APPENDIX G: ENERGY BY DESIGN – COOPERATIVE MITIGATION PLANNING FOR THE CD-C GAS FIELD

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Introduction and Background

In many cases the environmental mitigation process for development projects is *ad hoc*, opaque, and insufficient, failing to deliver effective outcomes for biodiversity conservation (McKenney and Kiesecker 2009). Mitigation planning too often reflects a reactive, piecemeal approach, focused on site-level impacts of the next proposed project. Here we seek to balance the needs of planned developments with those of biodiversity conservation. The aim is to bring greater efficiencies to development planning and impact mitigation, and more effective conservation outcomes. We seek to improve implementation of the "mitigation hierarchy" at each stage—avoid, minimize/restore, and offset—in a way that is transparent and transferable to industry and regulators, and complementary to the environmental assessment (Kiesecker et al. 2010a). By evaluating threats and impacts at regional and site levels, in a proactive fashion, mitigation planning can steer development projects away from conservation priorities and ensure mitigation provides a higher return for conservation. We generate this up-front planning information by harnessing decades of conservation planning experience, extensive ecological data, and advanced computer-modeling tools, and applying them to assess onsite conservation values as well as to locate compensatory mitigation opportunities.

Mitigation frameworks often ask developers if they have followed the mitigation hierarchy (Council on Environmental Quality 2000) of seeking to avoid, minimize, and restore biodiversity onsite before considering an offset for the residual impacts. However, no quantitative guidelines exist to guide this decision-making process. Landscape-level planning and associated tools provide a framework to address this problem. Identifying wildlife values at a landscape scale and understanding the landscape value of local occurrences can guide decisions regarding when impacts should be avoided or when they can be offset. Placing mitigation design within a landscape-level planning framework can ensure that development actions are consistent with conservation goals. Our landscape-level mitigation framework is intended as a voluntary addition to the EIS, and does not imply that mandatory mitigation will be required through the EIS process.

Here we describe an analysis for the Continental Divide-Creston (CD-C) natural gas field that can be used to inform avoidance of important resources onsite within the field, as well as compensatory mitigation opportunities. BP America Production Company (BP), one of the principal operators on the field, expressed the need for a structured framework to complement the Environmental Impact Statement (EIS) that could be used to avoid potential conflicts between development and onsite wildlife values and identify opportunities to balance onsite impacts with additional conservation options to offset these impacts. BP invited The Nature Conservancy to design such a plan. First, we identified areas within the field that have high value for wildlife or other resources from a regional landscape perspective and should be given special consideration for avoiding impacts from development. Second, we identified opportunities to utilize offsets to mitigate for unavoidable impacts associated with gas development on the field. We sought to design an offset framework where the offsets are ecologically equivalent to the impacts. All methods are adapted from a previous mitigation framework in Wyoming (Kiesecker et al. 2009, Kiesecker et al. 2010b).

Methods

The analysis for the CD-C development included six steps, each of which is described in more detail below: (1) assemble a working group, (2) identify representative biological targets, (3) gather spatial data for biological targets, (4) examine potential onsite development, (5) set impact goals for each biological target associated with the development, and (6) use the Marxan algorithm at increasing spatial extents to identify potential offset sites both on and off the project area.

Study area. Our study area was the 1.1-million acre CD-C natural gas field in Southern Wyoming where BP proposed a project that included drilling up to 8,950 new gas wells, and a larger 3.2 million-acre area surrounding the field for potential offset sites (Map F-3). The CD-C natural gas field is a high-desert xeric shrubland ecosystem that provides critical habitat for ungulates (pronghorn and mule deer), songbirds, and raptors, in the desert shrublands west of the Sierra Madre mountain range. Greater sage-grouse (*Centrocercus urophasianus)* populations within the field are also a concern, a species recently considered by the U.S. Fish and Wildlife Service (USFWS) for the endangered species list and issued a "warranted, but precluded" listing.

Assemble a working group

A mitigation-design science working group was formed to provide guidance on selection of representative biological targets, designing offsets, and integrating spatial data into the site selection process. These participants (see **Table F-1**) had expertise and involvement with the biological systems that may be impacted by the CD-C development and included representatives from the Wyoming Game and Fish Department (WGFD), Bureau of Land Management (BLM), USFWS, University of Wyoming (UW), biological consulting firms, and the local agricultural production community. The working group helped to provide the most current spatial data for the biological targets, assessed the predictive models being developed, and offered insights into the process being developed. We sought to apply rigorous, objective measures of conservation value whenever possible, recognizing that a quantitative assessment would need to be supplemented by expert opinion. Several meetings were held with members of the working group in 2008 and 2009.

Compile a list of representative biological targets

Biological diversity cannot easily be completely and directly measured. Thus practitioners are forced to select a set of components of biological diversity that can be measured effectively given existing resources, that adequately represent the range of biological phenomena in the project area, and that contribute the most to overall biological diversity of a project area. We addressed the selection of focal targets that would represent wildlife values on the CD-C field with sufficient breadth and depth by starting with the BLM sensitive species list for the Rawlins Field Office (http://swccd.us/images/-M_WyoBLM_Sensitivespecies.pdf). We also consulted the Wyoming Game and Fish Department's Species of Greatest Conservation Concern (http://gf.state.wy.us/wildlife/CompConv-Strategy/SectionI.pdf) and The Nature Conservancy's Wyoming Basins Ecoregional Assessment (Freilich et al. 2001). All biological targets from these lists with data demonstrating occurrence within the bounds of the CD-C field area were selected as a biological targets to be included in the mitigation planning.

This process resulted in 14 species and 10 systems being selected (**Table F-2**). The targets included three rare plant species—Nelson's milkvetch (*Astragalus nelsonianus*), Gibben's beardtongue (*Penstemon gibbensii*) and Persistent sepal yellowcress (*Rorippa calycina*)—all of which have the majority of their known occurrences within the study area (Fertig and Thurston 2003). All ecological systems occurring in the CD-C development area were included as targets and are listed in Table F-2. The eleven selected wildlife species included two amphibians: the northern leopard frog (*Rana pipiens*) and Great Basin spadefoot (*Spea intermontana*). Amphibian breeding habitat is quite rare in the Wyoming basins Ecoregion (Frelitch et al. 2000), meaning that occurrences of these habitats within the development area are particularly important. Crucial winter range and migration corridors were included for mule deer (*Odocoileus hemionus*) and pronghorn antelope (*Antilocarpa americana*). Adversely affecting these critical components of their habitat could lead to population loss—declines have been recently recorded for mule deer populations in the Upper Green River Basin and mule deer have been shown to avoid oil and gas development (Sawyer et al. 2009). The other wildlife species included were the black-footed ferret (*Mustela nigripes*), burrowing owl (*Athene cunicularia*), ferruginous hawk (*Buteo regalis*), mountain plover (*Charadrius montanus*), pygmy rabbit (*Brachylagus idahoensis*), and Wyoming pocket gopher (*Thomomys clusius*).

Wyoming pocket gophers are known only from a small area in south-central Wyoming, and the field may represent a significant portion of their range (Keinath and Beauvais 2006). In general, range-wide it is believed that pygmy rabbit abundance is declining in most known populations (Dobler and Dixon 1990). Information suggests that pygmy rabbit populations can decline rapidly in areas where suitable habitat is altered (Weiss and Vert 1984, Gahr 1993), necessitating additional consideration. Burrowing owls are a neotropical migrant that receives protection under the Migratory Bird Treaty Act and the Convention of International Trade in Endangered Species, and BLM has surface occupancy stipulations for the species (OMBM 1995). While the FWS recognizes the ferruginous hawk as a species of concern (USFWS 1996), it does not give the species any special status under the Endangered Species Act. However, the ferruginous hawk is considered to be declining in several areas, but there is little data available on magnitude of declines (Bechard 1981, Houston and Bechard 1984, Woffinden and Murphy 1989, Ure et al. 1991). Aquatic habitats are of critical importance for wildlife in arid environments and thus all aquatic ecological systems have been identified (playas and riparian wet meadows). Greater sage-grouse (*Centrocercus urophasianus*), previously widespread, have been extirpated from nearly half of their original range in western North America (Schroeder et al. 2004) with a range-wide population decline of 45 – 80 percent and local declines of 17 – 92 percent (Connelly and Braun 1997, Braun 1998, Connelly et al. 2004). Energy development has emerged as a key issue in sage-grouse conservation, as sage-grouse populations appear sensitive to oil and gas development (Holloran 2005, Aldridge and Boyce 2007, Walker et al. 2007).

Spatial data for biological targets

Spatial data were used to identify biological targets occurring within the CD-C field, as well as occurrence of those targets beyond the field boundary where offsets might be applied. The spatial datasets used to represent each target onsite and offsite are detailed in **Table F-2** and include point survey data, vegetation cover estimates, and predictive model estimates.

In cases where survey data were sufficient for estimating occurrence patterns, we relied on these data. For example, for pronghorn, we utilized pronghorn migration routes from the WGFD (2006). In cases where survey data were insufficient to estimate occurrence patterns across the study area, we used predicted habitat models based on species occurrence, observation, and survey data from the Wyoming Natural Diversity Database (WYNDD), Hayden-Wing Associates (HWA), WGFD, and the BLM. We created predictive habitat models for three species (Great Basin spadefoot, northern leopard frog, and sage-grouse winter habitat) for which existing models were not available, using methods from Kiesecker et al. (2009).

Offset goals for biological targets

Our intention with this analysis was not to reinvent the EIS process, as there is an extensive literature on this subject (Canter 1996, Sadar et al. 1995); rather we intended to provide an approach that could complement the ongoing EIS. Thus, for this assessment we used a simple approach to quantify field-level impacts and divided the field into four separate units based on the current well-spacing designations (160-acre spacing, 80-acre spacing, 60-acre spacing and 40-acre spacing) approved by the Wyoming Oil and Gas Commission (http://wogcc.state.wy.us/). Since companies must actively petition to decrease well spacing below 160-acre spacing, we assumed that these areas have a higher probability of development.

We set mitigation goals on and off the project field area differently. We intersected the spatial data for each of the biological targets with the well-spacing category and calculated the acres (for polygons) and number of occurrences (for points) of each target (**Map F-2, Table F-2**) that would need to be mitigated within these areas.

We examined two possible mitigation scenarios:

1. Where development and associated impacts would be concentrated with the areas designated as 40- and 60-acre well spacing, and set goals based on impacts to those areas. Also, we confined the areas that could serve as potential offset sites within the CD-C project area (**Map F-2**).
2. Development and associated impacts in the area designated as 80-acre spacing, and set goals based on impacts to those areas. Also, the analysis for potential offset sites was expanded to outside the CD-C project area (**Maps F-2 and F-3**).

Selecting potential mitigation sites with Marxan

We used the Marxan (version 1.8.2) site-selection algorithm (Ball and Possingham 2000) to select appropriate locations for potential offset sites within the onsite and offsite project areas. We developed criteria to ensure offsets would mitigate onsite impacts, and ran analyses based on the potential impacts associated with the two scenarios (40- to 60-acre spacing and 80-acre spacing).

Marxan is a siting tool for landscape conservation analysis that explicitly incorporates spatial design criteria into the site-selection process. Marxan operates as a stand-alone program and utilizes an algorithm called "simulated annealing with iterative improvement" as a heuristic method for efficiently selecting regionally representative sets of areas for biodiversity conservation (Possingham et al. 2000). Marxan allows inputs of target occurrences represented as points or polygons in a GIS environment and allows for conservation goals to be stated in a variety of ways, such as percent area or numbers of point occurrences. The program also allows for the integration of spatial data sets representing land use pattern and conservation status, and enables rapid evaluation of alternative configurations or scenarios. The ultimate objective is to minimize the cost of the sites selected (i.e. cost = landscape integrity, conservation cost in dollars, size of the reserve) while still meeting objectives.

The working group selected 100-hectare (approximately 250-acre) hexagons as the unit of analysis for running Marxan, because this was of sufficient spatial resolution to represent biological targets and also large enough to permit efficient analyses across broad landscape scales. The effectiveness of a contiguous set of hexagon units for defining natural variability, especially among spatially heterogeneous data sets, is well documented (White et al. 1992). Each hexagon was populated by summing the area of suitable habitat for the targeted community or species. In addition to the biological information used to select potential offset sites, we incorporated a series of additional rules. First we guided site selection to areas of high biological integrity (as per Copeland et al. 2007). This is equivalent to the "cost" function utilized by Marxan (Ball and Possingham 2000).

Results and Discussion

These results complement the planning and analysis work conducted as part of the CD-C EIS, provides an assessment of biological values that are important at a regional scale, and identifies areas where conservation projects targeted at impacted species may provide a way to offset impacts associated with development.

Mapping Sensitive Features

Our maps and data of sensitive features (**Map F-1**) could be used in a variety of ways to both avoid potential conflicts between development and key wildlife resources on the field and minimize impacts associated with development. For example, impacts to known rare plant occurrences (Nelson milkvetch, Gibbens' penstemon and persistent sepal yellowcress) should be avoided given their limited distributions and occurrence patterns. Furthermore, predictive habitat species models could be used to guide surveys prior to development. Impacts to rare and/or sensitive animal species (Wyoming pocket gopher, ferruginous hawk, pygmy rabbit, sage-grouse and burrowing owl) should be avoided whenever possible. For sage-grouse this should include both breeding (= leks) and wintering habitat. Aquatic targets (playas, wet meadows, and amphibians, including northern leopard frog and Great Basin spadefoot toad) should also be given special consideration and impacts to any riparian or wetland habitats should be avoided.

Onsite and Offsite Mitigation Areas

Mitigation sites could be used in a number of ways to compensate for impacts associated with development. A simple approach may be for BLM to establish a surface disturbance (or activity) threshold on a section-by-section basis (or some other spatial unit) and if development exceeds these disturbance caps it would trigger the need to offset the wildlife values within that section. Alternatively, monitoring plots both within development areas and outside development areas could be established for key wildlife targets. Monitoring that reveals departures (declining trends in populations or habitat quality indices) between development and non-development areas could trigger the need for offsets and could be directed at declining species. For this reason we have included an assessment of offset sites and the species/systems they may benefit.

It is important to note that our site-selection exercise did not account for future oil and gas development potential. Many proposed offset sites are within the Atlantic Rim or Desolation Flats Natural Gas Fields, and therefore may be unsuitable because of future development potential (Map F-3). Prior to establishing sites for actual mitigation offsets, the development potential should be carefully evaluated and incorporated into the decision-making process.

If offsets are used, a number of criteria will need to be addressed to ensure offsets provide the needed benefit. Critical to their usage will be the demonstration of additional conservations benefits (Kiesecker et al. 2009a) that accrue to impacted wildlife species and systems. Areas selected will only be valuable as offsets if opportunities exist to either restore (i.e. improve conditions for target species) habitat or abate future threats (i.e. prevent invasive weed establishment, conservation easements) to habitat in a manner that improves the condition for target species. Reaching no net loss from impacts associated with development will come from onsite actions that minimize impacts or restore habitat, combined with offsite actions that provide additional benefits. As on-the ground projects are considered, a finer currency that incorporates the size of the impact and offset, as well as values associated with ecological function, quality, and integrity will need to be established (Kiesecker et al. 2009a). For the sagebrush ecosystem, several site assessment tools are available for use (i.e., USFWS 1980, habitat evaluation procedures; USNRCS 1997, ecological site descriptions; Parkes et al. 2003, habitat hectares approach).

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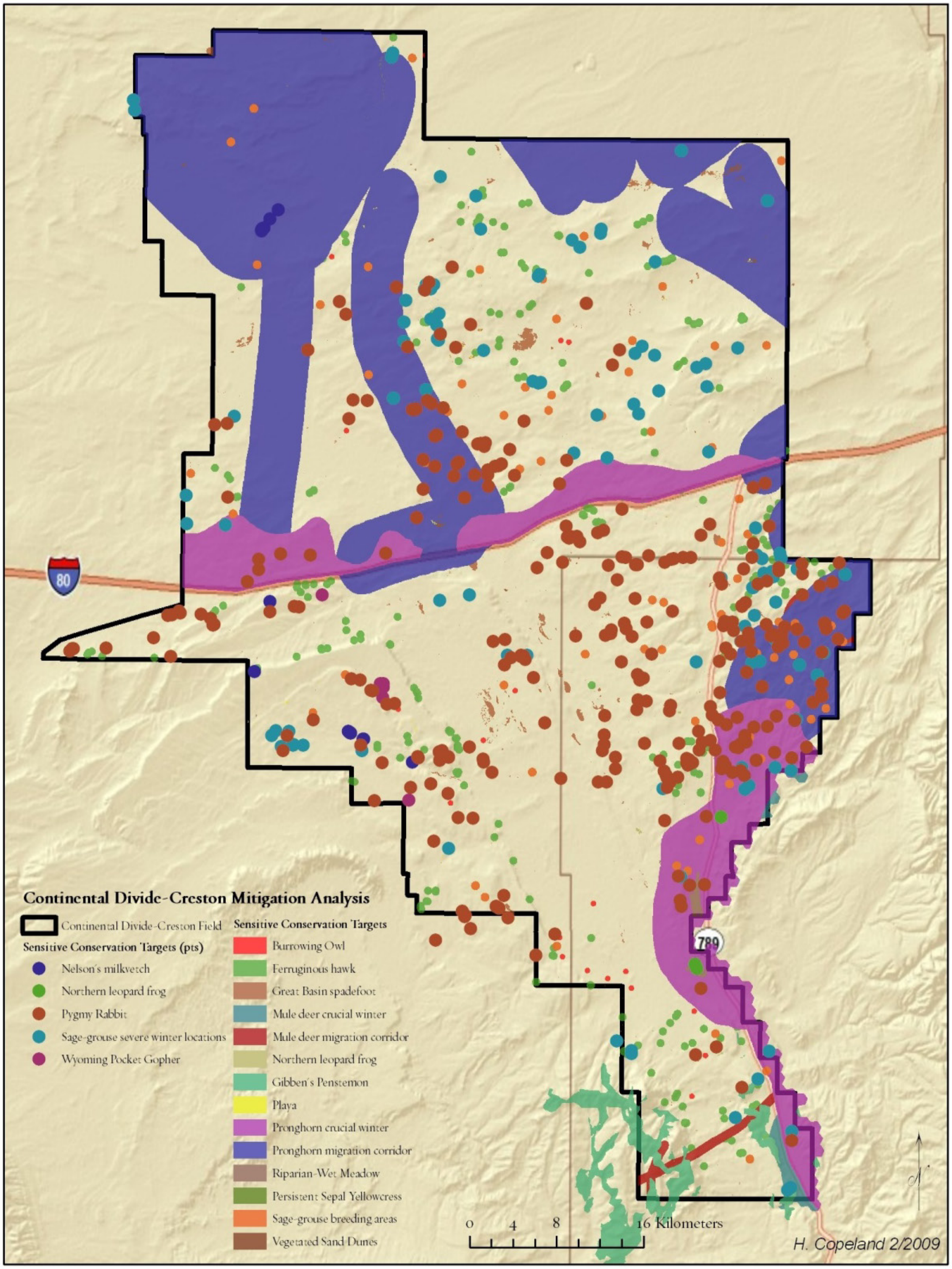
Table G-1. Biological targets selected for mitigation planning exercise and data source used to represent each target

Target Name	Onsite	Offsite
Basin Grassland	HWA vegetation map	WY Basins re-GAP vegetation map
Black-footed ferret habitat	BLM potential habitat from prairie dog town maps	BLM potential habitat from prairie dog town maps
Burrowing owl	BLM nest data (not including historical), with 825 ft buffer	BLM nest data (not including historical), with 825 ft buffer
Ferruginous hawk	BLM natural nests, not including historical, with 1/4 mi (1,200 ft) buffer	BLM natural nests, not including historical, with 1/4 mi (1200 ft) buffer
Gibben's beardtongue	WYNDD model (no known locations onsite)	WYNDD model
Greasewood Fans and Flats	HWA vegetation map	WY Basins re-GAP vegetation map
Great Basin spadefoot	BLM/WYNDD occurrences	BLM/WYNDD occurrences
Great Basin spadefoot habitat	National Wetlands Inventory (modeled habitat)	National Wetlands Inventory (modeled habitat)
Juniper Woodland	HWA vegetation map	WY Basins re-GAP vegetation map
Mixed Desert Shrub	HWA vegetation map	WY Basins re-GAP vegetation map
Mountain Big Sagebrush-Mixed Mountain Shrub	HWA vegetation map	WY Basins re-GAP vegetation map
Mountain Plover Habitat	HWA model	WYNDD domain model
Mule deer crucial winter	Wyoming Game and Fish Department (2004)	Wyoming Game and Fish Department (2004)
Mule deer migration corridor	Wyoming Game and Fish Department (2007)	Wyoming Game and Fish Department (2007)
Nelson’s milkvetch	WYNDD occurrences	WYNDD occurrences
Nelson’s milkvetch habitat	WYNDD habitat model	WYNDD habitat model
Northern leopard frog	BLM/WYNDD occurrences	BLM/WYNDD occurrences
Northern leopard frog habitat	National Wetlands Inventory (modeled habitat)	National Wetlands Inventory (modeled habitat)
Persistent sepal yellowcress	HWA Inventory (Lost Creek polygon)	WYNDD habitat model
Playa	HWA vegetation map	WY Basins re-GAP vegetation map
Pronghorn crucial winter range	Wyoming Game and Fish Department (2004)	Wyoming Game and Fish Department (2004)
Pronghorn migration corridor	Wyoming Game and Fish Department (2007)	Wyoming Game and Fish Department (2007)
Pygmy rabbit	BLM/WYNDD occurrences	BLM/WYNDD occurrences
Pygmy rabbit habitat	WYNDD habitat model (April 2008)	WYNDD habitat model (April 2008)
Riparian-Wet Meadow	HWA vegetation map	WY Basins re-GAP
Sage-grouse breeding areas	BLM/WGFD lek data, with 1/4 mi (1,200 ft) buffer	BLM/WGFD lek data, with 1/4 mi (1,200 ft) buffer
Sage-grouse severe winter range	HWA model (high potential) and known winter locations	TNC habitat model (2009)
Saltbush Fans and Flats	HWA vegetation map	WY Basins re-GAP vegetation map
Vegetated Sand Dunes	HWA vegetation map	WY Basins re-GAP vegetation map
Wyoming Big Sagebrush-Basin Big Sagebrush	HWA vegetation map	WY Basins re-GAP vegetation map
Wyoming pocket gopher	BLM/WYNDD occurrences	BLM/WYNDD occurrences
Wyoming pocket gopher habitat	WYNDD habitat model (Dec 2008)	WYNDD habitat model (Dec 2008)

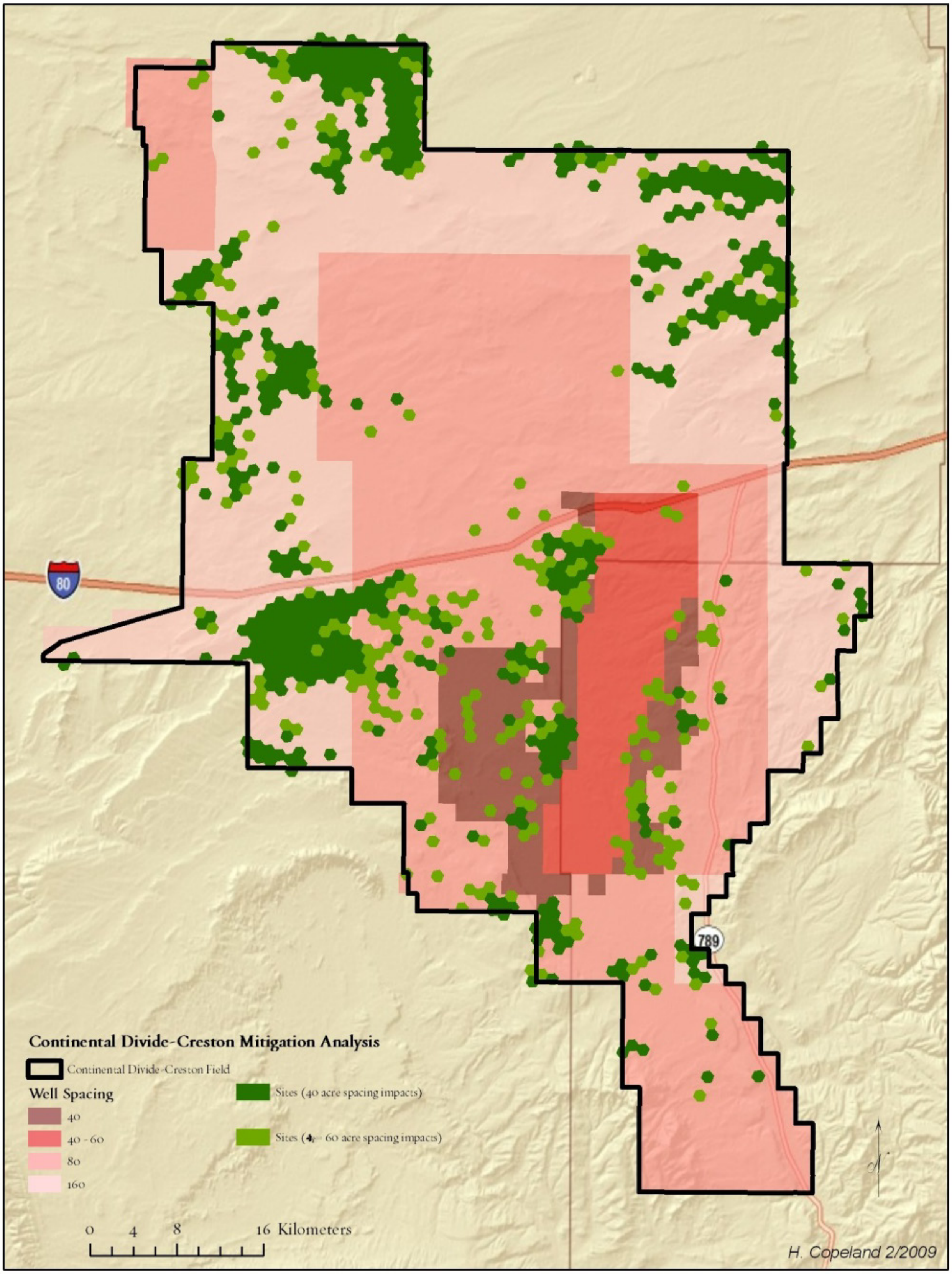
[1] These acre estimates were used as offset goals for Scenario 1 (40- and 60-acre spacing) and Scenario 2 (80-acre spacing).

Table G-2. Goals for each of the biological targets by scenario

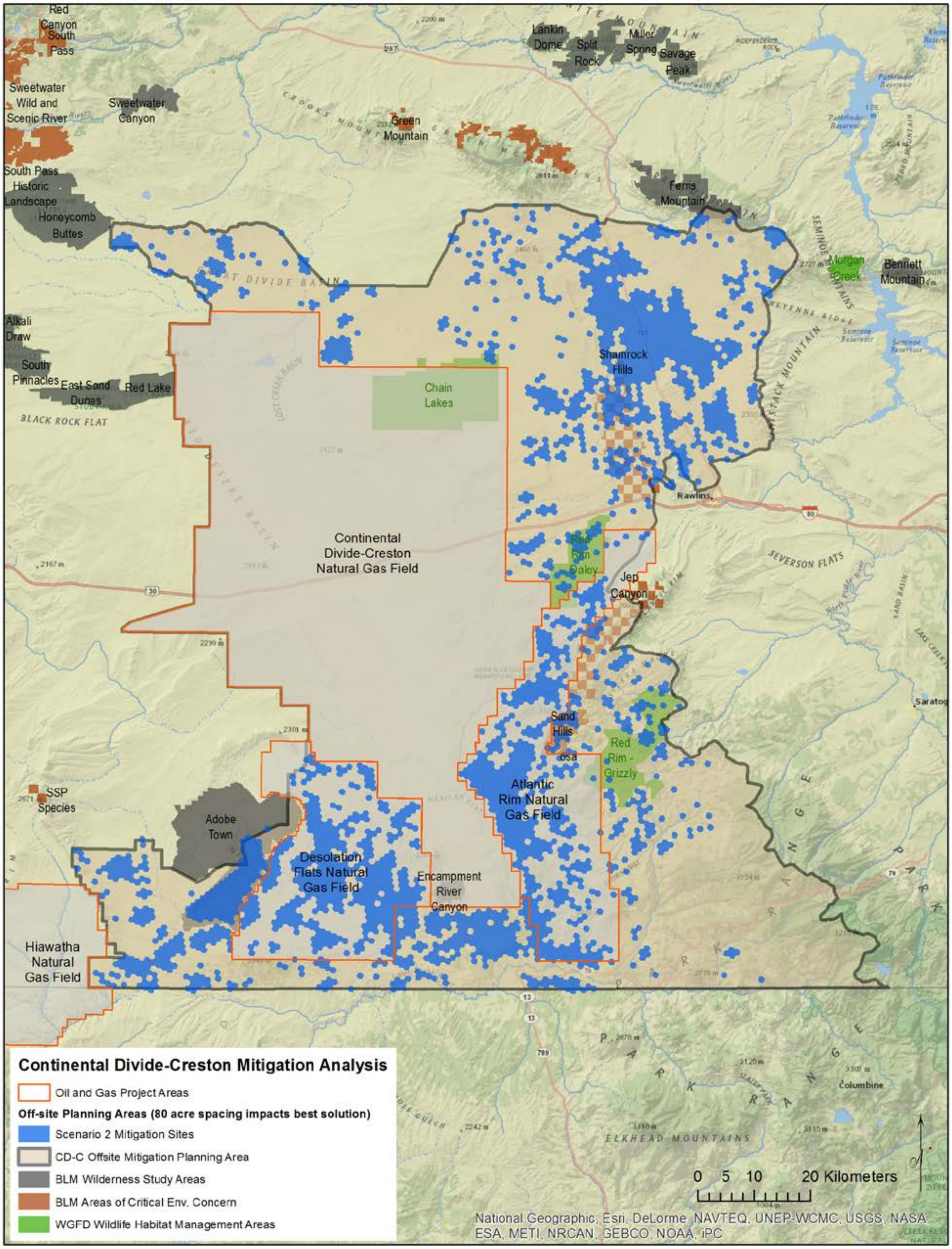
Target Name	Highly Sensitive	Conservation goals within the onsite project area (Scenario 1)	Acres selected onsite by Marxan	Conservation goals within the offsite project area (Scenario 2)	Acres selected offsite by Marxan
Basin Grassland	NO	391	391	1,404	2,141
Black-footed ferret habitat	NO	30,729	23,133	23,955	12,204
Burrowing owl	YES	53	73	328	315
Ferruginous hawk	YES	1,052	1,629	6,964	7,898
Greasewood Fans and Flats	NO	9,725	16,256	42,342	17,953
Great Basin spadefoot habitat	YES	448	741	815	968
Juniper Woodland	NO	0	0	122	794
Mixed Desert Shrub	NO	8,368	9,586	30,970	50,761
Mountain Big Sagebrush-Mixed Mountain Shrub	NO	1,660	4,117	11,456	11,470
Mountain plover habitat	NO	34,911	34,913	77,515	120,812
Mule deer crucial winter	YES	0	189	6,012	35,654
Mule deer migration corridor	YES	0	230	3,550	22,590
Nelson’s milkvetch	YES	0	2	0	0
Nelson’s milkvetch habitat	NO	0	9,490	15,517	2,837
Northern leopard frog	YES	0	1	1	2
Northern leopard frog habitat	YES	30	35	41	984
Gibben's beardtongue	YES	0	1	2,923	7,579
Playa	YES	3	5	25	3,914
Pronghorn crucial winter	YES	1,492	3,086	21,529	15,311
Pronghorn migration corridor	YES	0	22,245	35,494	35,521
Pygmy rabbit	YES	70	70	163	104
Pygmy rabbit habitat	NO	47,102	67,483	177,295	200,261
Riparian-Wet Meadow	YES	7	109	18	3,102
Persistent sepal yellowcress	YES	0	10	0	14,368
Sage-grouse breeding areas	YES	453	463	1,882	2,519
Sage-grouse severe winter locations	YES	2	13	0	0
Sage-grouse winter habitat	NO	10,536	13,176	38,766	34,105
Saltbush Fans and Flats	NO	17,196	17,189	27,015	27,016
Vegetated Sand Dunes	YES	0	71	35	10,923
Wyoming Big Sagebrush-Basin Big Sagebrush	NO	19,562	23,014	79,127	97,228
Wyoming pocket gopher	YES	0	1	5	1
Wyoming pocket gopher habitat	NO	43,654	43,658	100,754	100,952
Riparian-Wet Meadow	YES	7	109	18	3,102
Persistent sepal yellowcress	YES	0	10	0	14,368
Sage-grouse breeding areas	YES	453	463	1,882	2,519
Sage-grouse severe winter locations	YES	2	13	0	0
Sage-grouse winter habitat	NO	10,536	13,176	38,766	34,105
Saltbush Fans and Flats	NO	17,196	17,189	27,015	27,016
Vegetated Sand Dunes	YES	0	71	35	10,923



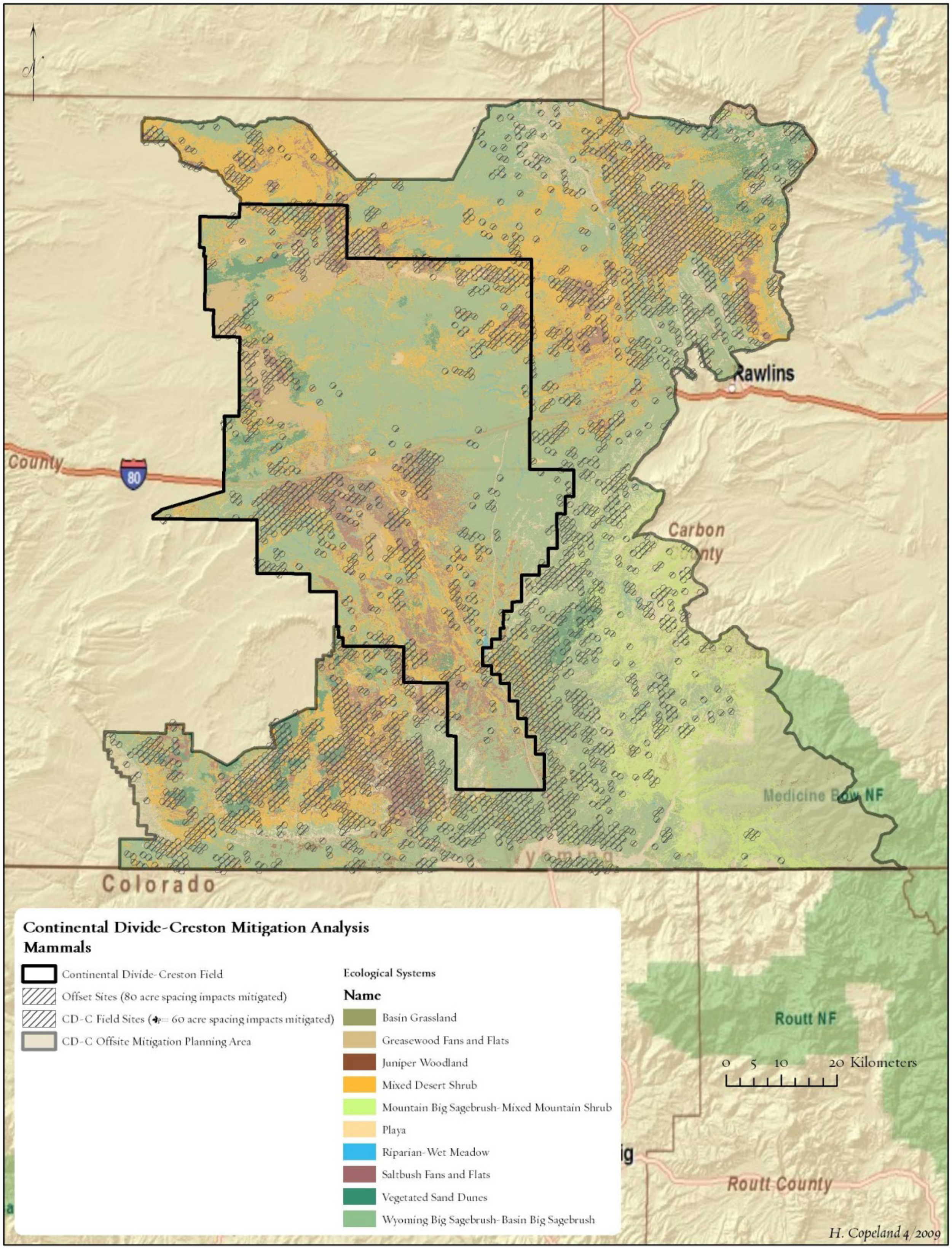
Map G-1. Biological targets with regional importance on the CD-C field.



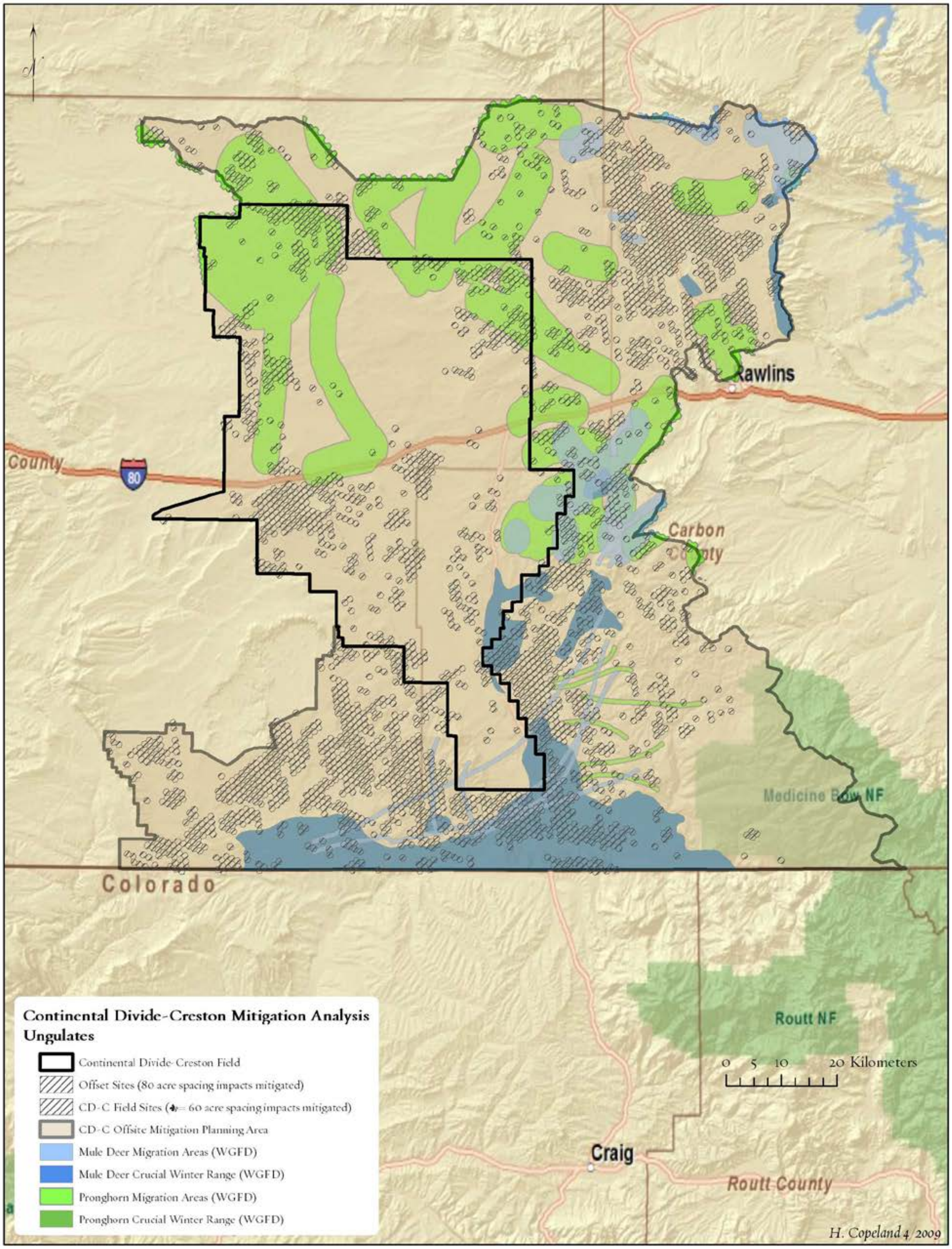
Map G-2. Well spacing designations on the CD-C Field and sites selected to offset impacts associated with development scenario 1 (wells concentrated with areas designated as 40- and 60-acre well spacing).



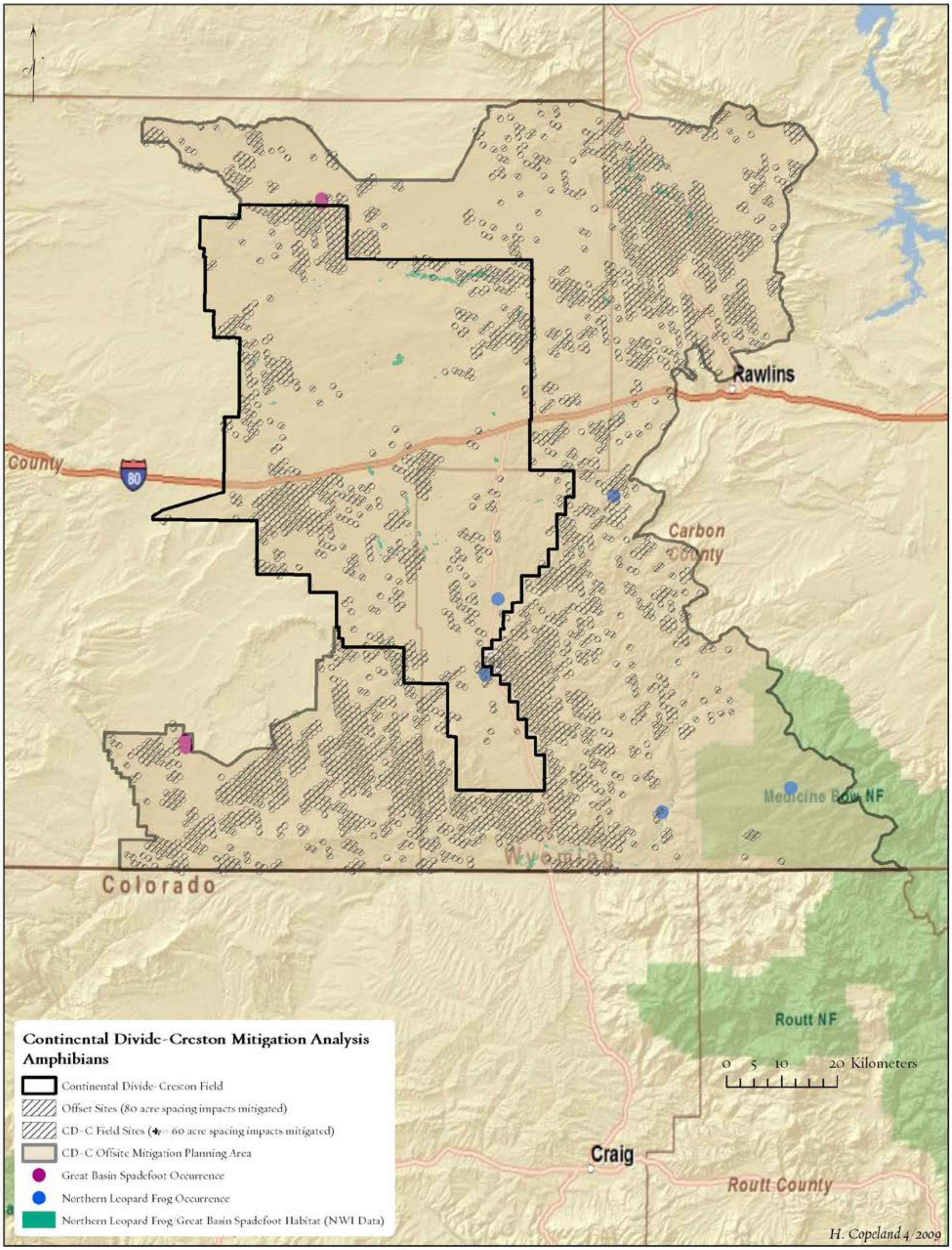
Map G-3. Sites selected outside the project area to offset impacts associated with scenario 2 (wells concentrated with areas designated as 80-acre well spacing).



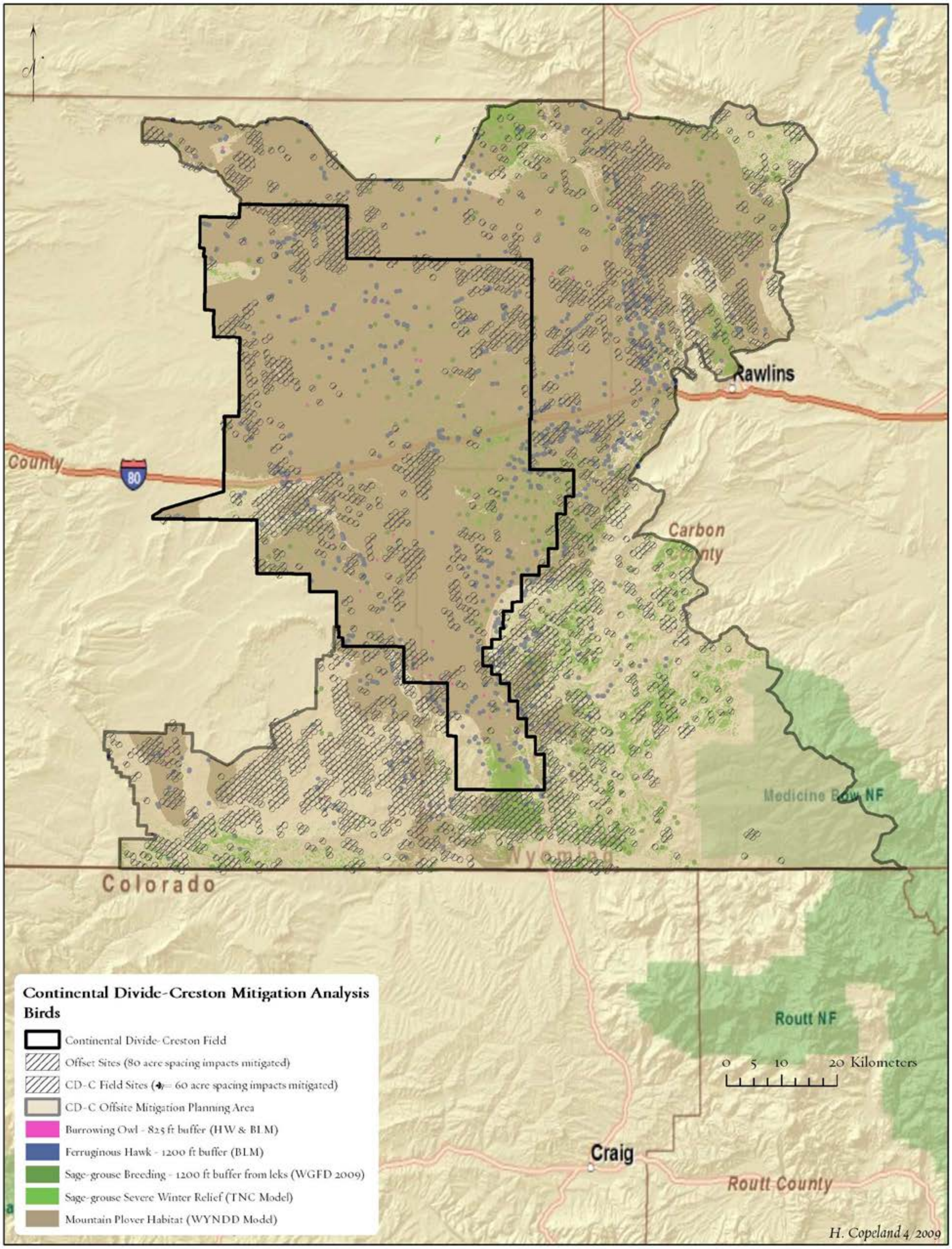
Map G-4. CD-C offset site mitigation analysis, mammals.



Map G-5. CD-C offset site mitigation analysis, ungulates.



Map G-6. CD-C offset site mitigation analysis, amphibians.



Map G-7. CD-C offset site mitigation analysis, birds.

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