



Monitoring Protocol for Greater Sage-Grouse (*Centrocercus urophasianus*) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve

Narrative Version 1.0

Natural Resource Report NPS/UCBN/NRR—2018/1789



ON THE COVER

Greater sage-grouse displaying on lek
NPS Photo

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Contents

	Page
Figures.....	v
Tables.....	vii
Appendices.....	vii
Narrative Change History	ix
Listing of Standard Operating Procedures	xi
Executive Summary	xiii
Acknowledgments.....	xv
List of Abbreviations	xv
Introduction and Background	1
Objectives	10
Sage-grouse monitoring.....	10
Approach.....	15
Defining area of inference	15
Logistical challenges associated with lek counts	15
Survey dates for lek counts.....	16
Implementation	19
Lek route instructions.....	19
Survey frequency at inactive leks.....	21
Revision of existing lek routes	21
Listening Points along lek routes	22
Data Management	25
Analysis and Reporting.....	27
Personnel Requirements.....	29
Training.....	29
Operational Requirements	31
Annual workload and field schedule	31

Contents (continued)

	Page
Facility and equipment needs	31
Startup costs and budget considerations.....	32
Partnerships.....	33
Protocol Testing and Revision	33
Glossary of Terms.....	35
Literature Cited	39

Figures

	Page
Figure 1. Change in greater sage-grouse abundance throughout their range based on lek counts from 1965 to 2013 from Garton et al. (2015).	1
Figure 2. Four general habitat categories at Craters of the Moon National Monument and Preserve: Non-sage-grouse habitat, non-upland vegetative communities and land-uses, high probability sage-grouse nesting habitat (sagebrush-dominated vegetative communities), and low probability sage-grouse nesting habitat (shrub/grass-dominated vegetative communities).	3
Figure 3. Four general sage-grouse habitat categories at City of Rocks National Reserve: non-upland vegetative communities and land-uses, non-sage-grouse habitat, high probability sage-grouse nesting habitat (sagebrush-dominated vegetative communities), and low probability sage-grouse nesting habitat (shrub/grass-dominated vegetative communities).	4
Figure 4. Craters of the Moon National Monument and Preserve and all sage-grouse leks within the park and a 5-km buffer.	5
Figure 5. City of Rocks National Reserve and all sage-grouse leks within CIRO and buffer surrounding CIRO.	6
Figure 6. Core, important, and general sage-grouse habitat within Craters of the Moon National Monument and Preserve.	8
Figure 7. General sage-grouse habitat within City of Rocks National Reserve. Status of leks in this figure is based on their status in 2017.	9
Figure 8. Grid overlaying CRMO for optional spatially explicit sampling approach.	24

Tables

	Page
Table 1. Standard operating procedures used for the UCBN sage grouse protocol.	xi
Table 2. Summary of current state and provincial methods used for counting sage-grouse at leks or along lek routes in the U.S. and Canada.....	11
Table 3. Sage-grouse leks associated with Craters of the Moon National Monument and Preserve (CRMO) and City of Rocks National Reserve (CIRO) and a 5-km buffer surrounding each NPS unit in 2017, including leks on existing lek routes and those not associated with existing lek routes.....	17
Table 4. Summary of revised lek routes on CRMO and CIRO and the number of leks on those routes as of 2017.....	22
Table 5. Annual budget for monitoring sage grouse at CRMO and CIRO.	32
Table 6. Sampling components of sage-grouse monitoring protocol on CRMO and CIRO, including optional components.....	48

Appendices

	Page
Appendix I. Vegetation Types at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve	43
Appendix II. An Area-Based Probabilistic Sampling Effort to Estimate Actual Density of Male Sage-Grouse (Optional)	45
Appendix III. Lek Counts for Leks That Are Not on Existing Lek Routes (Optional)	51
Appendix IV. IDFG Status Designations and Definitions for Sage-Grouse Leks	53

Narrative Change History

Note: Standard Operating Procedure 8: Revising the Protocol (see List of Standard Operating Procedures on next page) provides detailed guidance for making changes to this protocol.

Revision Log:

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #
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1. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, ...etc.) for minor changes. Major revisions must be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
2. Notify the UCBN Project Lead and Data Manager of any changes to the Protocol Narrative or SOPs so that the new version number can be incorporated in the Metadata of the project database.
3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOPs. A list will be maintained in the protocol revision SOP.

Listing of Standard Operating Procedures

Nine standard operating procedures are associated with the Upper Columbia Basin Network (UCBN) sage-grouse monitoring protocol (Table 1). To accommodate frequent changes, each standard operating procedure (SOP) is informally published online through the National Park Service Integrated Resources Management Applications (IRMA) portal (<https://irma.nps.gov/Portal>). The SOPs can be retrieved from IRMA using the citation or the hyperlinked record number, below. Versioning tools in IRMA will offer the most current version from these links.

Table 1. Standard operating procedures used for the UCBN sage grouse protocol.

Title	Citation	IRMA record number
SOP #1: Lek Monitoring Guidelines	Conway, C. J. and others. 2018. Standard Operating Procedure 1: Lek Monitoring Guidelines. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254863
SOP #2: Preparation for the Field Season and Field Season Closeout	Conway, C. J. and others. 2018. Standard Operating Procedure 2: Preparation for the Field Season and Field Season Closeout. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254864
SOP #3: Training Field Personnel	Conway, C. J. and others. 2018. Standard Operating Procedure 3: Training Field Personnel. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254865
SOP #4: Finding GPS Waypoints	Conway, C. J. and others. 2018. Standard Operating Procedure 4: Finding GPS Waypoints. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254866
SOP #5: Measuring Response Variables	Conway, C. J. and others. 2018. Standard Operating Procedure 5: Measuring Response Variables. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254867
SOP #6: Data Management	Conway, C. J. and others. 2018. Standard Operating Procedure 6: Data Management. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254869
SOP #7: Data Analysis and Reporting	Conway, C. J. and others. 2018. Standard Operating Procedure 7: Data Analysis and Reporting. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254870

Table 1 (continued). Standard operating procedures used for the UCBN sage grouse protocol.

Title	Citation	IRMA record number
SOP #8: Revising the Protocol	Conway, C. J. and others. 2018. Standard Operating Procedure 8: Revising the Protocol. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254871
SOP #9: Safety	Conway, C. J. and others. 2018. Standard Operating Procedure 9: Safety. Version 1. Monitoring Protocol for Greater Sage-Grouse (<i>Centrocercus urophasianus</i>) at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve. Unpublished National Park Service Report, Upper Columbia Basin Inventory and Monitoring Network, Moscow, Idaho.	2254872

Executive Summary

Sagebrush (*Artemisia* spp.)-steppe vegetation composes approximately half of the vegetated (non-lava) portions of Craters of the Moon National Monument and Preserve (CRMO) and is also a common land cover at City of Rocks National Reserve (CIRO) (Bell et al. 2009, Erixson and Cogan 2011). Thus, both park units contain substantial greater sage-grouse (*Centrocercus urophasianus*) nesting habitat. The Idaho Department of Fish and Game (IDFG) statewide lek database includes many leks that occur within or near the boundary of CRMO, and 11 leks within 5km of CIRO. Investigators from the University of Idaho (UI) and National Park Service (NPS) staff collaborated to develop a strategy and protocol for long-term monitoring of greater sage-grouse in and immediately adjacent to CRMO and CIRO. An explicit objective of the field methods for this protocol was compatibility with annual lek counts and lek routes coordinated by the IDFG, because data collected from this NPS protocol is intended to augment (not duplicate or replace) statewide sage-grouse monitoring efforts of IDFG and other agency partners. As the methods outlined in this protocol are implemented at these 2 NPS sites, and lessons are learned through additional field experience and through collaborative discussions with IDFG and BLM partners, revision of methods may be needed and an updated version of this document will be produced if warranted or appropriate.

This sage-grouse monitoring protocol, for implementation at CRMO and CIRO, expands upon the current IDFG sage-grouse lek count guidelines (IDFG 2016; Standard Operating Procedure 1: Lek Monitoring Guidelines), providing additional clarifications where needed and some modifications that were necessary to ensure that surveyors could implement/follow all of the guidelines. The protocol provides additional guidance regarding 6 issues: 1) the frequency with which to visit leks along lek routes, 2) revising lek routes so that all routes can be effectively surveyed as consistently as possible to IDFG guidelines, 3) clarification of methods to improve detection of new, unknown, and satellite leks along existing lek routes, 4) instructions for periodically counting leks that are not along lek routes, 5) an optional probabilistic sampling framework for area-based sampling that would provide unbiased estimates of grouse abundance within CRMO and CIRO, and 6) data management.

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List of Abbreviations

asl:	above sea level
ATV:	All-terrain Vehicle
BLM:	Bureau of Land Management
CIRO:	City of Rocks National Reserve
CRMO:	Craters of the Moon National Monument and Preserve
GIS:	Geographic Information Systems
GPS:	Geographic Positioning System
IDFG:	Idaho Department of Fish and Game
km:	kilometers
kph:	kilometers per hour
mph:	miles per hour
NPS:	National Park Service
SGMA:	Sage-grouse Management Area
UI:	University of Idaho
WAFWA:	Western Association of Fish and Wildlife Agencies

Introduction and Background

The greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) has been extirpated from 44% of its former range (Schroeder et al. 2004), and breeding populations had declined 17-47% by 1994 (Connelly and Braun 1997). Sage-grouse population declines were estimated at 2.0% per year from 1965-2003 (1.5% per year in Idaho) (Connelly et al. 2004). Other studies have documented significant range-wide declines through 2007 (WAFWA 2008, Garton et al. 2011), and a 56% range-wide decline in sage-grouse from 2007 through 2013 (Garton et al. 2015) (Figure 1). These losses have led to several petitions to list certain populations, subspecies, or species of sage-grouse as endangered or threatened under the Endangered Species Act (Ashe 2010). And these population declines and listing petitions have led to the development of state and federal sage-grouse management plans (Idaho Sage-grouse Advisory Committee 2006, Stiver et al. 2006).

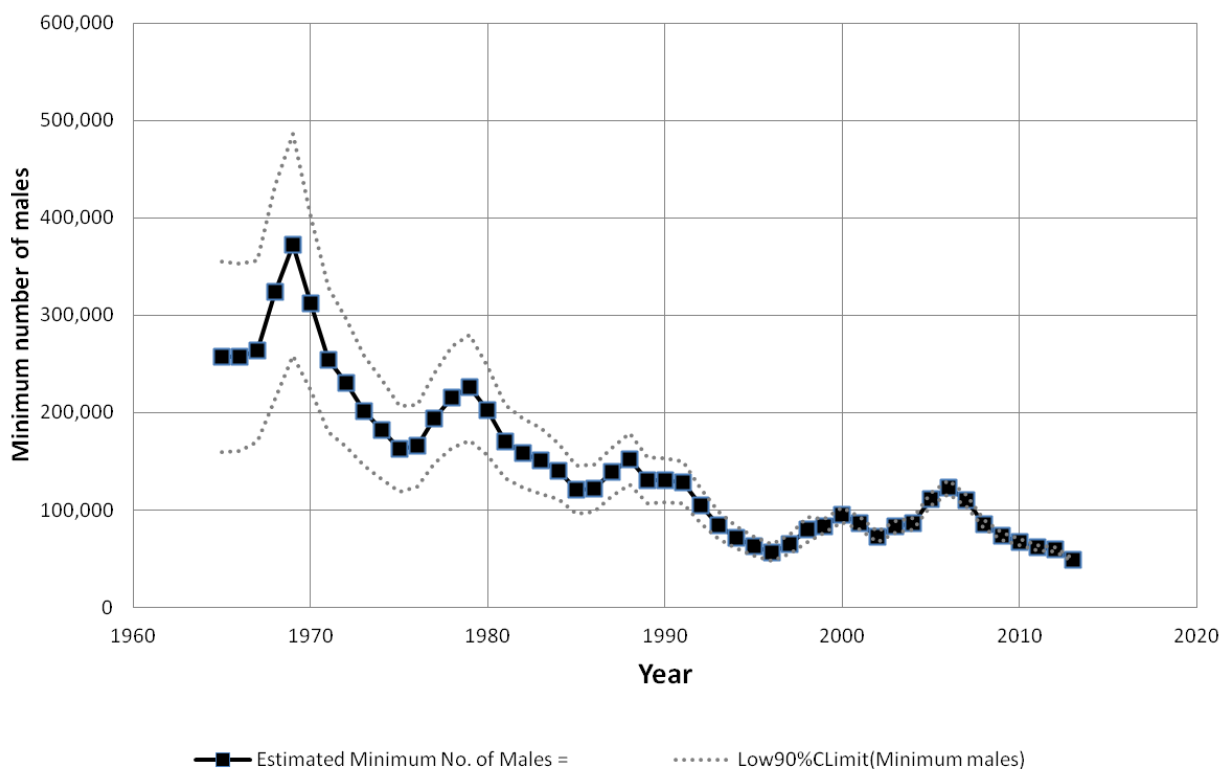


Figure 1. Change in greater sage-grouse abundance throughout their range based on lek counts from 1965 to 2013 from Garton et al. (2015).

The sage-grouse is considered a sagebrush-steppe obligate (Patterson 1952, Connelly et al. 2000) because it depends heavily on sagebrush for cover and forage. Sage-grouse are also considered a landscape species (Knick and Connelly 2011) because they need vast expanses of sagebrush habitat to meet their life history requirements, and an umbrella species (Rowland et al. 2006, Hanser and Knick 2011, Gamo et al. 2013) because their home range and habitat requirements are large enough that, if protected, will likely provide sufficient habitat for other sagebrush-obligate species. Declines in sage-grouse numbers and range are generally attributed to the loss, fragmentation, and alteration of

sagebrush-steppe vegetation across the intermountain west. Agricultural conversion, historical livestock grazing practices, altered fire regimes, and invasion of non-native plants are the primary sources of this habitat loss within Idaho (Idaho Sage-grouse Advisory Committee 2006).

Sagebrush-steppe vegetation composes approximately half of the vegetated (non-lava) portions of Craters of the Moon National Monument and Preserve (CRMO) and, thus, CRMO contains substantial sage-grouse nesting habitat (Figure 2). Sagebrush-steppe vegetation is also a common land cover at City of Rocks National Reserve (CIRO), which provides sage-grouse nesting habitat (Figure 3). The four vegetation classification categories shown in Figures 2 and 3 were derived from the more detailed vegetation maps for CRMO (Bell et al. 2009) and CIRO (Erixson and Cogan 2011). Sage-grouse occur in these 2 areas during all seasons of the year. CRMO supports relatively large numbers of breeding sage-grouse with >100 leks within or adjacent to CRMO, and a few leks occur within the original monument portion of the park (Figure 4). Use of CRMO by sage-grouse at other times of year has been confirmed, but detailed descriptions of use are lacking. CIRO appears less important to breeding grouse and areas used by grouse within its boundaries are on the periphery of more important habitat (Figure 5). Eleven leks occur within 5-km of CIRO, and nests, broods, and wintering individuals have occasionally been observed in both units of CIRO and in adjacent rangeland.

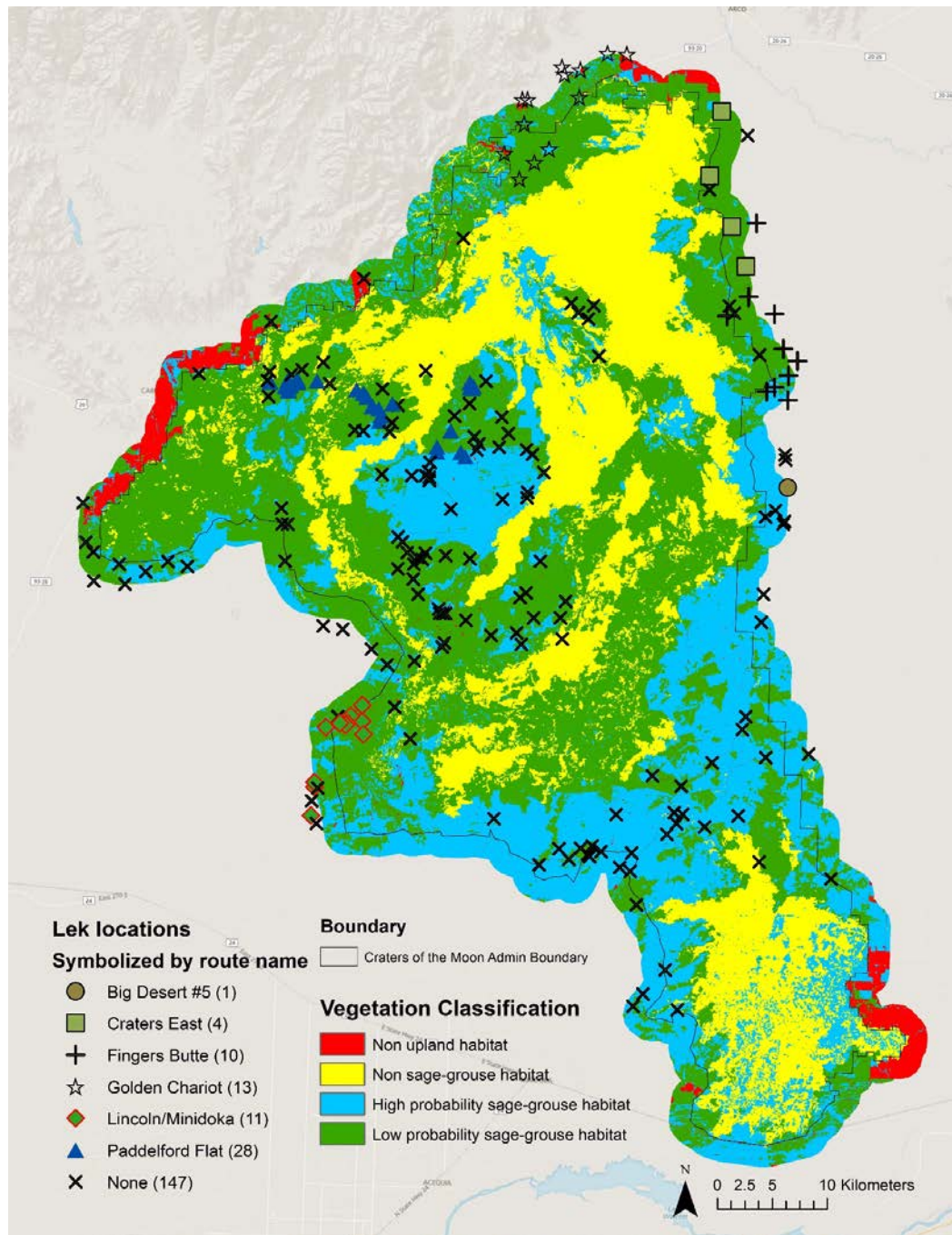


Figure 2. Four general habitat categories at Craters of the Moon National Monument and Preserve: Non-sage-grouse habitat, non-upland vegetative communities and land-uses, high probability sage-grouse nesting habitat (sagebrush-dominated vegetative communities), and low probability sage-grouse nesting habitat (shrub/grass-dominated vegetative communities). These 4 categories were based on pooling the vegetative communities in the park's complete vegetation map (from Bell et al. 2009) into 4 categories based on presumed suitability for nesting sage-grouse (see Appendix I for the vegetative communities that contribute to each of the 4 habitat categories). This map includes a 2-km buffer beyond the CRMO border because it is based on the communities in the complete park vegetation map and those only extend 2-km beyond the border. Most leks on CRMO are not associated with a lek route (those indicated by a black X).

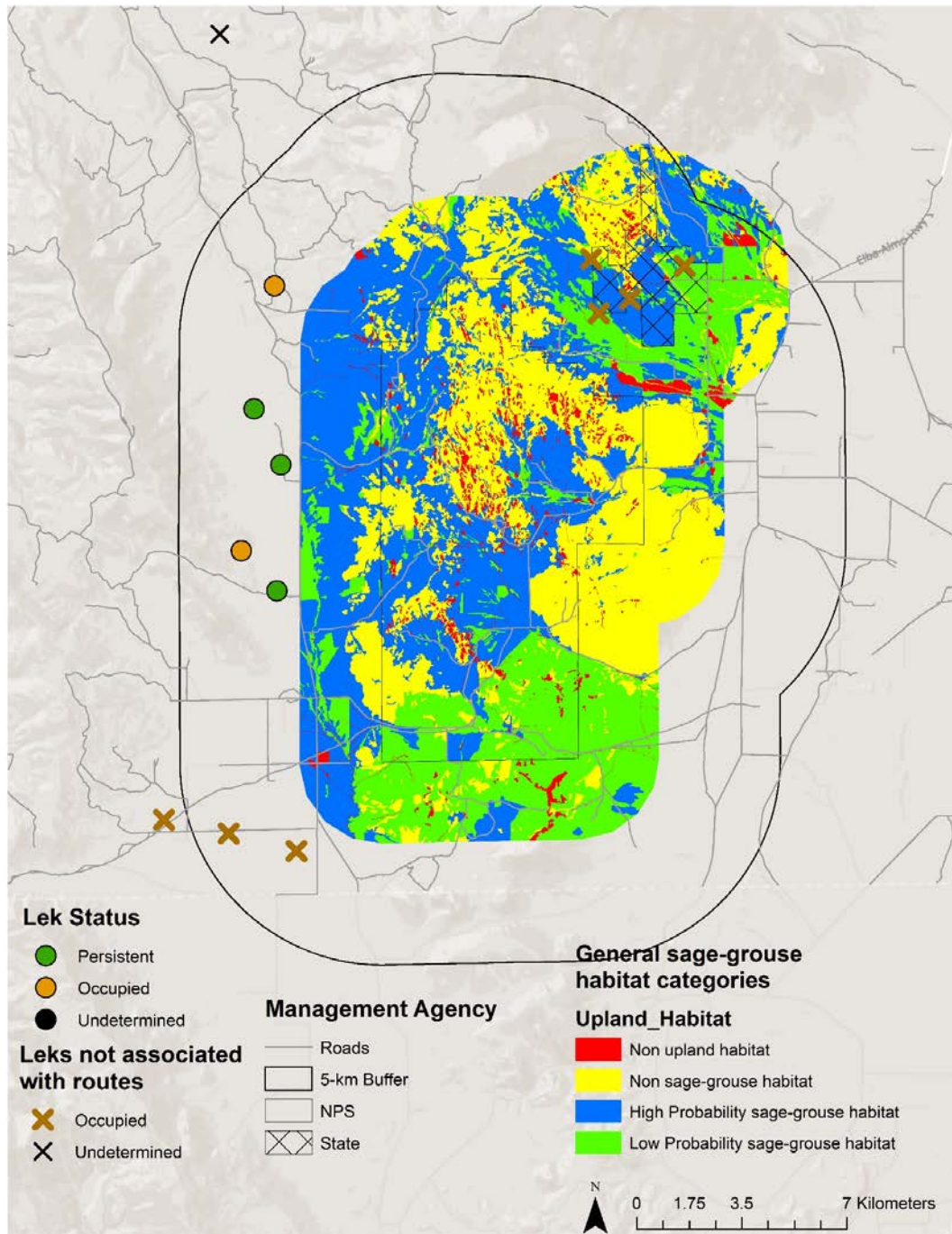


Figure 3. Four general sage-grouse habitat categories at City of Rocks National Reserve: non-upland vegetative communities and land-uses, non-sage-grouse habitat, high probability sage-grouse nesting habitat (sagebrush-dominated vegetative communities), and low probability sage-grouse nesting habitat (shrub/grass-dominated vegetative communities). These 4 categories were based on pooling the communities in the park's complete vegetation map (from Erixson and Cogan 2011) into 4 categories based on presumed suitability for nesting sage-grouse (see Appendix I for the vegetative communities that contribute to each of the 4 habitat categories). This map includes a 2-km buffer beyond the CIRO border because it is based on the communities in complete park vegetation map and those only extend 2-km beyond the border.

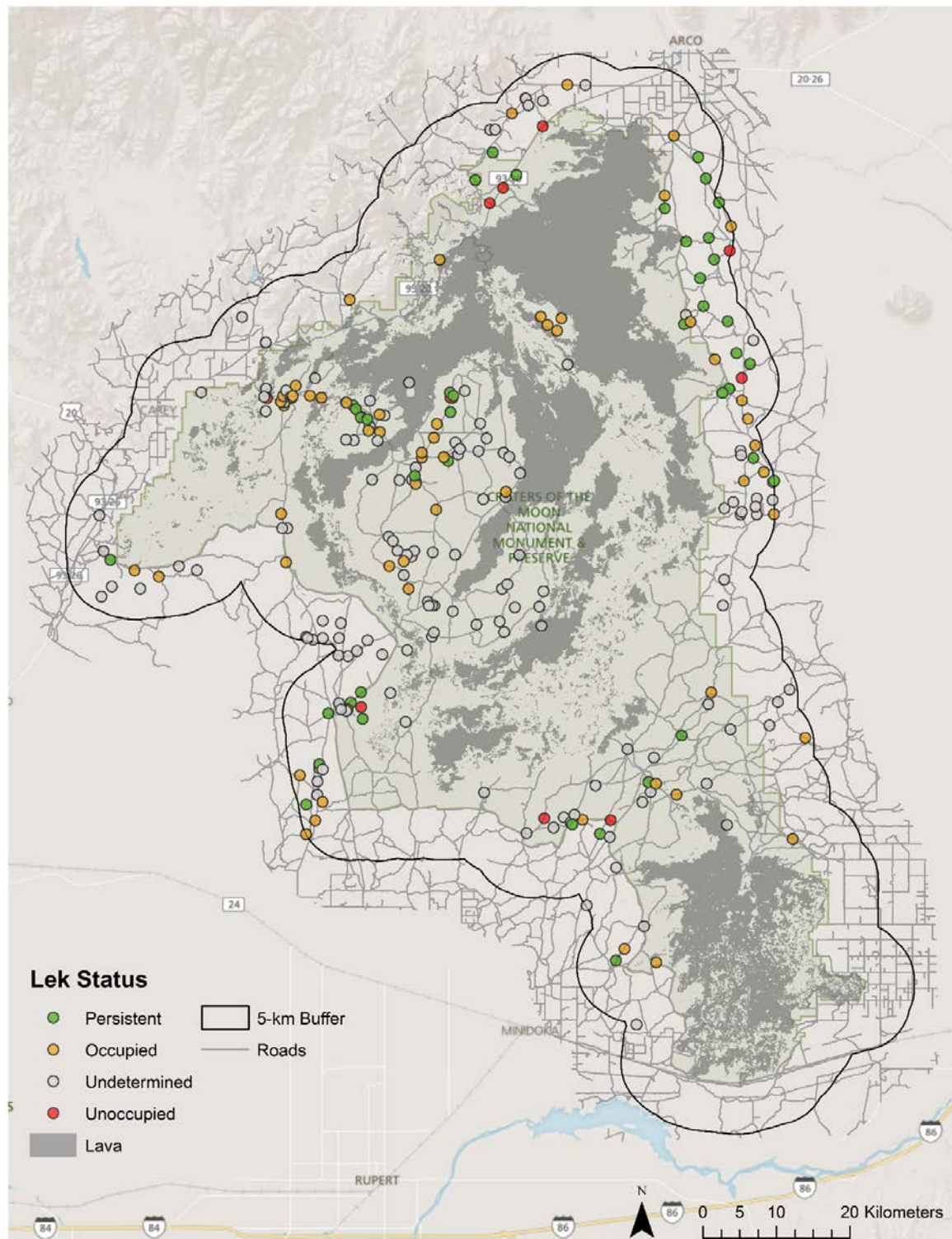


Figure 4. Craters of the Moon National Monument and Preserve and all sage-grouse leks within the park and a 5-km buffer. Within the boundary there are 139 leks: 3 new, 33 occupied but not persistent, 14 persistent (so 47 occupied), 9 unoccupied, and 80 undetermined. Including the 5-km buffer there are 250 leks: 6 new, 59 occupied but not persistent, 38 persistent, 11 unoccupied, 136 undetermined. Status of leks in this figure is based on their status in 2017. See Glossary for definitions of lek types.

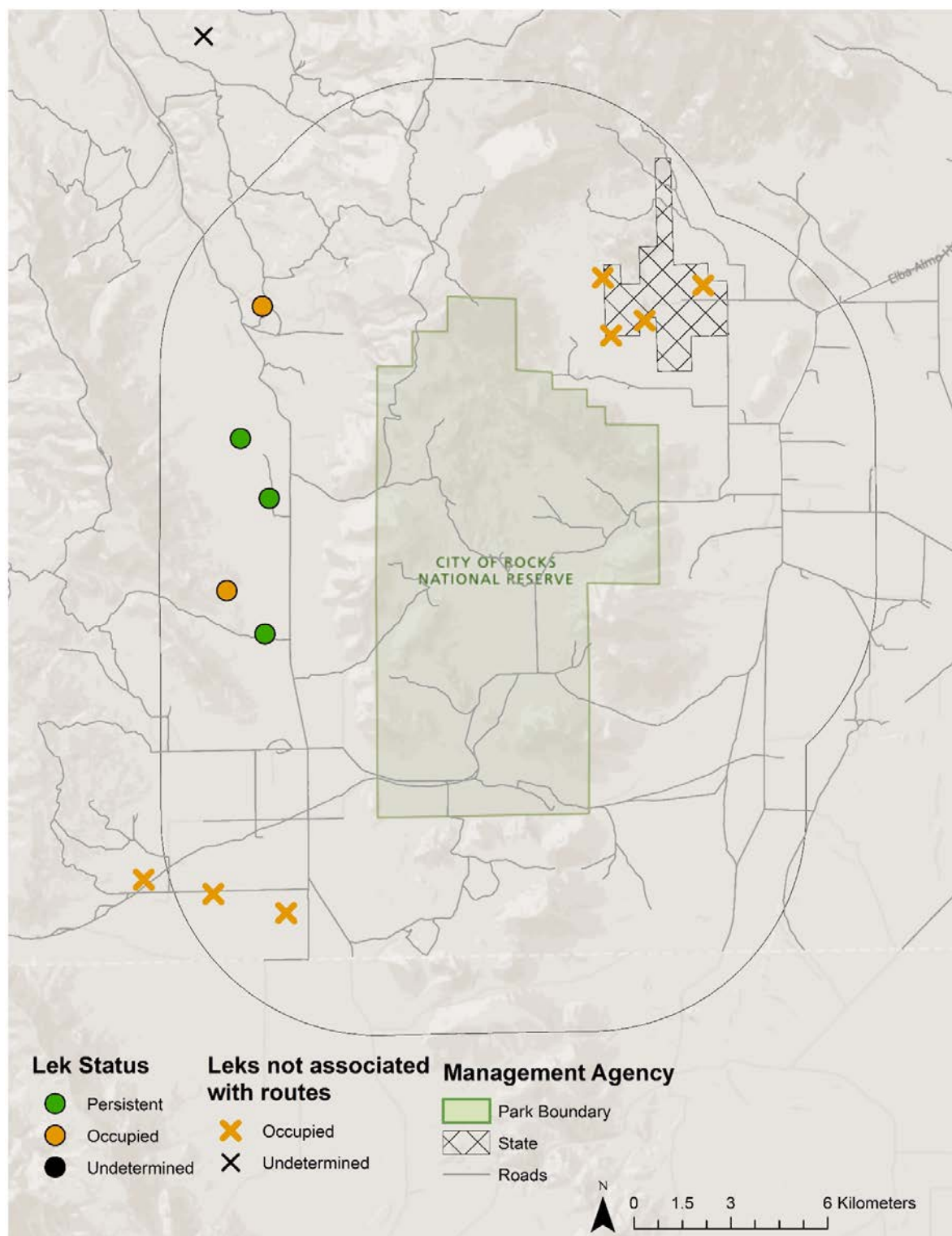


Figure 5. City of Rocks National Reserve and all sage-grouse leks within CIRO and buffer surrounding CIRO. The 1-km² grid includes a buffer surrounding the NPS unit boundary. No leks have been identified within the City of Rocks boundary. Within a 5-km buffer, there are 12 leks: 8 occupied but not persistent, 3 persistent, 1 undetermined. Status of leks in this figure is based on their status in 2017. See Glossary for definitions of lek types.

In 2012, the Governor of Idaho's Sage-grouse Task Force recommended actions that would provide a statewide regulatory mechanism to help ensure persistence of the greater sage-grouse. As a result of that effort, the Governor of Idaho established a sage-grouse management area (SGMA) of 15.22 million acres (61,593 km²) with 3 explicit sage-grouse management zones, each approximately 1/3 of the SGMA: core habitat, important habitat, and general habitat. Areas with core habitat were proposed as the most restrictive and general habitat was the least restrictive regarding the activities allowed in those areas. In the Idaho alternative for sage-grouse management (Otter 2012), CRMO includes substantial amounts of both core and important sage-grouse habitat (Figure 6) whereas CIRO includes only general habitat (Figure 7). Monitoring sage-grouse populations in and adjacent to NPS units will allow the NPS to better assess ecological conditions within CRMO and CIRO. Monitoring sage-grouse on CRMO and CIRO will also improve interpretive resources for the parks. Moreover, the importance of CRMO and CIRO to sage-grouse may increase as surrounding land cover shifts toward non-suitable land use or land cover. Monitoring sage-grouse populations in CRMO and CIRO will provide the information necessary to evaluate whether NPS lands and the activities on those lands are supporting healthy sage-grouse populations.

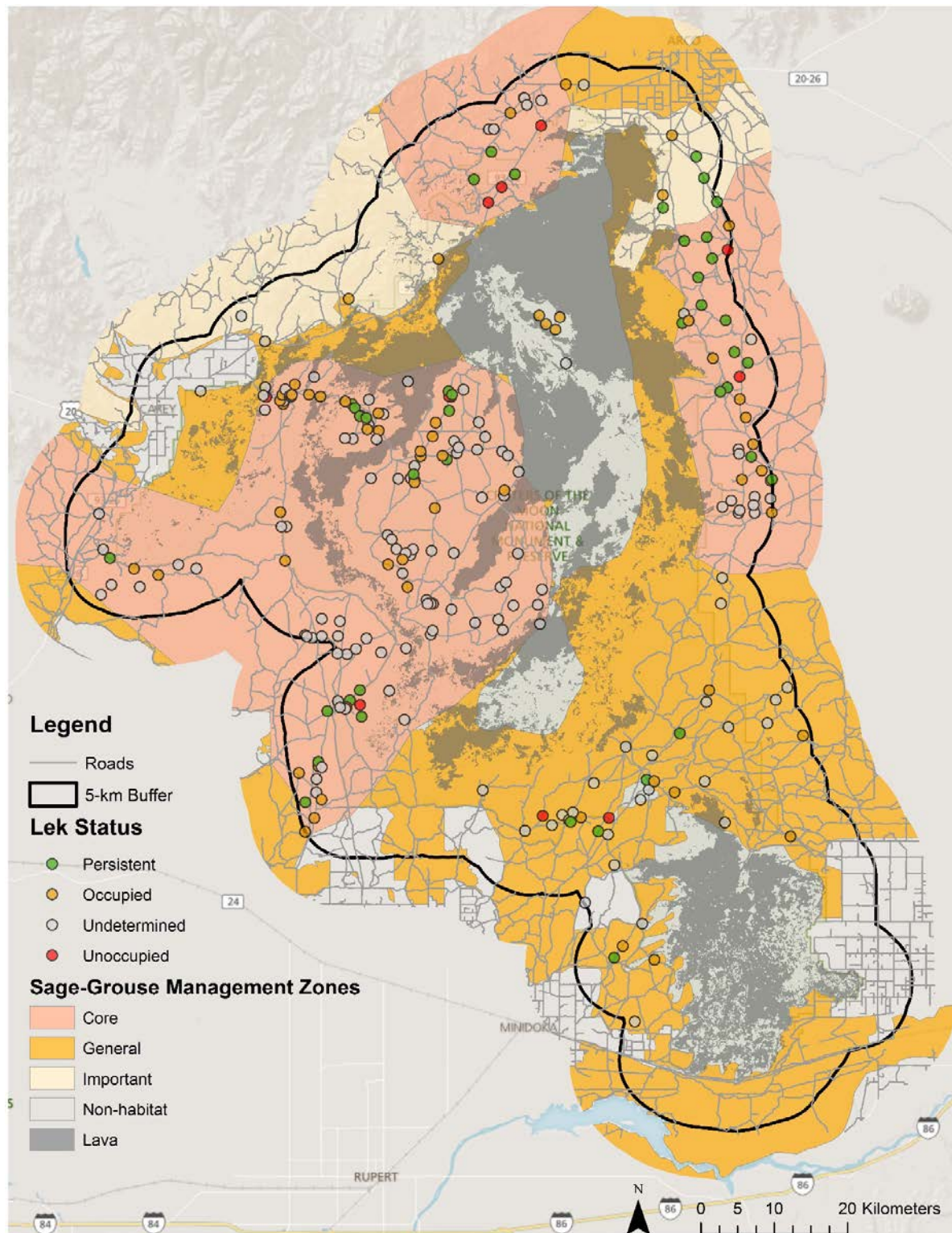


Figure 6. Core, important, and general sage-grouse habitat within Craters of the Moon National Monument and Preserve. Status of leks in this figure is based on their status in 2017. The areas labelled “non-habitat” within the area of inference were not considered core, important, or general habitat in Otter (2012), but some of those areas are indeed habitat and contain sage-grouse.

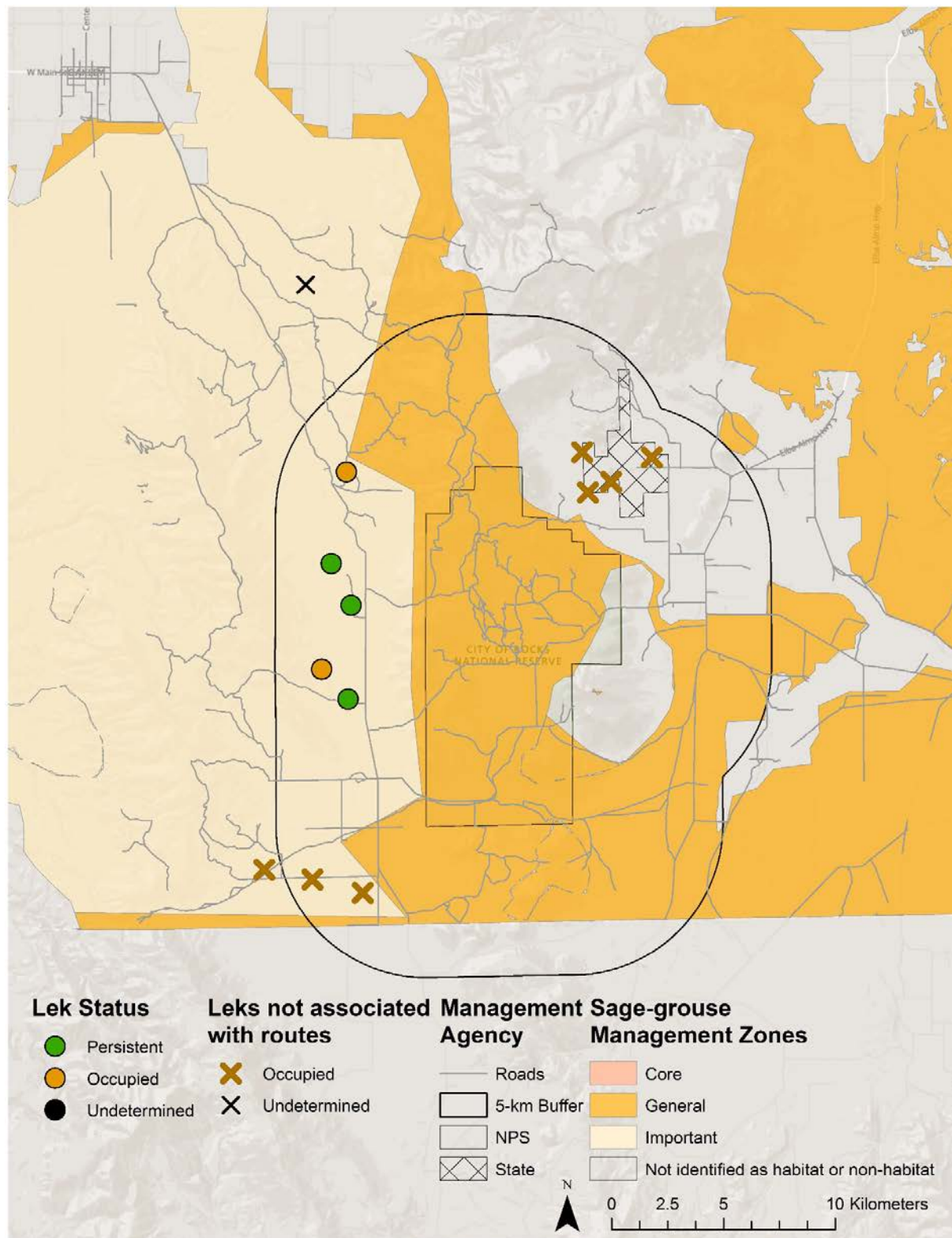


Figure 7. General sage-grouse habitat within City of Rocks National Reserve. Status of leks in this figure is based on their status in 2017. The areas labelled “non-habitat” within the area of inference were not considered core, important, or general habitat in Otter (2012), but some of those areas are indeed habitat and contain sage-grouse.

Objectives

- To estimate population trend of male sage-grouse at CRMO and CIRO.
- To provide guidance regarding further changes that would be necessary to estimate density, abundance, and trends in true abundance at CRMO and CIRO.
- To provide more detail and explicit methods for conducting lek counts at CRMO and CIRO.

This protocol describes methods and procedures to detect status, population change, and trends of sage-grouse in CRMO and CIRO. A specific objective of this effort was to improve understanding of the status of sage-grouse within these 2 parks, as well as provide meaningful contributions to regional sage-grouse monitoring efforts in a way that complements existing sage-grouse monitoring efforts in Idaho. In particular, this protocol is intended to be compatible with IDFG's existing sage-grouse lek count guidelines and meet NPS resource management information needs. As the methods outlined in this protocol are implemented at these 2 NPS sites, and lessons are learned through additional field experience and through collaborative discussions with IDFG and BLM partners, revision of methods may be needed and an updated version of this document will be produced if warranted or appropriate.

Sage-grouse monitoring

Sage-grouse populations throughout much of western North America have been monitored for over 60 years (Patterson 1952, Dalke et al. 1963). Because male sage-grouse visit leks (traditional display areas) each spring, monitoring breeding populations is more common than monitoring populations during other seasons. Breeding season monitoring efforts often include ≥ 1 of the following techniques: lek counts (count of male sage-grouse attending a lek), lek routes (a series of lek counts at a group of leks that are close enough together such that the observer can conduct counts at all leks associated with the lek route and effectively sample the area between those leks during the same morning survey window), and lek surveys (annually counting the number of active leks in a given area) (Connelly et al. 2003).

Autenrieth et al. (1982) attempted to standardize population data collection techniques and described methods available for documenting sage-grouse population characteristics. The sage-grouse guidelines (Connelly et al. 2000) stressed the importance of population monitoring and collecting quality data in sage-grouse management programs. Counting male sage-grouse at known leks (lek counts) has some limitations (Beck and Braun 1980), but lek counts have been the most common method used by state and provincial wildlife agencies to monitor sage-grouse populations (Dalke et al. 1960, Connelly et al. 2003). Connelly et al. (2003) proposed standardized methods for counting males on leks, and all states and provinces throughout the sage-grouse range conduct lek counts. Methods used for sage-grouse lek counts in states and provinces are generally similar, but there are also substantive differences in methodological details among states and provinces (Table 2). For example, the duration of the morning survey window varies considerably among states and provinces, from 60-min to 150-min (Table 2). We recommend that lek counts be limited to a 90-min window (30-min prior to 60-min after sunrise) given that the number of males that attend leks and sightability of grouse on leks often both drop precipitously soon after sunrise (Patterson

1952, Rothenmaier 1979, Walsh et al. 2004, Fremgen et al. 2016, Baumgardt et al. 2017). For example, the percentage of radio-marked male sage-grouse in Wyoming that was detected on leks dropped from ~40% at sunrise to <5% by 60 min past sunrise (Fremgen et al. 2016).

Table 2. Summary of current state and provincial methods used for counting sage-grouse at leks or along lek routes in the U.S. and Canada. California and Montana have more than one set of methods because they use different methods at different leks.

State	Start ^a	End ^a	Weather ^b	Changed since 1985	Counts ^c	Time ^d	Comments
AB	0.5 hr before	0.5 hr after	R,Y	Unknown	3	Yes	3 counts include ≥ 1 late season count at each lek
SK ^e	0.5 hr before	1.5 hr after	R,Y	Unknown	3	Yes	Count birds every 15 min during 2-hr interval; if no birds detected by sunrise, approach lek from downwind scanning area for ≥ 15 min
CA	0.75 hr before	1.5 hr after	R,N	Unknown	3	–	–
CA	0.5 hr before	1 hr after	U	Unknown	3	–	–
CO	0.5 hr before	1.5 hr after	R,N	Yes	3	–	–
ID	0.5 hr before	1.5 hr after	R,Y	Yes	4	Yes	4 counts/yr for leks along lek routes; 2 counts/yr for all other leks visited
MT	0.5 hr before	2 hr after	R,N	–	3	–	For adaptive harvest management leks
MT	0.5 hr before	2 hr after	R,N	No	1	–	Allows evening counts
MT	0.5 hr before	0.5 hr after	U	Yes	3	–	Single lek counted for 1 hr
ND	0.5 hr before	2 hr after	R,Y	No	2	–	–
NV	0.5 hr before	1 hr after	R,Y	No	3	–	–
OR	0.5 hr before	2 hr after	R,N	Unknown	3	–	–

^a Time relative to sunrise.

^b R = wind, temperature and precipitation recorded; Y = counts only made with clear to partly cloudy conditions, winds <15 kph, and without rain or snow; N = no guidance regarding weather conditions that are unsuitable for lek counts; U = unknown.

^c Minimum number of times the guidelines instruct that leks should be counted per year.

^d Time of each lek count recorded in database.

^e No active leks since 2007.

Table 2 (continued). Summary of current state and provincial methods used for counting sage-grouse at leks or along lek routes in the U.S. and Canada. California and Montana have more than one set of methods because they use different methods at different leks.

State	Start ^a	End ^a	Weather ^b	Changed since 1985	Counts ^c	Time ^d	Comments
SD	0.5 hr before	2 hr after	R,Y	No	1	–	Counts allowed in late afternoon; must have ≥ 1 early morning count/yr.
UT	0.5 hr before	1.5 hr after	R,N	Yes	3	–	Prior to 2009, counts were 0.5 hr before to 0.5 hr after sunrise
WA	0.5 hr before	1.5 hr after	R,Y	Yes	4	–	Window can vary; sometimes 3 counts/yr
WY	0.5 hr before	1 hr after	Y	No	3	–	–

^a Time relative to sunrise.

^b R = wind, temperature and precipitation recorded; Y = counts only made with clear to partly cloudy conditions, winds <15 kph, and without rain or snow; N = no guidance regarding weather conditions that are unsuitable for lek counts; U = unknown.

^c Minimum number of times the guidelines instruct that leks should be counted per year.

^d Time of each lek count recorded in database.

^e No active leks since 2007.

In Idaho, IDFG coordinates a statewide effort to annually conduct 82 lek routes in the state. Conducting lek routes has several benefits over merely conducting lek counts at individual leks:

1. increases the likelihood that the observer will detect satellite or new leks along the route, and thereby account for spatial shifts in the location of leks if they occur;
2. helps ensure that counts at individual leks are conducted at approximately the same time during the morning survey window across years;
3. increases efficiency of survey effort so that surveyors conduct counts at the maximum number of leks during the narrow survey window at sunrise.

Past lek routes at CRMO followed the Idaho lek count guidelines (Standard Operating Procedure 1: Lek Monitoring Guidelines). This NPS protocol expands upon those guidelines and includes methodological details for sage-grouse monitoring at CRMO and CIRO (i.e., guidance regarding how to conduct lek routes and lek counts in ways that will reduce biases)(Appendix II). This document also includes optional sampling methods that would allow estimates of true abundance (if additional sampling were implemented). This protocol addresses several methodological challenges that were unresolved or not explicit in the current IDFG lek count guidelines, including: an explicit limit to the length of a lek route such that all lek routes can be effectively surveyed within the recommended morning survey window, clarity regarding which historical leks along lek routes are visited and counted during lek routes, recommendations regarding lek counts at leks on CRMO that are not on lek routes (Appendix III), and recommendations regarding how to expand existing methods (if

resources are available) in a way that would provide an estimate of abundance per unit of space so that inferences can be made over a larger spatial extent (i.e., throughout CRMO and CIRO).

As of 2017, 7 lek routes intersect with CRMO or CIRO and the area of inference for both sites (Figures 1-7 in Standard Operating Procedure 2: Preparation for the Field Season and Field Season Closeout). Simple linear trends from lek count data at CRMO and CIRO are symptomatic of some of the challenges encountered when attempting to estimate trends in grouse abundance from the existing IDFG statewide lek count data. When temporal changes in count data over the past 50 years from CRMO and CIRO are examined on a lek basis, results suggest declines: 68% of the 99 leks along the 7 lek routes at CRMO and CIRO have a negative linear trend estimate for the change in max count over time, and 70% of the 30 leks with statistically significant slopes are negative. In contrast, when those same data are examined on a lek route basis, results suggest increases: the regression slopes of the sum of the max counts across all leks on a route are positive for all 7 of the lek routes at CRMO and CIRO, and the slopes on 4 of the 7 routes are statistically significant. The fact that the same data suggest opposite conclusions likely reflects two challenges: 1) trends in raw counts at individual leks are negatively biased because leks are not counted until they have males present and are detected by an observer (i.e., there are never zeros in the first year of counting a lek); and 2) trends in the sum of male counts along lek routes (sums of counts at all leks along a lek route) are potentially positively biased if lek routes are allowed to grow in length over time (as new leks are discovered in the vicinity and are added to the lek route) or if not all leks along lek routes were known when the lek routes were initially established and more leks are discovered along the routes in subsequent years. The first challenge is further amplified by ambiguities in the definition of a lek. Some analysts have tried to mitigate these biases by using a ratio of males per active lek (rather than actual counts from lek counts or lek routes), but that approach has limitations and potential biases also. These potential biases could be reduced by implementing some modifications and clarifications to the existing lek count and lek route guidelines. This protocol includes modifications and clarifications to help minimize some potential biases.

The IDFG lek count database includes counts at >2100 lek locations throughout Idaho with some of these leks having annual counts dating back to 1951. Long-term data sets like this have substantial value (Johnson and Rowland 2007) and, hence, this protocol includes modifications to the current Idaho lek count guidelines (Standard Operating Procedure 1: Lek Monitoring Guidelines) that are intended to address some of the concerns raised about existing monitoring methods (Beck and Braun 1980, Emmons and Braun 1984, Walsh et al. 2004). Additionally, we discuss detailed field methods, standardized data forms, explicit data storage and management guidelines, and appropriate analytic procedures that will be applied to these data.

Approach

Defining area of inference

After consulting maps, reviewing the IDFG statewide lek count database, assessing the relative certainty of lek counts, and coordinating with NPS personnel to discuss alternatives, we considered 4 potential scenarios for establishing an area of inference for both Craters of the Moon and City of Rocks. After several mapping/GIS exercises examining the feasibility and logistics of implementing the 4 scenarios, we chose an area of inference that includes the parks plus a 5-km buffer surrounding the parks (Figures 4, 5). Using GIS, a “fishnet” of 1-km² grid cells was draped over each of the areas of inference. These grid cells, or tiles, serve 2 purposes: 1) to inform the placement of listening points along existing lek routes (see the *Listening points along lek routes* section below), and 2) to form the sampling units for an optional area-based sampling design that would provide estimates of the total number of leks and hence an estimate of true abundance across the entire area of inference (see Appendix II).

Logistical challenges associated with lek counts

A logistical challenge with the current IDFG lek monitoring guidelines is that some leks listed in the IDFG statewide database are, in fact, no longer leks or perhaps never were leks. The proportion of these non-leks will only increase over time because leks can be added to the Idaho statewide database (and to lek routes) but leks are less commonly removed. Reasons why a location that is currently designated as a lek in IDFG database may not be an actual lek include: 1) males may display at a temporary display site that is not a lek on ≥ 1 mornings, or because they have been flushed off a nearby lek; 2) yearling sage-grouse (or subadults) may display at a site that is not a lek on ≥ 1 mornings while they are moving to another lek; 3) a few grouse may flush from a relatively bare area (no displaying occurs) early in the morning and an observer may inappropriately record the site as a lek; or 4) an actual lek may have multiple entries (with different coordinates) for the same lek because different observers recorded the coordinates at different activity centers during different years or because of simple data-entry errors. If many inactive leks (see Glossary for definition) occur along a lek route, observers may either decide to not stop at certain leks (because they assume that they won't be active based on past visits) or they stop at all of these leks each time they conduct a lek route and hence are inefficient with their time. These ambiguities can create unneeded inefficiency when conducting lek routes (and create uncertainty when using these databases to assess distribution and relative abundance of breeding sage-grouse). This protocol includes explicit guidance regarding how to deal with different types of leks (including inactive leks and locations that are in the IDFG database as leks but are likely not leks).

Sage-grouse leks listed in the statewide IDFG database are given 1 of 4 “annual status” designations (active, inactive, unknown, and new) and 1 of 4 “management status” designations (occupied, unoccupied, undetermined, and new) (Appendix IV). As of summer 2017, 80 of the 139 (58%) leks within the boundaries of CRMO were classified as undetermined, 9 (6%) were unoccupied, 47 (34%) were occupied, and 3 (2%) were new leks. Of the 250 leks within either CRMO or its 5-km buffer, 136 (54%) were classified as undetermined, 11 (4%) were unoccupied, 97 (39%) were occupied, and 6 (2%) were new leks. Of those 250 leks, 78 (31%) had not been visited/counted since 2011. The

year of the last reported check for 1 lek was 1972. Hence, only a small portion of the leks listed in the IDFG lek database for CRMO have grouse present and the status of many leks is not currently known. For this protocol, we introduced the term “persistent lek” which we defined as an active lek that has had >5 males counted for at least 3 of the last 5 years or ≥ 15 males have been counted in the last 2 years.

Most of the leks within the area of inference for CRMO and CIRO are not counted frequently enough to know if they are active. Moreover, many of the leks on the lek routes associated with CRMO are inactive. As an example, the Paddelford Flat lek route at CRMO has 29 leks associated with it but only 12 (41%) of these 29 leks were active in 2017. Twelve of the 29 leks on this route were not counted in 2017 (nor most of the previous 4 years). The Idaho lek count guidelines state that all leks along a lek route must be counted whenever a lek route is sampled, but it is logistically impossible to visit and count 29 leks during the morning survey window. The Golden Chariot lek route has 15 leks affiliated with it; only 3 (20%) of these 15 leks were reported as active in 2017. The status of the leks on other lek routes associated with CRMO are similar (Table 3). In 2017, only 3 of 6 leks on the Birch Creek lek route, just west of CIRO, were listed as active (Table 3). Thirteen leks on the 7 lek routes that intersect the 2 areas of inference are listed as “undetermined leks” (Table 3) which should not be possible given the lek route guidelines. Due to the short morning survey window, visiting leks that have a low probability of grouse reduces survey efficiency. This protocol provides explicit guidance regarding the frequency of visiting different types of leks based on their probability of having grouse present.

Survey dates for lek counts

All counts are restricted to an approximately 6-week time period beginning in late March and ending by 30 April (to coincide with peak lek attendance) (Connelly et al. 2003). The estimated date of peak male lek attendance should be determined in advance after discussion with IDFG, BLM, and NPS biologists; beginning dates may be adjusted by as much as a week after considering access and weather conditions. Normally, lek routes in Idaho are conducted during 4 periods: early (i.e., March 20-30), mid-1 (April 1-10), mid-2 (i.e., April 11-20), and late (i.e., April 21-30). Counts in Idaho can start a week earlier and end a week earlier at lower elevations (e.g., <1400m asl) that have relatively mild climates and can be shifted by a week later at higher elevations (e.g., >2000m asl) or areas with relatively harsh climates. The timing of the 4 counts coincides with typical dates of peak hen attendance (first 2 counts) and maximum male attendance (last 2 counts). Lek routes should only be conducted on days with clear to partly cloudy skies and winds less than 15 kph. If weather degenerates soon after a route has begun, the entire route will be run again on a different day within the same period (early, mid-1, mid-2, or late; see above).

Table 3. Sage-grouse leks associated with Craters of the Moon National Monument and Preserve (CRMO) and City of Rocks National Reserve (CIRO) and a 5-km buffer surrounding each NPS unit in 2017, including leks on existing lek routes and those not associated with existing lek routes. See Glossary for definitions of lek types.

NPS unit	Lek route	Total leks ¹	Active leks ²	Persistent leks ³	Occupied leks	Unoccupied leks	Undetermined leks	Historical leks	Route length (km)	2017 surveyor
CRMO	Paddelford Flat	29	12	7	18	4	7	0	36	C. Shackelford
	Fingers Butte	11	9	9	10	1	0	1	57	S.Minnie
	Golden Chariot	15	3	2	7	5	3	1	32.0	R.Morris
	Craters East	6	5	4	6	0	0	0	31.2	T.Stefanic
	Lincoln-Minidoka	12	2	3	8	3	1	0	21.8	R.Runyon
	Big Desert #5	18 ⁴	13	9	14	2	2	0	36	M.Horsmon
	Not on routes	171	12	7	48	2	121	–	–	–
CIRO	Birch Creek	6	3	4	5	1	0	0	39.5	A.Andruska
	Not on routes		0	3	7	0	1	–	–	–
Total on lek routes	–	97	47	38	68 ⁵	16	13	2	–	–
Total	–	270	54	50	135	9	134	–	–	–

¹ Number of leks on lek routes that intersect the areas of inference (not all leks are within the boundary of the NPS unit or even within the 5-km buffer because many routes cross ownership boundaries).

² Leks that had >1 male counted during 2017 monitoring efforts.

³ Leks that have had ≥ 5 males counted for ≥ 3 of the last 5 years or ≥ 15 males have been counted in each of the last 2 years. Persistent leks are a subset of Occupied Leks.

⁴ 0 of these leks occur inside CRMO, and 5 occur with the 5-km buffer of CRMO.

⁵ 7 of the 68 occupied leks were not counted during ≥ 1 of the past 5 years.

Implementation

Lek route instructions

Below is a bulleted list of considerations for conducting lek routes at CRMO and CIRO (also see Standard Operating Procedure 1: Lek Monitoring Guidelines). These considerations provide additional components or clarifications unique to this NPS protocol that are intended to further clarify established field methods and help ensure that methods are consistent across years and that all of the IDFG requirements can be accomplished on each lek route while males are still active at leks. Currently, surveyors are sometimes unable to achieve #5, #8 and #11 along some lek routes (i.e., on some lek routes with >10 leks, a surveyor may be physically unable to count all leks associated with the route, stop periodically to look and listen for new leks, drive <25 mph (40 kph) along the route, and achieve all of that within the narrow morning survey window).

1. Coordinate with the IDFG sage-grouse monitoring coordinator (currently Ann Moser) in January of each year to ensure that all lek routes that intersect with the CRMO and CIRO area of inference are surveyed 4 times annually by their assigned surveyor. Have an alternate plan in case the assigned surveyor is unable to perform the 4 counts.
2. Evaluate all lek routes that overlap the areas of inference to ensure that they continue to allow for surveying within the constraints of current lek monitoring guidelines (see Standard Operating Procedure 1: Lek Monitoring Guidelines). If a given lek route has become too long or includes too many leks, due to discovery of additional leks during past surveys, then the lek route may need to be split and conducted over more than a single morning. Doing so will allow all of the requirements below to be completed within the 1.5-hr survey window and allow surveyors to stop periodically to look and listen for new leks. This change will cause a one-time change in the time that each lek count is conducted on each visit (one of the benefits of lek routes) but once the routes are split, each lek will be counted at the same time moving forward.
3. Use the data form in the Standard Operating Procedure 1: Lek Monitoring Guidelines to conduct lek routes.
4. The starting and ending point for each route must remain the same each year. Do not change a route without consulting with the IDFG regional wildlife staff. Also consult the IDFG sage-grouse monitoring coordinator of any requested changes. The changes in start and end points identified in this protocol are intended to be one-time changes to rectify logistical problems; any future changes should be carefully considered.
5. Always count all leks affiliated with the route and all leks encountered along the route (see #7 below for additional guidance on this task). Make an entry on the data sheet for each lek encountered on the route. If no birds are present, record a zero for that lek. If >1 lek is visible from the same vantage point, count them together (they are effectively 1 lek that erroneously was given 2 names and 2 sets of coordinates in the database) and make a note of that on the datasheet.
6. If no grouse are seen at a lek, turn off the vehicle, exit the vehicle and listen for grouse for 2 minutes. Scan the surrounding landscape 360° with binoculars to look for grouse. These tasks will help locate previously undetected leks along the lek route.

7. Surveyors must stop and conduct a count at all of the undetermined leks on each lek route every year for 5 consecutive years, so that these undetermined leks can be assigned as occupied or unoccupied leks. Surveyors must stop and conduct a count at all of the unoccupied leks on each lek route every other year (e.g., half in odd years and half in even years). Surveyors must stop and conduct a count at all of the 'historical' leks on each lek route once every 10 years. Leks are classified as "historical" once they have had no grouse for 10 successive years (regardless of whether those years were consecutive years). If ≥ 2 displaying males are observed at an undetermined, unoccupied, or historical lek, it is immediately reclassified as an occupied lek and surveyed as such in subsequent years.
8. Surveyors must stop, turn off the vehicle, exit the vehicle, and conduct a 2-min listening survey at "listening points" along the lek route such that no spot along the route is farther than 1 km from either a listening point or an observation point where a lek count is conducted. The surveyor should move far enough away from the vehicle such that the vehicle noises do not affect aural detection of leks (vehicles can make noises after they are shut off). Adequate coverage along the lek route will be assessed by GIS using the 1-km² grid cells, or tiles, ensuring that the center of all 1-km² tiles that intersect the route are no more than 1.25-km from either a lek observation point or a listening point. During each listening survey, the surveyor will listen for displaying grouse and use binoculars to scan the surrounding landscape for grouse. These stops where surveyors exit the vehicle to listen and look for grouse along lek routes are not new – they merely formalize a component that was always part of the IDFG lek route guidelines (Standard Operating Procedure 1: Lek Monitoring Guidelines). By conducting these stops in a more formal way, surveyors will be more likely to detect satellite leks (and all existing leks within 1-km of the lek route) and, thus, the monitoring effort will be more standardized across time and across observers and the monitoring data will allow stronger inferences. Initial locations of listening points are identified in this document, but the first surveyor to stop at these proposed listening points can adjust the location of the point by <100m so that the point is in the most optimal location for detecting leks. Once that location has been adjusted on the first visit, the location remains static and should not change through time. We chose 1-km intervals between listening points and 1-km² tiles because a recent study documented that ~95% of the active leks within 1-km of an observer will be detected on >1 of 4 visits (I. Riley, unpubl. data).
9. A lek may have more than 1 activity center (i.e., distinct groups of males). If groups of birds are visible to each other then you are still looking at a single lek even if activity centers are separated by >200m. If there are 2 leks in the database associated with a lek route and you can count them from the same vantage points, be sure to put a number for both leks since you effectively counted both locations.
10. Make all counts from ½ hour before sunrise to 1 hour after sunrise. Do not drive more than 25 mph.
11. Count and report all males and all females observed.
12. Count each lek at least 4 times between 20 March and 30 April with approximately 1 week between counts.

13. Each lek is counted at least 3 times in succession while standing/parked at the observation point for that lek. Subdominant and yearling males are often less active than more-dominant males occupying the lek center and may be easily missed with a single count. Detailed methods for counting sage-grouse on a lek are provided (see Standard Operating Procedure 1: Lek Monitoring Guidelines).
14. All leks within 1km of the route should be detected and counted during the lek route. If a new lek is detected during the lek route and it is ≤ 1 km from the route, conduct a lek count at the new lek on the current lek route and on all future visits to that lek route.
15. Avoid making counts during rainy, inclement weather.
16. Record the time that you start your count at each individual lek along the route.
17. Record the coordinates of the observation point from where you conducted your count at each individual lek along the route, and record the coordinates of each listening point along the route (if the listening point location was adjusted). These points, once established, are saved as waypoints on the route so that surveyors on future visits stop at these same locations (as long as they remain the optimal locations to conduct counts).

Survey frequency at inactive leks

Leks may develop on new openings in sagebrush stands sometimes as a result of increasing sage-grouse populations (Dalke et al. 1960, Connelly et al. 1981, Gates 1985) and grouse may also re-occupy sites that had previously been identified as leks (i.e., often designated as “unoccupied” in the IDFG database). Therefore, unoccupied leks along lek routes need to be visited/counted periodically but not necessarily every year. After 5 consecutive years of zero grouse present at an occupied lek along a lek route, that lek is re-classified as ‘unoccupied’ and can be counted every other year. If grouse are detected at an unoccupied lek in a subsequent year, that lek is reclassified as occupied and again be counted annually during the lek route. If 10 years of counts have recorded zero grouse (10 years in succession but not necessarily consecutive years), an unoccupied lek along a lek route is re-classified as ‘historical’ and can be counted every 10 years. This can be done retroactively by looking backward into the data.

Revision of existing lek routes

Three of the 7 existing lek routes that intersect CRMO and CIRO will be revised so that surveyors conduct several separate routes (instead of the entire existing route) on subsequent mornings. This will allow the shorter routes to be surveyed during the morning survey window while still mostly adhering to the lek count guidelines described in this document (and those in the IDFG guidelines; Standard Operating Procedure 1: Lek Monitoring Guidelines). In most situations, adhering to these guidelines would require that a lek route include lek counts at ≤ 10 occupied leks and be no more than ~20 km long. This constraint on lek route length will ensure that during the morning survey window, surveyors can visit and count all leks on a lek route, stop at several listening points along the lek route, and still allow time in the event that surveyors locate additional leks or satellite leks that need to be counted during the lek route. These modifications will help ensure that surveyors can stay true to the intended restrictions on lek route methods, but will require 3 of the 7 current lek routes on CRMO and CIRO to be split into new (shorter) routes and sampled over >1 day (Figures 8-14 in

Standard Operating Procedure 2: Preparation for the Field Season and Field Season Closeout, Table 4).

Table 4. Summary of revised lek routes on CRMO and CIRO and the number of leks on those routes as of 2017. See Figures 8-14 in SOP 2 for maps of suggested revised lek routes.

NPS unit	Lek route	Total leks	Occupied leks	Unoccupied leks	Status Unknown	Route length (km)
CRMO	Paddelford Flat-East	9	8	1	0	16.9
	Paddelford Flat-Central	9	7	0	2	13.1
	Paddelford Flat-West	11	3	3	5	7.2
	Fingers Butte North	3	2	1	0	21.8
	Fingers Butte South	9	8	1	0	21.4
	Golden Chariot	15	7	5	3	32.0
	Craters East	6	6	0	0	31.2
	Lincoln-Minidoka	12	8	3	1	21.8
	Big Desert #5-East	9	6	1	2	14.4
	Big Desert #5-West	9	9	0	0	12.7
CIRO	Birch Creek	6	5	1	0	39.5
Totals	–	97	68	16	13	–

Listening Points along lek routes

On any given lek route, the probability of detecting an active but unknown lek is <100%. Reasons that an observer may fail to detect (and thus not stop to count) an active lek while sampling a lek route include: 1) the birds that formerly attend a lek that is listed on the lek route sheet may move but the observer is unaware of this and visits the original lek and records a “0”, 2) the observer may “ignore” a lek that he/she detects because it is not listed on their lek route sheet, 3) the observer may drive too fast along a lek route or not pay attention and fail to notice a lek that is not currently in the database, or 4) topography or vegetation may prevent the observer from seeing a unknown lek while traveling along the route between known leks. These scenarios are not uncommon and imperfect detection of active leks along lek routes creates bias when using lek route data to assess status and estimate trends in abundance of breeding sage-grouse, especially if surveyors vary in how they deal with these scenarios. These ambiguities can be reduced if observers stop periodically along lek routes to listen and look for previously undetected leks. Listening surveys to detect new or previously undiscovered leks will be conducted from the ground along existing lek routes on all 4 annual visits to increase the probability of detecting all leks within 1-km of existing lek routes. Roadside listening survey points will be placed along existing lek routes such that no spot along the route is further than 1-km from either a listening point or a lek observation point, and such that the center of all 1-km² tiles that intersect a route are within 1.25-km of either a lek observation point or a listening point (see

Figure 8 that shows a network of 1-km² tiles overlaid onto CRMO). At each listening point, the observer will turn off and exit the vehicle, and listen for sounds of displaying sage-grouse for 2 min. These surveys are conducted during the 1½-hour interval between 30 minutes before sunrise and 1 hour after sunrise (Connelly et al. 2003). Normally, on mornings with little wind, sounds of displaying male sage-grouse can be heard at a distance of at least 1.6 km. These “listening points” along lek routes will improve detection probability of leks.

The observer uses the locations of listening points identified on the route maps (Figures 8-14 in Standard Operating Procedure 2: Preparation for the Field Season and Field Season Closeout) to identify the general area for a listening point but then may adjust the location of the actual listening point based on the spot that provides the optimal vantage point to detect any new or previously undiscovered leks in the surrounding landscape (e.g., a hilltop). The purpose of the listening points is to help ensure that the observer detects new or previously undiscovered leks within any of the 1-km² tiles that intersect the road that serves as the center of the lek route. Tiles that do not contain any sage-grouse lek habitat (e.g., if a tile is farmland or consists of a conifer stand) do not have to have a listening point within 1-km. If a previously undiscovered lek is detected at any of these listening points during the actual 2-min listening survey, the observer should move to an optimal location to count the grouse on the newly discovered lek.

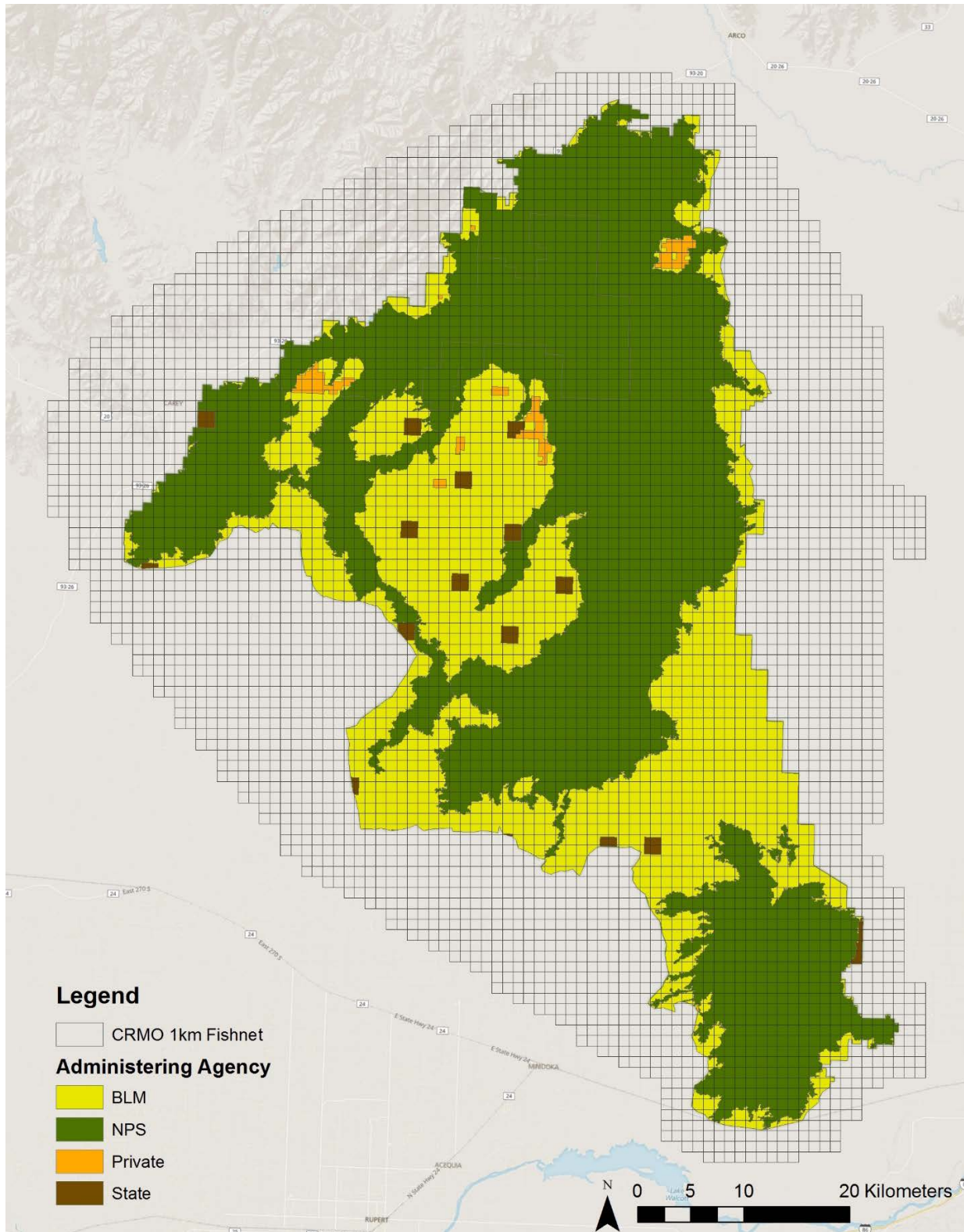


Figure 8. Grid overlaying CRMO for optional spatially explicit sampling approach.

Data Management

A standardized data form (slightly modified from IDFG data form) for all lek counts is used (see data form in Standard Operating Procedure 1: Lek Monitoring Guidelines) where observers indicate beginning and ending time of lek count, date, start time of each lek count, observers' full names, coordinates of the observation point, weather (estimated wind speed, percent cloudiness, temperature, precipitation), snow depth, and access conditions. When the observer returns to the office after a lek count, the data forms (i.e., raw data) must be reviewed by the park natural resource manager or the surveyor's supervisor within 24 hours to ensure that data were collected and recorded properly, and the handwriting is legible. All fields on the forms must be filled in, but zeros are only be used to indicate the number of birds observed; zeros are not be used to indicate a lek was not counted, nor should any field be left blank. A notation "not counted" is recorded if a lek that was supposed to be counted (i.e., along a lek route that was sampled) was not counted. Copies of the data must be shared with Idaho Department of Fish and Game and Bureau of Land Management. Raw counts at individual leks are recorded. It is not appropriate simply to report total males counted throughout the entire lek route or the maximum or average across the 4 visits.

Analysis and Reporting

Count data are recorded and summarized for individual leks as well as for lek routes, and each visit is saved as a separate count. From these raw data (counts at leks), analysts should report the following metrics annually (see SOP document for more detail):

1. Minimum number of males on the counted leks within area of inference ($\hat{\tau}(t)$): the highest of the 4 annual counts on each lek, summed across all leks)
2. SE of $\hat{\tau}(t)$
3. Total number of leks counted and total number of active leks
4. Maximum number of males observed at each lek among the 4 visits that year
5. Maximum number of males detected on each lek route (i.e., the highest count of male grouse detected on the lek route; the highest of the 4 visits)
6. The number of males detected per km² (#4 divided by the number of 1-km² grid cells that overlap the lek route)
7. λ_t (finite intrinsic rate of increase over the interval t to $t+1$)

$$\lambda_t = \frac{\sum_{i=1}^n M_i(t+1)}{\sum_{i=1}^n M_i(t)}, \text{ where } M_i(t) = \text{number of males counted at lek } i \text{ in year } t.$$

8. Variance of λ_t

$$Var(\lambda_t) = \frac{fpc}{n\bar{M}(t)^2} \frac{\sum_{i=1}^n [M_i(t+1) - \lambda(t)M_i(t)]^2}{n-1} \quad \text{where fpc is assumed to be 1.0.}$$

The maximum count among the 3-4 annual counts (#5 above) is often used as an index to the population in that local area. However, the maximum lek count from 4 spring visits to lek routes is a biased estimate of the number of males even if all leks along the route were counted (i.e., no leks were missed) because some males in the population that use a lek may be absent (or present but not detected) during the lek count (Johnson et al. 2007, Baumgardt 2011). Johnson et al. (2007) suggested that the Bounded-count (or jackknife) Estimator could be used as an alternative to the maximum count because it is relatively simple to compute (twice the largest count minus the second-largest count), it allows confidence limits to be calculated, and it effectively accounts for the males that are not detected during lek counts. However, some males will attend multiple leks (40% of male grouse in Wyoming made inter-lek movements at least once during the breeding season; Fremgen 2014) and neither the maximum count or the Bounded-count Estimator effectively deals with males that were counted at >1 lek.

If an area-based probabilistic sampling strategy is implemented and a suitable area-based stratification of CRMO and CIRO is identified, density (males per hectare) will also be estimated. Methods for estimating density will depend on the stratification adopted. The simplest approach to

stratification would be to separate CRMO and CIRO into 2 strata: 1) tiles that overlap existing lek routes, and 2) all other tiles throughout the park. A much more informative stratification would include habitat-based strata based on publicly available data layers based on habitat features that are proven to predict the probability that an area supports a sage-grouse lek (see description of a habitat-based stratification in Appendix II).

Personnel Requirements

Field observers must be willing and able to work early morning hours (often starting their day at 0400 hrs), be in good physical condition, and capable of walking at least 8 km in field conditions. Observers must have eyesight (corrected) capable of detecting grouse from at least 0.5 km away and must be able to hear the sounds of grouse displaying at a distance of at least 1.0 km.

Training

All personnel who will be assigned to lek counts or lek routes must be trained in proper counting techniques. Some state agencies, including IDFG, have implemented training modules. University of Idaho (UI) staff can provide lek count training to NPS personnel and IDFG/UI has a PowerPoint presentation intended to help train potential lek count surveyors that have not done prior lek counts. Training can be offered on-site and would take 1-2 hours of classroom time. An optional field exercise to actually count leks can also be included. Additionally, surveyors must be trained to properly use 4-wheel drive trucks, ATVs, and other necessary equipment (e.g., satellite phone, GPS, etc.). Surveyors must be sufficiently trained to identify grouse vocalizations so that previously undiscovered leks will be detected if present (but not visible) within 1 km of the lek route.

Operational Requirements

In January of each year, all lek count efforts will be coordinated with the appropriate IDFG regional office, the IDFG statewide sage-grouse survey coordinator, and the BLM field office to avoid duplication of efforts and possible interference during lek counts by having multiple observers counting the same leks on the same mornings. Because observers are often working in remote areas, 2-way radios, satellite phones or emergency beacons should be provided if the route is in an area without cell phone coverage. Additionally, fieldwork and travel routes should be supplied to an individual's immediate supervisor or other appropriate individual the day before the planned fieldwork. Access and travel within sagebrush steppe communities in Idaho can be difficult during March and April. Thus, in addition to a cell phone, satellite phone or emergency beacon, field vehicles should be equipped with tire chains, a tow rope or chain, shovel, and high-lift jack. If possible, an ATV should also be provided in case some roads are impassible to 4-wheel drive trucks or the truck gets stuck in mud or snow (where ATVs are allowed).

Annual workload and field schedule

At a minimum, fieldwork will require a single individual to expend ~4 hours per lek route (1.5 hours for the route plus driving time to/from the lek route) for 4 days per route from late March to late April every year. As an example, if CRMO staff conducts 3 lek routes per year, each route must be run 4 times or a total of twelve 4-5 hour field days. To sample all 7 of the current lek routes that intersect with CRMO and CIRO and their 5-km buffer, after incorporating the suggested lek route modifications (Figures 8-14 in Standard Operating Procedure 2: Preparation for the Field Season and Field Season Closeout; Table 4), will require 44 field days of 4-5 hours each (more if any lek routes are aborted due to weather or access). After fieldwork is completed, data analysis and report preparation and distribution should not take more than another 2 days. Monitoring effort is distributed over the March-April period as follows (Connelly et al. 2003):

- Count 1: March 20-30
- Count 2: April 1-10
- Count 3: April 11-20
- Count 4: April 21-30

Facility and equipment needs

No facilities per se are necessary because this effort largely consists of fieldwork. However, an office with computer will be necessary for data compilation and report preparation. Lek counts require the following equipment for each surveyor:

- 4-wheel drive truck equipped with chains, hi-lift jack, shovel, boards, and a tow rope (because surveyors may get stuck in mud or snow, especially during early lek count periods; boards or planks can be useful for extracting a truck stuck in mud)
- ATV (where allowed)
- binoculars

- GPS
- spotting scope
- wind speed anemometer
- thermometer
- cell phone (or 2-way radio or satellite phone if cell coverage in the area is poor)
- data forms or tablets

If an ATV is provided, care should be taken to ensure field personnel are trained in its proper use. Each crew member should have clothing appropriate for the weather conditions and good quality hiking boots.

Startup costs and budget considerations

Most, if not all, natural resource agencies have equipment needed for lek counts already on hand. Thus, startup costs are minimal. Accomplishing lek counts along lek routes outside of the NPS sites requires assistance from volunteers. Recruitment of volunteers and coordination of their activities is mostly accomplished through IDFG and working groups organized around sage grouse conservation efforts. Annual costs of conducting lek routes within and immediately adjacent to the NPS sites, managing that data, and summarizing and reporting on that data involve a few weeks of work from NPS staff (Table 5).

Table 5. Annual budget for monitoring sage grouse at CRMO and CIRO.

Monitoring budget	Time allotted	% of time spent on DM*	Cost in dollars DM*	Cost in dollars (2017)
Project Lead (GS-13)	1 week field season prep and logistics; 2 weeks QA/QC, data archiving, reporting, and close-out.	50%	\$3868	\$7735
CRMO Wildlife Biologist (GS-11)	1 week pre-season preparation review and logistics/consultation; 1 week fieldwork; 2 weeks QA/QC, data archiving, analysis and reporting, and closeout.	50%	\$3525	\$7050
UCBN Data Manager (GS-11)	2 weeks field season prep; 2 weeks QA/QC, data archiving, analysis and reporting, and closeout.	100%	\$7050	\$7050
Seasonal Volunteers	1 week field season prep; 2 weeks field survey.	30%	\$0	\$0
Operations/Equipment	—	—	—	\$250
Travel – CRMO vehicle	—	—	—	\$500
Other (contingency)	—	—	—	\$800
TOTAL	—	—	\$14,443	\$23,385

* DM = data management.

Partnerships

IDFG, NPS, BLM, and USFS have an interest in lek counts and IDFG is the lead agency for monitoring sage-grouse populations and maintaining the state lek count database. BLM manages lands within and adjacent to both CRMO and CIRO, and the USFS manages lands adjacent to CIRO. Thus, partnering with these agencies and especially IDFG is critical to the success of NPS sage-grouse monitoring. To date, no formal partnership agreements have been established between NPS and these agencies. Representatives from the agencies participate in working groups organized around sage grouse conservation efforts, and much of the work to complete annual lek counts along lek routes relies on volunteers and in-kind support from these agencies. As formal agreements become necessary to sustain the lek route effort, the NPS will coordinate with the appropriate agencies and organizations to meet partnership agreement requirements.

Protocol Testing and Revision

Following the first year of monitoring using this strategy, NPS staff, IDFG, University of Idaho scientists and other interested individuals should meet to review the data and discuss issues and concerns.

Glossary of Terms

Active lek—A term used by Idaho Department of Fish and Game to designate a lek that has been attended by >1 displaying male sage-grouse during a specific year or during the most recent year it was counted (but only if it was last counted during the last 5 breeding seasons). This can also be considered an “occupied lek”.

Activity Center—A group of displaying male grouse within a lek; small leks usually have only 1 activity center while larger leks (containing 25 or more males) may have multiple centers.

Breeding habitat—Habitat used by sage-grouse for breeding, nesting, or early brood rearing; generally occupied from early March to mid-June.

Breeding population—A group of sage-grouse associated with 1 or more occupied leks in the same geographic area separated from other leks by more than 20 km.

Brood route—A driving or walking route established to assess sage-grouse production by counting chicks or juveniles and hens along its length.

Chick—A sage-grouse up to 10 weeks of age.

Core sage-grouse habitat—The state of Idaho’s designation for habitat that represents strongholds for sage-grouse populations in Idaho and supports the largest populations. This zone represents the highest priority for conservation efforts and policies to address the primary threats to the species, such as wildfire.

Historical lek—An inactive lek that had no grouse present for 10 successive years (regardless of whether those years were consecutive years). If >1 male grouse is observed at an undetermined, unoccupied, or historical lek, it is immediately reclassified as an occupied lek.

Inactive lek—A term used by Idaho Department of Fish and Game to designate any lek where sufficient data suggests that there was no male attendance throughout the current breeding season or during the year referenced. Opposite of an active lek. If an inactive lek does not have grouse for 5 years, it can become an unoccupied lek and if it does not have grouse for 10 breeding seasons, it is considered a historical lek.

Juvenile—A sage-grouse that is more than 10 weeks of age but has not entered into its first breeding season.

Lambda—The annual finite rate of change in lek attendance comparing data from 2 consecutive years with lek counts.

Lek—An area where >1 male sage-grouse congregates during the breeding season to display and attempt to breed with females (ala Johnson and Rowland 2007). The area is normally located in a very open site in or adjacent to sagebrush-dominated habitats. Individuals attending a single lek

constitute a deme in genetic terms while multiple adjacent leks (amongst which females and young males move) together constitute a population.

Lek count—A tally of male sage-grouse on a lek.

Lek route—A driving route designed to allow an observer to detect (either visually or aurally) a group of leks that are relatively close together such that lek counts can be conducted on all of the leks along a route during the same morning.

Lek survey—A survey where observers classify leks as merely active or inactive (no counts of birds), often done from an aircraft.

New lek— A term used by Idaho Department of Fish and Game to designate an active lek that was first detected (or first reported) during the current year or 1 of the previous 2 years.

Not verified lek—A term used by Idaho Department of Fish and Game to designate a lek from a historical document that has been recently visited on the ground, but no birds were detected; the location is suspect and/or the birds that formerly attended the lek may have moved and created a new lek elsewhere.

Occupied lek—A term used by Idaho Department of Fish and Game to designate a lek that has been active during at least 1 breeding season within the prior 5 years (opposite of unoccupied lek, see below).

Persistent lek—An active lek that has had ≥ 5 males counted for at least 3 of the last 5 years or at least 15 males have been counted in the last 2 years and thus is likely to be detected during monitoring efforts (lek routes).

Sagebrush obligate species—A species dependent on sagebrush-dominated habitats for part or all of its life history requirements.

Satellite lek—An active lek (usually < 15 males) that develops < 1 km from a large lek during years with relatively high grouse populations and, hence, is active < 5 consecutive years.

Temporary display site – A site where male sage-grouse are observed that appears to be temporary within a year, likely representing displaced and/or transitory males. The temporary nature of these sites should be resolved within a single breeding season and they should not become part of the permanent lek database.

Umbrella species—A wildlife species whose habitat requirements are broad enough to include habitats for other wildlife species.

Undetermined lek—A term used by Idaho Department of Fish and Game to designate any lek that was once active but has not been counted or documented as active or has had insufficient information to determine its current status (neither active nor inactive) during the last 5 years. If an undetermined lek is sufficiently monitored, it will be reclassified as either active or inactive.

Unknown lek—A term used by Idaho Department of Fish and Game to designate a lek that was active in a prior year but was not counted during the most recent breeding season or for which its current status (as active or inactive) could not be determined. A lek visited 1 time during a breeding season via aircraft where 0 birds were observed would receive an unknown lek status. An unknown lek that is unknown for 5 years becomes an undetermined lek.

Unoccupied lek—A term used by Idaho Department of Fish and Game to designate a lek that has been counted but zero grouse were detected during a period of ≥ 5 consecutive years (opposite of occupied lek, see above).

Wing survey—A collection and classification of wings by age and sex. Wings are normally collected at hunter check stations, wing barrels, or through mail solicitation.

Yearling—A sage-grouse that has entered its first breeding season but not completed its second summer molt, normally between 10 and 17 months of age.

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Appendix I. Vegetation Types at Craters of the Moon National Monument and Preserve and City of Rocks National Reserve

Vegetation types were grouped into 4 general categories for this NPS protocol based on their relevance to sage-grouse nesting habitat (see Figures 2, 3 in the main protocol narrative).

Non-Upland Vegetative Communities and Land-Uses

- Agricultural business
- Orchards, groves, vineyards, nurseries, etc.
- Planted, cultivated lands
- Bare rock, sand, other bare-ground
- Quarries, strip mines, gravel pits
- Canal, ditch
- Lake, pond
- Reservoir
- Stream, river
- NPS facilities
- Residential
- Airstrip
- Transportation

Non-Sage-Grouse Habitat

- Doug Fir forest alliance
- Quaking aspen/mixed herbaceous forest complex
- Quaking aspen/mixed shrub forest complex
- Black cottonwood temporarily flooded woodland alliance
- Limber pine/antelope bitterbrush woodland
- Rocky Mountain juniper/Sandberg bluegrass/scabland penstemon woodland
- Aa lava/sparsely vegetated shrubland complex
- Curl-leaf mountain mahogany/bitterbrush/Sandberg bluegrass shrubland
- Pahoehoe lava/sparsely vegetated shrubland complex
- Speckled alder/mesic forbs shrubland
- Waterbirch intermittently flooded shrubland alliance
- Pahoehoe lava/sparsely vegetated herbaceous vegetation complex

- Limber pine-fernbush/Sandberg bluegrass/sparse vegetation
- Sparsely vegetated cinders
- Barren Aa lava
- Barren cinders
- Barren Pahoehoe lava

High Probability Sage-Grouse Nesting Habitat (Sagebrush-Dominated Vegetative Communities)

- Basin big sagebrush/cheatgrass semi-natural shrubland
- Basin big sagebrush shrubland alliance
- Low sagebrush shrubland alliance
- Mountain big sagebrush/cheatgrass semi-natural shrubland
- Mountain big sagebrush shrubland alliance
- Threetip sagebrush/cheatgrass shrubland complex
- Threetip sagebrush shrubland alliance
- Wyoming big sagebrush/cheatgrass (crested wheatgrass) shrubland complex
- Wyoming big sagebrush shrubland alliance

Low Probability Sage-Grouse Habitat (Shrub/Grass-Dominated Vegetative Communities)

- Quaking aspen/basin big sagebrush forest
- Limber pine/sagebrush woodland
- Bitterbrush shrubland alliance
- Chokecherry/basin wild rye shrubland
- Juniper/mixed shrub complex
- Rabbitbrush shrubland complex
- Spiny hopsage shrubland alliance
- Crested wheatgrass/cheatgrass semi-natural herbaceous vegetation
- Dried meadow mixed herbaceous vegetation mosaic
- Mixed weedy herbaceous vegetation complex
- Smooth brome/basin wild rye herbaceous vegetation

Appendix II. An Area-Based Probabilistic Sampling Effort to Estimate Actual Density of Male Sage-Grouse (Optional)

Implementation of this optional component of the monitoring protocol will depend on future funding/resources. An assessment of information gained from ≥ 1 years of implementing this component of the protocol will help greatly to improve the methods and determine the sampling intensity needed.

References in this appendix are included in the main Literature Cited section of this protocol.

Probabilistic, area-based sampling frame to estimate true abundance

Agencies have devoted considerable effort over the last 20 years to document sage-grouse leks within the sagebrush landscape in Idaho and most other western states (Connelly et al. 2004, Garton et al. 2011). These efforts have substantially improved knowledge of lek abundance and distribution. However, no one has implemented efforts to estimate the number of undocumented leks on the landscape or to apply a probability sampling approach to counting grouse. Because much, if not most, field research on sage-grouse breeding ecology results in discovery of previously unknown leks (J. W. Connelly, personal observation) it seems clear that a sizable number of undocumented leks exist within the sagebrush landscape. These leks could have recently developed as a result of increasing or shifting breeding populations or they may have existed for years but gone undetected because of their size (number of males), terrain features, or limited access. A formal sampling design and monitoring protocol that provides estimates of the total number of leks within a defined area and the number of birds per lek (and hence an estimate of true abundance) will allow inferences about lek distribution across a given landscape and allow for an unbiased estimate of male abundance and trend. The distribution of leks across the landscape can potentially change as a result of habitat change, natural disturbance, anthropogenic disturbance, changes in management, or changes in the sage-grouse breeding population. (e.g., increasing populations are often characterized by the development of satellite leks). Satellite leks are typically small leks (usually less than 15 males) that develop near (usually within 1 km) a large lek during years with relatively high grouse abundance but are transitory over a span of years. Therefore, an optimal monitoring strategy needs to account for changes in lek distribution on the landscape and to provide estimates of true abundance. Current lek route guidelines do not adequately account for changes in lek distribution. Garton et al. (2007) stated, “*Selection of a probability sample is required to assure validity of inferences made but few, if any, current lek counts for greater sage-grouse (*Centrocercus urophasianus*) were designed under a probability sampling approach.*” By adding some additional sampling, in addition to existing lek counts and lek routes, sage-grouse monitoring efforts would be more rigorous and meet requirements of probability sampling by incorporating monitoring efforts within a stratified probabilistic sampling frame (Garton et al. 2007). This optional component of the protocol described below would (if implemented) provide unbiased estimates of abundance, distribution, and trend for sage-grouse in CRMO and CIRO.

After overlaying maps of CRMO and CIRO with a layer of all known roads, delineate a grid of 1-km by 1-km spatial units throughout CRMO and CIRO (Figure 8). Then, identify the 1-km² tiles that: 1)

contain ≥ 1 persistent or new leks based on the IDFG statewide lek database (see Glossary for definitions of persistent lek, new lek, and other lek types); 2) contain no persistent or new lek, but contains ≥ 1 lek that is not a persistent or new lek; 3) contain no leks. Each of the 1-km² tiles that intersect a lek route will either include ≥ 1 observation point for a lek count or include a “listening point” within 1 km of its center where surveyors will stop and attempt to detect any other previously undiscovered leks occurring nearby along the route sampled (see methods in the main portion of this protocol regarding the establishment of these listening points along existing lek routes).

Data from the tiles that intersect with the 7 existing lek routes in CRMO will be used to generate a habitat-based continuous regression model (generated via IT model comparison) that predicts the number of males on all leks within each 1-km² tile. Then the model will be applied to the tiles that intersect the lek routes (the same tiles that ‘built’ the model) to obtain a model-based estimate of the number of males in each tile. Then the outcome from that application of the model (i.e., the validity of the model) will be used to estimate the number of males within all other tiles that intersect roads in CRMO (i.e., those not along the current 7 lek routes) and all the remaining tiles (those not along roads). The initial habitat model should be created using the best available spatial habitat data layers for the region (e.g., Colin Homer’s habitat layers; Homer et al. 2013, 2015), and new models should be generated as better habitat layers become available. Model estimates for the areas within CRMO and CIRO and their 5-km buffer zones that include tiles that do not intersect roads may be less accurate than for tiles that intersect roads, and so these areas should be surveyed (via aerial surveys) once every 5 years to document the number of males on leks within tiles in roadless areas. The initial aerial survey will provide data to evaluate whether the initial model performs satisfactorily for tiles in roadless areas and, if not, additional strata should be incorporated such that estimates are generated separately for tiles that intersect roads and those that do not. This is a stratified model-based approach with 1-km² tiles as the primary sampling unit where the model predicts the number of males in each tile (within each stratum) based on the habitat covariates in each tile (based on the covariates that the initial model identifies as most predictive). The model will be used to generate an estimate for each tile within CRMO and CIRO, then the estimates from all tiles can be summed to generate an estimate of the number of breeding males in the entire area of inference (i.e., within CRMO and CIRO).

An assumption of this model-based estimator is that the spatial units included in building the model include the full range of covariates throughout the area of inference to which the model is applied. The initial model may not meet that assumption because it will initially be generated based on data from tiles that intersect the existing 7 lek routes (i.e., all tiles used to generate the model will be close to roads and near known leks). After the first aerial survey, this assumption can be tested. If the initial habitat model proves to perform poorly in roadless areas (after the first aerial survey), 6 sampling strata should be included:

- Stratum 1. This stratum would consist of 1-km² spatial units that intersect a road and contain ≥ 1 persistent or new leks (identified from the IDFG statewide lek database); most of the units in stratum 1 will be along existing lek routes. This stratum would also include isolated persistent and new leks (those along roads but not on existing lek routes). Sampling units within stratum 1

should be sampled annually or as frequently as possible if resources do not allow annual sampling.

- Stratum 2. This stratum would consist of 1-km² spatial units that contain ≥ 1 persistent or new leks (identified from the IDFG statewide lek database) but do not intersect a road. These spatial units will be sampled by aircraft (e.g., helicopter transects or Aerial Infrared transects) every 5 years but may require replication within a sampled year for comparison to ground counts. Timing of aerial surveys would ideally correspond to the same 2-week window producing maximal counts from ground-based counts. These aerial surveys will also provide double sampling of Stratum 1 tiles (i.e., the aerial transects would sample tiles that belong to each strata (1-6).
- Stratum 3. This stratum would be composed of 1-km² spatial units that intersect a road and that include ≥ 1 leks that are not 'new' or 'persistent' (leks often characterized as unknown or unoccupied in the IDFG statewide lek database). All segments within this stratum that occur along existing lek routes would be sampled annually. A random subset of segments within this stratum (i.e., sage-grouse sampling strata) that do not occur along existing lek routes would be sampled every 2-3 years.
- Stratum 4. This stratum would be comprised of 1-km² spatial units that do not intersect a road and that include ≥ 1 lek that are not 'new' or 'persistent' (leks often characterized as unknown or unoccupied in the IDFG statewide lek database). Tiles within this stratum would be sampled every 5 years during aerial surveys.
- Stratum 5. This stratum would be comprised of 1-km² spatial units that intersect a road and do not contain any currently active leks or past evidence of historical leks. A subset of tiles within this stratum (those that occur along existing lek routes; see Stratum 1) would be sampled annually. Additionally, a random subset of segments within this stratum that do not occur along existing lek routes but occur along stratum 3 sample clusters would be sampled every 2-3 years. The random subsets (i.e., sage-grouse sampling strata) would be part of the 2-3 year sampling for strata 2 (see Stratum 3 above).
- Stratum 6. This stratum would be comprised of 1-km² spatial units that do not intersect a road and do not contain any currently active leks or past evidence of historical leks. Tiles within this stratum would be sampled every 5 years during aerial surveys.

Within this framework, Stratum 1 should be sampled annually. If resources are inadequate or the number of lek routes or individual leks within this stratum becomes too large to handle with existing resources, then random sampling of Stratum 1 tiles that do not intersect a lek route will be necessary. To allow meaningful calculation of finite rate of change (Garton et al. 2011), randomly selected lek routes and/or individual leks should be counted for 2 consecutive years. This allows for estimates of the annual rate of change for the area of inference. A theoretical example is provided in Table 6.

Table 6. Sampling components of sage-grouse monitoring protocol on CRMO and CIRO, including optional components. If insufficient resources are available in any given year, determine how many routes can be sampled that year and randomly select among the 7 routes but make sure that lek routes are counted in blocks of at least 2 consecutive years. For example, assume 7 lek routes exist but resources are only available to conduct counts along 2 routes in a particular year. The 2 lek routes are randomly selected for sampling and those same 2 routes (at a minimum) are sampled the following year if insufficient resources once again preclude sampling all 7 routes the following year.

Sampling stratum	Type of sampling	Sampling frequency	Comments
1	Lek routes (with revisions such that all lek routes have ≤ 10 occupied leks and length ≤ 20 km)	Annual	These routes include a combination of occupied leks, unoccupied leks, and historical or undetermined leks
2	Occupied leks not on lek routes	At least 2 consecutive years every 5 years	—
3	Unoccupied leks not on lek routes	At least once every 5 years	If grouse are detected at 1 of these leks, they immediately become an occupied lek
4	Undetermined leks not on lek routes	Every year for 5 years	Initially sampled annually until all of them can be classified as either occupied or unoccupied, and then sampled as per frequency above for those categories
5	Historical leks not on lek routes	At least once every 10 years	—
6	Aerial surveys to sample 1-km ² polygons throughout CRMO and CIRO	Every fifth year, or more frequently if resources allow	Aerial transects will fly down center of rows of 1-km ² polygons and will include surveys of polygons with and without known leks

Similarly, randomly selected routes (linear clusters of spatial units along roads) within strata 3 and 5 should be counted for 2 consecutive years. Once a few years of counts under this stratified sampling strategy are obtained and estimates of mean and variance are available for each stratum and estimates of person-hours are available, analysts can apply an optimal Neyman allocation (Scheaffer et al. 2012) of effort amongst strata and sampling methods to obtain the most accurate and precise estimates of sage-grouse trends and annual rates of change for the least cost possible. Likewise, these initial estimates will make it feasible to estimate the power of detecting declines of different magnitudes in sage-grouse population abundance, carrying capacity of the area, and long-term probability of persistence (Garton et al. 2011).

Ideally, the sampling design in future years should apply optimal sample allocation amongst the 6 strata identified above within constraints of available resources and the primary goals of estimating sage-grouse trends, annual rates of change, and long-term probability of persistence. All 1-km² spatial units are embedded within a stratified sample framework of actual and potential sage-grouse

breeding habitat. The number of tiles within strata 1, 3, and 5 that are sampled each year would depend on available resources and after 5 years of data collection under this protocol, a formal power analysis should be conducted to determine the number of tiles that should be sampled annually in these strata to achieve desired statistical power. To allow meaningful calculation of finite rate of change, sampled tiles within strata 3 and 5 that are not along existing lek routes should be randomly selected and should be counted for 2 consecutive years. For efficiency, tiles in strata 3 and 5 would be randomly selected as part of clusters of tiles along routes (clusters of spatial units that intersect a stretch of road and are surveyed as a group during the same morning survey window).

After 2-3 years of data collection, a group of biologists (e.g., University, NPS, IDFG, and BLM biologists) would evaluate whether the initial habitat model is effective. This approach would allow the NPS protocol to include only as much complexity as is warranted.

Aerial surveys

Helicopters or fixed-wing airplanes (Connelly et al. 2003) will be used once every 5 years to survey a subset of 1-km² tiles in roadless areas of CRMO and CIRO. Using either type of aircraft, observers should fly parallel north - south transects >1 km apart and 100-150 meters above ground level. Two observers should be used in addition to the pilot so that 1 observer is always looking away from the sun regardless of the direction the aircraft is flying. Careful attention should be paid to old lakebeds, stock-watering areas, and other relatively open sites surrounded by 15 to 25% sagebrush canopy cover. Aerial surveys should be conducted from 0.5 hour before to 1.0 hours after sunrise. A cryogenically cooled mid-wave infrared camera mounted onto an aerial platform on an airplane may be an alternative technique to conventional ground-based methods or traditional aerial surveys for detecting sage-grouse leks (Gillette et al. 2013, 2015). The contrast between sage-grouse infrared signatures and a background of vegetation and abiotic material was adequate for distinguishing and counting sage-grouse on or near leks (Gillette et al. 2013), but more research is needed before this approach can be used in a repeatable standardized monitoring effort. If this approach proves to be reliable it should eliminate the need for observers other than the pilot and reduce overall personnel needs for sage-grouse monitoring.

Aerial surveys will sample 1-km² tiles in all 6 strata to provide estimates of lek detection probability associated with aerial surveys (via proportion of known leks detected during aerial surveys) and estimates of lek detection probability associated with ground-based roadside counts (via double sampling along lek routes). Flight lines or sample polygons delineated to maximize logistical efficiency within the management constraints of the various ownerships might sample portions of NPS, BLM and State of Idaho lands while attempting to locate and count any active leks within 1-km wide transects. Newly discovered leks detected during aerial surveys should be verified by ground-based lek counts (using the methods outlined in this protocol) to better document the size (number of males) and location of the lek.

To the best of our knowledge, this optional portion of the protocol for long-term monitoring of sage-grouse described in this appendix is the first attempt to move sage-grouse monitoring out of the arena of convenience sampling and into the realm of probability sampling.

Appendix III. Lek Counts for Leks That Are Not on Existing Lek Routes (Optional)

In years when NPS has resources to conduct additional sampling, this appendix provides guidance on how to sample leks on the park units that are not currently sampled at all (i.e., leks that are not on existing lek routes).

1. For the occupied leks within the area of inference that are not on existing lek routes (currently 48 leks in CRMO area of inference), conduct lek counts at each of these leks at least 2 consecutive years every 5 years.
2. For the unoccupied leks within the area of inference that are not on existing lek routes (currently 2 leks), conduct lek counts at these leks at least once every 5 years (if grouse are detected, they become occupied and their monitoring schedule should be modified as such).
3. For the undetermined leks within the area of inference that are not on existing lek routes (currently 121 leks) conduct lek counts at each of these leks annually for the next 5 years or until each can be correctly classified as occupied or unoccupied (and then monitored accordingly as per the instructions above). If resources are insufficient to conduct lek counts at all the undetermined of these leks annually, randomly select a subset of them (based on how many that the available resources allow for) and conduct lek counts at them annually for the next 5 years.
4. Persistent leks in CRMO that are not currently on an existing lek route should be included in a new lek route if feasible (i.e., a new route should be established that incorporates the persistent lek if there are enough leks within 20 km that can be effectively counted during a single morning). If a persistent lek is isolated from other leks, the lek can be counted annually as a single lek or a new lek route can be established such that the persistent lek is in the geographic center of the route with ~10km of road in either direction of the lek. Each persistent lek within CRMO and CIRO (and thus the lek routes associated with each persistent lek) should ideally be counted annually.

Appendix IV. IDFG Status Designations and Definitions for Sage-Grouse Leks

Annual status—Lek status is assessed annually based on the following definitions:

- **Active**—A previously identified lek that has been attended by >1 displaying male sage-grouse or sharp-tailed grouse during the current breeding season. Acceptable documentation of grouse presence includes observation of birds using the site or recent signs of lek attendance (e.g. fresh droppings, feathers).
- **Inactive**—Any lek where sufficient data suggests that there was no male attendance throughout the current breeding season. Absence of male grouse during a single visit is insufficient documentation to establish that a lek is inactive. This designation requires documentation of either: 1) an absence of birds on the lek during at least 2 ground surveys separated by at least 7 days. These surveys must be conducted under acceptable weather conditions (clear to partly cloudy and winds <10 kph) and in the absence of obvious disturbance or, 2) a ground check of the exact known lek site late in the strutting season that fails to find any sign (fresh droppings/feathers) of attendance.
- **Unknown**—Leks that were not surveyed this breeding season or for which status as active or inactive could not be determined. Leks surveyed 1 time by air with 0 birds observed will received an unknown status.
- **New**—An observation of >1 displaying male in a new location. The new location should be thoroughly examined to assure that the observation is not one of a lek that has moved. Typically, new leks should be at least 0.5–1 km from other lek locations and/or separated topographically.

Management status—Based on its annual status, a lek is assigned to one of the following categories for management purposes:

- **Occupied**—A lek that has been active during at least 1 breeding season within the prior 5 years.
- **Unoccupied**—An unoccupied lek is one that has not been active during a period of 5 consecutive years. To be designated unoccupied, a lek must be “inactive” (see above criteria) in 5 consecutive breeding seasons. A lek may also be unoccupied if it has been surveyed in 7 of the last 10 years and no birds have been observed in any year. The site of an unoccupied lek should be re-visited at least once every 7-10 years to determine whether it has been reoccupied by grouse.
- **Undetermined**—Any lek that has not been surveyed or documented as active in the last 5 years, or has had insufficient survey information to designate the lek as unoccupied.
- **New**—A newly discovered lek. A “new” status is assigned to a location of >1 displaying male as defined above. Because grouse may temporarily display in a random location, the status of “new” leks must be determined within the following 4 years. If >1 displaying males are observed at the location in at least 1 of the following 4 years, the leks status converts to “occupied.” If the location is surveyed in at least 2 of the next 4 years, and 0 birds are observed, it is determined that the observation was not a true lek and the “new” lek is deleted from the current database. If the “new” lek is not surveyed in the next 4 years, the status reverts to “undetermined.”

- **Not verified**—A lek location from an historical document that has been recently visited on the ground, but no birds were detected; the location is suspect and/or the lek may have moved. Please note that IDFG removes these leks as ground conditions indicate the location is an error or that the original lek has likely been found in the general vicinity. 87 NOT VERIFIED SAGE-GROUSE LEKS AND 8 SHARP-TAILED GROUSE LEKS HAVE BEEN REMOVED FROM THE 2015 LEK DATABASES. Historic documentation of these leks remains on file with IDFG.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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