	Horses seen (raw count)	Actual sighting rate[b] (groups)	Actual sighting rate[b] (horses)
Front	90	1,064	84.1%	78.4%
Back	76	1,000	71.0%	73.7%
Both	59	707	55.1%	52.1%
Combined	107	1,357		

[a] Includes only groups and horses where protocol was followed.
[b] Percentage of all groups seen that were seen by each observer.

Table 3. Effect of observers and sighting condition covariates on estimated sighting probability of horse groups for both front and rear observers during the May 2024 survey of the Kiger, Riddle Mountain, and South Steens HMAs. Baseline case (bold) for horses presents the predicted sighting probability for a group of 7 horses (the median group size observed), >1/4 mile from the transect, that were not moving, in zero percent vegetation cover, not in high lighting conditions, not on the pilot side, and with the average back-seat observer. Other example cases vary a covariate or observer, one effect at time, as indicated in the left-most column, to illustrate the relative magnitude of each effect. Sighting probabilities for each row should be compared to the baseline (first row) to see the effect of the change in each observer or condition. Baseline values are shown in bold wherever they occur. Sighting probabilities are weighted averages across all 128 models considered (Burnham and Anderson 2002).

	Sighting probability		
	Front Observer[a]	Back Observer[b]	Combined Observers
Baseline	**90.2%**	**65.1%**	96.6%
Effect of Group size (N=1)	90.3%	65.4%	96.6%
Effect of Group size (N=10)	90.1%	65.0%	96.5%
Effect of Distance = 0.375	89.6%	63.9%	96.2%
Effect of Moving	94.9%	78.8%	98.9%
Effect of Moderate/Complex Background	87.9%	59.8%	95.1%
Effect of Veg 30%	89.3%	63.2%	96.1%
Effect of Veg 60%	88.1%	61.2%	95.4%
Effect of High Light	89.9%	64.5%	96.4%
Effect of PilotSide	41.1%	**65.1%**	79.4%
Effect of Observer KC	**90.2%**	68.2%	96.9%
Effect of back=front	**90.2%**	90.2%	99.0%

[a] Sighting probability for the front observers acting as a team, regardless of which of the front observers saw the horses first.

[b] Sighting probabilities for back observers for horse groups that are potentially visible on the same side of the aircraft as the observer. Sighting probability in the back is 0 for groups on the opposite side or centerline.

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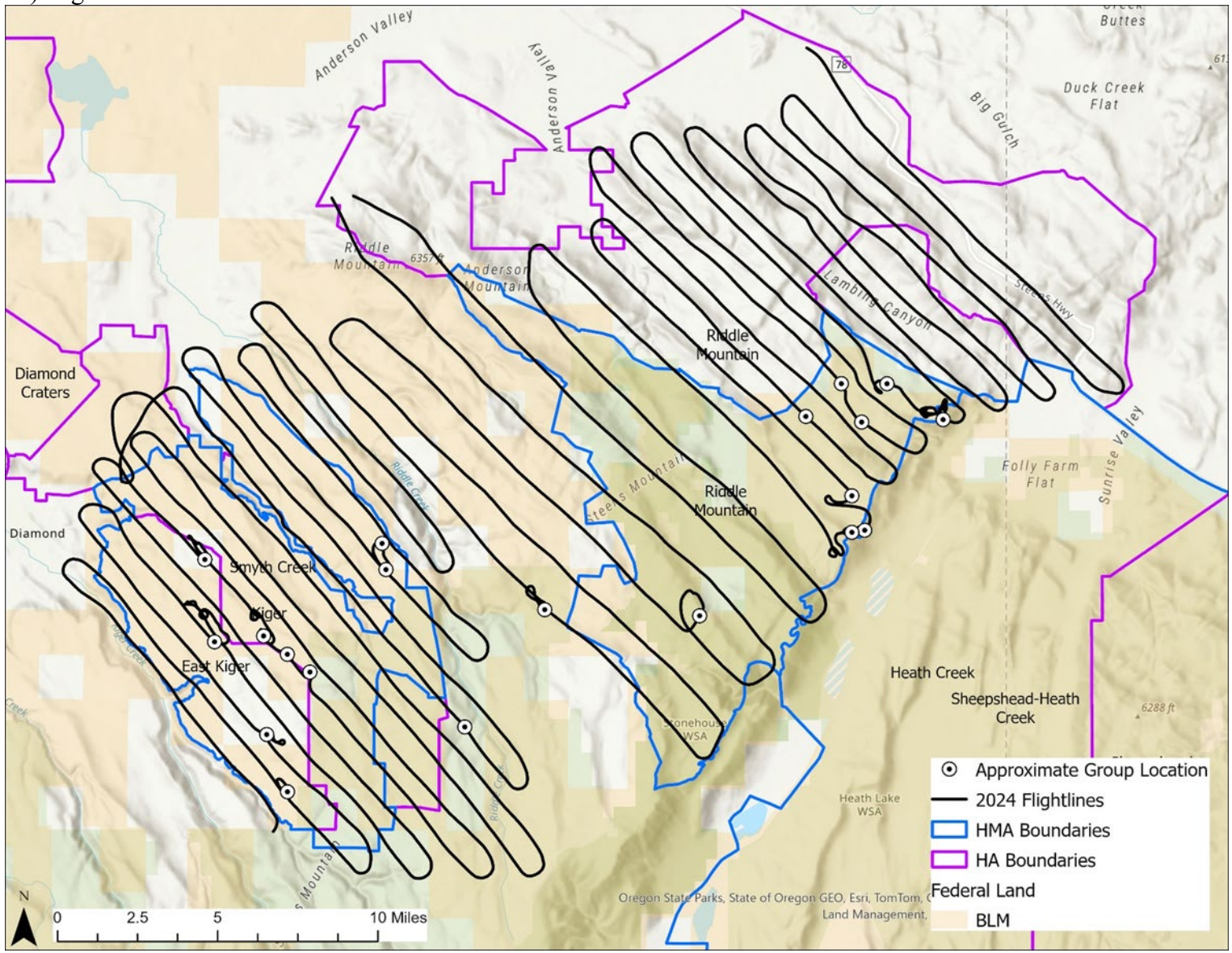
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Figure 1. Map of 2024 A.) Kiger and Riddle Mountain HMAs, and B.) South Steens HMA, survey tracks flown (black lines), approximate locations of observed horse groups (black and white circles), HMA boundaries (blue), HA boundaries (purple).

A.) Kiger and Riddle Mountain HMAs



B.) South Steens HMA

