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# Forest Grouse Ecology and Management in the Bear River Range Northern Utah

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# FOREST GROUSE ECOLOGY AND MANAGEMENT IN THE BEAR RIVER RANGE NORTHERN UTAH

by

Skyler Y. Farnsworth

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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# ABSTRACT

Forest Grouse Ecology and Management in the Bear River Range Northern Utah

by

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Utah State University, 2020

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To better manage dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*), hereafter forest grouse, managers require better information on forest grouse population status and habitat selection. To address this need, from 2015-2017, I conducted research on a sympatric populations inhabiting the Bear River Range of northern Utah to develop a breeding survey protocol, assess habitat selection, evaluate dusky grouse response to livestock grazing, and determine hunter harvest rates.

The breeding census protocol that I developed compared listening intervals with and without electronic playback calls at designated survey locations. I plotted the location of male forest grouse based on estimated locations for each detected individual using digital mapping software. I then evaluated grouse detections as a function of date, minutes post-sunrise, and electronic playback call response using generalized additive models, and to identify and classify habitat selection. Walking breeding surveys were an effective tool for monitoring forest grouse population trends. Information from resource selection analyses will help provide a baseline for evaluating forest grouse breeding

habitat in the Intermountain West and developing monitoring sites in other areas.

I assessed habitat selection for brood-rearing dusky grouse and the relationship between dusky grouse and seasonal livestock grazing. Dusky broods had a weak negative selection for areas with higher livestock distribution; however, the forests edges and mountain shrub communities that dusky grouse broods selected were not proximate to observed livestock distributions. My results suggest that dusky grouse brooding activities were compatible with livestock grazing in areas where mosaics of multiple overstory habitat types and open grassland areas area available. However, more research is needed in other areas that further assesses the relationship between dusky grouse habitats needs and livestock grazing.

I estimate population trends and hunter harvest based on data from wings of harvest birds obtained at wing barrels. I also captured and leg-banded forest grouse prior to the hunting seasons. Wing collection data proved useful in estimating population dynamics. Low leg-band returns suggested hunter harvest was limited and had minimal impacts on the forest grouse populations in the Bear River Range.

(149 pages)

# PUBLIC ABSTRACT


Forest Grouse Ecology and Management in the Bear River Range Northern Utah

Skyler Farnsworth

To better manage dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*), hereafter forest grouse, managers require better information on forest grouse population status and habitat selection. To address this need, from 2015-2017, I conducted research on a sympatric populations inhabiting the Bear River Range of northern Utah to develop a breeding survey protocol, assess habitat selection, evaluate dusky grouse response to livestock grazing, and determine hunter harvest rates.

The breeding census protocol that I developed compared listening intervals with and without electronic playback calls at designated survey stop locations. Using digital mapping software, I plotted the estimated location of male forest grouse based on where I heard males calling. I then evaluated grouse detections by using the date of detection, how many minutes post-sunrise calls were heard, and if grouse responded to electronic playback calls. I used the data to identify and classify habitat selection of each grouse. Walking breeding surveys were an effective tool for monitoring forest grouse population trends. Information from analyses will help provide a baseline for evaluating forest grouse breeding habitat in the Intermountain West and developing monitoring sites in other areas.

I intended to assess habitat selection for brood-rearing dusky grouse and the relationship between dusky grouse and seasonal livestock grazing. I found dusky grouse broods preferred to be near the forest edges or near mountain shrubs, whereas livestock

were in areas that were more open. My results suggest that dusky grouse brooding activities can be compatible with livestock grazing where foliage and trees create multiple layers of forest canopy. My findings highlighted the need for continued research to assess livestock grazing impacts on dusky grouse.

I used wing-collection barrels to estimate population trends and hunter harvest based on data from collected wings regarding species, age, and sex. I also captured and leg banded forest grouse prior to the hunting seasons. Wing collection data proved useful in estimating population dynamics. Low leg band returns suggested hunter harvest was limited within my study area. This level of harvest likely had minimal impacts on the forest grouse populations in the Bear River Range.

# DEDICATION

I dedicate this thesis to my father C. Brent Farnsworth. As a kid, my father wanted to be a wildlife biologist and eventually acquired a job as a conservation officer for Utah Division of Wildlife Resources where he worked for 35 years. Dad instilled a passion for the outdoors and a love of wildlife to all his children, as well as hundreds of other youth through hunter education courses, boy scouts, church, and school programs. My dad provided the foundation to my pursuit of becoming a wildlife biologist. I will do my best to share the same passion for wildlife with others that you instilled in me.

Skyler Y. Farnsworth

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To say that the success of the forest grouse project was due to the efforts of one person would be inaccurate. The research behind the resulting document was a collaborative effort from many dedicated individuals and parties. I would like to start by thanking my major advisor Dr. David Dahlgren. Dave's passion for grouse is unparalleled and infectious. As the catalyst for the forest grouse project, he successfully brought this project to fruition. During the recruiting process, Dave saw potential in me and I will always be grateful for the chance that he took to put me on the project. I want to thank him for the support he gave me through the graduate school process and helping the project run smoothly from the management end. Dave also spent many hours helping collect data with breeding surveys, capturing grouse, and checking trap sets. I am grateful that he trusted me with his prized German shorthaired pointers for locating grouse. Thanks Dave, I will always have a bird dog obsession because of you.

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Although Dr. Dwayne Elmore at Oklahoma State University was not on my committee, he spent time in the field, donated resources to the project, and allowed us to

use his equipment. Dr. Elmore's insight was invaluable to the project. I would also like to thank Dr. Michel Kohl, post-doctoral fellow and Utah Sage-Grouse Habitat Assessment Framework Coordinator, for the many hours he spent helping me with my analyses. Michel was patient with me as I pestered him daily, even amidst his own challenges.

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I acknowledge the many technicians that worked for me on the forest grouse project: Rhia Bottemer, Kyle Hawk, Stephen Lytle, Justin Brimhall, Kade Lazenby, Zach Slick, Kyle Forsyth, Skyler Arent, Sophie Thelen, Hailey Wayment, and Chuck Carpenter. Thank you for your hard work and dedication. This project was physically taxing, yet my technicians rose to the challenge and were the wheels that made the project run.

I also acknowledge all those that volunteered on my project. Volunteers helped conduct breeding surveys, capture grouse, and allowed us to use their good bird dogs for grouse locating. I am grateful for the contribution of grouse hunters that utilized our

wing-collection barrels, which allowed us to collect harvest data.

I would like to thank those from the Utah Agricultural Experiment Station (UAES), US Forest Service (USFS), the Utah Division of Wildlife Resources (UDWR), Wyoming Game and Fish Department (WGFD), Pheasants Forever, and the Utah Chukar and Wildlife Foundation for making the Utah forest grouse project possible. Funding was provided from UDWR Pittman-Roberston funds and from the UAES seed grant program. Jennefer Parker and Anthony VonNiederhausern from the USFS allowed me crucial springtime access onto the forest when gates were closed to the public. Jason Robinson and Avery Cook with UDWR provided invaluable support and insight that were important to the success of the project. Adam Brewerton with UDWR allowed us to use his equipment. The UDWR and WGFD lent us trapping materials. The Cache Valley and Salt Lake City Chapters of Pheasants Forever and the Utah Chukar and Wildlife Foundation, and Ron and Aleen Kienholz provided valuable support to the forest grouse project.

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Other individuals deserve acknowledgement for their assistance with this thesis.

Although, I cannot name you all, know that I am aware of who you are. I am grateful for the love and support that I have received from so many.

Skyler Y. Farnsworth

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# CHAPTER 1

# INTRODUCTION AND LITERATURE REVIEW

## CLASSIFICATION

Blue grouse (*Dendragapus* spp.) were first classified by Say in 1823 as *Tetrao obscurus* (Johnsgard 1983). Scientific nomenclature changed many times after 1823 but *obscurus*, Latin for the color dusky, remained. As the name implies, blue grouse are blue or dusky in color. Blue grouse inhabit the forested montane systems of western North America from the Yukon Territory and Alaska in the north to the Arizona-New Mexico border, and west to east from California to Colorado (Aldrich 1963).

Blue grouse originated from a common ancestor with prairie chickens (*Tympanachus* spp.) and sage-grouse (*Centrocercus* spp.; Persons et al. 2016). Blue grouse were split into eight subspecies (Aldrich 1983); however, Barrowclough et al. (2004) determined the blue grouse complex should be recognized as two distinct species, sooty and dusky, after comparing mtDNA sequences of each major subspecies. Sooty grouse (*D. fuliginosus*) are found in coastal contiguous forests of western North America (Bendell and Elliott 1966), whereas, dusky grouse (*D. obscurus*) are found in montane forests of interior western North America.

Dusky and sooty grouse have several distinguishing morphological differences and were thought of as two distinct species as early as the 1920s (Brooks 1929). Sooty grouse tend to have darker plumage than dusky grouse. Sooty grouse typically only have 18 tail feathers while dusky grouse have 20 tail feathers. Sooty grouse tails also have a gray subterminal band whereas the dusky grouse subterminal band is less pronounced

underneath the dull black (Schroeder 2006). Dusky grouse primary wing feathers are longer than that of sooty grouse (Zwickel and Bendell 2004). Furthermore, sooty grouse males have a yellow air sac and dusky grouse males have a red air sac used for breeding displays to attract females.

Barrowclough et al. (2004) found that among populations of dusky grouse, estimates of gene flow were heterogeneous, reflecting large-scale population distribution fragmentation. For example, this genetic variability in dusky grouse is indicative of the species' distribution in isolated "sky islands" of the Great Basin. However, much of dusky grouse distribution in the Rocky Mountains is relatively connected north to south (Johnson 1975).

Past studies on blue grouse focused primarily on sooty grouse, particularly, isolated subpopulations on Vancouver Island, British Columbia (Bendell 1955, Lance 1967, Redfield 1973, Zwickel 1975, Falls and McNicholl 1979). Even though dusky grouse have a greater spatial distribution than sooty grouse, only about one third (99 out of 262) of all current blue grouse publications are focused on dusky grouse (Fig. 1-1). Most blue grouse research took place during the 1970s and 1980s and has dropped off in recent years. Therefore, currently there is a paucity of dusky grouse basic life history information.

## DUSKY GROUSE LIFE HISTORY

### Distribution

Dusky grouse are found in the following states or provinces: New Mexico, Arizona, Colorado, Utah, Nevada, Wyoming, Montana, Eastern Oregon and Washington,

British Colombia, Alberta, and Yukon and Northwest Territories. Like most other grouse species, dusky grouse are sexually dimorphic. Males weigh as much as 1.3 kg and females 0.9 kg and there are marked plumage differences between the sexes (Bendell 1955). Dusky grouse diet is largely composed of vegetative material, though arthropods are an important source of food during the summer for all age classes, but especially for growing chicks (Beer 1943, Barnes 1974).

**Breeding Ecology**

During the spring, male and female dusky grouse move to breeding grounds, often at lower elevations, where males display to attract females. Blue grouse are not considered a lekking species, however, it is unclear if males loosely congregate or establish display grounds individually (Lewis 1985). Dusky grouse are polygynous. Males perform nuptial displays to attract females by expressing an audible hoot through the inflation of colorful air sacs on each side of their neck, enlarging colorful eye combs, posturing with a fanned tail, and behaving aggressively towards other males (Blackford 1958).

Breeding males stay on their territories and call or hoot from April through June. Sooty grouse males emit a strong multiple-syllable hoot, which can be heard for hundreds of meters. Dusky grouse have a quieter multiple-syllable hoot, which is not audible from more than 50 m away (Barnes 1974). However, dusky grouse males produce a single-syllable hoot that is much louder and can also be heard from hundreds of meters away (Zwickel 1972). Both males and females also call clapping their wings together, which can be heard from larger distances (Wing 1946, Blackford 1963).

Dusky grouse migrate into lower elevations during the breeding season and males defend territories as large as 0.8 ha (Martinka 1972). Martinka (1972) observed breeding territories consisted of approximately 3000 trees per ha. Within breeding territories, males used younger tree thickets with an average tree diameter of 12.4 cm. Dusky grouse do not favor a specific tree species, however thickets of coniferous trees dominated the breeding territories in the Martinka (1972) study. Edge habitat may be important for dusky grouse breeding as the male territories in the Martinka (1972) study had a mean of 206 m of edge habitat per territory. Maestro (1971) and Stauffer and Peterson (1986) indicated that maple (*Acer* spp.) stand structure may also be important for dusky grouse breeding.

**Nesting Ecology**

Like other grouse, dusky grouse are ground nesters (Caswell 1954, Barnes 1974, Pekins 1988) and lay approximately 7 eggs per clutch during a first nest attempt. Males do not contribute to parental care. Little is known about dusky grouse nesting ecology, however, it is likely that dusky grouse life history characteristics are similar to sooty grouse. Sooty grouse females can renest following an unsuccessful first nesting attempt, with adults re-nesting more frequently than yearlings. Females lay smaller clutches with each successive nest attempt (Zwickel and Lance 1965, Sopuck and Zwickel 1983). Incubation time for both sooty and dusky grouse is 26 days (McKinnon and Zwickel 1988, Pekins 1988). Sooty, and presumably dusky, grouse lay one egg every 1.5 days during the nest initiation period (Caswell 1954, Standing 1960). Nesting sooty grouse were discovered to have territorial spacing among nesting females, with adult females

showing more aggressive behavior towards subordinate females (Bergerud and Butler 1985). However, Bergerud conducted his research in areas with limited nesting habitat space and this may not be a characteristic of blue grouse nesting ecology in general.

Sooty grouse (Zwickel 1975) and dusky grouse (Pelren and Crawford 1999) nesting ecology have been studied, but little has been done to document dusky and sooty grouse habitat use. Nest site selection varies greatly among blue grouse. Blue grouse nests have been found in areas with little cover such as on recent burns, or complete cover by logs, stumps, vegetation, and overhanging rocks (Zwickel and Bendell 2004). Barnes (1974) and Weber (1972) found all dusky grouse nests on their Utah study site under sagebrush (*Artemisia* spp.), although they also found it easier to search for nests in sagebrush areas which may have biased results.

**Brooding Ecology**

Dusky grouse chicks are precocial and after hatch, spend time foraging in open areas with bunchgrasses and broadleaf forbs. They will stay with the female for thermoregulation and protection until 13 weeks of age. Chicks grow their first flight feathers by the end of week one and can make short flights (Zwickel and Lance 1966, Redfield and Zwickel 1976). Females with young stay in breeding habitat longer than males and females without young.

Brooding habitat of dusky grouse has not been studied thoroughly. Mussehl (1963) reported herbaceous cover of grasses and forbs as important brooding habitat in western Montana. The basic physical requirements for brood cover included high grass and shrub canopy coverage, adequate plant height, an interspersion of varied plants and

life forms, and minimal bare ground. Barnes (1974) observed dusky grouse broods in Utah spending much of their time in open areas with an abundance of forbs, grasses, and bugs. Dusky grouse broods often inhabit pastures in conjunction with grazing livestock during the summer (Mussehl 1963, Zwickel 1972, Barnes, 1974).

**Winter Ecology**

Dusky grouse migrate to higher elevations in the winter, which is termed reverse migration (Cade and Hoffman 1993). They have been known to move large distances between summer range and winter range. Dusky grouse become social during the winter and will often flock together in larger groups (Cade 1985, Pelren 1996). Cade and Hoffman (1990) observed dusky grouse wintering in high elevation conifer stands on steep upper slopes and ridgetops. Males and females used the same winter habitats.

Douglas-fir (*Pseudotsuga menziessi*) trees have been shown to be particularly important in winter as sources of food and shelter for dusky grouse (Remington and Hoffman 1996). Their specialized digestive systems allow them to consume a diet of almost entirely conifer needles in winter (Bryant and Kuropat 1980). Large conifers may also offer thermo-regulatory benefits for grouse (Pekins 1988, Pekins et al. 1991).

Dusky grouse have been documented submerging themselves in snow roosts, similar to ruffed grouse (*Bonasa umbellus*) and sage-grouse, but this is not considered a predominant behavior (Pekins 1988). Dusky grouse have high winter site fidelity and are prone to stay in small confined areas preferentially selecting specific trees (Cade 1985). Winter habitat is often thought of in terms of food selection, but other factors like microclimate and predator avoidance may also be contributing factors.

## RUFFLED GROUSE

Ruffed grouse are also a forest dwelling grouse with a range associated with the distribution of aspen (*Populous* spp.; Huempfner and Tester 1988, Jakubas and Gullion 1991, Hewitt and Messmer 2000). Ruffed grouse have the largest range of any of the North America grouse species ranging from the East Coast to Alaska. There is a general lack of knowledge of ruffed grouse in the western part of its range. Ruffed grouse are managed and hunted as an individual species in the Eastern U.S., however in the western U.S. they are commonly harvested in aggregated with other forest grouse species for bag and possession limits, as is the case in Utah (Bernales et al. 2016).

Stauffer and Peterson (1985b) found ruffed grouse in aspen stands exclusively in winter in the Bear River Range, Idaho. Ruffed grouse used mixed conifer, open conifer, maple stands, and mountain mahogany (*Cercocarpus ledifolius*), along with aspen during the other three seasons (Stauffer 1985a). In Utah, aspen buds are an essential component of the wintering ruffed grouse diet, although, more than 20% of their winter diet is comprised of buds from other deciduous trees (Hewitt and Messmer 2000).

## CONSERVATION AND MANAGEMENT OF DUSKY GROUSE

### Livestock Grazing

One of my study questions was to explicitly assess the relationship between livestock and dusky grouse using quantitative grazing measurements and known grouse locations. The U.S. Forest Service (USFS) administers 78.1 million ha of land in the United States. Roughly 3.3 million ha (15%) of Utah are owned and managed by the USFS (Congressional Research Service 2017). The habitat is managed for multiple-use

by the USFS and these lands are generally grazed seasonally by livestock on a permit basis. In Utah, most suitable forest grouse habitat has seasonal livestock disturbance. Though, no research studies have explicitly tested the impacts of livestock grazing on dusky grouse populations, a few past studies have used correlative relationships and logic to implicate livestock grazing as having a negative effect (Mussehl 1963, Zwickel 1972, Weber 1975, Stauffer and Peterson 1985a).

Prior research has postulated that as any livestock graze they reduce the height and cover of grasses and forbs and therefore, have a negative effect on dusky grouse habitat. Mean heights of grasses and forbs at brood locations were assessed in Montana on two study sites, one grazed and one ungrazed, and compared against each other (Mussehl 1963). As expected the grazed study site had low mean vegetation heights so Mussehl postulated that grazing had a negative effect on dusky grouse habitat, however he did not consider food or microclimate as possible functions of the brood locations. Zwickel (1972) also conducted a study between a grazed and ungrazed pasture of similar proportions and recorded dusky grouse observations within both pastures. He found more post-hatch hooting males on the ungrazed study site, but detected no difference in the number of broods. Grazing may impact breeding behaviors but brooding is unaffected. Other studies did not assess any livestock relationships, rather made anecdotal observations that livestock had a negative effect on dusky grouse habitat because of the reduction of ground cover (Marshall 1946, Weber 1975, Stauffer and Peterson 1985a).

**Habitat Selection and Management**

The USFS Region 4 desires to achieve sustainable management of forest

resources within its jurisdiction (USFS 2018). Within Region 4, the Uinta-Wasatch-Cache National Forest has established management objectives for specific areas including wildlife, habitat, logging, and fire. The regional plan has not established specific goals for dusky grouse habitat management.

The USFS plans focus on managing for increased biodiversity to meet the demands of various wildlife populations (USFS 2003). Specific goals include allowing natural disturbances to occur by restoring composition, diversity, and patch sizes for all vegetation types and by maintaining multiple age classes of vegetation to provide the ground cover necessary for healthy watersheds. These goals are carried out by promoting sustainable and renewable timber harvest and allowing fire to play a more active role where it has previously been suppressed.

Aspen have suffered large decreases in distribution since European settlement (Bartos 2001). Humans have suppressed natural fire and altered historic fire regimes. Successional stages have been altered and climax communities of shade-tolerant conifers, like subalpine fir (*Abies lasiocarpa*), have encroached in areas with shade-intolerant aspen. Although the Uinta-Wasatch-Cache National Forest does not have specific goals for management of dusky grouse, they do have objectives to stimulate aspen regeneration in areas near encroaching conifer species and to increase grass and forb production through treating specific new areas every year.

**Harvest Management**

The two main principles of the North American Model for Wildlife Conservation are that wildlife belongs to everyone and wildlife needs to be managed in a way that their

populations are sustainable. The Wildlife Restoration Tax Act has generated 6.8 billion dollars on guns and ammunition sales since 2002, which are allocated back to the states for wildlife conservation (USFWS 2018). Utah has received over 71 million of those dollars for wildlife conservation purposes (USFWS 2018). Hunting is a prominent form of recreation in Utah. Many species of upland game are pursued including forest grouse. Forest grouse are easily accessible on public land resulting in stable hunting interest over the last 50 years (Bernales et al. 2016).

Currently, dusky and ruffed grouse are managed together as forest grouse in terms of harvest. Dusky grouse and ruffed grouse have two distinct life histories. Ruffed grouse have more offspring and a relatively low survival. Dusky grouse, however, have fewer offspring and higher survival. There is little information regarding harvest management of forest grouse in Utah. With both bird species, biologists tasked with managing grouse populations are unsure of the stability of the populations and whether they are decreasing, maintaining, or increasing. The effect of hunter harvest on forest grouse populations is also unknown. The most recent change in forest grouse management came in 2011 when UDWR extended the forest grouse season from September 11 to September 1.

**Population Monitoring**

Aldo Leopold said, “Continuous census is the yardstick for success or failure in conservation (Leopold 1933:169).” Monitoring wildlife populations plays a key role in providing managers with information on population status and evaluating the effectiveness of management actions, allowing for adaptive management (Lyons et al. 2008). Most past census efforts on dusky grouse and sooty grouse have been harvest

related (Rogers 1963, Hoffman 1985).

There has been little dusky or sooty grouse breeding monitoring range wide, including in Utah. Past breeding censuses, like those conducted by Stirling and Bendell (1966) on sooty grouse, were relatively short in duration. The Oregon Department of Fish and Wildlife recently implemented an ongoing spring sooty grouse monitoring protocol (Budeau 2016). Population monitoring occurs annually on some upland game species in Utah through census counts for sage grouse, sharp-tailed grouse, chukar partridge (*Alectoris chukar*), and cottontail rabbits (*Sylvilagus* spp), but no statewide monitoring for forest grouse has occurred to date (Bernales et al. 2016). Little is known about dusky grouse population status in Utah.

## PAST RESEARCH ON DUSKY GROUSE IN UTAH

A series of dusky grouse projects took place in the 1970s on the south end of the Bear River Range, Utah (Maestro 1971, Barnes 1974, and Weber 1975). Maestro (1971) determined important factors related to habitat selection by dusky grouse during spring and summer. To conduct the research Maestro flushed grouse on 102 sample areas then completed estimates for habitat variables including: elevation, percent forest, percent maple, primary cover species, secondary cover species, percent mixed brush cover, and percent sage brush cover. Maestro found the structure of the maple stand was more important for cover than the species itself. Important habitat factors included draws and tree edge. Areas with higher maples also had higher mixed brush.

Barnes (1974) and Weber (1972) studied the ecology, habitat requirements, and anthropogenic effects on dusky grouse on the south end of the Bear River Range, Utah.

Barnes studied an herbicidal habitat manipulation project pre-treatment and post-treatment with his main objective to determine the effects of herbicidal spraying of Mule's ears (*Wyethia amplexicaulis*) upon numbers and distribution of dusky grouse. The dusky grouse in the study area spent a great deal of time in the sagebrush, Mule's ears complex. Random searches of these complexes were completed with the aid of an American Brittany dog (*Canis lupus familiaris)*. The entire study area was searched every few days for dusky grouse.

The aims of the study were to determined male breeding territories on each site, to count the number of females with broods on each site, and to catch and mark dusky grouse for re-identification. Barnes and Weber found no difference in the number of male territories between the two years. There was a difference in distribution of grouse during the study. Grouse were evenly distributed during the pre-treatment monitoring in 1971. In 1972, the blue grouse distribution was mostly in edge habitat near shrubs and trees. The ratio of males to females was the same throughout the study, two females to every male. Dusky grouse population continued to persist in the area after herbicidal spraying of Mule's ears.

In conjunction with finding male dusky grouse territories, nest and brood searches were also conducted. Weber (1975) found 16 dusky grouse nests, including 11 post-hatch nests, mostly outside the herbicidal sprayed area. Weber found that juvenile grouse eat large amounts of insects, especially grasshoppers. The herbicidal spraying did not appear to affect grouse foraging behavior and the number of estimated broods on study site did not change.

Pekins (1988) conducted a study on the Bear River Range on wintering dusky

grouse. He measured characteristics of diurnal and nocturnal roost sites of dusky grouse. Dusky grouse winter diets were also analyzed. Pekins found that dusky grouse roosted in Douglas-fir trees during the day and subalpine fir (*Abies lasiocarpa*) trees at night. Nocturnal roosts provided greater canopy and denser shelter than day roosts. Day roosts favored foraging.

Bunnell et al. (1977) collected hunter harvested grouse wings over six years from UDWR hunter check stations in northern Utah during the opening weekend of the grouse hunt. They recorded wing lengths and plumage characteristics from 2300 wings and used these data to develop a key to classify dusky grouse sex and age.

## STUDY AREA

My research focused on a dusky and ruffed grouse population located in the Bear River Range, Utah encompassing nearly 120,000 ha in Cache and Rich Counties (Fig. 1-2). Most of the study area (83%) was part of the USFS Uinta-Wasatch-Cache National Forest in the Logan Ranger District of the US Forest Service, but also included private land (11%), Utah School Institutional Trust Land (2%), and Utah Department of Natural Resources land (4%). The study area was bound by Bear Lake Valley and Cache Valley to the east and west, respectively, and the Idaho state line to the north and Blacksmith Fork Canyon to the south. I focused on the area on either side of Highway 89 in Logan Canyon because of the availability and access to forest grouse, as well as my research interest in livestock management of pastures throughout the area.

Grazing occurs on pastures throughout the Bear River Range with both sheep and cattle grazing allotments. Elevation ranges from to 1450–3000 meters. Vegetation in the

study area includes big sagebrush communities, mountain mixed shrub, maple (*Acer* spp.), mountain mahogany (*Cercocarpus ledifolius*), juniper (*Juniperus* spp.), aspen (*Populous tremuloides*), and coniferous forest (*Abies* spp., *Pinus* spp., *Picea* spp., and *Pseudotsuga menziessi*).

Precipitation in the Bear River Range averages between 23 and 150 cm a year depending on elevation and location with most of the precipitation dropping as snow. The Bear River Range varies in snow depth during the winter months. Common species to the area include mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), moose (*Alces alces*), snowshoe hares (*Lepus americanus*), and a variety of passerine birds and small rodents. Common predators in the Bear River Range include: red-tailed hawks (*Buteo jamaicensis*), great horned owls (*Bubo virginianus*), northern goshawks (*Accipiter gentilis*), Cooper's Hawks (*A. cooperii*), golden eagles (*Aquila chrysaetos*), American badgers (*Taxidea taxus*), striped skunks (*Mephitis mephitis*), coyotes (*C. latrans*), red foxes (*Vulpes vulpes*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), pine martens (*Martes americana*), black bears (*Ursus americanus*), and cougars (*Puma concolor*). Nest predators may also include red squirrels (*Tamiasciurus hudsonicus*), ground squirrels (*Urocitellus* spp.), common ravens (*Corvus corax*), and other corvids such as Clark's nutcrackers (*Nucifraga Columbiana*), and Stellar's Jays (*Cyanocitta stelleri*).

Dusky grouse and ruffed grouse are commonly hunted in the Bear River Range. The duration of the forest grouse hunting season in Utah is September 1 to December 31 and the daily bag limit is 4 birds per day in the aggregate (Bernales et al. 2016). With over 2500 forest grouse hunters afield in Cache County in 2016, the Bear River Range draws more grouse hunters than any other Utah location. According to UDWR estimates,

more than 8000 forest grouse were harvested in Cache County in 2016 (Bernales et al. 2016).

## RESEARCH PURPOSE

The purpose of my research was to:

1. Evaluate the effectiveness of a spring populations indexing protocol on monitoring populations of dusky and ruffed grouse. (Chapter 2)
2. Determine preferred nesting and brooding habitat of dusky grouse. (Chapter 3)
    a. What microhabitats are preferred by dusky grouse for nesting and brooding?
    b. Does livestock distribution on seasonal use locations influence dusky grouse habitat selection?
3. Identify the characteristics and hunter harvest rate for forest grouse in the Bear River Range. (Chapter 4)

The thesis chapters were written following the "Journal of Wildlife Management" and "Wildlife Society Bulletin" style guidelines (Cox et al. 2018).

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**FIGURES**

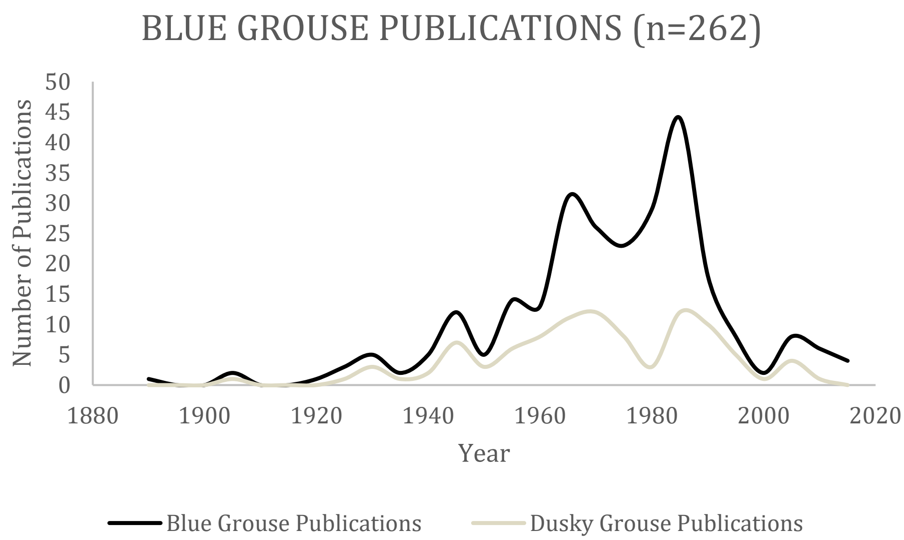


**Figure 1-1.** Blue grouse (*Dendragapus* spp.) publication timeline shows the number of journal publications over time for all blue grouse compared to dusky grouse (*D. obscurus*) over time, thus the difference between the lines represents publications for sooty grouse (*D. fuliginosus*).

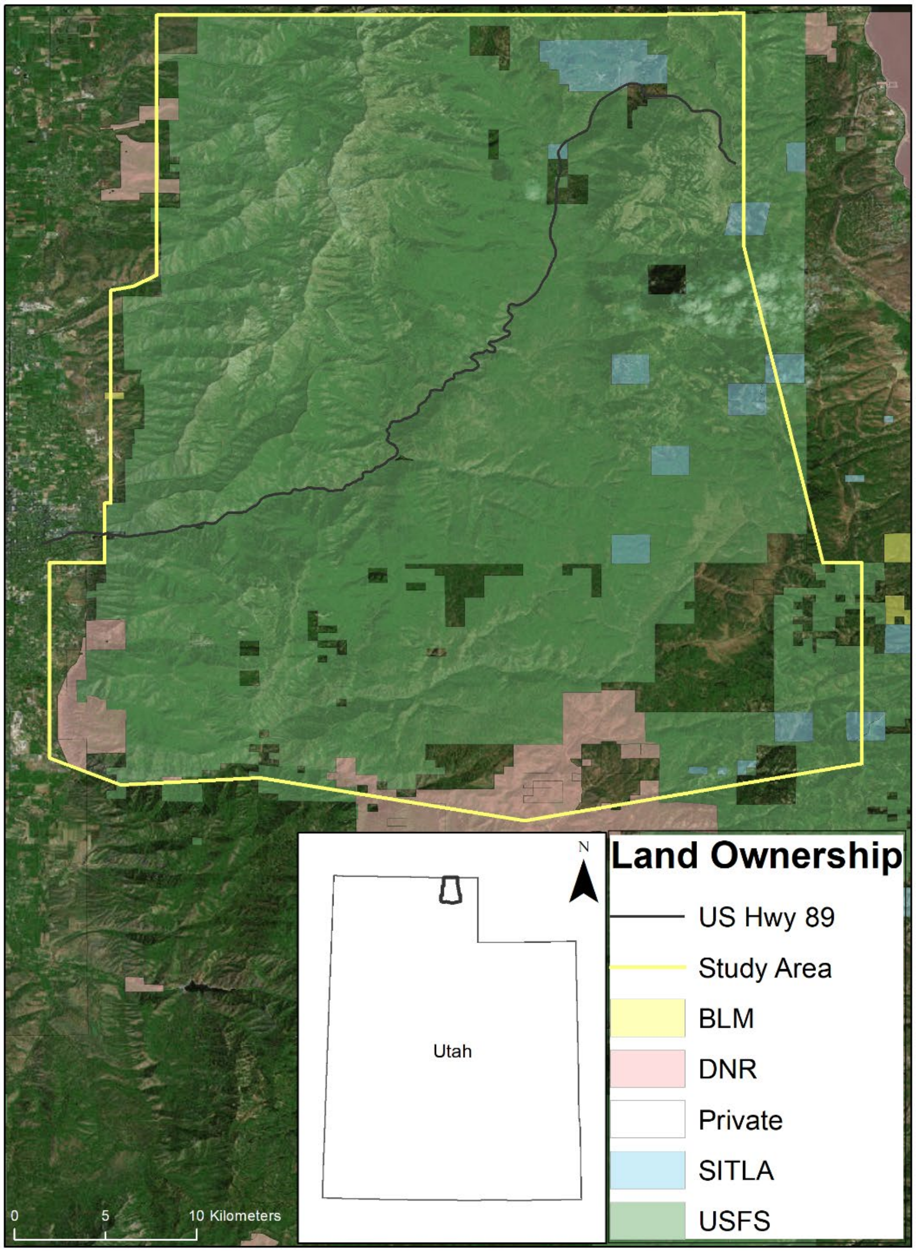


**Figure 1-2.** Forest grouse study area in Bear River Range, Utah 2015–2017. The study area was made up of different property ownership including, Utah Division of Wildlife Resources (DWR), Utah School Institutional Trust Land Administration (SITLA), U.S. Forest Service (USFS), and privately-owned lands.

# CHAPTER 2

# USING SURVEYS OF MALE FOREST GROUSE TO ASSESS BREEDING POPULATIONS AND HABITAT IN NORTHERN UTAH

## ABSTRACT

Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) are poorly understood Galliformes in western North America, especially regarding population status and habitat requirements, even though they are important upland game resources throughout the Intermountain West, including Utah. In 2016 and 2017, I developed a breeding census protocol and classified habitat selection within a sympatric population of dusky and ruffed grouse in the Bear River Range of northern Utah. To conduct my research I completed 128 walking surveys along 21 routes during the 2016 (n = 67) and 2017 (n = 61) breeding seasons. I compared listening intervals with and without electronic playback calls at survey stop locations. I detected 242 male dusky grouse and 307 male ruffed grouse, plotted estimated locations for each detected individual using digital mapping software, and evaluated grouse detections as a function of date, minutes post-sunrise, and electronic playback call response using generalized additive models. The detection probability estimates for dusky grouse and ruffed grouse for 2016 and 2017 were 0.466 (SE = 0.0424) and 0.687 (SE = 0.0274) and 0.494 (SE = 0.0449) and 0.699 (SE = 0.0326), respectively. Using estimated male locations and computerized landscape variables, I assessed breeding habitat selection for both grouse species through resource selection functions at the second order scale. Dusky grouse preferred maple (*Acer* spp.) communities, but also mountain shrub (*Amelanchier* spp. and

*Prunus virginiana*, aspen (*Populus tremuloides*), and open (grassland and *Artemisia* spp.) communities as breeding habitat. Ruffed grouse selected for mountain shrub and aspen communities, and avoided conifers. Forest edge habitats were important for both species. Walking breeding surveys were an effective tool for monitoring dusky and ruffed grouse population trends. Information from resource selection analyses will help provide a baseline for evaluating forest grouse breeding habitat in the Intermountain West and developing monitoring sites in other areas.

## INTRODUCTION

Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) are important upland game resources in Utah. The Utah Division of Wildlife Resources (UDWR) currently manages dusky grouse and ruffed grouse together as forest grouse (Bernales et al. 2016). Information, such as annual breeding surveys to monitor population change and a description of breeding habitat for forest grouse, in the West is lacking.

Dusky and ruffed grouse have unique breeding behaviors, making them candidates to develop new census techniques. Prior to the dusky grouse breeding season, males migrate to lower elevations and establish localized territories, usually made up small tree thickets (Martinka 1972, Cade and Hoffman 1993). Males defend their territories and attract females through audible hoots, wing flutter, and nuptial displays, where females respond with precopulatory calls (Blackford 1958). Electronic playback of female whinny and cantus calls have been found to elicit responses from both sooty grouse (*D. fuliginosus*) and dusky grouse (Stirling and Bendell 1966, Martinka 1972,

Falls and McNicholl 1979). Stirling and Bendell (1966) established electronic callbacks as an acceptable form of census for sooty grouse, although using electronic callbacks during dusky grouse breeding surveys has not been evaluated nor implemented as a common practice for state agencies tasked with managing blue grouse populations.

Like dusky grouse, ruffed grouse also breed in the spring, primarily in May. Males “drum” on elevated structures, typically logs, which serve the purpose of attracting females and establishing or maintaining territories. While drumming surveys to monitor ruffed grouse breeding populations have been developed throughout the eastern distribution of the species, generally western states have not established regular drumming surveys (Dhuey 2017). Of note, ruffed grouse surveys in the Midwest and East have usually taken place in flat areas as roadside surveys.

The audible nature of male breeding displays of these two species provides an opportunity for biologists to detect, observe, and count male forest grouse. Prohibitive issues for conducting dusky and ruffed grouse surveys include cost and lack of time for biologists already tasked with monitoring several wildlife species during spring breeding seasons. Another prohibitive issue for conducting dusky and ruffed grouse surveys in the West is that most dusky and ruffed grouse habitat occurs at higher elevations where snowpack and road access is limited during the breeding season. To my knowledge, Oregon Department of Wildlife (ODOW) is the only state wildlife agency that currently conducts regular breeding surveys for forest grouse in the West (i.e., sooty grouse) within the coastal ranges of western Oregon (Budeau 2016). Roadside surveys for ODOW were established with the intent to develop a cost-effective and unbiased survey that accurately indexed sooty grouse populations. To reduce bias, these roadside surveys were designed

to focus on grouse vocalizations during peak breeding season. Such survey data for other western forest grouse species and in other states would be valuable to help managers better implement conservation of dusky and ruffed grouse populations throughout the region.

Limited research indicates that dusky grouse breeding habitat consists of a mosaic of plant communities dominated by a mixture of shrub-steppe, deciduous, and conifer communities (Zwickel and Bendell 2004). Vertical structure from maples (*Acer* spp.) and quaking aspen (*Populous tremuloides*) provide important breeding habitat for dusky grouse (Martinka 1972, Weber 1975, Stauffer and Peterson 1986). Martinka (1972) found that male breeding territories included thickets of young trees near openings. In previous research within the Bear River Range, dusky grouse utilized similar thickets including maple stands for breeding (Maestro 1971, Stauffer and Peterson 1985b). Furthermore, research conducted on sooty grouse indicated that they also used small open habitat types for displaying (Bendell and Elliott 1966, Niederleitner 1987, Bland 2013). The boundary between forest and open habitat types, also known as edge habitat, may be an important feature of breeding habitat for dusky grouse (Barnes 1974, Martinka 1972).

Ruffed grouse breeding habitat is typically dense vegetation and drumming areas are small openings within the dense habitat that offer male ruffed grouse escape cover and female ruffed grouse nesting habitat (Stauffer and Peterson 1985a, Thompson et al. 1987). Limited research in the West indicates that ruffed grouse are generally dependent on aspen for food and shelter, but also utilize mixed shrub and maple communities (Stauffer and Peterson 1985a, Stauffer and Peterson 1985b, Hewitt and Messmer 2000). To my knowledge, little research has been conducted on ruffed grouse breeding habitat in

western North America.

Given the lack of research on breeding forest grouse in western North America and the importance of forest grouse as an upland game bird in Utah, and other states, my objectives for this study included: 1) developing a breeding survey protocol for both dusky and ruffed grouse to establish an index to population trends, and 2) to explicitly assess and contrast breeding habitat selection for both species using a resource selection function analyses. My objectives sought to improve monitoring of dusky and ruffed grouse populations using survey techniques different from prior research. I hypothesized that male ruffed grouse would have a higher detection probability compared to male dusky grouse because ruffed grouse are known to regularly drum every 4-5 minutes in the early to mid-morning hours whereas dusky grouse make audible displays irregularly during the same period. I also hypothesized that electronic playbacks would increase detection rates for dusky grouse. I predicted that dusky grouse demonstrate a broader selection for available habitat types compared to ruffed grouse.

## STUDY AREA

My study area encompassed 120,000 ha of the Bear River Range in Northeastern Utah. The study area occurred in Cache and Rich counties and was bounded on the north by the Idaho state line and on the south by Blacksmith Fork Canyon, and from east to west Bear Lake Valley to Cache Valley, respectively. Most of the study area (83%) was part of the U.S. Forest Service (USFS) Uinta-Wasatch-Cache National Forest in the Logan Ranger District (Fig. 2-1). Private land constituted 11% of the study area where the majority of private parcels included cabin areas less than 1 ha, located near U.S.

Highway 89 and larger parcels up to 10,000 ha in the southeast corner of the study area near Hardware Ranch Wildlife Management Area. Utah School and Institutional Trust Land (SITLA) made up 2% of the study area and UDWR land made up 4% of the study area. The UDWR land (4700 ha) consisted of Hardware Ranch, Millville Face, and Richmond Hill Wildlife Management Areas. I primarily focused on a subsection of the study area that was easily accessible and provided forest grouse habitat for both species throughout; i.e., within Logan Canyon on both sides of Highway 89 from Right Hand Fork to Franklin Basin.

Elevation ranges from 1450–3043 m in my study area. Topography was rugged and steep. The Bear River Range varies in vegetation types including: conifer (*Abies* spp., *Picea* spp., *Pinus* spp., and *Pseudotsuga menziessi*), quaking aspen, maple, mountain mahogany (*Cercocarpus ledifolius*), mixed mountain shrub such as serviceberry (*Amelanchier* spp.) and chokecherry (*Prunus virginiana*), and sagebrush (*Artemisia* spp.) communities.

Precipitation in the study area varied with elevation. The average annual precipitation at Temple Fork was 72.1 cm, with most of the precipitation falling from December through April in the form of snow (Utah Climate Center 2018). Precipitation was higher than average in both 2016 and 2017 at 83.9 cm and 88.1 cm, respectively. Less snow fell in 2016 than in 2017, but the study area received more summer precipitation in 2016 compared to 2017. September 2016 through September 2017 the study area received 95.2 cm of precipitation as opposed to 58.3 cm in 2015. The average monthly temperature ranged from a high of 19.6° C in July to a low of -4° C in December (Utah Climate Center 2018).

## METHODS

### Survey Methods

I conducted walking surveys for breeding dusky and ruffed grouse with a crew of technicians from April to June in 2016 and 2017 along circular survey routes that consisted of six stops spaced ≥ 500 m apart (Fig. 2.2). I identified survey route starting points by using a random location generator in ArcMap 10.3.1 (ESRI, Redlands, CA). All survey starting points were within 400 m of a road to ensure accessibility. Stops were then located in various habitat types including: ridge tops, canyon bottoms, conifer stands, aspen and maple stands, and open sagebrush to help assess available habitat types within these areas.

I sampled each route at least three times during the 2016 and 2017 breeding seasons. Surveys began, based on the photoperiod, at sunrise through the early part of the morning, primarily up to 2 hours post sunrise, although some surveys continued up to 6 hours post sunrise when the grouse were most active. Sampling of survey routes was repeated and walked in clockwise or counter clockwise fashion on different dates, attempting to keep samples > 1 week apart for individual routes, so that survey interval times (i.e., post sunrise) varied by stop location.

I completed surveys by first listening for vocalizations of male grouse at each stop for three consecutive, but distinct, four-minute intervals, followed by a fourth four-minute electronic callback (ecall) interval using pre-recorded dusky grouse female cackle, cantus, and whinny calls. I chose four-minute increments because ruffed grouse reportedly drum on average once every four minutes (Petraborg et al. 1953). I recorded

the species and number of detected male grouse in each interval and kept track of each individual in subsequent intervals. I estimated the distance and location of each individual male grouse detected during the survey period using aerial imagery on geo-referenced mapping software. I assumed that each interval was an independent sample for analysis purposes (Fiske and Chandler 2011). For instance, a male detected in interval one, was resampled as a new detection in interval two, but still identified as the same individual from interval one.

I recorded each detected individual grouse location and time, as well as the estimated distance of the bird from the stop location, using Cybertracker digital mapping software (Cyber Tracker Conservation 2013) by digitally measuring the Euclidean distance from the stop and the estimated location. At random, I located and flushed a subsample of 41 detected male grouse of both species to obtain an error rate between the estimated and actual location of the detected bird (Fig. 2-3). I recorded additional information pertaining to survey stops including noise level, wind speed, temperature, and cloud cover. Noise levels were assessed using a subjective Likert-type scale that ranged from one to 4, where 1 was no noise and 4 was high noise (Beach et al. 2011). I estimated wind speed using the Beaufort Scale (Bayne et al. 2008). I recorded temperature at the first route stop each morning. I visually estimated cloud cover into 5 percentage categories that ranged from 0 to 100% cloud cover.

**Detection Probabilities**

To estimate detection probabilities for dusky grouse and ruffed grouse I analyzed grouse detections per interval for each survey route. To achieve this, I used a hierarchical

modeling approach in which each listening interval was nested within subsequent visits. The sampling unit was each grouse detection. I then estimated detection probabilities for each year using the multi-season occupancy model in the R package unmarked (Fiske and Chandler 2011).

**Temporal Activity**

I estimated forest grouse vocalizations using generalized additive models (GAM) to determine when dusky grouse and ruffed grouse were most active as a function of time of day and time of year. A GAM is an additive function that uses a link function to establish a relationship between the mean of the response variable and a ‘smoothed’ function of the explanatory variable (Guisan et al. 2002). I recorded dusky grouse and ruffed grouse detection data separately. To control for changing sunrise time, I analyzed vocalizations as a function of time after sunrise. I recorded each survey route by Julian date. I used combinations of collected covariate data to select the best fitting model. I evaluated 16 models for daily temporal activity and 18 models for time of year activity, then chose the models with the lowest Akaike’s Information Criterion (AIC) value (Akaike 1998).

To assess the relative probabilities of ecall playback and listening for dusky grouse, I also used GAMs. I randomly selected one of the three intervals using a random number generator in MS Excel for comparison with the ecall to compare independent samples from the listening intervals. As with grouse detection by date, the ecall comparison was assessed by Julian date. I compared GAMs similar to the aforementioned date of activity for the ecall interval and the listening sample. I chose the best fitting

model for each of the ecall and listening sample using the lowest AIC. I then plotted the ecall and listening sample to visually assess the difference between the two models.

**Landscape Variables**

For resource selection function (RSF) analyses, I acquired spatial data to estimate forest grouse breeding distributions from the Utah Automated Geographic Reference Center (<www.gis.utah.gov>, accessed 21 March 2018) or the U.S. Geological Survey LANDFIRE 2014 vegetation cover type dataset (LANDFIRE 2014). All resource variables were 30 $m^2$ cells. Biotic variables included elevation, obtained from the Utah Digital Elevation (DEM) model and slope derived from DEM (<www.gis.utah.gov>, accessed 21 March 2018). Anthropogenic factors included Euclidean distance to roads and anthropogenic trails. Vegetation land cover types were obtained from the LANDFIRE 2014 data and grouped into six vegetation communities including: conifer, aspen, maple, mountain shrubs, open (sagebrush and grassland), and other (cliffs, water, and development) (Table B-1). I also generated measures of the spatial distribution of vegetation classes using the focal tool in R version 3.3.1 for conifer, aspen, mountain shrubs, and open communities. The focal tool is essentially a moving window analysis that estimates plant community density in the surrounding areas of any given cell by calculating the proportion of each vegetation categories within a 3x3 cell grid (Fedy et al. 2014). This produced a proportional measure of vegetation (e.g., conifer) from 0 to 1. Because dusky and ruffed grouse may respond to edge effects that coincide with tree cover (Martinka 1972), I estimated distance from trees moving inward and outward from the abrupt forest edge as delineated by LANDFIRE 2014.

**Habitat Selection Analysis**

I used an RSF framework at the second order (Johnson 1980) for dusky and ruffed grouse breeding habitat within a used-available design (Manly et al. 2002). The RSF model was calculated as follows with g($x$) estimated for location $i$ of individual $j$:

$$g(x) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \cdots \beta_n x_{nij} + \gamma_{0j}$$

where $\beta_0$ is the mean intercept, $x_n$ are covariates with fixed regression coefficient $\beta_n$ , and $\gamma_{0j}$ is the random intercept for individual $j$.

I generated buffers around each audibly detected individual grouse at scales of 200 m and 250 m for ruffed and dusky grouse, respectively. I identified 200 m buffers as a suitable buffer for ruffed grouse because this represented the typical radius of a home range size of a breeding male reported in the literature (Gullion 1989, McDonald et al. 1998, Fearer and Stauffer 2003, Whitaker et al. 2007). For dusky grouse, I estimated the home range size of breeding males from 4 Global Positioning System Platform Transmitter Terminal (GPS-PTT) radio-marked dusky grouse males (see Chapter 3) within my study area because no home range estimates were previously published (IUCUC #2368). I estimated home range size by calculating the 95% kernel home range using the KernelUD tool in the adehabitat package (Calenge 2011) in R. I then estimated the radius of each home range (Fig. 2-4). To estimate use points, I then sampled every 30 $m^2$ cell within the buffer. These used points were compared to a systematic sample of points across the entire breeding survey study area representing available habitat (Fig. 2-2). Sampling occurred systematically in every fifth 30 $m^2$ cell to expedite processing. My a priori sampling demonstrated that more intensive (e.g., every 3$^{rd}$ cell) sampling did not

produce any difference in the mean or standard deviation of covariate data. All use and random locations were then intersected with all covariate data. I constructed piecewise spline graphs from the resulting beta coefficients to determine the relative probability of use of dusky and ruffed grouse at the tree edge (Kohl et al. 2019).

**Model Selection**

I evaluated dusky grouse and ruffed grouse breeding habitat as a function of the landscape variables using generalized linear models (GLMs). Because the sampling data reflected used and available locations comprised of zeros and ones, I used logistic regression in the resource selection analysis. All landscape variables were normalized (m = 0, sd = 1) for model convergence. Because of my interest in the relative impacts of landscape variables on breeding grouse, I did not use any model selection approaches, but rather used all variables and combinations thereof. My a priori sampling demonstrated a better representation of habitat selection for dusky grouse using vegetation as categorical data. As an example, the lme4 package compared the last five vegetation categories against the first category, in this case, conifers. For ruffed grouse, the best representation for habitat vegetation selection was derived from using focal moving window analyses. I excluded distance to roads and elevation from the models for both species because all breeding survey locations were delineated within close proximity to roads due to access issues and occurred within a limited elevation range. Concomitantly, when distance to roads and elevation data were included, the a priori sampling results were heavily skewed, showing strong selection for both variables.

**RESULTS**

I completed 128 breeding surveys from 21 routes during the 2016 (n = 67) and 2017 (n = 61) breeding seasons. Because of logistical constraints, I only sampled 6 routes twice in a season. During the breeding surveys, I recorded 242 male dusky grouse and 307 male ruffed grouse, and plotted an estimated location for each (Fig. 2-2). Of those males, I located and physically observed 26 dusky grouse males and 15 ruffed grouse males and recorded actual grouse display locations to test for the error included in my estimation of locations using digital aerial imagery within GPS mapping software. All but two estimated locations were within 45 m of the actual location (Fig. 2-3).

The 2016 and 2017 detection probability estimates for dusky grouse and ruffed grouse were 0.466 (SE = 0.0424) and 0.687 (SE = 0.0274), and 0.494 (SE = 0.0449) and 0.699 (SE = 0.0326), respectively. Dusky grouse detections peaked on April 28 (Julian day 118) and a second smaller detection peak occurred in the middle of June (Fig. 2-5). Of the 18 dusky grouse detection-by-date models, the best fitting model excluded wind speed, temperature, or cloud cover. None of the covariate data showed a strong effect on dusky grouse detection. The peak of detection for ruffed grouse occurred about May 1 (Julian day 121; Fig. 2-5). Similar to dusky grouse, the collected covariate data did not have a strong effect on ruffed grouse detections.

The highest detection rates for both dusky grouse and ruffed grouse occurred at sunrise (Fig. 2-6). Both dusky grouse and ruffed grouse detection rates dropped linearly over time; however, ruffed grouse detection rates declined relative to increasing sunlight over 50% faster than dusky grouse detection rates. The best fitting model for dusky grouse detection time of day used a combination of noise and cloud cover. The strongest

model for ruffed grouse used a combination of both wind and noise level.

The ecall increased detections of dusky grouse overall by 26% (n = 63). The best fitting model for listening without a call back included less wind speed. Low cloud cover was the best fitting model for ecall detection. Where the listening without call back interval model peaked in April 20, the ecall detection was mostly linear, slowly becoming more positive through time (Fig 2-7).

Maple cover had the strongest influence on dusky grouse habitat selection compared to other vegetation types (Fig. 2-8). However, all five habitat parameters were important and selected in the following order of significance: maple, open sagebrush and grassland, mountain shrubs, aspen, and 'other' and all of the vegetation factors were selected more than conifer (Table 2-1). Dusky grouse selected for tree edge from either inside or outside tree cover (Fig. 2-9). Dusky grouse selected for less slope, and tended to select for areas farther away from trails.

Ruffed grouse selected against conifer cover (Fig. 2-10). They also selected against open sagebrush and grassland, but selected for areas with mountain shrub and aspen communities near edge habitat (Table 2-2). Similar to dusky grouse, ruffed grouse selected for tree edge from both inside and outside tree cover and selected against anthropogenic trails (Fig. 2-11).

## DISCUSSION

Results from my study suggest that maple tree communities are an important component of breeding habitat for dusky grouse in the Bear River Range. Two previous studies in the Bear River Range suggested such a relationship between breeding dusky

grouse and maple communities, however, they did not attempt to quantitatively assess breeding habitat at landscape scales (Maestro 1971, Stauffer and Peterson 1986). My data confirmed their findings and demonstrated that maple tree cover was important to dusky grouse breeding habitat at the landscape scale. Maple habitat selection by dusky grouse may be due to the dense structure of the vegetation community and protection it provided for predator avoidance. Small tree communities like maple, mahogany, and young aspen likely provide more cover and vertical structure compared to mature conifer and aspen stands. Gullion and Marshall (1968) concluded that the structure provided by smaller trees in densely packed thickets influenced ruffed grouse survival more than the specific tree species.

Martinka (1972) and Maestro (1971) suggested dusky grouse select tree edge habitat. Using RSFs, my results confirm that dusky grouse in the Bear River Range prefer forest edge, as do ruffed grouse. Dusky and ruffed grouse may use the edge habitat for ease of access to available resources found in open or forested landscapes (Ries et al. 2004). Edge habitat may be selected by many wildlife species because of an increase in plant community diversity due to increased light levels near the forest edge (Ortega and Capen 1999, Watkins et al. 2003). Gullion (1984) suggested that persistent use of edge habitat by ruffed grouse was an indicator of inadequate habitats and that they would abandon edge situations with uniform available habitat elsewhere. I was unable to evaluate his suggestion. In contrast, Kubisiak (1985) found the best cover for ruffed grouse at the tree edge, especially where shrubs and tree saplings occurred on sites with good exposure to sunlight. My results also indicated that ruffed grouse in my study area use edge habitat at the landscape scale, although further research is needed to explicitly

assess this relationship. Overall, ruffed grouse habitat in my study area tended to be patchy and discontinuous, which may explain some of the variation in selection for edge by ruffed grouse.

Ruffed grouse habitat selection was more specialized than dusky grouse (Fig. 2-8; Fig. 2-10). Both dusky and ruffed grouse selected for less slope, although dusky grouse were frequently located near ridge tops, while ruffed grouse were located at lower elevations. Ruffed grouse habitat selection was restricted almost exclusively to aspen and maple stands. Although there was some overlap in selection for aspen and mountain shrub communities, open sagebrush was additionally important for dusky grouse, while ruffed grouse showed strong selection against this habitat type. Dusky grouse selected for a wider spatial scale and variety of habitat types than ruffed grouse, thus demonstrating that dusky grouse are more habitat generalists compared to ruffed grouse. Additional research into the effects of specific management actions is needed to better understand how to conserve and improve forest grouse habitat, especially where sympatric populations of forest grouse species occur.

Results from my breeding survey suggest that although detection rates varied between dusky and ruffed grouse, sympatric populations of breeding dusky and ruffed grouse can be surveyed simultaneously. To my knowledge, my study on dusky grouse in the Bear River Range was the first study to develop a method to survey for, and explicitly assess, detection rates for both species of sympatric breeding dusky and ruffed grouse. Both forest grouse detection peaks were within days of each other and as such, did not require separate sampling periods. However, dusky grouse detection peaked a second time in the middle of June for both years. Similar to other grouse species (*Centrocercus*

spp. and *Tympanuchus* spp.) a second peak may be due to re-nesting attempts from females, although I could not verify this (Walsh et al. 2004, McNew et al. 2011). Peak ruffed grouse breeding has been reported with much variation across the species range. Gullion (1966) reported the peak ruffed grouse detection to be between April 28 and May 2 on any given year in Minnesota, similar to what I found during my study. Hansen et al. (2011) however, reported peak detection probabilities in South Dakota on May 19, suggesting that outside factors such as precipitation, temperature, location, or the lunar cycle may influence the time of year that breeding occurs (Archibald 1976).

Detection probabilities for dusky grouse were lower than ruffed grouse. The difference in detection was likely because of breeding display biology of each species. Ruffed grouse tend to display regularly (~ 4 minute intervals), thus my sampling design was able to detect them more reliably compared to dusky grouse, which display and vocalize more sporadically and in relation to the proximity of females (Petraborg et al. 1953, Zwickel and Bendell 2004). Detection probabilities for ruffed grouse in the Bear River Range were higher than previously reported in other areas (0.27 and 0.29; Zimmerman and Gutierrez 2007, Hansen et al. 2011). Zimmerman and Gutierrez (2007) also reported that noise affected detectability for ruffed grouse in Minnesota. Noise levels in my study had an effect on dusky and ruffed grouse detection as a function of time of day, but not as a function of date (Fig. 2-5; Fig. 2-6).

The use of ecalls provided a consistent detection probability for my survey method for monitoring dusky grouse throughout the breeding season (Fig. 2-7). Ecalls increased detection compared to non-ecall intervals during the early and latter parts of the breeding season, providing consistency in detection probability over time. At the

beginning of the breeding season, or post-peak as the breeding season progressed and less females sought out males, the positive effect of the ecall was evident. Peak breeding season was the ideal timeframe for conducting listening interval surveys without ecalls.

Similar to other bird species, the optimal time of day for both dusky and ruffed grouse detection was near sunrise (Hartzler 1974, Mennill et al. 2004). Males may find greater breeding success with earlier breeding calls than males that begin calling later in the morning (Poesel et al. 2006). In one study, the majority of greater sage-grouse copulations took place within the first 40 minutes after sunrise (Hartzler 1974). I would expect to see breeding call activity close to dawn associated with higher rates of breeding success for both forest grouse species, although I did not sample prior to sunrise, which may have influenced the linear detection patterns I reported.

## MANAGEMENT IMPLICATIONS

Currently, nearly all western state wildlife agencies, including the UDWR, do not monitor forest grouse populations via breeding surveys. Based on my research, breeding surveys can be an effective tool for monitoring forest grouse breeding populations and provide trends over time. When implementing forest grouse breeding surveys, wildlife managers should survey near the peak detection dates, or if surveying for dusky grouse use an ecall (see Appendix A for a survey protocol). I recommend only conducting two listening intervals instead of three followed by the ecall as over 90% of my detections took place in the first two intervals or with the ecall. Surveys should begin at or just before sunrise, which was the time of day with the highest detection rates.

Information concerning habitat selection from my resource selection analyses

may help provide a baseline for developing locations for breeding surveys in other regions. However, I acknowledge that the strength of spatial inference will likely dissipate with increasing distances from my study area because of the scale and habitat types within my study area. An option is to initially use my results to locate breeding survey sampling locations and then conduct a similar analysis once data have been collected in that local area. Further research and implementation of breeding surveys would help managers understand the annual changes in population trends of forest grouse both in the Bear River Range and in other areas.

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**TABLES AND FIGURES**

**Table 2-1.** Resource Selection Function models incorporating all abiotic, biotic, and anthropogenic variables for dusky grouse (*Dendragapus obscurus*) through the April–June 2016–2017 breeding season on the Bear River Range, Utah.

| Variables | β | SE | *P* |
|---|---|---|---|
| Intercept | -0.330 | 0.023 | ≤0.001 |
| Slope | -0.12 | 0.007 | ≤0.001 |
| Distance to trails | 0.16 | 0.006 | ≤0.001 |
| Distance to tree edge (inside) | 0.250 | 0.015 | ≤0.001 |
| Distance to tree edge (outside) | -0.497 | 0.020 | ≤0.001 |
| Conifer | n/a[a] | n/a[a] | n/a[a] |
| Aspen (*Populous tremuloides*) | 0.539 | 0.018 | ≤0.001 |
| Mountain shrubs | 0.742 | 0.037 | ≤0.001 |
| Maple (*Acer* spp.) | 1.084 | 0.024 | ≤0.001 |
| Open (*Artemisia* spp. and grassland) | 0.877 | 0.033 | ≤0.001 |
| Other (developed) | 0.152 | 0.045 | ≤0.001 |

[a]All other vegetation types measured against conifer

**Table 2-2.** Resource Selection Function models incorporating all abiotic, biotic, and anthropogenic variables for ruffed grouse (*Bonasa umbellus*) through the April–June 2016–2017 breeding season on the Bear River Range, Utah.

| Variables | β | SE | *P* |
|---|---|---|---|
| Intercept | -0.013 | 0.013 | ≤0.001 |
| Slope | -0.238 | 0.008 | ≤0.001 |
| Distance to trails | 0.206 | 0.007 | ≤0.001 |
| Distance to tree edge (inside) | 0.257 | 0.019 | ≤0.001 |
| Distance to tree edge (outside) | -0.549 | 0.025 | ≤0.001 |
| Percent conifer | -0.726 | 0.011 | ≤0.001 |
| Percent aspen (*Populus tremuloides*) | -0.171 | 0.011 | ≤0.001 |
| Percent mountain shrubs | -0.147 | 0.011 | ≤0.001 |
| Percent open (*Artemisia* spp. and grassland) | -0.294 | 0.015 | ≤0.001 |

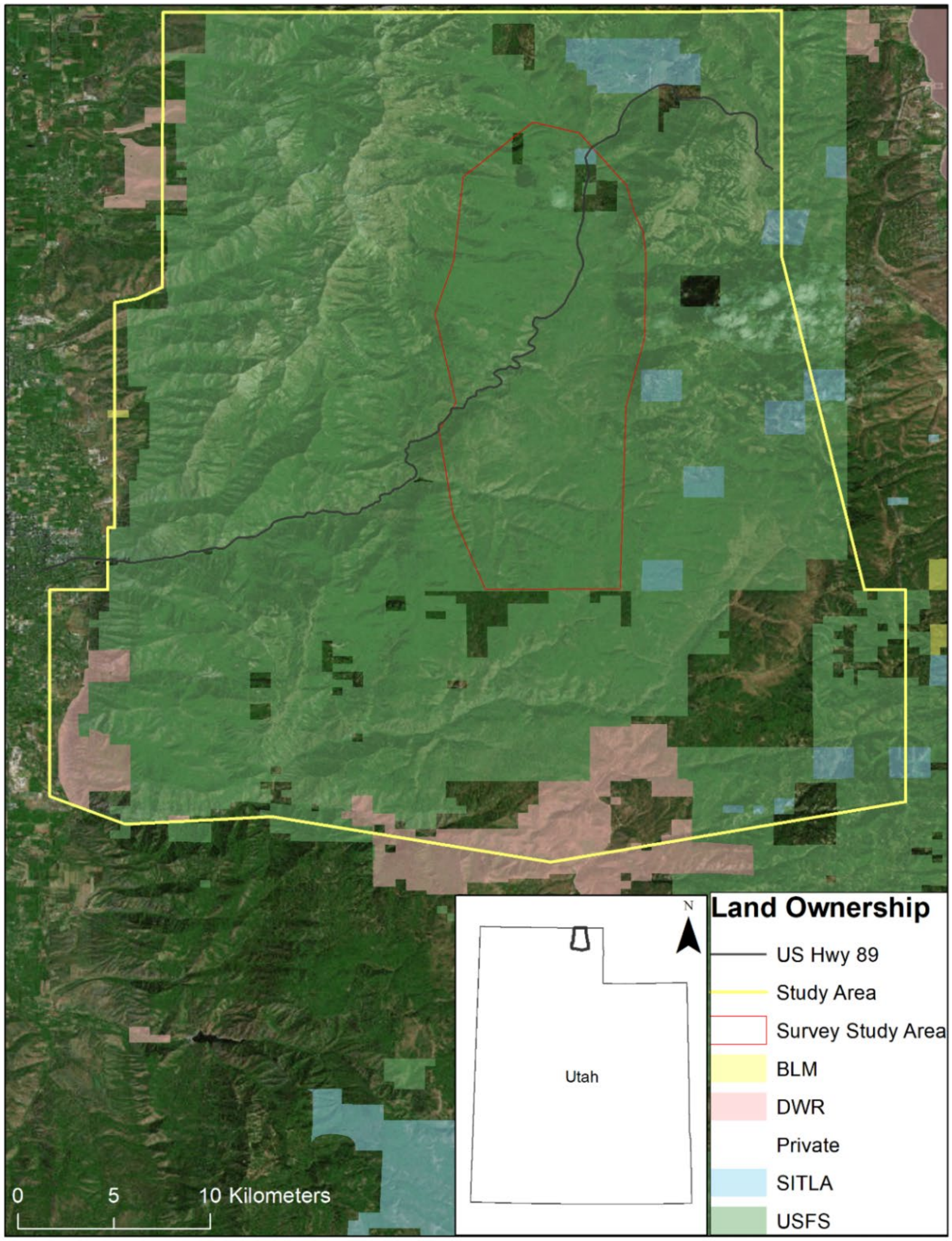


**Figure 2-1.** Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) study area in the Bear River Range, Utah in 2016 and 2017. The study area was made up of different property ownership including, Utah Division of Wildlife Resources (DWR), Utah School Institutional Trust Land Administration (SITLA), U.S. Forest Service (USFS), and privatelyowned lands.

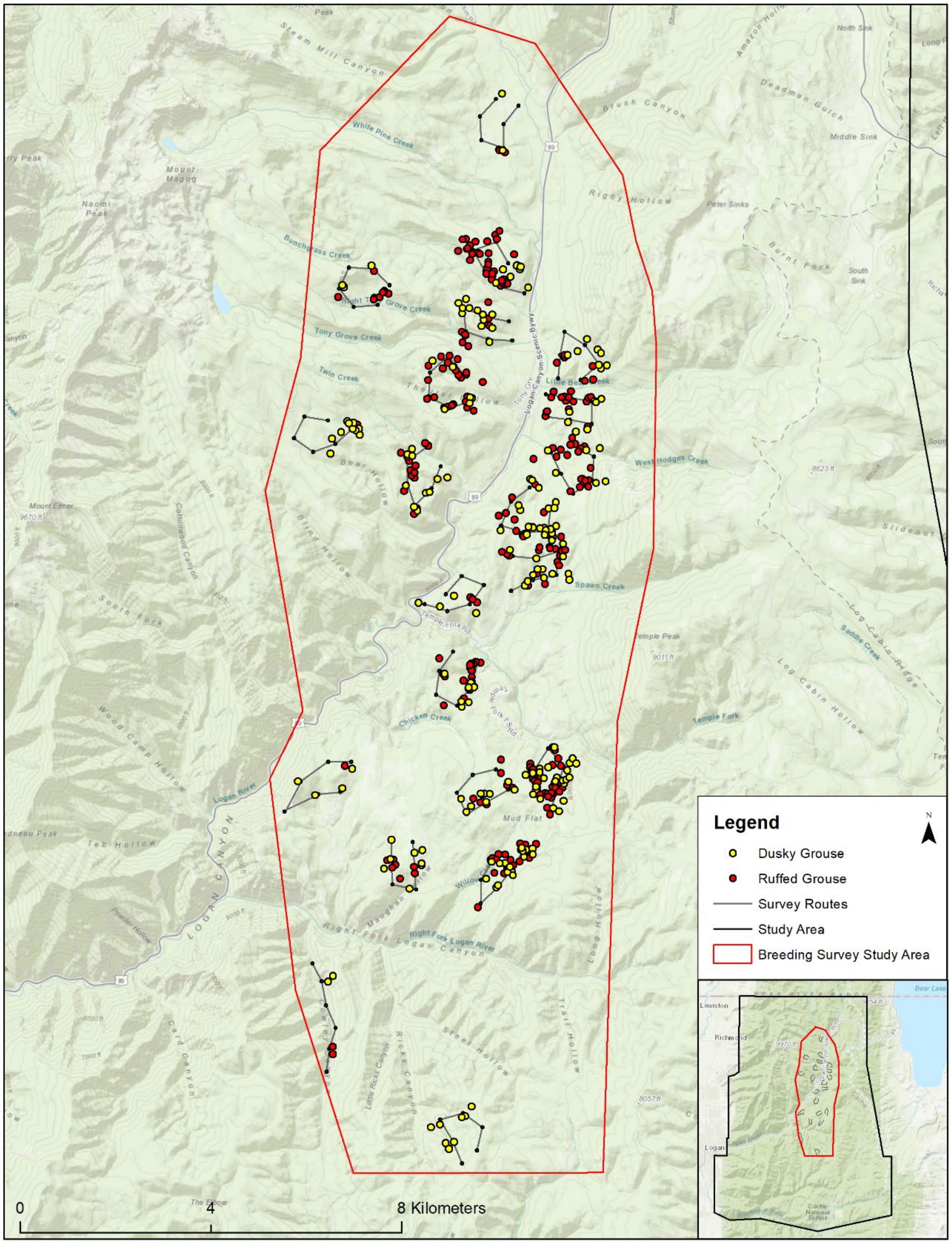


**Figure 2-2.** Locations of detected breeding dusky (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) males along survey routes in 2016 and 2017 in the Bear River Range, Utah.

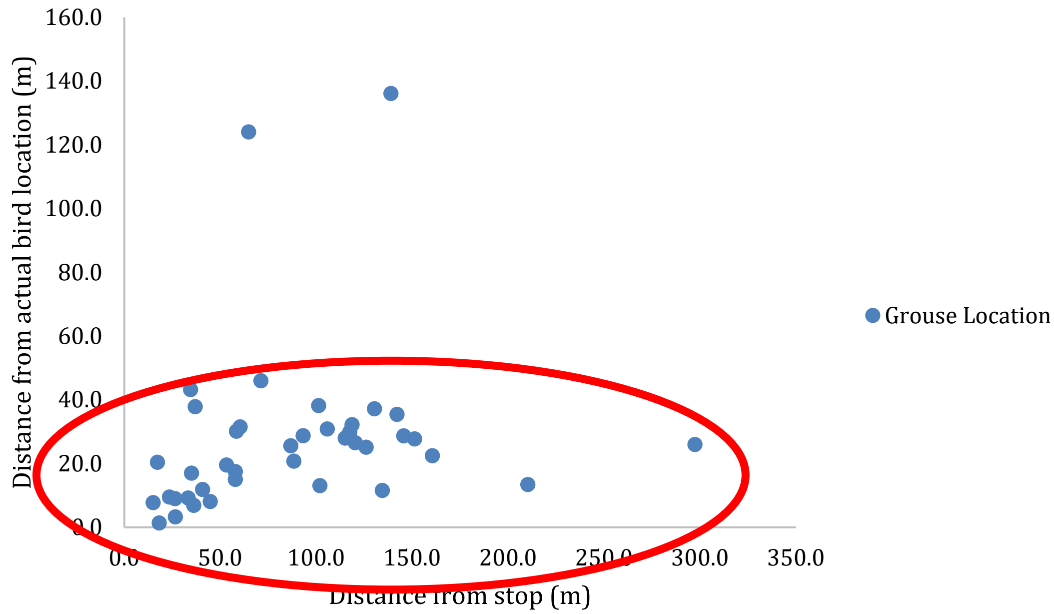


**Figure 2-3.** Error rates derived from estimating locations of vocal dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) males using digital mapping software, and then flushing the bird immediately following the survey to obtain an actual bird location. Error rates were calculated for breeding season (April–June 2016–2017) in the Bear River Range study area.

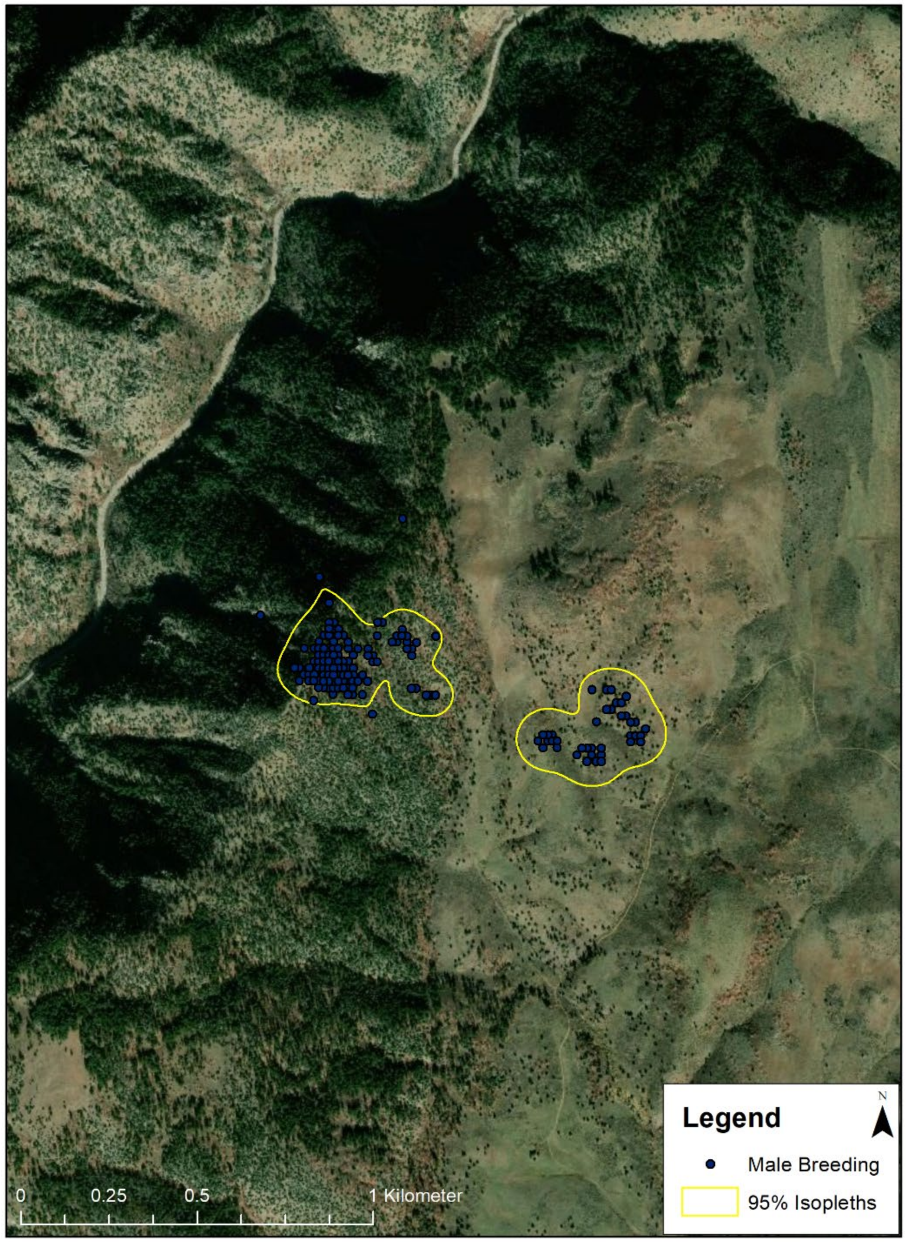


**Figure 2-4.** Breeding season home range estimates based on a 95% kernel density estimate derived from 2 male dusky grouse (*Dendragapus obscurus*) marked with Global Positioning System Platform Transmitter Terminals in the Bear River Range, Utah in 2016 and 2017.

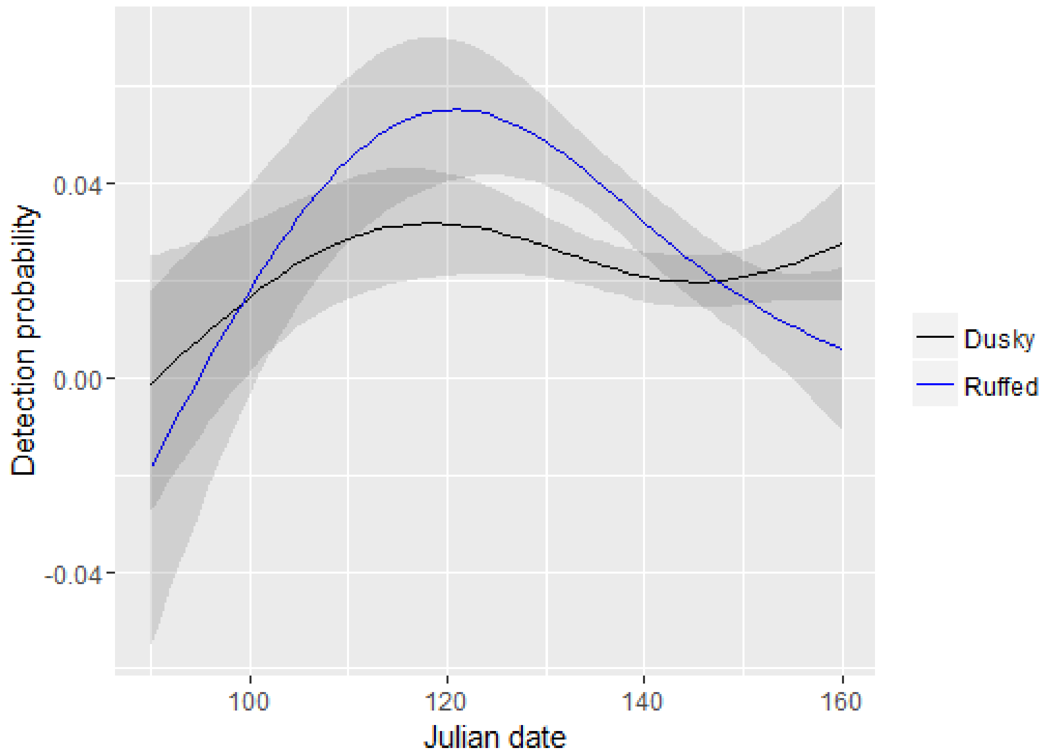


**Figure 2-5.** Male dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) detection rates as a function of Julian date during the April–June 2016–2017 breeding seasons, Bear River Range study area.

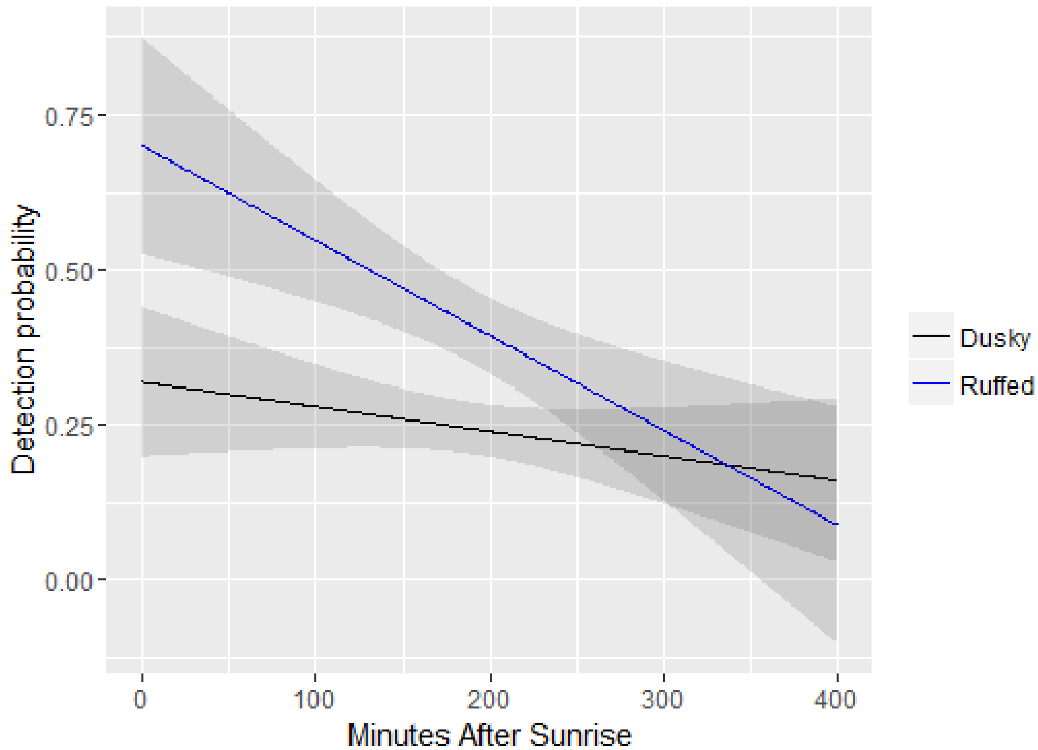


**Figure 2-6.** Male dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) detection rates as a function of minutes after sunrise during the breeding season April–June 2016–2017, Bear River Range study area.

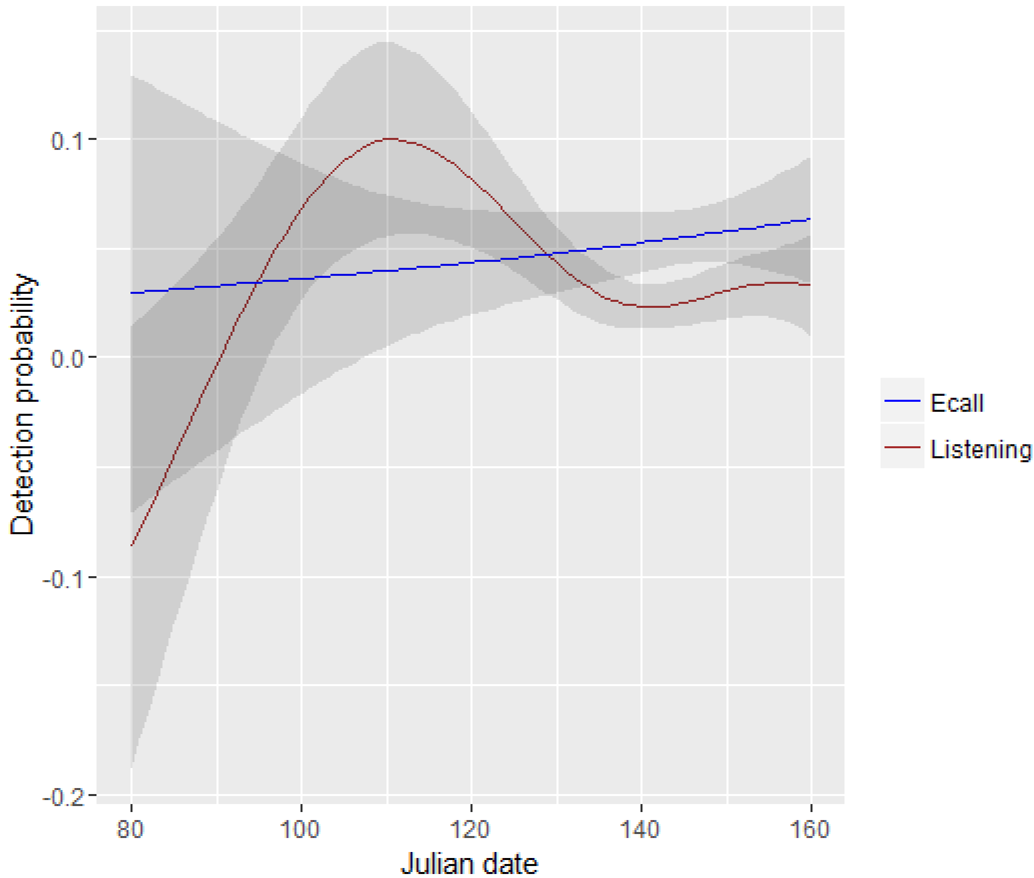


**Figure 2-7.** Detection comparisons of listening intervals versus electronic playback calls for male dusky grouse (*Dendragapus obscurus*) during April–June 2016–2017 breeding seasons, Bear River Range study area.

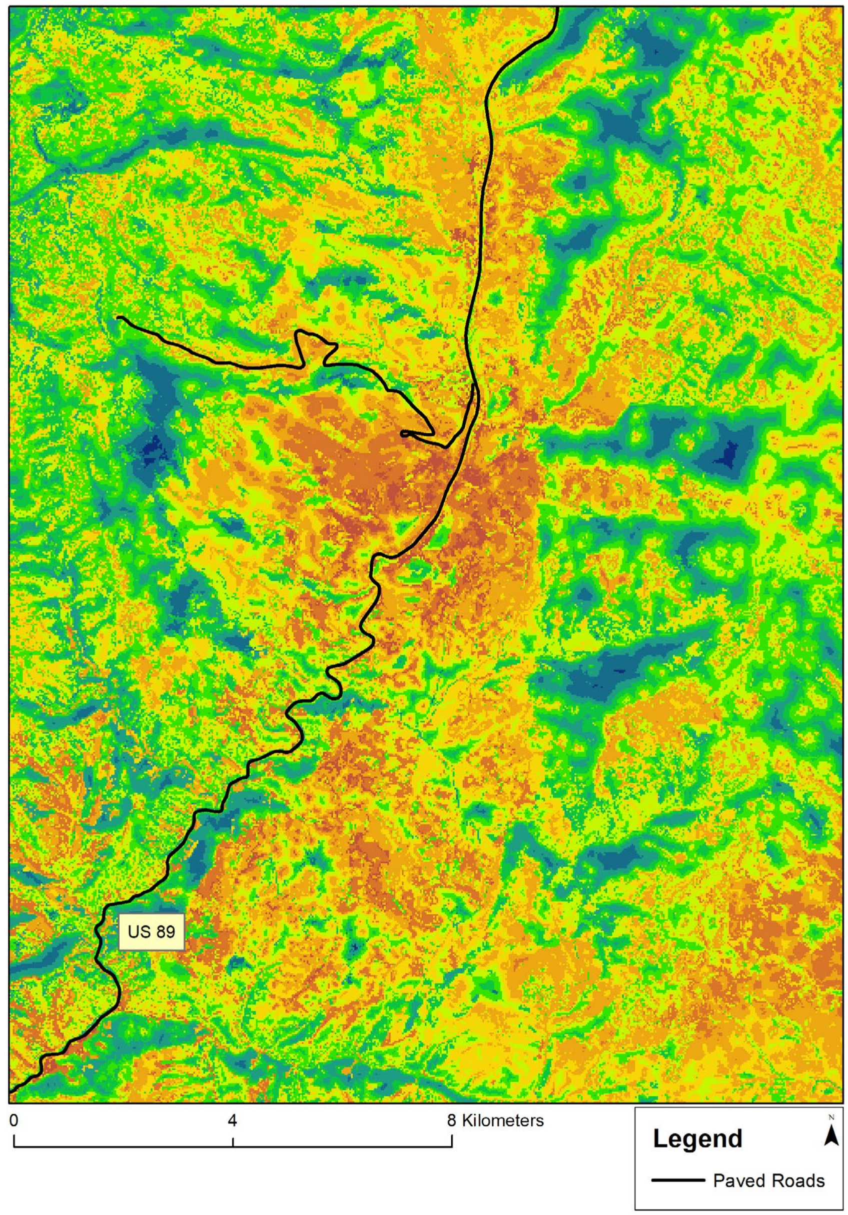


**Figure 2-8.** A heat map of predicted resource selection (i.e., values of 0–1) for dusky grouse (*Dendragapus obscurus*) during the April–June 2016–2017 breeding seasons, Logan Canyon Bear River Range study area, Utah. I assessed habitat selection using predicted bird locations from breeding surveys in 2016 and 2017. Warmer (red) colors represent areas of highest likelihood for detecting dusky grouse.

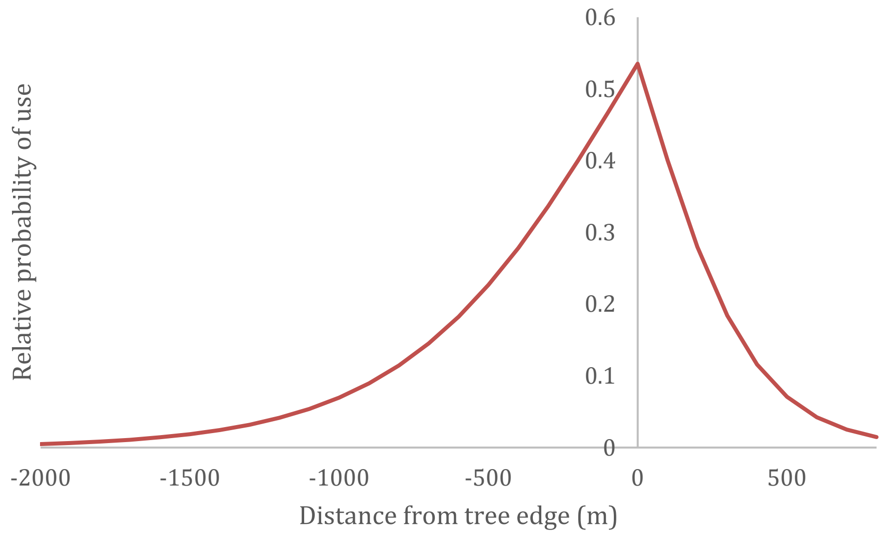


**Figure 2-9.** Piecewise spline for the relative probability of use of dusky grouse (*Dendragapus obscurus*) at the tree edge during the April–June 2016–2017 breeding seasons in the Bear River Range study area. Negative distances were from inside the tree edge and positive distance were outside the trees.

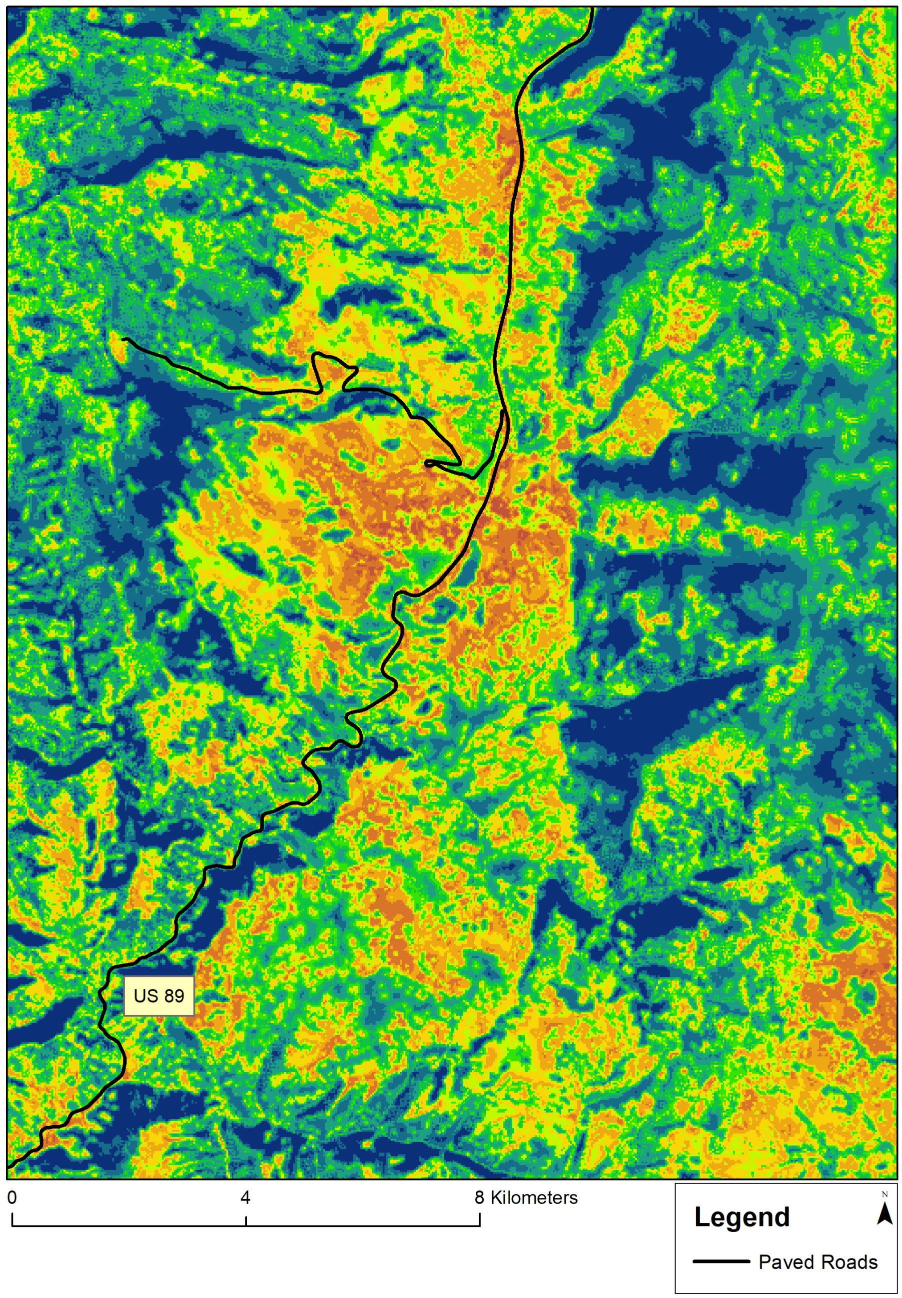


**Figure 2-10.** A heat map of predicted resource selection (i.e., values of 0–1) for ruffed grouse (*Bonasa umbellus*) during the April–June 2016–2017 breeding seasons, Logan Canyon Bear River Range study area, Utah. I assessed resource selection using bird locations from breeding surveys in 2016 and 2017. Warmer (red) colors represent areas of highest likelihood for detecting dusky grouse.

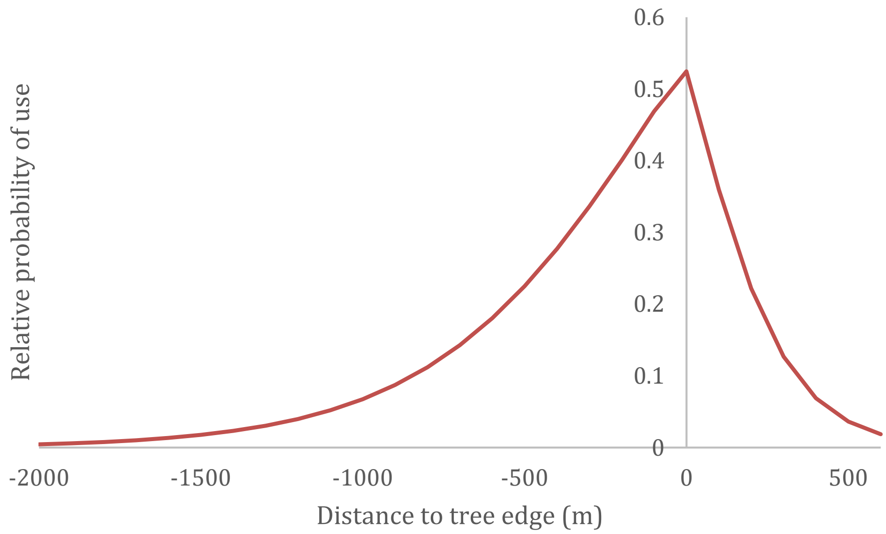


**Figure 2-11.** Piecewise spline for the relative probability of use of ruffed grouse (*Bonasa umbellus*) at the tree edge during the April–June 2016–2017 breeding seasons in the Bear River Range study area, Utah. Negative distances were from inside the trees and positive distance were outside the trees.

# CHAPTER 3

# DUSKY GROUSE BROOD-REARING HABITAT SELECTION WITH SYMPATRIC LIVESTOCK GRAZING IN NORTHERN UTAH

**ABSTRACT**

Dusky grouse (*Dendragapus obscurus*) inhabit montane landscapes in the Bear River Range in northeastern Utah that are often seasonally grazed by livestock. Little is known regarding dusky grouse habitat selection at larger spatial scales. Furthermore, little research has been done to quantitatively evaluate the relationship between dusky grouse and livestock grazing. I assessed habitat selection for brood-rearing dusky grouse and the relationship between dusky grouse and seasonal livestock grazing. From April to August in 2016 and 2017, I captured brood-rearing dusky grouse females and marked them with Global Positioning System (GPS-PTT) rump-mounted radios. I used a resource selection function (RSF) framework by comparing these marked brood female locations to with available resources a. I estimated livestock grazing distribution across pastures where livestock and GPS marked females occurred via systematic transects and the landscape appearance method at the end of the grazing season, in September and October 2016 and 2017. My results suggest that dusky grouse brooding activities were compatible with livestock grazing in areas where mosaics of multiple overstory habitat types and open grassland areas area available. Brood-rearing females selected most for mixed mountain shrub communities (*Prunus virginiana* and *Amelanchier* spp.), followed by aspen (*Populus tremuloides*), and then open grassland and sagebrush (*Artemisia* spp.) communities, although they tended to select against conifers (*Abies* spp., *Picea* spp.,

*Pinus* spp., and *Pseudotsuga menziessi*). Furthermore, broods preferred forest edge; i.e., distinct changes in dominant overstory, tree or shrub, habitat type. My results suggest that dusky grouse brooding activities can be compatible with livestock grazing where multiple overstory habitat types are available. My findings highlighted the need for continued research that explicitly assesses the compatibility of livestock grazing with dusky grouse habitat.

## INTRODUCTION

Throughout much of their distribution, dusky grouse (*Dendragapus obscurus*) inhabit montane landscapes that have often been seasonally grazed by livestock. Brood-rearing females in particularly inhabit lower elevations in the summer months near aspen (*Populus tremuloides*), maple (*Acer* spp.), mountain shrubs, such as chokecherry (*Prunus virginiana*) and serviceberry (*Amelanchier* spp.), and open grassland and sagebrush (*Artemesia* spp.) areas that have often been managed for summer livestock grazing (Mussehl 1963, Maestro 1971, Zwickel 1973, Barnes 1974, Weber 1975). Livestock consume and reduce herbaceous cover, especially grasses, and past literature has strongly implicated livestock grazing as having a negative effect on dusky grouse. However, past research has reported an associative relationship between livestock grazing and dusky grouse; e.g., livestock removes grasses and dusky grouse were located in areas with tall grass. These studies concluded that grazing must have a negative impact on dusky grouse (Mussehl 1963, Zwickel 1972). To date, no quantitative assessments of the influence of livestock grazing on dusky grouse have been completed.

Livestock grazing is the predominant global anthropogenic land use (Alkemade et

al. 2013). Seventy percent of the western United States landscapes have been grazed including private, state, and federally managed lands (Fleischner 1994). Rangeland professionals implement grazing management decisions with the general goal to have sustainable livestock production and rangelands. However, sustainable management may or may not take into consideration the effect livestock grazing can have on wildlife species (Krausman et al. 2009). Improper grazing management may reduce primary forage productivity and alter species composition of grasses, shrubs, and forbs that provide wildlife with food and cover, particularly for many grouse species (Krausman et al. 2009, Boyd et al. 2011). Habitat loss and degradation have been identified as the primary threats to grouse and there is increasing concern for these species (Storch 2007, 2015). Despite current research, the of impact livestock grazing on grouse, especially at landscape scales important to these species, is poorly understood (Zwickel and Bendell 2004, Knick and Connelly 2011, Haukos and Boal 2016). Dettenmaier et al. (2017) identified a void in published studies specifically assessing livestock grazing impacts on grouse vital rates and the authors encouraged more research concerning the impacts to grouse of livestock type, current and historic timing, duration, and stocking rates.

My primary objective was to assess the relationship between brood-rearing dusky grouse and livestock grazing using a resource selection function (RSF) framework (Cooperative Extension Service 1999). My secondary objective was to assess landscape scale (i.e., 3$^{rd}$ order) habitat selection for brood-rearing dusky grouse (Johnson 1980, Boyce 2006). Because of past research, I predicted that livestock distributions would negatively affect dusky grouse brood habitat selection. My null hypothesis was that livestock distributions would not affect dusky grouse habitat selection. I also predicted

that habitat edge, areas of distinct change in the dominant species providing canopy, tree or shrub cover, would be selected for. My null hypothesis is that no resource or landscape feature would influence dusky grouse brood habitat selection, and that all resources would have the same probability of being selected for or against.

**STUDY AREA**

My study area encompassed ~ 120,000 ha of the Bear River Range in Cache and Rich counties in northern Utah. The study area was bounded on the north by the Idaho state line and on the south by Blacksmith Fork Canyon, and from Bear Lake Valley to Cache Valley from east to west, respectively (Fig. 3-1). Most of the study area (83%) was part of the U.S. Forest Service (USFS) Uinta-Wasatch-Cache National Forest Logan Ranger District. Private land constituted 11% of the study area with parcels of private land, usually cabin lots less than 1 ha, located near U.S. Highway 89 and larger parcels up to 10,000 ha in the southeast corner of the study area near Hardware Ranch Wildlife Management Area. Utah School and Institutional Trust Land (SITLA) made up 2% of the study area and Utah Division of Wildlife Resources (UDWR) land made up 4% of the study area. The UDWR land (4,700 ha) consisted of Hardware Ranch, Millville Face, and Richmond Hill wildlife management areas. I primarily focused on USFS lands in Logan Canyon on both sides of Highway 89, which contained the Little Bear and Logan Canyon grazing allotments.

One sheep (*Ovis aries*) grazed pasture within the Little Bear sheep allotment (4,500 ha) was included in my study area, with up to ~ 1,100 ewe-lamb pairs for a permittee-selected 90 consecutive days between June 20 and September 30 (Logan

Ranger District 2018a). Grazing management for the Little Bear allotment consisted of a rotational schedule so that each pasture was completely rested once every six years. The pastures that I sampled were not on a scheduled rest year at any point during my study. Sheep herds rotated pastures when USFS stubble height standards were met (Table 3-1). I also sampled 9 cattle (*Bos taurus*) grazed pastures in the Logan Canyon cattle allotment (7,600 ha), with up to 1,478 cow-calf pairs on three pastures for permittee-selected 105 consecutive days between June 11 and October 5 (Fig. 3-1; Logan Ranger District 2018b). Grazing management consisted of all 9 pastures being grazed every year until USFS stubble height standards were met, but the sequence of pastures grazed changed each year to enable a rotation in growing season rest across all pastures. USFS stubble height standards were the same for both cattle and sheep allotments (Table 3-1).

Elevation ranged from 1450–3043 m in my study area. The Bear River Range included a variety of vegetation types including: conifer (*Abies* spp., *Picea* spp., *Pinus* spp., and *Pseudotsuga menziessi*), quaking aspen, maple, mountain mahogany (*Cercocarpus ledifolius*), mountain shrub, and sagebrush dominated communities. Precipitation varied with elevation, with the average annual precipitation at Temple Fork (approximately in the middle of the study area) being 72.1 cm, with most of the precipitation falling from December through April in the form of snow (Utah Climate Center 2018). Precipitation was higher than average in both 2016 and 2017 at 83.9 cm and 88.1 cm, respectively. Less snow fell in 2016 than in 2017, but the study area received more summer precipitation in 2016 compared to 2017. September 2016 through September 2017 the study area received 95.2 cm of precipitation as opposed to 58.3 cm in from September 2015 to September 2016. The average monthly temperature ranged

from 4° C in December to 19.6° C in July (Utah Climate Center 2018).

## METHODS

### Dusky Grouse Captures

I captured dusky grouse females from April–August in 2016 and 2017. Grouse were captured using several methods including: walk-in style traps, using pointing dogs (*Canis lupus familiaris*) to locate birds and then noose poles to capture, long handled dip nets, and hand-held net launchers (Wildlife Capture Services, Flagstaff, AZ) to secure them (Schroeder 1986, Pelren and Crawford 1995, Dahlgren et al. 2012). I used several different breeds of dog, primarily pointing breeds, to aid in locating grouse for capture including: German shorthaired pointer, German wirehaired pointer, Llewellin setter, Brittany, and English springer spaniel. I marked all captured grouse with an aluminum leg band, and a subsample of yearling and adult female grouse with Global Positioning System (GPS) rump-mount radios. Additionally, each captured grouse received.

In 2016, I used solar-powered GPS Platform Transmitter Terminal (GPS-PTT) ARGOS-enabled transmitters from Microwave Telemetry, Inc. (Microwave Telemetry, Inc., Columbia, MD). In 2017, I used solar-powered GPS store-on-board remote download transmitters from Ecotone (Ecotone Telemetry, Gdynia, Poland). All GPS transmitters were programmed to record 6 locations daily, and included either Very High Frequency (VHF) or Ultra High Frequency (UHF) ground-tracking signals. I monitored each radio-marked female following capture until the female migrated from its summer range to winter range. Females that successfully hatched nests (i.e., ≥ 1 egg hatched) and females that had chicks present when they were captured, were monitored at least until

the chicks were 50 days old. When chicks were captured, I estimated chick age following criteria reported by Zwickel and Lance (1966).

**Grazing Forage Surveys**

To estimate the spatial distribution of livestock grazing, I completed grazing forage removal surveys at the conclusion of the livestock grazing season on 10 USFS pastures containing my radio-marked brood-rearing females in September–October of 2016 and 2017 using a modified landscape appearance method (Gillen et al. 1984, Cooperative Extension Service 1999). I designed forage removal surveys in ArcMap 10.3.1, which consisted of systematically placing linear transects 0.5 km apart, where each transect traversed the entire pasture from border to border (ESRI, Redlands CA). I located a survey plot every 100 m along each transect and the observer completed an ocular forage removal estimate for all grass species in a 5 x 5 m area by comparing observations with written descriptions of each forage removal class. I classified each survey plot into one of seven categories, one being little or no forage removal and a seven being the highest level of forage removal (Table 3-2). Survey plots located with 30% slope on cattle grazed pastures were assumed to have little forage removal and given a value of one (Cook 1966). If a plot ended up in a location that could not be sampled (e.g., a road or pond, etc.), the observer moved forward 10 m on the transect and completed a survey.

**Landscape Variables**

I selected landscape variables RSF analyses based on potential relevance to dusky grouse. I acquired spatial data t from the Utah Automated Geographic Reference Center

(<www.gis.utah.gov>, accessed 21 March 2018) or U.S. Geological Survey LANDFIRE 2014 vegetation cover type dataset (LANDFIRE 2014). All resource variables were 30 $m^2$ cells. Slope and elevation were derived from Utah Digital Elevation Model (<www.gis.utah.gov>, accessed 21 March 2018). I developed distance-to metrics for surface water from streams, springs, and lakes, using Euclidean distance estimates in ArcMap 10.3.1 and the National Hydrography Dataset (<www.gis.utah.gov>, accessed 21 March 2018). I obtained categorical values of vegetation land cover types from the LANDFIRE 2014 data and combined cover types into five basic vegetation communities including: conifer, aspen, mountain shrubs, open (i.e., sagebrush or grassland), and other (cliffs, development, etc.; Table B-2). Because dusky grouse may be influenced by edge effects of tree cover (Martinka 1972), I estimated distance from forest edge moving inward and outward as delineated by LANDFIRE 2014.

I interpolated grazing data using an inverse distance weighted (IDW) tool in ArcMap 10.3.1, which resulted in every 30 x 30 m cell assigned a value by taking the average of the 12 surrounding grazing values. I used the IDW tool for each pasture independently as fences kept livestock within pastures. The interpolated spatial data was a probability value between 0 and 1 and could be displayed as a heat map indexing livestock distribution. I used the livestock distribution values across pastures as an independent variable within the dusky grouse brood resource selection analysis described below.

**Habitat Selection Analysis**

I used an RSF at the third order scale (Johnson 1980) within a used-available

design with used locations from radio-marked brood female GPS data (Manly et al. 2002). I measured fix success for each female by taking the actual number of successful fixed locations divided by the total possible number of locations given the pre-programed fix schedule of 6 locations per day. Females with less than 80% fixed success were censored from the analysis.

I estimated home-range size for broods by calculating the 95% kernel home range using the KernelUD tool in the adehabitat package (Calenge 2011) in R. Brood locations were compared to every available 30 x 30 m cell within each home range. I extracted covariate data by the intersection with brood and all available locations. I evaluated resource selection of dusky grouse broods as a function of the aforementioned landscape variables using generalized linear mixed models (GLMMs). The use of GLMMs allowed me to ignore spatial autocorrelation for the locations of an individual brood female by estimating random and fixed effects and to compare year-specific use locations for each female to locations available to that individual within a given year (Gillies et al. 2006, Bolker et al. 2009). The RSF model was calculated as follows with g($x$) estimated for location $i$ of individual $j$:

$$g(x) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \cdots \beta_n x_{nij} + \gamma_{0j}$$

where $\beta_0$ is the mean intercept, $x_n$ are covariates with fixed regression coefficient $\beta_n$ , and $\gamma_{0j}$ is the random intercept for individual $j$.

I accounted for annual variation in home range selection by separating brood seasons by year (e.g., Female-A in 2016 and the same Female-A in 2017 were treated as two separate individuals). All landscape variables were normalized (m = 0, sd = 1) to

assist with model convergence. Because my sampled data comprised of zeros and ones, I was able to implement logistic regression in my models. I used all variables and combinations and did not employ a model selection approach because of the lack of information on dusky grouse brood resource selection and due to my interest in the relative impacts of landscape variables on brood-rearing females. A priori sampling demonstrated a better representation of habitat selection for dusky grouse using categorical vegetation data. Beta estimates for each independent variable were relative to a pre-selected independent variable. For example, Beta estimates for the four vegetation categories (i.e. aspen, mountain shrub, open, 'other') were relative to the first variable listed, in this case, conifers. A positive land cover coefficient indicated stronger selection than conifers and negative indicated weaker selection than conifers.

For landscape variables classified as distance metrics, except for distance to inside tree edge, in the model summary table (Table 3-3), a positive coefficient indicated avoidance while a negative coefficient indicated selection. Positive outside tree edge negative inside tree edge indicated selection for the edge and vice versa. For distance to edge, inside or outside the edge, I constructed a piecewise spline graph (Fig. 3-2) representing the relative probability of use. A positive coefficient for slope, elevation, and livestock distribution, indicated brood selection for that land cover type.

## RESULTS

I obtained 888 brood-rearing grouse locations from four GPS marked brood females in 2016 and n = 1312 locations from six brood females in 2017 (Fig. 3-3). In my sample of radio-marked brood-rearing females, ten of eleven transmitters gave over 80%

of the possible GPS fixes (Table. 3-4). I assessed forage removal from 783 plots in both 2016 and 2017 as an index for livestock distribution. I recorded higher forage removal values overall in 2016 than in 2017 (2016 mean = 2.213 sd = 0.439 and 2017 mean = 1.788 sd = 0.611; Fig. 3-3).

The resulting beta coefficients for the RSF differed from 0 except for distance to water and 'other' land cover types (Table 3-3). Brood-rearing females showed strongest selection for mountain shrub communities ($\beta = 0.986$ sd = 0.085), then aspen ($\beta = 0.694$ sd = 0.077), and open communities ($\beta = 0.506$ sd = 0.108) also being selected for more than the conifers. Broods selected for forest edge, both inside ($\beta = 0.532$ sd = 0.061) and outside ($\beta = -0.126$ sd = 0.053), although inside tree edge had a stronger selection (Fig. 3-2). Females selected against areas with high livestock distributions ($\beta = -0.153$ sd = 0.035). Dusky grouse brood-rearing females also selected for lower elevations ($\beta = -0.514$ sd = 0.040) with more moderate slopes ($\beta = 0.155$ sd = 0.024; Fig. 3-4, Fig. 3-5).

## DISCUSSION

The relationship between dusky grouse brood habitat selection and livestock distribution was weakly negative (Table 3-3). Selection against higher livestock distribution levels was likely an artifact of other indirectly related selective factors. For example, livestock selected for more open areas farther away from forest edges and the mountain shrub communities preferred by dusky grouse broods. Because of my findings, I suggest that past studies which reported anecdotally-based negative impacts from grazing on dusky grouse brood-rearing habitat may not have accounted for broader landscape-scale difference in locations selected by grouse and livestock (Marshall 1946,

Mussehl 1963, Stauffer and Peterson 1985, and Weber 1975). Conversely, my preliminary results do not mean that livestock grazing may not negatively impact dusky grouse broods but rather suggest a more research is needed to better define this relationship.

Although the methods I used to assess livestock distribution through forage removal was sufficient for this study, one weakness of the landscape appearance method is that this method is qualitative and does not allow precision of estimates (Cooperative Extension Service 1999). I decided to use the landscape appearance method because large pastures could be quickly sampled with limited labor. The USFS currently uses forage removal standards to determine sustainable rangeland conditions for livestock. However, these standards do not necessarily consider benefits to wildlife (Logan Ranger District 2018a).

In my study, brood-rearing dusky grouse preferred mountain shrub communities, followed by aspen, sagebrush, and grassland. When selecting for these habitat types, dusky grouse broods used forest edges. Although dusky grouse broods selection of these vegetation communities has been reported in other studies, my study was the first to quantify and compare selection at landscape scales (Maestro 1971, Mussehl 1963, Stauffer and Peterson 1985, Weber 1975). As mountain shrub's berries ripen they become increasingly important for broods (Mussehl 1963). Aside from feeding, broods may use more open understory in mixed shrub communities for predator avoidance and loafing (Stauffer and Peterson 1985, Zwickel and Bendell 2004). My research and others have shown that dusky grouse broods have been reported to frequent open vegetation communities such as mule's ear and balsamroot (Mussehl 1960, 1963), likely in search of

arthropods, particularly grasshoppers, for chick growth (Barnes 1974, Beer 1943, Weber 1972). Weber (1975), in a study area within 20 km of mine, found that dusky grouse chicks in June, July, and the early part of August had a higher percentage of grasshoppers in their crops than any other food item.

Aspen stands are also used by brood-rearing dusky grouse to seek out food, loafing cover, and refuge from predators (Maestro 1971, Weber 1975, Zwickel and Bendell 2004). Young aspen stands may be particularly important because they have a higher tree density and provide cover with vertical structure that grouse use for predator avoidance (Martinka 1972). Healthy aspen stands also have diverse understory communities, including forbs that are important for arthropods that may benefit broods. Stauffer and Peterson (1986) found that dusky grouse broods did not select late seral aspen stands as often as expected, likely because of the loss of quality understory.

Forest edge habitat, both inside and outside edge, was highly selected for by dusky grouse broods. Similar to my research, previous studies reported most brood observations in more open shrub and grasslands were within 50 m of tree cover (Barnes 1974, Mussehl 1963, Weber 1975, Zwickel and Bendell 2004). Brood-rearing females may utilize the tree edge because of the ease of access to a diversity of resources found in open and forested landscapes (Ries et al. 2004). Sunlight levels near the forest edge can increase plant community diversity, which likely benefits broods searching out forbs and insects (Ortega and Capen 1999, Watkins et al. 2003).

Brood-rearing females selected for lower elevations with moderate slopes. The open and sagebrush communities that brooding females selected for mostly occurred at the lower elevations within my study area. Distance to a water source was not a

significant factor within my analyses and suggested that dusky grouse broods did not select for riparian or open water sources at the third order scale. Similarly, Weber (1975) suggested that broods did not utilize free-standing water, but he did report that broods used mesic habitats for insects and cover. Certain types of succulent foods may preclude dusky grouse from needing to consume free water (Beer 1943). Use of free water may be more prevalent in drier areas or years, though more research in other areas and years is needed to assess this relationship (Wing et al. 1944, Marshall 1946).

To my knowledge, this research was the first study to mark dusky grouse with GPS transmitters, which allowed for collection of large location datasets in short time frames. A challenge to using solar-powered GPS transmitters was maintaining enough battery charge to consistently acquire locations as dusky grouse spent longer periods of time under tree canopy in the fall and winter. Inconsistent GPS locations have the potential to result in biased location data sets. All but one radio-marked brood-rearing female had over 80% fixed success during my study (Table 3-4). A decrease in fix-rates during the fall and winter for brooding females demonstrated a definitive shift in seasonal habitat selection and may have resulted in a more biased location history during these periods. Lastly, the selection for forest edges suggests that the solar panels would have a higher likelihood of being exposed to direct sunlight. Therefore, given the high fixed success rates and these other factors, I assumed that locations from my sample of GPS marked brooding females were representative of the population and not biased against tree cover.

My study has demonstrated the need for continued research to better understand dusky grouse. In particular, brood spatial relationships with livestock distributions as well

as mesic areas and free-standing water could be of future interest. With advances in GPS technology, we can fine-tune our understanding of dusky grouse habitat selection and relationships with their environment. Research concerning brood habitat selection in early (i.e., chicks < 3 weeks old) and late season (i.e., chicks > 3 weeks old) brood-rearing would be beneficial, as there are likely differences. Additionally, research to better understand daily habitat selection differences; e.g., early morning, afternoon, evening, and nocturnal roosting, may benefit future conservation of brood-rearing habitats.

## MANAGEMENT IMPLICATIONS

My study suggested that to conserve brooding habitat, livestock grazing regimes should be maintained, while seeking opportunities to increase heterogeneity on rangelands and prevent localized instances of overgrazing. Other research has shown that prescribed fire may be used on areas where climax conifer species, like subalpine fir and Douglas-fir, were encroaching on aspen communities to increase early seral aspen communities, thus providing more and higher quality dusky grouse brooding habitat. However, managers should consider conserving conifer stands for dusky grouse winter habitat. Management such as disking, mowing, herbicide, and prescribed fire in these high elevation rangelands also has potential to stimulate perennial grass growth and enhance forb production. However, these same techniques can also promote invasive plant species. Therefore, reseeding and revegetation techniques may be important measures to counteract this potential for negative impacts.

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**TABLES AND FIGURES**

**Table 3-1.** U.S. Forest Service grazing utilization and stubble height standards as found on https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5190207.pdf

| Vegetation Type | Utilization or Stubble Height Standard |
|---|---|
| Upland and Aspen (Populus tremuloides) | 50% |
| Riparian Class I (away from the greenline) | 50% |
| Riparian Class II and III (away from the greenline) | 60% |
| Upland/Riparian shrubs and trees (all classes) | 50% current year's growth |
| Riparian Class I (Greenline) | ≥5" |
| Riparian Class II (Greenline) | ≥4" |
| Riparian Class III (Greenline) | ≥3" |

**Table 3-2.** Herbaceous forage removal classes and descriptions for the landscape appearance method found at https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044249.pdf

| Class | Class % | Description of Landscape Method |
|---|---|---|
| 1 | 0–5% | The rangeland shows evidence of no grazing or of negligible use |
| 2 | 6–20% | The rangeland has the appearance of very light grazing. The herbaceous forage plants may be topped or slightly used. Current seed stalks and young plants are little disturbed. |
| 3 | 21–40% | The rangeland may be topped, skimmed, or grazed in patches. The low value herbaceous plants are ungrazed and 60 to 80 percent of the number of current seed stalks of herbaceous plants remain intact. Most young plants are undamaged. |
| 4 | 41–60% | The rangeland appears entirely covered as uniformly as natural features and facilities will allow. 15 to 25 percent of the number of current seedstalks of herbaceous species remain intact. No more than 10 percent of the number of low-value herbaceous forage plants are utilized. |
| 5 | 61–80% | The rangeland has the appearance of complete search. Herbaceous species are almost completely utilized, with less than 10 percent of the current seedstalks remaining. Shoots of rhizomatous grasses are missing. More than 10 percent of the number of low-value herbaceous forage plants have been utilized. |
| 6 | 81–94% | The rangeland has a mown appearance and there are indications of repeated coverage. There is no evidence of reproduction or current seedstalks of herbaceous species. Herbaceous forage species are completely utilized. The remaining stubble of preferred grasses is grazed to the soil surface. |
| 7 | 95–100% | The rangeland appears to have been completely utilized. More than 50 percent of the low-value herbaceous plants have been utilized |

**Table 3-3.** Resource Selection Function models incorporating abiotic, biotic, and anthropogenic variables for dusky grouse (*Dendragapus obscurus*) through the brooding season (June–August 2016–2017) on the Bear River Range, Utah study area.

| Variables | B | SE | *p* |
| --- | --- | --- | --- |
| Intercept | -0.87201 | 0.32299 | 0.007 |
| Elevation | -0.51407 | 0.04038 | ≤0.001 |
| Slope | 0.15517 | 0.02400 | ≤0.001 |
| Livestock distribution | -0.15268 | 0.03509 | ≤0.001 |
| Distance to water | 0.05832 | 0.03409 | 0.087 |
| Distance to tree edge (inside) | 0.53207 | 0.06134 | ≤0.001 |
| Distance to tree edge (outside) | -0.12607 | 0.05343 | 0.018 |
| Conifer | n/a[a] | n/a[a] | n/a[a] |
| Aspen (*Populus tremuloides*) | 0.69354 | 0.07688 | ≤0.001 |
| Mountain shrubs | 0.98644 | 0.08461 | ≤0.001 |
| Open (*Artemisia* spp. and grassland) | 0.50579 | 0.10824 | ≤0.001 |
| Other (developed) | -1.76431 | 1.02155 | 0.084 |

[a]All other variables measured against conifer

**Table 3-4.** Fixed success for brooding female dusky grouse (*Dendragapus obscurus*) marked with rump-mounted Global Positioning System Platform Transmitter Terminals (GPS-PTTs) in the Bear River Range, Utah study area, June–August 2016–2017.

| Bird ID | Year | Number of Actual Locations | Fixed Success % |
|---|---|---|---|
| DGF127750A | 2016 | 291 | 97 |
| DGF127737A | 2016 | 300 | 100 |
| DGF127729B | 2016 | 108 | 100 |
| DGF127732A[a] | 2016 | 191 | 64 |
| DGF127733A | 2016 | 189 | 81 |
| DGF127733A | 2017 | 273 | 91 |
| DGF127737A | 2017 | 288 | 96 |
| DGFHAR07A | 2017 | 95 | 99 |
| DGFHAR08A | 2017 | 289 | 96 |
| DGFHAR05A | 2017 | 246 | 100 |
| DGFHAR16A | 2017 | 121 | 96 |

[a]The brood-rearing female with GPS fixed success less than 80% was not included in resource selection analysis

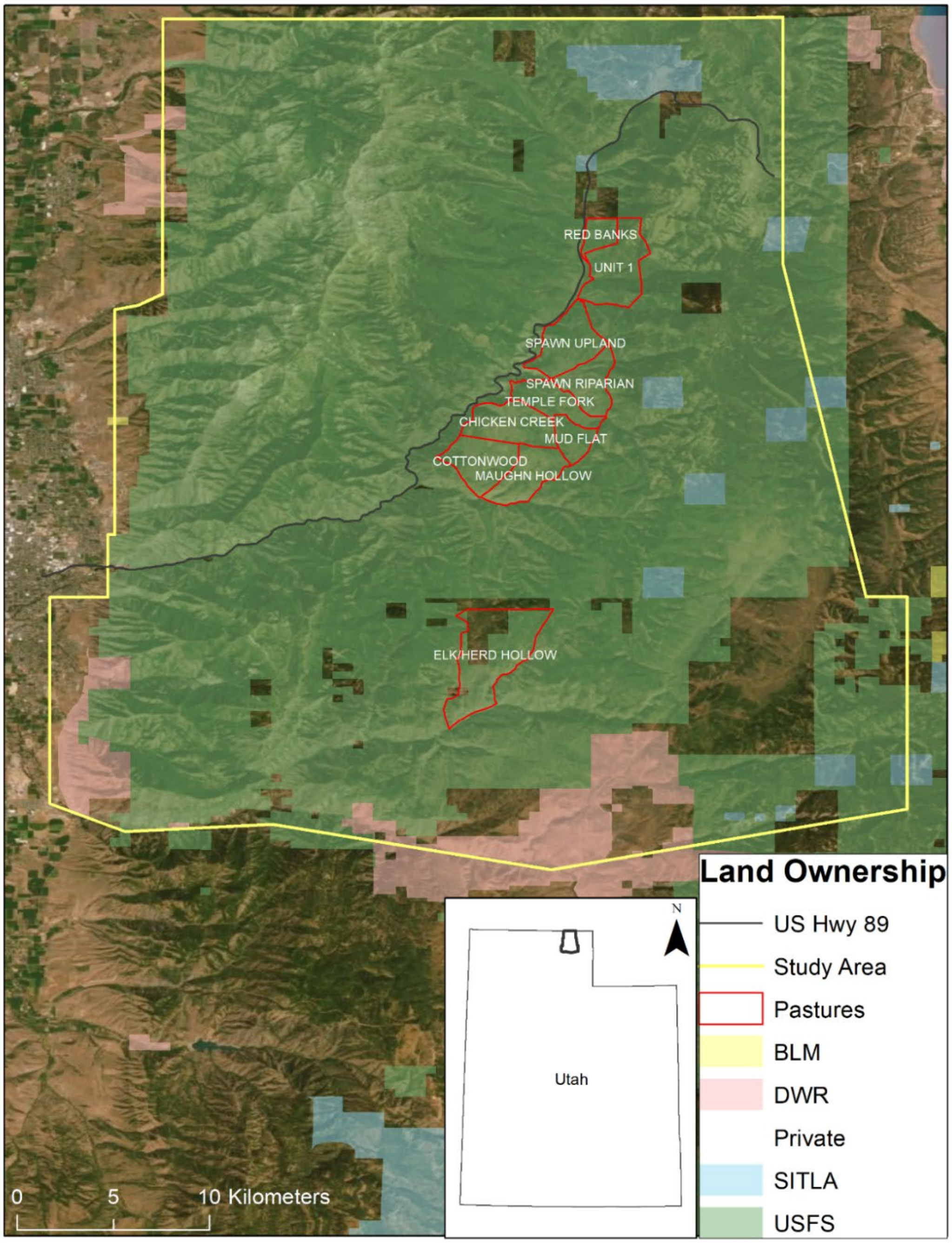


**Figure 3-1.** Dusky grouse (*Dendragapus obscurus*) study area in the Bear River Range, Utah 2016–2017. I surveyed the 10 pastures shown for grazing forage removal using the landscape appearance method. The study area was made up of different property ownership including: Utah Division of Wildlife Resources (DWR), Utah School Institutional Trust Land Administration (SITLA), U.S. Forest Service (USFS), and privately-owned lands.

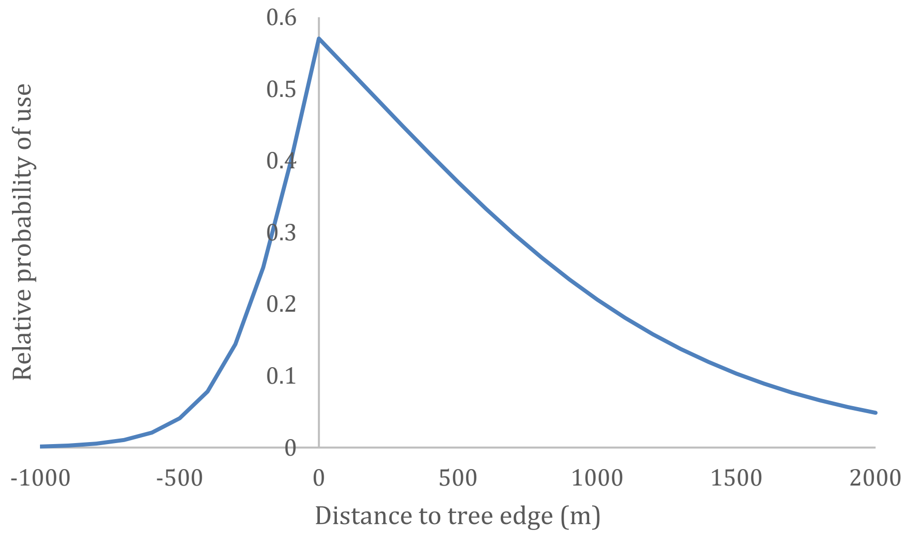


**Figure 3-2.** Piecewise spline for the relative probability of use of dusky grouse (*Dendragapus obscurus*) at the forest edge boundary during the June–August 2016–2017 brood-rearing seasons in the Bear River Range study area. Negative distance was from inside the trees and positive distance was outside the trees.

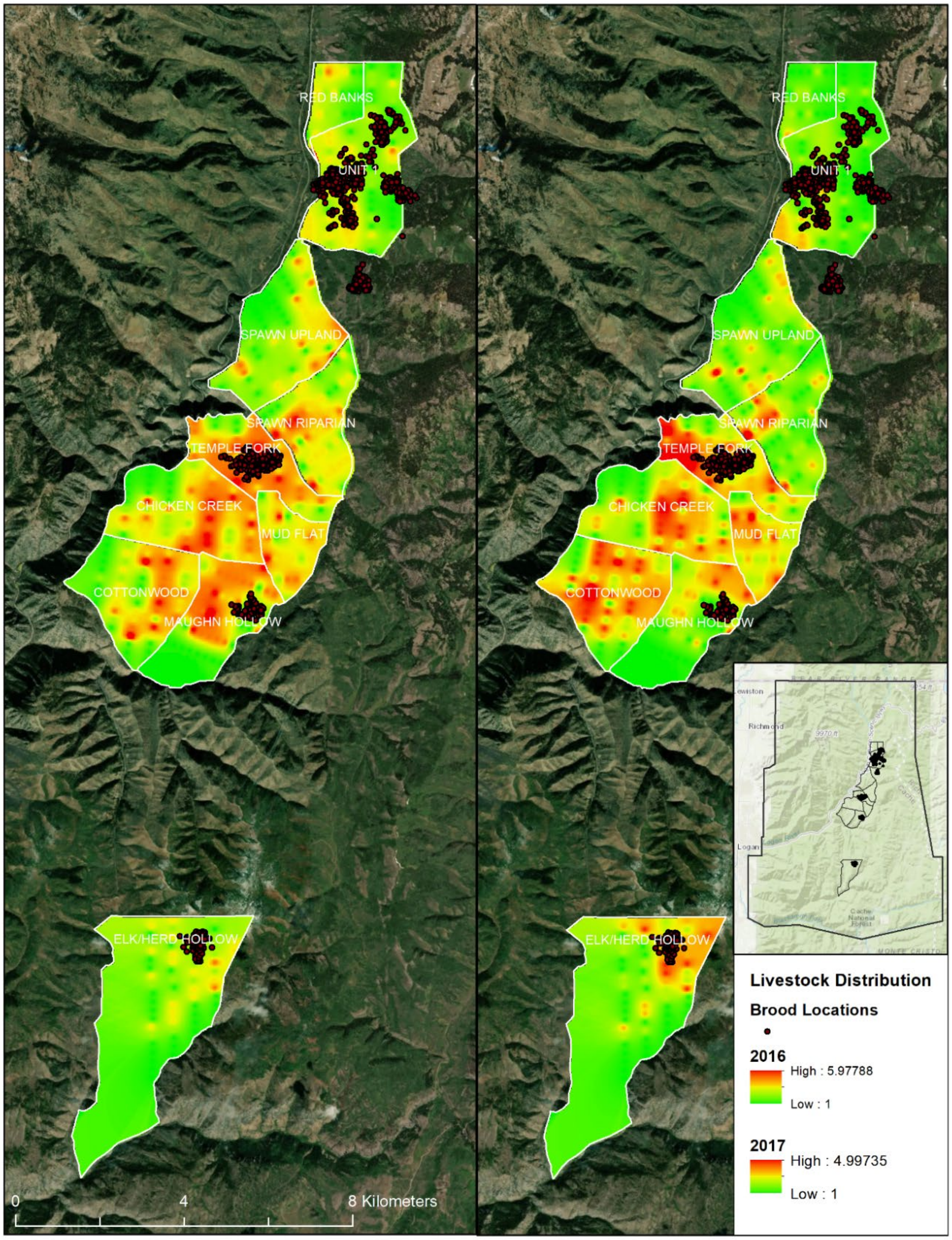


**Figure 3-3.** Heat map of grazing livestock distributions and Global Position System marked dusky grouse (Dendragapus obscurus) brood-rearing females in the Bear River Range, Utah study area September–October 2016–2017. I derived livestock distributions using forage removal estimates across 10 pastures and then interpolating the resulting values.

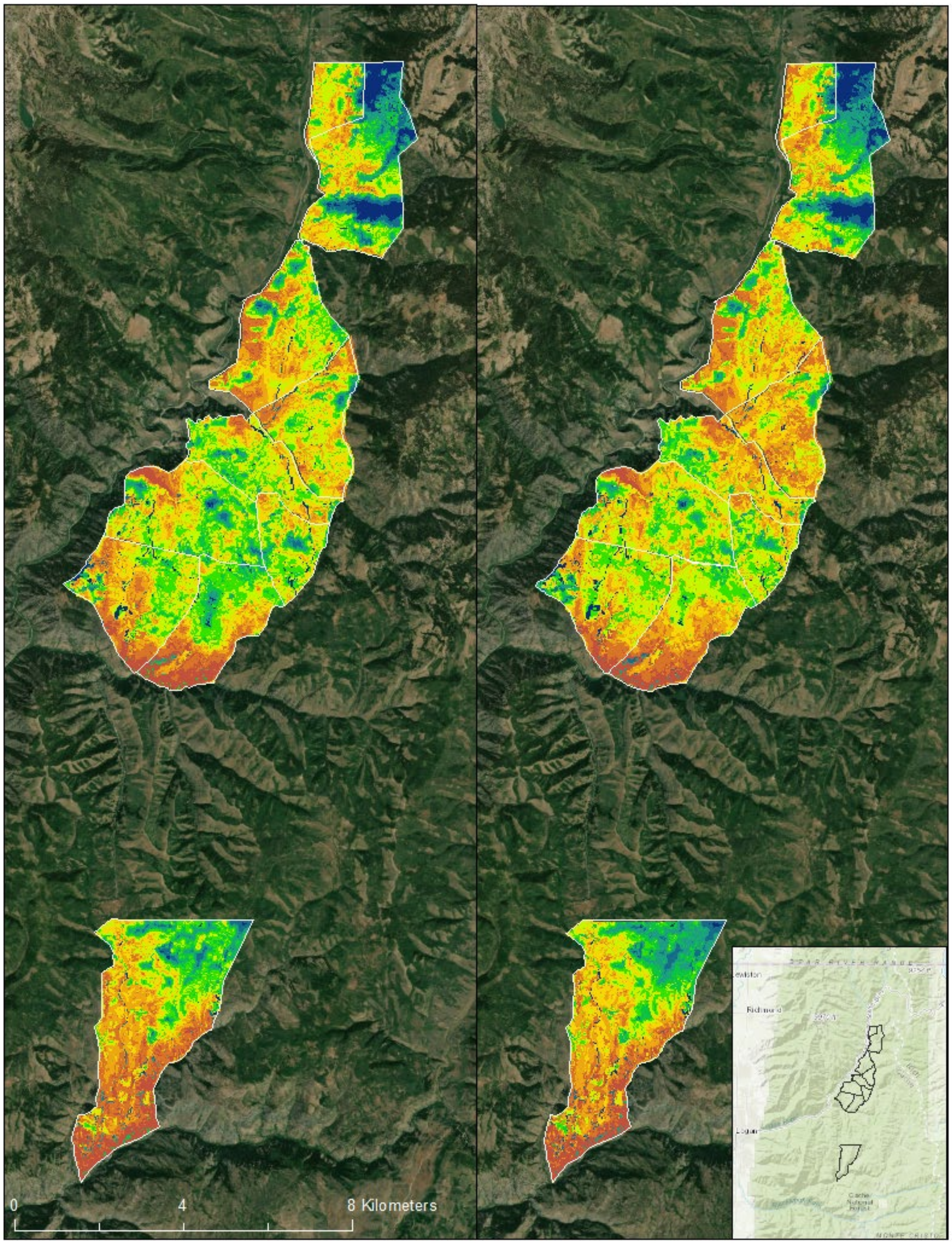


**Figure 3-4.** A heat map of predicted habitat selection (i.e., values of 0–1) for dusky grouse (*Dendragapus obscurus*) during the June–August 2016 (left) and 2017 (right) brooding seasons in the Bear River Range study area, Utah. I assessed habitat selection using locations from Global Positioning System marked brood-rearing females. Warmer colored 30 $m^2$ pixels (red) represent areas of highest likelihood for brood use and colder colored pixels (blue) represent areas of lowest likelihood for brood use.

# CHAPTER 4

# ASSESSMENT OF FOREST GROUSE HARVEST IN NORTHERN UTAH


## ABSTRACT

Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*), i.e., forest grouse, are native gamebirds of Utah and pursued annually by over 12,000 hunters. There is currently a lack of information regarding population trends and hunter harvest for forest grouse in the western U.S., including Utah. Voluntary wing collection (i.e., wing barrels) is a method for acquiring population and harvest trend estimates of forest grouse. Estimates can be made for the collected wings regarding species, age, and sex. For 2015–2017 hunting seasons (September 1–December 31), I set up ten wing-collection barrels in Logan and Blacksmith Fork Canyons in the Bear River Range, Utah. I also captured and leg banded both dusky and ruffed grouse prior to the hunting seasons of 2015–2017 (n = 21 ruffed and n = 89 dusky grouse). I collected 340, 332, and 278 forest grouse wings in 2015, 2016, and 2017 respectively. Most wings were deposited in September during weekends, especially on weekends of big game hunt openers. From collected wings, I determined that the dusky grouse age ratios exhibited an older population structure, particularly in 2015, compared to ruffed grouse. I did not receive any leg-band returns until 2017 when 2 marked dusky grouse were reported. Wing collection data proved useful in estimating population dynamics. The low leg-band returns suggested hunter harvest was limited within my study area, which has reportedly the highest hunting pressure of any area in Utah. This level of harvest likely had minimal impacts on the forest grouse populations in the Bear River Range.

**INTRODUCTION**

Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) are native gamebirds in Utah and hunting is managed by the Utah Division of Wildlife Resources (UDWR). Dusky grouse and ruffed grouse are highly sought after by Utah upland bird hunters. Over 12,000 hunters harvested over 47,000 dusky and ruffed grouse collectively in 2016 (Bernales el al. 2016). The UDWR manages both species in combination as forest grouse for harvest. This means that daily bag and possession limits for hunters include both dusky and ruffed grouse in aggregate (i.e., any combination of the two species up to the limit). Of the 13 western states and provinces that hunt forest grouse species, 10 states and provinces have aggregated daily bag and possession limits for forest grouse. During this research Utah's forest grouse season began September 1 and ended December 31 of each year. The bag and possession limits were 4 and 12, respectively. Over the last several decades, with some small variations, the season has generally begun in early September and ended in November or December with similar bag and possession limits.

Although forest grouse in western states have been harvested under state regulations in for many years, little is known about the effects of harvest on dusky grouse populations. Harvest impacts on ruffed grouse have been studied, but all studies occurred in the eastern part of their range and little is known about populations in the West (DeStefano and Rusch 1986, Small et al. 1991, Devers et al. 2007, Knoche and Lupi 2013). Thus, we currently have no information on harvest rates or the impact of harvest for either forest grouse species in Utah. Each state periodically surveys hunters and reports harvest estimates, but this information can be biased by hunter-effort (Rupp et al.

2000). Furthermore, without baseline information on population levels, the harvest rate and its impacts are of little use.

Wildlife managers use information gathered from hunters to better understand population dynamics, including age and sex composition, from voluntary wing collection (Hoffman 1981, 1985). Wing collection stations (i.e., wing barrels) are commonly used to collect wings from dusky grouse gamebird species (Hoffman 1981). By analyzing dusky grouse wings, biologist have estimated age and sex composition, nest hatch dates, female nest success, and production within populations (Bunnell et al. 1977, Hoffman 1983). These data can also provide insights into population dynamics, such as a good reproductive year may yield high juvenile to adult ratios of harvested birds and vice versa for a poor reproductive year. Changes in population abundance, may be estimated by using leg-band returns to assess differences in births, deaths, immigration, and emigration, within a capture-mark-recapture framework (Brownie et al. 1985, Buckland et al. 2000). Although wing data allows for a better understanding of some population dynamics, including productivity; however, population estimates cannot be obtained without significant sample sizes and band returns (Broms et al. 2010).

In recent decades in Utah, forest grouse are the only upland game that have been demonstrating an upward trend in the number of hunters that pursue them (Bernales et al. 2016). One possible explanation for the reason hunters have been increasingly pursuing forest grouse is that in Utah the species primarily inhabit public lands, much of which is managed by the U.S. Forest Service (USFS), and is readily accessible to the public. The purpose of this study was to gather and assess harvest information from wing collection and band return data for forest grouse in the Bear River Range, Utah.

**STUDY AREA**

My study area encompassed ~ 120,000 ha of the Bear River Range in northern Utah (Fig. 4-1). The study area included montane areas in Cache and Rich Counties and was bounded on the north by the Idaho state line, on the south by Blacksmith Fork Canyon, and to the west by Cache Valley and to the east by Bear Lake Valley. Most of my study area was open to hunting and publically accessible by hunters with ~ 83% USFS Uinta-Wasatch-Cache National Forest in the Logan Ranger District, ~ 2% Utah School and Institutional Trust Land (SITLA), and ~ 4% UDWR wildlife management areas (Fig. 4-1). Private land constituted about 11% of the study area with parcels of private land cabin areas less than 1 ha, located near U.S. Highway 89 and larger parcels up to 10,000 ha in the southeast corner of the study area, near Hardware Ranch Wildlife Management Area.

More hunters annually pursue forest grouse in Cache County than any other county in Utah (Bernales et al. 2016). Hunters generally pursue forest grouse in small groups by walking through areas with tree cover and often with the aid of dogs (*Canis lupus familiaris*) to locate, point or flush, and retrieve downed game. Other hunters harvest forest grouse as they flush them incidentally while in pursuit of big game. Generally, hunters have used shotguns to harvest grouse, but archery, and pistols were also permitted for harvesting forest grouse (UDWR 2018)

Elevation ranged 1450–3043 m in my study area. Vegetation types in the Bear River Range varied and included: conifer (*Abies* spp., *Picea* spp., *Pinus* spp., and *Pseudotsuga menziessi*), quaking aspen (*Populus tremuloides*), maple (*Acer* spp.), mountain mahogany (*Cercocarpus ledifolius*), mixed mountain shrub such as

serviceberry (*Amelanchier* spp.) and chokecherry (*Prunus virginiana*), and sagebrush (*Artemisia* spp.) communities.

Precipitation in the study area varied with elevation. The average annual precipitation at Temple Fork was 72.1 cm, with most of the precipitation falling from December through April in the form of snow (Utah Climate Center 2018). Precipitation was higher than average in both 2016 and 2017 at 83.9 cm and 88.1 cm. Less snow fell in 2016 than in 2017, but the study area received more summer precipitation in 2016 compared to 2017. From September 2016 through September 2017 the study area received 95.2 cm of precipitation as opposed to 58.3 cm in 2015. The average monthly temperature ranged from a high of 19.6° C in July to a low of -4° C in December (Utah Climate Center 2018).

## METHODS

### Harvested Wing Information

I placed wing collection barrels at ten locations at all major intersections where unpaved roads met Highway 89 (i.e., Logan Canyon) and State Route 101 (i.e., Blacksmith Fork Canyon) for the duration of the forest grouse hunt (September 1–December 31, 2015–2017; Fig. 4-2). I positioned each wing barrel for high visibility and accessibility by hunters. After consulting with the UDWR about wing barrel construction and placement, I constructed them by using two t-posts, an orange 19 L bucket with a lid, and a corrugated plastic sign (Fig. 4-3). I cut a rectangular hole into the bucket lid large enough to fit dusky grouse wings into the barrel and the signs were then zip-tied to the t-posts. Voluntary hunters were instructed to place one wing from each harvested bird into

the wing barrel. I collected wings twice per week, following weekdays (Friday morning) and following weekends (Monday morning) in order to acquire harvest distribution over space and time. I placed wings in plastic freezer bags and labeled each by the date and wing barrel location, then stored each bag in a freezer until processed.

I analyzed each forest grouse wing to determine the species and obtain information regarding the age class and sex of the bird. Because ruffed grouse cannot be sexed by wing characteristics, I only classified ruffed grouse wings by age class: adult, yearling, and juvenile (Hale 1954). I classified dusky grouse by sex and age class (Hoffman 1985). I determined the age of ruffed grouse and dusky grouse by the molt pattern and the retention of the two outer primary feathers (P9 and P10) as juvenile grouse retain their outer primary feathers for the first year of life (Hale 1954, Hoffman 1985). I classified everything as adult, yearling, or juvenile. I was able to identify harvested yearling birds prior to the molting of P9 and P10 feathers (September); after molting there are no distinguishable traits between yearlings and adults, thus yearlings harvested after September were classified as adults (Hoffman 1985). I classified wings as unknown if wing characteristics were lacking or did not allow me to age the harvested bird (e.g., wing tips shot off).

I classified early season harvested female dusky grouse as successful nesters or unsuccessful nesters based on their molt pattern. While incubating the nest, females delay the start of their molt, but begin their molt as soon as the nest fails or hatches, thus, yearling or adult females that were molting their inner primaries (i.e., P6 and P7) in September were assumed to have nested successfully and those molting their outer primaries (i.e., P9 and P10) were considered to be unsuccessful (Hoffman 1985). This

was only applicable for September harvested birds because most female dusky grouse complete their annual molt by October whether successful or not. I aged dusky grouse juveniles to the nearest day after hatch and estimated the hatch date based on wing molt patterns (Hoffman 1985).

**Leg Banding**

I captured male and female forest grouse using walk-in style traps, and pointing or flushing dogs to locate birds; then noose poles, long handled dip nets, and net guns were used to secure them (IUCUC #2368; Schroeder 1986, Pelren and Crawford 1995, Dahlgren et al. 2012). Most birds were captured in late June–August from 2015–2017. For capture activities, I used several different breeds of well-trained pointing and flushing dogs including: German shorthaired pointers, German wirehaired pointers, Llewellin setters, American Brittany, and English springer spaniels. Captured ruffed grouse and female dusky grouse received a size 16 aluminum leg band, and dusky grouse males received a size 14 aluminum leg band, all with a unique identification number and phone contact information for reporting leg band returns. Juvenile grouse were marked with aluminum bands that had cotton glued to the inside of the band so that their legs could grow unrestricted (Carroll et al. 2017). Juvenile dusky grouse were classified by gender based on the color of the under feathers on the sides of their neck, where a white indicated a male and drab gray indicated a female. (Caswell 1954)

**RESULTS**

I collected ruffed grouse wings in 2015, 2016, and 2017, respectively, as follows: n = 224, n = 201 and n = 139 total; n = 98, n = 100, and n = 63, adult; n = 114, n = 97,

and n = 74 juvenile; and n = 12, n = 4, and n = 2 unknown (Table 4-1). Dusky grouse wings collected in 2015, 2016, 2017, respectively, included: n = 116, n = 131, and n =139 total; n = 75, n = 65, and n = 77 adult; n = 40, n = 64, and n = 62 juvenile; n = 59, n = 63, and n = 66 female; and n = 56, n = 68, and n = 73 male; and n = 1, n = 2, and n = 0 unknown (Table 4-1). Unknown wings were not classified as adults or juveniles but were included in species totals. Ruffed grouse juvenile to adult ratios were 1.2, 1.0, and 1.2 in 2015, 2016, and 2017, respectively (Table 4-2). Dusky grouse juvenile to adult ratios were 0.5 in 2015, 1.0 in 2016, and 0.8 2017. Dusky grouse male to female sex ratios were proportionally similar each year at a 1:1 ratio (Table 4-2). The average estimated hatch date for September harvested dusky grouse juveniles (n = 130) in 2015, 2016, and 2017 was June 4, June 6, and June 14, respectively (Table 4-3).

The weekend following the forest grouse hunt opening day (i.e., September 1) yielded the most wings all three years (Fig. 4-4). I also collected more wings than would be expected on weekends following general big game hunt opening days. The Temple Fork wing barrel received the most ruffed grouse wings all three years of the study (Table 4-4). Temple Fork also yielded the most dusky grouse wings in 2015 and 2017, but Right Hand Fork yielded the most in 2016. The proportion of all wings collected at each wing barrel location did not vary annually (Table 4-5). Temple Fork yielded the highest proportion of wings (24%) followed by Right Hand Fork (17%), Peter Sinks (10%), Curtis Creek (10%), the Forestry Experiment Station (9%), Blacksmith Fork Canyon (catch all; 9%), Logan Canyon (i.e., catch all; 8%), Left Hand Fork (5%), Tony Grove (5%), and Franklin Basin (5%).

I captured and banded 21 ruffed grouse and 89 dusky grouse from fall 2015 to fall

2017 (Table 4-6). Hunters reported 2 male dusky grouse with bands in 2017. A hiker reported a third leg band that was found on rock still attached to separated leg of a dead dusky grouse in the early spring of 2017.

**DISCUSSION**

I collected similar numbers of forest grouse wings for the first two years of the study, but the number of ruffed grouse wings declined 34% from 2016 to 2017. Higher snow accumulation and lower mean temperatures during the breeding season in 2017 than 2015 or 2016 may have affected ruffed grouse reproduction, hence the number of birds available to hunter during the season (Larsen and Lahey 1958, Dorney and Kabat 1960, Neave and Wright 1969, Utah Climate Center 2018). Cold weather also affects female nest initiation timing which may explain why my estimated hatch dates from juvenile dusky grouse wings indicated a later hatch in 2017 than 2015 or 2016 (Table 4-3; Flanders-Wanner et al. 2004).

My 1:1 wing sex ratios for dusky grouse were consistent with the reported literature (Zwickel and Bendell 2004). I classified over 50 % of the dusky grouse wings as adults or yearlings in all three years of the study, exhibiting an older population structure than reported in other studies (Zwickel et al. 1975, Hoffman 1985, Zwickel and Bendell 2004).

Some of my wing barrels received more wings than other wing barrels, which may be due to road accessibility and habitat availability. For example, my wing barrel at temple fork with the greatest number of wings collected was located near Highway 89 that several other mountain roads funnel towards (Fig 4-5). In contrast the Tony Grove

road ends 5 miles away at a roadless wilderness area and had the lowest percentage of total wings collected.

Following weekends after general big game hunt opening dates, I collected more wings than would be expected given the broader declining trend over the entire hunting season. This was likely due to more hunters afield on those weekends (Fig 4-4). Other than the opening weekend of the forest grouse hunt, big game hunters and/or other hunters associated with big game hunters seemed to have provided a large percentage of forest grouse harvest across the entire annual hunting season. Although it has been speculated by some, to my knowledge this phenomenon of increased forest grouse harvest due to big game opening weekends has not been described to date. Forest grouse hunter demographics may be more complex than simply considering hunters defined as traditional upland game hunters. Future harvest management approaches should account for the role that big game hunting activities, especially opening weekends, influence forest grouse harvest.

Late season harvest, in November and December, was essentially non-existent for forest grouse during my study. Though the forest grouse hunting season ends December 31, my wing barrel collection indicated that the hunter effort essentially ceased by November 1 each year (Fig. 4-4). Forest grouse may become increasingly difficult to find as fall progresses towards winter, but is most likely due to increasing snow cover and lack of road access because the USFS closed 32 seasonal unpaved roads and All-Terrain Vehicle (ATV) trails for road surface protection on November 15$^{th}$ each year, leaving 2 paved roads open within my study area (Cade and Hoffman 1990, Pekins et al. 1991, Logan Ranger District 2018).

Incidentally, my wing barrels received minimal damage during hunting season, however, I had one wing barrel and sign taken. I pulled garbage out of the barrels a few times as well as a few wings from other bird species such as mallard ducks (*Anas platyrhynchos*) and greater sage-grouse (*Centrocercus urophasianus*) placed in my barrels.

I was unable to estimate harvest rates because only two leg bands were reported due to harvest over my 3 year study period. Large samples of marked individuals are needed to achieve valid harvest rates and calculate population abundance, which I found difficult because of the level of difficulty capturing forest grouse (McAlister et al. 2017). Additionally, prolonged periods of several hunting seasons with band collection is usually necessary to obtain enough band returns for valid analyses (Broms et al. 2010). Studies that produced successful harvest rates and abundance estimates trapped for at least three seasons and needed at least two years of leg band returns and usually five or more, to achieve valid estimates (Fischer and Keith 1974, Hepp et al. 1987, Lint et al. 1995). However, considering 1) the number of forest grouse I banded, 2) the paucity of band returns during my study, and 3) that my study area consistently received the highest hunting pressure of any county in Utah, indicated that harvest rates were likely very low and do not warrant concern at this time.

## MANAGEMENT IMPLICATIONS

My research demonstrates the usefulness of wing collection data to understand population dynamics. Forest grouse harvest wing collection is not currently being conducted in Utah and we suggest a broader statewide effort could lend to more

population dynamics than is currently known. Based on my lack of harvested leg band returns, harvest rate was not estimable and appeared to be very minimal. To reliably estimate harvest rates and achieve population-level estimates forest grouse harvest research needs to continue for several more years. For now, the low band return numbers indicated harvest is likely having little to no effect on forest grouse populations in my study area. The availability of game and accessibility to land to hunt on have reportedly been significant barriers to hunter recruitment and retention. Because forest grouse in Utah occur primarily on public land and can be abundant, they potentially provide important opportunities for recruiting new hunters and retaining current hunters. We encourage managers interested in recruitment and retention efforts to consider Utah's forest grouse resources.

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**TABLES AND FIGURES**

**Table 4-1.** Forest grouse wing totals collected from hunters during the September 1–December 31 2015–2017 forest grouse hunting season in the Bear River Range, Utah study area. Hunters voluntarily placed one wing from each harvested bird into a wing barrel.

| Grouse Wing Totals | 2015 | 2016 | 2017 |
|---|---|---|---|
| Total Grouse Wings | 340 | 332 | 278 |
| Total Dusky Grouse | 116 | 131 | 139 |
| Adult/Yearling | 75 | 65 | 77 |
| Juvenile | 40 | 64 | 62 |
| Unknown Age | 1 | 2 | 0 |
| Total Females | 59 | 63 | 66 |
| Total Males | 56 | 68 | 73 |
| Unknown Sex | 1 | 0 | 0 |
| Successful Hens | 4 | 4 | 7 |
| Unsuccessful Hens | 15 | 20 | 23 |
| Total Ruffed Grouse | 224 | 201 | 139 |
| Adult/Yearling | 98 | 100 | 63 |
| Juvenile | 114 | 97 | 74 |
| Unknown Age | 12 | 4 | 2 |

**Table 4-2.** Forest grouse hunter harvest ratios derived from wings collected during the September 1–December 31 2015–2017 hunting seasons in the Bear River Range, Utah study area.

| Ratios | 2015 | 2016 | 2017 |
|---|---|---|---|
| Harvested male dusky grouse per female | 0.9 | 1.1 | 1.1 |
| Harvested juvenile dusky grouse per adult | 0.5 | 1.0 | 0.8 |
| Harvested juveniles per successful female | 10.0 | 16.0 | 8.9 |
| Harvested unsuccessful females per successful female | 3.8 | 5.0 | 3.3 |
| Ruffed grouse harvested per dusky grouse | 1.9 | 1.5 | 1.0 |
| Harvested juvenile ruffed grouse per adult | 1.2 | 1.0 | 1.2 |
| Ratio of birds harvested on weekends versus weekdays | 1.9 | 2.6 | 2.1 |

**Table 4-3.** Dusky grouse (*Dendragapus obscurus*) juvenile estimated hatch dates collected from September 2015–2017 harvested wings in the Bear River Range, Utah study area.

| Chick projected hatch dates | 2015 | 2016 | 2017 |
|---|---|---|---|
| Number aged chick wings | 32 | 51 | 47 |
| Earliest hatch date | 14-May | 16-May | 21-May |
| Latest hatch date | 7-July | 8-July | 14-July |
| Average hatch date | 4-June | 6-June | 14-June |

**Table 4-4.** Forest grouse wing totals by wing barrel location collected from the Bear River Range, Utah study area during the September 1–December 31 2015–2017 forest grouse hunting seasons.

| Wing Barrel Location | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|
| | Dusky | Ruffed | Dusky | Ruffed | Dusky | Ruffed |
| Logan Canyon | 10 | 3 | 8 | 16 | 20 | 16 |
| Right Hand Fork | 23 | 27 | 34 | 36 | 22 | 17 |
| Temple Fork | 29 | 58 | 11 | 63 | 31 | 38 |
| Forestry Experiment Station | 1 | 33 | 11 | 24 | 7 | 10 |
| Tony Grove | 3 | 11 | 7 | 6 | 5 | 10 |
| Franklin Basin | 1 | 15 | 8 | 9 | 5 | 6 |
| Peter Sinks | 18 | 19 | 27 | 10 | 13 | 10 |
| Blacksmith Fork Canyon | 13 | 23 | 15 | 16 | 10 | 7 |
| Left Hand Fork | 4 | 19 | 2 | 5 | 8 | 7 |
| Curtis Creek | 14 | 16 | 8 | 16 | 18 | 18 |
| Totals | 116 | 224 | 131 | 201 | 139 | 139 |

**Table 4-5.** Proportions of total forest grouse wings collected from each wing barrel in the Bear River Range, Utah study for the September 1–December 31 2015–2017 forest grouse hunt.

| Wing Barrel Proportions | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|
| Logan Canyon | 3.8 | 7.2 | 12.9 | 8.0 |
| Right Hand Fork | 14.7 | 21.1 | 14.0 | 16.6 |
| Temple Fork | 25.6 | 22.3 | 24.8 | 24.2 |
| Forestry Experiment Station | 10.0 | 10.5 | 6.1 | 8.9 |
| Tony Grove | 4.1 | 3.9 | 5.4 | 4.7 |
| Franklin Basin | 4.7 | 5.1 | 4.0 | 4.6 |
| Peter Sinks | 10.9 | 11.1 | 8.3 | 10.1 |
| Blacksmith Fork Canyon | 10.6 | 9.3 | 6.1 | 8.7 |
| Left Hand Fork | 6.8 | 2.1 | 5.4 | 4.8 |
| Curtis Creek | 8.8 | 7.2 | 12.9 | 9.6 |

**Table 4-6.** Captured and leg-banded dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) in the Bear River Range, Utah study area 2015–2017.

| | | | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Dusky Grouse | Adult/Yearling | Male | 1 | 16 | 15 |
| | | Female | 0 | 16 | 7 |
| | Juvenile | Male | 1 | 2 | 5 |
| | | Female | 1 | 14 | 7 |
| | | Unknown | 0 | 2 | 2 |
| | | Totals | 3 | 50 | 36 |
| Ruffed Grouse | Adult/Yearling | Male | 0 | 2 | 2 |
| | | Female | 2 | 0 | 0 |
| | Juvenile | Male | 1 | 0 | 0 |
| | | Female | 2 | 0 | 0 |
| | | Unknown | 4 | 4 | 4 |
| | | Totals | 9 | 6 | 6 |

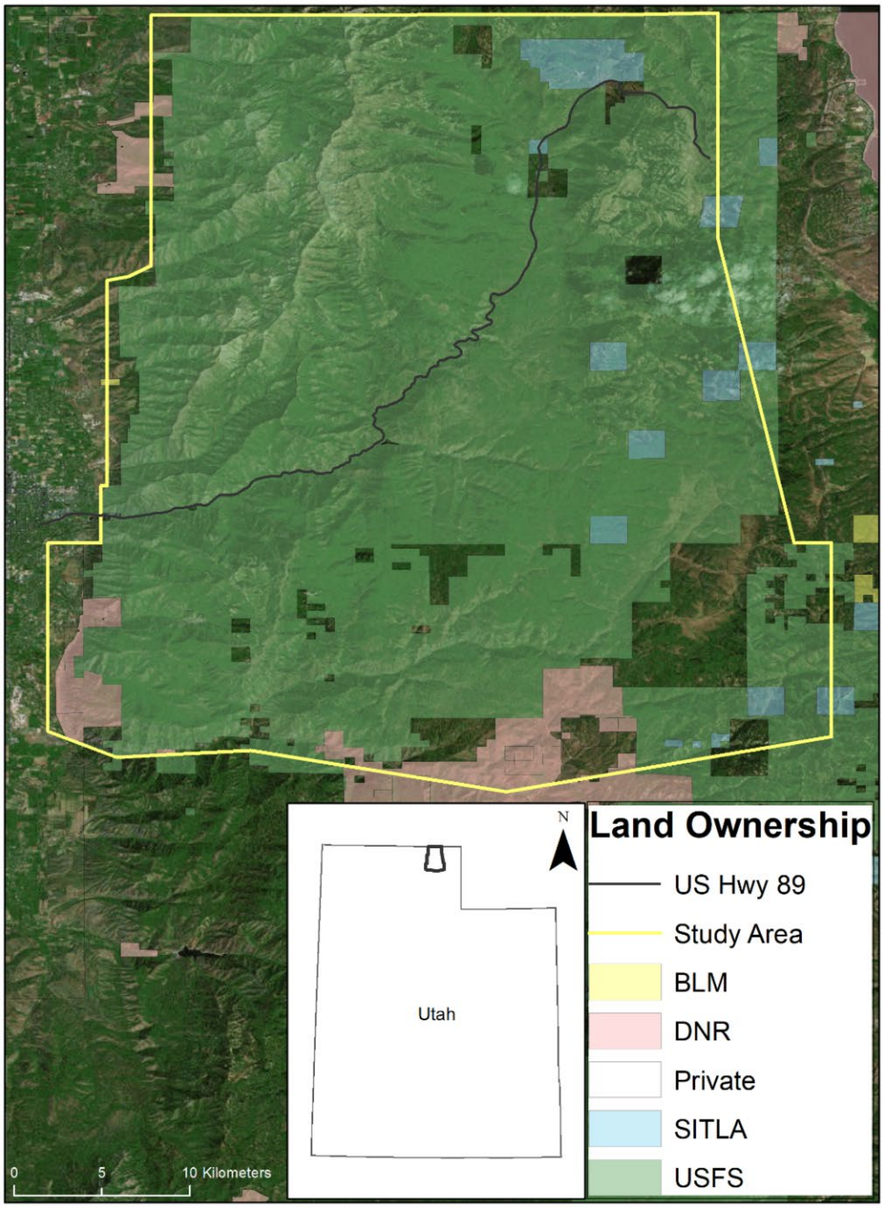


**Figure 4-1.** Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) study area in the Bear River Range, Utah study area 2015–2017. The study area was made up of different property ownership including, Utah Division of Wildlife Resources (DWR), Utah School Institutional Trust Land Administration (SITLA), U.S. Forest Service (USFS), and privately-owned lands.

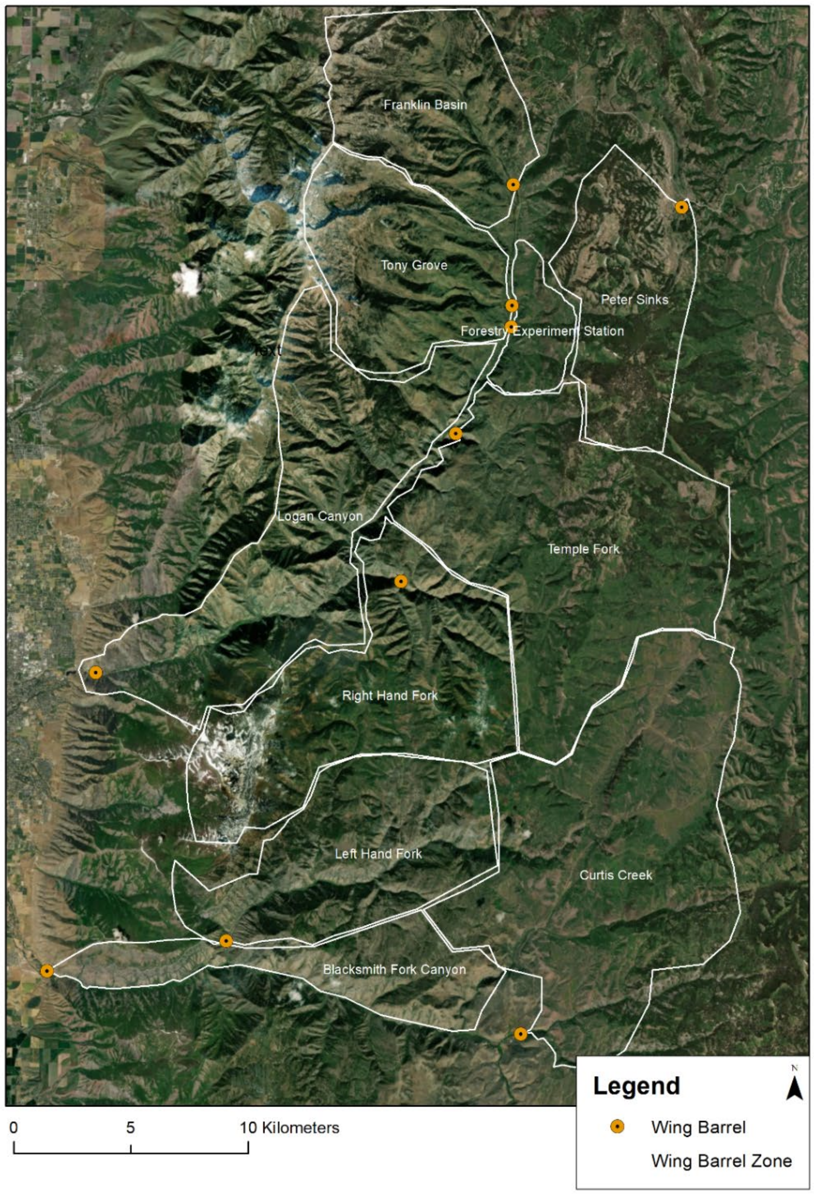


**Figure 4-2.** Wing barrel location and area that each barrel presumably encompasses in the Dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) study area Bear River Range, Utah during the forest grouse hunting seasons (September 1–December 31 2015–2017). Wing barrels were placed in all major canyon exits within Logan and Blacksmith Fork Canyons to be visible and near pullouts for accessibility. The wing barrels at the bottom of Logan and Blacksmith Fork Canyons (westernmost barrels) were placed as a "catch all" for hunters driving out of the canyons that may have missed the other wing barrels.


**Figure 4-3.** Wing barrel placement on the Peter Sinks road in Logan Canyon, Utah during the 2015–2017 forest grouse hunting seasons (September 1–December 31).

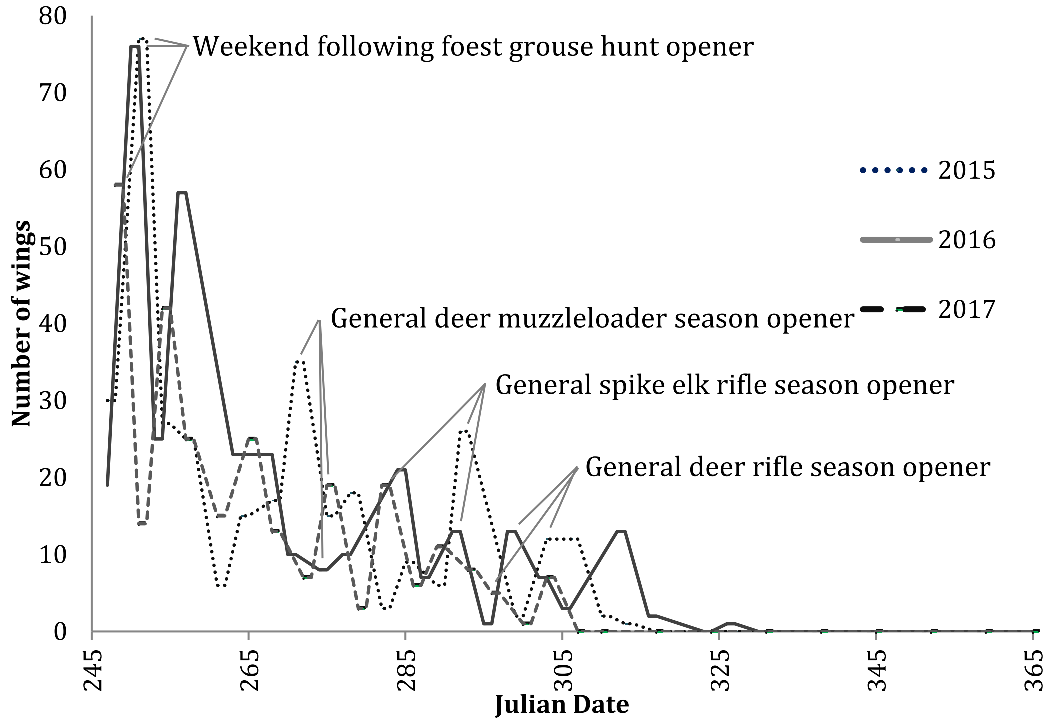


**Figure 4-4.** The graph represents forest grouse wing collection from hunter harvest during the September 1–December 31 2015–2017 forest grouse hunting seasons. I collected wings twice per week (following weekdays and weekends) from ten wing barrels placed in Logan and Blacksmith Fork Canyons in the Bear River Range, Utah study area. Hunter harvest spikes occurred following big game hunt opening weekends.

# CHAPTER 5

# CONCLUSIONS

Dusky grouse (*Dendragapus* obscurus) and ruffed grouse (*Bonasa umbellus*) are important upland game resources in many forested montane regions of western North America. While other species of grouse are experiencing population declines primarily due to habitat loss and degradation, limited research on dusky grouse and western populations of ruffed grouse is available regarding population monitoring, population dynamics, habitat selection, livestock grazing impacts, and hunter harvest impacts (Storch 2007, 2015). In 2015, I began a study to assess these research needs of a sympatric population of dusky and ruffed grouse, i.e. forest grouse, on US Forest Service managed land in the Bear River Range, Utah, which was comprised of livestock grazed pastures inhabited with forest grouse. My study area also yielded the highest annual forest grouse harvest in Utah (Bernales et al. 2016).

In Chapter 2, I examined the effectiveness of conducting forest grouse breeding surveys to monitor populations and assess habitat selection at the second order using a resource selection function (RSF) framework. I completed 128 walking surveys during the 2016 (n = 67) and 2017 (n = 61) breeding seasons comparing listening intervals and electronic playback calls at survey stop locations. I documented 242 male dusky grouse and 307 male ruffed grouse, plotted estimated locations for each individual using digital mapping software, and evaluated grouse responses as a function of date, minutes post-sunrise, and electronic playback call response using generalized additive models. I found that forest grouse can be monitored simultaneously during the breeding season because

the peak breeding activity for both species occurred within a few days of each other (April 28 for dusky grouse and May 1 for ruffed grouse). The 2016 detection probability estimates for dusky grouse and ruffed grouse were 0.466 (SE = 0.0424) and 0.687 (SE = 0.0274) respectively and in 2017 were 0.494 (SE = 0.0449) and 0.699 (SE = 0.0326).

Using estimated male locations and computerized landscape variables, I determined breeding habitat selection for both grouse species through RSFs. I found that Dusky grouse showed a generalist nature primarily selecting for maple (*Acer* spp.) communities, but also mountain shrubs such as chokecherry (*Prunus virginiana*) and serviceberry (*Amelanchier* spp.), aspen (*Populus tremuloides*), and open grassland and sagebrush (*Artemisia* spp.) communities. Ruffed grouse selected for mountain shrub and aspen communities, but avoided conifers. Forest edge habitat proved to be important for both species.

To my knowledge, my research was the first to conduct breeding surveys at this magnitude for dusky grouse. I have demonstrated that breeding surveys are an effective tool for monitoring dusky and ruffed grouse population trends. Furthermore, information from my RSFs will help provide a starting point for developing monitoring sites in other regions.

In Chapter 3, I evaluated the relationship between brood-rearing dusky grouse and seasonal livestock grazing from cattle (*Bos Taurus*) and sheep (*Ovis aries*), as well as habitat selection for brood-rearing females using an RSF at the third order. In April–August 2016–2017, I captured dusky grouse females and marked them with Global Positioning System (GPS) radios. I used locations from n = 10 marked brood-rearing females as well as biotic and abiotic factors to assess habitat selection. I assessed

livestock distributions via the landscape appearance method at the end of the grazing season, in September–October 2016–2017 across pastures inhabited with livestock and GPS marked females. My results indicated a negative relationship between brood-rearing females and livestock distributions, which are likely an indirect artifact of location because the areas with the highest livestock distributions were not near forest edges or mountain shrub communities that broods selected. Brood-rearing females selected mixed mountain shrub communities the strongest, followed by aspen, and open grassland and sagebrush communities, but avoided conifers. Furthermore, broods preferred the forest edge. My study demonstrates that dusky grouse co-exist with livestock, although this relationship may not be preferred. I also demonstrated the need for continued research to assess grazing impacts on dusky grouse habitat selection.

Chapter 4 focused on understanding forest grouse population dynamics through hunter harvest wing surveys and leg bands. During the forest grouse hunting seasons 2015–2017, I collected n = 340, n = 332, and n = 278 wings from hunters voluntarily placing a wing from each harvested bird in one of my ten placed wing-collection barrels. I collected wings from each barrel twice per week then determined the age and sex of each wing. I collected most wings in September and following weekends, especially on weekends following big game hunt openers. I determined that the dusky grouse age ratios exhibited an older population structure, particularly in 2015, whereas ruffed grouse exhibited a younger population age structure. My extensive wing collection data proved useful in understanding forest grouse population dynamics in my study area. I also captured and leg banded both dusky and ruffed grouse prior to the hunting seasons 2015–2017 (n = 21 ruffed, n = 89 dusky) but did not receive any leg band returns until 2017

when I received n = 2 dusky grouse. The low leg band returns suggest that hunter harvest currently has minimal effect on forest grouse populations in the Bear River Range, study area.

My research was the first to attach GPS radios to dusky grouse, allowing me to collect up to six locations daily for each bird, thus creating a large movement dataset in a short timeframe. Using GPS radios helped me map daily and seasonal movements. A challenge to using solar-powered GPS radios was maintaining enough charge to consistently acquire locations as dusky grouse spent longer periods of time under tree canopy in the fall and winter, potentially biasing location datasets. However, the data that GPS radios provided has been invaluable to my research (See Table B-3 in Appendix B for dusky grouse movement table).

My results provide new information to help guide conservation and management of forest grouse. From this research, improved methods for conducting forest grouse breeding surveys and monitoring annual population trends have been established and may be used by others, especially western state wildlife upland game programs. Quantification improved overall understanding of forest grouse breeding habitat selection and dusky brood-rearing habitat selection at larger landscape scales. I have demonstrated the need for continued research on dusky grouse interactions with livestock. Information collected from forest grouse harvest in this study can be used to assess annual population fluctuations estimate forest grouse abundance with time. The increased understanding of forest grouse ecology provided by my research will help establish population trend counts and improve management and conservation practices for forest grouse.

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# APPENDICES

# APPENDIX A: SUPPLEMENTARY FOREST GROUSE BREEDING SURVEY PROTOCOL

## Forest grouse breeding survey protocol

### Routes

- Surveys are conducted for both dusky and ruffed grouse simultaneously.
- Survey routes should consist of up to six pre-determined route stops spaced ≥ 500 m apart in a circular pattern.
- The first route stop should be placed within 400 m of a road for accessibility.
- Each route should be surveyed at least twice, once clockwise and once counter-clockwise, during the breeding period.
- The survey period for breeding forest grouse is April 15–May 25.
- Surveys should start before sunrise and end within 4 hours of start.
- The observer begins the survey at route stop 1 or 6, records temperature, wind speed (Beaufort scale), and cloud cover %.
- Surveys should not be completed on windy days (>12 mph).

### Stops

- Navigate to route stop and wait 1 minute before starting survey
- Listen for 2, 4-min continuous listening intervals (i.e., 8 continuous minutes).
- Keep track of each individual dusky or ruffed grouse male for two 4-min intervals (e.g., DG1, DG2, RG1, RG2, etc.), and use hash marks to indicate the number of dusky grouse soft hooting, loud single note hoots, wing flutters, or ruffed grouse drumming for each individual per interval.
- Record noise level (none, low, medium, high) after each interval
- For the final interval, play an electronic dusky grouse female cackle and/or whinny call (on for 30 sec off and listening for 30 sec) for another 4 min.
- Generally, but not always, dusky grouse hooting can usually only be detected within 100m or so. However, dusky grouse single note hoots and wing flutters and ruffed grouse drumming can be heard up to 200-300m or more away.

Note: The following data sheet is designed for collecting data on paper in the field.

However, this data sheet could be easily adapted to geo-referenced electronic data collection software on smart phones or tablets. Applications such as Cybertracker, ARC GIS Data Collector, or Epicollect are readily available. Digital data collection reduces error rates and can increase overall processing time.

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FOREST GROUSE BREEDING SURVEY | | | | | | | | | | | | | | | | | | | | | | | |
| Date | | | | | | Survey Route # | | | | | | | | | | | | Observer | | | | | |
| Wind Speed 0-3 | | | | | | Cloud Cover (%) | | | | | | | | | | | | Temp (F) | | | | | |
| Stop 1 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |
| Stop 2 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |
| Stop 3 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |
| Stop 4 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |
| Stop 5 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |
| Stop 6 | UTM | DG1 | | | | DG2 | | | DG3 | | | DG4 | | | DG5 | | | RG 1 | RG 2 | RG 3 | RG 4 | RG 5 | RG 6 |
| | Northing | N | H | B | W | H | B | W | H | B | W | H | B | W | H | B | W | D | D | D | D | D | D |
| Int1 | | | | | | | | | | | | | | | | | | | | | | | |
| Int2 | Easting | | | | | | | | | | | | | | | | | | | | | | |
| Ecall | | | | | | | | | | | | | | | | | | | | | | | |

N=noise; H=hoots; B=booms; W=wing flutters; Int=interval; Ecall= electronic call back; DG=dusky grouse; RF=ruffed grouse; D=Drums
Beaufort wind scale: 0 = Calm (0 mph); 1 = Light (1-3 mph); 2 = Gentle Breeze (4-7 mph); 3 = Moderate Breeze (8-12 mph)
Noise scale: None = no noise; Low = minimal noise from roads or passerine birds ; Medium = babbling creek, some highway noise, may miss some birds at greater distances away; High = rushing creek, constant road noise, or other loud background

# APPENDIX B: SUPPLEMENTARY TABLES FOR CHAPTERS 2, 3, AND 5

**Table B-1.** Re-classification of LANDFIRE 2014 vegetation categories for land cover predictor variables utilized in breeding resource selection analysis for dusky grouse (*Dendragapus obscurus*) and ruffed grouse (*Bonasa umbellus*) in the Bear River Range, Utah. See Chapters 2 and 3.

| RSF Variable | LANDFIRE 2014 CLASSNAME |
|---|---|
| Conifer | Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland, Northern Rocky Mountain Subalpine Woodland and Parkland, Rocky Mountain Foothill Limber Pine-Juniper Woodland, Rocky Mountain Lodgepole Pine Forest, Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland, Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland, Southern Rocky Mountain Ponderosa Pine Woodland, Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland, Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland, Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland, Inter-Mountain Basins Montane Riparian Forest and Woodland, Rocky Mountain Montane Riparian Forest and Woodland, Middle Rocky Mountain Montane Douglas-fir Forest and Woodland, Abies concolor Forest Alliance, Dry-mesic Montane Douglas-fir Forest, Mesic Montane Douglas-fir Forest, Xeric Montane Douglas-fir Forest, Western Cool Temperate Urban Evergreen Forest, Western Cool Temperate Urban Mixed Forest |
| Aspen | Rocky Mountain Aspen Forest and Woodland, Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland |
| Mountain Shrub | Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland, Rocky Mountain Alpine Dwarf-Shrubland, Rocky Mountain Lower Montane-Foothill Shrubland, Northern Rocky Mountain Montane-Foothill Deciduous Shrubland, Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland, Rocky Mountain Montane Riparian Shrubland, Rocky Mountain Subalpine/Upper Montane Riparian Shrubland, Western Great Plains Floodplain Shrubland, Inter-Mountain Basins Montane Riparian Shrubland |
| Maple | Rocky Mountain Bigtooth Maple Ravine Woodland, Rocky Mountain Gambel Oak-Mixed Montane Shrubland, Quercus gambelii Shrubland Alliance, |
| Open | Inter-Mountain Basins Sparsely Vegetated Systems, Rocky Mountain Alpine/Montane Sparsely Vegetated Systems, Colorado Plateau Mixed Low Sagebrush Shrubland, Wyoming Basins Dwarf Sagebrush Shrubland and Steppe, Great Basin Xeric Mixed Sagebrush Shrubland, Inter-Mountain Basins Big Sagebrush Shrubland, Columbia Plateau Steppe and Grassland, Columbia Plateau Low Sagebrush Steppe, Inter-Mountain Basins Big |

| | |
|---|---|
| | Sagebrush Steppe, Inter-Mountain Basins Montane Sagebrush Steppe, Inter-Mountain Basins Semi-Desert Grassland, Inter-Mountain Basins Semi-Desert Grassland, Rocky Mountain Subalpine-Montane Mesic Meadow, Southern Rocky Mountain Montane-Subalpine Grassland, Introduced Upland Vegetation-Annual Grassland, Introduced Upland Vegetation-Perennial Grassland and Forbland, Introduced Upland Vegetation-Annual and Biennial Forbland, Arctostaphylos patula Shrubland Alliance, Inter-Mountain Basins Sparsely Vegetated Systems II, Artemisia tridentata ssp. vaseyana Shrubland Alliance, Rocky Mountain Alpine/Montane Sparsely Vegetated Systems II, Western Great Plains Floodplain Herbaceous, Western Cool Temperate Urban Herbaceous, Western Cool Temperate Urban Shrubland, Western Cool Temperate Undeveloped Ruderal Shrubland, Western Cool Temperate Undeveloped Ruderal Grassland |
| Other | Colorado Plateau Pinyon-Juniper Woodland, Great Basin Pinyon-Juniper Woodland, Inter-Mountain Basins Mat Saltbush Shrubland, Inter-Mountain Basins Mixed Salt Desert Scrub, Mojave Mid-Elevation Mixed Desert Scrub, Great Basin Semi-Desert Chaparral, Sonora-Mojave Semi-Desert Chaparral, Inter-Mountain Basins Juniper Savanna, Southern Rocky Mountain Ponderosa Pine Savanna, Inter-Mountain Basins Semi-Desert Shrub-Steppe, Northern Rocky Mountain Subalpine-Upper Montane Grassland, Northwestern Great Plains Mixed-grass Prairie, Rocky Mountain Alpine Turf, Inter-Mountain Basins Greasewood Flat, Northern Rocky Mountain Conifer Swamp, Western Great Plains Floodplain Forest and Woodland, Rocky Mountain Wetland-Herbaceous, Introduced Riparian Forest and Woodland, Juniperus occidentalis Woodland Alliance, Grayia spinosa Shrubland Alliance, Introduced Riparian Shrubland, Open Water, Snow-Ice, Barren, Developed-Low Intensity, Developed-Medium Intensity, Developed-High Intensity, Developed-Roads, Western Great Plains Depressional Wetland Systems, Western Cool Temperate Urban Deciduous Forest, Western Warm Temperate Urban Deciduous Forest, Western Warm Temperate Urban Herbaceous, Western Cool Temperate Developed Ruderal Deciduous Forest, Western Cool Temperate Developed Ruderal Evergreen Forest, Western Cool Temperate Developed Ruderal Mixed Forest, Western Cool Temperate Developed Ruderal Shrubland, Western Cool Temperate Developed Ruderal Grassland, Western Warm Temperate Developed Ruderal Grassland, Western Cool Temperate Undeveloped Ruderal Deciduous Forest, Western Cool Temperate Undeveloped Ruderal Evergreen Forest, Western Cool Temperate Orchard, Western Cool Temperate Row Crop - Close Grown Crop, Western Cool Temperate Row Crop, Western Cool Temperate |

| | |
|---|---|
| | Close Grown Crop, Western Cool Temperate Fallow/Idle Cropland, Western Cool Temperate Pasture and Hayland, Western Cool Temperate Wheat |

**Table B-2.** Re-classification of LANDFIRE 2014 vegetation categories for land cover predictor variables utilized in brooding resource selection analysis for dusky grouse (*Dendragapus obscurus*) in the Bear River Range, Utah.

| RSF Variable | LANDFIRE 2014 CLASSNAME |
|---|---|
| Conifer | Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland, Northern Rocky Mountain Subalpine Woodland and Parkland, Rocky Mountain Foothill Limber Pine-Juniper Woodland, Rocky Mountain Lodgepole Pine Forest, Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland, Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland, Southern Rocky Mountain Ponderosa Pine Woodland, Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland, Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland, Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland, Inter-Mountain Basins Montane Riparian Forest and Woodland, Rocky Mountain Montane Riparian Forest and Woodland, Middle Rocky Mountain Montane Douglas-fir Forest and Woodland, Abies concolor Forest Alliance, Dry-mesic Montane Douglas-fir Forest, Mesic Montane Douglas-fir Forest, Xeric Montane Douglas-fir Forest, Western Cool Temperate Urban Evergreen Forest, Western Cool Temperate Urban Mixed Forest |
| Aspen | Rocky Mountain Aspen Forest and Woodland, Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland |
| Mountain Shrub | Rocky Mountain Bigtooth Maple Ravine Woodland, Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland, Rocky Mountain Alpine Dwarf-Shrubland, Rocky Mountain Lower Montane-Foothill Shrubland, Northern Rocky Mountain Montane-Foothill Deciduous Shrubland, Rocky Mountain Gambel Oak-Mixed Montane Shrubland, Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland, Quercus gambelii Shrubland Alliance, Rocky Mountain Montane Riparian Shrubland, Rocky Mountain Subalpine/Upper Montane Riparian Shrubland, Western Great Plains Floodplain Shrubland, Inter-Mountain Basins Montane Riparian Shrubland |
| Open | Inter-Mountain Basins Sparsely Vegetated Systems, Rocky Mountain Alpine/Montane Sparsely Vegetated Systems, Colorado Plateau Mixed Low Sagebrush Shrubland, Wyoming Basins Dwarf Sagebrush Shrubland and Steppe, Great Basin Xeric Mixed Sagebrush Shrubland, Inter-Mountain Basins Big Sagebrush Shrubland, Columbia Plateau Steppe and Grassland, Columbia Plateau Low Sagebrush Steppe, Inter-Mountain Basins Big Sagebrush Steppe, Inter-Mountain Basins Montane Sagebrush Steppe, Inter-Mountain Basins Semi-Desert Grassland, Inter-Mountain Basins Semi-Desert Grassland, Rocky Mountain |

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| | Subalpine-Montane Mesic Meadow, Southern Rocky Mountain Montane-Subalpine Grassland, Introduced Upland Vegetation-Annual Grassland, Introduced Upland Vegetation-Perennial Grassland and Forbland, Introduced Upland Vegetation-Annual and Biennial Forbland, Arctostaphylos patula Shrubland Alliance, Inter-Mountain Basins Sparsely Vegetated Systems II, Artemisia tridentata ssp. vaseyana Shrubland Alliance, Rocky Mountain Alpine/Montane Sparsely Vegetated Systems II, Western Great Plains Floodplain Herbaceous, Western Cool Temperate Urban Herbaceous, Western Cool Temperate Urban Shrubland, Western Cool Temperate Undeveloped Ruderal Shrubland, Western Cool Temperate Undeveloped Ruderal Grassland |
| Other | Colorado Plateau Pinyon-Juniper Woodland, Great Basin Pinyon-Juniper Woodland, Inter-Mountain Basins Mat Saltbush Shrubland, Inter-Mountain Basins Mixed Salt Desert Scrub, Mojave Mid-Elevation Mixed Desert Scrub, Great Basin Semi-Desert Chaparral, Sonora-Mojave Semi-Desert Chaparral, Inter-Mountain Basins Juniper Savanna, Southern Rocky Mountain Ponderosa Pine Savanna, Inter-Mountain Basins Semi-Desert Shrub-Steppe, Northern Rocky Mountain Subalpine-Upper Montane Grassland, Northwestern Great Plains Mixed-grass Prairie, Rocky Mountain Alpine Turf, Inter-Mountain Basins Greasewood Flat, Northern Rocky Mountain Conifer Swamp, Western Great Plains Floodplain Forest and Woodland, Rocky Mountain Wetland-Herbaceous, Introduced Riparian Forest and Woodland, *Juniperus occidentalis* Woodland Alliance, *Grayia spinosa* Shrubland Alliance, Introduced Riparian Shrubland, Open Water, Snow-Ice, Barren, Developed-Low Intensity, Developed-Medium Intensity, Developed-High Intensity, Developed-Roads, Western Great Plains Depressional Wetland Systems, Western Cool Temperate Urban Deciduous Forest, Western Warm Temperate Urban Deciduous Forest, Western Warm Temperate Urban Herbaceous, Western Cool Temperate Developed Ruderal Deciduous Forest, Western Cool Temperate Developed Ruderal Evergreen Forest, Western Cool Temperate Developed Ruderal Mixed Forest, Western Cool Temperate Developed Ruderal Shrubland, Western Cool Temperate Developed Ruderal Grassland, Western Warm Temperate Developed Ruderal Grassland, Western Cool Temperate Undeveloped Ruderal Deciduous Forest, Western Cool Temperate Undeveloped Ruderal Evergreen Forest, Western Cool Temperate Orchard, Western Cool Temperate Row Crop - Close Grown Crop, Western Cool Temperate Row Crop, Western Cool Temperate Close Grown Crop, Western Cool Temperate Fallow/Idle Cropland, Western Cool Temperate Pasture and Hayland, Western Cool Temperate Wheat |

**Table B-3.** Seasonal movement table of dusky grouse (*Dendragapus obscurus*) adult females captured and fitted with Global Positioning System (GPS) transmitters in the Bear River Range, Utah 2016–2017.

| | GPS Fixed Rate (%) | | | | Daily Distance Average (m) | | | | Max Daily Distance (km) | | | | Seasonal Max Distance (km) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Individual ID | Breeding | Brooding | Fall | Winter | Breeding | Brooding | Fall | Winter | Breeding | Brooding | Fall | Winter | |
| DGF127729B | N/A | 100 | 24 | N/A | N/A | 695 | 771 | N/A | N/A | 2.7 | 3.0 | N/A | 5.6 |
| DGF127731A | N/A | 44 | 4 | N/A | N/A | 588 | 83 | N/A | N/A | 8.9 | 0.9 | N/A | 4.3 |
| DGF127732A | N/A | 64 | 16 | N/A | N/A | 404 | 694 | N/A | N/A | 1.7 | 2.9 | N/A | 3.2 |
| DGF127733A | 46 | 87 | 20 | 4 | 462 | 507 | 488 | 202 | 2.3 | 2.2 | 2.6 | 1.1 | 3.8 |
| DGF127737A | 71 | 98 | 49 | 7 | 479 | 444 | 659 | 195 | 3.0 | 1.4 | 5.5 | 0.9 | 18.9 |
| DGF127739C | 52 | 72 | 4 | 2 | 266 | 174 | 418 | 890 | 1.3 | 0.4 | 2.1 | 2.9 | 7.2 |
| DGF127750A | 72 | 73 | 19 | 2 | 403 | 504 | 798 | 178 | 3.1 | 4.6 | 9.7 | 0.3 | 10.1 |
| DGF146378A | 53 | 31 | 1 | 1 | 505 | 599 | 639 | 190 | 9.1 | 1.1 | 3.4 | 0.3 | 4.3 |
| DGF158823A | 29 | 7 | 6 | 5 | 234 | 1,908 | 384 | 102 | 1.0 | 5.2 | 3.1 | 0.4 | 3.1 |
| DGF158824A | N/A | 69 | 2 | N/A | N/A | 496 | 1,407 | N/A | N/A | 1.3 | 4.1 | N/A | N/A |
| DGFHAR04A | N/A | 99 | N/A | N/A | N/A | 504 | N/A | N/A | N/A | 2.2 | N/A | N/A | N/A |
| DGFHAR05A | N/A | 100 | N/A | N/A | N/A | 419 | N/A | N/A | N/A | 1.6 | N/A | N/A | N/A |
| DGFHAR07A | N/A | 99 | N/A | N/A | N/A | 584 | N/A | N/A | N/A | 1.2 | N/A | N/A | N/A |
| DGFHAR08A | N/A | 96 | 92 | N/A | N/A | 365 | 416 | N/A | N/A | 1.1 | 0.4 | N/A | 1.4 |
| DGFHAR09A | N/A | 100 | N/A | N/A | N/A | 472 | N/A | N/A | N/A | 0.7 | N/A | N/A | N/A |
| DGFHAR16A | N/A | 96 | N/A | N/A | N/A | 426 | N/A | N/A | N/A | 1.4 | N/A | N/A | N/A |