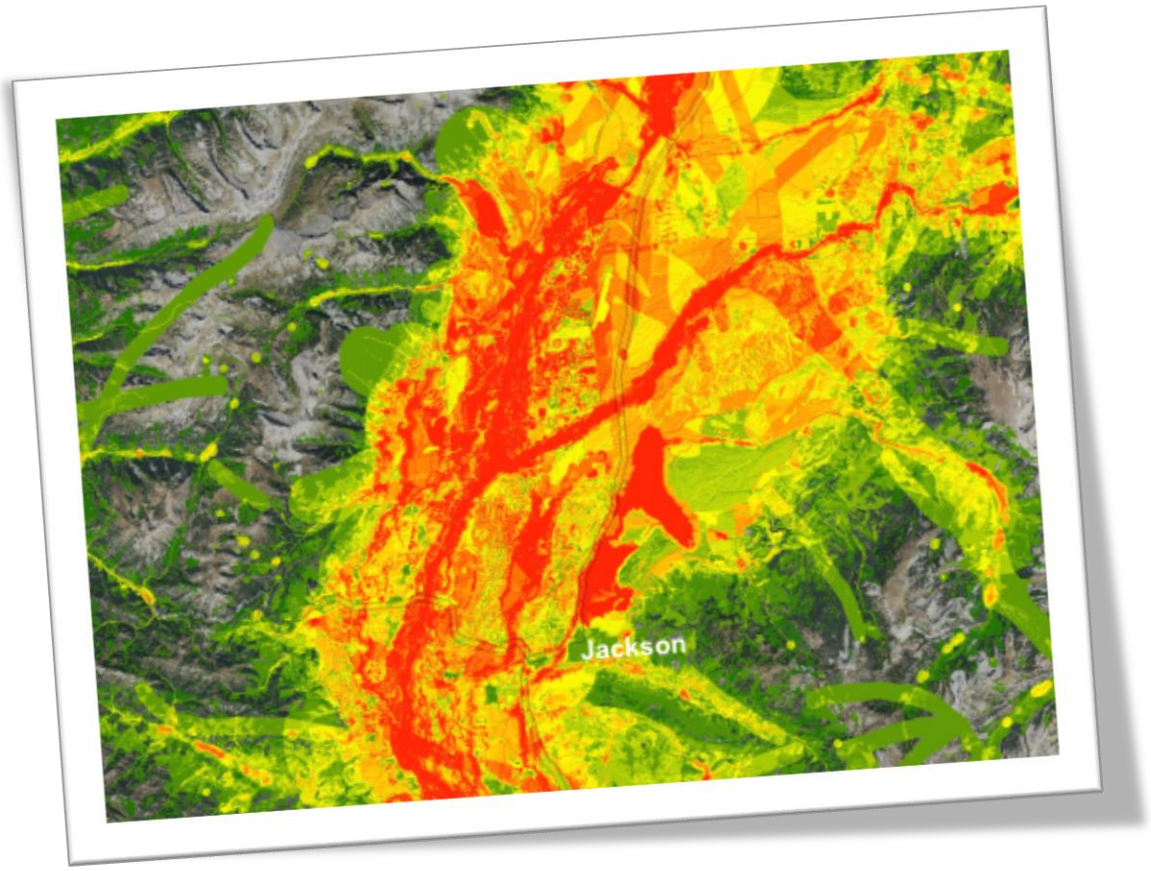
FOCAL SPECIES HABITAT MAPPING
FOR
TETON COUNTY, WY

FINAL REPORT



April 21, 2017

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FINAL REPORT:
Focal Species Habitat Mapping for Teton County, WY

For planning purposes to revise natural resource land development regulations for Teton County, WY.

FINAL REPORT DATE: April 21, 2017

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This project, inclusive of GIS products and report, received both informal and formal peer-review by subject matter experts throughout the course of the project. Peer-reviewers included representatives from Teton County Planning and Development Department, Natural Resources Technical Advisory Board, Wyoming Game and Fish and outside experts as requested.

Views, statements, findings, conclusions, recommendations and data in this report do not necessarily reflect views and polices of Teton County Planning and Development Department. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The final version of this report will be available from the Teton County Planning and Development Department website at: http://www.tetonwyo.org/pdplan

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Focal Species Habitat Narratives citations: Cite these narratives as a section within this report, crediting the Primary and Secondary Authors listed at the end of each narrative.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

Alder	Alder Environmental, LLC
BTNF	Bridger-Teton National Forest
BLM	Bureau of Land Management
Comprehensive Plan	Jackson/ Teton County Comprehensive Plan (2012)
County	Teton County, WY
CTNF	Caribou-Targhee National Forest
DEM	Digital Elevation Model
GIS	Geographic Information System
GPS	Global Positioning System
GTNP	Grand Teton National Park
NRO	Natural Resources Overlay District
NRTAB	Natural Resources Technical Advisory Board
TC Planning	Teton County Planning & Development Department
USFWS	US Fish and Wildlife Service
WGFD	Wyoming Game and Fish Department
WMI	Wyoming Migration Initiative
WYNDD	Wyoming Natural Diversity Database

PROJECT OVERVIEW

The Jackson/Teton County Comprehensive Plan (Comprehensive Plan) calls for the protection of native species populations through a system of regulations and requirements that are based on relative value of habitat. The purpose of this *Focal Species Habitat Mapping for Teton County, WY* was to produce a map of Teton County indicating the relative values of habitat throughout the County.

Policy 1.1.a of the Comprehensive Plan (2012) states the following:

> *"Protecting wildlife requires protecting wildlife habitat and wildlife movement corridors. Our Natural Resource Overlay (NRO) that protects wildlife habitat and wildlife movement corridors will consider the importance and abundance of habitat types and be based on a set of focal species that indicate the health of all native species and includes culturally and economically significant species. The most abundant and visible wildlife species are not necessarily indicative of overall ecosystem health. Likewise, while a habitat may be important, it may also be abundant and therefore only relatively critical, while another important habitat may be declining and/or disappearing due to development and climate change and therefore absolutely critical. As our NRO and other programs to protect wildlife habitat from the impacts of development and transportation evolve, they should be updated to reflect the best available data on the relative critical value of different habitat types for identified focal species."*

In 2013, Teton County completed a Geographic Information System (GIS) digital layer of vegetation and non-vegetation cover types on all private lands in Teton County, Wyoming (Cogan and Johnson, 2013). These vegetation cover types, in addition to similar vegetation GIS data for Grand Teton National Park (GTNP), Bridger-Teton National Forest (BTNF) and Caribou-Targhee National Forest (CTNF) were foundational to this focal species habitat mapping project.

This focal species habitat mapping project is a pivotal step in fulfilling the Comprehensive Plan's goal as outlined in Policy 1.1.a. Furthermore, this mapping project set forth to produce a product that not only conveyed relative habitat values of all areas across Teton County (including public and private lands) but can also be revised as habitat and wildlife species information is updated or created. In an effort to address wildlife movement corridors across jurisdictions, all lands in Teton County were included in this mapping project, regardless of ownership. In a county that is approximately 97% public lands and 3% private lands, it is imperative to take into consideration that wildlife do not abide by jurisdictional lines particularly when protecting movement corridors across the landscape.

EXECUTIVE SUMMARY

In September 2016, under contract with Teton County Planning and Development Department (TC Planning), Alder Environmental LLC (Alder) initiated a mapping project to develop a digital layer of relative habitat values in Teton County, WY based on a suite of focal wildlife species. To achieve this goal, the *Focal Species Habitat Mapping for Teton County, WY* project was conducted in three phases. Throughout the process, a high level of collaboration and peer-review by Alder's Team of Experts, Wyoming Game and Fish Department (WGFD), the Natural Resources Technical Advisory Board (NRTAB) and TC Planning was included during each project phase.

Prior to project initiation with Alder, the NRTAB, WGFD and TC Planning initiated the selection of focal species. The first phase of the project was to refine the focal species list and to conduct literature and primary research reviews on each focal species' habitat requirements. The products of this first phase were 17 species-specific habitat narratives. The second phase of the project was to take the specific habitat requirements outlined in each species habitat narrative and generate GIS-based habitat layer(s) based on seasonal habitat requirements. Twenty (20) habitat layers were produced during this second

phase to be used as inputs for the third phase mapping product. The third, and final, phase was to combine these 20 GIS-based habitat layers using a weighted sum methodology to create a relative values habitat map for Teton County, WY. The weights, or ranking, used in this final phase were based on criteria developed specifically for this project and ranked by a committee of project partners. The product of this final phase was the "Relative Values Habitat Map" for Teton County, WY.

FOCAL SPECIES SELECTION

Wildlife species selection for the project was initiated by the NRTAB, WGFD and TC Planning prior to award of contract with Alder. This initial selection of species, based on expert opinion that is inherently subjective, should be recognized as an underlying bias of the project. The suite of species selected undoubtedly influences the project's results. Ideally the suite of focal species chosen are representative of other species across the landscape. Similar projects suggest that for corridor design studies a suite of 10-20 species may be sufficient (Majka et al, 2007) while in the case of focusing on threatened and endangered species including every species may be appropriate (USFWS, 2007). For this inaugural Teton County project, the selection of 17 species including representative mammals, birds, fish and amphibians was based on project constraints.

The species selection process a paring down of species lists from Wyoming Game and Fish Department's Species of Greatest Conservation Need tiers (WGFD, 2010), US Fish and Wildlife Service's designated species (threatened, endangered, experimental and critical habitats) for Teton County, WY (USFWS, 2016), Bridger-Teton National Forest's Sensitive Species (BTNF, 2016) and the Bureau of Land Management's Sensitive Species (BLM, 2010). This collection of possible species resulted in a list of 265 species. This list was cross-referenced with The Nature Conservancy's list of vulnerable species in Wyoming (Pocewicz et al, 2014) and Nature Mapping Jackson Hole's list of amphibian, mammal and bird records in Teton County (NMJH/ JHWF, 2016a). Only those species found in Teton County were retained for a resulting list of 64 possible species.

WGFD, NRTAB and TC Planning developed three criteria for further narrowing of this list. To be retained, species met all three of the criteria:

- "focal" or "important" species that were good indicators of ecosystem health or had economic/cultural significance within Teton County, WY;
- not rare and were present on private lands (note that "rare" was not associated with definitions used for federally and state listed endangered or threatened species, but simply indicated that a species' observed population and habitat use in Teton County were relatively small but still large enough to function as an appropriate focal species); and
- had sufficient data, or demonstrable habitat associations, derived from review of literature or well-documented expert opinion, to be relevant in the Focal Species Habitat Mapping process.

The culling of the species list based on the above criteria resulted in the retention of 16 species:

Mammals
Elk
Moose
Mule Deer

Fish
Snake River Cutthroat Trout

Amphibians
Western Toad

Birds
Bald Eagle
Brewer's Sparrow
Common Yellowthroat
Great Blue Heron
Great Gray Owl
Greater Sage-Grouse
Northern Goshawk
Sage Thrasher
Trumpeter Swan
Western Meadowlark
Willow Flycatcher

The NRTAB, WGFD and TC Planning reviewed the habitat types represented to confirm that there were no obvious omissions of known important habitats in Teton County. This habitat review resulted in the addition of the Northern Harrier to represent open agricultural grassland associates which are abundant on private lands in Teton County, WY. The resulting 17 species were then included in the project proposal.

The final phase of focal species list refinement was a collaboration between Alder, NRTAB and WGFD and TC Planning. At this final phase of review, Alder suggested that aspen forest habitat, a habitat in decline across the Rocky Mountains, was not well represented as a primary habitat by the proposed list of focal species. In addition to aspen, further consideration was given to all major habitat types with an eye toward including habitat obligates for each major habitat type. This habitat based refinement resulted in the removal of the Willow Flycatcher, Common Yellowthroat and Sage Thrasher and the addition of MacGillivray's Warbler, Boreal Chorus Frog and Red-naped Sapsucker. Based on budgetary constraints, the number of species needed to remain at 17. The removed species represented duplication in habitat with other species and species added were intended to be habitat obligates for aspen and wetland areas. The final list of 17 focal species used for this habitat mapping project were the following:

Mammals
Elk (*Cervus elaphus*)
Moose (*Alces alces shirasi*)
Mule Deer (*Odocoileus hemionus*)

Fish
Snake River Cutthroat Trout (*Oncorhynchus clarkii* spp.)

Amphibians
Boreal Chorus Frog (*Pseudacris maculata*)
Western Toad (*Anaxyrus boreas*)

Birds
Bald Eagle (*Haliaeetus leucocephalus*)
Brewer's Sparrow (*Spizela breweri*)
Great Blue Heron (*Ardea herodias*)
Great Gray Owl (*Strix nebulosa*)
Greater Sage-Grouse (*Centrocercus urophasianus*)
MacGillivray's Warbler (*Geothlypis tolmiei*)
Northern Goshawk (*Accipiter gentilis*)
Northern Harrier (*Circus cyaneus*)
Red-naped Sapsucker (*Sphyrapicus nuchalis*)
Trumpeter Swan (*Cygnus buccinator*)
Western Meadowlark (*Sturnella neglecta*)

FOCAL SPECIES HABITAT NARRATIVES AND HABITAT MAPS

For each focal species, we researched species' habitat requirements and produced a narrative summarizing our findings (Phase 1) (Appendix A). These focal species habitat narratives provide concise information focusing on the species' habitat needs in Teton County and risk factors that could affect habitat use or should be considered in the revision of land development regulations. Narratives were not intended to be complete natural history summaries for each species. Rather the information contained in each formed the basis of ecological inputs used in the mapping process. The majority of the information included in each narrative was found in secondary research sources (e.g. northern Rocky Mountain published, peer-reviewed research projects or agency documents such as WYNDD, USFS and BLM Species Assessment reports, etc.). For six of the species (i.e. Northern Goshawk, Great Gray Owl, Greater Sage-Grouse, Western Toad, Boreal Chorus Frog and mule deer) the narrative's primary author had experience conducting primary research on that species in Teton County and therefore used a combination of both primary (i.e. his/ her research knowledge) and secondary research sources. This type of scientific literature based research and habitat mapping methodology is supported by Clevenger et al. (2002) who found that models based on peer-reviewed literature most closely approximated models based on empirical data (e.g. primary research). Additionally, literature based models were more similar to empirical models than models based on expert opinion alone which tended to overemphasize one habitat type over another based on expert bias (Clevenger et al., 2002).

Narratives include the species' important habitat characteristics (summer, winter and/ or migration as appropriate), primary and secondary research sources and suggested GIS habitat inputs for the creation of habitat map(s) for the species. Each narrative was drafted by a primary author (some also had a secondary author) and was reviewed by both a primary expert reviewer (e.g. WGFD personnel or other Rocky Mountain based species expert) and a secondary NRTAB reviewer.

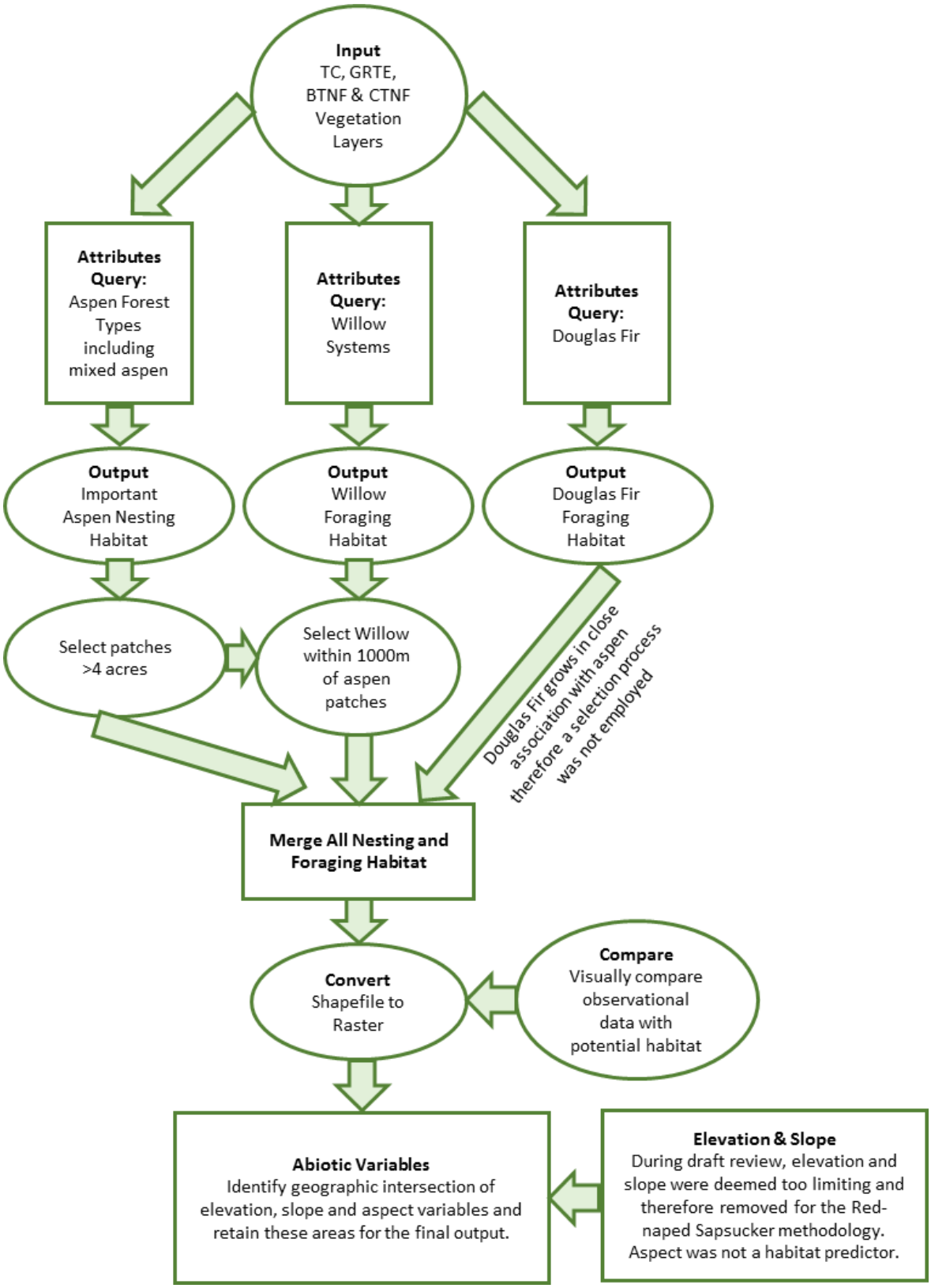
Once narratives were complete, we used the habitat information contained within to create habitat map(s) for each species (Phase 2) (Appendix A). While this process was unique for each species, we generally used a spatial intersection of variables pertaining to vegetation cover, elevation, slope, aspect and distance from various resources to characterize important habitat for that species.

Where possible, we used more refined data filters such as patch size or percent cover. However, in many cases, the available spatial data inputs did not contain the refined detail needed to meet the species habitat preferences. For example, sagebrush percent cover preferred by Greater Sage-Grouse during nesting and brood-rearing seasons is known from previous research (Connelly et al, 2000). However, the vegetation data available for this project contained percent cover categories that were too broad to align with the known percent cover preferences of sage-grouse. Therefore, we included all appropriate sagebrush species regardless of percent cover.

Furthermore, during the creation and review processes for each species habitat map, we worked to balance input variable refinement with maintaining known habitat use areas. Known habitat use areas could be lost if input variables were too strictly defined. Through these reviews, we found that habitat preferences identified for species often proved too constraining for the geographic data available. Therefore, we expanded them slightly, or removed them, based on expert opinion (WGFD biologists and species experts) of the local ecosystem and known habitat use. For example, wintering mule deer prefer habitats on 22-45 degree slopes (Riginos, et al, 2013). However, when a draft habitat map was produced, we observed that sagebrush areas near the base of local hillsides, where the slope angles were lower and deer are known to forage, were not included as habitat. Therefore, we expanded the slope variable to 15-45 degrees to include these known use areas (A Courtemanch, WGFD Wildlife Biologist, *pers. commun*.).

With the exception of the Great Gray Owl for whom both summer and winter habitat models existed (Bedrosian et al., 2015) and Northern Goshawk for whom a summer habitat model existed (Bedrosian et al., 2016) for Teton County, each species narrative contains two habitat variables tables (Appendix A). The first table lists possible habitat characteristics found through the narrative research and lists possible GIS data sources to be used as well as the literature or expert source where that habitat characteristic was referenced. The second table lists the specific inputs employed in the generation of a habitat map for that species. In instances where refinements of the spatial variables were altered through the mapping process or changes in data sources were needed, these alterations are noted in the tables. When alterations in data inputs were needed, these decisions were made in consultation with WGFD and local species experts. Additionally, this second table lists the specific GIS methods used in the generation of each habitat layer. These tables will be informative to future updates of habitat maps for this suite of focal habitat species. All habitat maps use the NAD83 UTM Zone 12N coordinate system. This methodology is illustrated below using the Red-naped Sapsucker's habitat mapping methodology as an example (Figure 1).

Figure 1. Example Schematic: Red-naped Sapsucker Methodology



For complete annotated methodology, see Appendix A.

While some species are year-round residents in Teton County, others are only present in the summer months. For year-round species, narrative research covered both seasons while only one season was chosen for our mapping process (Table 1). The season chosen for mapping was based on life strategies, habitat use and/ or critical periods in a species annual cycle. For example, mule deer and elk summer in the higher elevation mountainous regions of Teton County that are mostly public land and therefore not associated with the private land development regulations this project aims to inform. Furthermore, the winter season is critical to these species survival. Therefore, only the winter habitat was mapped for these species. Three species are the exception to this statement: Great Gray Owl, Greater Sage-Grouse and Trumpeter Swan. For these three, year-round species, both winter and summer seasons are important and substantially different areas are used within Teton County. Therefore, we created two seasonal habitat maps for each of these species.

A habitat map was not created for MacGillivray's Warbler. This warbler was included as an aspen obligate. However, through the literature review, it was revealed that this warbler is a shrub understory specialist not an aspen obligate. Vegetative GIS data containing information on shrub understory was not available therefore a habitat map was not created. Further explanation is contained within the MacGillivray's Warbler narrative (Appendix A). Since this species' habitat was not mapped, future updates to this project should consider the inclusion of aspen obligate species in addition to the Red-naped Sapsucker.

We considered ungulate migration corridors separately from summer and winter habitats for mule deer, moose and elk. While research for these migration corridors was contained within each narrative, the decision was jointly made by Alder, NRTAB and WGFD to merge all mule deer, moose and elk migration corridors into one GIS layer. The migration layer output used here does not allow for one to distinguish between the three species migration corridors. If there is a need to distinguish between species migration corridors for land planning purposes then this request should be incorporated into a future update of this migration layer. In this future update, it may be informative to distinguish areas that multiple species use for seasonal migration corridors. Narratives, GIS methods and habitat maps for each species are contained in Appendix A.

As mentioned above, it bears emphasizing that the species habitat narratives are not complete natural history summaries for each species. Rather, these narratives are the basis of ecological inputs used in the mapping process and primarily based on literature reviews. It follows then that habitat maps derived from literature and expert review based models, such as these, are not precise habitat maps. Rather these maps indicate areas of *potential* habitat within the County but do not guarantee presence or use by the focal species.

Observational data from Wyoming Game and Fish Department's Wildlife Observation System (WOS) and the Jackson Hole Wildlife Foundation's Nature Mapping JH citizen science database (NMJH/ JHWF, 2016b) were compared with habitat maps for each species. While a mathematical comparison of overlap is possible within the GIS format, we found that this method did not produce useful results. The accuracy of the observation locations is not precise. When the GIS mathematically compared these observations to the 10m pixel habitat layer by species, the result was not a reliable comparison. Therefore, we found that a visual comparison of overlaying observations on the habitat layer proved more informative. This visual comparison allowed reviewers of the habitat layers to identify ideas where observations have been made to assure that they aligned with areas identified as habitat.

Table 1. Focal Species Habitats Mapped

CATEGORY	FOCAL SPECIES	HABITAT MAPPED
Mammal	Elk	Winter
	Moose	Winter
	Mule Deer	Winter
Bird	Bald Eagle	Year-round
	Brewer's Sparrow	Summer
	Great Blue Heron	Summer
	Great Gray Owl	Winter & Summer
	Greater Sage-Grouse	Winter & Summer
	MacGillivray's Warbler	Narrative only
	Northern Goshawk	Summer
	Northern Harrier	Summer
	Red-naped Sapsucker	Summer
	Trumpeter Swan	Winter & Summer
	Western Meadowlark	Summer
Fish	Snake River Cutthroat Trout	Year-round
Amphibian	Boreal Chorus Frog	Year-round
	Western Toad	Year-round
Migration	Migration (elk, moose, mule deer)	Migration Corridors

RELATIVE VALUES HABITAT MAP OF TETON COUNTY

The 17 focal species habitat narratives and associated 20 habitat maps were used to create a Relative Values Habitat Map (Phase 3; Figure 2). The combination of 20 habitat map layers using a GIS weighted sum methodology allowed for a "ranking" of the 20 species habitat layers based on criteria. This process resulted in one inclusive map displaying relative habitat values across the County.

The criteria employed were jointly developed by Alder, NRTAB and WGFD. While developing these criteria, consideration was given to avoid correlation between criteria to greatest extent possible. However, the group did not have the ability to statistically measure correlation. It was also accepted that when working with habitat function and wildlife, some degree of correlation is likely unavoidable. Consideration was given to the Comprehensive Plan's goals and to the desired outcome of a relative values habitat map intended to inform future revisions to land development regulations for private lands.

To the knowledge of all parties involved in the development of this ranking system, a methodology developed to weight various focal species habitats has not been conducted before. Projects with similar goals have been conducted but none with precisely the same methodology. Similar projects were largely based on the USFWS Habitat Suitability Index (HSI) methodology (USFWS, 1980). In this HSI methodology, weights (based on expert opinion) are applied to each habitat input variable during the creation of species habitat maps. This results in a species habitat map containing relative values. If these relative values, species habitat maps are combined under the HSI methodology, the values are mathematically combined through averaging or additive techniques. The important difference between our methodology and that outlined in the HSI methodology is the step at which weights are employed. In our methodology, all species habitat maps have a standardized value (1 for habitat, 0 for non-habitat) and therefore do not indicate the relative value of habitat for that species across the County. Weights (based on a criteria system with expert opinion ranking) are uniformly applied to species habitat maps and then combined through an additive process to create a relative values map for the county-wide area.

WEIGHTING METHODOLOGY

In this Teton County project, weights are based on a suite of criteria guided by expert opinion. This suite of criteria is a key component to the Teton County methodology intended to be transferable to future revisions of the relative values habitat map. The criteria were developed through a group discussion format including members of NRTAB, WGFD, TC Planning and Alder. The criteria are intentionally broad and therefore applicable to different species types (e.g. mammals, birds, amphibians, fish) as well as focused on issues that are typically applicable to human-wildlife coexistence on private lands. The criteria we used were:

> *Disjunct Local Population* – A disjunct local population is not connected to other populations. The local population does not interbreed or interact with neighboring populations primarily because of geographic constraints (but other reasons may also apply). The decline or extirpation of Teton County's local population will not be recovered by immigration from neighboring populations.
>
> *High Sensitivity to Humans* – The species is highly sensitive to human presence, activities or the built environment. While it is recognized that all species react to humans at some level, the built environment and associated disturbances produce a spectrum of sensitivity. The species associated with this criterion are highly sensitive to humans. These species may abandon

preferred habitats or nests, disrupt breeding behavior or display aggressive behaviors toward the disturbance variable (e.g. human presence, disturbance or infrastructure).

Limiting Habitat – The species' fitness and survival is directly dependent on the habitat that is mapped. In some cases, the habitat type is scarce or the amount of available habitat has already been impacted or decreased by human activities and development. If this habitat was removed, the species would become imperiled in the Teton County landscape.

Population at Risk/ In Decline – The population is at risk or in decline in Teton County. Decline may be a result of climate change, disease, habitat change/ alterations or other factors.

Social and Economic Importance – The species is socially and economically important in Teton County. Economically important includes, but is not limited to, those species that are hunted, fished, highly attractive to birdwatchers and photographers, or contribute to important wildlife-based tourism. Included in this list are mule deer, elk and moose which are also listed in the Comprehensive Plan as economically important.

Each species was ranked by a committee of biologists composed of representatives from Alder, WGFD NRTAB and TC Planning in a discussion format. For each criterion, the species was assigned a 1 if applicable and a 0 if not applicable. The criteria assignments were then summed for each species resulting in a total "rank" by species. This species' total rank was applied as the species' habitat layer's weight when input to the relative values habitat map GIS weighted sum methodology (Table 2).

Table 2. Species Criteria Rankings

Habitat Layer	Season	Disjunct Local Population	High Sensitivity to Humans	Limiting Habitat	Population at Risk/ In Decline	Social and Economic Importance	TOTAL RANK
MAMMALS							
Migration	**Spring & Fall**	0	1	1	1	1	**4**
Moose	**Winter**	0	1	1	1	1	**4**
Elk	**Winter**	0	0	1	0	1	**2**
Mule deer	**Winter**	0	0	1	0	1	**2**
BIRDS							
Trumpeter Swan	**Summer**	1	1	1	1	1	**5**
Trumpeter Swan	**Winter**	0	1	1	1	1	**4**
Greater Sage-Grouse	**Summer**	1	1	0	1	1	**4**
Greater Sage-Grouse	**Winter**	1	0	1	1	1	**4**
Bald Eagle	**Year-round**	0	1	1	0	1	**3**
Great Gray Owl	**Winter**	0	0	1	1	1	**3**
Great Gray Owl	**Summer**	0	0	0	1	1	**2**
Northern Goshawk	**Summer**	0	1	1	0	0	**2**
Brewer's Sparrow	**Summer**	0	0	0	1	0	**1**
Great Blue Heron	**Summer**	0	1	0	0	0	**1**
Northern Harrier	**Summer**	0	1	0	0	0	**1**
Red-naped Sapsucker	**Summer**	0	0	1	0	0	**1**
Western Meadowlark	**Summer**	0	1	0	0	0	**1**
FISH							
Snake River Cutthroat Trout	**Year-round**	0	1	1	0	1	**3**
AMPHIBIANS							
Western Toad	**Summer**	1	1	1	1	0	**4**
Boreal Chorus Frog	**Summer**	1	1	1	0	0	**3**

Criteria Applicability

Applicability of each criterion ranged from being applicable to at least 5 species to a maximum of 14 species (average 10.8 species for each criterion) (Table 3). Disjunct local population criterion was assigned to five species while limiting habitat criterion was assigned to 14 species. No criterion was applicable to all species.

Table 3. Species Criteria Applicability

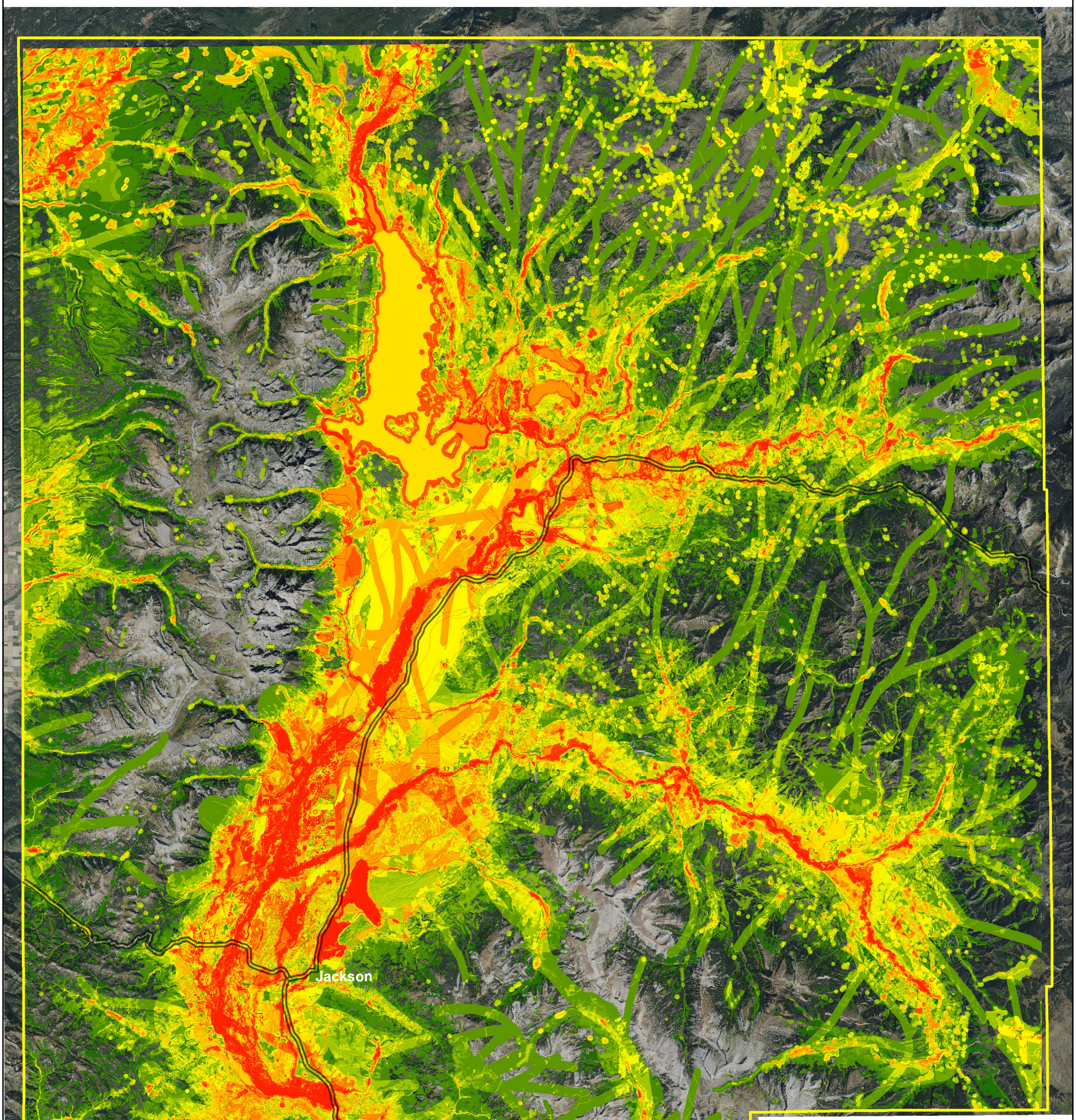
Criteria	Number of Species
Disjunct Local Population	5
Population at Risk/ In Decline	10
Social and Economic Importance	12
High Sensitivity to Humans	13
Limiting Habitat	14

RELATIVE VALUES HABITAT MAP OF TETON COUNTY

We input weighted focal species habitat layers (rasters) in a GIS to create a relative values habitat map of Teton County. Each raster contained only binary pixel values (i.e. 0 or 1; non-habitat or habitat). To apply the species rank from Table 2, we multiplied each raster by the total criteria rank assigned to that species using a weighted sum GIS tool (Spatial Analysist, ESRI ArcMap Desktop 10.5). For example, we multiplied the pixels in the Trumpeter Swan summer habitat raster uniformly by 5 (Table 2), resulting in a raster with pixel values of 5 for habitat and 0 for non-habitat. We then summed the 20 weighted rasters in GIS to produce the relative values habitat map for Teton County.

Given the possible criteria rankings and 20 focal species input rasters, the maximum *possible* relative value for a pixel under this methodology was 100 (20 rasters each with a ranking of 5). Input criteria rankings for this suite of focal species limited the highest possible value of a pixel to a possible weight of 54 (the sum of 20 focal species all overlapping on one pixel multiplied by the assigned rankings). The resulting output raster contained relative values ranging from 0 to 42. The raster values had a non-normal distribution with a median integer value of 7 (zeros removed from the calculation; Zonal Statistics, Spatial Analyst, ESRI ArcMap Desktop 10.5) indicating that geographically the top 50% of pixels with values ranged from 7-42 in relative values. The highest value of 42 indicates that there was no single location in Teton County where all 20 habitat layers overlap.

The final relative values habitat map is displayed using a stretched symbology (a color spectrum stretched across the values range) and maintaining a 10m pixel size. We maintained a 10m pixel size throughout this methodology based on the Digital Elevation Model (DEM) input pixel size. However, the application of this precise pixel size raster is likely inappropriate for answering both county-wide and parcel land development queries. Therefore, we recommend generalization of the output to a larger pixel size before application of the output for planning purposes. Application at the more precise scale produced here has limited applicability for county wide planning. Rather, a generalized version of this relative values habitat map should be generated that is of an appropriate scale to answer future planning questions. Extreme caution is recommended for application of this output without further refinement based on the proposed use.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 2:

Relative Values Habitat Map

April 21, 2017

This relative values habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/RelValues.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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FUTURE UPDATES

An integral component of the methodology developed for this inaugural mapping project is its ability to update the relative values habitat map. As with the species habitat information used thus far, the revision process could be initiated based on new developments in either primary or secondary research or from updated data sources. Research developments that could initiate a revision to the relative values habitat mapping project include:

a) a precise habitat map is produced through extensive research efforts for a focal, protected and/or sensitive species in Teton County;
b) a Rocky Mountain region based habitat research project brings to light significantly updated habitat information for a focal, protected and/ or sensitive species in Teton County; or
c) the spatial GIS data for Teton County changes significantly.

The process envisioned for updates is outlined in the schematic in Figure 3 and includes two primary methodologies, or tracks, for revision, Track A or Track B:

Track A – County-wide precise habitat model is created for a species

If a precise species habitat map is produced for a focal, protected and/or sensitive species in Teton County, these data could be incorporated through Track A of the Figure 3 schematic. This revision will be modeled after the method used for Great Gray Owl and Northern Goshawk in this initial exercise (Appendix A). County-wide relative probability habitat maps existed for these two species. Therefore, the most probable habitat values were chosen (in consultation with B. Bedrosian, the models' primary author) and used for this project. Since species habitat inputs were weighted equally in this project's methodology, all chosen subset values for the species probability inputs will be converted to a binary scale (i.e. 1 for habitat, 0 for non-habitat). This subset of the county-wide habitat model will then be used as an input to the weighted sum methodology.

Track B – Rocky Mountain region based habitat research project significantly updates habitat information for a focal, protected and/ or sensitive species in Teton County

If a research project is conducted elsewhere in the Rocky Mountain region that discovers significantly updated habitat information, then a species narrative, GIS inputs and habitat map can be completed (in the case of a new focal species) or revised (in the case of an existing focal species) (Track B; Figure 3). In either case, these habitat maps will be compared (visually and through GIS analysis) with the relative values habitat map and a collaborative team of experts (i.e. NRTAB, WGFD) will review and decide whether these species habitat maps should be incorporated into the relative values habitat map or not. If incorporation is desired, a weight will be assigned based on the criteria outlined above and the weighted sum methodology will be conducted including all existing and new focal species habitat layers.

Revision of Spatial GIS Data

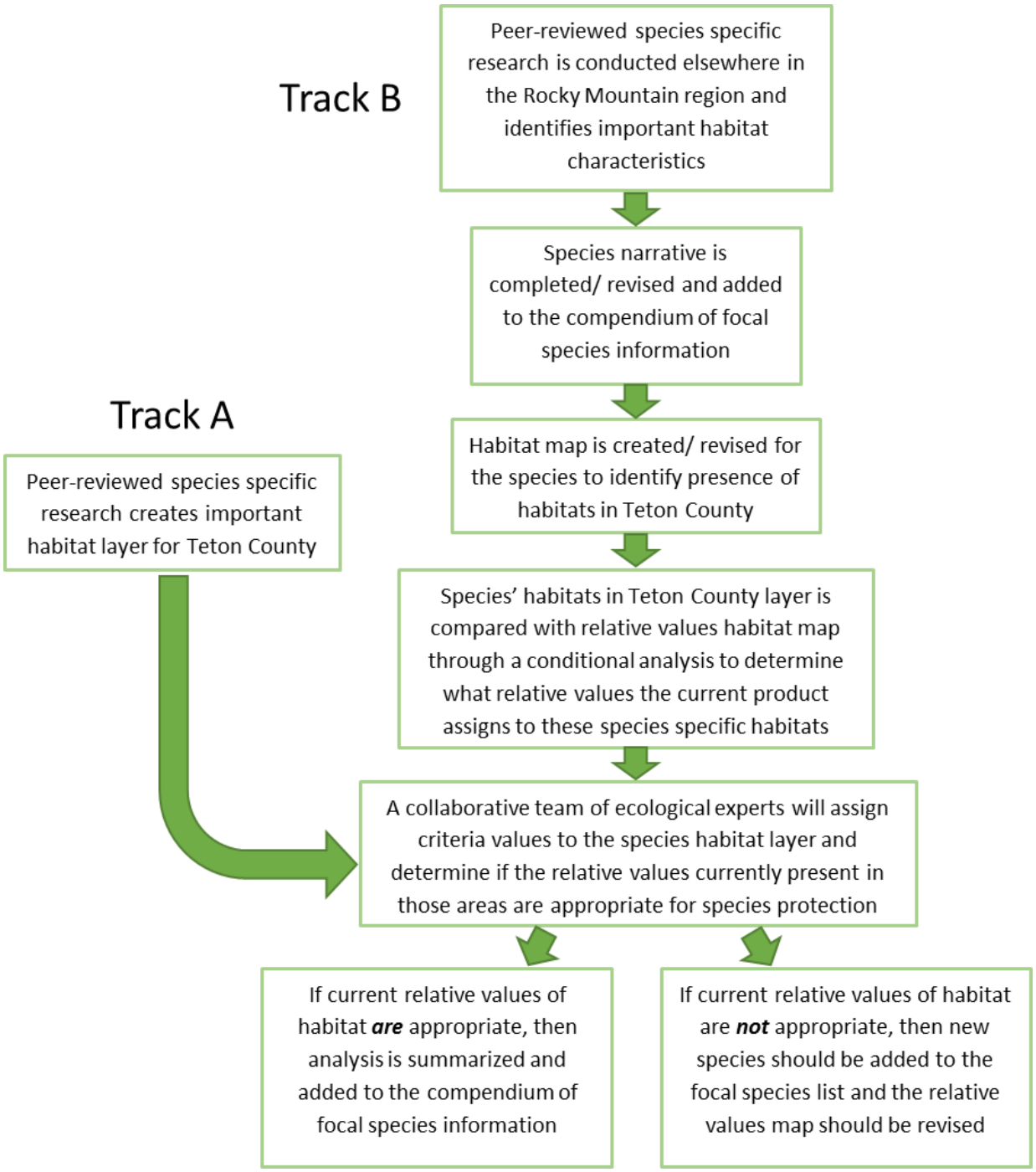
The third possibility for initiating a revision to this project would be the significant update of GIS data sources, such as the vegetative cover data or migration routes for Teton County. If the vegetative cover data were updated, all focal species habitat layers should be revised necessitating a revision of the relative values habitat map.

Anticipated Update

The first recommendation for an update is anticipated in October 2017 when the Wyoming Migration Initiative at the University of Wyoming is expected to publish Teton County migration corridors spatial data based on GPS collared mule deer, elk and moose. Once this migration corridor information is available, the relative values habitat map should be updated through the methods of incorporating

primary research (Track A). This update could also include an additional analysis of these migration corridors relative to residential areas and other human development within Teton County. Furthermore, during this revision process, the discussion should be had as to whether to include the USFS-designated Path of the Pronghorn (Berger, et al, 2006) migration corridor in this migration layer. Pronghorn were not included as a focal species because the vast majority of their habitat is located on public lands in Teton County. However, the pronghorn migration corridor passes through some private lands and therefore, there is interest in including this in the ungulate migration corridor layer for this project.

Figure 3. Future Updates Methodology Schematic



DISCUSSION

RELATIVE VALUES HABITAT MAP

It is common knowledge with local wildlife biologists that the entirety of Teton County's landscape is important to one wildlife species or another and connectivity between habitats and through this landscape is of utmost importance to the sustainability of the County's diverse wildlife populations. The relative values habitat map and associated focal species habitat maps support this common knowledge and emphasize that connectivity between habitats and permeability through the landscape is of utmost importance to local wildlife species. Connectivity across the landscape is associated with the effects of development density on permeability for wildlife. While higher density levels generally provide for less wildlife permeability; permeability through high-density development is possible. This relative values habitat map for Teton County illustrates that permeability for wildlife should be provided and planned for through *all* levels of development density in order to maintain connectivity between habitats across Teton County.

As is true throughout the Rocky Mountains, and displayed in this relative values habitat map, water resources and their associated riparian vegetation continue to be an important component within the Teton County landscape. The major waterways and associated riparian corridors of the County are characterized by higher relative values. These relative values decline as the linear distance from these corridors increases. Upland areas proximate to water resources also received higher relative habitat values. The spatial association between water resources and nearby uplands likely reflects the riparian habitat needs of many wildlife species in Teton County.

Lower elevation valley areas continue to be important habitat, particularly winter habitat, for some species. An important contingency to this statement is that this mapping project is a snapshot in time and does not illustrate the temporal change in relative values from pre-development to the current landscape composition. The relative value of this lower elevation habitat may have decreased or changed since pre-development and the level at which development will totally negate the relatively high values of the habitat is unknown. In this community, private lands and human development tend to be found in lower elevation valley areas. These areas are also where wildlife, particularly ungulate species, frequent during winter months when snow-levels are high in the surrounding public lands. This relative values habitat map again emphasizes for Jackson/ Teton County residents that coexistence with wildlife is a central tenet of our community. Furthermore, permeability for wildlife through this lower elevation landscape, particularly around waterways within developed areas such as Flat Creek and across barriers such as roadways, are important considerations for land planners concerned with the health of wildlife populations.

Throughout the relative values habitat map, there are narrow offshoots of habitat that appear tendril-like. These areas are most clearly visible in areas where they border non-habitat (zero pixel values) but are also identifiable within the habitat areas. These tendrils of habitat are a relic of the project's reliance on WGFD-mapped migration corridors, an outdated dataset, as inputs to the migrations layer. The Wyoming Migration Initiative is expected to publish Teton County migration corridor data based on GPS collared mule deer, elk and moose in October 2017. Once this migration corridor information is available, the relative values habitat map should be updated. It is expected that current migration corridor data will enhance the relative values of important migration corridors as well as add clarity to this relative values habitat map.

The stress levels animals endure when utilizing habitat near human development is an important variable when considering human and wildlife coexistence and is not accounted for, or illustrated, in this mapping exercise. Species known to experience high levels of stress resulting from human interactions

were assigned value under the "high sensitivity to humans" criterion ranking. However, during the mapping process, species habitat maps were not altered to account for whether or not human development was included in or near the areas identified as potential habitat. For instance, if a cottonwood forest was located next to a residential development area, this cottonwood forest input was not weighted in any way to account for its proximity to human development. At the time when the migration layer is updated, an additional analysis of these migration corridors and the updated relative values map in contrast to residential areas and other human development may be informative for revisions to land development regulations.

Continued caution is recommended against assigning value to vegetative cover types based on the relative values produced here. Since the vegetative cover types are used as input for the species habitat maps, a strong inherent correlation is present between vegetative cover type and the relative values output. Similarly, although not precisely known, it is likely that the biological meaning of the inputs has been unavoidably altered during the weighted sum process for multiple focal species' habitat maps. After all, one species' use of a piece of land can be for very different reasons, in different seasons and of varying importance to its life strategies than that same piece of land is for another species. Nonetheless, in our methodology, two species' use of one piece of land is treated as mathematically equal (both have a pixel value of 1). An illustrative example would be the use of a sagebrush area by elk, Brewer's Sparrow, migrating ungulates (including elk), Northern Harriers, Greater Sage-Grouse and Western Meadowlark. Some of these species are breeding in this area, some are using it for winter habitat and some are migrating through, yet the sagebrush landscape is important to all of them in some capacity during various seasons. The role this sagebrush landscape plays in multiple species' life strategies is not indicated by the relative value assigned to the area nor is the reverse an appropriate interpretation. Furthermore, the importance of habitat to wildlife is also likely altered based on location within the Teton County landscape so an area of sagebrush surrounded by development would likely play a different role than an area of sagebrush on the open flats. Once species habitat layers are combined to create the relative values habitat map, the relative values indicate only that, relative values of habitat across the landscape based on the number of species using that area and the importance assigned to those species' habitats. Because of correlation issues, these relative values should not be reassigned back to either vegetative cover types or individual wildlife species. Comparisons may be made between layers but assignment of relative values back to variables used as inputs would be inappropriate.

NEXT STEP

As stated above, we maintained a 10m pixel size throughout this methodology based on the Digital Elevation Model input pixel size. However, the application of this precise pixel size raster is likely inappropriate for answering both county-wide and parcel land development queries. Therefore, we recommend generalization of the output to a larger pixel size before application of the output for planning purposes. A designation by TC Planning regarding the desired application of these data (e.g. tiers, classes, etc.) and the output needed for a revision of the land development regulations would determine the appropriate scale to which these data should be generalized.

SIMILAR PROJECTS

Two similar projects were found and compared with the methodology developed here. One project, Corridor Designs (Majka et al, 2007), was developed for mapping and designing wildlife corridor systems. The other, USFWS Gulf of Maine Coastal Watershed Habitat Analysis (USFWS, 2007), was designed to "strategically protect fish and wildlife habitat for endangered, threatened, rare or declining trust species in the Gulf of Maine watershed" (USFWS, 2007). Both projects based their methodologies on the USFWS Habitat Suitability Index (HSI) methodology developed in 1980 (USFWS, 1980). As mentioned above, the USFWS HSI methodology employed a relative weights system where the weights

were applied to each habitat input variable in the creation of a weighted species habitat map. In the Corridor Designs methodology, these weighted species habitat maps were combined through an averaging process. In the Gulf of Maine methodology, weights were summed, averaged and layers were overlaid on each other retaining the values for individual species.

In contrast to the two projects mentioned above, in this Teton County project, the decision was made to equally weight all potential habitat identified for a focal species (pixel value = 1 for habitat), rather than produce species habitat maps with relative weights such as low, medium and high importance habitats. The rationale behind this decision was that a relative value weight for one species may not equate to the same numeric relative value for another species. For example, elk habitat that resulted in a pixel weight of 3 from a weighted criteria methodology wouldn't necessarily have the same biological value to Northern Harrier habitat that also resulted in a pixel weight of 3 from a weighted methodology specifically for harriers. Furthermore, the use of relative value weights during the creation of focal species habitat maps for Teton County would have greatly complicated, and potentially refuted, the methodology for combining all focal species habitat maps into one relative values map. The limited time and resources available to this project demanded a simpler approach. Therefore, the technique of applying mathematical weights to input layers was reserved for the third phase of the project, creating a relative values habitat map for the County.

SUGGESTIONS FOR FUTURE METHODOLOGY USE

While future updates to this Teton County Focal Species Habitat Mapping Project should adhere to the process outlined here, hindsight provides some insights that may be helpful to others considering similar planning. The primary suggestion, which applies broadly to the project's structure, is that other projects may find it more appropriate to begin with habitat types rather than species. To begin with habitat types, one would identify the primary habitat types in the area and then select species that represent these habitat types. This alteration in starting point could allow for more confidence in equal representation of habitat types across the landscape during the project's initial stages thereby possibly removing some of the assumptions or biases associated with the selection of focal species. Many species use multiple habitat types (forage vs. cover vs. breeding vs. winter) and therefore some duplication and/or correlation is inherent in the species-first methodology (used here) that could possibly be lessened in the habitat-first methodology. In a habitat-first methodology, it would be further suggested that multiple species be chosen to represent each habitat type since within a habitat type, use by species differs. The level of mapping detail included for each project would have implications for the number of species selected for each habitat. Since the selection of habitats and species is based on expert opinion in both methodologies, bias will be inherent with either approach. It is therefore a matter of choosing the methodology that best fits the project's desired outcome and limits bias and correlation to the greatest extent possible.

If a species-first approach was preferred, consideration could be given to broad categories of species. Example categories could include area-sensitive species, habitat specialists, those with dispersal limitations, sensitivity to barriers and otherwise ecologically or economically important. Using all state sensitive species that occur within the focal area may be another option depending on project resources (this could result in a large number of species). Categorical differentiation of species could limit the subjectivity used when choosing a subset of species and therefore providing a more transparent and defensible methodology.

REFERENCES

Bedrosian, B, K Gura, B Mendelsohn, and S Patla. 2015. Occupancy, nest success, and habitat use of Great Gray Owls in western Wyoming. State Wildlife Grant Final Report. Teton Raptor Center.

Bedrosian, B., N. Hough, K. Gura, and S. Patla. 2016. Northern Goshawk Nesting Survey Report. Teton Raptor Center report to Teton Conservation District.

Berger, J., S.L. Cain, and K.M. Berger. 2006. Connecting the dots: an invariant migration corridor links the Holocene to the present. Biology Letters. Available online at http://www.journals.royalsoc.ac.uk

BLM. 2010. Bureau of Land Management's Wyoming Sensitive Species List 2010 Update. Available online at: https://www.blm.gov/policy/im-wy-2010-027

BTNF. 2016. Intermountain Region (R4) Threatened, Endangered, Proposed and Sensitive Species. Report Dated June 2016. Available online at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5370041.pdf

Clevenger A., J. Wierzchowski, B. Chruszcz, and K. Gunson. 2002. GIS-Generated, Expert-Based Models for Identifying Wildlife Habitat Linkages and Planning Mitigation Passages. Conservation Biology. 16(2): 503-514.

Cogan, D. and S. Johnson. 2013. Final Report: Vegetation and Non-Vegetation Cover Type Mapping for Teton County. Jackson, Wyoming. Available online at: http://www.tetonwyo.org/plan

Comprehensive Plan.2012. Jackson/ Teton County Comprehensive Plan. Accessed March 2017 at: http://www.tetonwyo.org/compp/topics/jacksonteton-county-comprehensive-plan/251817/

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28:967-985.

ESRI®. 2017. ArcMap Desktop™ 10.5 mapping software. Redlands, CA. www.esri.com

Majka, D., J. Jenness, and P. Beier. 2007. CorridorDesigner: ArcGIS tools for designing and evaluating corridors. Accessed January 2017 at: http://corridordesign.org.

NMJH/ JHWF. 2016a. Nature Mapping Jackson Hole List of Species Observed in Teton County, WY. Requested of the Jackson Hole Wildlife Foundation. Online at: http://jhwildlife.org/our-work/nature-mapping/

NMJH/ JHWF. 2016b. Nature Mapping Jackson Hole/ Jackson Hole Wildlife Foundation, Jackson, WY. Observational Wildlife Data distributed 11/22/2016.

Pocewicz, A., H.E. Copeland, M.B. Grenier, D.A. Keinath, and L.M. Waskoviak. 2014. Vulnerability of Wyoming's terrestrial wildlife and habitats. Report by The Nature Conservancy, Wyoming Game and Fish Department and Wyoming Natural Diversity Database. Available online at: https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/wyoming/science/wyoming-wildlife-vulnerability-assessment-summary.pdf

Riginos, C., Krasnow, K.D., Hall, E., Graham, M., Sundaresan, S., Brimeyer, D., Fralick, G., & Wachob, D. 2013. Mule Deer (*Odocoileus hemionus*) Movement and Habitat Use Patterns in Relation to Roadways in Northwest Wyoming. FHWA-WY-13/08F.

Teton County. 2012. Jackson/ Teton County Comprehensive Plan. Accessed February 2017 at: http://www.tetonwyo.org/compp/topics/jacksonteton-county-comprehensive-plan/251817/

USFWS. 1980. Ecological Services Manual – Standards for the Development of Habitat Suitability Index Models. Washington DC. Accessed January 2017 at: https://www.fws.gov/policy/ESMindex.html

USFWS. 2007. Gulf of Maine Coastal Watershed Habitat Analysis. Accessed January 2017 at: https://www.fws.gov/GOMCP/identify.html

USFWS. 2016. US Fish and Wildlife Service Official Species List Request for Teton County, WY. Dated 4/25/2016. Accessed from Information for Planning and Consulting. Available online at: https://ecos.fws.gov/ipac/

WGFD. 2010. Wyoming Game and Fish Department's Species of Greatest Conservation Need in State Wildlife Action Plan. Available online at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/SWAP/Front-Matter-Table-of-Contents.pdf

SPECIES NARRATIVES

ELK

Year-round resident in Teton County.

Important Habitat Characteristics

Elk (*Cervus elaphus*) are adaptable foragers with a mixed diet and frequent a variety of habitats. Elk move seasonally between summer and wintering range that are largely distinguished by elevation, snow levels and vegetation diversity (Boyce et al, 2003). Like other ungulates, elk undergo seasonal migrations to track high quality and nutritious forage in the spring and summer and conserve energy in areas with low snow in the winter (Hebblewhite et al. 2008, Parker et al. 2009). Small groups of elk sometimes forgo migration and winter on wind-swept, more exposed parts of their summer range (USFWS, 2007). In Jackson Hole, a growing segment of the Jackson Elk Herd only migrates a short distance from the National Elk Refuge in the winter to private lands in the summer (Cole et al. 2015).

Elk are versatile generalists and use a mixture of habitat types in all seasons. Having evolved as an ecotone species in cold, temperate climates, elk retain features adaptive to both forested and grassland environments. They prefer open areas but also use dense coniferous forests for cover. Elk distribution is related to elevation, aspect, forage, cover, predator distribution, human disturbance and weather variables (USFWS, 2007).

Throughout the year, elk rely on a matrix of forested and grassland areas, specifically the forest/ grassland edge is important for thermal/ hiding cover and forage. The configuration of open space and cover is important and in Oregon 80 percent of elk use in summer forage areas occurred within 300 yards of this edge (Skovlin, 2002). Beyond sharing certain characteristics of two vegetative cover types, areas between forested areas and grassland and/or sagebrush meadows have higher diversity and greater quantity of forage plants than individual vegetative cover types. Elk primarily forage on grass and forb species during the summer, while in winter they incorporate more woody browse species such as aspen, willow, serviceberry and chokecherry into their diet. Elk use decreases as distance from forest edge increases (Toweill and Thomas, 2002). Additionally, elk often make use of upper slopes, regardless of season. Their vertical movements along these upper slopes, may be due to cooling wind patterns, visibility and/or cover type (Toweill and Thomas, 2002).

Three elk herds live in Teton County including the Jackson Elk Herd, the Targhee Elk Herd and a portion of the Fall Creek Elk Herd. The Jackson Herd is one of the largest in North America, currently numbering 11,200 animals (WGFD 2015a). The Fall Creek Herd is found in the southern portion of Teton County and estimated to be 4,500 animals (WGFD 2015b) and the Targhee Herd on the west side of the Teton Mountain Range has an unknown number of elk due to lack of annual surveys.

Winter Habitat

The majority of elk in the Jackson and Fall Creek Herds winter on one of the seven state-administered feedgrounds in Teton County or on the National Elk Refuge (NER). The Wyoming Game and Fish Department (WGFD) runs three elk feedgrounds in the Gros Ventre drainage (Alkali, Patrol Cabin and Fish Creek) and 4 elk feedgrounds south of the Town of Jackson (South Park, Camp Creek, Horse Creek and Dog Creek). Elk native winter range in Teton County and its vicinity includes areas north of Ditch Creek, the Spread Creek-Uhl Hill areas, the Buffalo River valley, the Gros Ventre River and Snake River floodplains, National Forest lands east of the NER and the north end of the NER (USFWS, 2007; WGFD, 2016a). Variation in snowfall affects elk distribution annually. During years of heavy snowfall, a larger portion of the herd can be found wintering on the NER and WGFD feedgrounds. Conversely, in years of little snowfall, fewer elk migrate south to the NER and more elk remain on native winter range. These changes in movement patterns are likely an effect of snow depth and winter severity alterations of

winter range and food availability. However, in recent years a larger portion of the Jackson Elk Herd has utilized feedgrounds (even during relatively mild winters) which may be partly explained by increasing wolf pressure on native winter ranges (Cole et al. 2015). In winter, elk primarily use open grassland, when available, but can also be found in forests with grassland openings, especially aspen forests (USFWS, 2007).

It is common for elk to attempt to utilize stored hay and hay on livestock feedlines during the winter. In Teton County, state-run and NER feedgrounds are a tool to provide elk with an alternative food source, separate them from private agricultural lands and prevent co-mingling with livestock or damage to stored hay in the winter (WGFD 2016b). In most cases in Teton County, WGFD personnel haze elk away from private agricultural lands in the winter to prevent potential transmission of brucellosis to cattle and damage to stored crops (WGFD 2016b).

Elk utilize wind-swept slopes in winter as these tend to have less snow cover than nearby sheltered areas where snow accumulates. In north-central Idaho, elk were found to prefer slopes of 18 percent or less (Skovlin et al, 2002). Similarly, elk tend to prefer south facing slopes where, again, the snowpack is shallower than surrounding areas (Skovlin et al, 2002). In Yellowstone National Park, a largely forested habitat, elk primarily selected grasslands with interspersed forests as foraging areas (Boyce et al, 2003).

Summer and Calving Habitat

Calving takes place during the spring while elk are transitioning between winter and summer ranges. Elk give birth in late May to early June. Cow elk use various habitats for calving but seem to prefer sagebrush, aspen and willow habitats on gentle slopes near the forest edge and close to water (USFWS, 2007; Toweill and Thomas, 2002). Elk parturition areas tend to be selected based primarily on micro-habitat variables, including local shelter and available forage, rather than on landscape variables. In late summer and fall elk use a variety of grassland and forest types. Grass species comprise the majority of an elk's diet in all seasons (USFWS, 2007).

In north-central Idaho, Elk prefer slopes ranging from 20 to 40 percent and northeasterly aspects (Skovlin et al, 2002) while making frequent movements between ridge tops and drainage bottoms. During the Rocky Mountain summers, water is an important resource for elk. Their optimal distance from water is no more than a half mile with elk use declining at distances greater than a half mile (Toweill and Thomas, 2002).

General characteristics of elk summer habitat found in Toweill and Thomas (2002) include:

- Elk feed primarily in grassland and open areas but also rely on forested areas for cover and hiding.
- The areas where forested and grassland or sagebrush vegetative cover meet is important for both forage and cover.
- Elk use decreases as distance from interface of forest and non-forest communities increase with 80 percent of elk use occurring within 300 yards of the forest edge
- Canopy cover requirements for Rocky Mountain elk vary by time of day, season and weather conditions. Crown density influences the use of cover for elk with the heaviest elk use in areas of 75 -100 percent crown canopy. Feeding within the forested cover types typically occurs in areas with 0 - 25 percent canopy cover.
- In summer, elk prefer slopes of 20-40 percent and habitat within half mile from surface water is a high use area

Migration Corridors

In spring elk use relatively open grassland with some timber. Migrations may occur over periods of a few days to several weeks. Initiation of migration occurs with increased snow in fall and receding snow and new vegetation growth in the spring (April or May) (USFWS, 2007).

In the fall, elk use a variety of grassland and forest types. Elk make short movements in the fall after the first frosts occur, they generally remain on summer range until heavier snow covers forage, stimulating migrations to lower wintering areas. A few elk forgo migration and winter on wind-swept, more exposed parts of their summer range (USFWS, 2007).

Fall migrations begin in October or November and usually end in mid-December. Elk move down from their summer ranges toward lower elevation winter ranges, channeled in some places by steep terrain and lakes. Some Jackson elk move only a short distance, while others cover up to 60 miles between summer and winter ranges. Migrations may occur over periods of a few days to several weeks (USFWS, 2007).

Wachob and Smith (2003) found that elk in Jackson Hole were not using screening vegetation during migration route selection. Alternatively, Wachob and Smith (2003) suggested that the viewscapes across open habitat within a migration route is an important variable for route selection. Elk in Jackson Hole may prefer migration routes that cross open areas with a line of sight to visible woody vegetation. Wachob and Smith (2003) found that the length of woody vegetation visible was positively correlated with the number of elk choosing to cross the open landscape.

Non-wildlife friendly fencing functions as potential migration barriers to elk moving through the landscape (Paige, 2012; WGFD, 2004). Additionally, roads can act as migration barriers and hazards, especially if they have high traffic volumes.

The Wyoming Migration Initiative is working on developing a GIS layer for Jackson and Fall Creek elk high use migration corridors using GPS collar data. This information will not be available for this version of the Teton County Focal Species Habitat Mapping Project but should be incorporated in the future. Dr. Matt Kauffman is expecting that the results should be available by October 2017 (Dr. Matt Kauffman, *pers. communication*).

Risk Factors to Habitat/ Habitat Function

While loss of habitat and habitat fragmentation are of primary concern to elk, the continued existence of migration routes is of utmost importance. Throughout their annual cycle, elk utilize a large portion of the landscape available within Teton County, WY. In order to complete their seasonal migrations, elk must negotiate numerous roads, fences, levees and other human alterations to the landscape that can potentially cause increased energy expenditure, stress, injury and sometimes death (Clark 1999). Historically, winter range in the valley floor has been lost to residential development. Therefore, the ability to access and utilize existing winter range is of utmost importance to this mobile species. Winter is an energetically difficult time, in which elk must balance energy expenditures against energy intake in order to survive (Parker et al. 2009). Elk may eventually become habituated to repeated and predictable human activity, such as cars on a road, horse-drawn sleighs on a feedground or larger feeding machinery on the NER. However, elk are easily disturbed by deviations from normal patterns (Clark 1999) such as off-trail snowmobiling, cross-country skiers or a human stepping off a sleigh on a feedground. Therefore, providing areas of undisturbed winter habitat is important for this species.

Literature Sources

Boyce, M. J Mao, E Merrill and D Fortin. 2003. Scale and Heterogeneity in Habitat Selection by Elk in Yellowstone National Park. Ecoscience 10(4):421-431.

Clark, W. 1999. Effects of winter recreation on elk. Pages 17-30 in T. Olliff, K. Legg, and B. Kaeding, editors. Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: a Literature Review and Assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming, USA.

Cole, E.K., Foley, A.M., Warren, J.M., Smith, B.L., Dewey, S.R., Brimeyer, D.G., Fairbanks, W.S., Sawyer, H., and P.C. Cross. 2015. Changing Migratory Patterns in the Jackson Elk Herd. Journal of Wildlife Management 79:877-886.

Hebblewhite, M., E. Merrill, and G. McDermid. 2008. A multi-scale test of the forage maturation hypothesis in a partially migratory ungulate population. Ecological Monographs 78:141-166.

Paige, C. 2012. A Landowner's Guide to Fences and Wildlife: Practical Tips to Make Fences Wildlife Friendly. Wyoming Land Trust, Pinedale, WY.

Parker, K.L., P.S. Barboza, and M.P. Gillingham. 2009. Nutrition integrates environmental response in ungulates. Functional Ecology 23:57-69.

Skovlin J, P Zager and B Johnson. 2002. Elk Habitat Selection and Evaluation. Chapter 12 in Toweill, D and J. Thomas. 2002. North American Elk Ecology and Management. Smithsonian Institute Press, Washington D.C.

Toweill, D and J. Thomas. 2002. North American Elk Ecology and Management. Smithsonian Institute Press, Washington D.C.

USFWS. 2007. Bison and Elk Management Plan and Environmental Impact Statement National Elk Refuge Grand Teton National Park.

Wachob & C, Smith. 2003. Elk migration through a human dominated landscape in Jackson Hole, Wyoming. Final report. Teton Science School Kelly, WY and National Elk Refuge, Jackson, WY.

WGFD. 2004. Fencing Guidelines for Wildlife. Habitat Extension Bulletin No. 53. Wyoming Game and Fish Department. Cheyenne, WY.

WGFD. 2015a. Jackson Elk Herd Job Completion Report. Alyson Courtemanch, Wildlife Biologist. Accessed October 2016 at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_BGJACKSON_ELK_2015.pdf

WGFD. 2015b. Fall Creek Elk Herd Job Completion Report. Gary Fralick, Wildlife Biologist. Accessed October 2016 at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_BGJACKSON_ELK_2015.pdf

WGFD. 2016a. Jackson Elk Herd Unit Population Objective Review. Alyson Courtemanch, Wildlife Biologist. 17 pp.

WGFD. 2016b. Jackson Elk Herd Unit Brucellosis Management Action Plan Update. Accessed October 2016 at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Wildlife/E102_BMAPUpdate_060216-Jackson-Elk.pdf

Habitat Characteristics

No known habitat model exists for elk in Teton County, WY.

While habitat characteristics are listed below for both winter and summer habitat, it has been decided by WGFD and NRTAB to not map summer habitat. Most summer habitat is in high-elevation montane areas that are primarily located on public lands in Teton County.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Winter	Elk Feedgrounds	WGFD Feedground layer; NER	All feedgrounds; On the NER, feeding is done on the southern end of the NER. The northern end should be mapped as native winter range for elk based on veg criteria.	WGFD
Winter	grasslands and sagebrush and aspen	TC Veg Layer	Grasslands, sagebrush (with grass understory), aspen forest	Skovlin et al, 2002
Winter	Elevation	Digital Elevation Model	<= 9,400 feet	WGFD defined based on aerial surveys
Winter	Aspect	Digital Elevation Model	Southerly aspects (SW to SE)	Skovlin et al, 2002
Winter	Slopes	Digital Elevation Model	<36%	Skovlin et al, 2002 & WGFD aerial surveys
Migration	Migration Route	WGFD	Use all	WGFD
Parturition	Parturition Habitat	WGFD Parturition Areas map (finalized approx. 11/4/16)	Parturition areas	WGFD is finalizing a map
Summer	Forest/ grassland edge	TC Veg Layer	Conifer/ grassland/ shrub associations	Skovlin et al, 2002
Summer	Ecotone	Create	300 yards from the forest edge constitutes higher importance habitat	Skovlin et al, 2002
Summer	River bottoms	TC Veg Layer	Riverine drainages and wetland depressions	Skovlin et al, 2002 & General knowledge
Summer	Aspect	DEM	Northerly aspects (NW to NE)	Skovlin et al, 2002
Summer	Slope	DEM	20-40%	Skovlin et al, 2002
Summer	Water Source	National Hydrography Dataset(NHD)	0.5 mi from surface water constitutes higher importance habitat	Skovlin et al, 2002

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Secondary Reviewer: Patrick Wright, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Elk Feedgrounds	Digitize feedground areas	All	Edit	Polygon of Parcels or digitized general area
Important Veg Cover	From BTNF, CTNF, GRTE & TC Veg layers, select grasslands (including agricultural fields) and sagebrush and aspen	See Definition Query Selection Below	Definition Query; Merge Layer	All Elk winter veg covers
All Important Habitat	Merge shapefiles (Veg and feedgrounds)		Merge Polygons	All habitat
Remove Deep Snow areas	Remove northern Antelope Flats (north of Antelope Flats Rd), Timbered Island sagebrush area (Baseline Flat) and Potholes west of Snake River bench and south of Jackson Lake Dam.	Area digitized. Removed from all habitat polygon	Erase tool	All habitat without deep snow area
Convert Shapefile to Raster	Convert Elk Winter Veg Cover Areas Shapefile to a Raster	Add Values Field; Calculate Field to 1; Convert Polygon to Raster	Add Field, Calculate Field; Polygon to Raster	Elk Winter Veg Cover Raster
Elevation	Retain elevations < 2865 m (9,400 ft) in Gros Ventre and <2320m (7600 ft) in remainder of Teton County	VALUE < 2865 m in GV and VALUE < 2320 in remainder of TC	Extract By Attribute (creates two rasters)	Elev & Slope & Aspect for GV and remainder of TC
Slope	Retain slopes < 36°	VALUE < 36 OR VALUE = -1 (flat)	Extract By Attribute	
Aspect	Retain aspects E to W – 90-270	VALUE > 135 AND VALUE <	Extract By Attribute	

		225 AND VALUE = -1		
Intersection of Elevation, Slope and Aspect	Select areas of overlap between elevation, slope and aspect rasters	Retain areas of overlap.	Simple sum calculation (creates two rasters)	
Define GV and TC areas	Clip Elev/Slope/Aspect Rasters to GV and TC Areas and combine	Clip rasters; Mosaic together	Clip; Mosaic to New Raster	Mosaic Raster for Extracting Veg
Extract Veg by Elevation/ Slope/ Aspect	Winter veg habitat <36° slope and E to W aspects with < 9400 ft in GV and < 7600 feet in the remainder of TC	Extract by Mosaic Elev/ Slope/ Aspect	Extract by Mask; Reclassify so No Data = 0	Product
Compare with WOS and NMJH observations	Visually compare observations with output.			

Veg Cover Definition Query Categories

Teton County Map Codes:
Irrigated Agricultural Fields - NIPI
Non-Irrigated Agricultural Fields - NIPN
Perennially Flooded Agricultural Fields - NIPF
Montane Mesic Forb Herbaceous Vegetation - HFD
Mixed Grassland Herbaceous Vegetation - HGL
Mixed Planted and Introduced Grassland Herbaceous Vegetation - HPG
Recently Burned Sparse Vegetation - VRB
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Mixed Tall Deciduous Shrubland - SMR
Rubber Rabbitbrush Shrubland - SRB
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SES, SMSD, SSD
Aspen Forest - FAP
Aspen Forest - FAP, FEP
Aspen Woodland Regeneration - RAP

Grand Teton Nation Park Map Codes:
Irrigated Fields - NIP
Bracken Fern Herbaceous Vegetation - HBR
Montane Mesic Forb Herbaceous Vegetation - HFD
Subalpine Mixed Herbaceous Vegetation - HSA
Mixed Grassland Herbaceous Vegetation - HGL
Montane Xeric Forb Herbaceous Vegetation - HFX

Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SSD
Aspen Forest - FAP
Aspen Woodland Regeneration - RAP

Bridger-Teton National Forest MU CODE:
Agriculture - AG
Alpine Vegetation - AL
Grassland/Forbland - GF
Sparse Vegetation - SV
Tall Forbland - TF
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Mountain Shrubland - MS
Sagebrush/Bitterbrush Mix - SB
Silver Sagebrush/Shrubby Cinquefoil - SS
Spiked Big Sagebrush - SK
Aspen - ASP
Aspen/Conifer Mix - MAS

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Aspen - AS
Caribou-Targhee Aspen/Conifer - AS/C
Bridger-Teton Grassland/Forbland - GF
Bridger-Teton Tall Forbland - TF
Caribou-Targhee Montane Herbaceous - MTNH
Caribou-Targhee Subalpine Herbaceous - SUBH
Bridger-Teton Sparse Vegetation - SV
Caribou-Targhee Agriculture - AGR
Caribou-Targhee Barren/Sparse Vegetation - BR/SV
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB

Metadata

Title

ELK_Win.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Elk Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

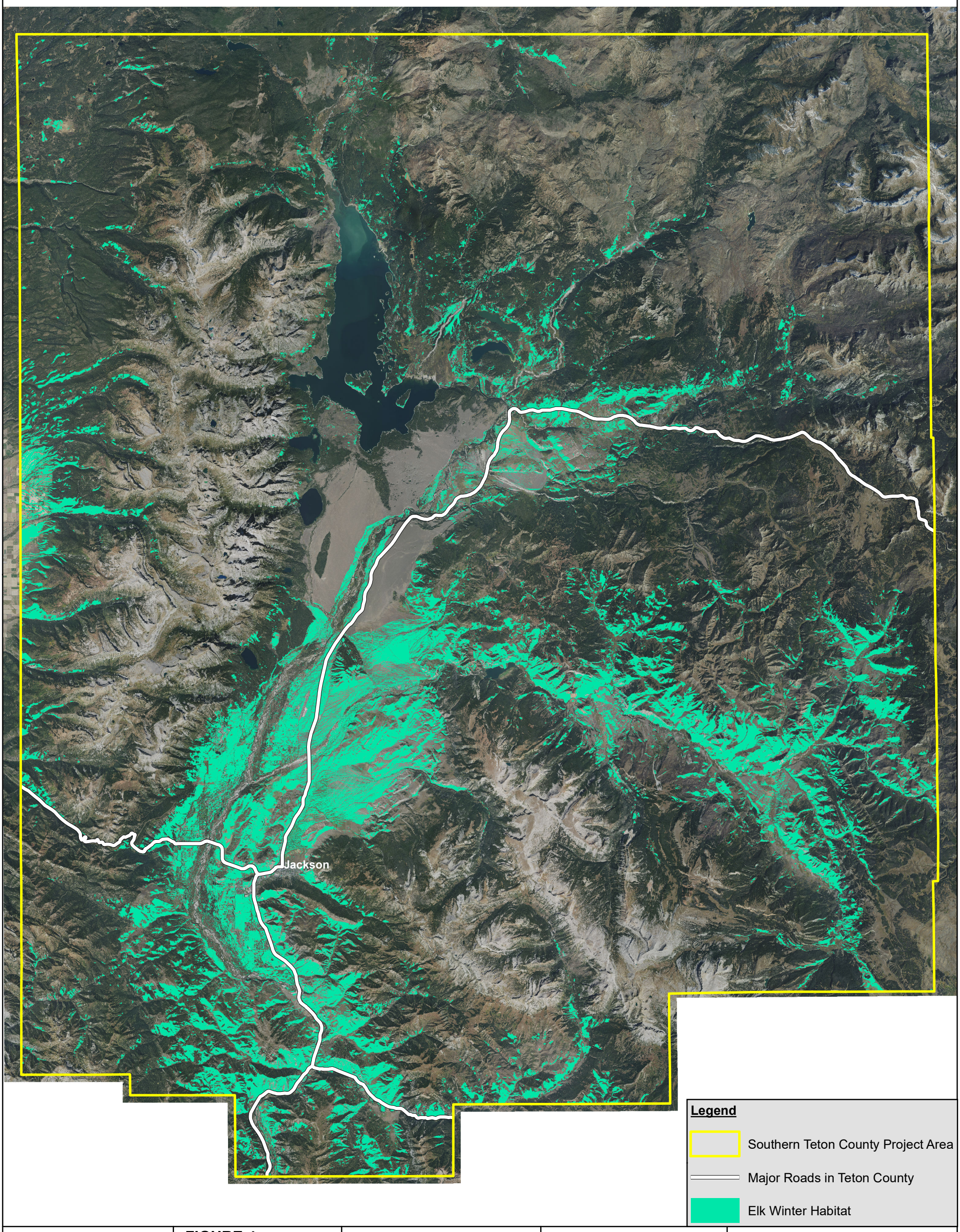
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the elk is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 4:

Elk Winter Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

ALDER ENVIRONMENTAL, LLC
Water • Wetlands • Ecological Consulting
P.O. Box 6519, Jackson, Wyoming 83002
(307) 733-5031 www.alderenvironmental.com

MOOSE

Year-round resident in Teton County.

Important Habitat Characteristics

Wyoming Game and Fish Department lists the Shiras moose (*Alces alces shirasi*) as a species of greatest conservation need (NSS4) based on declines in habitat and population (WGFD, 2010). It is generally believed that moose immigrated into Wyoming from Montana and Idaho in the 1850s. By 1950 an estimate of 2,597 moose resided in Wyoming (Houston, 1968). Teton County includes portions of two moose herds, the Jackson Herd (northern Teton County) and the Sublette Herd (southern Teton County). The Jackson Moose Herd was once the largest in Wyoming, numbering approximately 3,000-5,000 animals in the late 1980s (WGFD, 2015a). However, the population underwent a dramatic crash beginning in the early 1990s due to a combination of habitat degradation through over-browsing (Smith et al. 2011), re-colonizing wolves and grizzly bears (WGFD, 2015a), climate warming and disease (WGFD, 2015a). Currently the Jackson Moose Herd population estimate is less than 500 individuals with trend counts data registering 71% below objective (WGFD, 2015b). The Sublette Moose Herd includes portions of Teton, Sublette and Lincoln Counties and includes more individuals but is still 33% below its population objective (WGFD, 2015c).

Both the quantity and quality of forage are important variables for moose survival. Throughout the year, moose depend on willow, aspen, shrub and conifer habitats (Franzmann and Schwartz 2007). Moose are prone to overheating; therefore, thermoregulation is an essential component of moose survival (Renecker and Hudson 1986). As a result, the spatial distribution of forage and available cover are both necessary habitat requirements (Tyers 1999; van Beest et al, 2012). Several studies have found that probability of moose utilizing an area increased when a diversity of forage and cover vegetative components were present (Becker, 2008 & Maier et al., 2005).

Across Wyoming, crucial winter range is a limiting factor for moose populations (Hnilicka and Zornes, 1994). Milner et al. (2013) found that reproductive success of moose is limited by winter nutritional condition. Therefore, not only is the availability of this limited resource (crucial winter range) important but the quantity and quality of forage available in these areas is also critically important. Furthermore, security from human disturbance is critical during winter months when food resources are scarce and energetic demands are high (Tyers, 1999).

Osko et al. (2004) and Pierce and Peek (1984) found that moose habitat preferences varied across different populations and even among individuals within the same population. When highest quality habitat is not available, moose have limited ability to modify their behavior to adapt to local conditions (Becker, 2008; Miquelle and Jordan, 1979). Vartanian (2011) found that individual moose exhibited high fidelity to their seasonal ranges and migration routes, even when forage quality in those areas was low. These studies suggest that moose may exhibit some flexibility in their habitat selection at the home range scale, but not at the landscape scale. Therefore, moose will continue to use traditional areas even if they are poor quality, which can result in decreased reproductive success and survival (Tyers 1999; Vartanian 2011).

Winter Habitat

In winter, moose generally migrate to lower elevation areas where a shallower snow pack allows for greater mobility and decreased energetic demands (Parker et al, 2009). These low elevation winter sites are generally associated with riparian willow zones in conjunction with forest cover which allow for utilization of closed canopy areas as environmental conditions dictate (Becker, 2008; Baigas, 2010). In general, winter range will include a concentration of accessible browse, such as deciduous trees (aspen) and shrubs (especially willow species and mountain shrubs such as serviceberry, chokecherry and bitterbrush) (Tyers, 1999). Moose may also browse on subalpine fir saplings (Baigas, 2010; Vartanian, 2011). Oftentimes, the highest quality winter range is found were forage species occur in juxtaposition with forest cover (Tyers, 1999).

In south central Montana, Van Dyke et al. (1995) found that moose select aspen over lodgepole pine in all seasons and wetland shrub areas (willows) in winter and spring. Conifer communities are often considered marginal winter habitat but have been found to be used extensively in areas with limited willow habitat (Pierce and Peek 1984).

In northwest Wyoming (Buffalo Valley), Becker (2008) found that moose selected winter habitat with a high proportion of riparian/ deciduous shrub and aspen vegetation types, low elevation, high habitat diversity, moderate slopes and proximate to conifer cover. Predictive maps indicated that these areas were generally found along relatively flat, low elevation drainages dominated by riparian and deciduous shrub habitats interspersed with conifer and aspen patches (Becker, 2008). In southeastern Wyoming (Snowy Range), Baigas (2010) found similar results with respect to vegetative communities with additional emphasis on the incorporation of distance to riparian shrub, deciduous forest and forest edge being important components of habitat selection.

Moose can be negatively impacted by human activity and disturbance in the winter (Tyers, 1999). Because they are often in an environment where snow is deep, escape from a perceived threat can be energetically costly. Human activities in the form of skiing, snowshoeing and snowmobiling can cause stress, displacement and prevent moose from using important habitats (Tyers, 1999; Neumann et al, 2010). Moose require large patches of undisturbed habitat for foraging, resting and conserving energy during the winter. Specific results from both Becker (2008) and Baigas (2010) were used as a basis for the GIS Inputs for Task B outlined below.

Summer Reproductive Habitat

Moose movements are less constrained in the summer months than in winter. Nonetheless, heat stress is an issue that moose need to regulate in the summer through habitat selection of areas that provide both forage and thermal cover (van Beest et al, 2012). Moose generally move to higher elevation habitats in the summer (in comparison to winter habitats) which may be one means of temperature regulation. Migration to higher elevation summer habitats is most likely driven by enhanced forage quality due to delayed vegetation phenology (green-up) (Hebblewhite et al, 2008; Merkle et al, 2015). Becker (2008) found that moose in summer moved >300 meters (984 feet) higher in elevation and were > 100 meters (328 feet) closer to cover than in winter high use areas. In summer, Becker (2008) also found that moose selected habitats at moderate elevations, on moderate slopes and close to cover. Baigas (2010) had similar findings in the Snowy Range of southeast Wyoming with the most significant summer habitat predictor being the total area of willow within a 1 km radius. Specific results from both Becker (2008) and Baigas (2010) were used as a basis for the GIS Inputs for Task B outlined below.

Migration Corridors

Moose in Teton County, WY generally conduct seasonal migrations of varying distances between summer and winter home ranges. In some cases, summer and winter home ranges may overlap slightly while others may be distinctly away from one another. Becker (2010) found migration routes in northwestern Wyoming to range from 3.1 to 44.0 km (1.9 to 27.3 miles) over two years (2005 ave. 19.8 ± 3.4 km; 2006 ave. 23.1 ± 3.1 km). Moose have only been GPS-collared in the Buffalo Valley area in Teton County, so fine-scale data on migration routes is not available elsewhere in the County. WGFD has identified potential moose migration routes in Teton County using ground observations and local knowledge. However, these routes are estimations and are unlikely to be a complete listing of migration routes. Additionally, the Wyoming Migration Initiative at the University of Wyoming is working on developing a GIS layer for Buffalo Valley moose high use migration corridors. This information will not be available for this version of the Teton County Focal Species Habitat Mapping Project but should be incorporated in the future. Dr. Matt Kauffman is expecting that the results should be available by October 2017 (Dr. Matt Kauffman, *pers. communication*).

Risk Factors to Habitat/ Habitat Function

Primary risk factors for moose habitat and habitat function in Teton County include direct and indirect habitat loss and degradation, habitat fragmentation, climate change (WGFD, 2015a) and anthropogenic disturbance.

Habitat Loss and Degradation

Moose respond to environmental variables within a few kilometers of their location (Maier et al, 2005). The protection of high quality winter habitat that also promotes forage production will allow for resource needs to be met in a smaller area thereby allowing for lower travel costs (Poole and Stuart-Smith, 2005). Direct competition between elk and moose during the winter could also negatively affect their energy requirements since moose may be forced to occupy areas of deeper snow than either elk or deer (Jenkins and Wright, 1988). Competition between moose and cattle is found in the form of shared resources. While cattle browse willow in the summer during the growing season, moose depend on this same resource during the winter months. This competition can be difficult to measure and can vary greatly across sites. It is well documented that willow growth benefits from protection from browsing ungulates, both wild and domestic (Manouklan and Marlow, 2002; Matney et al, 2005). Therefore, the best means of mitigating competition between cattle and moose may be through the protection of willow and other riparian shrub plants from livestock.

Indirect habitat loss can occur through human activity and disturbance that displaces moose from preferred areas (Tyers, 1999; Neumann et al, 2010). Neumann et al. (2010) found that moose showed increased movement rates for up to 3 hours following disturbance by cross-country skiers and left their foraging areas. In addition, adult moose increased their energetic usage by an estimated 48% and calves by 61% following disturbance. The intensity of response can vary by individual and some individuals may become habituated to certain types of repeated activity over time (Neumann et al, 2010).

Habitat Fragmentation

The majority of moose in Teton County rely on seasonal migrations from low elevation winter ranges to high elevation summer ranges to survive. Moose that are non-migratory and remain near urban and suburban development year-round also require movements between foraging and resting areas. Existing moose habitats become fragmented from residential and commercial development, roads and traffic, pathways and trails and full or partial barriers such as fences. This fragmentation makes it more difficult

for moose to move across the landscape to access the resources they need to survive and reproduce and will eventually lead to population decline.

Climate Change

Wyoming is at the southern edge of the circumpolar distribution of moose (Franzmann and Schwartz, 2007) and warming seasonal temperatures could affect our moose populations. As climate change occurs, a warming trend in seasonal temperatures may force moose populations to move north within their current distribution area (Lenarz et al, 2008). Moose suffer from heat stress when summer temperatures rise above 14 °C (57°F) (Schwartz and Renecker, 1997 in Becker, 2008). Similarly, January temperatures above a critical threshold were found to be inversely correlated with survival rates (Lenarz et al, 2008). As temperatures increase, moose ranges may be altered and survival may decrease in the southern reaches of their current distribution area. Indeed, Monteith et al. (2013) found that warm temperatures had a negative influence on moose calf recruitment in the Jackson and Sublette Moose Herds. Furthermore, relatively dry spring and summer seasons also had a negative influence on recruitment. This is likely caused by suppressed nutritional condition of cow moose through (1) increased thermoregulation demands associated with warming temperatures (i.e. moose spend more time resting in the shade instead of feeding) and (2) shortened duration of availability of high quality forage in spring and summer (i.e. plants dry up faster so moose have a short window to fatten up on high quality, green vegetation) (Monteith et al, 2013). Therefore, climate change is expected to lead to decreased moose calf recruitment and potentially contribute to population decline in the Jackson and Sublette Herds.

Literature Sources

Baigas, P, R Olson, R Nielson, S Miller and F Lindzey. 2010. Modeling Seasonal Distribution and Spatial Range Capacity of Moose in Southeastern Wyoming. Alces 46:89-112.

Becker, S, 2008. Resource Selection and Population Dynamics of Shiras moose (Alces alces shirasi) in Northwest Wyoming. MS Thesis University of Wyoming, Laramie, Wyoming.

Franzmann, A. W., and C. C. Schwartz, editors. 2007. Ecology and management of the North American Moose, 2nd edition. University Press of Colorado, Boulder, CO.

Hebblewhite, M., E. Merrill, and G. McDermid. 2008. A multi-scale test of the forage maturation hypothesis in a partially migratory ungulate population. Ecological Monographs 78:141-166.

Hnilicka, P. and M Zornes. 1994. Status and management of moose in Wyoming. Alces 30:101-107.

Houston, D. B. 1968. The Shiras moose in Jackson Hole, Wyoming. Technical Bulletin No. 1. Grand Teton Natural History Association.

Jenkins, K. J., and R. G. Wright. 1988. Resource partitioning and competition among cervids in the northern Rocky Mountains. Journal of Applied Ecology 25:11-24.

Lenarz, M. S., M. E. Nelson, M. W. Schrage, and A. J. Edwards. 2008. Temperature mediated moose survival in northeastern Minnesota. The Journal of Wildlife Management 73:503-510.

Maier, J. A., J. M. Ver Hoef, A. D. McGuire, R. T. Bowyer, L. Saperstein, and H. A. Maier. 2005. Distribution and density of moose in relation to landscape characteristics: effects of scale. Canadian Journal of Forest Research 35:2233-2243.

Manouklan, M., and C. B. Marlow. 2002. Historical trends in willow cover along streams in southwestern Montana cattle allotment. Northwest Science 76:213-220.

Matney, C. A., C. S. Boyd, and T. K. Stringham. 2005. Use of felled junipers to protect streamside willows from browsing. Rangeland Ecology and Management 58:652-655.

Merkle. J.A., Monteith, K.L., Aikens, E.O., Hayes, M.M., Hersey, K.R., Middleton, A.D., Oates, B.A., Sawyer, H., Scurlock, B.M., and M.J. Kauffman. Large herbivores surf waves of green-up during spring. Proceedings in Biological Sciences 283.

Milner, J.M., F.M. van Beest, E.J. Solberg, and T. Storaas. 2013. Reproductive success and failure: the role of winter body mass in reproductive allocation in Norwegian moose. Oecologia 172:995-1005.

Miquelle, D.G. and P.A. Jordan. 1979. The importance of diversity in the diet of moose. Proceedings of the North American Moose Conference and Workshop 15: 54-79.

Monteith, K.L., R.W. Klaver, K.R. Hersey, A.A. Holland, T.P. Thomas, and M.J. Kauffman. 2015. Effects of climate and plant phenology on recruitment of moose at the southern extent of their range. Oecologia 178:1137-1148.

Neumann, W., Ericsson, G., and H. Dettki. 2010. Does off-trail backcountry skiing disturb moose? European Journal of Wildlife Research 56:513-518.

Osko, T. J., M. N. Hiltz, R. J. Hudson, and S. M. Wasel. 2004. Moose habitat preferences in response to changing availability. Journal of Wildlife Management 68:576-584.

Parker, K.L., P.S. Barboza, and M.P. Gillingham. 2009. Nutrition integrates environmental response in ungulates. Functional Ecology 23:57-69.

Pierce, D. J., and J. M. Peek. 1984. Moose habitat use and selection patterns in north-central Idaho. Journal of Wildlife Management 48:1335-1343.

Poole, K. G., and K. Stuart-Smith. 2005. Fine-scale winter habitat selection by moose in interior montane forests. Alces 41:1-8.

Renecker, L.A. and R.J. Hudson. 1986. Seasonal energy expenditures and thermoregulatory responses of moose. Canadian Journal of Zoology 64:322-327.

Schwartz, C.C. and L.A. Renecker, 1997. Nutrition and energetics. Pages 441-478 *in* Franzmann, A. W., and C. C. Schwartz, editors. 2007. Ecology and management of the North American Moose, 2nd edition. University Press of Colorado, Boulder, CO.

Smith, M.A., Kilpatrick, S., Younkin, B., Work, L., and D. Wachob. 2011. Assessment of crucial moose winter habitat in western Wyoming. Alces 47:151-162.

Tyers, D. 1999. Effects of winter recreation on moose. Pages 73-96 in T. Olliff, K. Legg, and B. Kaeding, editors. Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: a Literature Review and Assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming, USA.

Van Dyke, F., B. L. Probert, and G. M. Van Beek. 1995. Seasonal habitat use characteristics of moose in south-central Montana. Alces 31:15-26.

Vartanian, J. 2011. Habitat Condition and the Nutritional Quality of Seasonal Forage and Diets: Demographic Implications for a Declining Moose Population in Northwest Wyoming. MS Thesis Department of Zoology and Physiology, University of Wyoming. Laramie, Wyoming.

van Beest, F., Van Moorter, B.F.A., and J.M. Milner. 2012. Temperature-mediated habitat use and selection by a heat-sensitive northern ungulate. Animal Behaviour 84:723-735.

WGFD. 2010. Wyoming Game and Fish Department State Wildlife Action Plan Species Account. Wyoming Game and Fish Department Report. Cheyenne, WY.

WGFD. 2015a. Jackson Moose Herd Unit Population Objective Review. Alyson Courtemanch, Wildlife Biologist. 22 pp.

WGFD. 2015b. Jackson Moose Herd Job Completion Report. Alyson Courtemanch, Wildlife Biologist. Accessed in October, 2016 at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_BGJACKSON_MOOSE_2015.pdf

WGFD. 2015c. Sublette Moose Herd Job Completion Report. Dean Clause, Wildlife Biologist. Accessed in October, 2016 at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_BGPINE_MOOSE_2015.pdf

Younkin, BL, L Work, D Wachob, M Graham. 2008. Jackson Moose Herd Habitat Assessment Final Report. Conservation Research Center of the Teton Science Schools. Jackson, Wyoming.

Habitat Characteristics

No known habitat model exists for moose in Teton County, WY. However, habitat studies were done in northern Teton County (Becker, 2008; Vartanian, 2011) and in the Snowy Range in Southeastern Wyoming (Baigas, 2010) which quantified habitat selection and/ or use by collared moose. These studies were used as guides for the GIS inputs information.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Winter	Riparian Shrub	Veg Layer	Patch size <1.75 ha (4.3 ac) are optimal	Baigas, 2010 In Teton County, the larger the willow patch, the better.
Winter	Distance to Riparian Shrub	Buffer Willow	Within 200 m (656 ft) of riparian shrub patch	Baigas, 2010
Winter	Forest and shrub habitat other than riparian	Veg Layer	mesic shrub, mixed mountain shrub (incl bitterbrush), deciduous forest, mixed forest, subalpine fir, aspen/ conifer mix within 200m of riparian area	Baigas, 2010
Winter	Slopes	DEM	< 20° are used; 0-10° are optimal	Baigas, 2010
Winter	Elevation	DEM	Max of 8,600 based on WGFD winter flights. (Becker reported an ave elevation of 6,936 ft for most predicated habitat).	Becker, 2008 and WGFD winter survey flights

Winter		Create layer	< 1 km (3,280 ft); most locations (80%) were <200m (656 ft) from forest edge	Baigas, 2010
Summer	Habitat within 1km of riparian shrub (willow)	TC Veg Layer	Veg Cover types within 1 km of willow (3,280 ft)	Baigas, 2010
Summer	Distance to Forest Edge (Cover)	Create layer of veg cover types within 100 m (328 ft) buffer of deciduous forest (aspen, aspen/ conifer mix, cottonwood) edge and combine with forest polygons that were buffered	Distance to deciduous forest [Becker ave 49m (161 ft) from cover]; >100 m (328 ft) closer than in winter	Becker, 2008
Summer	Elevation	DEM	Valley floor to 8,900 ft (winter max + 300 m)	>300 m (984 ft) higher than winter reported by Becker, 2008
Migration	Migration Routes	WGFD	All identified migration routes	WGFD

Contributors

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Secondary Reviewer: Renee Seidler, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Important Veg Cover	From TC, GRTE, BTNF & CTNF Veg layers, select willow, mesic shrub, mixed mountain shrub (incl tall shrub), deciduous forest, subalpine fir, aspen/ conifer mix	See Definition Query Selection Below	Definition Query; Merge Layer	Winter veg covers
Veg within Distance of Important Veg Cover	Buffer Important Veg Cover over 2.0 acres in size by 200 m (200 m chosen per A. Courtemanch's review, *pers. commun.*)	Merge, Dissolve, Multipart to Singlepart, Select By Attribute >=	Merge; Dissolve; single part to multipart;	Import Habitat and Cover Area Buffer

		2.0 acres, Buffer 200m, Dissolve	Buffer and Dissolve	
Conifer Cover Habitat	From TC, GRTE, BTNF & CTNF Veg layers, select conifer cover types; Select conifer that is within 200m of important habitat	Select By Attribute, clip by 200m buffer around important habitat	Select By Attribute; Merge; Clip	Conifer Cover Habitat
Merge Forage and Cover Habitats	Combine foraging and cover habitat; include major willow system in Karns Meadow south to Josie's (lost because of patch size) per A Courtemanch, *pers. commun.*	Merge	Merge	Important and Cover Habitat
Convert shapefile to Raster	Convert import and cover veg cover shapefile to raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Winter Habitat Raster
Elevation	Retain elevations <2620 (8600 ft) in Gros Ventre and <2255 m (7400 ft) in remainder of TC	VALUE < 2620 m in GV and VALUE < 2255 in remainder of TC	Extract By Attribute (creates 2 rasters)	Likely Elev & Slope
Slope	Retain appropriate slopes < 20°	VALUE < 20	Extract By Attribute	
Intersection of Elevation and Slope	Extract Elevation by Slope Mask	Extract Slope by Elevation Mask to retain slope values	Extract By Mask (creates two rasters)	
Define GV and TC areas	Clip Elev/Slope Rasters to GV and TC Areas	Clip rasters then mosaic together	Clip; Mosaic to New Raster	Mosaic Elev/ Slope Raster for Extracting Veg
Extract Veg by Elevation/ Slope Mosaic	Winter veg habitat <20° slope with <8600 ft in GV and <7400 ft in the remainder of TC	Extract by Likely Elev & Slope	Extract by Mask; Reclassify so No Data = 0	Product
Compare with WOS and NMJH observations	Visually compare observations with output.			

Veg Cover Definition Query Categories

Teton County Map Codes:
Mixed Tall Dec Shrubland - SMR
Sagebrush - Antelope Bitterbrush Mixed - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry - SMSD
Aspen Forest - FAP
Aspen Regeneration - RAP
Subalpine Fir Englemann Spruce Forest - FSF
Blue Spruce Riparian Forest - FBS
Mixed Conifer Forest - FMC
Mixed Blue Spruce - Aspen - Cottonwood semi-natural - FBAC
Mixed Evergreen - Aspen Forest - FEP
Cottonwood Riparian Forest - FCW
Mixed Cottonwood - Blue Spruce Forest - FRM
Alder Shrubland - SAI
Willow Shrubland - SWL

Grand Teton Nation Park Map Codes:
Mixed Deciduous Shrubland - SDS
Mixed Tall Deciduous Shrubland - SMR
Aspen Forest - FAP
Aspen Regeneration - RAP
Subalpine Fir Englemann Spruce Forest - FSF
Mixed Conifer Forest - FMC
Blue Spruce Riparian Forest - FBS
Mixed Conifer Woodland Regeneration - recent fire? - RMC
Mixed Evergreen - Poplar Forest - FEP
Mixed Subalpine Fir, Engelmann Spruce Woodland, Deciduous - RAM
Cottonwood Riparian Forest - FCW
Mixed Cottonwood - Blue Spruce Forest - FRM
Willow Shrubland - SWL
NO bitterbrush b/c fall not winter

Bridger-Teton National Forest MU CODE:
Spruce/ Subalpine Fir Mix - MSF
Aspen - ASP
Aspen/ Conifer Mix - MAS
Cottonwood - CTW
Willow - WI
Mountain Shrubland - MS

Caribou-Targhee National Forest MU CODE BT:
Spruce/ Fir Mix - SF
Aspen - AS
Aspen/ Conifer - AS/C
Conifer/ Aspen - C/AS
Riparian Shrublands - RSH
Mountain Shrublands - FMSH
Mountain Mahagony Mix - MMmix

Metadata

Title

MOO_Win.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Moose Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

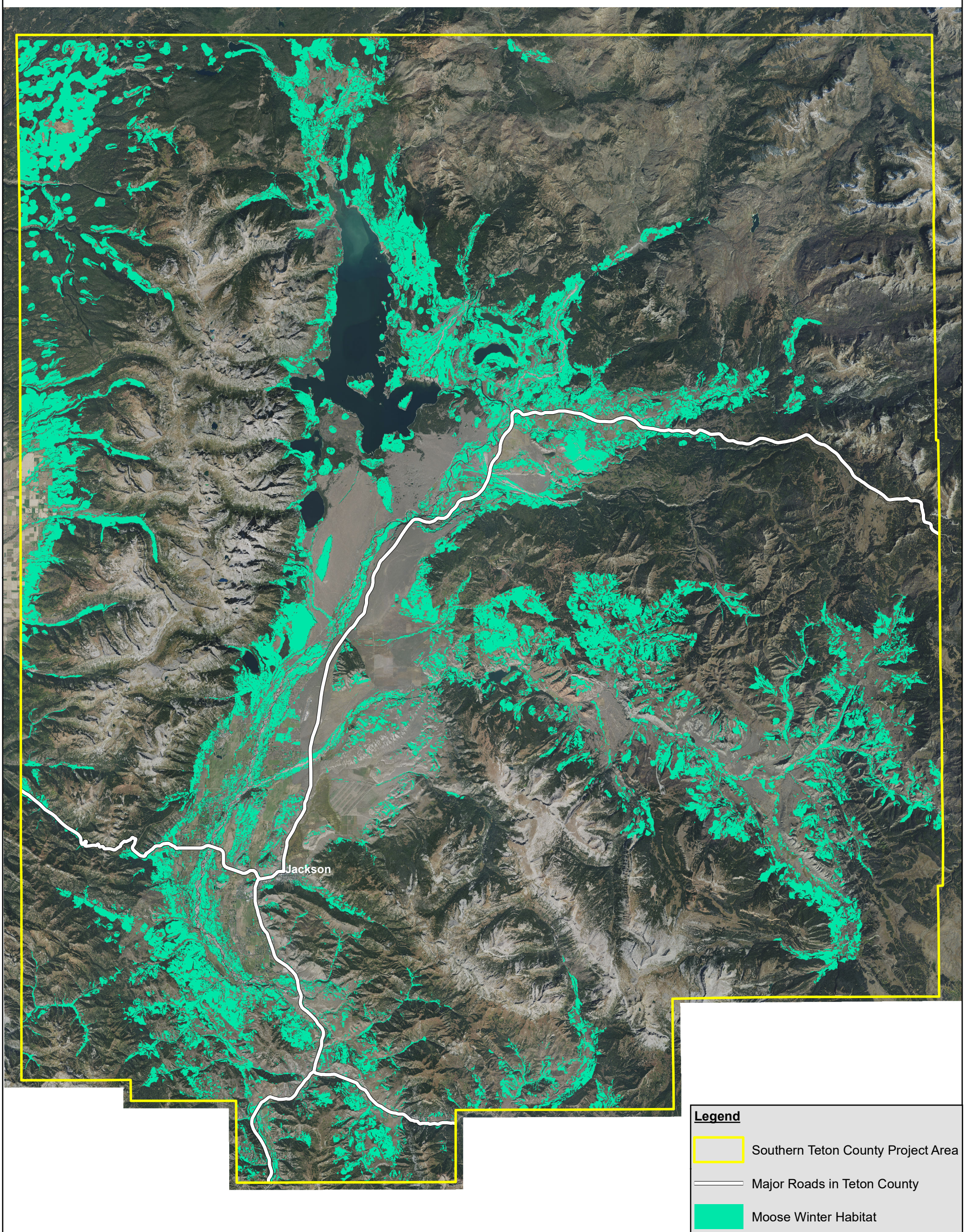
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the moose is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 5:

Moose Winter Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

ALDER ENVIRONMENTAL, LLC
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(307) 733-5031 www.alderenvironmental.com

MULE DEER

Year-round resident in Teton County.

Important Habitat Characteristics

Mule deer (*Odocoileus hemionus*) are the most widely distributed and abundant of all large mammal species in western North America. Nonetheless, they are in decline across the west (deVos, 2003). They occur in habitats ranging from moist, dense coniferous forests to dry, open plains and deserts and alpine habitats (Hamlin and Mackie 1991; Innes 2013). Mule deer occur in tallgrass, mixed-grass and shortgrass prairies of the Great Plains, in shrublands, woodlands and forests of the Rocky Mountains and in sagebrush communities, pinyon-juniper woodlands and desert scrub of the Southwest. In terms of elevation, they occur from coastal communities up to subalpine and alpine communities (Mackie et al., 2003). To some degree, "the multitudinous habitats of the mule and black-tailed deer are so diverse as to defy generalization" (Wallmo, 1981).

In northern mountainous areas of the West, mule deer summer ranges consist primarily of montane and subalpine forest communities and winter ranges consist primarily of open, shrub-dominated slopes and ridges (Mackie et al., 2003). Throughout the year, mule deer use a variety of habitat including forests of quaking aspen (*Populus tremuloides*), conifers, as well as meadows and alpine communities, grasslands and open ponderosa pine (*Pinus ponderosa*) forests. In northern mountainous regions, sagebrush (*Artemisia tridentata*) steppe, juniper-pinyon (*Juniperus osteosperma, Pinus monophylla*) woodland and true mountain-mahogany (*Cercocarpus montanus*)/oak scrub are the most extensive winter range habitat types (Wallmo, 1981).

Mule deer may inhabit the same range throughout the year or migrate to separate summer-fall and winter ranges (Hygnstrom et al. 2008; Mackie et al., 2003). Migratory mule deer are generally found in mountainous regions, where they move up and down along elevational gradients in response to weather and seasonal changes in vegetation. Transitional ranges are used in spring and fall as mule deer move between summer and winter ranges (Hygnstrom et al. 208; Mackie et al., 2003). Recent research has highlighted the importance of these transitional ranges and especially migration “stop-over” sites for foraging (Sawyer and Kauffman, 2011). Nonmigratory individuals tend to occur at low elevations year-round (Hanley, 1984; this nonmigratory pattern as observed in 26% of collared does in the Jackson Hole area Riginos et al. 2013). Individuals generally retain the same ranges from year to year and have high fidelity to their migration routes between ranges (Hygnstrom et al. 2008; Mackie et al., 2003).

Much of the information below is based on “Mule deer movement and habitat use patterns in relation to roadways in northwest Wyoming“ by Riginos et al. (2013). The study area for the Riginos et al. (2013) project included the area from Hoback Junction to Jackson and Wilson and therefore does not cover all of Teton County. There is a possibility that mule deer in northern Teton County utilize habitats that differ slightly from those located within the project area. As part of the habitat mapping exercise in for this project, educated inferences will be made about the habitat located within Teton County but outside of the Riginos et al (2013) study area. For instance, mule deer in Buffalo Valley may utilize the available habitat differently in an area of low human density than those in the Town of Jackson where buttes are more prominent and human density is higher. When not specified otherwise, the information below refers to the Riginos et al 2013 study.

Winter Habitat

Winter habitat use was particularly concentrated on the low elevation mixed shrub, herbaceous and juniper (*Juniperus scopulorum*)-dominated south, southeast and southwest facing slopes. In general, south- and west-facing slopes tend to have less snow than other aspects due to solar radiation (Hanley, 1984) and are often scoured by the dominant wind direction in Jackson Hole. In high snow areas in British Columbia and Alaska, "critical" winter rangelands include areas at low elevations; areas with southern aspects on moderate to steep (40%-100%, 22-45 degrees) slopes (Bunnell, 1990). In southern Jackson Hole, the major landforms providing winter habitat for mule deer were low elevation, shrub covered, south-facing slopes: East Gros Ventre Butte (and to a lesser degree West Gros Ventre Butte), High School Butte, the ridge east of the Rafter J development, Boyle's Hill and the Porcupine Creek, Game Creek and Horse Creek drainages (Riginos et al. 2013, Figure 1). This affinity for open, hilly habitat dominated by sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*)—both of which are important winter forage for mule deer—is consistent with the winter habitat preferences of mule deer elsewhere in the region (Pierce et al. 2004, Anderson et al. 2012). Other important shrub species for mule deer in the Jackson Hole area include: curl-leaf mountain mahogany (*Cercocarpus ledifolius*), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), rabbitbrush (*Chrysothamnus viscidiflorus* spp. *lanceolatus*), snowberry (S*ymphoricarpos albus*) and snowbrush ceanothus (*Ceanothus velutinus*) (Cox et al. 2009).

Mule deer in southern Jackson Hole also exhibited an affinity for areas dominated by mixed trees (many of which were ornamentals in developed areas), juniper and riparian vegetation—potentially because these cover types afforded them thermal cover, browse and/or a shallower snowpack (Bunnell, 1990). Mule deer require cover for security, thermal protection and snow interception (Dorrance 1967, Mackie et al. 2003, Wallmo 1981)- cover reduces metabolic costs for thermoregulation, increases forage, protects deer from detection and effectively reduces snow depth. Conifers and other evergreen plants provide some of the best cover for mule deer in winter (Olson 1992). Areas close to Karns Meadow and Flat Creek show a hotspot of winter mule deer use in the town of Jackson – possibly for hiding/thermal cover and/or water access.

Mule deer undergo a continuous decline in body condition throughout the winter due to naturally poor quality forage and the energetic demands of surviving in cold temperatures and deep snow. Therefore, minimizing energy expenditure is paramount to their over-winter survival and ability to produce healthy fawns in the spring. Reducing disturbance from human activities on winter ranges is important. Disturbance can cause ungulates to expend energy by fleeing, increasing their time spent vigilant instead of feeding, elevating stress levels and causing displacement from preferred habitats (Sawyer et al. 2006). Common disturbances on mule deer winter ranges in Teton County are roads and traffic, recreational activity such as snowmobiling, cross country skiing and snowshoeing and domestic dogs that are out of their owner's control. Providing effective winter range for mule deer includes not only the space and food requirements, but also areas that are free of disturbance.

Fawning Areas

The highest energy demands for female mule deer occur in the spring during the last two months of gestation and early lactation (mid-April through late June) (Parker et al, 2009). In fact, energy requirements increase by 65-215% post-partum for females due to the energetic demands of lactation (Oftedal, 1985). Sources of calcium, protein and replenishing of rumen micro-fauna are a requirement during this period. An abundant supply and distribution of early forbs later perennial forbs and early basal growth of grasses are essential. Newly emergent vegetation is high in nutritional quality (crude protein and digestibility) (Parker et al, 2009).

During and soon after parturition, female mule deer prefer areas with concealment cover, such as areas with dense vegetation (Dorrance, 1967). Reviews stated that "ideal" fawning habitat for mule deer in Wyoming, Oregon and Washington includes small areas (0.4-2.0 ha) of low shrubs or small trees 2 to 6 feet (0.6-1.8 m) tall, with about 50% canopy cover, slopes <15%, water within 180 m and abundant high quality forage (grasses and forbs) (Olson, 1992). These habitats can include aspen forest, mixed aspen/conifer forest, cottonwood riparian areas and willow riparian areas (Olson, 1992; WGFD, 2015). (Olson, 1992).

Summer Habitat

In the summer, mule deer focus on a high carbohydrate diet to build up fat reserves for winter. Fawn and doe survival and reproduction in the upcoming winter is significantly affected by the quality of diet in the summer months (Tollefson et al, 2010; Monteith et al, 2013). Mule deer summer habitat is generally characterized by high-elevation montane and subalpine forests and meadows (Mackie et al, 2003). In the Teton, Gros Ventre, Salt and Wyoming Mountain Ranges in western Wyoming, mule deer are associated with tall forb habitats, which is a unique habitat type occurring at high elevations and dominated by dense, lush forb species (WGFD, 2015). This cover type provides critical summer range for mule deer due to its high forage quality (WGFD, 2015). However, mule deer can also be found in lower elevation riparian areas, ephemeral stream corridors, aspen forests and irrigated and sub-irrigated meadows (WGFD, 2015).

In the Jackson Hole area, the following cover types comprised the areas used most intensively by collared does in a recent study (Riginos et al, 2013). Based on a selection of Riginos et al (2013) collared GPS points, the following vegetative cover types were selected from the Grand Teton National Park vegetation map and listed in order of use intensity:

1. Cliff and talus sparse vegetation
2. Engelmann spruce / subalpine fir forest
3. Whitebark pine forest
4. *Ceanothus* shrubland (tobacco-brush shrubland – often associated with lodgepole pines in GRTE vegetation GIS data and ecologically post-fire)
5. Douglas-fir forest
6. Alpine herbaceous

Summer habitat use was particularly intense in the area around the Jackson Hole Mountain Resort ski slopes. It is likely that the habitat complexity formed by a mixture of open meadows and closed forest is attractive to deer. Deer's attraction and use of urban and suburban landscapes and areas like ski resorts is typically a response to food availability and the creation of edge habitats.

In Riginos et al (2013) twenty-six percent of the collared animals were classified as "non-migratory"; these animals stayed in the lower elevation areas of Jackson Hole throughout the year. Several of these animals had home ranges that centered around golf courses (Jackson Hole Golf and Tennis just north of the Gros Ventre River and Teton Pines west of WY-390). It is likely that the high quality forage of these fertilized, irrigated golf courses attracted the deer and allowed them to maintain a relatively high nutritional condition even in the dry summer months. Other nonmigratory individuals' home ranges centered on the slopes of Boyle's Hill, Porcupine Creek and Game Creek. It appears that these individuals shifted their habitat use somewhat in summer to include the more forested north-facing slopes of these hills.

Migration Routes

In southern Teton County, Brownian Bridge Movement Modeling was used to determine a population level migration utilization distribution for 41 collared does during the spring and fall migrations for both 2011 and 2012 (Riginos et al. 2013).

The Wyoming Migration Initiative at the University of Wyoming is working on developing a GIS layer for mule deer high use migration corridors in Teton County. This effort will map additional migration corridors to those produced by Riginos et al. (2013). This information will not be available for this version of the Teton County Focal Species Habitat Mapping Project but should be incorporated in the future. Dr. Matt Kauffman is expecting that the results should be available by October 2017 (Dr. Matt Kauffman, pers. communication).

West Gros Ventre Butte provides a very important migration stopover point for deer heading southeast from the Teton Range on their fall migration (Riginos et al, 2013). Most collared deer crossed the Snake River just south of its confluence with the Gros Ventre and all deer heading out of the Tetons stopped over on West Gros Ventre Butte before moving on to East Gros Ventre Butte (another critical stopover feature) or lower slopes further south. For the southern Jackson Hole does, the north- and east-facing slopes of Munger Mountain and surrounding hills were frequent stopover sites (Riginos et al, 2013).

Migration road crossings accounted for only 5 percent of all road crossings in a recent study in Jackson Hole (Riginos et al, 2013). Although few in number, these crossings are likely very important for sustaining the population. Far more numerous are winter daily movements where roads bisect winter habitat (Riginos et al, 2013).

Literature Sources

Anderson, E. D., Long, R. A., Atwood, M. P., Kie, J. G., Thomas, T. R., Zager, P., & Bowyer, R. T. (2012). Winter resource selection by female mule deer Odocoileus hemionus: functional response to spatio-temporal changes in habitat. Wildlife Biology, 18(2): 153–163.

Bunnell, F. L. (1990). Ecology of black-tailed deer. In: Nyberg, J. B.; Janz, D. W., tech. eds. Deer and elk habitats in coastal forests of southern British Columbia. Special report series 5. Victoria, BC: British Columbia Ministry of Forests, Research Branch: 31-63. In cooperation with Wildlife Habitat Canada.

Cox, M., Lutz, D. W., Wasley, T., Fleming, M., Compton, B.B., Keegan, T., ... & Carpenter, L. (2009). Habitat guidelines for mule deer: Intermountain West ecoregion. *Mule Deer Working Group, Western Association of Fish and Wildlife Agencies*.

deVos, J, M Conover, and N Headricks, editors. 2003. Mule deer conservation: issues and management strategies. Berryman Institute Press. Utah State University, Logan, USA.

Dorrance, M.J. (1967). A literature review on behavior of mule deer. Special Report Number 7. [Denver, CO]: Colorado Department of Game, Fish, and Parks, Game Research Division; Colorado Cooperative Wildlife Research Unit. 26 p.

Hamlin, K. L., & Mackie, R.J. (1989). Mule deer in the Missouri River Breaks, Montana: A study of population dynamics in a fluctuating environment. Final Report. Helena, MT: Montana Department of Fish, Wildlife, and Parks. 401 p.

Hanley, T.P. (1984). Relationships between Sitka black-tailed deer and their habitat. Gen. Tech. Rep. PNW-168. Portland, OR: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 21 p.

Hygnstrom, S.E., Groepper, S.R., VerCauteren, K.C., Frost, C.J., Boner, J.R., Kinsell, T.C., & Clements, G.M. (2008). Literature review of mule deer and white-tailed deer movements in western and midwestern landscapes. Great Plains Research: A Journal of Natural and Social Sciences. Paper 962: 219-231.

Innes, R.J. (2013). Odocoileus hemionus. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/animals/mammal/odhe/all.html [2016, October 12].

Mackie, R.J., Kie, J.G., Pac, D.F., & Hamlin, K.L. (2003). Mule deer (Odocoileus hemionus). In: Feldhamer, George A.; Thompson, Bruce C.; Chapman, Joseph A., eds. Wild mammals of North America: Biology, management, and conservation. 2nd ed. Baltimore, MD: Johns Hopkins University Press: 889-905

Oftedal, O.T. (1985) Pregnancy and lactation. In: Bioenergetics of Wild Herbivores. Eds R.J. Hudson & R.G. White, pp. 216–238. CRC Press, Inc., Boca Raton, Florida, USA.

Olson, R. (1992). Mule deer habitat requirements and management in Wyoming. B-965. Laramie, WY: University of Wyoming, Cooperative Extension Service. 15 p.

Monteith, K., T. Stephenson, V. Bleich, M. Conner, B. Pierce, and T. Bowyer. 2013. Risk-sensitive allocation in seasonal dynamics of fat and protein reserves in a long-lived mammal. Journal of Animal Ecology, 82:377-388.

Parker, K.L., P.S. Barboza, and M.P. Gillingham. (2009). Nutrition integrates environmental response in ungulates. Functional Ecology 23:57-69.

Pierce, B. M., Bowyer, R. T., & Bleich, V. C. (2004). Habitat selection by mule deer: forage benefits or risk of predation? *Journal of Wildlife Management*, *68*(3): 533–541.

Riginos, C., Krasnow, K.D., Hall, E., Graham, M., Sundaresan, S., Brimeyer, D., Fralick, G., & Wachob, D. (2013). Mule Deer (Odocoileus hemionus) Movement and Habitat Use Patterns in Relation to Roadways in Northwest Wyoming. FHWA-WY-13/08F.

Sawyer, H. and M.J. Kauffman. 2011. Stopover ecology of a migratory ungulate. Journal of Animal Ecology 80:1075-1087.

Sawyer, H., M. Hayes, B. Rudd, and M. J. Kauffman. 2014. The Red Desert to Hoback Mule Deer Migration Assessment. Wyoming Migration Initiative, University of Wyoming, Laramie, WY.

Tollefson, T., L. Shipley, W. Meyers, D. Keisler, and N. Dasgupta. 2010. Influence of summer and autumn nutrition on body condition and reproduction in lactating mule deer. Journal of Wildlife Management, 74:974-986.

Wallmo, O.C. (1981). Mule and black-tailed deer of North America. Lincoln, NE: University of Nebraska Press: 1-26.

WGFD. 2015. Mule Deer Working Group. Recommendations for Managing Mule Deer Habitat in Wyoming. Wyoming Game and Fish Department. Cheyenne, WY.

Additional References

Documents on WAFWA Mule Deer Working Group site:
http://www.wafwa.org/committees___groups/mule_deer_working_group/publications/

Ager, A. A., B. K. Johnson, J. W. Kern, and J. G. Kie. 2003. Daily and seasonal movements and habitat use of Rocky Mountain elk and mule deer. Journal of Mammalogy 84:1076–1088.

D'Eon, R. G., and R. Serrouya. 2005. Mule deer seasonal movements and multiscale resource selection using global positioning system radiotelemetry. Journal of Mammalogy 86:736–744.

Long, R. A., J. G. Kie, R. T. Bowyer, and M. V. Hurley. 2009. Resource selection and movements by female mule deer *Odocoileus hemionus*: effects of reproductive stage. Wildlife Biology 15:288–298.

Peterson, C., and T. A. Messmer. 2011. Biological consequences of winter-feeding of mule deer in developed landscapes in northern Utah. Wildlife Society Bulletin 35:252–260.

Sawyer, H., M. J. Kauffman, R. M. Nielson, and J. S. Horne. 2009. Identifying and prioritizing ungulate migration routes for landscape-level conservation. Ecological Applications 19:2016–2025.

Sawyer, H. and M. Kauffman. 2009. Identifying mule deer migration routes to and from the Pinedale Anticline Project Area. Report prepared for University of Wyoming School of Energy Resources. November 25, 2009.

Sawyer, H., R. M. Nielson, F. Lindzey, and L. L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. Journal of Wildlife Management 70:396–403.

Habitat Characteristics

Riginos, C., Krasnow, K.D., Hall, E., Graham, M., Sundaresan, S., Brimeyer, D., Fralick, G., & Wachob, D. (2013). Mule Deer (Odocoileus hemionus) Movement and Habitat Use Patterns in Relation to Roadways in Northwest Wyoming, was a study conducted for WYDOT in the southern portion of Teton County (south of Gros Ventre junction) that was used as the basis of a mule deer habitat mapping exercise for this project. This WYDOT study did not encompass all of Teton County, WY. Therefore, some inferences about habitat located within Teton County but outside of the 2013 study area will be made.

Summer Habitat

While GIS inputs are listed below for both winter and summer habitat, it has been decided by WGFD and NRTAB to not include summer habitat in our mapping exercise. Most summer habitat is in high-elevation montane areas which are primarily located on public lands in Teton County.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Winter	Shrub component	Vegetation	dominated by shrubs	Riginos et al, 2013
Winter	Winter cover	Vegetation	forest type and canopy cover--could be Juniper or Douglas fir or deciduous (often Salix), within 1 mile of foraging sites with shrub cover and southern aspect and >2 acres patch size	Riginos et al, 2013 K Krasnow, *pers. commun.*
Winter	Exposed hillside sparse vegetation	Vegetation	on Southern exposure at low elevation (see aspect and elevation below)	Riginos et al, 2013
Winter	Slope	DEM	40-100% (22-45 degrees)	Riginos et al, 2013
Winter	Aspect	DEM	Southeast, south and southwest aspect (135-225 degrees)	Riginos et al, 2013
Winter	Elevation	DEM	1800-2400 meters above sea level most important habitat in Jackson area study	Riginos et al, 2013
Parturition	Cover type	Vegetation	Aspen, aspen/conifer mix, cottonwood and willow riparian with >50% overstory	WGFD
Parturition	Distance to water	Stream layer	<600 feet	WGFD
Parturition	slope	DEM	<15%	WGFD
Summer	Summer Vegetation	Vegetation	Cliff and talus sparse vegetation, Engelmann spruce / subalpine fir forest, Whitebark pine forest, *Ceanothus* shrubland (tobacco-brush shrubland – often associated with lodgepole pines in GRTE vegetation GIS data and ecologically post-fire), Douglas-fir forest, Alpine herbaceous	Riginos et al, 2013
Migration	Migration corridors	WGFD & TSS & WMI study	All identified corridors (TSS does not cover all deer)	Riginos et al, 2013, WGFD, 2008 & Sawyer & Kauffman, 2009

Contributors

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Secondary Reviewer: Amy Girard, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Shrub Veg Cover	From TC, GRTE, BTNF & CTNF Veg layers, select juniper, sagebrush, bitterbrush, curl-leaf mahogany, serviceberry, chokecherry, rabbitbrush, snowberry, snowbrush *ceanothus*, exposed hillside with sparse vegetation (often xeric grasses)	See Query Selection Below	Select By Attribute; Merge Layers	Import Shrub Habitat Cover
Elevation	Retain elevations below 2,400 m. Elevations below 1,800 were retained to fill in connectivity between known high use habitats	VALUE <= 2400	Extract By Attribute	Elevation
Slope	Retain slopes between 15°-45°. Slope range was expanded per A Courtemanch to include known habitat near bottom of buttes	VALUE >= 15 AND VALUE <= 45	Extract By Attribute	Slope
Aspect	Retain southern aspects (E to W; 90-270 degrees) and flat (-1)	VALUE >= 90 AND VALUE <= 270 OR VALUE = -1	Extract By Attribute	Aspect
Intersection of Elevation, Slope and Aspect	Select areas of overlap between elevation, slope and aspect rasters	Conduct a simple sum raster calculation to retain only areas where the three layers overlap. Raster cells with No Data in any one of the layers will be excluded. Output raster cell values will be irrelevant	Simple sum calculation with the Raster Calculator	Slope/ Elevation/ Aspect
Extract Import Shrub Veg Cover by Elevation/ Slope/ Aspect	Shrub veg habitat below 2,400 m elevation southern aspects and slopes between 15-45°	Clip shrub veg by Elev/ Slope/ Aspect	Convert Elev/ Slope/ Aspect to Integer Raster;	Important shrub vegetation confined by

			Convert to Polygon; Dissolve; Clip	Elev/ Slope/ Aspect
Distance from forage habitat buffer	Buffer shrub veg by 1 mile	Buffer shrubs by 1 mile	Buffer; Dissolve	Potential Area for Winter Cover
Winter Cover	Select from TC, GRTE, BTNF & CTNF vegetation layers Juniper, Douglas Fir, Salix	See Query Selection Below	Select By Attribute; Merge Layers	Winter Cover Veg Types
Winter Cover within 1 mile of Forage Areas and > 2 acres in size	Select patches > 2 ac	Dissolve Merged Layer; Multipart to Singlepart, Calculate Area, select polygons >2 ac.; Clip to 1mi Buffer	Dissolve; Multipart to Singlepart; Add Geometry Attributes (Area); Select by Attributes; Clip	Winter Cover within 1 mile of Forage Areas and > 2 acres in size
Winter Movement Areas	Important winter movement areas identified by Conservation Research Center (2013; C. Riginos and K. Krasnow, *pers. commun.*)	Digitized off of Winter 2011 & 2012 Habitat layer provided by CRC	Create new polygon from raster values >8,500 (raster values have only relative value)	Winter Movement Areas
All Important Habitat	Merge foraging areas, winter cover within 1 mi buffer that is > 2 ac and movement areas		Merge Polygons	Forage/ Cover/ Movement habitat
Convert Shapefile to Raster	Convert Forage/ Cover polygon to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster; Reclassify so No Data = 0	Winter Important Habitat Raster
Compare with CRC Winter Habitat, WOS and NMJH Data	Visually compare output raster CRC winter model and NMJH data	Note that winter use in area of JH Golf & Tennis is due to feeding (C. Riginos, *pers. commun.*)		

Veg Cover Definition Query Categories

Winter Forage Veg Cover Types

Teton County Map Codes:
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Mixed Tall Deciduous Shrubland - SMR
Rubber Rabbitbrush Shrubland - SRB
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush Dry Shrubland - SES, SMSD, SSD
Cliff and Talus Sparse Vegetation - VCT
Exposed Hillside Sparse Vegetation - VEH
Rocky Mountain Juniper Woodland Stand - FJ

Grand Teton Nation Park Map Codes:
Low Sagebrush Dwarf Shrubland - DSE
Ceanothus Shrubland - SCV
Mixed Deciduous Shrubland - SDS
Mixed Tall Deciduous Shrubland - SMR
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SSD
Exposed Hillside Sparse Vegetation - VEH
Rocky Mountain Juniper Woodland Stand - FJ
Lodgepole Pine - Ceanothus Woodland Regeneration - RLC

Bridger-Teton National Forest MU CODE:
Grassland/Forbland - GF
Sparse Vegetation - SV
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Mountain Shrubland - MS
Sagebrush/Bitterbrush Mix - SB
Spiked Big Sagebrush - SK

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Grassland/Forbland - GF
Bridger-Teton Sparse Vegetation - SV
Caribou-Targhee Barren/Sparse Vegetation - BR/SV
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB
Caribou-Targhee Juniper Mix - Jmix
Caribou-Targhee Mountain Mahagony Mix - MMmix

Winter Cover Habitat Veg Cover Types

Teton County Map Codes:
Douglas-fir Forest - FDF
Rocky Mountain Juniper Woodland Stand - FJ
Willow Shrubland - SWL

Grand Teton Nation Park Map Codes:
Douglas-fir Forest - FDF
Rocky Mountain Juniper Woodland Stand - FJ
Willow Shrubland - SWL

Bridger-Teton National Forest MU CODE:
Douglas Fir Mix - MDF
Willow - WI

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Douglas Fir Mix - MDF
Caribou-Targhee Douglas-fir - DF
Caribou-Targhee Juniper Mix - Jmix
Caribou-Targhee Riparian Shrublands and Deciduous Forest - RSH

Metadata

Title

MDR_Win.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Mule Deer Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

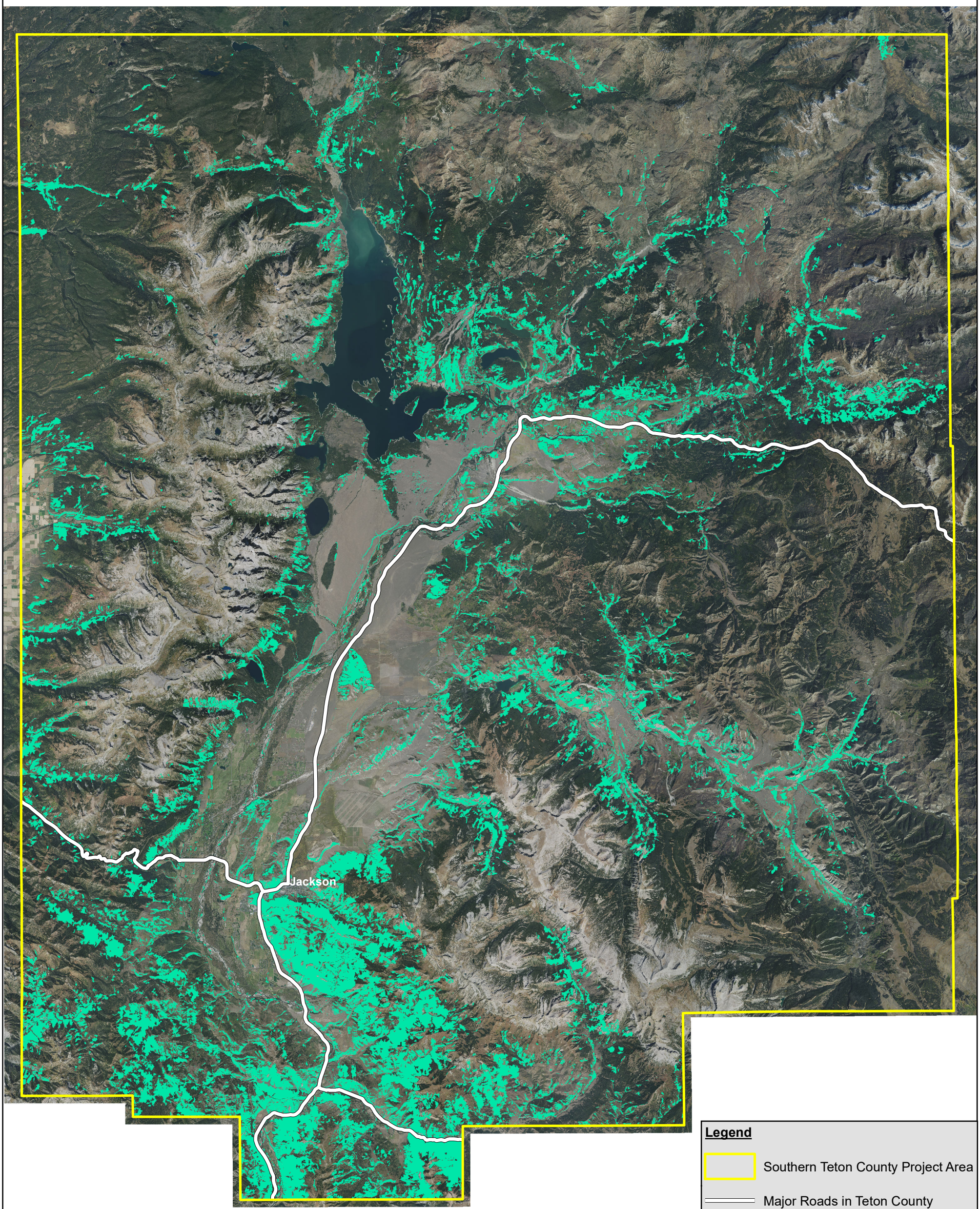
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the mule deer is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please consult the project's final report for appreciation of other's past projects that were used as inputs to this GIS layer.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 6:

Mule Deer Winter Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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Water • Wetlands • Ecological Consulting
P.O. Box 6519, Jackson, Wyoming 83002
(307) 733-5031 www.alderenvironmental.com

BALD EAGLE

Year-round resident in Teton County

Important Habitat Characteristics

Year-round Habitat

Bald Eagles (*Haliaeetus leucocephalus*) in Teton County have been known to stay on and defend, their nesting territories throughout the year (*S. Patla pers.comm.*). Habitat characteristics include:

- Cottonwood riparian forest near large lakes and rivers.
- Coniferous forest, including lodgepole pine, Douglas fir, Englemann-spruce and mixed coniferous forest, near large lakes and rivers.
- Large, mature, dominant trees, usually >23m, and large snags within view of foraging areas on rivers and lakes.
- Proximity to foraging opportunities: riffles, shallows and pools in rivers; lake shallows; areas with fish or mammal carrion; and areas of waterfowl concentrations.
- Relatively low levels of human disturbance.

Foraging Habitat

The Bald Eagle (*Haliaeetus leucocephalus*) primarily hunts fish, small mammals, waterfowl and scavenges carrion (fish and mammals), ungulate gut piles on hunt grounds and placenta on birthing grounds (including livestock calving areas). Eagles forage at or near the surface of water bodies and <500 m from perches on shorelines (Buehler, 2000).

Primary foraging habitats are large lakes, rivers and wetlands that support abundant fish and waterfowl. Water body attributes that allow access to prey include open water available in winter, shallows where waterfowl congregate or fish are more easily captured and high river sinuosity with an abundance of islands, riffles, runs and pools (Buehler, 2000; WGFD, 2010)

Secondary habitats include hunt areas and elk feedgrounds where ungulate carcasses or gut piles may be discovered and scavenged (WGFD, 2010).

Perches used for hunting are usually tall, easily accessible, trees or snags on shorelines near shallow water, with several perching opportunities and away from human disturbance (Buehler, 2000).

Winter Habitat

Winter habitat is found in cottonwood riparian forest and/or coniferous forest near large lakes and rivers that support abundant prey (fish and waterfowl). In Jackson Hole, Bald Eagles forage in the winter along foothill ungulate winter ranges in search of carrion (S. Patla, *pers. observations*). Furthermore, juvenile Bald Eagles born in Jackson Hole migrate to the west coast for their first winter (Harmata et al, 1999). Bald Eagles use large, mature live trees and/or snags along shorelines or within view of water bodies for perching while foraging. Open, ice-free areas of lakes and rivers allow access to fish and waterfowl (Buehler, 2000; MBEWG, 1991; WGFD, 2010). Note that resident bald eagles in Teton County occupy nest territories year-round where the Snake River does not freeze (*S. Patla pers. commun.*).

Roost sites are generally protected from prevailing winter winds by sheltering foliage and topography. Roosts offer open flight paths and a clear view of the area and are located in large conifers, ranging from 30 to 110 cm DBH and 15 to 60 m tall. Roost sites are generally associated with water but may be farther from water bodies than nest sites and are located away from houses and roads. Communal

roosts may range from 0.5 mile to 18 miles from water and be located in one or many trees (Buehler, 2000; MBEWG, 1991).

Summer Reproductive Habitat

Summer habitat includes cottonwood riparian forest, mixed cottonwood/ coniferous riparian forest and/or coniferous forest within <2 km of large lakes and rivers that support abundant prey (fish and waterfowl). Coniferous forest includes lodgepole pine, Douglas fir, Englemann-spruce and mixed coniferous species (Buehler, 2000; Orabona et al. 2009; WGFD, 2010).

Bald eagle pairs occupy and defend territories that include the active nest, alternate nest sites and foraging habitat. The number and density of territories, and hence territory size, depends largely on food abundance (Buehler 2000; Orabona et al, 2009; WGFD, 2010). Nesting eagles studied on the Upper Snake River (Teton County, WY) chose sites based on maximizing foraging opportunities at minimum distance from the nest; presence of suitable nest trees; and low levels of human activity. More than 50% of foraging took place within 2km of nests. Eagles selected cottonwoods for nest sites disproportionately to their availability and productive nests were also closer to meadows than unused sites (Harmata and Oakleaf, 1992).

Over 50 nesting territories have been identified in Teton County with 34-45 occupied every year. Territory densities depend on the abundance of prey and the territorial behavior of adults. Distance between territories ranges from 300 m to over 1,600 m with most nests having a distance of at least 800 m apart from one another (S. Patla, *pers. commun.*). In Teton County, the main stem of the Snake River from the Gros Ventre River south to the southern county line harbors the highest density of nest territories in the state. Territories on Jackson Lake are fewer and more widely spaced. Although the lower reaches of the Gros Ventre River appear to have excellent nesting habitat, few pairs have been productive below Slide Lake likely as a result of naturally occurring high selenium levels (S. Patla, *pers. commun.*; WGFD, 2010).

There are a few territories that are located farther than 2 km from major rivers and lakes. Nests are usually within <2 km, of a large body of water where eagles forage. Actual distance to water varies among pairs and populations and distance is less critical than the quality of foraging opportunities nearby. Birds will nest farther from water in areas with greater shoreline development and human activity if foraging habitat is available (Buehler, 2000). Forest tracts around the nest site have relatively open canopies and either a habitat edge (e.g., a shoreline) or high foliage-height diversity (emergent mature trees with surrounding lower canopy) that allow access to nest trees (Buehler, 2000).

The nest is built in a large-diameter, mature to old-growth tree (cottonwood or conifer; usually >23 m with large limbs capable of supporting a nest that can weigh >1000 pounds. Large snags may be used occasionally and this use may be increasing as conifer mortality has increased in recent years. The nest tree is usually one of the dominant trees within the canopy and tree structure is more important than species. The nest tree often also provides a perch with view of a nearby water body. A clear view and flight path are important attributes. Nests are used for many years, in both live and dead nest trees, unless the nest is infected with parasites, destroyed or reproduction fails, in which case an alternate nest within the same territory may be used in subsequent years (Buehler, 2000; MBEWG, 1991; USFWS, 2007).

Large nest trees, perch trees, abundant prey and relatively low human disturbance are crucial factors for the species' survival (USFWS, 2007, WGFD, 2010). Although the minimum distance of nests from human development in some populations is <100 m, the average distance in most population is >500 m (Buehler 2000). Important abiotic factors in Wyoming include: open water available in winter, low

severity of early spring weather, high river sinuosity with an abundance of islands, riffles, runs and pools (Swenson et al, 1986; WGFD, 2010).

The sensitivity to human disturbance is highly variable between pairs and can be due to a number of factors including the extent, severity, frequency, distance to and duration of the disturbance, as well as prior experiences and learned tolerance of the birds themselves. Bald eagles are most sensitive to disturbance throughout courtship, nest building, egg-laying and incubation -- disturbances during these periods can cause nest abandonment. Once nestlings hatch, eagles are less inclined to abandon a nest, however disturbances may cause missed feedings or cause young birds to flush from the nest prematurely and affect survival (USFWS, 2007). Management zones defined by the Greater Yellowstone Bald Eagle Management Plan (1996) are included under Risk Factors below.

Migration Corridors

In autumn, migrating bald eagles from Alaska and Canada move through Teton County on their way to more southern wintering areas with highest numbers occurring in October and November.

Migration stopover habitats are those areas that provide foraging opportunities: cottonwood riparian forest and coniferous forest near large lakes, wetlands and rivers with open water that support concentrations of prey (e.g., fish spawning areas and concentrations of waterfowl) (Buehler, 2000). In Teton County, stopover habitat also includes hunt areas and elk feedgrounds that provide scavenging opportunities for ungulate carrion and gut piles (Orabona et al, 2009; WGFD, 2010). Additionally, it has been found in Teton County that migrating eagles feed on ungulate gut piles more than resident eagles (Bedrosian, 2012).

Risk Factors to Habitat/ Habitat Function

Loss of old, mature trees along river corridors and shorelines due to conifer mortality (e.g. age, beetle kill, fire) and lack of cottonwood regeneration may limit or reduce availability of suitable nest trees. Dikes, water diversions and manipulated flows on the Snake River have eliminated natural floods that would promote cottonwood regeneration along the river (Harmata and Oakleaf, 1992; WGFD, 2010).

Human activity and developments, including residential development, recreation and business developments and recreation activities on and near rivers and lakes can reduce and degrade nesting habitat (WGFD, 2010; USFWS, 2007). The Greater Yellowstone Bald Eagle Management Plan (1996) defines management zones around bald eagle nests consistent with understanding of bald eagle nesting territory use and sensitivity to human activities: Zone 1 nest site (400 m or 0.25-mile radius), Zone II primary use area (800 m or 0.5-mile radius) and Zone III foraging habitat within 2.5-mile radius. The plan outlines management recommendations for human activity and habitat alterations within each zone (GYBEWG, 1996). More recent USFWS National Management Guidelines for the entire country recommend management zones to 330 feet and 660 feet of the nest, depending on the type of disturbance, visibility from the nest and existence of similar activities (USFWS, 2007). However, managers continue to recommend referring to the GYE working group management recommendations which are based on local, site specific knowledge. It should be noted that birds that choose to nest in more developed areas of the county show much greater tolerance to human activity than those nesting in fairly undisturbed habitats (Harmata and Oakleaf, 1992).

In Teton County, severe weather in the spring such as late season snow storms are a limiting factor to Bald Eagle local populations (S. Patla, *pers. commun.*). Fluctuations in fish and waterfowl populations affect prey availability (WGFD, 2010). Rivers with naturally high levels of selenium limit productivity (WGFD, 2010). Lead poisoning has been found in Teton County Bald Eagles and other scavenging birds. Lead is acquired from ingesting lead bullet fragments in carcasses (ungulate gut piles left by hunters). A

study in Teton County found that resident bald eagles were less likely to feed on gut piles than migrant eagles and an initiative to provide area hunters with lead-free ammunition resulted in a marked decrease in lead incidence in Teton County Bald Eagles (Bedrosian et al, 2012). Eagles may also acquire lead from feeding on carcasses of ground squirrels, coyotes and other species shot with lead ammunition, or from feeding on fish and waterfowl that have ingested lead fishing sinkers.

Literature Sources

Bedrosian B, Craighead D, and R. Crandall. 2012. Lead Exposure in Bald Eagles from Big Game Hunting, the Continental Implications and Successful Mitigation Efforts. PLoS ONE 7(12): e51978. oi:10.1371/journal.pone.0051978

Buehler, D. 2000. Bald Eagle (Haliaeetus leucocephalus), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/baleag; DOI: 10.2173/bna.506

GYBEWG. 1996. Greater Yellowstone Bald Eagle Management Plan: 1995 update. Greater Yellowstone Bald Eagle Working Group, Wyoming Game & Fish Department, Lander, WY. 47pp.

Harmata, A. and B. Oakleaf. 1992. Bald Eagles in the Greater Yellowstone Ecosystem: An Ecological Study with Emphasis on the Snake River, Wyoming. Wyoming Game and Fish Department, Cheyenne, WY. 2 volumes.

Harmata, A, G. Montopoli, B. Oakleaf, P. Harmata and M. Restani. 1999. Movements and Survival of Bald Eagles Banded in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 63(3): 781-793.

MBEWG. 1991. Habitat Management Guide for Bald Eagles in Northwestern Montana. Montana Bald Eagle Working Group. 29pp.

Orabona, A, S. Patla, L. Van Fleet, M. Grenier, B. Oakleaf and Z. Walker. 2009. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department, Nongame Program, Lander, WY. 227pp.

Patla, S. Personal Communication. Jackson Region Nongame Biologist. Wyoming Game and Fish Department, Jackson, WY.

Raynes, B. 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

Swenson, J. E., K. L. Alt, and R. L. Eng. Ecology of bald eagles in the Greater Yellowstone Ecosystem. 1986. Wildlife Monographs, No. 95. The Wildlife Society. 46pp.

USFWS. 2007. National Bald Eagles Management Guidelines. U.S. Fish and Wildlife Service. Accessed at https://www.fws.gov/southdakotafieldoffice/NationalBaldEagleManagementGuidelines.pdf

Wyoming Game and Fish Department. 2010. Wyoming State Wildlife Action Plan – Species Accounts: Bald Eagle. Accessed from https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/SWAP/Birds/Bald-Eagle.pdf

Habitat Characteristics

No known habitat model exists for Bald Eagle in Teton County, WY. However, nest locations are known and these will be a critical component of a potential habitat map as outlined below.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Summer	Nest Sites	WGFD nest locations	All nest points	WGFD, 2015
Summer and Winter	Cottonwoods	Vegetation Layers	Canopy > 23m tall; <1 mile from major river (e.g., Snake River) or large lake (e.g., Jackson Lake); <5% shoreline developed within 1 mile (this is based on canopy heights in northwestern MT)	MBEWG, 1991
Summer and Winter	Coniferous forest includes lodgepole pine, Douglas fir, Englemann-spruce and mixed coniferous species	Vegetation Layers	Canopy > 23m tall; < 1 mile from major river (e.g., Snake River) or large lake (e.g., Jackson Lake); <5% shoreline developed within 1 mile	MBEWG, 1991
Summer and Winter	Foraging sites	Create with Vegetation Layers	Lake shallows; river shallows, riffles and shallow pools; Wetlands; open meadows, forested foothills, elk feedgrounds within 2.5 miles of nests	Buehler, 2000; WGFD, 2010; WYBEWG, 1996
Summer and Winter	Open Water	Vegetation layers	All major waterways and water bodies (Snake River and Gros Ventre River)	WYBEWG, 1996

Contributors

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Megan Smith, Senior Wildlife Ecologist, Alder Environmental

Primary Reviewer: Susan Patla, WGFD Nongame Biologist

Secondary Reviewer: Siva Sundaresan, NRTAB

GIS Methods – Year-round Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Nest Sites	WGFD Nest Site	All WGFD Nest Sites buffered by 660 ft per current TC LDRs	Buffer	Nests
Forage Distance around Nest Sites	2.5 mile buffer of all WGFD known nest sites	Buffer WGFD Nests Sites by 2.5 miles	Buffer	Forage Distance Area
Forage Veg Covers	Select all lake shallows; river shallows, riffles and shallow pools; Wetlands; open meadows, forested foothills	Select veg types, clip all veg cover by 2.5 mi forage distance from nests	Select by Attribute; Merge; Clip	Forage Veg Cover
Feedgrounds Forage Habitat	All elk feedgrounds	Include entirety of feedgrounds properties	Digitize	Feedgrounds Forage Habitat
Nests, Forage and Feedground Area	Combine Nests, Forage Veg Cover and Feedgrounds	All	Merge	Forage, Feedground and Nests Forage Habitat
Open Water	All major waterways (Snake River, Gros Ventre River and Hoback River, Fish Creek, Flat Creek, Spring Creek, Cody Creek, Granite Creek, Buffalo Fork) and waterbodies (Jackson Lake)	Select from WGFD Stream layer (polyline) and WGF Lake layer (polygon)	Definition Query; Buffer Rivers by 0.1 mile each side (line to polygon); Merge	Major waterways and waterbodies
Open Water Distance	1.0 mile buffer from major waterways and water bodies to clip potential nest trees	Buffer major waterways (polygon) and water bodies by 1.0 miles	Buffer	Potential Nest Locations Proximate to Water
Potential Nesting Habitat	Select from TC, GRTE, BTNF Veg: Cottonwoods, coniferous forest includes lodgepole pine, Douglas fir, Englemann-spruce and mixed coniferous species (no overlap with CTNF)	Select by Attribute; Clip by Nest to Water 1.0 mile distance; Not possible to select by Canopy Height – available categories are too broad	Select by Attribute; Merge; Clip	Potential Nesting Habitat

Bald Eagle Habitat	Merge all nests, foraging habitat, potential nest habitat and major water layers	Merge	Merge	Important Habitat
Convert Shapefile to Raster	Convert Important Habitat Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster; Reclassify so No Data = 0	Habitat Raster
Compare with WOS and NMJH observations	Compare observations with output.			

Veg Cover Definition Query Categories

Foraging Vegetation
Teton County Map Codes:
Montane Mesic Forb Herbaceous Vegetation - HFD
Mixed Grassland Herbaceous Vegetation - HGL
Montane Xeric Forb Herbaceous Vegetation - HFX
Aspen Forest - FAP, FEP
Streams and Rivers - NST
Lakes, Ponds and Reservoirs - NLP
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA

Grand Teton Nation Park Map Codes:
Bracken Fern Herbaceous Vegetation - HBR
Montane Mesic Forb Herbaceous Vegetation - HFD
Subalpine Mixed Herbaceous Vegetation - HSA
Mixed Grassland Herbaceous Vegetation - HGL
Montane Xeric Forb Herbaceous Vegetation - HFX
Aspen Forest - FAP
Streams - NST
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA

Bridger-Teton National Forest MU CODE:
Aspen - ASP
Aspen/Conifer Mix - MAS
Grassland/Forbland - GF
Sparse Vegetation - SV
Tall Forbland - TF
Riparian Herbland - RH

Caribou-Targhee National Forest MU CODE BT: There was no CTNF within Forage Areas

Potential Nest Trees/ Habitat

Teton County Map Codes:
Subalpine Fir - Engelmann Spruce Forest - FSF
Douglas-fir Forest - FDF
Limber Pine Forest - FLM
Lodgepole Pine Forest - FLP
Mixed Conifer Forest - FMC
Blue Spruce Riparian Forest - FBS
Douglas-fir Forest - FDF
Cottonwood Riparian Forest - FCW
Mixed Cottonwood - Blue Spruce Riparian Forest - FRM

Grand Teton Nation Park Map Codes:
Douglas-fir Forest - FDF
Lodgepole Pine Forest - FLP
Mixed Conifer Forest - FMC
Subalpine Fir - Engelmann Spruce Forest - FSF
Blue Spruce Riparian Forest - FBS
Limber Pine Forest - FLM
Mixed Subalpine Fir - Engelmann Spruce Woodland - Deciduous Shrubland Regeneration - RAM
Cottonwood Riparian Forest - FCW
Mixed Conifer - Cottonwood Riparian Forest - FRM

Bridger-Teton National Forest MU CODE:
Douglas Fir Mix - MDF
Limber Pine - LBP
Lodgepole Pine Mix - MLP
Spruce/Subalpine Fir Mix - MSF
Cottonwood - CTW

Caribou-Targhee National Forest MU CODE BT:
No overlap between potential nesting areas and CTNF in Teton County

Metadata

Title

BAEA_Yrd.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Bald Eagle Year Round Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

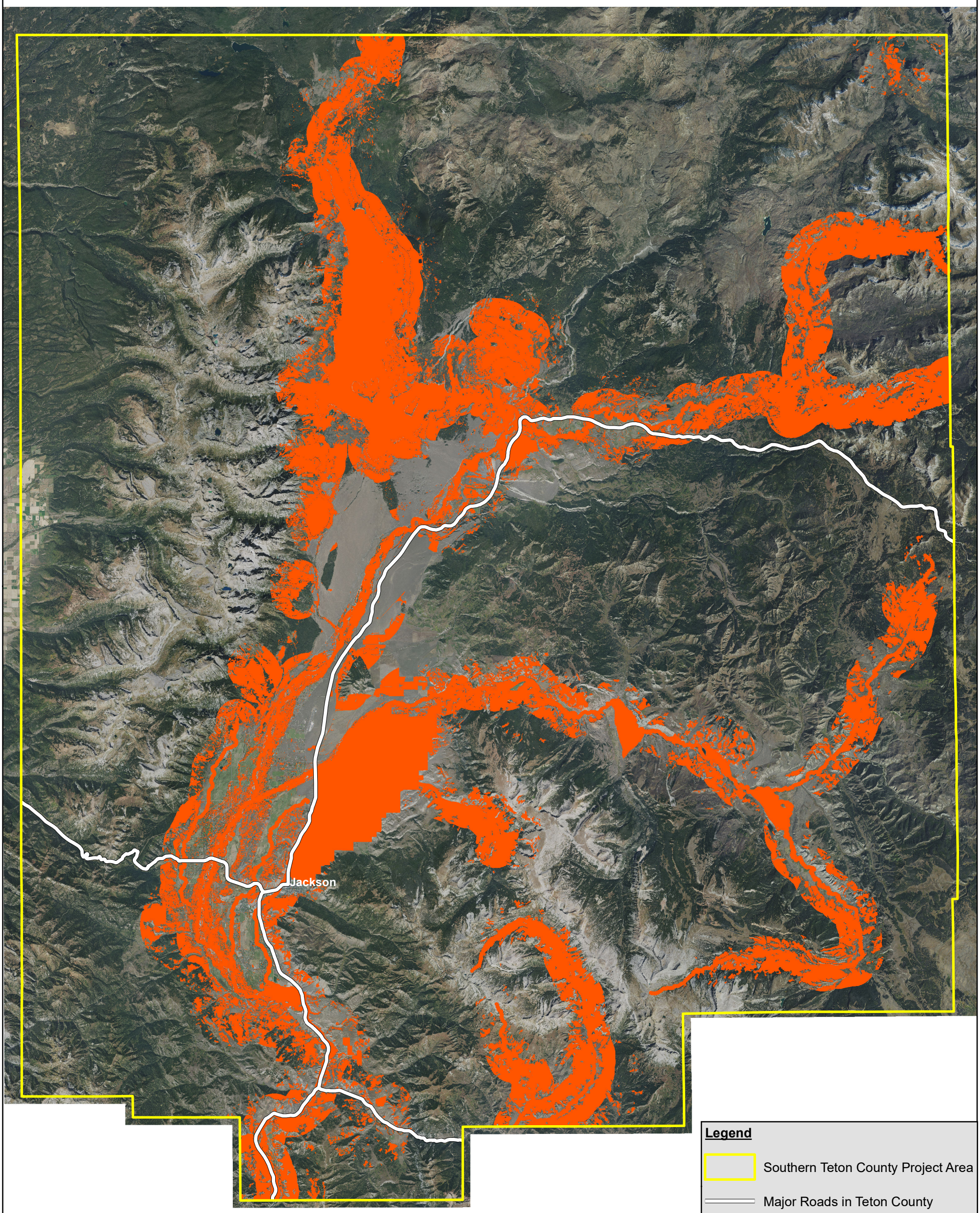
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Bald Eagle is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 7:

Bald Eagle Year-round Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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BREWER'S SPARROW

Summer resident in Teton County

The Brewer's Sparrow (*Spizela breweri*) has two recognized subspecies: Brewer's Sparrow (*S. b. breweri*) and Timberline Sparrow (*S. b. taverneri*) (AOU, 1957). Some recent evidence suggests that the Timberline Sparrow may be a separate species (Rotenberry et al, 1999) which may occur in Teton County at higher elevations. For the purposes of this narrative, the subspecies will not be distinguished.

Important Habitat Characteristics

Summer Habitat

The Brewer's Sparrow is considered a sagebrush-obligate meaning sagebrush rangelands are crucial to the species' survival. Brewer's Sparrows are tightly associated with landscapes dominated by big sagebrush (*Artemesia tridentata*), particularly areas with abundant, scattered shrubs and short grass (Rotenberry et al. 1999). Within sagebrush habitats, it will use tall dense sagebrush, open patchy sagebrush, grass cover for nests and areas of shortgrass and bare ground (Paige and Ritter 1999). The average canopy height of breeding habitat is usually <1.5m (Rotenberry et al. 1999).

Brewer's Sparrow numbers are positively correlated with the amount of sagebrush shrub cover, large shrubland patch size, above-average vegetation height and measures of horizontal habitat heterogeneity. Brewer's Sparrows are negatively correlated with grass cover, spiny hopsage and budsage. They prefer areas dominated by shrubs rather than those dominated by grass (Rotenberry and Wiens 1980, Wiens and Rotenberry 1981; Larson and Bock 1984). Brewer's Sparrows avoid burned sagebrush in favor of unburned sagebrush (Bock and Bock 1987) and showed identical preference patterns across spatial scales for shrub height and shrub cover (Chalfoun & Martin, 2007). At a landscape scale, greater shrub cover (24%-32% average on the territory) was a clear indicator of territory selection over non-territory habitats.

Males sing from perches in sagebrush shrubs. Brewer's Sparrows forage on insects and seeds (Rotenberry et al, 1999) primarily within shrubs and much less on open ground between shrubs (Wiens et al. 1987). Shrubs used for foraging are larger and more vigorous than randomly available shrubs and are sagebrush species more often than other shrub species (Rotenberry and Wiens, 1998). Breeding territories measured in Oregon, Washington and Nevada averaged 0.63 to 1.25 ha (1.5 to 3 ac) and contracted as breeding densities increased (Wiens et al. 1985).

Brewer's Sparrows build an open-cup nest within a shrub and prefer a large, living sagebrush bush. Nests are placed in shrubs that are taller and denser than surrounding shrubs, with reduced bare ground and herbaceous cover (Peterson and Best, 1985). Concealment and cover provided by living sagebrush foliage are important to protect the nest from cowbirds and predators (Rotenberry et al, 1999).

In an Idaho study, the height of the nest shrub averaged 69 cm (27in) and ranged from 42 to 104 cm (16.5 to 41 in). Shrubs shorter than 50 cm (19.5 in) were rarely used (Peterson and Best, 1985). In Oregon and Nevada, nest shrub height averaged 71cm (28 in) and ranged from 50 to 170cm (20 - 67in) (Rotenberry et al, 1999).

Invasive exotic weeds are a primary conservation concern for sustaining sagebrush communities, however a study in Teton County found Brewer's Sparrow nest success was higher in habitats with exotic smooth brome (*Bromus inermis)* (Ruehman et al, 2011). Although Brewer's Sparrows settled earlier and clutch size was larger in sagebrush with native grass and forb understory, daily survival was higher in habitats with smooth brome, which may offer greater refugia for insects in dry years and greater nest concealment (Ruehman et al, 2011).

Migration

Habitats used during migration are shrublands, in particular sagebrush shrublands, similar to those used during breeding season (Rotenberry et al 1999).

Risk Factors to Habitat/ Habitat Function

Risk factors include degradation of sagebrush rangelands and loss of robust sagebrush communities due to overgrazing, sagebrush control by herbicides, or wildfire as well as cowbird parasitism. Invasive cheatgrass (*Bromus tectorum)* alters fire regimes in sagebrush habitats by increasing the size and intensity of range fires and reducing the ability of sagebrush habitats to reseed naturally. Large scale fragmentation and loss of sagebrush habitat has occurred across the species' range due to livestock grazing, residential and energy development, agricultural conversion and invasive species (Paige and Ritter 1999; Rotenberry and Wiens 1999; Ingelfinger and Anderson, 2004). In Wyoming, habitat is listed as a severe limiting factor (WGFD, Wy State Action Plan, 2010)

Literature Sources

American Ornithologists' Union. 1957. Check-list of North American birds, 5th ed. Washington, D.C: Am. Ornithologists Union.

Bock, C.E. and J.E. Bock. 1987. Avian habitat occupancy following fire in a Montana shrubsteppe. Prairie Naturalist 19:153-158.

GBBO. 2010. Nevada Comprehensive Bird Conservation Plan Version 1.0. Great Basin Bird Observatory, Reno, NV. Accessed September 2016 at www.gbbo.org

Ingelfinger, F and S Anderson. 2004. Passerine response to roads associated with natural gas extraction in a sagebrush steppe habitat. Western North American Naturalist. 64(3):385-395.

Larson, D.L. and C.E. Bock. 1984. Determining avian habitat preference by bird-centered vegetation sampling. Pages 37-43 *in* J. Verner, M.L. Morrison, and C.J. Ralph, eds. Wildlife 2000: Modeling habitat relationship of terrestrial vertebrates. Univ. of Wisconsin Press, Madison.

Paige, C. and S.A. Ritter. 1999. Birds in a Sagebrush Sea: Managing Sagebrush habitats for Bird Communities. Partners in Flight Western Working Group, Boise, ID. 48 pp.

Raynes, B. 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

Rotenberry, J.T. and J.A. Wiens, 1980. Temporal variation in habitat structure and shrubsteppe bird dynamics. Oecologia 47:1-9.

Rotenberry, J.T. and J.A. Wiens, 1998. Foraging patch selection by shrubsteppe sparrows. Ecology 79:1160-1173.

Rotenberry, J.T., M.A. Patten, and K.L. Preston. 1999. Brewer's Sparrow (*Spizella breweri*). *In* The Birds of North America, No. 390. (A. Poole and F. Gill, eds.) The Birds of North America, Inc., Philadelphia, PA. 24 pp.

Wiens, J.A. and J.T. Rotenberry. 1981. Habitat associations and community structure of shrubsteppe environments. Ecological Monographs. 51:21-41.

Wiens, J.A., J.T. Rotenberry, and B. Van Horne. 1985. Territory size variations in shrubsteppe birds. The Auk 102:500-505.

Wiens, J.A., B. Van Horne, and J.T. Rotenberry. 1987. Temporal and spatial variations in the behavior of shrubsteppe birds. Oecologia 73:60-70.

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

No known habitat model exists for Brewer's Sparrow in Teton County, WY. USFS District 2 completed one for the Grand Mesa, Uncompahgre and Gunnison National Forests in September 2005 (Vasquez, M. 2005. Brewer's Sparrow Species Assessment – Draft. Accessed September 2016 at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5199815.pdf)

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Sources
Summer	Vegetation	Vegetation layer	sagebrush shrubsteppe	Rotenberry, 1999
Summer	Patch Size	Vegetation layer	Minimum patch ≥ 6 ha (~15 ac); recommended patch size >150 ha (350 ac); optimum or average patch size are not known	Vasquez, 2005; GBBO, 2010
Summer	Shrub Cover	TC veg layer	13-50% ave shrub cover (Chalfoun ~24-32%; USFS District 2, 13-50%)	Chalfoun & Martin, 2007; Vasquez, 2005
Summer	Ave Shrub Height	TC Veg layer	< 1.5 m (~5 ft) – this may not be a viable variable	GBBO, 2010
Summer	Slope	DEM 10 m	≤ 30 degrees – this may need to be expanded to steeper slopes for TC. Base possible expansion on known nesting locations and DEM attributes for those sites.	Vasquez, 2005

Contributors

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Megan A. Smith, Senior Wildlife Ecologist, Alder Environmental

Primary Reviewer: Susan Patla, Nongame Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Renee Seidler, NRTAB

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From BTNF, CTNF, GRTE & TC Veg layers, select sagebrush, mixed grassland	See Definition Query Selection Below Mixed grasslands added for Teton County and Grand Teton National Park but not National Forests because could not distinguish mixed grasses from all grasses	Select By Attribute; Merge; Dissolve	Summer veg cover
Minimum Patch Size	Patch size of >= 6 ha (~15 ac)	Select patches of >15 acres	Multipart to Singlepart; Calculate Geometry; Select By Attribute	Refined vegetation patches >15 ac
Shrub Cover and Height	Variable not used	Variable was removed because available categories were too broad to be effective and known habitat was removed (S Patla, *pers. commun.*)		
Convert Shapefile to Raster	Convert Veg Cover Shapefile to Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Veg Cover Raster
Slope (degree)	Retain slopes < 30°	VALUE < 30	Extract By Attribute	Slope
Extract Veg by Slope	Summer veg habitat <30° slope	Extract by Slope	Extract by Mask; Reclassify so No Data = 0	Summer Habitat
Compare with WOS and NMJH observations	Visually compare observations with output.			

Veg Cover Definition Query Categories

Teton County Map Codes:
Low Sagebrush Dwarf Shrubland - DSE
Mixed Tall Deciduous Shrubland - SMR
Rubber Rabbitbrush Shrubland - SRB
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SES, SMSD, SSD
Mixed Grassland Herbaceous Vegetation - HGL

Grand Teton Nation Park Map Codes:
Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland – SSD
Mixed Grassland Herbaceous Vegetation - HGL

Bridger-Teton National Forest MU CODE:
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Sagebrush/Bitterbrush Mix - SB
Spiked Big Sagebrush - SK

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB

Metadata

Title

BRSP_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Brewer's Sparrow Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

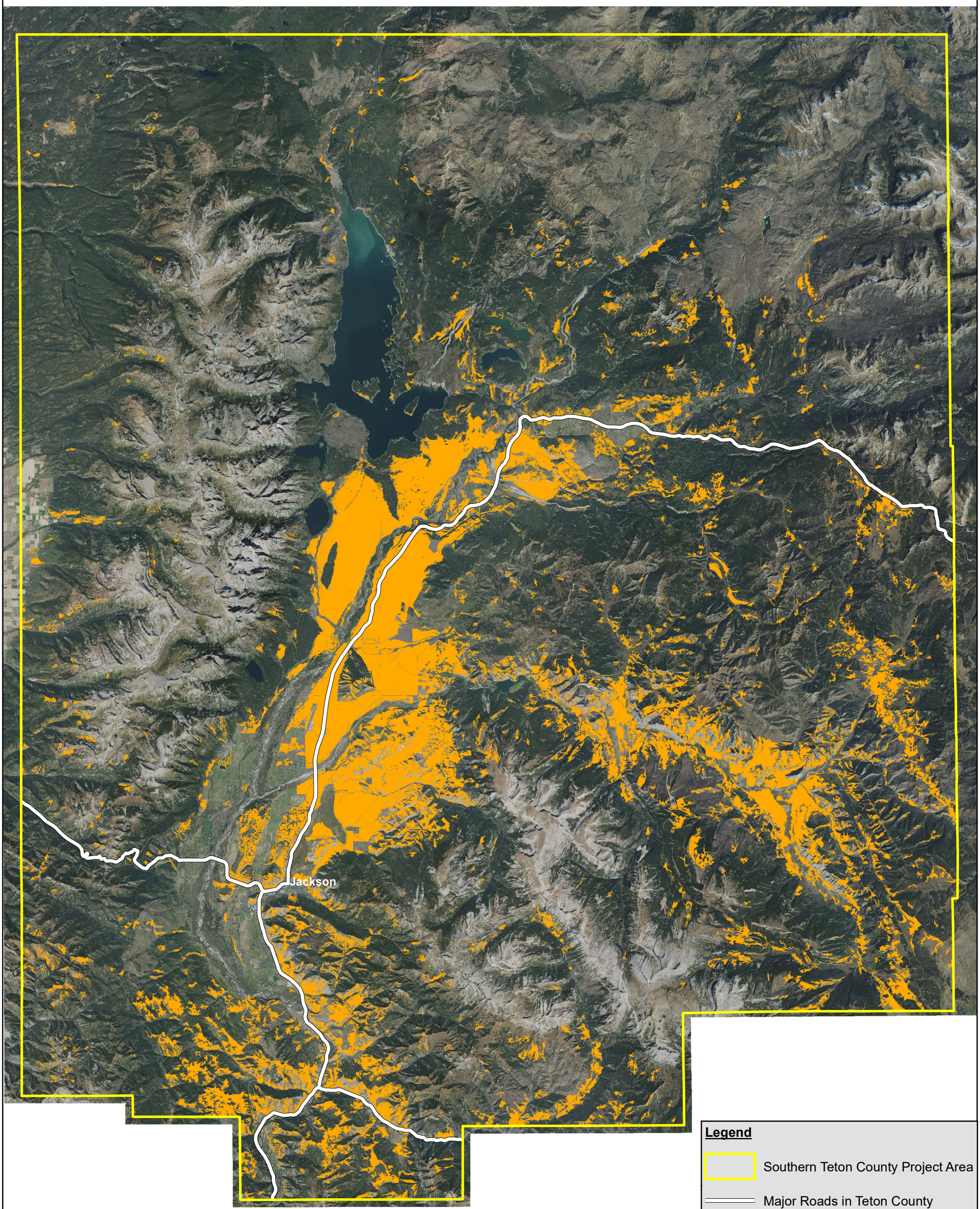
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Brewer's Sparrow is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 8:

Brewer's Sparrow Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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GREAT BLUE HERON

Summer resident in Teton County.

Important Habitat Characteristics

Summer Habitat

Across their North American range, Great Blue Herons (*Ardea herodias*) use a diversity of habitats that meet their foraging and nesting needs. Within Teton County, important habitat characteristics include shallow water habitat (<0.5 m/ 1.6 feet deep) containing fish for foraging opportunities in close proximity (within 2.3-6.5 km/ 1.4-4.0 miles) to a stand of trees able to support a colony, a breeding colony of a collection of nests that are commonly placed 5-15 m above the ground but can be found above 30 m high (Vennesland and Butler, 2011; Short and Cooper, 1985) in a stand of trees. Colonies are used annually and individual birds will return to the same area and, if undisturbed, to the same nest for many years (Short and Cooper, 1985). Rookeries may shift slightly in location over time.

Tree species used for nesting include cottonwoods and conifers and are usually located near water in riparian forests and wetland meadows, although occasionally found in upland areas (Vennesland and Butler, 2011). Trees with open canopy structure or exposed limbs allow herons to readily enter and exit the colony (Short and Cooper, 1985). Minimum patch size for groves of trees supporting colonies were presumed by Short and Cooper (1985) to be at least 0.4 ha (> 1 acre) in size. However, Great Blue Herons have been known to nest in much smaller tree stands within or near wetland complexes (Teton County Nest Data, 2016). Alternative suitable nesting locations include former nests and are more likely in trees within 0.8 km (0.5 miles) of an established colony (Vennesland and Butler, 2011; Short and Cooper, 1985). Other factors important for selecting nests sites include buffering from human disturbance and low road density (Butler 2011). On average, colony sites are located 2.3-6.5 km from primary foraging areas (Vennesland and Butler, 2011).

Great Blue Herons appear to be more susceptible to human disturbance while nesting than while foraging. Furthermore, nesting herons surrounded by land appear to need a greater buffer zone than those surrounded by water (see Risk Factors section below) (Short and Cooper, 1985).

Great Blue Herons forage mostly on fish but also eat amphibians, invertebrates, reptiles, mammals and birds (Butler 2011). While a firm bottom in foraging areas is a desirable habitat characteristic for Great Blue Herons, other abiotic factors do not appear to be significant determinants for habitat selection (Montana Heritage Program, 2016). Great Blue Heron nesting and foraging habitat are both generally associated with wet, flat areas.

It follows logically, and has been found true for herons, that there is a direct correlation between the size of nearby foraging habitats and the number of nests a colony or assemblage of colonies can support as well as the reproductive performance of breeding pairs (Kelly et al, 2008). As the size and health of foraging habitats increase, the number of nests and number of fledglings produced in a 10 km (6.2 miles) buffered area around the foraging habitat also increase. Therefore, the enhancement, creation or restoration of wetlands within 10 km (6.2 miles) of a Great Blue Heron nesting site may have a positive influence on this species' resource requirements.

Risk Factors to Habitat/ Habitat Function

Great Blue Herons are extremely sensitive to disturbance from humans particularly during the beginning of their breeding cycle. Therefore, a buffer distance of 250-300 m (approx. 830 ft) on land and 150 m (approx. 500 ft) over water should be maintained between human disturbance and nesting sites (Short and Cooper, 1985; Vennesland and Butler, 2011). Great Blue Herons appear to have more tolerance for

disturbance when surrounded by water than when surrounded by land. Furthermore, foraging herons can tolerate disturbances outside of a 100 m (approx. 330 ft) buffer zone (Short and Cooper, 1985). Colonies can be abandoned due to human disturbance. Parker (1980) found that distance to roads is also an indicator of human disturbance. The average distance to a road in Parker's Montana study was 1.25 km (approx. 0.75 mi).

In addition to human disturbance, predation by Bald Eagles and the loss of nesting and foraging habitat with healthy fish populations are primary threats to Great Blue Herons (Butler, 1991; Vennesland and Butler, 2011; COSEWIC, 2008). Because Great Blue Herons are mobile and change colony locations frequently, habitat protection measures should be adaptive to ensure that current locations are protected and that alternative locations are maintained for future use (Vennesland and Butler, 2011). There is no clear evidence regarding the effects of contaminants on Great Blue Herons (see Vennesland and Butler, 2011 for an overview).

Literature Sources

Butler, R. 1991. Habitat Selection and Time of Breeding in the Great Blue Heron (*Aredea herodias*). PhD Thesis. Simon Fraser University.

COSEWIC. 2008. COSEWIC assessment and update status report on the Great Blue Heron *fannini* subspecies *Ardea herodias fannini* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 39 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Kelly, JP, D Stralberg, K Etienne, M McCaustland. 2008. Landscape Influence on the Quality of Heron and Egret Colony Sites. The Society of Wetland Scientists. Wetlands. 28:2 (257-275).

Montana Heritage Program. 2016. Great Blue Heron (*Ardea herodias*) predicted suitable habitat models created on July 19, 2016. Montana Natural Heritage Program, Helena, MT.

Parker, J. 1980. Great Blue Herons (*Ardea herodias*) in Northwestern Montana: Nesting Habitat Use and the Effects of Human Disturbance. MS Thesis, University of Montana.

Short, H. L., and R. J. Cooper. 1985. Habitat suitability index models: Great blue heron. U.S. Fish Wildlife Service Biological Report. 82(10.99).

Teton County Nest Data. 2016. Great Blue Heron Nest Locations compiled from Grand Teton National Park, Wyoming Game and Fish Department and S Patla, WGFD Non-Game Biologist. Not available for distribution.

Vennesland, Ross G. and Robert W. Butler. (2011). Great Blue Heron (Ardea herodias), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/grbher3. DOI: 10.2173/bna.25

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

There is no known habitat model exists for Great Blue Heron in Teton County, WY. The habitat criteria listed below are primarily based on a USFWS habitat suitability index model (Short and Cooper, 1985) and on a Montana Heritage Program Predicted Suitable Habitat Model (Montana Heritage Program, 2016).

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Sources
Summer	Potential colony Habitat	Veg Layer	Cottonwood, conifer, riparian forested areas within 250 m (820 ft) (arbitrary distance chosen by USFWS) of water	Short and Cooper, 1985
Summer	Tree Patch Size	Veg Layer	Stand size >1 ac (>0.4 ha)	Short and Cooper, 1985
Summer	Colony Disturbance Buffer	Create	Buffer tree stands by 300 m (~1,000 ft) from disturbance. Analyze to see if this buffer corresponds to nesting practices in Teton County.	Short and Cooper, 1985
Summer	Forage habitat	Veg Layer	Shallow wetlands, streams, ponds (<0.5 m/ 1.6 feet deep) containing small fish including the edges of ponds and rivers	Short and Cooper, 1985
Summer	Disturbance free zone around foraging habitat	Create	Disturbance free zone of 100 m (329 ft) around potential foraging habitat	Short and Cooper, 1985
Summer	Forage habitat	Create	Distance between forage habitat and potential nesting locations, shorter is better, within 250 m (820 ft) to 1 km (0.62 mi) of the potential colony locations is the most important but foraging habitat within 10 km is used	Kelly et al, 2008
Summer	Known Colonies	GTNP, WGFD, NMJH	Known colony locations	WGFD, 2016; GTNP, 2016; NMJH, 2015
Summer	Distance to known/ former colony. Area contained there has increased habitat importance	Create	Potential habitat close (<1 km, (0.62 mi) to known/ former colony has a higher likelihood of additional nests/ new colony establishment than potential habitat farther away.	Vennesland and Butler, 2011; Short and Cooper, 1985

Contributors

Narrative Author: Megan A. Smith, Senior Wildlife Ecologist, Alder Environmental

Primary Reviewer: Susan Patla, Non-Game Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Patrick Wright, NRTAB

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Known Colonies	GTNP, WGFD, NMJH known colonies	Use all and buffer by 300 m disturbance distance.	Buffer	Known colony locations
Potential Colony Habitat within 1 km of foraging habitat	From TC, GRTE, BTNF, CTNF select cottonwood, conifer and riparian forested areas within 1km of foraging habitat	Select by Attribute, Merge; Buffer foraging habitat by 1km; clip merged forested areas by foraging habitat 1km buffer	Select by Attribute; Merge; Buffer; Clip	Potential Colony Areas
Forage Habitat	From TC, GRTE, BTNF, CTNF select wetlands, open water, rivers, waterbodies within 5 km of potential nesting habitat	Select by Attribute, Merge; Buffer potential nesting habitat by 5km to clip foraging habitat within 5 km of potential nesting habitat	Select by Attribute; Merge; Buffer; Dissolve; Clip	Potential Forage Habitat within 5 km of Nesting Habitat
Foraging habitat fringe	Increase width by 25 ft on each side to incorporate fringe foraging areas		Buffer	Foraging Habitat Refined
Combine known colonies, nesting habitat and forage habitat	Combine known colonies, nesting habitat and forage habitat shapefiles	Merge All	Merge	Import Habitat
Convert Shapefile to Raster	Convert Import Habitat Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Polygon to Raster	Important Habitat
Elevation	Retain elevations <7500 ft (~2,290 m)	VALUE <=2290	Extract by Attribute	Elevation
Extract Important Habitat by Elevation	Important habitat <=7,500 ft in elevation	Extract by Elevation	Extract By Mask	Summer Habitat
Compare with WOS and NMJH observations	Compare observations with output.			

While Short and Cooper (1985) indicated that stand size should be > 1.0 acres, this does not appear to be true in Teton County based on known nest locations. Therefore, patch size was not used as a variable. While foraging habitat can be within 10 km of a nesting / colony site, this buffer was too

extensive for Teton County. Therefore, a distance of 1 km (the most important areas [Kelly et al, 2008]) was used to limit the distance potential colony habitat could be from open water and the distance foraging habitat could be from potential colony habitat.

Veg Cover Definition Query Categories

Colony Habitat
Teton County Map Codes:
Subalpine Fir - Engelmann Spruce Forest - FSF
Douglas-fir Forest - FDF
Limber Pine Forest - FLM
Lodgepole Pine Forest - FLP
Mixed Conifer Forest - FMC
Blue Spruce Riparian Forest - FBS
Cottonwood Riparian Forest - FCW
Mixed Cottonwood - Blue Spruce Riparian Forest - FRM

Grand Teton Nation Park Map Codes:
Douglas-fir Forest - FDF
Lodgepole Pine Forest - FLP
Mixed Conifer Forest - FMC
Subalpine Fir - Engelmann Spruce Forest - FSF
Blue Spruce Riparian Forest - FBS
Limber Pine Forest - FLM
Cottonwood Riparian Forest - FCW
Mixed Conifer - Cottonwood Riparian Forest - FRM

Bridger-Teton National Forest MU CODE:
Douglas Fir Mix - MDF
Limber Pine - LBP
Lodgepole Pine Mix - MLP
Spruce/Subalpine Fir Mix - MSF
Cottonwood - CTW

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Douglas Fir Mix - MDF
Bridger-Teton Lodgepole Pine Mix - MLP
Bridger-Teton Spruce/Subalpine Fir Mix - MSF
Caribou-Targhee Conifer Mix -Cmix
Caribou-Targhee Douglas-fir - DF
Caribou-Targhee Douglas-fir/Lodgepole Pine - DF/LP
Caribou-Targhee Lodgepole Pine - LP
Caribou-Targhee Spruce/Fir - SF

Forage Habitat

Teton County Map Codes:
Canals - NID
Streams and Rivers - NST
Lakes, Ponds and Reservoirs - NLP
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA
Exposed Shore - Stream Deposit Sparse Vegetation - VSL
Non-vegetated Cobble Bars - NVS

Grand Teton Nation Park Map Codes:
Irrigation Canals - NID
Streams - NST
Lakes and Reservoirs - NLP
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA
Non-vegetated Sand Bars - NVS
Exposed Lake Shoreline - Stream Deposit Sparse Vegetation - VSL
Non-vegetated Sand Bars - NVS

Bridger-Teton National Forest MU CODE:
Water - WA
Riparian Herbland - RH

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Water - WA
Caribou-Targhee Riparian Herbaceous - RHE

Metadata

Title

GBHE_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Great Blue Heron Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Great Blue Heron is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

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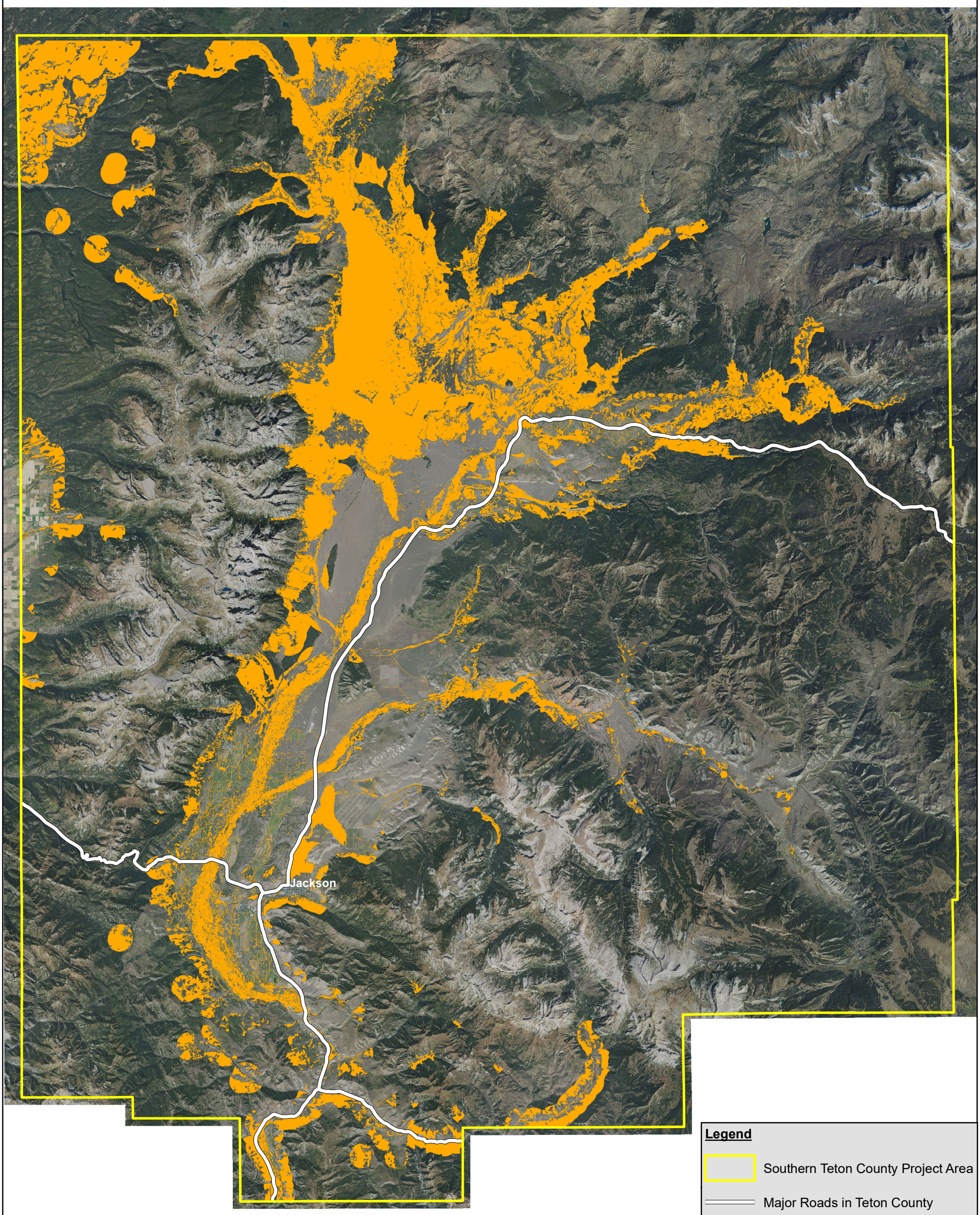

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 9:

Great Blue Heron Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

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GREAT GRAY OWL

Year-round resident in Teton County.

Important Habitat Characteristics

Summer (Breeding) Habitat

For nesting Great Gray Owls (*Strix nebulosa*), the species of dominant trees within a stand, as measured within a GIS, are not as important as other vegetation characteristics and abiotic factors (Bull et al, 1988, Bedrosian et al., 2015). Franklin (1988), Whitefield and Gaffney (1997) and Bedrosian et al. (2015) all found that the majority of nest sites within the southern Greater Yellowstone Ecosystem were in lodgepole pine (*Pinus contora*) trees, followed by Douglas fir (*Pseudotsuja megziesii*), aspen (*Populus tremuloides*) and spruce (*Picea* spp). Bedrosian et al (2015) also found active nests in cottonwood trees in the Snake River corridor in Jackson Hole. The density and availability of suitable snags (a standing, dead or dying tree, often missing a top or most of the smaller branches) may be a limiting factor for nest sites (Wu et al. 2015) considering that roughly half of nest sites within Teton County are located on broken-topped trees (Bedrosian et al., 2015).

Generally, literature on Great Gray Owl nesting indicates that late-successional stage forest stand structure is important for Great Gray Owls (e.g., Foresman and Bryan, 1984; Winter, 1986; Franklin, 1988; Bull and Henjum, 1990; Fetz et al, 2003). Total basal area of nest sites in Oregon was ca. 4,750m^2/ha (1.2 acres basal area/2.5 acres land area). Great Gray Owls in Teton County have been found to select for forests with higher canopy cover and higher stand height (used as a proxy for stand age in modeling exercises, Bedrosian et al., 2015). Similarly, Wu et al. (2015) found that owls selected nest sites with higher canopy cover than surrounding areas.

Great Gray Owls nest in stands that have an average canopy cover of 70-73% (Whitfield and Gaffney, 1997; Bedrosian et al., 2015). Average diameter at breast height (DBH) of trees with stick nests used by Great Gray Owls was 36 cm (14 in) and 74 cm (29 in) for snags (Bedrosian et al, 2015). There was no difference in canopy cover measured at nests sites compared to the stand, indicating selection at the stand level in Teton County. Mean shrub cover below nests was 17.2% (Whitfield and Gaffney, 1997). Using a GIS to measure canopy cover at nest sites resulted in a similar canopy cover percentage at known nest sites (67%).

Distance to wet meadows has also been a significant factor for nest sites in some studies (e.g., van Ripper et al., 2013; Wu et al., 2015). In Teton County, the mean distance of a nest to the nearest meadow or forest opening in which an owl can forage was 49m (243 ft). Forest openings and meadows are harder to detect using a 30m (98 ft) GIS vegetation layer and the mean distance measured from nests to openings using a GIS was 218m (715 ft). However, owls also regularly forage within closed canopy forests (Bull et al., 1988; B Bedrosian, *pers. observ.*).

Because Great Gray Owls often use snags for nesting, late successional stage forests with higher snag basal areas are preferred nesting habitat (Wu et al. 2015). At nest sites in California, mean basal area of snags was 12m^2/ha (130ft^2/2.5ac) and 4 snags/50m (164 ft) plots, while the mean stand level (250m scale) had a 8.4m^2/ha (90.4ft^2/2.5ac) snag basal area and 2.5 snags/plot.

Generally uncommon for Great Gray Owls, nesting habitat within Teton County also includes mixed conifer/cottonwood riparian areas in the Snake River and Gros Ventre drainages (Bedrosian et al., 2015). Recent data has also indicated that mixed conifer/hardwood forests at lower elevations in California are host to nesting Great Gray Owls (Polasik et al., 2016). These nesting sites are associated with late-successional spruce/fir/cottonwood forests.

Information on patch size of nesting stands is limited. Bedrosian et al. (2015) documented that core areas for breeding owls was roughly 0.83 km^2 (0.32 mi^2) (roughly equivalent to a 500m (1,640 ft) radius surrounding the nest). This was determined using the 50% Kernel density estimate from breeding owls during the nesting season (see also Van Ripper et al. 2013 for methods). The mean nearest neighbor distance between nests was 914m (2,998 ft).

Breeding Great Gray Owls select for nest stands further from roads in Jackson Hole, indicating they are likely disturbed by regular human presence (Bedrosian et al., 2015). This is also substantiated by van Ripper et al. (2013).

Abiotic Habitat Characteristics (Based on Bedrosian et al., 2015)

In Jackson Hole, Great Gray Owls select for lower sloped forest habitats, at lower elevations further from roads. The mean elevation for nests was 2,052 m (6,732 ft) (range = 1,850-2,404) and mean slope was 8.2% (range = 0.2 – 27.5). We found that the majority of nests were situated on north aspects (50%), followed by east (33%), south (12.5%) and west (0.5%). Nests at the northern end of the valley tended to be at higher elevation. Nest site elevation was positively-correlated with fledge date in 2015 (P = 0.031). Likewise, fledge date was also correlated to latitude (p = 0.028) because of a strong correlation between latitude and elevation (p = 0.003). However, these results were strongly influenced by one high altitude nest (2404 m, 7,887 ft)) in the northern portion of the study area (Rosie's Ridge). After removing this outlier, fledge dates were correlated to latitude (p = 0.007) but not elevation (P = 0.085) (Bedrosian et al, 2015).

Primary breeding habitats are treed areas that are generally, but not necessarily, coniferous. Great Gray Owls nest in both old raptor stick nests [primarily Northern Goshawks (*Accipiter gentilis*) but include Red-tailed Hawks (*Buteo jamacensis*), Common Ravens (*Corvus corax*) and Cooper's Hawks (*Accipiter cooperii)]* and broken-topped snags. Great Grays generally prefer closed canopy, older aged forest stands with little human presence. Presence of nearby meadows for hunting may be important, but not a limiting factor for the presence of breeding Great Gray Owls in Teton County. It is likely that forest stands of at least 0.8 km^2 (3.1 mi^2) are preferred for nesting based on estimated core area home range sizes.

Winter Habitat

Great Gray Owls in Teton County move to lower elevations during the winter months and select slightly different habitats then in summer months. Specific habitat types became more important when owls selected flat habitats at lower elevations, closer to meadows and closer to roads. There was higher use of cottonwood forests, particularly in the Snake River Drainage. No marked owls were known to winter north of Moose, WY in Jackson Hole. Older-aged forests were also important for winter habitat, as evidenced by a selection for higher tree heights in wintering forest stands.

The selection for habitats closer to roads is likely an artifact that lower elevation, flat habitats close to meadows also correspond to areas of higher human habitation in Teton County.

Primary winter habitats within Teton County are the Snake River drainage, south of Moose, Wyoming, the lower elevation conifer forests at the base of the mountains surrounding the valley, particularly on the western side of the valley and agricultural lands, such as Spring Gulch. Great Grays are limited by snow pack and snow characteristics and the cottonwood and mixed conifer/cottonwood river bottoms and agricultural lands can provide optimal habitats.

Risk Factors to Habitat/Habitat Function

Wyoming is the southernmost extent of the breeding range for Great Gray Owls in the Rocky Mountains (Bull and Duncan, 1993). Population status and trends for the Great Gray Owl are unknown in Wyoming but suspected to be stable, while habitat is restricted and vulnerable, so they are designated a Species of Greatest Conservation Need in Wyoming (WGFD 2010) and a Sensitive Species by the US Forest Service. The mature, boreal and montane forest habitats across the West that Great Gray Owls are typically associated with (Bull and Henjum, 1990) are at increasing risk from both natural and anthropogenic disturbances such as wildfire, disease outbreak, drought, climate change, logging and development. Great Gray Owls are long-lived (ca. 10-20 yr), have delayed age-at-first breeding (Bull et al., 1989) and specialize on northern pocket gophers (*Thomomys talpoides*) for the majority of their prey in Wyoming (Franklin 1988, unpubl data) making them vulnerable to habitat change.

Risks to breeding habitats within the private lands of Teton County are forest fires, fire mitigation projects and increased development; particularly at the base of the Teton Range from Grand Teton National Park to the Snake River Canyon. While large-scale forest fires may eliminate nesting stands completely, fire mitigation projects may open canopy cover and reduce snag density to levels that reduce nesting sites. Future subdivision of properties may increase human presence within and near nesting sites which may reduce nesting or increase nest failures.

Much of the relevant literature has placed emphasis on meadows as important habitat. While that is not discounted in Teton County, it does not appear to be a limiting factor. Most nest sites are no closer than 100m (328 ft) from the forest edge, indicating the need for intact forest patches. Increased trail or mosaic forest treatments may lead to decreased nesting habitat.

The recommended buffer size of nest sites based on core areas of breeding owls is a 500 m (1,640 ft) surrounding nest sites. Emphasis should be placed on planning for and maintaining low elevation, late-successional stage forests with at least 50% canopy cover and at least 4 or more (100cm (39.3 in) DBH) snags/ha (Wu et al., 2015).

Literature Sources

Bedrosian, B, K Gura, B Mendelsohn, and S Patla. 2015. Occupancy, nest success, and habitat use of Great Gray Owls in western Wyoming. State Wildlife Grant Final Report. Teton Raptor Center.

Bull, E. L., and M. G. Henjum. 1990. Ecology of the Great Gray Owl. US Department of Agriculture, Forest Service, General Technical Report. PNW-GTR-265. Pacific Northwest Research Station, Portland, Oregon, USA.

Bull, E. L., M. G. Henjum, and R. S. Rohweder. 1988. Nesting and foraging habitat of Great Gray Owls. Journal of Raptor Research 22:101-106.

Fetz, T. W., S. W. Janes, and H. Lauchstedt. 2003. Habitat characteristics of Great Gray Owl sites in the Siskiyou Mountains of southwestern Oregon. Journal of Raptor Research 37:315-322.

Forsman, E.D. and T. Bryan. 1984. Distribution, abundance, and habitat of Great Gray Owls in south-central Oregon. OR Dept. of Fish and Wildlife. Nongame project #84-9-05, Corvallis, OR

Franklin, A.B. 1988. Breeding biology of the Great Gray Owl in southeastern Idaho and northwester Wyoming. Condor. 90:689-696.

Polasik, J.S., J.X. Wu, K.N. Roberts, and R.B. Siegel. 2016. Great Gray Owls nesting in atypical, low-elevation habitat in the Sierra Nevada, California. Journal of Raptor Research. 50:194-206.

van Ripper, III, C., J. J. Fontaine, and J. W. van Wagtendonk. 2013. Great Gray Owls (Strix nebulosa) in Yosemite National Park: on the importance of food, forest structure, and human disturbance. Natural Areas Journal 33:286-295.

Whitfield, M. B. and M. Gaffney. 1997. Great Gray Owl (Strix nebulosa) breeding habitat use within altered forest landscapes. in Biology and conservation of owls of the northern hemisphere: 2nd International Symposium. (eds. Duncan, James R.; Johnson, David H.; Nicholls, Thomas H.). General Technical Report NC-190. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station.

Winter, J. 1986. Status, distribution and ecology of the Great Gray Owl (Strix nebulosa) in California. MS Thesis. San Francisco State University, San Francisco, CA, USA.

Wu, J. X., R. B. Siegel, H. I. Loffland, M. W. Tingley, S. I. Stock, K. N. Roberts, J. J. Keane, J. R. Meadley, R. Bridgman, and C. Stermer. 2015. Diversity of Great Gray Owl nest sites and nesting habitats in California. Journal of Wildlife Management. 79:937-947

Wyoming Game and Fish Department. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Habitat Characteristics

Bryan Bedrosian, Teton Raptor Center, have created a breeding season (summer) model and a preliminary winter model for Great Gray Owls (Bedrosian et al, 2015). A portion of the data in these models (top percentages) were used here.

Excerpt on Modeling

Habitat modeling was completed with the help of Matt Hayes from Lone Pine Analytics, LLC. We investigated several covariates to include in a resource selection model to predict breeding and winter habitat, including land cover type, elevation, slope, aspect, distance to roads, distance to meadows, total vegetation height (as a proxy for stand age) and canopy cover. All raster covariates were resampled to thirty meters and projected in UTM zone 12N NAD 83. Elevation was measured and slope and aspect were calculated from a 30 m digital elevation model created by USGS and accessed from the NRCS Data Gateway web service (https://gdg.sc.egov.usda.gov/). Aspect was transformed into a TRASP (transformation of aspect) index, which is a circular transformation where a value of zero is an area on north/northeast slopes (coolest and wettest orientation in northern latitudes) and a value of 1 is an area on southerly slopes (Roberts & Cooper, 1989). A distance-to-road layer was created from a statewide Wyoming Department of Transportation road shapefile, which included numbered Forest Service roads. This layer shows the distance to the nearest road for the center of each 30 m cell. Land cover was reclassified, several ways, using the NLCD layer. Distance to meadow was created by reclassifying the NLCD land cover data into a meadow/no meadow classification and calculating the shortest distance for each cell to a cell of the reclassified meadow. We reclassified the NLCD on two scales based on biological relevance to owls. First, we reclassified the NLCD into seven categories and second, we created a forest/no forest layer. Vegetation height and percent of tree canopy cover were both taken from the Landfire data products accessed at http://landfire.cr.usgs.gov/. These metrics provide a measure of the height of vegetation in a pixel as well as the percent of the canopy, which is from trees.

We created breeding habitat models using the actual used relocations from all ≥2 yr old owls from 1 May – 31 August, excluding any relocations of incubating females (all points were combined, forming a population-level model). We created a set of "available" points to compare with owl relocation points (i.e., "used" points). To create the available points, we randomly selected 5x the number of used points in a 25 km buffer outside of the 75% KDE created from the known used points. This insured that we

were not sampling available points within our KDE. After running the global model, we ran all possible combinations of that model because it is realistic that any subset of that model would be biologically relevant and meaningful. We ranked the models using AICc and used the top model as our best model. We calculated odds ratios and coefficients from this final model.

We also created models of winter habitat. Because we were interested in assessing winter habitat during peak snow depths, we reduced the total relocation dataset to 15 December – 31 January, which resulted in a relatively small sample size. Because we had too few "Used" locations during this time period, we created 90% KDE home ranges for winter range using all owls to create a population level model. Used points were sampled randomly within this KDE and available points were, again, sampled within a 25 km buffer around the KDE at a ratio of 1:5 for used: available. We ran all possible model permutations because it is realistic that any subset of that model would be biologically relevant and meaningful. We ranked the models using AICc and used the top model as our best model. We calculated odds ratios and coefficients from this final model.

For all models we ran a 10-fold cross validation and reported the cross validation error. Final models for both seasons were predicted spatially at a resolution of 30 m for use in subsequent work and publications. All data were processed in Program R (R Core Team, 2015) utilizing various packages. All models were binomial logistic regressions.

Great Gray Owls typically need large stands of contiguous, suitable habitat. Modeling habitats creates an index of habitat "value" for each 30 m cell, but unless there is sufficient habitat surrounding that cell, then the habitat is not actually available for nesting. We created a measure to help account for this. We created a layer using, conservatively, the top 10% of the predictive breeding model and eliminated any areas not within the top predicted 10%. We then calculated the number of cells within a 500 m (1,640 ft) radius that also occurred within the top 10% of the model. Each cell then had a value of all the cells within a typical owl territory size with predicted habitat with a maximum of 901 cells. We binned the resulting layer into quartiles, removed any cells with less than 25% suitable habitat within 500 m (1,640 ft) radius and created a predictive layer incorporating patch size.

Contributors

Primary Author: Bryan Bedrosian, Senior Avian Ecologist, Teton Raptor Center

Primary Reviewer: Susan Patla, Nongame Biologist, WGFD

Secondary Reviewer: Patrick Wright, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Winter Resource Selection Model (Bedrosian et al, 2015)	Top 10% of probability of use for winter habitat (Quantile classification method of raster).	10% was chosen as the cutoff per B Bedrosian	Extract by Attributes	Most probable important winter habitat
Exclude areas known to not provide habitat	Clip to Teton County excluding Town, Refuge and Jackson Lake but not Cache Creek	Clip by polygon	Clip	Clip
Simplify Raster Values	Reclassify all values to 1 and No Data = 0	Reclassify	Reclassify; No Data = 0	Product
Compare with WOS and NMJH observations	Visually compare observations with output.			

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Breeding Season Resource Selection Model (Bedrosian et al, 2015)	Top 20% of probability of use for breeding habitat (Quantile classification method of raster).	20% was chosen as the cutoff per B Bedrosian. Great Gray Owls are more dispersed across the landscape in the summer than in the winter.	Extract by Attributes	Most probable important winter habitat
Clip to Teton County	Clip to Teton County polygon	Clip by polygon	Clip	Clip
Simplify Raster Values	Reclassify all values to 1 and No Data = 0	Reclassify	Reclassify; No Data = 0	Product
Compare with WOS and NMJH observations	Compare observations with output.			

Metadata - Winter

Title

GGOW_Win.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Great Gray Owl Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Great Gray Owl is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

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Metadata - Summer

Title

GGOW_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Great Gray Owl Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

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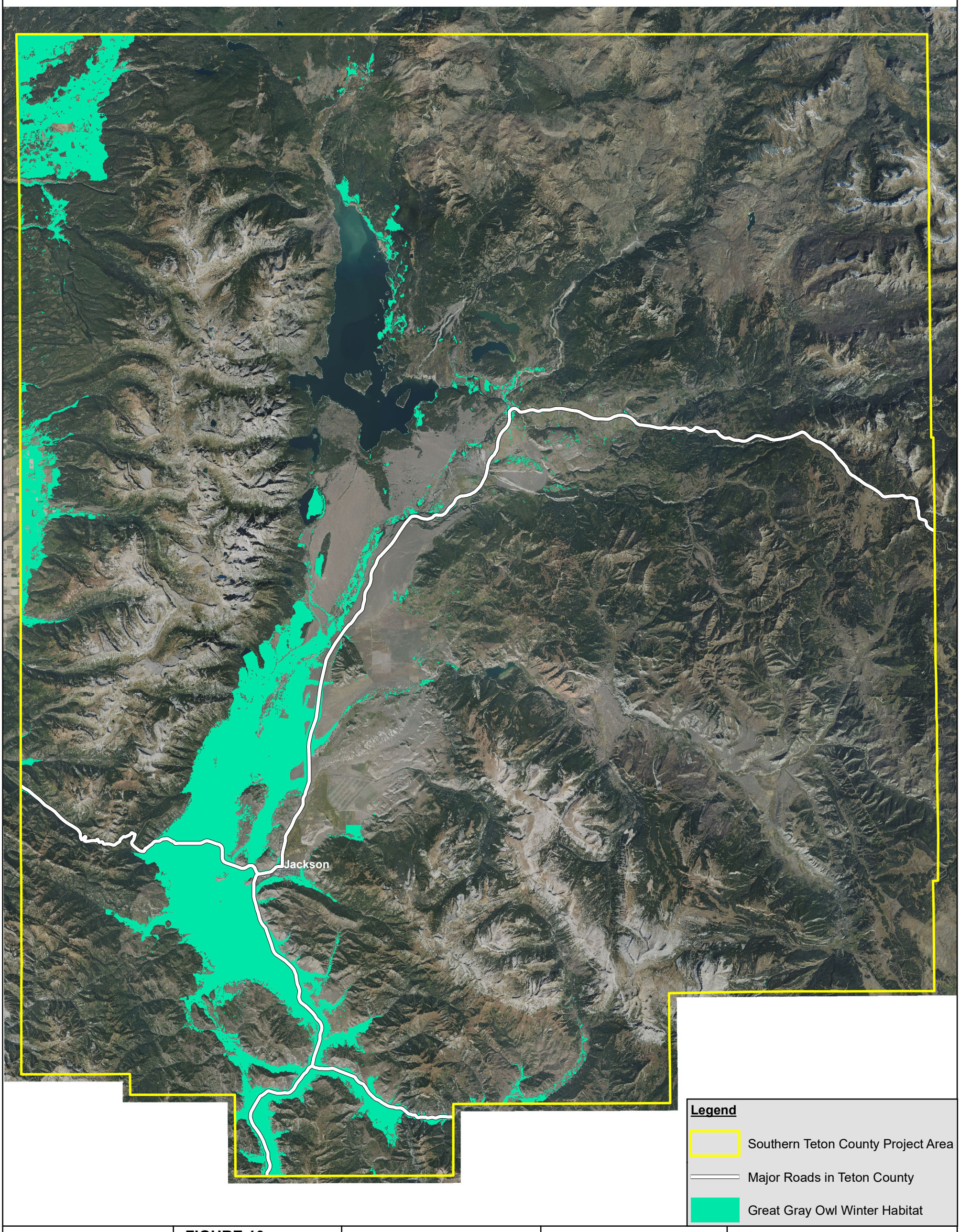

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 10:

Great Gray Owl Winter Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

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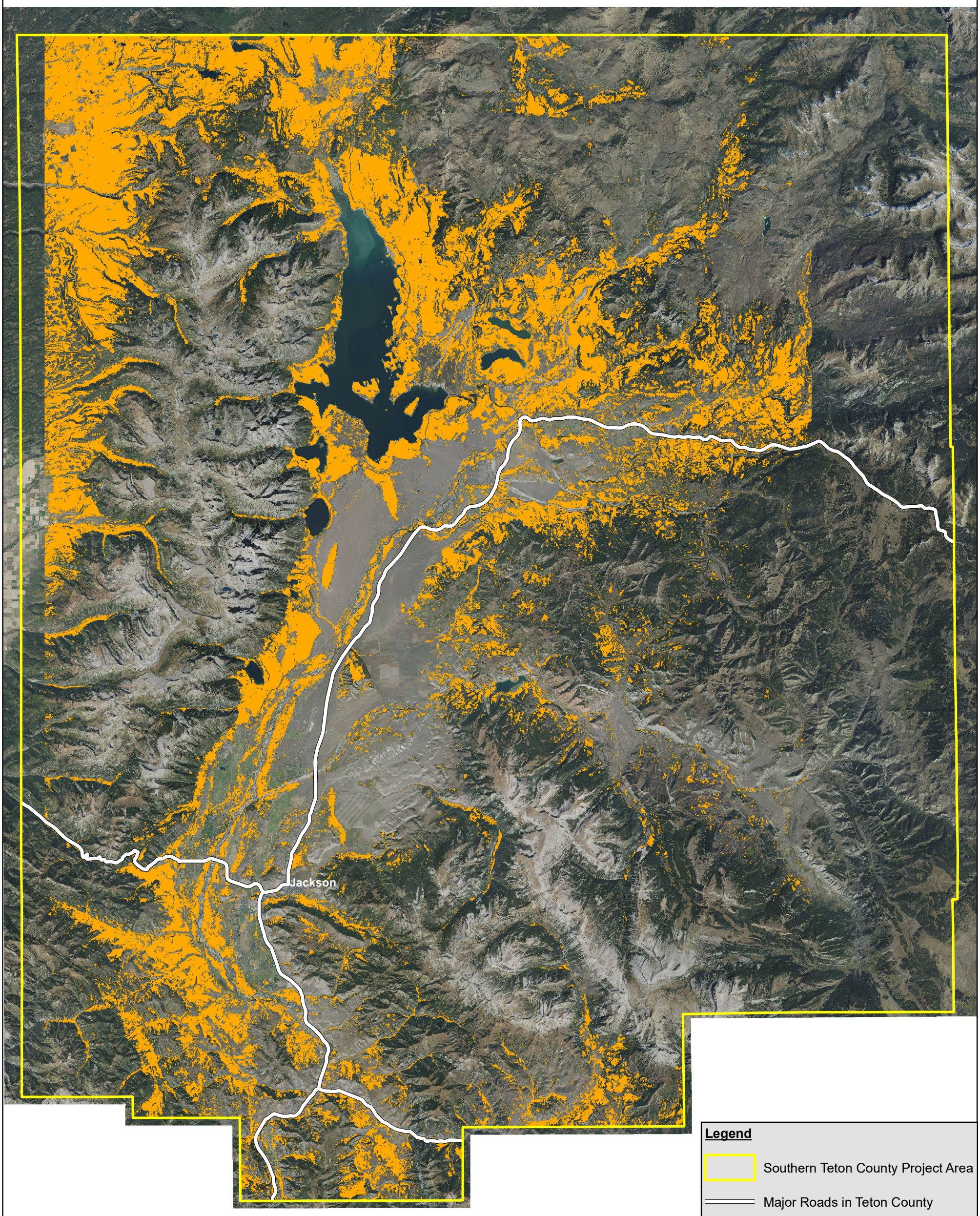

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 11:

Great Gray Owl Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

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GREATER SAGE-GROUSE

Year-round resident in Teton County.

Important Habitat Characteristics

Greater Sage-grouse (*Centrocercus urophasianus*) are a sagebrush community obligate. Sage-grouse have declined across their range during the past 50 years, as has the distribution and quality of their sagebrush habitat. They are particularly sensitive to human activity and disturbance, especially during lekking (courtship) and nesting periods. Historically, loss of sagebrush habitat due to urbanization, conversion to agriculture and other anthropogenic causes has been the most significant factor for permanent habitat loss for sage-grouse in Teton County (Bedrosian, 2010; Upper Snake River Basin Sage-Grouse Working Group, 2014). Sage-grouse in Teton County are managed as part of the Upper Snake River Basin Area, which includes Jackson Hole, the Gros Ventre drainage, areas around Hoback and Bondurant and Star Valley (WGFD, 2014). However, recent research has demonstrated that Sage-grouse in Jackson Hole and the Gros Ventre drainage are genetically isolated and exhibit a high degree of inbreeding (Schulwitz et al, 2014). This makes them particularly vulnerable to local extinction in the future. Sage-grouse in the Upper Snake River Basin Area are monitored using lek counts in the spring. Leks are cooperatively monitored by Grand Teton National Park, National Elk Refuge, Wyoming Game and Fish Department, Bridger-Teton National Forest, Teton Conservation District, Teton Raptor Center and volunteers. There has been an upswing in male numbers at leks in the past 5 years in Jackson Hole and the Gros Ventre drainage, which is a promising trend (WGFD 2014). However, this population remains vulnerable due to its small numbers, genetic isolation and limited habitat.

Breeding Habitat

As a lekking species, maintaining lek sites (courtship areas) is critical to maintaining sage-grouse populations. There are currently 11 known, occupied sage-grouse leks in Teton County, including 7 in Grand Teton National Park, two on Bridger-Teton National Forest and two on the National Elk Refuge. There are also several historical leks that have been unoccupied by birds for more than 10 years. There are currently no known leks on private lands within Teton County.

Sage-grouse breeding habitat is typically divided into three categories, based on time and behavior (nesting, early brood-rearing and late brood-rearing). Nesting habitat includes mature sagebrush communities, including mountain big sagebrush, Wyoming big sagebrush, basin big sagebrush, silver sagebrush and antelope bitterbrush. Sage-grouse nests tend to be located within 5km of the lek (Holloran and Anderson, 2005). Residual herbaceous and grass cover levels significantly affect nest success (Holloran, 1999) and can be altered by annual precipitation, native ungulate grazing and cattle grazing. In Jackson Hole, average shrub height at nest sites was 0.76 m (2.5 ft), with 80% of sagebrush canopy alive (Bedrosian, 2010). Average sagebrush cover at nests sites ranges from 15-27% in Teton County, but tends closer to 25% in Wyoming (Connelly et al, 2000). Grass cover at nest sites is variable (4-51%) but 20 cm (7.9 in) height is the desired management goal.

Sage-grouse chicks are precocial (they can survive and move immediately after hatching) and the habitats needed to sustain younger and older chicks are different from, but just as important as, nesting habitat. Early and late brood rearing habitats have a higher proportion of forbs and insects than typical nesting habitats. These areas tend to be wetter, at higher elevations and on steeper slopes than nesting habitat. In Jackson Hole, early brood rearing habitat is typically from late April – June and does not differ from nesting habitat due to cool, wet springs at this high elevation. Late brood rearing habitats (July – Sept) tend to have less sagebrush canopy cover and is found in wetter areas than nesting. Late brood rearing habitats can include wet meadows, open pasturelands, agricultural meadows and grasslands

adjacent to nesting and early brood rearing habitats. Sage-grouse typically avoid monotypic brome grass fields, but do utilize native grasslands and lightly grazed agriculture meadows for late brood rearing habitats.

Most sage-grouse nest within several miles of a lek site. In Teton County, this precludes most private lands from hosting nesting habitat. However, some private lands in Spring Gulch, East and West Gros Ventre Buttes, south and west of the Airport and in the Gros Ventre drainage are within several miles of active leks. Several Wyoming State School sections within Grand Teton National Park are host to nesting and brood rearing habitats. While no estimates of patch size exist for breeding habitat in Teton County, movement data indicate that there is very little nesting habitat within Teton County private lands. However, several privately held grazing allotments within Grand Teton National Park and Bridger-Teton National Forest have the potential to negatively affect breeding habitat based on grazing intensity (Beck and Mitchell, 2000).

Abiotic Habitat Characteristics

Sage-grouse nest in areas with very little topographic relief. In late winter and early spring, sage-grouse also seek out specific locations to ingest soil as a dietary supplement and/or digestive aid (a.k.a., geophagy). These sites have been identified on public lands within Teton County, including the National Elk Refuge and Grand Teton National Park.

Winter Habitat

The population of sage-grouse in Teton County is likely limited by the amount of available winter habitat (Holloran and Anderson 2004; Courtemanch et al, 2007; Bedrosian, 2010). Sage-grouse are reliant on exposed sagebrush for both food and cover in the winter. Due to snow depths in Teton County, this restricts winter habitat to mature (>30-yr-old) sagebrush. Sage-grouse migrate within the valley to several specific areas in the winter that meets these requirements (Bedrosian, 2010). Main wintering areas include eastern Antelope Flats, Warm Ditch north of Kelly Hayfields, northern hills on the National Elk Refuge, Spread Creek, benches east of Uhl Hill, Blacktail Bench and Breakneck Flats, Fish Creek and Slate Creek areas in the Gros Ventre drainage (Holloran and Anderson, 2004; Bedrosian, 2010). Average slope at winter locations of sage-grouse was <5 degrees, sagebrush height was 53 cm (20.8 in) with a density of 53 plants/0.004 ha (0.01 ac).

There are several habitats atypically occupied by sage-grouse in Teton County during the winter, such as the cottonwood river bottom of the Gros Ventre River (Bedrosian, 2010; Chong et al, 2011). Similarly, during the spring melt, sage-grouse have been shown to utilize steep, open east facing slopes further south than their typical range in Teton County. These areas include the eastern aspects of East and West Gros Ventre Buttes. These areas are typically snow-free first and may provide the first green forbs and/or soil for geophagy. The relative use of these sites is very low for this population, but may provide a critical bridge for forage between winter and spring months.

Risk Factors to Habitat/Habitat Function

In 2008, Wyoming Governor Freudenthal issued Executive Order 2008-2 establishing sage-grouse Core Areas and stipulations to protect sage-grouse habitat and populations in those Core Areas. Following the release of the "warranted but precluded" listing decision by the U.S. Fish and Wildlife Service in 2010, the governor issued a new executive order to replace that from 2008. In 2011, newly elected Governor Mead issued a 3rd executive order which reiterated and further clarified the intent of the Core Area Policy. This executive order was further updated by Governor Mead in 2015 (Executive Order 2015-4) to include new Core and Connectivity Areas. The current Executive Order and Core Area Policy can be found on the Wyoming Game and Fish Department website. Sage-grouse core areas carry protections

that limit surface disturbance, whether on public or private lands. In Teton County, the majority of core area occurs on public lands but private lands on East and West Gros Ventre Buttes, Spring Gulch, Kelly, private in-holdings in Grand Teton National Park and in the Gros Ventre drainage are also included (Executive Order 2015-4).

Historically, loss of sagebrush habitat due to urbanization, conversion to agriculture and other anthropogenic causes has been the most significant factor for permanent habitat loss in Teton County (Bedrosian, 2010; Upper Snake River Basin Sage-Grouse Working Group, 2014). Currently, the vast majority of breeding habitat in Teton County is protected by federal lands. Several in-holdings occur within public lands that are host to sage-grouse habitat. One of the largest threats to sage-grouse habitat is wildfire and cheatgrass invasion into sagebrush communities. Particularly, loss of wintering habitat to wildfire has the potential to significantly reduce overall population size.

Sage-grouse in Teton County are genetically isolated and have a high degree of inbreeding (Schulwitz et al, 2014). Reduction in population size may significantly impact the long-term viability of sage-grouse locally. Burned sagebrush patches take at least 35 years to mature to the point to where they may become winter habitat again (Baker 2006). Bedrosian (2010) estimated that over 1,100 ha (2,718 ac) of winter habitat has been lost due to wildfire since 1994 in GTNP and won't fully regenerate until ca. 2038. Several of the old agricultural fields in Grand Teton National Park are being converted back to native sagebrush communities and have promise for long-term habitat benefit.

Increased anthropogenic footprints and cumulative reduction of sagebrush will continue to negatively impact sage-grouse. There is some evidence to suggest an avoidance of roadways and potentially increased human presence on pathways through sagebrush can affect grouse use (Manier et al. 2014). The existing use and potential future expansion of the Jackson Hole Airport is an important issue for sage-grouse. There is an active lek and an unoccupied lek within the airport perimeter and sage-grouse use areas within the perimeter fence for brood-rearing in later summer and early fall. There are concerns from the Federal Aviation Administration about the risk to human safety of sage-grouse strikes to aircraft. On the other hand, there is concern from Grand Teton National Park and members of the Upper Snake River Basin Sage-Grouse Working Group that increased plane traffic and infrastructure could negatively affect sage-grouse.

Fences have been shown to be a cause of mortality for sage-grouse in flight and should be removed where possible in occupied habitats. Where fences are unable to be removed, attaching visibility tags can help prevent sage-grouse strikes. While there is no significant effect of predators, such as Common Ravens on sage-grouse in Jackson Hole (Bui et al, 2009), reduction of vertical structures such as remnant cottonwoods and power poles in sage-grouse habitat may benefit sage-grouse populations. Residential development can cause increases in local mammalian predator abundance, such as red foxes, raccoons and outdoor domestic cats. Residential development on private lands adjacent to sage-grouse habitats could lead to increased predation rates (Upper Snake River Sage-Grouse Working Group, 2014). Mammalian predation is the leading cause of sage-grouse adult and chick mortality in Jackson Hole (Bedrosian, 2010).

Literature Sources

Baker, W.L. 2006. Fire and restoration of sagebrush systems. Wildlife Society Bulletin. 34: 177-185.

Beck, J.L. and D.L. Mitchell. 2000. Influences of livestock grazing on sage-grouse habitat. Wildlife Society Bulletin. 28:993-1002.

Bedrosian, B. 2010. Sage-grouse completion report: 2007-2009. Final Report to Wyoming Game and Fish Department. Craighead Beringia South. http://www.beringiasouth.org/s/Grouse_Report_Final-updb.pdf

Bui, T.D, J.M. Marzluff, and B Bedrosian. 2010. Common Raven activity in relation to land use in western Wyoming: Implications for Greater Sage-grouse reproductive success. Condor. 112: 65-78.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sagegrouse populations and their habitats. Wildlife Society Bulletin 28:967-985.

Chong, G.W., W.C. Wetzel, and M.J. Holloran. 2011. Greater sage-grouse of Grand Teton National Park: Where do they roam? Park Science. 27: 42-49.

Courtemanch, A.B., Chong, G.W., and S. Kilpatrick. 2007. A remote sensing analysis of sage-grouse winter habitat in Grand Teton National Park and Bridger-Teton National Forest, Wyoming. Appendix 3 in Upper Snake River Basin Sage-Grouse Conservation Plan. January 2014. Upper Snake River Basin Sage-Grouse Working Group.

Executive Order 2015-4. Greater Sage-Grouse Core Area Protection. Office of the Governor, State of Wyoming. 45 pp. https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SG_Executive_Order.pdf

Holloran, M. J. 1999. Sage-grouse (*Centrocercus urophasianus*) seasonal habitat use near Casper, Wyoming. Thesis, University of Wyoming, Laramie, USA.

Holloran, M.J. and S.H. Anderson. 2004. Greater sage-grouse seasonal habitat selection and survival in Jackson Hole, Wyoming. M.S. Thesis. University of Wyoming, Laramie, Wyoming, USA.

Holloran, M.J. and S.H. Anderson. 2005. Spatial distribution of Greater Sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742-752.

Manier, D.J., Bowen, Z.H., Brooks, M.L., Casazza, M.L., Coates, P.S., Deibert, P.A., Hanser, S.E., and Johnson, D.H. 2014. Conservation buffer distance estimates for Greater Sage-Grouse—A review: U.S. Geological Survey Open-File Report 2014–1239, 14 p., http://dx.doi.org/10.3133/ofr20141239.

Schulwitz, S., B. Bedrosian and J.A. Johnson. 2014. Low neutral genetic diversity in isolated Greater Sage-grouse populations in northwest Wyoming. Condor. 116:560-573.

Upper Snake River Basin Sage-Grouse Working Group. 2014. Upper Snake River Basin Sage-Grouse Conservation Plan. 137 pp. Accessed October 2016: https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SG_USR_CONSERVPLAN.pdf

WGFD. 2014. Upper Snake River Basin Sage-Grouse Job Completion Report. Pages 189-206 in 2014 Greater Sage-Grouse Job Completion Report. Accessed October 2016: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/2014-15_SG_JCR_Complete_optimized.pdf

Habitat Characteristics

No known habitat model exists for Sage-Grouse in Teton County, WY. However, existing occupied habitat layers based on sage-grouse telemetry locations do outline sage-grouse habitat in Teton County. Additionally, there are data and population level kernel density estimates (KDE) of occupied winter habitats from Bedrosian, 2010.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Winter	Sagebrush & Cover	Vegetation layers	Sagebrush cover types with height > 20 inches and > 21% cover; exclude silver sagebrush west of Snake River but include all Mountain and Big Basin Sagebrush	Bedrosian, 2010; Holloran and Anderson, 2004
21% cover (above) is an estimate by Bedrosian based on measurements (made during the summer) of used winter habitat from GPS birds. Avg. crown diameter of each sagebrush = 45cm. Avg # plants = 53. Total = 8.43 sq m of surface area in a 40sq m plot				
Winter	Exposed sagebrush	Courtemanch	Winter habitat model based on exposed sagebrush (data not available)	Courtemanch et al, 2007
Winter	Atypical winter habitat known to be used in Teton County	Vegetation layers	Pure cottonwood in GV River (golf course to moose pullout) Ditch Creek bottom and east aspects of East and West Gros Ventre Buttes	Bedrosian, 2010; Chong et al, 2011
Winter	Known Primary Habitat Areas	Beringia results	All known winter habitat areas	Bedrosian, 2010
Winter	Elevation	DEM	Winter elevation of habitat occupied by JH sage-grouse population ranges from 1800 – 2100m	Bedrosian, 2010
Nesting	Slope	DEM	< 5%	Connelly et al, 2000
Early/ Late Brood Rearing	Slope	DEM	Slopes around the valley floor	Bedrosian *pers. comm.*
Early Brood Rearing/ Nesting	Habitat proximate to lek locations	WGFD Lek locations	5 km radius around leks (65% of nests) and 8.5 km of nests (93% of nests)	Holloran and Anderson, 2005

Early Brood Rearing/ Nesting/ Late Brood Rearing	Sagebrush Cover	TC Veg GIS & BTNF Veg/ nesting habitat & GRTE Veg	Sagebrush cover types with 15-25% cover minimum, BTNF has identified late summer brood rearing and nesting	Connelly et al, 2000
Late Brood Rearing	Wet Cover Types adjacent to sagebrush	TC Veg GIS	Wet meadows, open pastures, agriculture grasslands adjacent to sagebrush brood rearing habitat	Bedrosian, 2010
Occupied Summer Habitat	Core Habitat Area	Governor's Core Area	All in Teton County	WGFD, 2015 (B. Bedrosian, *pers. comm.*)

Contributors

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Primary Reviewer: Aly Courtemanch, Wildlife Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Amy Girard, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Important Veg Cover	From TC, GRTE, BTNF & CTNF: Sagebrush cover types excluding silver sagebrush. Height and cover class were not included as this definition was too precise for the veg data available	See Definition Query Selection Below	Definition Query for each source; Select by Attribute; Merge	All sagebrush veg covers
Beringia Known Primary Habitat Areas	Confirm that known areas are represented by Veg Cover.	Compared with other habitat layers and not used as it was included in geographic area of other variables		
Atypical Known Habitat	Pure cottonwood in GV River (golf course to moose pullout) Ditch Creek bottom	Definition Query for Cottonwood, Clip to geographic area.	Definition Query, Select by Attribute, Merge, Clip	Atypical Cottonwood Habitat

Merge all Habitat Areas			Merge	Winter Habitat Merged
Remove high snow areas and areas in Granite Creek	Remove mapped habitat in Granite Creek. Per Joe Bohne and S Patla *pers. commun.* areas south of Jackson are potential winter habitat except Granite Creek	Delete polygons in Granite Creek Drainage	Multipart to Singlepart; Edit; Delete	Winter Habitat Refined
Convert to Shp Raster	Convert Merged Winter Veg Cover Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Winter Veg Cover Raster
Elevation	Known occupied habitat is located between 1800 – 2200m (increased to include Spread Creek Area)	VALUE >=1800 AND VALUE <=2200	1800 – 2100m	Elevation
GV Habitat	Area in Gros Ventre that is known to be winter habitat per B Bedrosian that falls above the 2,200m elevation area	Section of Core Area that contains the Gros Ventre drainage and is above 2,200 m	Convert Polygon to Raster; Mosaic Rasters	Elevation and Gros Ventre Habitat Area
Extract Veg by Elevation and Gros Ventre Mosaic	Winter veg habitat between 1800 – 2100m and known area in Gros Ventre	Extract by Mosaic Raster	Extract by Mask; Reclassify so No Data = 0	Product
Compare with WOS and NMJH observations	Compare observations with output.			

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, GRTE, BTNF & CTNF Sagebrush cover types excluding silver sagebrush. Height and cover class were not included as this definition was too precise for the veg data available	See Definition Query Selection Below	Definition Query; Select by Attribute; Merge Layer	All sagebrush veg covers
Wet Cover Types adjacent to sagebrush	Wet meadows, open pastures, agriculture grasslands adjacent to sagebrush is brood rearing habitat	Select wet veg covers types	Definition Query; Select by Attribute; Merge Layer	Adjacent Wet Cover Types
Leks and buffered area	WGFD Leks – all occupied and undetermined 2016 buffered by 8.5 km of nests (93% of nests)	Buffer leks by 5 km and 8.5 km radius		Nesting Area
Limit Veg Cover to around Leks	Limit sage and wet veg covers to nesting areas around leks	Clip Veg by Lek buffer	Clip	Brood Rearing Habitat
Core Habitat Area	Governor's Core Area	Jackson polygon		Governor's Core Area
BTNF Habitat Layer	BTNF Habitat Layer	Compare with veg results to see if inclusive		BTNF Habitat Layer
Merge all Habitat Areas			Merge	Summer Habitat
Convert to Shp Raster	Convert Merged Summer Veg Cover Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster; Reclassify so No Data = 0	Summer Raster
Compare with WOS and NMJH observations	Visually compare observations with output.			

Note: Slope was removed per the recommendation by B Bedrosian since all brood rearing categories were addressed as one.

Veg Cover Definition Query Categories

Winter & Summer Sagebrush Habitat

Teton County Map Codes:
Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SES, SMSD, SSD

Grand Teton Nation Park Map Codes:
Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SSD

Bridger-Teton National Forest MU CODE:
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Mountain Shrubland - MS
Sagebrush/Bitterbrush Mix - SB
Spiked Big Sagebrush - SK

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB

Atypical Cottonwood Habitat (selects for all cottonwood)
Teton County Map Codes:
Cottonwood Riparian Forest - FCW
Mixed Cottonwood - Blue Spruce Riparian Forest - FRM

Grand Teton Nation Park Map Codes:
Cottonwood Riparian Forest - FCW
Mixed Conifer - Cottonwood Riparian Forest - FRM

Bridger-Teton National Forest MU CODE:
Cottonwood - CTW

Caribou-Targhee National Forest MU CODE BT:
No cottonwood included in this area of CTNF

Wet Meadow and Open Pasture Brood Rearing Habitat (selects for all cover types)

Teton County Map Codes:Irrigated Agricultural Fields - NIPI
Non-Irrigated Agricultural Fields - NIPN
Perennially Flooded Agricultural Fields - NIPF
Montane Mesic Forb Herbaceous Vegetation - HFD
Flooded Wet Meadow Herbaceous Vegetation - HGS

Grand Teton Nation Park Map Codes:
Irrigated Fields - NIP
Montane Mesic Forb Herbaceous Vegetation - HFD
Flooded Wet Meadow Herbaceous Vegetation - HGS

Bridger-Teton National Forest MU CODE:
Grassland/Forbland - GF
Tall Forbland - TF
Riparian Herbland - RH

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Grassland/Forbland - GF
Bridger-Teton Tall Forbland - TF
Caribou-Targhee Riparian Herbaceous - RHE

Metadata - Winter

Title

GRSG_Wint.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Greater Sage-Grouse Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Greater Sage-Grouse is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.

Metadata - Summer

There are two layers for Greater Sage-Grouse: Summer and Winter

Title

GRSG_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Greater Sage-Grouse Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

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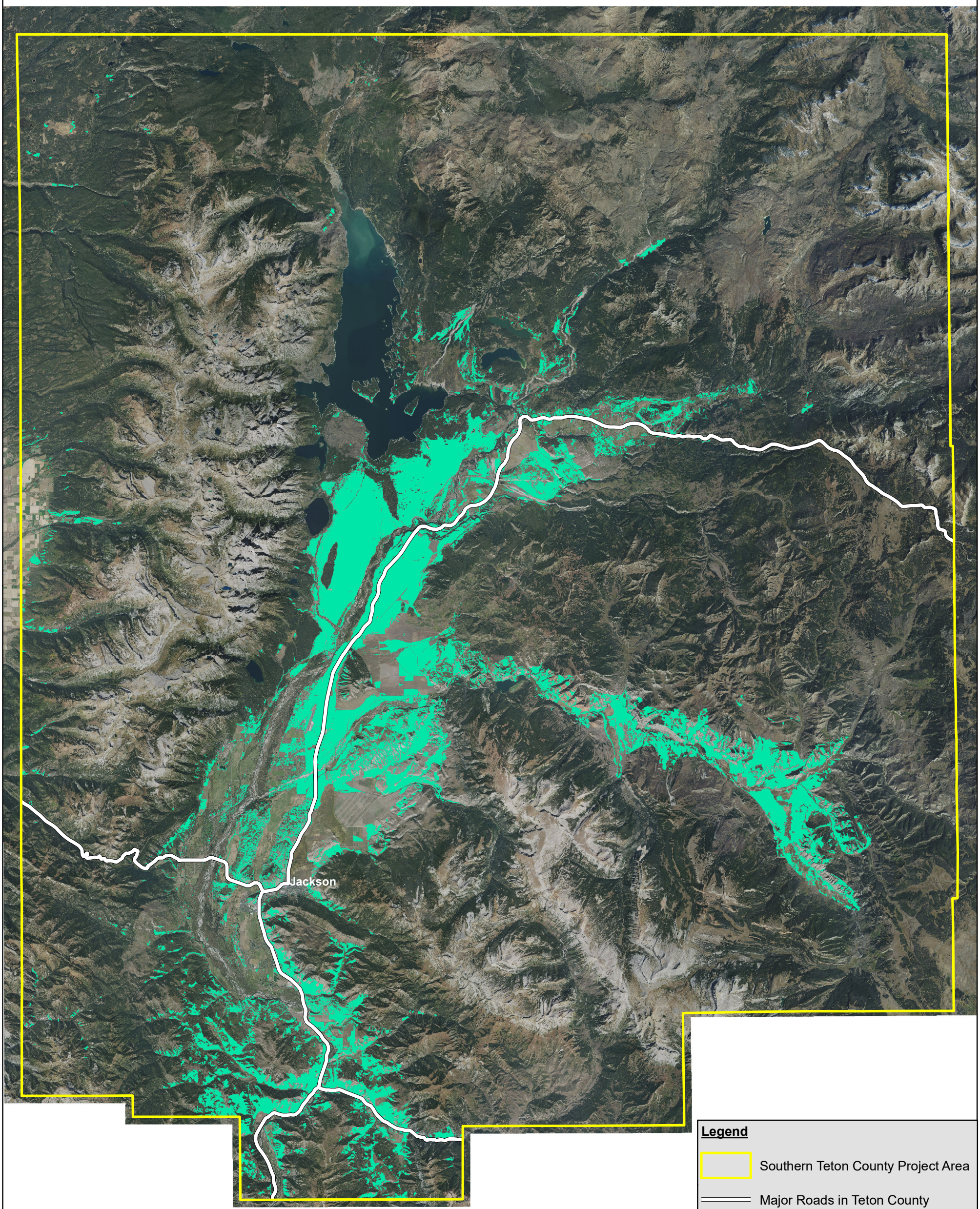

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 12:

Greater Sage-Grouse Winter Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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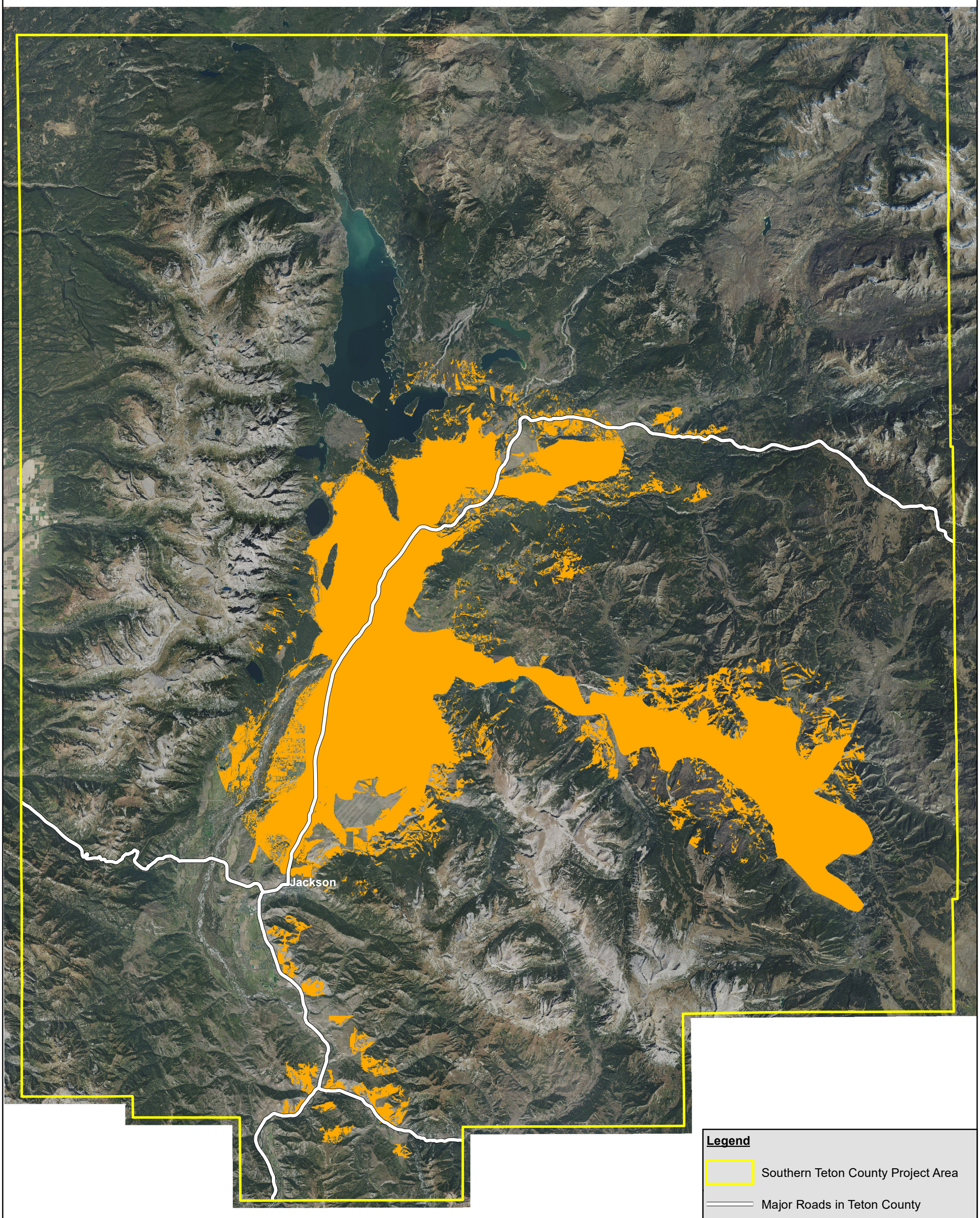
(307) 733-5031 www.alderenvironmental.com



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 13:

Greater Sage-Grouse Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

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MACGILLIVRAY'S WARBLER

Summer resident in Teton County.

Important Habitat Characteristics

MacGillivray's Warbler (*Geothlypis tolmiei*) breeds across much of Wyoming including Teton County, in aspen, cottonwood-riparian and riparian shrub habitat below 9,000 feet (WGFD, 2012). This warbler builds open-cup nests, relatively close to the ground in dense shrubs and feeds mostly on insects (WGFD, 2012). In Grand Teton National Park, this species has been classified as an obligate riparian bird which is not found in the most heavily browsed willow communities (Debinski, 2003).

Much of the available habitat information for MacGillivray's Warbler is focused on microhabitat characteristics such as foraging height, selection of shrub density, etc. (Finch, 1989; Hutto, 1999, NatureServe, 2015; Pitocchelli, 2013) and impacts of logging operations (Hutto, 1999). For the purposes of mapping this songbird's summer breeding habitat across a landscape scale of Teton County we would need to have broader habitat characteristics (e.g. specific overstory vegetative cover types) that do not appear to be available from the literature. Microhabitat characteristics (e.g. shrub understory) are not represented by the vegetation GIS data available. Therefore, a potential habitat mapping exercise was not conducted for MacGillivray's Warbler due to a lack of applicable GIS data that would produce an appropriate result.

Summer Reproductive Habitat

While this species can be found in various habitats (e.g. cottonwood, aspen and conifer) across the western United States a shrubby understory is *the* critical component to breeding habitat (Hutto, 1999; Pitocchelli, 2013). In Wyoming, MacGillivray's Warbler is commonly found in shrubby habitats below 9,000 ft in elevation (WGFD, 2012). In southwestern Wyoming, Rich (2002) classified MacGillivray's Warbler to be a riparian dependent species since 60-90% of both its nests and its abundance occurred in riparian habitat. Recent logging operations and other types of activity (e.g. road building) that create early forest succession sites with a dense shrubby understory (no upper canopy required) appear to provide habitat for this species. Hutto (1999) emphasizes that we do not know whether reproductive success is high in these human disturbed, early successional areas or if they are ecological traps for the species. Teton County is not home to extensive logging operations, therefore, these human created, early successional forest habitats are not likely potential habitat variables for our mapping exercise.

In the mountains of Wyoming, upper story canopy does not seem to be an important variable in habitat selection as MacGillivray's Warblers are often found breeding in willow habitats with dense shrubs and no upper canopy (Finch, 1989). Willows with a dense mix of wetland herbaceous plants such as rushes, horsetails, grasses and sedges have also been found to provide valuable habitat (Pitocchelli, 2013). In Oregon, this species was found to breed in deciduous forests containing 45% shrubs and coniferous forests containing 64% shrubs (Morrison 1981).

Fleischman et al (2005) found MacGillivray's Warbler to be a good indicator of species richness within riparian communities of Nevada's Great Basin region. In a complementary study, Tewksbury et al (2002) found abundance of MacGillivray's Warbler to have a negative relationship with human settlement density and increased agricultural in the area across both local (within 500 meters (1,640 feet)) and regional (within 5 kilometers (3.1 miles)) scales.

Risk Factors to Habitat/ Habitat Function

Grazing, pesticides, human development and any human-induced disturbance that remove or degrade dense shrubby habitat could have a negative effect on local populations (Otahal, 2016; NatureServe, 2015).

Literature Sources

Debinski, D. 2003. Trophic Cascades and Biodiversity in Grand Teton National Park. University of Wyoming National Park Service Research Center Annual Report: Vol. 27, Article 4.

Finch, D. 1989. Habitat Use and Habitat Overlap of Riparian Birds in Three Elevational Zones. Ecology. 70(4): 866-880.

Fleischman, E, J Thomson, R MacNally, D Murphy, J Fay. 2005. Conservation Biology, p. 1125-1137.

Hutto, R. and J. Young. 1999. Habitat Relationships of Landbirds in the Northern Region, USDA Forest Service. Gen. Tech. Rep. RMRS-GTR-32. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Morrison, M. 1981. The Structure of Western Warbler Assemblages: Analysis of Foraging Behavior and Habitat Selection in Oregon. Auk. 98:578-588.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: October 2016).

Otahal, C. 2016. California Partners in Flight Coniferous Bird Conservation Plan for the MacGillivray's Warbler (*Oporornis tolmiez*). Point Reyes Bird Observatory. Available at http://prbo.org/calpif/htmldocs/species/conifer/mgwaacct.html (Accessed: October 2016)

Pitocchelli, J. 2013. MacGillivray's Warbler (*Geothlypis tolmiei*), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/macwar

Raynes, B. 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

Tewksbury, J, A Black, N Nur, V Saab, B Logan, D Dobkin. 2002. Effects of Anthropogenic Fragmentation and Livestock Grazing on Western Riparian Bird Communities. Studies in Avian Biology 25: 158-202.

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

"Optimum patch sizes and most aspects of landscape relationships are unknown. Patch size would presumably depend on habitat quality given the species geographic variation in density." – NatureServe, 2015.

The variation in vegetative cover types used by this species and lack of quantified information available at the landscape level indicates that it is not an appropriate choice for a focal species within Teton County's Focal Species Habitat Mapping Project. If GIS data were available on shrub understory densities within aspen, cottonwood, conifer and riparian communities in Teton County, a two-variable mapping exercise (i.e. shrub habitat and elevation) could be attempted. However, this would not be a robust mapping exercise.

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NORTHERN GOSHAWK

Population is partially year-round, partially migrant (summer) in Teton County.

Important Habitat Characteristics

Breeding/ Summer Habitat

Northern Goshawks (*Accipiter gentilis*) in Teton County nest and forage mainly in coniferous, mixed coniferous/aspen and aspen habitats across North America. Goshawks select habitat based more on forest structure than species composition (Greenwald et al. 2005). Foraging areas generally include a more diverse array of habitats than nesting, both in vegetation classes and openness (Squires and Reynolds 1997). For nest site selection, goshawks typically select dense forest stands with high canopy cover (Hayward and Escano 1989). Nest sites are generally associated with patch size, lower slopes, northern aspects, older-aged stands, proximity to water or meadow habitats and forest openings (Woodbridge and Hargis 2006), though distance to water or openings (e.g. meadows, roads, barren land, etc) are not likely to be factors driving selection. Most nests are not re-used in the following year, as is the case for many other raptor species, but some nests can be re-used as long as 8 years or longer after previous use. Goshawks will rotate through a number of alternate nests within the same territory over time. Annually, 95% of alternate nest sites can be found within 1km of the previous years' nest (Reynolds et al. 2005) and the average inter-nest distance from one year to the next based on long-term monitoring projects is over 500 m (Patla 2005, Reynolds et al. 2005), making patch delineation important for defining goshawk nesting habitat. To effectively define nesting areas, a 2,428 ha area based on the centroid of all known nest sites should be used (Reynolds 1983, Patla 2005). While multiple nests may exist within a territory, the territory boundary itself likely does not regularly shift so using a buffer surrounding the centroid is an effective strategy for territory protection.

Goshawks generally nest in stands that include the tallest trees in the area (Squires and Kennedy 2006). On the Caribou-Targhee National Forest which includes the west side of the Teton Range, Patla (1997) found that mean nest tree height was 25 m. In a 2016 Jackson area study, 33% of nest sites were located in spruce/fir forests, 25% in lodgepole pine (*Pinus contora*), 25% in Douglas fir (*Pseudosuga megneseii*) and 17% in mixed conifer/aspen stands in Teton County (Bedrosian et al. 2016). In the Caribou/Targhee National Forest, most goshawks used Douglas fir for nest trees (78%), followed by lodgepole pine (8%), aspen (2%) and spruce (2%) (Patla 1997). Extracting data from the 2011 30m Landfire vegetation data for nest sites located in Teton County in 2016, canopy cover was ≥ 40%, canopy height ≥10m, mean slope of 10 degrees (range = 1-24) and most nests were located on northern aspects (Bedrosian et al. 2016). This is similar to most studies in North America that found canopy cover >40% (Greenwald et al. 2005). However, Squires and Kennedy (2006) estimate that canopy cover should be at least 50% for nesting habitat, with open understories. When using remote sensing layers to estimate covariates such as canopy cover, it should be acknowledged that the GIS estimates used are for landscape modeling and do not reflect the actual ground measurements.

Several regional studies using on-the-ground measurements have documented that mean canopy cover at nests sites is higher than when measured in a GIS. Hayward and Escano (1989) found canopy cover at nest sites of 75-85% in MT and ID; Squires and Ruggiero (1996) found mean canopy cover of 65% in southern WY; and Patla (1997) found higher canopy cover in the Caribou-Targhee National Forest of 79%. From six nests in the Wyoming Range, the mean canopy cover was 80% at the nest and 71% for the nest area (Figure NG-1; Patla unpubl data). Few studies have directly addressed patch size for goshawk nest sites but Reynolds (1983) defined the nest area as 12 ha of high intensity of use. Woodbridge and Detrich (1994) suggested that stands of 34-80 ha because of evidence that smaller patches had decreased occupancy for nesting. McGrath et al. (2003) reported that a 60 ha patch size may be most

appropriate for management. Patla (1997) recorded the nest area mean of 80.4 ha in the CTNF and this area was also surrounded by much larger areas of mature forests. Based on these recommendations and others (e.g., Squires and Kennedy 2006), we used a 83ha (500 m) radius to determine patch size (see below for more details).

Basal area estimates of nest stands range from 28.5 to 50.8 m^2/ha (McGrath et al. 2003) and mean basal area of 27.7 m^2/ha for live, mature trees in CTNF (Patla 1997) and 16 m^2/ha for the Wyoming range (Patla unpubl data). Most nest stands are not "old-growth" in the classic sense, but tend to be rather even-aged, single storied, mature stands with fewer, but larger, trees (Squires and Ruggiero 1996). Nest site habitat data collected at 49 nest tress on the CTNF shows that there is often a diversity of age classes present of both live trees and snags in older age conifer stands where goshawk chose to nest even though the dominant age class is older aged trees. The average age of the nest tree itself was 143 years for Douglas-fir and 96 for lodge pole pine (Patla 1997). In BTNF, 89% of the nest area was forested (as measured in a GIS), 81% of the post-fledgling area and 70% of the foraging area was forested.

Habitat used by goshawks during the breeding season extends beyond the nest site, into the post-fledging area (170 ha encircling the nest area) and foraging area (2,186 ha encircling the nest area) and covers more diversity of habitats and openings but still includes an average of at least 50% mature forests (Squire and Ruggiero 1997, Patla 1997, Reynolds et al. 2007).

Nesting goshawks can be disturbed from human presence, including active logging activities within 100m of a nest and camping near nests (Squires and Kennedy 2006). Forest treatments may have different levels of effect, based on the level of treatment. Treatments that reduce canopy cover less than 40-50% may reduce occupancy (Squires and Kennedy 2006).

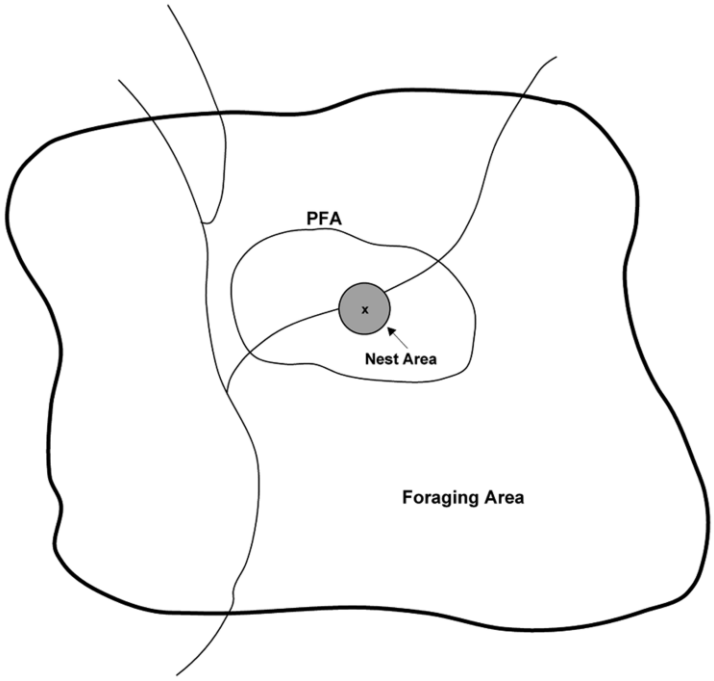

Figure NG-1. Example for important ecological scales for nesting Northern Goshawks (from Squire and Kennedy 2006). PFA = Post-fledging area.

Breeding Season Abiotic Habitat Characteristics

In the western US, goshawks appear to select for north and northeast aspects for nesting, but Squires and Ruggiero (1996) did not find a preference for aspect in south-central Wyoming. In general, goshawks nest on gentle slopes or slope sheltered areas on steeper hillsides. Mean slopes are typically ca. 10-20 degree but can range from 0-35 degrees. Patla (1997) found a mean slope of 22 degrees in eastern Idaho/western WY and that most nests were located on northern and western aspects. However, clear topographic patterns do not appear to exist across the species range in North America (Squires and Kennedy 2006). Overall, most nests are located in sites that offer some degree of topographic protection from weather and also make visual detection difficult (Patla, pers. comm.)There appears to be a selection of nest sites closer to water (e.g., Squires and Reynolds 1997, Hargis et al. 1994), typically within 500m. Goshawks in some studies seem to select nest sites close to forest openings, old 2-tracks, dirt roads and fallen trees (Squires and Kennedy 2006), but this may be an artifact of survey bias. Most nests in Wyoming are located below 9000 ft in elevation (WGFD 2010). Goshawks appear to avoid open roads, generally locating their nests > 1 km from the nearest road. Nest distance to edge varies considerably and can range up to 1610 m with an average of 300 m (median = 122 m; Patla 1997). Due to the large variation and ambiguity in defining "edge," this is likely not an informative parameter for modeling nest site selection.

Winter Habitat

There are goshawks that overwinter in Teton County, but it is unknown if those individuals are year-round residents or migrants from more northern latitudes. Squires and Ruggiero (1995) found that each of four adults monitored from southern Wyoming migrated south for the winter. Goshawks are regularly recorded in Teton County during the winter months (Bedrosian, *pers. observ.*). Few wintering studies of habitat exist, but suggest that goshawks utilize a much broader array of habitat types in winter, including conifer, mixed conifer/aspen, spruce/fir, lodgepole, shrublands and riparian/cottonwood habitats (Squires and Ruggiero 1995, Drennan and Beier 2003). Observations of goshawks in winter have included the mixed conifer/cottonwood forests of the Snake River Bottom and coniferous forests at the base of the Tetons (Bedrosian, *pers. observ.*).

Patla tracked a few adult goshawks on the CTNF (*unpublished data*). After the nesting season in October, one male made repeated multiday trips about 25 miles to a patch of riparian aspen habitat near St. Anthony, Idaho on the Snake River but would then return to his nest area. Another male ranged over 30 miles from his nest area in the Centennial Mountains and an adult female was killed in mid-winter 10 miles from her nest area on the west side of the Teton Range, by an undetermined avian predator. These data suggest that at least some of the resident adults remain in the area but have greatly increased ranges.

Risk Factors to Habitat/Habitat Function

Population status and trends for the Northern Goshawks are unknown in Wyoming but suspected to be stable, while habitat is restricted and vulnerable, leading them to remain a Species of Greatest Conservation Need in Wyoming (WGFD 2010) and Sensitive Species for the US Forest Service. Nesting goshawks utilize several scales of broad landscapes to meet their breeding requirements. Specifically, there are three scales to consider: the nest area, the post-fledging area and foraging area (Figure 1).

The nest area, or area immediately surrounding the nest tree, often contains from 1-8 alternate nests that can be re-used over a period of years. Major focus for goshawk conservation has been the maintenance of the nest stand, rather than a single nest from a particular year. It is thought to be important to maintain nesting areas that the habitat in a 13 ha area surrounding the main activity center. However, protecting the PFA will likely better maintain nesting populations by increasing

juvenile survival. Functionally, protecting an 83 ha area (500 m radius) surrounding the activity center has been recommended to serve goshawk conservation but this remains untested (Squires and Kennedy, 2006). This protection should maintain stand structure and canopy cover because goshawks are sensitive to the loss of protective habitat surrounding their nest stands. There should also be a goal of maintaining habitat heterogeneity in a 2,000 ha foraging area for diverse prey habitats and reducing human activity within this area. The foraging area should contain a high percentage of mature forest cover which not only provides prey but also cover for foraging goshawks.

The influence of climate change, fire and forest management such as timber harvesting and thinning can be significant factors for goshawk conservation. Specifically, increased beetle kill may significantly affect nesting goshawks by decreasing canopy cover, altering prey communities and loss of mature trees. Fire can eliminate large patches of mature forest nesting and foraging habitats and thinning can reduce canopy cover and prey density. Maintaining larger, intact mature forest patches is recommended, not just in the nest area. Emphasis should be placed on forested habitat with >50% canopy cover on <35 degree slopes.

Winter ranges of goshawks are substantially larger than breeding foraging areas and may be largely influenced by prey availability. Goshawk winter habitat in Teton County likely extends into the riparian habitats in addition to breeding season habitats.

Literature Sources

Bedrosian, B., N. Hough, K. Gura, and S. Patla. 2016. Northern Goshawk Nesting Survey Report. Teton Raptor Center report to Teton Conservation District.

Greenwald, D.N., D.C. Crocker-Bedford, L. Broberg, K.F. Suckling, and T. Tibbitts. 2005. A review of northern goshawk habitat selection in the home range and implications for forest management in the Unites States. Wildlife Society Bulletin. 33:120-129.

Hayward, G.D. and Escano, R.E. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor. 91: 476-479.

McGrath, M. T., S. DeStefano, R. A. Riggs, L. L. Irwin, and G. J. Roloff. 2003. Spatially explicit influences on northern goshawk nesting habitat in the interior Pacific Northwest. Wildlife Monographs 154.

Patla, S. M. 1997. Nesting ecology and habitat of the Northern Goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Master's Thesis, Idaho State University. 164 pp.

Patla, S. M. 2005. Monitoring results of northern goshawk areas in the Greater Yellowstone Ecosystem: is decline in occupancy related to habitat change? Journal of Raptor Research 39:324–334.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. U.S. Forest Service, General Technical Report RM-102, Fort Collins, Colorado, USA.

Reynolds, R. T., J. D. Wiens, S. M. Joy, and S. R. Salafsky. 2005. Sampling considerations for demographic and habitat studies of northern goshawks. Journal of Raptor Research 39:274–285.

Squires, J.R. and P.L. Kennedy. 2006. Northern Goshawk. An assessment of current knowledge and information needs for conservation and management. Studies in Avian Biology. 31:8-62.

Squires, J.R.; Reynolds, R.T. 1997. Northern goshawk (Accipiter gentilis). In: Poole, A.; Gill, F., eds. The birds of North America, No. 298. Philadelphia, PA: Academy of Natural Sciences; Washington, DC: American Ornithologists' Union. 32 p.

Squires, J.R. and L.F Ruggiero. 1995. Winter movements of adult northern goshawks that nested in southcentral Wyoming. Journal of Raptor Research. 29:5-9.

Woodbridge, B. and Detrich, P.J. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Studies in Avian Biology. 16: 83-87.

Woodbridge, B. and Hargis, C.D. 2006. Northern goshawk inventory and monitoring technical guide. Gen. Tech. Rep. WO-71. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

Habitat Characteristics

Bridger-Teton has created a breeding season habitat model for Northern Goshawks for forest service lands. However, Bedrosian et al. 2016 found that only one of five nests within BTNF were predicted by that layer. It is suggested not to use those parameters for a private lands model. The model was also built from the BTNF landcover layer, which does not extend to private lands.

Bedrosian et al. 2016 created a preliminary model for Teton County but the model was based on a non-random sample of nest sites and may not be appropriate for use as a predictive model. Bedrosian and BTNF are working on refining both models and their refined model should be used when it is complete.

Season	Habitat Characteristic	GIS Source	Selection criteria	Source
Breeding	Canopy Cover	Landfire	>40% canopy cover	Bedrosian et al. 2016; Greenwald et al. 2005
Breeding	Slope	DEM	<35%	Bedrosian et al. 2016
Breeding	Cover Class	Vegetation Layers	FAP, FDF, FEP, FLP, FMC, FSF	Patla, 1997
Breeding	Land Use	Vegetation Layers	>150 m from Impervious Land Use	Patla, 1997; Bedrosian et al, 2016
Breeding	Patch Size	Vegetation Layers	class selection above that makes up a continuous patch; >83 ha (500 m radius) comprised of >40% canopy cover for >50% of the total area	Bedrosian *pers. commun.*; Patla, 1997
Winter	Slope	DEM	<35%	Bedrosian and Patla, *pers. observ.*
Winter	Cover Class	Vegetation Layers	FAP, FBS, FCW, FDW, FEP, FJ, FLP, FMC, FRM, FSF	Squires and Ruggiero 1995, Drennan and Beier 2003
Winter	Canopy Cover	Landfire	>30% canopy cover	Bedrosian and Patla, *pers. observ.*

A winter seasonal model should not be produced based on a lack of understanding of this species actual winter use and habitat requirements in Teton County (Bryan Bedrosian, *pers. commun.*).

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Secondary Reviewer: Siva Sundaresan, NRTAB

GIS Methods – Summer Habitat

Bryan Bedrosian has developed a habitat model for Northern Goshawk based on nesting surveys for Northern Goshawks. Nesting surveys were conducted between June 22 and August 15, 2016. Please see Teton Raptor Center's Teton County Northern Goshawk Study 2016 Progress Report for more information. This is an on-going study which was initiated in 2016. While the model used is based on preliminary data, it is the best available and should be updated as the study progresses.

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Clip Bedrosian NOGO Habitat to Teton County	Remove values outside of Teton County	Retain values within Teton County	Clip	BB_NOGO_TC
Reclassify all values to 1	Convert all values (1-900) to 1	Reclassify all values to 1; No Data = 0	Reclassify	BBB_NOGO_TC_recl2.tif final
Compare with WOS and NMJH observations	Compare observations with output.	See definition queries below limiting observations.		

Metadata

Title

NOGO_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Northern Goshawk Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

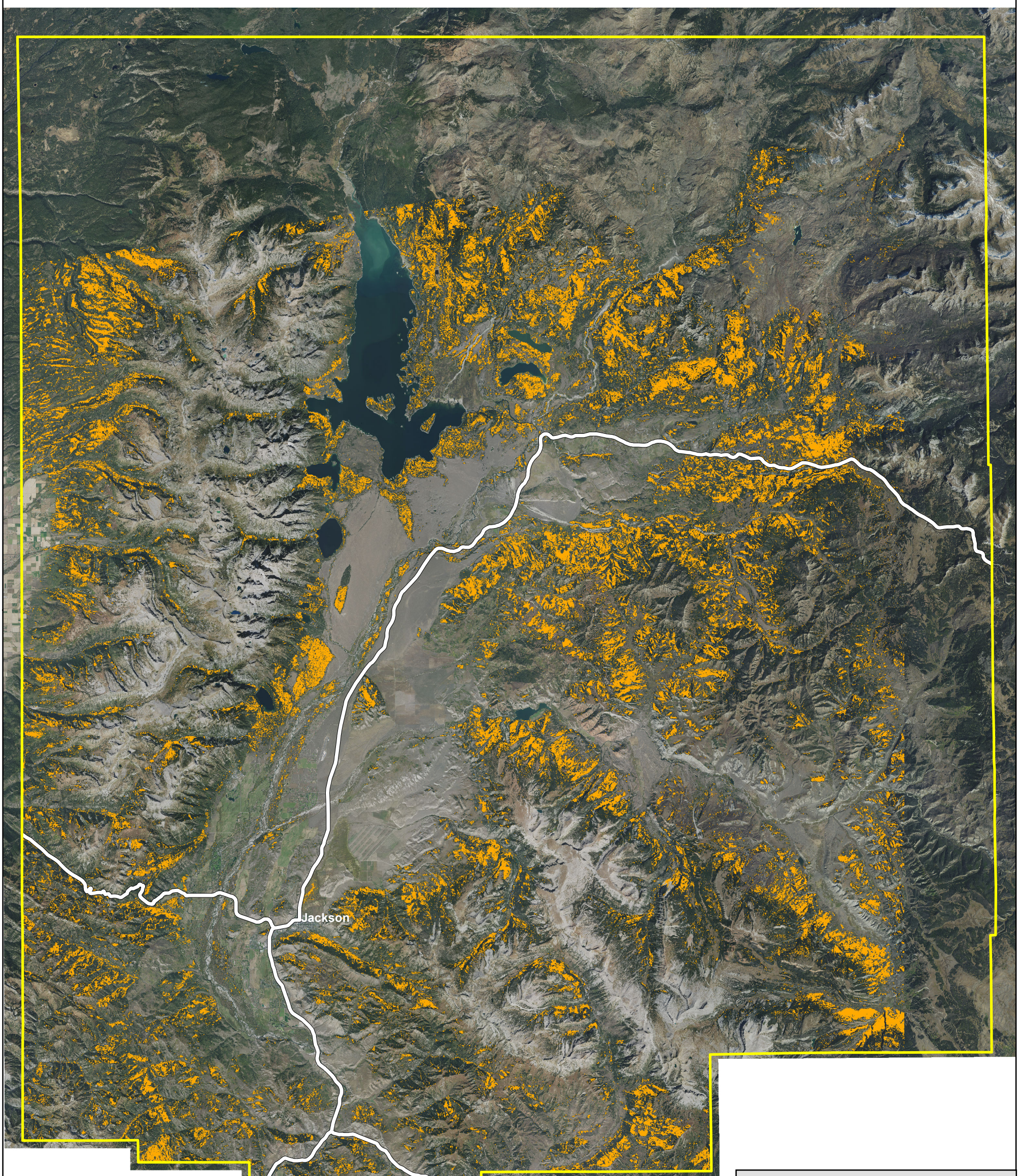
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Northern Goshawk is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. This habitat layer is a subset of work completed by Bryan Bedrosian at the Teton Raptor Center as a part of the 2016 "Teton County Northern Goshawk Study: 2016 Progress Report" project. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project Teton County, WY	**FIGURE 14:** **Northern Goshawk Summer Habitat** April 21, 2017	*This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.*	*NAIP* *- 2015 1-m Aerial Photography* *NRCS* *- Teton County Boundary* 2017/TC/TCFSHMP/TaskBSppLayers.mxd	1 inch = 5 miles 0 1 2 3 4 5 Miles NORTH ALDER ENVIRONMENTAL, LLC *Water • Wetlands • Ecological Consulting* *P.O. Box 6519, Jackson, Wyoming 83002* *(307) 733-5031 www.alderenvironmental.com*

NORTHERN HARRIER

Summer resident in Teton County.

Important Habitat Characteristics

Summer Habitat

There is little published information on habitat preference for Northern Harriers (*Circus cyaneus*), particularly in the Intermountain West. Harriers are an open-county species that mainly aerially forages from 1-5 m off the ground. Frequency of use among habitats is likely related to both prey biomass and vegetative cover (Preston, 1990). Harriers prefer open habitats characterized by tall, dense vegetation and abundant residual vegetation (Dechant et al, 2002). They generally avoid mowed agricultural lands (Massey et al, 2009) and may avoid certain agricultural fields, such as winter wheat (Littlefield and Johnson, 2005). Grazed fields may be utilized for nesting if enough residual cover remains. In Wyoming, harriers nest on the ground in sagebrush steppe, native and non-native grasslands, wet meadows and marshes. Harriers have been known to nest in bromegrass (*Bromus* spp), wheatgrass, cultivated fields [timothy grass (*Phleum* spp) and alfalfa (*Medicago sativa*)], rangeland prairies, sagebrush (*Artemsia* spp), bitterbrush (*Purshia tridentata*) and wetlands dominated by willows, grasses, sedges and herbaceous shrubs (Macwhiter and Bildstein, 1996). In North America based on 428 records from Cornell University nest card program, 17% of nests were in wet marshy meadows, 18% were in freshwater marshes, 26% in dry grasslands and 8% in cultivated fields or prairie rangeland (Apfelbaum and Seelbach, 1983 from Morrow and Morrow, 2016). Nests are generally built within patches of dense and relatively tall vegetation in undisturbed areas. There is a preference for nesting within or near water sources when available, likely to help avoid predation, although a few pairs in Wyoming in sage-steppe were found nesting far from water (Morrow and Morrow 2016). Abundance of harriers over large landscapes is correlated to the percentage of wetlands and precipitation in the preceding year (Forcey et al, 2014). Simmons and Smith (1985) found that nest success was most correlated to moisture and vegetation cover. An average to 20-30 cm vegetation is preferred for nesting habitat in the Intermountain West (Kantrud and Kologiski,1982).

Harriers do not re-use nests annually, but do re-use the same nesting patches in subsequent years. In the event of a nest failure, females may re-nest that year, typically within 200 m of the original nest. Harriers are generally monogamous, but can be polygynous, with males having up to five females in a single year. Nests are defended from conspecifics within a relatively small area (~10 ha) but male territory size is closer to 100 ha (Simmons,1983). Territory size may not be indicative of patch size needed for nesting and small fragments of intact habitat may be used if located close to larger blocks of contiguous sagebrush or grasslands (Dechant et al, 2002). There are conflicting accounts of patch size across the US, but the home rage size of females indicates that patch size for maintaining nesting habitat is near 100 ha (Johnson *in* Dechant et al, 2002; Toland, 1985; Hammerstrom and DeLaRonde Wilde, 1973; Martin, 1987).

Nests are sensitive to disturbance during the early nesting period when females are laying eggs and during incubation (Fernandez and Azkona, 1993). Human-caused flushing can cause nest abandonment and increase potential for predation (Morrow and Morrow, 2016). Later in the season, nests in agricultural lands can be destroyed and young killed during haying and other similar operations.

Breeding Season Abiotic Habitat Characteristics

Harriers appear to prefer non-forested landscapes with very little overall topography. However, a few nests in WY have been found in sites with scattered trees (Morrow and Morrow, 2016). In Jackson Hole, nests are generally on the valley floor and rarely in open benches at elevations greater than 8,000 ft.

Preference for nest sites are on standing water or near water sources. Three nest sites found in Jackson Hole were in sagebrush located 380 m, 1,032 m and 1057 m from the Snake River (Morrow and Morrow, 2016). However, distance to the Snake River may not be distance to the nearest waterway. There are other waterbodies (Ditch Creek, Warm Ditch and the Gros Ventre River), within this study area. Nest platforms are often built on top of standing water. Flooding and irrigation practices have the potential to cause nest failure.

Winter Habitat

With limited exceptions, most harriers migrate out of Jackson Hole in the winter.

Risk Factors to Habitat/Habitat Function

Conversion of sagebrush communities and native grasslands to monotypic agriculture or urbanization is the largest threat to local populations of harriers. Mechanized agriculture and early mowing can destroy nests. Subdivision of lightly grazed ranchlands will eliminate potential nesting and foraging habitats. Further, planting of ornamental trees in areas otherwise treeless will likely reduce use of the area by harriers and increase habitat for potential nest predators, such as American Crows and raccoons. Overgrazing can reduce adequate cover for moth nesting and prey populations. Further, early flushing of hens off nests can cause abandonment and/or failure. Harriers have been shown to reduce use of livestock-grazed grasslands (Bildstein, 1987; Bock et al, 1993). Conservation measures for waterfowl and wetlands likely benefit Northern Harriers. Use of rodenticides in agricultural settings can negatively affect survival.

Long-term changes to climate and precipitation will likely significantly affect future populations of harriers. Similarly, irrigation practices can affect nest density and success of harriers by both diverting water from natural wetlands and creating artificial wetlands through flood irrigation. However, the latter may hinder nesting due to the later timing of this practice in Jackson Hole (after or later in the nesting cycle). It is recommended that water levels not be allowed to rise >15 cm from April to August because nests in wetland habitat may become submerged (Hands et al, 1989). Total burning and natural burns can eliminate nesting habitats. Light burning or grazing every 3-5 years may help nesting habitat by promoting small mammal communities and abundance. Nesting occurs in lightly grazed habitats, but not in heavily grazed allotments. Deferred grazing (after July 15) is preferred over continuously grazed pastures (Prescott et al, 1995).

Literature Sources

Bildstein, K. L. 1987. Behavioral ecology of Red-tailed Hawks, Rough-legged Hawks, Northern Harriers, and Americal Kestrels in south-central Ohio. Ohio Biol. Surv. Notes 18.

Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296-309 in D. M. Finch and P. W. Stangel, editors. Status and management of Neotropical migratory birds. U.S. Department of Agriculture, Forest Service General Technical Report RM-229.

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, M. P. Nenneman, and B. R. Euliss. 1998 (revised 2002). Effects of management practices on grassland birds: Northern Harrier. Northern Prairie Wildlife Research Center, Jamestown, ND. 15 pages.

Fernandez, C. and P. Azkona. 1993. Human disturbance affects parental care of marsh harriers and nutritional status of nestlings. Journal of Wildlife Management. 57:602-608.

Forcey, G. M., W. E. Thogmartin, G. M. Linz, and P. C. McKann. 2014. Land use and climate affect Black Terns, Northern Harrier, and Marsh Wren abundance in the Prairie Pothole Region of the United States. Condor. 116:226-241.

Hamerstrom, F., and DeLaRonde Wilde, D. 1973. Cruising range and roosts of adult harriers. Inland Bird Banding News 45:123-127.

Hands, H. M., R. D. Drobney, and M. R. Ryan. 1989. Status of the Northern Harrier in the northcentral United States. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 18pages.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish and Wildlife Service, Wildlife Research Report 15. 33 pages.

Littlefield, C. D. and D. H, Johnson. 2005. Habitat preferences of migrant and wintering Northern Harriers in Northwestern Texas. Southwestern Naturalist. 50:448-452.

MacWhirter, R. B., and K. L. Bildstein. 1996. Northern Harrier (Circus cyaneus). In A. Poole and F. Gill, editors. The birds of North America, No. 210. The Academy of Natural Sciences, Philadelphia, Pennsylvania.; The American Ornithologists' Union, Washington, D.C.

Martin, J. W. 1987. Behavior and habitat use of breeding Northern Harriers in southwestern Idaho. Journal of Raptor Research 21:57-66.

Massey, B. H., C. R. Griffin, and K. McGarigal. 2009. Habitat use by foraging Northern Harriers on Nantucket Island, Massachusetts. Wilson Journal of Ornithology 121:765-769.

Morrow L. and J. Morrow. 2016. Northern harriers nesting in sagebrush steppe in central Wyoming. Western Birds 47: 231-233. Doi10.21199/WB47.3.4

Preston, C. R. 1990. Distribution of raptor foraging in relation to prey biomass and habitat structure. Condor 92:107–112.

Prescott, D. R. C., A. J. Murphy, and E. Ewaschuk. 1995. An avian community approach to determining biodiversity values of NAWMP habitats in the aspen parkland of Alberta. NAWMP-012. Alberta NAWMP Centre, Edmonton, Alberta. 58 pages.

Raynes, B 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

Simmons, R., and P. C. Smith. 1985. Do Northern Harriers (Circus cyaneus) choose nest sites adaptively? Canadian Journal of Zoology 63:494-498.

Toland, B. R. 1985. Nest site selection, productivity, and food habits of Northern Harriers in southwest Missouri. Natural Areas Journal 5:22-27.

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

No known habitat model exists for Northern Harrier in Teton County, WY.

Season	Habitat Characteristic	GIS Source	Selection criteria	Source
Breeding	Slope	DEM	<10%	Bedrosian and Patla, *pers. commun.*
Breeding	Cover Class	Vegetation Layers (TC Veg Codes Listed)	SES, SES, SMSD, SRB, SSD, SSW, SWL, DSE, HA, HFD, HFX, HGL, HGS, HPG, NIPF, NIPI, NIPN	Bedrosian and Patla, *pers. commun.*
Breeding	Patch Size	Vegetation Layers	Minimum 30 ha patch with >50% of surrounding 120 ha with intact habitat	Johnson *in* Dechant et al, 2002

Contributors

Narrative Author: Bryan Bedrosian, Senior Avian Ecologist, Teton Raptor Center

Primary Reviewer: Susan Patla, Nongame Biologist, WGFD

Secondary Reviewer: Siva Sundaresan, NRTAB

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, GRTE, BTNF & CTNF, Veg layers, select agricultural fields, herbaceous vegetation, sagebrush and willows	See Definition Query Selection Below	Select by Attribute; Merge	All summer veg covers
Patch Size	Patch size removed because it was limiting of known used fields. Fragmentation of patches by roads caused this problem			
Convert Shapefile to Raster	Convert Veg Cover Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Veg Cover Raster

Slope	Retain appropriate slopes <= 10°	VALUE < =10	Extract By Attribute	Slope & Elevation
Elevation	Retain elevations on the valley floor (e.g. <=7,500 ft or ~2,290 m)	VALUE <= 2290	Extract By Attribute	
Slope/ Elevation	Extract Slopes <= 10° and Elevation <= 7,500 ft	Extract	Extract by Mask	
Extract Veg by Slope/ Elevation	Summer veg habitat <=10° slope and <= 7,500 ft elevation	Extract by Slope/ Elevation	Extract by Mask; Reclassify so No Data = 0	Product
Compare with WOS and NMJH observations	Visually compare observations with output.			

Veg Cover Definition Query Categories

Teton County Map Codes:
Irrigated Agricultural Fields - NIPI
Non-Irrigated Agricultural Fields - NIPN
Perennially Flooded Agricultural Fields - NIPF
Montane Mesic Forb Herbaceous Vegetation - HFD
Mixed Grassland Herbaceous Vegetation - HGL
Mixed Planted and Introduced Grassland Herbaceous Vegetation - HPG
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SES, SMSD, SSD
Flooded Wet Meadow Herbaceous Vegetation - HGS
Willow Shrubland - SWL

Grand Teton Nation Park Map Codes:
Irrigated Fields - NIP
Montane Mesic Forb Herbaceous Vegetation - HFD
Mixed Grassland Herbaceous Vegetation - HGL
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SSD
Willow Shrubland - SWL
Flooded Wet Meadow Herbaceous Vegetation - HGS

Bridger-Teton National Forest MU CODE:
Agriculture - AG
Grassland/Forbland - GF
Tall Forbland - TF
Riparian Herbland - RH
Willow - WI
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Mountain Shrubland - MS
Sagebrush/Bitterbrush Mix - SB
Silver Sagebrush/Shrubby Cinquefoil - SS
Spiked Big Sagebrush - SK

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Grassland/Forbland - GF
Bridger-Teton Tall Forbland - TF
Caribou-Targhee Montane Herbaceous - MTNH
Caribou-Targhee Agriculture - AGR
Caribou-Targhee Riparian Herbaceous - RHE
Caribou-Targhee Riparian Shrublands and Deciduous Forest - RSH
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB

Metadata

Title

NOHA_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Northern Harrier Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

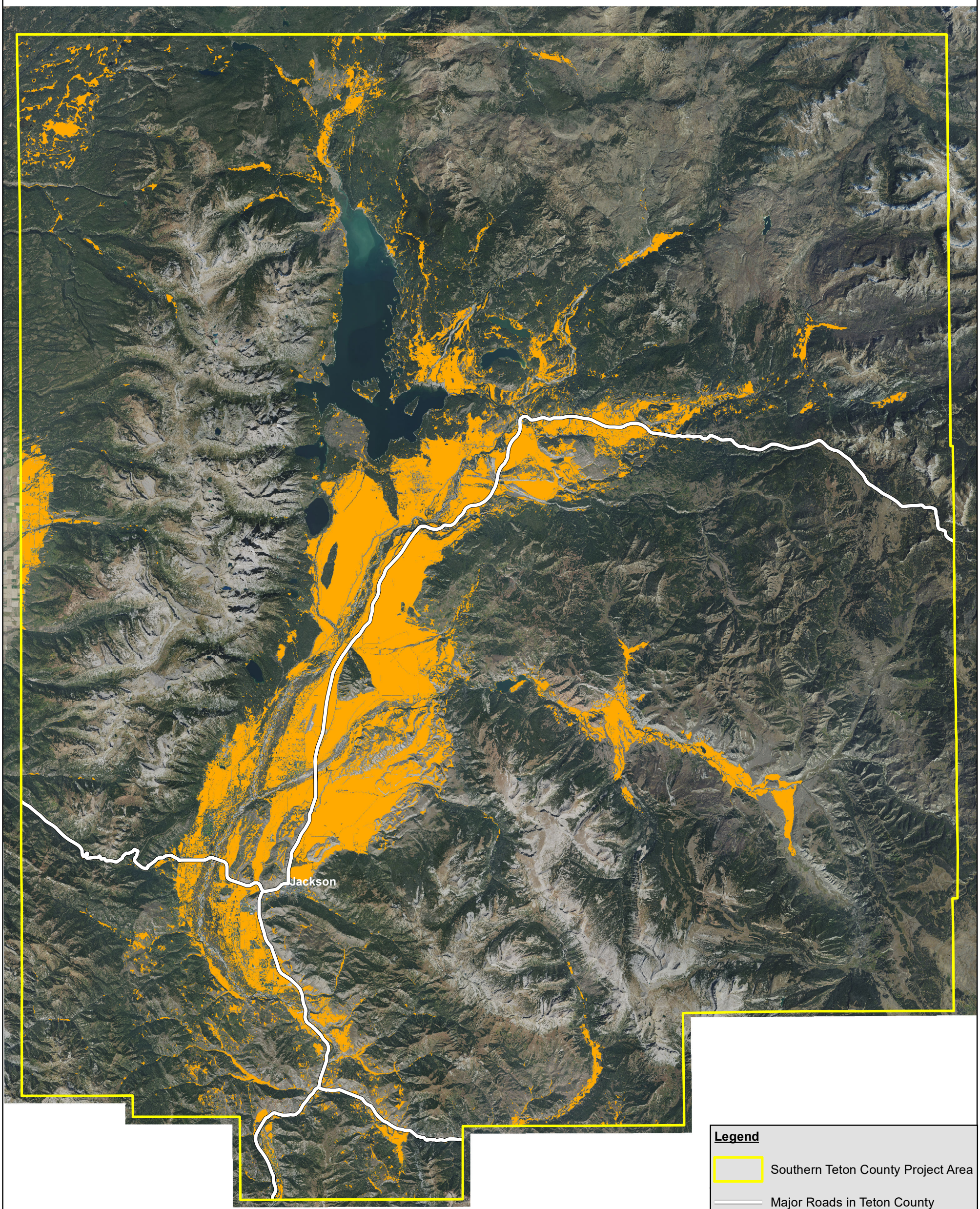
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Northern Harrier is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 15:

Northern Harrier Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

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RED-NAPED SAPSUCKER

Summer resident in Teton County.

Important Habitat Characteristics

Summer Habitat

Red-naped Sapsucker (*Sphyrapicus nuchalis*), a double keystone species (Walters, 1995), is a summer breeding species commonly found in Teton County, WY. Primarily utilizing aspen for nesting territories, Red-naped Sapsuckers will forage by gleaning for insects on conifer species, showing a preference for Douglas-fir, and harvest sap from a variety of plants including willow and aspen.

As their name suggests, sapsuckers make sap wells in the bark of woody plants by drilling shallow holes through the outer bark to the underlying phloem or xylem tissues. The sapsuckers then feed on the plant's sap that collects in these holes, or wells, and the insects that become trapped in the sap. (Walters, 2014). Red-naped Sapsuckers will eat insects, cambium and tree tissue as well as fruit and seeds. The species is a double keystone species since both its nest cavity and sap wells will be used subsequently by other species. Swallows, bluebirds, chickadees, flickers and wrens are reported as secondary cavity nesters while 40+ species including mammals and insects are reported to use sap wells as a food source (NatureServe, 2015).

In Wyoming, Red-naped Sapsuckers nest in deciduous tree cavities (primarily aspen) and feed on insects and sap (Crockett and Hadow,1975; WGFD, 2012). Aspen, cottonwood-riparian and conifer habitats from 5,000-9,000 ft are used throughout Wyoming (WGFD, 2012).

Red-naped Sapsuckers tend to build their cavity nests in live and dead aspen trees that have a larger diameter at breast height (DBH) than available aspen (Loose and Anderson, 1995) and particularly in those showing signs of infection and heart rot (Loose and Anderson, 1995; Crockett and Hadow, 1975). Loose and Anderson (1995) found nest trees to be at least 18 cm DBH (approx. 7 inches). A diameter at breast height (dbh) of >18 cm characterizes an aspen tree that is approximately 100 years old.

Sapsuckers have been shown to choose their nest sites for their proximity to foraging habitat rather than for the micro-habitat characteristics of the nest tree stand (Crockett and Hadow, 1975). Percent aspen in a territory is positively correlated with nest productivity and available nest sites (Sadoti and Vierling, 2010). Therefore, higher percentages of aspen could be an indicator of higher value habitat for Red-naped Sapsuckers. Vasquez (2005) found that the majority of observations were within 292 m (approximately 1,000 ft; range 3-2,760m) of the nearest aspen patches. Vasquez (2005) also reported the average Red-naped Sapsucker use of riparian foraging habitat was within approximately 250 m (820 ft) of aspen habitat. Therefore, it would follow that a protection distance around aspen trees of approximately 250 m (approximately 800 ft) could assist to limit fragmentation of Red-naped Sapsuckers' nesting and foraging habitat.

Risk Factors to Habitat/ Habitat Function

While the Red-naped Sapsucker population is reported to be stable (NatureServe, 2015; WGFD, 2012), loss of habitat, both foraging and nesting, is the primary risk factor (Walters et al. 2014). Riparian willow habitat loss or degradation could result from over grazing by cattle or ungulates. Loss of mature aspen stands needed for nesting, may result from residential development, timber harvest, firewood cutting, or disease (Vasquez, 2005; NatureServe, 2015; Walters et al, 2014).

Literature Sources

Crockett, A and H Hadow. 1975. Nest site selection by Williamson's and Red-naped sapsuckers. Condor 77:365-368.

Loose, S and S Anderson. 1995. Woodpecker Habitat Use in the Forests of Southeast Wyoming. Journal of Field Ornithology. 66(4): 503-514.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. Accessed: October 2016.

Raynes, B 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

Sadoti, G and KT Vierling. 2010. Nonideal Habitat Selection by a North American Cavity Excavator: Pecking Up the Wrong Tree? Canadian Journal of Zoology. 88:527-535.

Vasquez, M. 2005. Red-naped Sapsucker *(Sphyrapicus nuchalis*) Species Assessment Draft. Prepared for the Grand Mesa Uncompahgre and Gunnison National Forests. Gunnison, CO.

Walters, E. 1995. Habitat and Space Use of the Red-naped Sapsucker (*Sphyrapicus nuchalis*) in the Hat Creek Valley, South-Central British Columbia. MS Thesis University of Victoria, BC.

Walters, E, E Miller and P Lowther. 2014. Red-naped Sapsucker (*Sphyrapicus nuchalis*), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/rensap.

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

No known habitat model exists for Red-naped Sapsuckers in Teton County, WY. Parameters below were adapted from Vasquez's 2005 Red-naped Sapsucker Species Assessment for the Grand Mesa, Uncompahgre and Gunnison National Forests prepared for the USFS.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Sources
Summer	Aspen vegetative cover and mixed forest containing aspen component	Vegetation Layers	Patch size >1.7 ha (4 ac); If available the number of trees >18 cm DBH (approx. 7 inches) would reflect a measure of available nest trees	Loose and Anderson, 1995
Summer	Slope	DEM	8.0 – 34.0% (17% average)	Vasquez, 2005
Summer	Elevation	DEM	Valley floor to approximately 9,000 ft. In GRTE, aspen phases out at ~9,500 ft. In Grand Junction CO elevations were 2,459-3,291m (8,000 – 10,800 ft).	WGFD, 2012; Vasquez, 2005

Summer	Distance from aspen to riparian willow areas	Created from Vegetation Layers	250 m (~800 ft)	Vasquez, 2005
Summer	Association with foraging vegetation (Douglas Fir and willow areas) within 16 ha (40 ac – approx. home range)	Created from Vegetation Layers	Percent aspen in a territory is positively correlated with nest productivity and available nest sites. Therefore, higher percentages of aspen could be an indicator of higher value habitat	Sadoti and Vierling, 2010

Contributors

Narrative Author: Megan A. Smith, Senior Wildlife Ecologist, Alder Environmental

Primary Reviewer: Susan Patla, Nongame Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Renee Seidler, NRTAB

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, GRTE, BTNF, CTNF, Veg layers, select aspen and aspen/ conifer mix	See Definition Query Selection Below	Select By Attribute; Merge Layer	All aspen nesting veg covers
Aspen patch size	>4 acre aspen patches needed	Dissolve Veg, Explode, select >4 acres	Dissolve Veg; Singlepart to Multipart; Select > 4 acres; Buffer by 1,000m	Potential Nesting Patches and Buffer
Nearby Willow	Select willow foraging habitat within 1,000m of aspen. After an inspection of results of a 250m buffer and a second review of Vasquez (2005) buffer distance was increased to 1000m.	Select willow and clip willow selection by aspen 1,000m buffer	Select by attribute; Merge; Clip willow by 1000m aspen buffer	Willow foraging habitat
Douglas Fir Foraging	Select Douglas Fir foraging habitat. Douglas Fir was not limited by 1000m buffer because it grows in close association with aspen and aspen/ conifer mix.	Select Douglas Fir	Select By Attribute; Merge	Douglas Fir foraging habitat

Important Habitat	Merge nesting and foraging habitats (aspen, willow and Douglas Fir)		Merge Polygons	Potential nesting and foraging habitat
Convert Shapefile to Raster	Convert nest/ forage shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster; Reclassify so No Data = 0	Potential Foraging and Nesting Raster
Compare with WOS and NMJH observations	Visually compare observations with output.			

Slope and elevation were removed as variables since they were too limiting and produced an output that excluded known habitat in Teton County (pers. commun. S Patla).

Veg Cover Definition Query Categories

Nesting: aspen and aspen/ conifer mix
Teton County Map Codes:
Aspen Forest - FAP, FEP
Aspen Woodland Regeneration - RAP
Mixed Blue Spruce - Aspen - Cottonwood Semi-natural Planted Woodland - FBAC
Mixed Evergreen - Aspen Forest - FEP

Grand Teton Nation Park Map Codes:
Aspen Forest - FAP
Aspen Woodland Regeneration - RAP
Mixed Evergreen - Poplar Forest - FEP

Bridger-Teton National Forest MU CODE:
Aspen - ASP
Aspen/Conifer Mix - MAS

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Aspen - AS
Caribou-Targhee Aspen/Conifer - AS/C
Caribou-Targhee Conifer/Aspen - C/AS

Foraging: willow
Teton County Map Codes:
Willow Shrubland - SWL

Grand Teton Nation Park Map Codes:
Willow Shrubland - SWL

Bridger-Teton National Forest MU CODE:
Willow - WI

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Riparian Shrublands and Deciduous Forest - RSH

Foraging: Douglas Fir
Teton County Map Codes:
Douglas-fir Forest - FDF

Grand Teton Nation Park Map Codes:
Douglas-fir Forest - FDF

Bridger-Teton National Forest MU CODE:
Douglas Fir Mix - MDF

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Douglas Fir Mix - MDF
Caribou-Targhee Douglas-fir/Lodgepole Pine - DF/LP

Metadata

Title

RNSA_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Red-Naped Sapsucker Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

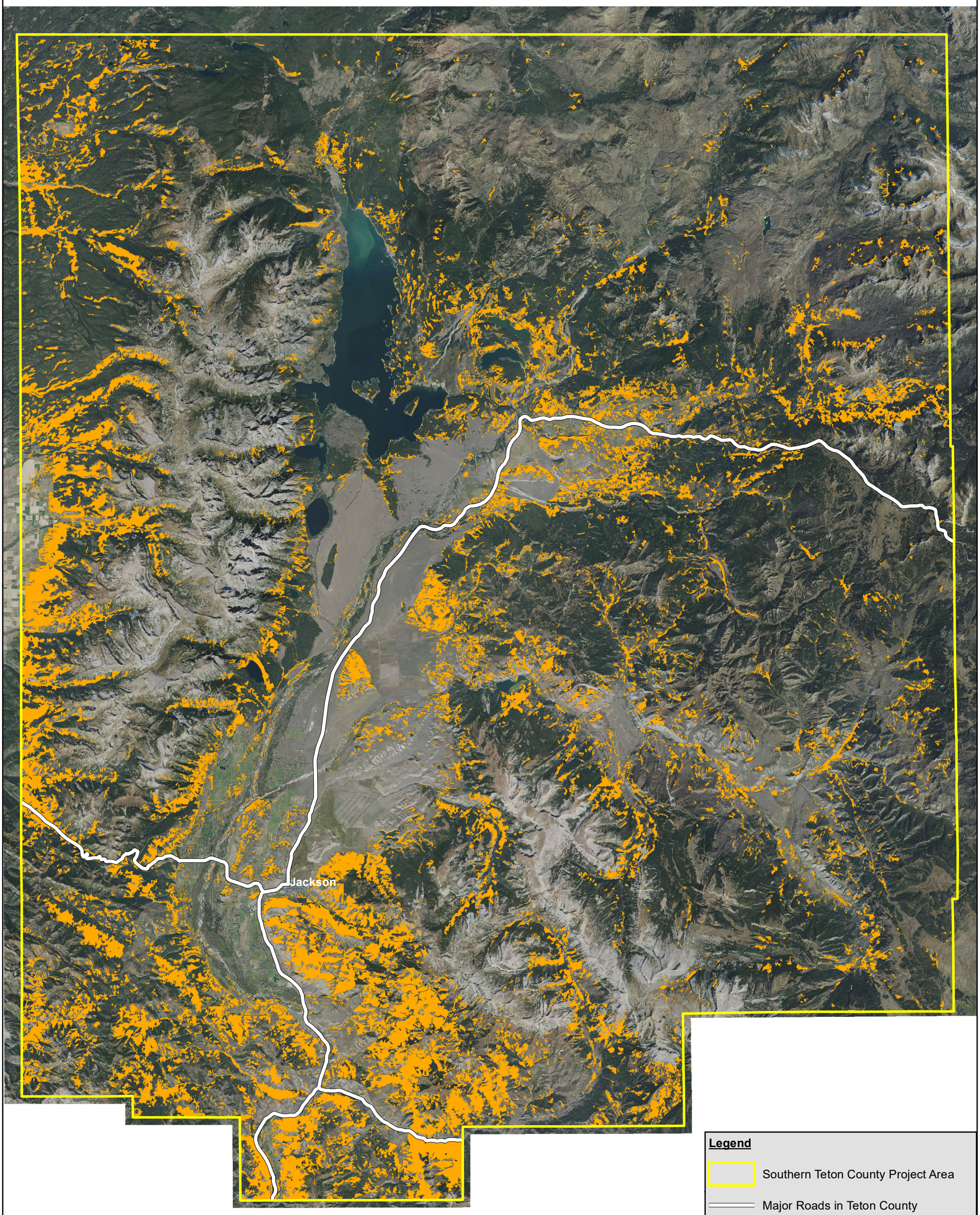
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Red-Naped Sapsucker is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 16:

Red-naped Sapsucker Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

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TRUMPETER SWAN

Year-round resident in Teton County.

Important Habitat Characteristics

Throughout the year, Trumpeter Swans (*Cygnus buccinator*) will use freshwater springs, streams and rivers, ponds, lakes and reservoirs (Mitchell and Eichholz, 2010). Teton County's summer Trumpeter Swan population is primarily non-migratory and remains within the county year-round. A large percentage of wintering swans migrate from breeding ranges in interior Canada and likely a small number from elsewhere in the Greater Yellowstone Ecosystem (or Tri-state population that nests in Montana, Idaho and Wyoming). Swans are one of the few avian species for which we have actual yearly count data for Teton County since the 1980s and documentation of known nest areas and wintering sites.

Winter Habitat

Open (ice-free) water and sufficient forage are a requirement for winter survival. Trumpeter Swans breeding in Teton County, and elsewhere in the Rocky Mountains, make local movements to ice-free waters as open water freezes and access to forage is limited (Gale et al. 1987; Lockman et al. 1987; S. Patla, *pers. commun.*). Swans also often move daily between a variety of secure loafing sites and foraging sites. The presence and absence of ice and forage are driving factors for what habitat Trumpeter Swans utilize throughout the winter. Trumpeter Swans will move between open ponds, the Snake and Gros Ventre Rivers and small spring-fed creeks throughout the winter as ice conditions dictate. Major flyways occur along the Snake River Corridor and over the Town of Jackson between the National Elk Refuge and spring-creek habitat in and south of Wilson. Trumpeter Swans' use of winter habitat is different in ponds than in creeks. Large numbers of Trumpeter Swans will congregate in shallow pond habitat and quickly consume the available aquatic vegetation. After available forage has been consumed, swans will continue to congregate in these areas and in deeper ponds for loafing purposes. Alternatively, smaller waterbodies such as spring creeks are utilized by smaller numbers of swans for both foraging and loafing purposes especially during sustained, colder periods when pond habitat becomes ice covered (S. Patla, *pers. commun.; Alder Environmental pers. obs.*). Classification based purely on high swan observation counts would clearly favor pond habitats and overlook the important role smaller creek habitats play in winter swan survivability (S. Patla, *pers. commun.*). The Snake River and its larger tributaries that stay open throughout the winter are the most important winter habitats during severe cold snaps when other water sources freeze over.

Lockman et al. (1987) identified ideal Trumpeter Swan winter habitat in this region as:

- areas with open surface water > 100 m in length or width;
- stream channel widths > 15 m;
- water velocity < 45 cm/s;
- banks with little or no shrub cover;
- water depth > 0.6 m and < 1.3 m for foraging;
- water > 10 cm and/or sand/gravel bars for loafing and roosting;
- bank slopes < 1:2;
- soft substrates > 5 cm deep;
- abundant, diverse aquatic vegetation;
- >75% open (ice-free) water in winter;
- water freezing only intermittently and < 2 consecutive days;
- no wire fences or power lines crossing habitat or flight paths;

- pollutant free (especially lead);
- little or no human disturbance.

Summer & Reproductive Habitat

Trumpeter Swans will nest on a wide variety of freshwater marshes, ponds, lakes and occasionally rivers (Banko 1960; Hansen et al. 1971; Gale et al. 1987). Regardless of water body type, security and forage resources are the two most important factors to determine the suitability of nesting sites as well as adult and young survival (Patla and Lockman, 2004). Territories are often used by one pair for up to a decade and once the breeding pair is lost sub-adults will take over the territory (Patla and Lockman, 2004). Young swans often return to the area where they were raised and occupy nearby areas (Patla and Lockman, 2004). Security and forage are of importance for both the nesting process as well as for the safety of young once hatched. Additionally, subadults and adults go through a 3-4 week molt in July during which they are flightless and therefore vulnerable to predation (Patla and Lockman, 2004).

A nesting pair will arrive on their summer territory soon after ice-off and remain for 157-200 days (approx. 5 – 6+ months). Average initial date of incubation is the third week of May but ranges from early May through mid-June (S. Patla, *pers commun.*). An adequate summer breeding pond will contain a take-off and landing zone of approximately 300 feet (91 m) that is open water and clear of obstructions (vegetation) (Patla and Lockman, 2004). In total, a summer breeding pond will be at least 8-15 acres of open water including 5 acres of wetland complex/ shallow areas less than 4 feet deep (Patla and Lockman, 2004). In addition to ponds, wetland complexes are ideal breeding habitat in that they provide a variety of security and forage areas.

Nesting islands can include muskrat or beaver mounds, floating sedge mats or emergent vegetation. Islands are generally > 2 ft above normal water mark and up to 100 sq feet in area (Patla and Lockman, 2004). The water level in a nesting pond should have no substantial seasonal water level fluctuations (Travsky and Beauvais, 2004) as to protect the nest location from flooding. Additionally, while Trumpeter Swans may adapt to human disturbance, they are also easily disturbed during the nesting and breeding periods. Therefore, low human disturbance around nesting areas is desired (Mitchell and Eichholz, 2010).

Non-breeding birds (typically <4 years old) usually gather together in flocks in areas not occupied for breeding such as at the Oxbow area of the Snake River or along edges of Jackson Lake in Grand Teton National Park or at the WGFD South Park WHMA wetland ponds south of town (Travsky and Beauvais, 2004; S. Patla, *pers. commun.*).

Migration Corridors

Teton County's summer Trumpeter Swan population is primarily non-migratory. A large percentage of wintering swans migrate from breeding ranges in interior Canada and elsewhere in the Greater Yellowstone Ecosystem to winter in the valley from November through mid-March. In February 2015, a total of 568 swans (472 adults and 96 cygnets) were counted in the Snake River drainage outside of YNP in WY during the annual WGFD winter aerial survey. This is in comparison to a total summer population in Teton County of 68 swans (58 adults and 10 cygnets) (S. Patla, 2016). Swans employ fly corridors daily over the town of Jackson and along the Snake River where collisions can occur with power lines and fences/bridges especially in foggy or low light conditions.

Stopover ponds include those that are ice free and high in forage including aquatic vegetation (primarily *Potamogeton pectinatus*) and tubers (LaMontagne, 2003)

Risk Factors to Habitat/ Habitat Function

The average number of year-round resident adult Trumpeter Swans in the Snake River drainage of western Wyoming from 1999-2016 was 62 with annual fluctuations from 42 to 73. There has been no sustained growth in overall population numbers and only a handful of nest sites produce young consistently every year. Loss of these active nest sites would likely lead to a decline in the resident population. Some historic nesting sites no longer support swans due to declining water levels. Long-term drought combined with increasing temperatures will likely reduce shallow water wetland habitat required for nesting in the future. Managed wetlands where water levels can be controlled will likely be needed to support this population in the long-term. In addition, the large influx of migrant swans in winter creates competition for limited aquatic vegetation needed by resident swans. When migrants depart in March, if spring conditions remain cold and wetlands fail to open up (aka become ice free), a lack of spring forage creates a situation where resident pairs fail to nest or have low productivity due to poor body condition. Weak swans are also vulnerable to predators and disease.

Risk factors for resident swans include:

- collisions with power lines and fences and illegal shooting which account for nearly 60% of the identified Trumpeter Swan mortalities in Wyoming 1991-2015 (S. Patla, 2016).
- lack of suitable pre-nesting habitat in spring (S. Patla, 2016).
- limited nest sites suitable to support a nesting pair and its offspring (Patla and Lockman, 2004)
- competition with an increasing number of migrant swans for limited winter habitat
- feeding of swans in winter which results in higher concentrations of migrant swans remaining in the Jackson area that might otherwise move on to other wintering areas.
- flooding of nest areas in years with high run-off or from irrigation flows
- contaminants such as lead and selenium which can affect health and productivity
- predation by coyote, fox, Bald Eagle and loose dogs

A winter habitat development buffer should be employed to lessen human disturbance. Current Teton County Land Development Regulations protect winter habitat from development taking place within the habitat and likely within 50 ft of the shore if the winter habitat is a stream or wetland. These regulations should be maintained (S Patla. *pers. commun.*). Additionally, the current nest buffer of no development within 300 ft of a Trumpeter Swan nest should be maintained within Teton County's Land Development Regulations to lessen human disturbance (S Patla. *pers. commun.*).

Literature Sources

Banko, W. E. 1960. The Trumpeter Swan: Its history, habits, and population in the United States. N. Amer. Fauna no. 63.

Gale, R. S., E. O. Garton and I. J. Ball. 1987. The history, ecology, and management of the Rocky Mountain Population of Trumpeter Swans. Missoula, MT: U.S. Fish and Wildlife Service, Montana Cooperative Wildlife Research Unit.

Hansen, H. A., P. E. K. Shepard, J. G. King and W. A. Troyer. 1971. The Trumpeter Swan in Alaska. Wildlife Monographs No. 26:1-83.

Kilpatrick, D. E. 2007. Translocating Trumpeter Swans from the Rocky Mountain population: habitat, movement and survival. Master's thesis, University of Idaho, Moscow.

LaMontagne, JM, L J Jackson, RMR Barclay. 2003. Characteristics of ponds used by trumpeter swans in a spring migration stopover area. Canadian Journal of Zoology. 81: 1791-1798.

Lockman, D. 2005. Wyoming Green River Basin Trumpeter Swan Summer Habitat Project. February 14, 2005. Wyoming Game and Fish Nongame Program. Lander, WY. Unpublished Report. State Wildlife Grants Project

Lockman, D. C., R. Wood, H. Burgess, R. Burgess and H. Smith. 1987. Rocky Mountain Trumpeter Swan population. Wyoming flock. 1982-1986. Cheyenne: Wyoming Game and Fish Dept.

Patla, S. WGFD Non-Game Biologist. Personal Communication.

Patla S. and D. Lockman. 2004. Considerations and Prescriptions for the Design, Construction, and Management of Shallow Water Wetlands for Spring through Fall Use by Trumpeter Swans (Cygnus buccinators) in Western Wyoming.

Patla, S. 2016. Monitoring and management of the Rocky Mountain Population of Trumpeter Swans (*Cygnus buccinator*) in Wyoming in *Threatened, endangered and nongame bird and mammal investigations* June 2016, edited by Andrea Orabona. Wyoming Game and Fish Department Nongame Program, Wildlife Division, Cheyenne, WY. Accessed at: https://wgfd.wyo.gov/WGFD/media/content/PDF/Hunting/JCRS/JCR_NONGAMEACR_2016.pdf

Proffitt, K. M. 2008. Yellowstone National Park Trumpeter Swan conservation assessment. Bozeman, MT: Rocky Mountain Cooperative Ecosystem Studies Unit.

Squires JR, Anderson SH, Lockman DC. 1992. Habitat selection of nesting and wintering Trumpeter Swans. In: McCullough DR, Barrett RH, eds. Wildlife 2001: populations. New York: Elsevier Applied Sciences. p 665-75.

Mitchell, Carl D. and Michael W. Eichholz. (2010). Trumpeter Swan (Cygnus buccinator), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/truswa, DOI: 10.2173/bna.105

Mitchell, C. D. and L. Shandruk. 1992. "Rocky Mountain population of Trumpeter Swans: status, distribution, and movements." In Proc. and Papers of the 13th Trumpeter Swan Society Conf., edited by C. D. Mitchell, J. R. Balcomb and J. E. Cornely, 3-18. Maple Plain, MN: The Trumpeter Swan Society.

Travsky, A. and G Beauvais. 2004. Species Assessment for the Trumpeter Swan (Cygnus buccinator) in Wyoming. Prepared for the Bureau of Land Management Wyoming State Office. Wyoming Natural Diversity Database. Laramie, WY.

Habitat Characteristics

No known habitat model exists for Trumpeter Swans in Teton County, WY.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Winter	Open (ice-free) water	Vegetation Layer	Ponds >100 m (328 ft) in length or width; increased importance if proximate to the Snake River – examine within 1 mile as a buffer (educated assumption)	Lockman et al, 1987
Winter	Open (ice-free) water	Vegetation Layer or NHD	Rivers and tributaries > 15 m (50 ft) wide and spring creeks (may be <50 ft wide)	Lockman et al, 1987
Summer	Aquatic Veg	Vegetation Layer or NWI	Emergent wetlands > 5 ac in size may be given higher importance but emergent wetlands along spring creeks should also be included	Patla and Lockman, 2004
Summer	Nesting areas	WGFD and/ or NMJH	Known nests buffered by 300 ft disturbance buffer	S Patla, pers. commun. and current TC LDRs
Summer	Open Surface Water	Vegetation Layer or NHD	> 5 acres complexes and at least 300 feet in either length or width; rivers at least 20 feet wide; wetland complexes	Patla and Lockman, 2004
Summer	Open Surface Water buffer	Create Layer	Buffer open water habitat by 50 ft buffer	S Patla, pers. commun.

Contributors

Narrative Author: Megan A. Smith, Senior Wildlife Ecologist, Alder Environmental

Primary Reviewer: Susan Patla, Non-Game Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Patrick Wright, NRTAB

GIS Methods – Winter Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Ponds	From BTNF, CTNF, GRTE & TC Veg layers, select ponds. Include Romney Ponds south of GV that are not mapped correctly; add parts of Jackson Lake that remain open: southeastern bay by Jackson Lake Dam and northern area, GTNP pond select by attributes is for ponds < 80 acres to allow for	See Definition Query Selection Below	Select By Attribute; Merge Layer	Potential Ponds

	the removal of Leigh, Jenny, Bradly, Taggert and other large ponds that freeze completely but are under 7,000 ft in elevation (see below).			
Rivers and tributaries	From BTNF, CTNF, GRTE & TC Veg layers, select rivers and tributaries including Flat Creek, Spring Creek, Fish Creek, Buffalo Valley. Flat Creek on the NER is not mapped/ attributed correctly therefore digitizing was done.	See Definition Query Selection Below	Select By Attribute	Rivers Streams
All Water	Merge ponds and rivers and streams polygons		Merge Polygons	Streams and Ponds Merged
Convert Shapefile to Raster	Convert Winter Habitat Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Streams and Ponds Merged
Elevation	Retain elevations < 2,133 m (7,000 ft)	VALUE < 2133 m	Extract By Attribute	Elevation
Extract Streams and Ponds by Elevation	Streams and Ponds under 7,000 ft in elevation	Extract	Extract by Mask; Reclassify so No Data = 0	Winter Habitat
Visually compare with WOS and NMJH observations	Compare observations with output.			

Veg Cover Definition Query Categories

Winter Ponds
Teton County Map Codes:
Lakes, Ponds and Reservoirs - NLP

Grand Teton Nation Park Map Codes:
Lakes and Reservoirs - NLP

Bridger-Teton National Forest MU CODE: Ponds and Streams are the same code
Water - WA

Caribou-Targhee National Forest MU CODE BT: Ponds and Streams are the same code
Caribou-Targhee Water - WA

Winter Rivers and Streams
Teton County Map Codes:
Streams and Rivers - NST
Non-vegetated Cobble Bars - NVS
Exposed Shore - Stream Deposit Sparse Vegetation - VSL

Grand Teton Nation Park Map Codes:
Streams - NST
Non-vegetated Sand Bars - NVS
Exposed Lake Shoreline - Stream Deposit Sparse Vegetation - VSL

Bridger-Teton National Forest MU CODE: Ponds and Streams are the same code
Water - WA

Caribou-Targhee National Forest MU CODE BT: Ponds and Streams are the same code
Caribou-Targhee Water - WA

NER Flat Creek Habitat was selected by hand due to unusual classification where a query either selects too much of too little habitat.

GIS Methods – Summer Habitat

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Aquatic Ponds, rivers and Emergent Wetlands	From BTNF, CTNF, GRTE & TC Veg layers, select ponds, rivers/ streams and emergent wetlands	See Definition Query Selection Below	Select By Attribute; Merge Layer	Potential Ponds and Wetland Areas
Wet Complexes	>2 acres; digitize Puzzleface Ponds because built post Vegetation mapping but known to be used	Dissolve Veg, Explode, select > 2 acres	Dissolve Veg; Singlepart to Multipart; Select > 2 acres	Potential Nesting Patches
Nest Habitat Buffer	Buffer potential nesting habitat > 2 ac by 50 ft	Buffer by 50 ft	Buffer	Potential Nesting Habitat
Known nests	From WOS and NMJH observations select known nests and buffer by 300 ft	See Definition Query Selection Below; buffer by 300 ft	Select By Attribute; Merge; Buffer	Known Nest Areas
All Nesting Habitat	Merge nesting habitat and known nest areas	All	Merge Polygons	Nesting Habitat Buffered

Convert Shapefile to Raster	Convert Nesting Habitat Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster; Reclassify so No Data = 0	Summer Habitat
Visually compare with WOS and NMJH observations	Compare observations with output.			

Veg Cover Definition Query Categories

Summer Nesting Habitat
Teton County Map Codes:
Streams and Rivers - NST
Lakes, Ponds and Reservoirs - NLP
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA
Non-vegetated Cobble Bars - NVS
Exposed Shore - Stream Deposit Sparse Vegetation - VSL

Grand Teton Nation Park Map Codes:
Streams - NST
Lakes and Reservoirs - NLP
Flooded Wet Meadow Herbaceous Vegetation - HGS
Herbaceous Aquatics - HA
Non-vegetated Sand Bars - NVS
Exposed Lake Shoreline - Stream Deposit Sparse Vegetation - VSL

Bridger-Teton National Forest MU CODE:
Water - WA
Riparian Herbland - RH

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Water - WA
Caribou-Targhee Riparian Herbaceous - RHE

Nest locations from NMJH and WOS

Metadata - Winter

Title

TRUS_Win.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Trumpeter Swan Winter Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Trumpeter Swan is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.

Metadata - Summer

Title

TRUS_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Trumpeter Swan Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Trumpeter Swan is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

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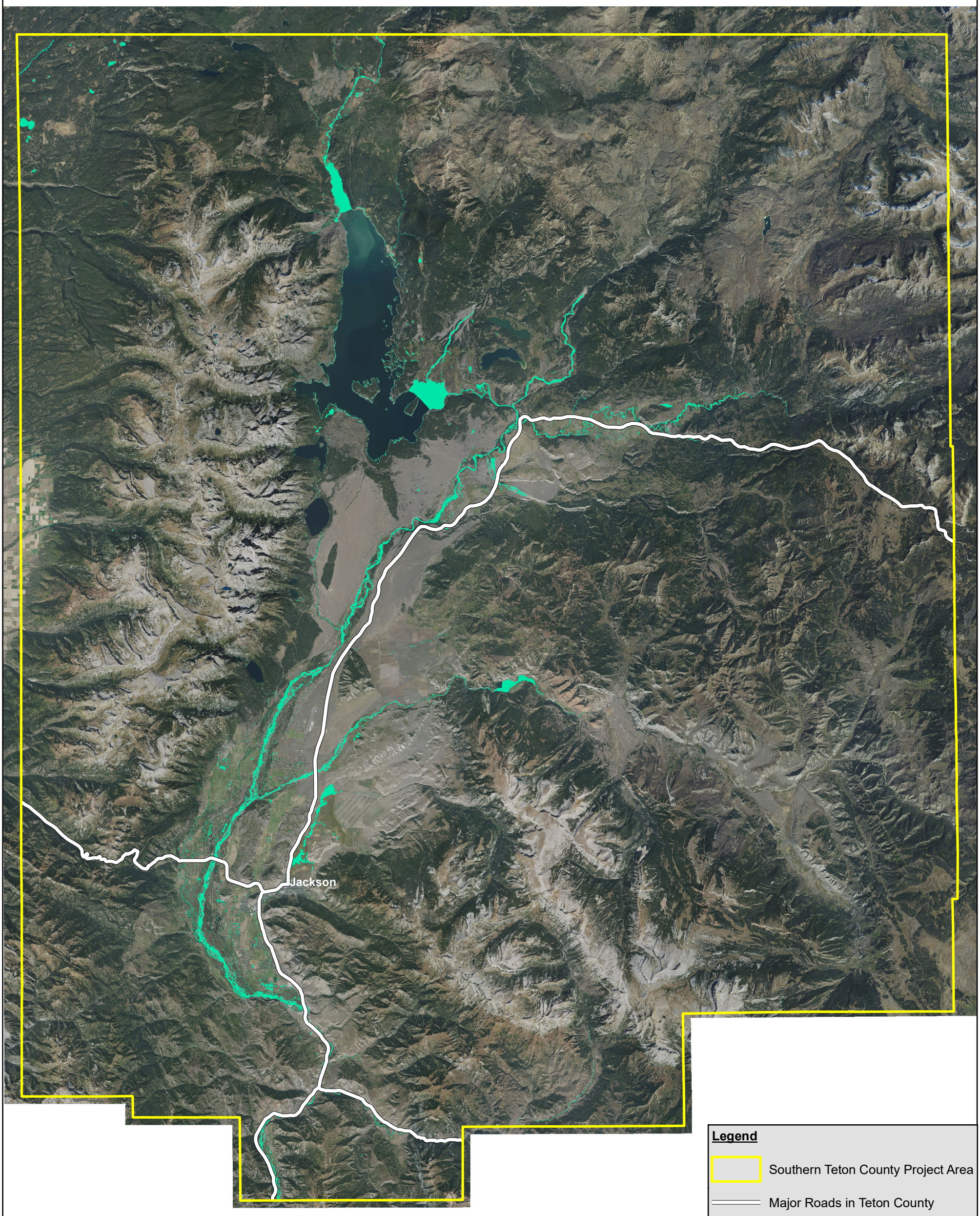
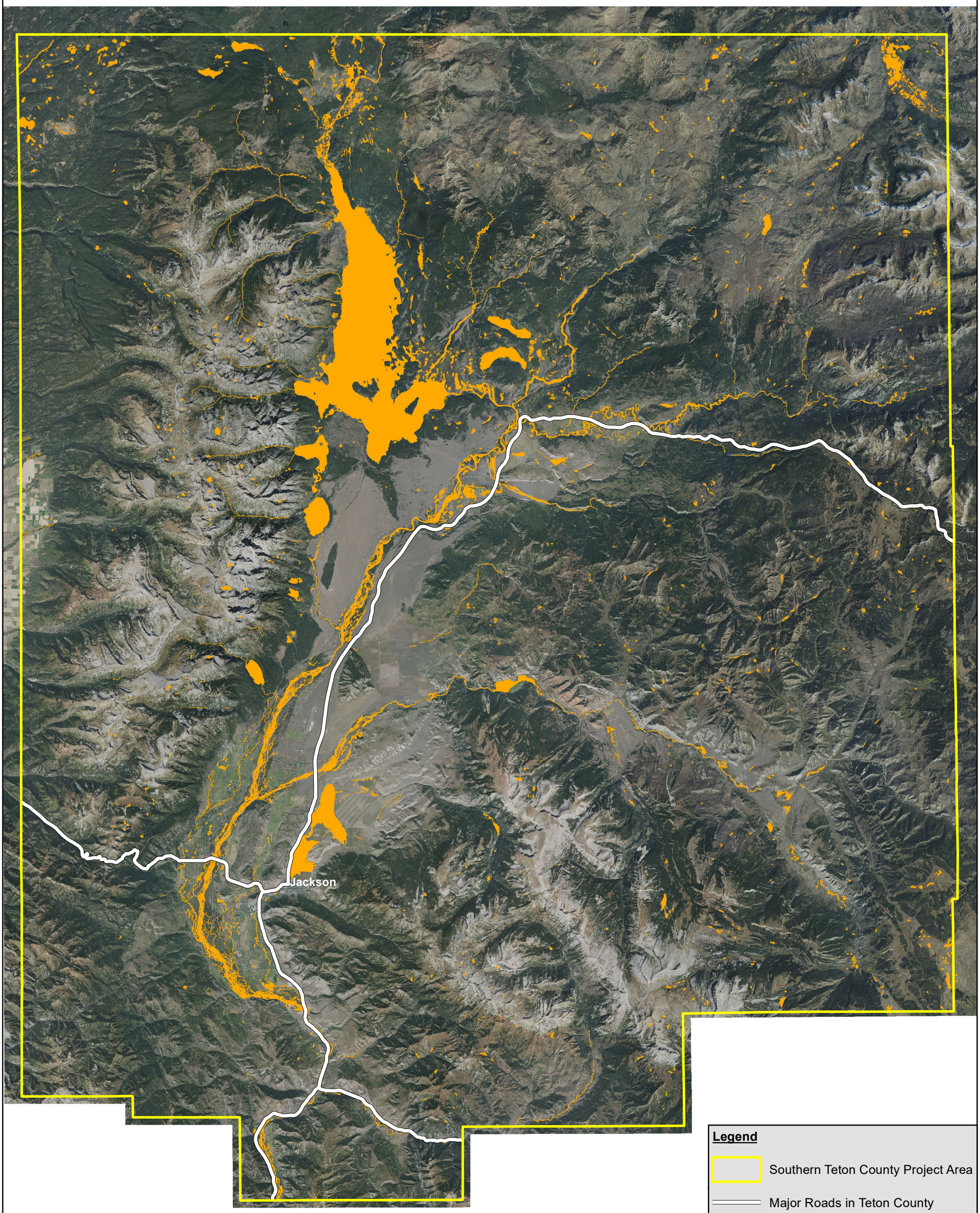


Legend

- Southern Teton County Project Area
- Major Roads in Teton County
- Trumpeter Swan Winter Habitat

Teton County Focal Species Habitat Mapping Project Teton County, WY	**FIGURE 17:** **Trumpeter Swan Winter Habitat** April 21, 2017	*This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.*	*NAIP* *- 2015 1-m Aerial Photography* *NRCS* *- Teton County Boundary* 2017/TC/TCFSHMP/TaskBSppLayers.mxd	1 inch = 5 miles 0 1 2 3 4 5 Miles NORTH ALDER ENVIRONMENTAL, LLC *Water • Wetlands • Ecological Consulting* *P.O. Box 6519, Jackson, Wyoming 83002* *(307) 733-5031 www.alderenvironmental.com*



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 18:

Trumpeter Swan Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

ALDER ENVIRONMENTAL, LLC
Water • Wetlands • Ecological Consulting
P.O. Box 6519, Jackson, Wyoming 83002
(307) 733-5031 www.alderenvironmental.com

WESTERN MEADOWLARK

Year-round resident in Teton County.

Important Habitat Characteristics

As a conspicuous species, Western Meadowlarks (*Sturnella neglecta*) appear to be numerous across the western United States. However, Breeding Bird Surveys (BBS) have found that throughout the US, the species has declined an annual rate of 1.5% annually from 1966-2006 (Davis et al, 2008). Nonetheless, it is ranked as a species of least concern nationwide (S. Patla, *pers. commun.*)

Past habitat selection models have shown that Western Meadowlarks are not sensitive to landscape variables but rather respond to the quality of vegetative components such as shrub and grassland cover at a local scale (Knick and Rotenberry, 1995; Bakker et al, 2002). Therefore, while we have suggested potential mapping variables below, it should be acknowledged and cautioned that this species is more reactive to the density/ quality of available shrub and grass species rather than to the potential expanse of those vegetative components across the landscape. Nonetheless, Western Meadowlarks tend to have large territories relative to other grassland passerine species, (Davis et al, 2008).

Summer Habitat

Western Meadowlarks reside in Teton County during the breeding season arriving in March or April and departing in October or November (Raynes 2000). This species is widespread and abundant across Wyoming (WGFD, 2012). It is the state bird of Wyoming.

Western Meadowlark, a grassland species, is found in basin-prairie and mountain foothill shrublands and grasslands across Wyoming (WGFD, 2012). Typically found below 8,000 ft, this species will also make use of agricultural areas (WGFD, 2012). A ground nester, the Western Meadowlark will build its nest in natural or scraped depressions within the grassland vegetative cover using the surrounding grass species to both build and shelter the nest (Davis and Lanyon, 2008). In Manitoba, CA average nesting territory size defended by males was found to be 17.5 ac (7 ha) (Schaeff and Picman, 1988 *in* Davis et al, 2008). Rocky Mountain Bird Observatory reported territories ranging from 3-32 acres (1.2-13.0 ha) but most commonly 7-8 acres (2.8-3.2 ha) (Vercanteren and Gillihan, 2004). It is likely the quality and type of grass species present influence territory size (Davis et al, 2008). During the breeding season, Western Meadowlarks are extremely sensitive to human disturbance and will abandon a nest if flushed during nesting attempts (SAS, 2016).

While able to breed in a wide range of grassland habitats, Western Meadowlarks prefer native grassland cover with a sparse shrub cover and moderate densities of litter and forbs (Davis and Lanyon, 2008; Knick and Rotenberry, 1995). The occupancy rates of Western Meadowlark have been found to be higher in large mixed-grass regions as well as in suitable patches within landscapes of high grassland abundance (Bakker et al, 2002) thereby indicating that the resources available within the patch are potentially more important than the size of the patch. Western Meadowlarks appear to exhibit area sensitivity through an adjustment in densities rather than strictly presence or absence (Bakker et al, 2002).

A consistent habitat variable across studies is that Western Meadowlarks are negatively affected by wooded vegetation on the edge of grassland/ shrub habitats. Higher nest parasitism is found within 45 m (147 ft) of wooded edges (Johnson and Temple within Bakker et al, 2002). Additionally, the percent of exotic species in the landscape has a negative relationship with the presence of Western Meadowlarks (Haire et al, 2000). This is an indicator that the amount of grass species cover present is the primary

variable for habitat selection and that control of invasive species within grassland and grassland/ shrub environments is an important management consideration for Western Meadowlarks (Haire et al, 2000).

Risk Factors to Habitat/ Habitat Function

Management of grassland habitat can directly influence breeding populations through alteration of vegetation structure and composition. Creation of grassland habitat increases breeding populations as the Western Meadowlark is uncommon in cropland habitat. In cropland habitats, moderate grazing intensities and maintaining non-mowed areas along fence lines, ditches and through hayfields may help maintain marginal habitat in areas with few native grasslands (Peterson, 2016). The Western Meadowlark is negatively impacted by grassland patches with woodland or urban edges therefore preservation of grassland patches buffered from woodlands and urban areas are important (Davis et al. 2008). Haire et al (2000) found that dominance of plant communities by exotic species has consistent negative effects on Western Meadowlarks; therefore, control of invasive vegetation species is important to this grasslands species.

Literature Sources

Bock, C, J Bock and B Bennett. 1999. Songbird abundance in grasslands at a suburban interface on the Colorado High Plains. *In:* Ecology and conservation of grassland birds of the Western Hemisphere., edited by P.D. Vicery and J.R. Herkert.

Davis, S and W Lanyon. 2008. Western Meadowlark (*Sturnella neglecta*), The Birds of North America (P.G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; retrieved form the Birds of North America: https://birdsna.org/Species-Account/bna/species/wesmea.

Haire, S, C Bock, B Cade, B Bennett. 2000. The role of landscape and habitat characteristics in limiting abundance of grassland nesting songbirds in urban open space. Landscape and Urban Planning 48:65-82.

Knick, S and J Rotenberry. 1995. Landscape Characteristics of Fragmented Shrubsteppe Habitats and Breeding Passerine Birds. Conservation Biology 9:1059-1071.

Peterson, R. 2016. South Dakota Meadowlarks Facts Sheet. South Dakota Department of Game, Fish and Parks. Pierre, SD. Accessed November 2016 at: www3.northern.edu/natsource/BIRDS/ Sdmead1.htm.

Raynes, B. 2000. Birds of Jackson Hole: The Occurrence, Arrival and Departure Dates, and Preferred Habitat of Birds of the Jackson Hole, Wyoming Area. Pamphlet. Homestead Publishing, Moose, WY.

SAS. 2016. Seattle Audubon Society Bird Web. Accessed November 2016 at birdweb.org.

Schaeff, C and J Picman. 1988. Destruction of eggs by Western Meadowlarks. Condor no. 90:935-937

Vercanteren, T and S Gillihan. 2004. Integrating Bird Conservation into Range Management. Rocky Mountain Bird Observatory. Accessed November 2016 at www.birdconservancy.org

WGFD. 2012. Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. Wyoming Game and Fish Department. Nongame Program, Biological Services Section Wildlife Division. June 2012 Report.

Habitat Characteristics

No known habitat model exists for the Western Meadowlark in Teton County, WY.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Summer	Vegetation	Teton County vegetation layer	Grassland, upland shrubland, pastures (not hay fields). Minimum patch size of 15 acres (arbitrary patch size based on territory sizes)	Vercanteren and Gillihan, 2004
Summer	Elevation	Teton County DEM (Digital Elevation Model)	Elevations less than 8,000 feet (2,438 m)	WGFD, 2012
Summer	Distance from Woody Vegetation	Create	100 m (328 ft) buffer away from forested habitat (100 m/ 328 ft) is an arbitrary distance based on a doubling of nest parasitism distance	Davis et al. 2008; Johnson and Temple within Bakker et al, 2002
Validation	Observations	WGFD WOS & NMJH	Overlay	

Contributors

Primary Authors: Megan A. Smith, Senior Wildlife Ecologist, Alder Environmental
Amy Kuszak, Environmental Planner, Alder Environmental

Primary Reviewer: Susan Patla, Nongame Biologist, Wyoming Game and Fish Department

Secondary Reviewer: Amy Girard, NRTAB

GIS Methods – Summer Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, BTNF, CTNF & GRTE Veg layers, select grassland and upland shrubland.	See Definition Query Selection Below	Definition Query for each source	Summer veg covers
Pastures	It is not possible to distinguish between pastures and hayfields therefore agricultural fields east of Snake River and south of Gros Ventre and all fields south of South Park Wildlife Management Area were used (S. Patla, *pers. commun.*)	See Definition Query Selection Below then Clip by area	Select By Attributes; Clip	Pastures
Merge Veg	Combine all Veg layers		Merge	All WEME summer veg cover combined
Minimum Patch Size	Retain veg that has a patch size of greater than 15 acres (arbitrary patch size based on territory sizes)	In merged veg, select patches of greater than 15 acres	Dissolve merged veg; Multipart to Singlepart; Add Geometry (Area); Select patches ≥15ac	Summer veg patches ≥15 ac patches
Distance from Woody Vegetation	Select all forested cover types, buffer by 100 m, remove from refined summer vegetation cover	Select Forested, Buffer full, 100m, dissolve, clip	Select; Merge; Buffer; Dissolve; Erase	Summer habitat with high fecundity potential
Minimum Patch size – 2nd filter	Retain veg that has a patch size of ≥15 acres (arbitrary patch size based on territory sizes). Several patches that were 15 ac in the first round are <15 acres after the conifer buffer removal	select patches ≥15 acres	Recalculate Area; Select By Attribute	Summer habitat
Convert Shapefile to Raster	Convert Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert	Add Field; Calculate Field; Polygon to Raster	Summer habitat

		Polygon to Raster		
Elevation	Retain elevations less than 8,000 feet (2,438 m)	VALUE <2438 m (8,000 ft)	Extract By Attribute	Elevation
Extract Veg by Elevation	Summer habitat <8,000ft	Extract Elevation	Extract by Mask with No Data = 0 setting	Product
Visually Compare with WOS and NMJH observations	Compare observations with output.			

Veg Cover Definition Query Categories

Summer Veg Selection

Teton County Map Codes:
Montane Mesic Forb Herbaceous Vegetation - HFD
Mixed Grassland Herbaceous Vegetation - HGL
Recently Burned Sparse Vegetation - VRB
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Mixed Tall Deciduous Shrubland - SMR
Rubber Rabbitbrush Shrubland - SRB
Sagebrush - Antelope Bitterbrush Mixed Shrubland - SES
Sagebrush - Snowberry - Chokecherry - Serviceberry Mixed Shrubland - SMSD
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SES, SMSD, SSD
Flooded Wet Meadow Herbaceous Vegetation - HGS
Alder Shrubland - SAI
Willow Shrubland - SWL

Grand Teton Nation Park Map Codes:
Bracken Fern Herbaceous Vegetation - HBR
Montane Mesic Forb Herbaceous Vegetation - HFD
Subalpine Mixed Herbaceous Vegetation - HSA
Mixed Grassland Herbaceous Vegetation - HGL
Montane Xeric Forb Herbaceous Vegetation - HFX
Low Sagebrush Dwarf Shrubland - DSE
Alder Shrubland - SAI
Ceanothus Shrubland - SCV
Mixed Deciduous Shrubland - SDS
Mixed Tall Deciduous Shrubland - SMR
Sagebrush - Antelope bitterbrush Mixed Shrubland - SES
Sagebrush / Shrubby Cinquefoil Mesic Shrubland - SSW
Sagebrush Dry Shrubland - SSD
Flooded Wet Meadow Herbaceous Vegetation - HGS

Willow Shrubland - SWL

Bridger-Teton National Forest MU CODE:
Grassland/Forbland - GF
Sparse Vegetation - SV
Tall Forbland - TF
Riparian Herbland - RH
Willow - WI
Low/Alkali Sagebrush - LA
Mountain Big Sagebrush - MB
Mountain Shrubland - MS
Sagebrush/Bitterbrush Mix - SB
Silver Sagebrush/Shrubby Cinquefoil - SS
Spiked Big Sagebrush - SK

Caribou-Targhee National Forest MU CODE BT:
Bridger-Teton Grassland/Forbland - GF
Bridger-Teton Tall Forbland - TF
Caribou-Targhee Montane Herbaceous - MTNH
Caribou-Targhee Subalpine Herbaceous - SUBH
Caribou-Targhee Riparian Herbaceous - RHE
Caribou-Targhee Riparian Shrublands and Deciduous Forest - RSH
Bridger-Teton Mountain Big Sagebrush - MB
Caribou-Targhee Forest/Mountain Shrublands - FMSH
Caribou-Targhee Mountain Big Sagebrush - MSB

Agricultural Lands
Teton County Map Codes:
Irrigated Agricultural Fields - NIPI
Non-Irrigated Agricultural Fields - NIPN
Perennially Flooded Agricultural Fields - NIPF

Grand Teton Nation Park Map Codes:
Irrigated Fields - NIP

Bridger-Teton National Forest MU CODE:
Agriculture - AG

Caribou-Targhee National Forest MU CODE BT:
None available

Forested Areas to Buffer and Remove
Teton County LUC_II Codes:
Deciduous Forest Land
Evergreen Forest Land
Mixed Forest Land
Forested Wetland

Grand Teton Nation Park LUC_II Codes:
Deciduous Forest Land
Evergreen Forest Land
Mixed Forest Land
Forested Wetland

Bridger-Teton National Forest MG_CLASS:
Conifer
Deciduous
Cottonwood

Caribou-Targhee National Forest VEG_GROUP1:
Conifer Forest
Deciduous Forest
Woodland

Metadata

Title

WEME_Sum.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Western Meadowlark Summer Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Western Meadowlark is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

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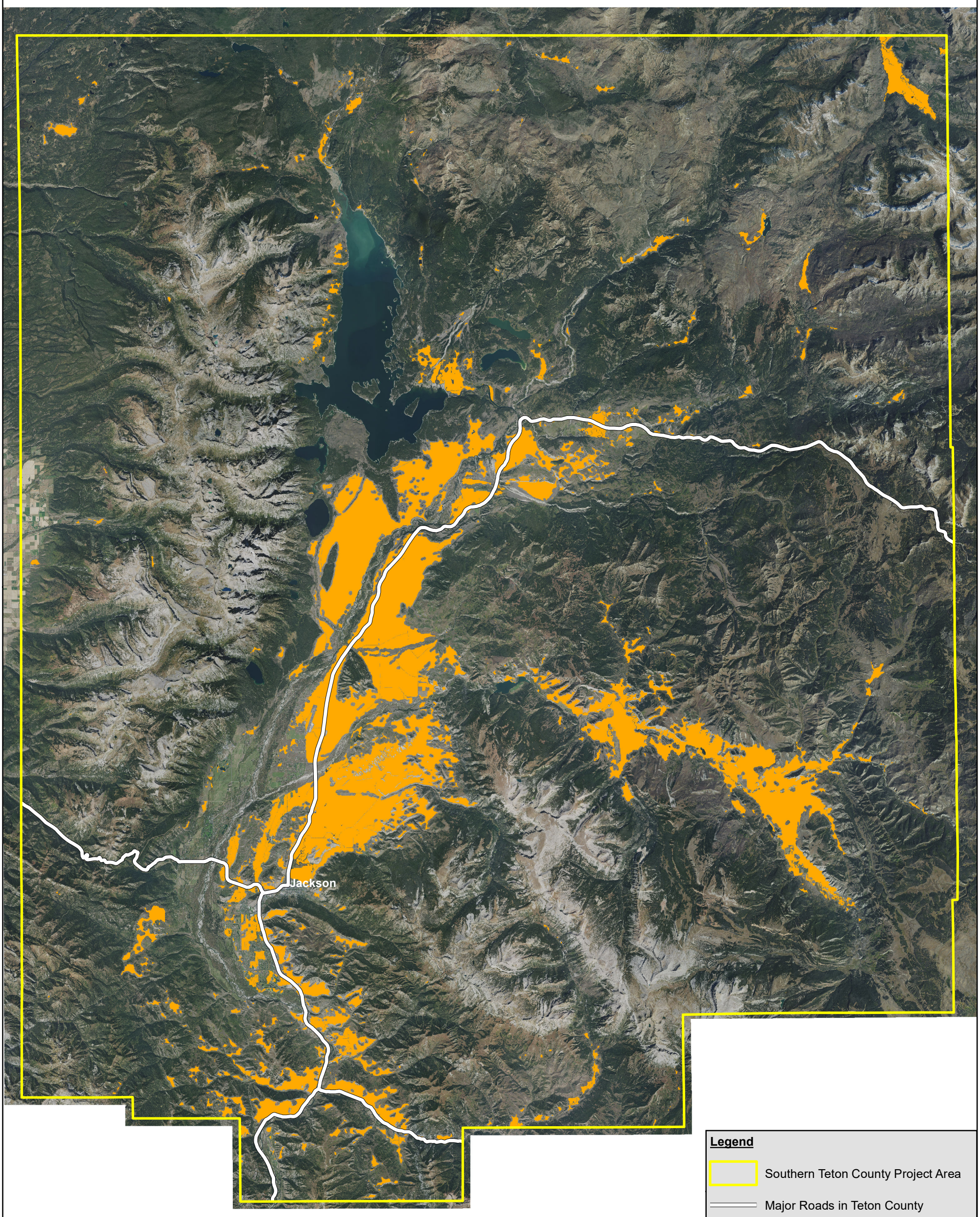

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 19:

Western Meadowlark Summer Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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SNAKE RIVER CUTTHROAT TROUT

Year-round resident in Teton County.

Important Habitat Characteristics

Year-Round Habitat

Snake River cutthroat trout (*Oncorhynchus clarkii* spp.) are found year-round on public and private lands within Teton County rivers and small stream tributaries in the upper Snake River watershed upstream of Palisades Reservoir (Homel 2013, WGFD 2010). They use all stream orders, however extremely steep and unproductive (e.g. lacking aquatic insects) headwater streams may contain fewer and smaller cutthroat trout than larger downstream riverine habitat (USFWS 1982, Trotter 1987). Snake River cutthroat trout may also inhabit irrigation ditches and artificial or constructed ponds and water features.

Optimal Snake River cutthroat trout riverine habitat is characterized by clear, cold water (<54°F optimal, not to exceed 72°F); silt free rocky substrate in riffle-run reaches; an approximately 1:1 pool-riffle ratio with areas of slow, deep water; well vegetated streambanks; abundant instream cover; relatively stable water flow, temperature regimes and streambanks (USFWS 1982).

Snake River cutthroat trout lacustrine habitat, lakes and ponds, is not addressed here because it does not constitute abundant or meaningful native and wild trout habitat on private lands within Teton County.

Winter Habitat

A major factor limiting cutthroat trout densities in streams may be the amount of adequate overwintering habitat (USFWS 1982). Snake River cutthroat trout that spawn in the spring-fed Snake River tributaries generally drift downstream in the fall and early winter and overwinter in deeper water (Kiefling 1978, Sanderson 2007). Winter hiding and downstream movement is generally triggered by low temperatures and/ or rapidly decreasing flows (Homel 2013). In some cases this movement is to avoid physical injury from ice formation and scour (USFWS 1982).

Overwintering habitat for Snake River cutthroat trout consists of slower, deeper water pools with sufficient instream cover such as boulders, logs, roots and other debris (Sanderson 2007, USFWS 1982). In mainstem river systems, water depth can overcome the need for alternative cover types.

Snake River cutthroat trout winter use of run and off-channel pool habitat was significantly correlated to water temperature. Run use was most frequent when mean water temperature exceeded 1.08°C (33.9°F) and off-channel pool use was greatest when mean water temperature was below 1.08°C (33.9°F) (Harper 2004). Large, deep, off-channel pools with groundwater influences and large, woody debris cover were frequently selected as overwintering habitat.

Summer Reproductive Habitat

Snake River cutthroat trout use the mainstem and side channels of the Snake River, runoff dominated tributaries and groundwater dominated spring creek complexes to spawn (Gresswell and Homel 2008, Homel 2013, Kiefling 1997, Sanderson 2007). These areas are crucial to the survival of the Snake River cutthroat trout species. Kiefling (1978) described approximately 15 of the 31 Snake River tributaries as having Snake River cutthroat trout spawning redds and 10 of those streams are considered important. Snake River cutthroat trout generally migrate prior to and before high water and mountain snowmelt runoff. Snake River cutthroat trout begin moving upstream into tributaries in April with a peak in spawning taking place in May (Gresswell and Homel 2008, Sanderson 2007). Spawning continues into June and early July in some creeks (e.g. BarBC Creek). The peak and timing of spawning is variable by

creek and is influenced by elevation, water temperature and possibly genetic influences. During these spawning periods Snake River cutthroat trout primarily use and occupy run and riffle habitat (Sanderson 2007).

Generally, choice and success of spawning areas for the cutthroat trout is dependent on combined water temperature, dissolved oxygen, water velocity and gravel permeability characteristics (USFWS 1982). A more recent study conducted by Homel et al (2015) found radio-tagged Snake River cutthroat trout in the upper Snake River exhibited variation in spawning habitat type and location, migration distance, spawn timing, postspawning behavior and susceptibility to mortality sources. According to Kiefling (1978), Snake River cutthroat trout spawning redds are found in round and oval gravels ranging from 1 – 2½ inches in size and free of fine sediment and sands. Redds are typically constructed in stream riffle sections with reduced velocity (0.5 – 2.0 ft/s), such as near banks and below a bend in the creek (Kiefling 1978). Water depths in spawning riffles are typically less than 12 inches deep. Secondary summer reproductive habitat, including instream cover and pool habitat, provides protection from predators during spawning periods.

After hatching, cutthroat trout fry move to rearing areas of low velocity and cover (USFWS 1982). Rearing habitat includes shallow water pools, runs and backwater with instream cover in the form of aquatic vegetation, woody debris piles and interstitial spaces between rocks. The diet of fry consists largely of plankton, which requires relatively warm, slow moving water to persist abundantly (Trotter 1987).

Foraging and Food Supply Habitat

Lower water velocity and access to plentiful food supply is the primary foraging habitat of Snake River cutthroat trout. Overhead cover is preferred, but not essential, however escape cover must be nearby (USFWS 1982). The Snake River cutthroat trout's primary food source is aquatic insects which occur in different stream geomorphic reaches, habitat types and submerged aquatic vegetation (Li et al. 2016). Snake River cutthroat trout predation on sculpin and dace as well as worms, leeches and gastropods in deeper water suggests these areas are as productive food supplies as riffles (Kiefling 1978, Trotter 1987).

Migration Corridors

Migration corridors for Snake River cutthroat trout consist of the Snake River and tributary streams. Sufficient flows and water depths as well as creeks free of vertical and physical barriers are crucial for Snake River cutthroat trout migration to spawning areas. In the upper Snake River, movements among reaches and segments were more frequent during times of rapidly changing discharge (October), base flow, or spring runoff, but distances were typically short (Homel 2013). Although long spawning migrations (30-40 km, 18-25 mi) were observed in the Upper Snake River (Homel et al 2015), it appears that "nonspawners" occupying a high-quality stream have little need to move. Postspawning behavior and migration varies; by August each year, 28% of spring-creek spawners remained in their spawning location, compared with 0% of Snake River side-channel spawners and 7% of tributary spawners (Homel et al 2015).

Risk Factors to Habitat/ Habitat Function

Risk factors to Snake River cutthroat trout habitat include:

- Altered spawning habitat due to the construction of levees (e.g. post-levee construction flushing and regenerating flows no longer exist in spawning tributaries negatively affecting spawning gravels and cottonwood regeneration)
- Aquatic invasive species
- Non-native fish species (e.g. brook trout competition, rainbow trout hybridization
- Diseases
- Passage barriers due to irrigation water dams and diversions, undersized and perched road and driveway culverts, other human made structures
- Livestock and ranching operations (e.g. bank trampling, spawning redd trampling, sedimentation, pollutant loading, riparian vegetative cover removal, temporary and permanent passage barriers)
- Diversions and dewatering; trout entrainment in irrigation canals and ditches.
- Irrigated land conversion to dryland reducing groundwater and surface water recharge to spring creeks
- Water discharges to creeks from poorly designed or managed constructed ponds may negatively impact water quality. Data supporting discharges from well-designed ponds having negligible measurable impacts to creeks is available (Alder Environmental, 2014).
- Climate change (e.g. natural water supplies and water temperature increases, nuisance species proliferation)
- 303d listed streams, including Flat Creek (e.g. urban runoff and sediment from road sanding)
- Streams with documented aquatic habitat degradation and negatively impacted due to human uses, Fish Creek (e.g. nutrients)

Stream buffers or development setbacks to reduce potential negative impacts to Snake River cutthroat trout habitat should be established based off individual buffer functions criteria such as functional value and adjacent land use intensity (Castelle et. al. 1994). Stream buffers and the native vegetation within them have many benefits, including:

- Capturing water quality pollutants and sediment in runoff
- Providing shade to keep waters cool
- Providing leaves and sticks for aquatic insects that serve as a food source for fish and other aquatic life.
- Ecologically diverse instream and riparian habitat supports more robust food webs, allowing for increased productivity and resilience to degradation.
- Providing logs and branches that serve as habitat and feeding areas for trout and aquatic insects
- Protecting stream banks from disturbances and instability
- Preventing erosion and sediment transport to streams
- Minimizing and discouraging human and pet activity within and adjacent to the creek

For Snake River cutthroat trout, variable width buffer criteria should consider the potential for direct runoff (carrying pollutants) to the stream, riparian vegetation and shade cover, diversity of native vegetation, streambank stability, slopes and development intensity/ percentage of impermeable surfaces. Castelle et al (1994) found a range of buffer widths from 3 meters (9.8 feet) to 200 meters (656 feet) was found to be effective in protecting streams and wetlands. They concluded a buffer of at least 15 meters (49 feet) was necessary to protect streams under most conditions. For the purposes of

evaluating riparian and wetland habitat and development impacts adjacent to Snake River cutthroat trout streams on private lands in Teton County, a 100-meter (328 feet) assessment buffer is recommended. Snake River cutthroat trout stream habitat on private lands in Teton County are generally on flat, well vegetated areas with low intensity land uses and development, suggesting a 15-meter (49 feet) minimum buffer from development may be suitable.

Literature Sources

Alder Environmental. 2014. Stream Monitoring Report: Evaluation of potential water quality impacted due to a constructed residential pond. Unpublished Report to Jackson Hole Land Trust and Teton County, WY. Alder Environmental LLC. Jackson, WY.

Castelle, A.J., A.W. Johnson, and C. Conolly, Wetland and Stream Buffer Size Requirements - a Review. Journal of Environmental Quality, 1994. 23(5): p. 878-882.

Cogan, D. and S. Johnson. 2013. Final GIS Data & Report: Vegetation and Non-Vegetation Cover Type Mapping for Teton County. Jackson, Wyoming.

Gresswell, B. and Homel, K. 2008. Evaluating the Movement Patterns of Snake River Finespotted Cutthroat Trout in the Snake River Below Jackson Lake Dam, Grand Teton National Park. University of Wyoming National Park Service Research Center Annual Report: Vol. 31, Article 5.

Harper, D. and A. Farag. 2004. Winter Habitat Use by Cutthroat Trout in the Snake River near Jackson, Wyoming. American Fisheries Society 133:15±25, 2004.

Homel, K. 2013. Spatial Ecology And Life-History Diversity Of Snake River Finespotted Cutthroat Trout *Oncorhynchus Clarkii Behnkei* In The Upper Snake River, WW. Doctorate Thesis. Montana State University, Bozeman, Montana. April 2013.

Homel, K., Gresswell, B. and J. Kershner 2015. Life History Diversity of Snake River Finespotted Cutthroat Trout: Managing for Persistence in a Rapidly Changing Environment. North American Journal of Fisheries Management 35(4):789-801 · July 2015

Kiefling, J.W. 1978. Studies on the ecology of the Snake River cutthroat trout. Wyoming Game and Fish Department administrative report, Cheyenne, Wyoming. 198pp.

Kiefling, J. 1997. A history of Snake River Spring Creek spawning tributaries. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Li, J., W. Gerth, R. Van Driesche, D. Bateman and A. Herlihy. 2016. Seasonal and spatial fluctuations in Oncorhynchus trout diet in a temperate mixed-forest watershed. Canadian Journal of Fisheries and Aquatic Sciences. June 2016.

Olsson Associates. 2016. Draft Upper Snake River Basin Level 1 Watershed Study.

Sanderson, T. B. 2007. Habitat diversity and access to tributaries are important to adult Snake River cutthroat trout residing in the Salt River, Wyoming, M.S., Department of Zoology and Physiology, May, 2007.

Trotter, P. 1987. Cutthroat, Native Trout of the West. Colorado Associated University Press. Boulder, CO.

USFWS. 1982. Habitat Suitability Index Models: Cutthroat Trout. Biological Services Program. Report Number FWS/OBS-82/10.5. Fort Collins, CO.

USGS. 2015. National Hydrography Dataset (NHD) GIS Data Layer. United States Geological Survey. Reston, VA

WDEQ 2016. Wyoming's 2014 Integrated 305(b) and 303(d) Report. Document #16-0126. Wyoming Department of Environmental Quality Water Quality Division. Cheyenne, WY.

WGFD. 2010. Wyoming State Wildlife Action Plan – Species Accounts: Snake River Cutthroat Trout. Wyoming Game and Fish Department. Cheyenne, WY. Accessed from https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/SWAP/ Fish/Snake-River-Cutthroat-Trout.pdf

WYGISC. 2016a. Accessed October 5, 2016. Wyoming Geospatial Hub. http://geospatialhub.org/. Wyoming Geographic Information Science Center, Laramie, WY.

WYGISC. 2016b. Accessed October 5, 2016. Wyoming Interagency Spatial Database & Online Management (WISDOM) System. http://wisdom.wygisc.org/

Habitat Characteristics

No known habitat model exists for Snake River Cutthroat Trout in Teton County, WY. The Wyoming Geospatial Hub (WYGISC 2016a) was the primary source for GIS data layer sources due to the completeness and credibility of the data. The Wyoming Interagency Spatial Database & Online Management (WISDOM) System (WYGISC 2016b) was used to research and assess the WGFD stream GIS data. Year-round habitat is inclusive of spawning, rearing, migration and overwintering seasons.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Year-round	Riparian vegetation, streams	Vegetation Layers	Streams; vegetation within 100-meter buffer of streams	Castelle et al 1994, Cogan et al 2013
Year-round	Streams & ditches	Teton County River, Creek	This might be the same as vegetation layer and thus redundant.	Cogan et al 2013, USGS 2015
Year-round	Rivers and tributaries; constructed ditches may also be of value	USGS National Hydrography Dataset (1:24,000); Hydrography Flowline	StreamRiver, CanalDitch, Connector, Artificial Path; possible redundancy, but qualifies waterbody type.	USGS 2015
Year-round	cold water sport fish production	WGFD Stream Classification Blue >= 600 lbs trout/ mi Red = 300-599 lbs trout/ mi Yellow = 50-299 lbs trout/ mi Green = 1-49 lbs trout/ mi	Blue and Red Ribbon Streams are recognized as "special resources" under the Wyoming Stream Mitigation Procedure (WSMP) promulgated by the US Army Corp of Engineers (USACE); Yellow Ribbon Streams have fewer trout per mile. Caution: Using this layer's streams may not account for streams that are important for spawning. Many spawning streams may not hold	WYGISC 2016b

			large populations of fish during most of the year.	
Year-round	Stream corridors with significant biological or ecological values. These are areas that need to be protected or managed to maintain viable healthy population aquatic wildlife.	WGFD Crucial Stream Corridors	All crucial stream corridors should be included.	WGFD 2010, WYGISC 2016b
Year-round	Stream protections & threatened streams	WDEQ Stream Classification & 303(d) listed Streams, 2014 Assessed Water GIS Shapefile	Use Designation for Game Fish & Aquatic Life; 303(d) listed streams	WYGISC 2016a, WDEQ 2016

Contributors

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Reader: Carlin Girard, Member of the Public/ Aquatic Resource Specialist

GIS Methods – Year-round Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important waterways	From TC & GRTE Veg layers, select rivers, streams and ditches. BTNF & CTNF were not used because veg classifications combine all water. Streams and rivers in BTNF & CTNF are found in NHD and other layers	See Definition Query Selection Below	Select By Attribute; Merge Layer	Rivers and Streams
NHD Waterways	From NHD select rivers and tributaries; also constructed ditches may be of value	Selection includes all features in TC		TC NHD Waterways
WGFD Stream Classifications	From Trout WGFD Stream Classifications select all streams with trout classifications	Select Blue, Red, Yellow, Green	Select By Attribute	WGFD Trout Streams
WGFD Crucial Stream Corridors	Select all in TC	All		WGFD Crucial Streams
WDEQ Stream Classifications	Select all in TC	All		WDEQ Classified Streams
Polylines to Polygons	Buffer all Polylines by 5m (~15 ft) on each side of line for a 10m (~30 ft) wide waterway; including Jackson Lake	Buffer and Merge Layers: NHD Waterways, WGFD Trout Streams, WGFD Crucial Streams and WDEQ Classified Streams, Clip to Project Area	Buffer; Merge; Clip	Important Waterways Polygons
Waterways and Riparian Vegetation	Buffer all waterways polygons by 15m to incorporate riparian vegetation	All Important Waterways Polygons	Buffer	Waterways and Riparian Vegetation
Convert Shapefile to Raster	Convert Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster;	Trout Important Habitat

			Reclassify so No Data = 0	
Accuracy	JHCA NRO 2008 Project Trout habitat layer was visually compared with output.	Discrepancies appear to be based on changes in the NHD dataset between the 2006 and 2014 updates.		

GIS Methods – Summer Habitat

Veg Cover Definition Query Categories

Teton County Map Codes:
Canals - NID
Streams and Rivers - NST
Non-vegetated Cobble Bars - NVS
Exposed Shore - Stream Deposit Sparse Vegetation - VSL

Grand Teton Nation Park Map Codes:
Canals - NID
Streams and Rivers - NST
Non-vegetated Sand Bars - NVS
Exposed Lake Shoreline - Stream Deposit Sparse Vegetation - VSL

Bridger-Teton National Forest & Caribou-Targhee National Forest vegetation layers were not used because their veg classifications combine all water. Streams and rivers in BTNF & CTNF are contained within NHD and other layers.

Metadata

Title

SRCT_Yrd.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Snake River Cutthroat Trout Year Round Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

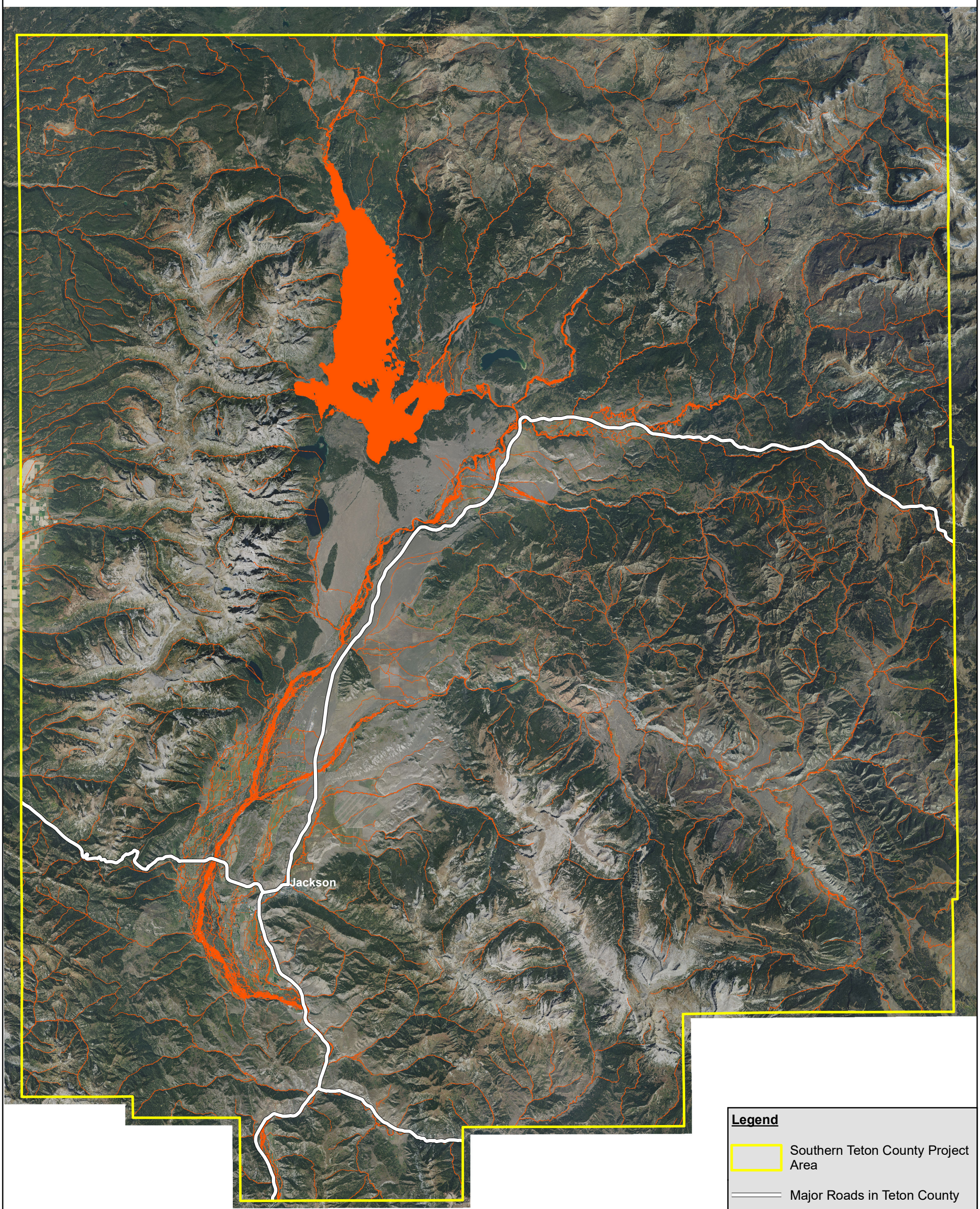
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the Snake River cutthroat trout is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 20:

Snake River Cutthroat Trout Year Round Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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BOREAL CHORUS FROG

Year-round resident in Teton County.

"*Pseudacris triseriata* is a good flagship species for promoting awareness of healthy environments as it is easily heard in spring and its presence indicates the maintenance of natural habitats even in developed areas. In Quebec, it has become a symbol for protection of species at risk and their habitat, especially in suburban areas." (COSEWIC 2008)

Note: *P. triseriata* is either closely related or the same species as *P. maculata*, depending on the taxonomist and the age of the publication.

Important Habitat Characteristics

Wetland breeding habitat

Boreal Chorus Frogs (*Pseudacris maculata*) reproduce in a variety of wetlands with shallow, non-flowing water. Boreal Chorus Frog mate and lay eggs in these aquatic habitats from April to early or mid-June in Teton County. Male Boreal Chorus Frog call loudly at potential breeding sites, creating a notable acoustic feature of Jackson Hole's spring soundscape. Timing of breeding depends on spring weather conditions (air and water temperatures) and site characteristics. Mating is accomplished by the male clinging to the back of the female until she deposits eggs, which are fertilized externally. Egg clusters are attached to vegetation in shallow water. Hatching occurs in 1 to 3 weeks, depending on water temperature. The larvae (tadpoles) inhabit these water bodies until metamorphosis, 6 to 10 weeks after hatching (Werner et al., 2004). After metamorphosis, the tiny frogs (about 0.5" long) promptly emerge from the water and move to terrestrial habitats.

Vegetation type: Emergent vegetation is an essential component of breeding habitat because egg masses are attached to firm stems and leaves under water. Emergent vegetation also provides hiding cover for tadpoles, while allowing sunlight to warm the water. Diverse species of thin-stemmed sedges, rushes, and wetland grasses are the dominant vegetation at breeding sites. Breeding sites have emergent vegetation around the edges, surrounding deeper, open water, or are shallow enough to have emergent vegetation throughout the site. Aquatic vegetation (e.g., pond lilies and other aquatic plants, and algae) typically inhabits deeper portions (> 0.5 m) of water bodies used for breeding. Boreal Chorus Frog breeding populations in Grand Teton and Yellowstone national parks demonstrate increased occupancy of sites with extensive cover by emergent and aquatic vegetation (Gould et al., 2012). At the onset of breeding, breeding sites have decumbent stems from the previous year's growth of emergent vegetation in addition to new spring growth.

Health indicators: The condition of wetland breeding sites can be indicated by emergent vegetation (Pilliod and Wind 2008)

i. Declining water levels can lead to the loss of emergent vegetation around edges of the water body (pond, pool or lake) as it contracts.
ii. A pond that has lost surface water (no longer suitable for Boreal Chorus Frog breeding) but retains subsurface water can convert to a uniform stand of sedges.
iii. Emergent vegetation disappears where drying is severe, indicating that subsurface water is no longer sufficient to sustain a wetland even in wet years.
iv. Patches of emergent vegetation around a water body shrink in size or vanish if subject to intensive disturbance from livestock, wildlife, vehicles or machinery.

Canopy cover: Most Boreal Chorus Frog breeding sites are in open canopy, sunny locations (Ouellet et al. 2009).

The percent cover by emergent and aquatic vegetation within breeding sites is typically >50%. In Grand Teton and Yellowstone national parks, 78% of Boreal Chorus Frog breeding sites had emergent/aquatic vegetation cover of 51 - 100% (NPS, 2016).

Minimum patch area: Very small water bodies can be used for breeding, particularly in dry years and as seasonal wetlands shrink during the summer. Minimum size of water bodies with Boreal Chorus Frog tadpoles in June in a dry year (2015) in Grand Teton and Yellowstone National Parks was as small as 9-10 square meters. Average minimum size of the three smallest occupied water bodies in typical years (2012-2014) was approximately 142 square meters, with a median size of about 800 square meters in June (NPS, 2016).

Disturbance interactions: Seasonal or ephemeral wetlands used for breeding may completely dry up in summer. This is not a problem if metamorphosis is complete (typically by early to mid-July to early August) and may be a benefit because some kinds of predators are much less likely in seasonal water bodies (e.g., predatory fish and aquatic insects). Water bodies that dry up or are drained while tadpoles are still present results in reproductive failure for the year. Boreal Chorus Frog are more strongly affected by drought than other amphibians in this region, because of their frequent reliance on ephemeral water bodies for breeding (Ray et al. 2016). Due to the longevity of adults, which is 5 - 7 years (Muths et al. 2016), populations can sustain occasional reproductive failures.

Tadpoles are vulnerable to potentially high levels of predation from fish, birds, mammals, snakes and aquatic invertebrates. Breeding sites typically are fishless or have zones that are not accessible to fish.

Abiotic factors: Boreal Chorus Frog breeding sites include seasonal, semi-permanent and permanent water bodies, including marshes, vernal pools, ditches, ponds (natural ponds, beaver impoundments and man-made ponds) and the shallow margins of lakes and reservoirs (Hammerson 1999). Almost any shallow water body (e.g., < 0.5 m water in a portion or all of the water body) with emergent vegetation may be used for reproduction (Werner et al. 2004). The species is considered widespread or even ubiquitous in wetlands of the Greater Yellowstone Ecosystem, with no reports of declines in breeding occupancy on federal lands (Peterson and Koch 1995; Gould et al. 2012; Hossack et al. 2015; Ray et al. 2016).

Slope: Water bodies used for breeding are on flat or gentle topography due to the requirement of stagnant or nearly-stagnant water. Steep slopes encourage formation of streams rather than the ponded water required for breeding.

Aspect: Amphibians in this region often use the north side of water bodies for egg laying because snow melts earlier in this zone and the water warms up more quickly in spring. After hatching, tadpoles disperse throughout the water body (D. Patla, personal observ). Water bodies that are shaded much of the day by forests or topography are less suitable than sites with abundant sunshine (Werner et al. 2009).

Elevation range: Breeding sites are found from the valley floor (about 6000') to 9400' elevation (Koch and Peterson, 1995).

Stream order: Wetlands in proximity of any stream order may be suitable.

Water temperature: Cold water inhibits development of eggs (embryos) and tadpoles. Presumably, breeding adults avoid spring-fed pools or springs where water temperatures remain low (e.g. <10 - 12°C). Tadpoles seek out the warm portions of water bodies: shallow zones on sunny days and deeper

zones on cold nights. In Quebec, water temperatures at breeding sites varied from 12 to 19°C (Ouellet et al., 2009). In Yellowstone and Grand Teton amphibian monitoring surveys, the lowest water temperature of a water body occupied by Boreal Chorus Frog tadpoles was recorded as 4°C and the average summer temperature (mid-June and July) was 19.1 °C (N=1149 measurements taken during the day at breeding sites from 2006 through 2016, sd = 5.0°C [NPS, 2016]). In terms of upper temperature limits, tadpoles do not tolerate temperatures greater than about 38°C (Hammerson, 1999).

Water depth: Egg deposition takes place in water that is 0.5 m or less (Corkran and Thoms, 2006). Most Boreal Chorus Frog breeding sites have a maximum depth of 1 m or less, but deeper water bodies with shallow portions are also used (NPS, 2016).

Summer habitat

Boreal Chorus Frog adults migrate from aquatic breeding sites after breeding, spending the remainder of the active (warm) season in upland terrestrial areas. Young of the year migrate away from breeding sites immediately following the completion of metamorphosis (typically July - early August). Due to their small size and cryptic behavior, adult and juvenile Boreal Chorus Frog are infrequently observed in their summer habitats (Koch and Peterson, 1995). Boreal Chorus Frog adults are too small to carry radio transmitters tracking their movements, so precise information on summer habitat use is scant.

Dominant Vegetation: Summer habitat includes a wide variety of types, including wet meadows, grasslands, shrublands, open woodlands including aspen and conifers and urban environments with suitable habitat of these types. Open, moist areas in proximity to breeding sites is regarded as the best descriptor, rather than any specific classification of habitat type (COSEWIC, 2008). Descriptions of micro-sites where Boreal Chorus Frog are found include leaf litter, cracks in the ground, under logs and woody debris (Moriarty and Lannoo, 2005)

Canopy cover: Relatively open canopy that allows sunlight penetration and high levels of ground cover (Ouellet et al., 2009)

Minimum patch area: Based on the low end of summer movement distances by adult Boreal Chorus Frog (100 m), minimum patch area of summer habitat around breeding sites is about 31,400 square m (7.8 acres), calculated as the area of a circle around the center of the breeding site. Reported home range size varies from 641 m^2 to 6024 m^2, with a mean of 2117 m^2 (COSEWIC, 2008).

Disturbance interactions: Disturbances that remove ground cover result in reduced survivorship and decrease connectivity among suitable habitat patches that enable persistence of populations over time. Spring and early summer flooding that increases moisture through the summer in zones around breeding sites probably benefits Boreal Chorus Frog adults and juveniles, while drought has adverse effects.

Abiotic factors: Of most relevance is the existence of suitable habitats (in terms of ground cover and moisture) in proximity to breeding sites, rather than slope, aspect, etc. In Montana, adult Boreal Chorus Frog are described as ranging up to 800 m or more from breeding sites (Werner et al., 2004). In Colorado, Boreal Chorus Frogs are said to range within about 700 m of breeding sites (Hammerson, 1999). For a closely related species (*P. triseriata*), the literature describes movements to summer habitat as being mostly within about 100 meters of the breeding site, with some individuals moving over 200 m (COSEWIC, 2008 and sources therein). In northeast Alberta, chorus frogs were not found more than 100 m from the breeding sites (Ouellet et al., 2009). Mean dispersal distance for *P. triseriata* in Michigan was considered to be within 100-150 m based on review of existing information (Werner et al., 2009).

Winter habitat

In cold climates, Boreal Chorus Frog hibernate for more than half the year (Muths et al., 2016). Boreal Chorus Frogs are among a small number of amphibian species (four or five frog species) that have freeze tolerance, meaning physiological adaptations that allow them to survive sub-zero temperatures and freeze-thaw cycles during hibernation. While frozen, breathing, heartbeat and blood flow cease (Pinder et al., 1992).

Boreal Chorus Frogs hibernate in terrestrial habitats at or near the soil surface, described as under rocks and logs, in leaf litter and loose soil under snow, in tree roots and in animal burrows. Jackson Hole residents occasionally find Boreal Chorus Frog in late fall, winter, or early spring in or near their houses or out-buildings, such as in garages, basements and in the associated features of building foundations or irrigation systems.

Vegetation type: Characteristics of vegetation type that provide winter habitat include ample amounts of woody debris, vegetative litter and non-compacted soils.

Abiotic factors: General proximity to foraging and breeding sites, in combination with suitable micro-sites, are likely the most important factors. Some research suggests that Boreal Chorus Frogs (or closely related species) hibernate within 100 m of breeding sites (COSEWIC, 2008 and sources therein).

Migration Corridors

Boreal Chorus Frogs migrate from their hibernation sites to aquatic breeding sites (wetlands) in spring. After breeding, adults migrate from breeding sites to summer foraging habitats and from there to over-wintering sites. Following metamorphosis, young of the year Boreal Chorus Frogs migrate away from the aquatic sites to upland areas for foraging and hibernation. Mass migrations (many frogs going to the same place at the same time) are not thought to occur (Moriarty and Lannoo, 2005). Boreal Chorus Frogs individually migrate or disperse considerable distances relative to their small body size (moving 100 m - 800 m, see summer habitat section above). Corridors of natural vegetation (such as riparian zones, grass-forb meadows and moist forests) that link core habitat patches occupied by Boreal Chorus Frogs boost the probability that an area with human developments can sustain this and other amphibian species (Pilliod and Wind, 2008).

Barriers: Disturbed and developed areas lacking vegetative ground cover; managed landscapes with fertilizer or herbicides toxic to frogs; vertical surfaces that frogs cannot climb (e.g. smooth wall, plastic erosion barriers); bridges and culverts not allowing frog passage (due to high water velocity or abrupt drops in water level); roads and pathways (which inhibit frog movements and result in high mortality where frogs attempt to cross); large or swift water bodies (Boreal Chorus Frogs are not good swimmers).

Risk Factors to Habitat/ Habitat Function

Habitat loss and degradation due to urbanization and agriculture are a leading cause of amphibian population declines occurring in the US and worldwide. To conserve semi-aquatic species such as the Boreal Chorus Frogs in areas subject to land use changes, core habitat must be protected. Core habitat for Boreal Chorus Frog consists of aquatic wetland breeding sites surrounded by terrestrial zones of upland habitat used by the frogs for summer foraging and for hibernation. Upland habitat is harder to define and map than wetland breeding habitat and thus is often overlooked by land managers and conservation planners (Semlitsch and Jensen, 2001; Semlitsch and Brodie, 2003). Maintaining adequate terrestrial habitat for juvenile and adult segments of Boreal Chorus Frog populations is critical to avoid local extinctions (Werner et al., 2009).

To retain populations of this species, existing information suggests that a minimum of 100 m should be protected from the edge of wetland breeding sites, extending to 200 m or more if portions of the upland area around breeding sites are degraded or subject to disturbance. The highest concentration of Boreal Chorus Frogs moving to and from the breeding site occurs immediately around the water body used for breeding; one study reported that most frogs were found within 20 m of the water margin (Ouellet et al., 2009). The upland zone (100 m or more) has two purposes: (1) It provides critical habitat where adults and juveniles forage and overwinter (although some individuals may be traveling much farther from wetland breeding sites if possible) and (2) it can protect the aquatic breeding habitat from harmful inputs. Furthermore, a buffer zone around the upland habitat would serve to protect core terrestrial habitat from pollutants and encroachment (Semlitsch and Jensen, 2001); a buffer of 50 m is generally recommended (USDA NRDC Iowa)

Risk factors in wetland breeding habitat:

1) Wetland fill and conversion. This is the most common and destructive risk factor in urbanizing environments. Small, seasonal wetlands may not be mapped and thus are not visible during the planning stage of projects.

2) Loss of wetlands with suitable characteristics for Boreal Chorus Frog breeding. Drought and water diversions or other hydrological alterations can shrink aquatic water bodies or cause them to dry prematurely. Shallow wetlands used by Boreal Chorus Frogs are at high risk from on-going climate change and repeated droughts (Ray et al., 2016).

3) Pollutants inadvertently entering the water body from adjacent land uses (Pilliod and Wind, 2008). Of particular concern are runoff of nitrogen-based fertilizer, herbicides and pesticides not intended for use in aquatic areas and illegal dumping of petroleum products (e.g., motor oil) and waste materials (such as recreational vehicle holding tanks). Nitrogenous fertilizers can exert a spectrum of adverse impacts, from directly lethal to indirect ecological effects (Murphy et al., 2000). The risk of contaminants can be avoided or minimized by protecting upland terrestrial Boreal Chorus Frog habitat (100 - 300 m) surrounding breeding sites.

4) Application of pesticides to kill mosquitos. Products used by Teton County Weed and Pest (A. Girard, pers comm 2016) include the following:

    a) The larvicide *Bacillus thuringiensis var. israelensis* (Bti) has been used in Teton County for several decades and worldwide for over 50 years and is regarded as benign for amphibians at levels expected in treated wetlands (A. Girard, pers comm 2016). Researchers caution that further investigation is needed to understand the eco-toxicological risk of frequent application in urban/suburban water bodies (Lajmanovich et al., 2015)

    b) The product used to control mosquito pupae, Agnique (a surfactant film), has no information or data available about ecological effects (Material Data Safety Sheet for Agnique)

    c) The product used to control adult mosquitos, Aquahalt, contains natural pyrethrin, which may or may not have adverse effects on amphibians, depending on the limited research available (O'Brien et al., 2013). Piperonyl butoxide, the other main ingredient of Aquahalt, is known to be toxic to amphibians at relatively low concentrations (EPA, 2006). Direct application of pyrethrin/piperonyl butoxide to water is not used by the Teton County Weed and Pest District (A. Girard, *2016 pers. commun.*); however, adult and juvenile amphibians in terrestrial habitats are vulnerable, as are tadpoles in wetlands where unintentional aerial drift of pesticide occurs (Quarles, 2015).

5) Herbicides. Many different herbicide formulations are approved for use in wetland environments (A. Girard, pers comm 2016). In addition, pesticides not approved for aquatic use frequently find their way into wetlands via wind and runoff, with lethal and sublethal effects to amphibians (Quarles, 2016 and sources therein). Aquatic glyphosate (i.e. Rodeo) is recommended for use in wetlands by Teton County Weed and Pest District on rare occasions (A. Girard, pers comm 2016). Glyphosate itself appears to be benign, but surfactants added to some glyphosate formulations are a major concern, with lethal effects to chorus frog tadpoles (Battaglin, *2016 pers. commun.*; Relyea, 2005). Toxic effects of glyphosate formulations are disputed by industry researchers, complicating the task of determining risks (Quarles, 2016).

6) Removal of emergent and aquatic vegetation (by nob-chemical means). Aquatic vegetation eradication results in the loss of egg deposition sites for Boreal Chorus Frogs, food resources (tadpoles graze on organisms growing on plant surfaces) and hiding cover. Eradication or reduction of algae adversely affects tadpole growth and development by diminishing food and oxygen. The decay of algae and aquatic plants killed by herbicides can result in lethal hypoxic or anoxic conditions for tadpoles (Murphy et al., 2000).

7) Aquatic diseases affecting amphibians that are spread by humans working in or traversing wetlands. This risk can be avoided or minimized by cleaning and disinfecting foot wear and gear between visits to wetlands.

8) Extirpation and removal of beavers. Beavers create and maintain aquatic wetland habitats (Hossack et al., 2015) beneficial to amphibians.

9) Introduction of predatory (game) fish to manmade ponds and natural water bodies.

10) Isolation from other wetland breeding habitat patches. This prevents the colonization of suitable, unoccupied habitat and re-colonization where a local population is extirpated (Gould et al., 2012; Werner et al., 2009).

Risk factors in summer habitat:

1) Roads, pathways and parking areas. Boreal Chorus Frogs are slow-moving due to their small size and are easily killed when they try to cross areas used by wheeled vehicles. Risk increases with traffic volume. Roads also fragment habitat and pose migration barriers.

2) Vegetation treatments. A wide variety of chemicals are likely used by Teton County landowners. Herbicides and nitrogen-based fertilizers applied to upland habitat can be directly toxic to amphibians and have indirect adverse effects (Murphy et al., 2000). Sublethal effects from pesticides include changes in amphibian growth and development, reproductive failures, increased predation, endocrine system disruption and depressed immune systems (Quarles, 2016 and sources therein). Adult amphibians in terrestrial environments are particularly vulnerable to chemicals (compared to other vertebrates) because of their permeable skin, but exposure and toxicity information for amphibians is remarkably scarce (Bruhl et al., 2011). Furthermore, combinations of chemicals present in the environment and interactions with environmental variables (such as pH and the presence of disease organisms) pose yet more challenges to amphibian populations (Bruhl et al., 2011; Murphy et al., 2000). Recent research findings emphasize the benefit of reducing pesticide use on land surrounding amphibian habitat to protect the health of amphibian populations (Battaglin et al., 2016).

3) Lawn (and other artificial landscape) maintenance. Mowing can kill frogs and reduce habitat quality (Pilliod and Wind, 2008; USDA NRDC).

4) Invasive, non-native plants can have adverse impacts on amphibians due to declines in arthropod (prey) abundance and changes in microclimates (Maerz et al., 2005; Watling et al., 2011). Limiting introductions of invasive species in addition to preserving native plant/shrub communities in Teton County can reduce this risk.

Risk factors in winter:

The micro-sites needed for overwintering can be eliminated by land uses that reduce vegetation cover (including plant litter, fallen trees and woody debris) and that compact or simplify natural soil conditions (loose soil, rodent burrows, cavities). Examples of such land uses are recreational developments, landscaping, livestock grazing, fuels management and prescribed fire. This risk can be avoided or minimized by maintaining natural vegetation conditions in upland core habitat surrounding potential breeding sites.

Literature Sources

Battaglin, W.A., K.L. Smalling, C. Anderson, D. Calhoun, T. Chestnut, and E. Muths. 2016. Potential interactions among disease, pesticides, water quality and adjacent land cover in amphibian habitats in the United States. Science of the Total Environment. 556-557: 320-332.

Battaglin, W. Personal Communication. Research Hydrologist, U.S. Geological Survey, Denver. Emails 2016.

Bruhl, C.A., S. Pieper, and B. Weber. 2011. Amphibians at risk? Susceptibility of terrestrial amphibian life stages to pesticides. Environmental Toxicology and Chemistry 30 (11): 2465-2472.

Corkran, C.C. and C. Thoms. 2006. Amphibians of Oregon, Washington, and British Columbia, revised and updated. Lone Pine. Edmonton, Alberta, Canada.

COSEWIC. 2008. Assessment and update status report on the Western Chorus Frog *Pseudacris triseriata* Carolinian population and Great Lakes/St. Lawrence B Canadian Shield population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 47 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

EPA. 2006. Reregistration Eligibility Decision (RED) Document for Piperonyl Butoxide (PBO). https://archive.epa.gov/pesticides/reregistration/web/pdf/piperonyl_red.pdf

Girard, A. Personal Communication. Mosquito Program Coordinator, Teton County Weed and Pest. Emails 2016.

Gould, W.R., D.A. Patla, R. Daley, P.S. Corn, B.R. Hossack, R. Bennetts, & C.R. Peterson. 2012. Estimating occupancy in large landscapes: evaluation of amphibian monitoring in the Greater Yellowstone Ecosystem. Wetlands (2012): Volume 32, Issue 2, Pages 379-389.

Hammerson, G.A. 1999. Amphibians and Reptiles in Colorado, 2nd edition. University Press of Colorado & Colorado Deivison of Wildlife, Niwot, CO.

Hossack, B.R., W.R. Gould, D.A. Patla, E. Muths, R. Daley, K. Legg, and P.S. Corn. 2015. Trends in Rocky Mountain amphibians and the role of beaver as a keystone species. Biological Conservation 187:260-269.

Koch, E.D. and C.R. Peterson 1995. Amphibians and Reptiles of Yellowstone and Grand Teton National

Lajmanovich, R.C., C.M Junges, M.C. Cabagna Zenklusen, A.M. Attademo, P. M. Peltzer, M. Maglianese, V.D. Márquez , and A.J. Beccaria. 2015. Toxicity of Bacillus thuringiensis var. israelensis in

aqueous suspension on the South American common frog Leptodactylus latrans (Anura: Leptodactylidae) tadpoles. Environmental Research 136:205 12.

Maerz, J. C., B. Blossy, and V. Nuzzo. (2005). Green frogs show reduced foraging success in habitats invaded by Japanese knotweed. Biodiversity and Conservation 14: 2901-2911.

Moriarty, E. and M.J. Lannoo. 2005. Pseudacris triseriata complex (including feriarum, kalmi, triseriata, and maculata). Species account, pages 485-488 in M. Lannoo (editor). Amphibian Declines: the conservation status of United Stated Species. University of California Press, Berkeley, CA.

Murphy, J.E., C.A. Phillips, and V.R. Beasley. 2000. Aspects of amphibian ecology. Pages 141- 178 in D.W. Sparling, G. Linder, C.A. Bishop, editors. Ecotoxicology of amphibians and reptiles. Pensacola, FL: Society of Environmental Toxicology and Chemistry (SETAC).

Muths, E., R.D. Scherer, S.M. Amburgey, T. Matthews, A.W. Spencer, and P.S. Corn. 2016. First estimates of the probability of survival in a small bodied, high elevation frog or, how historical data can be useful. Canadian Journal of Zoology 94(9): 599 606.

National Park Service (NPS). 2016. Summary of amphibian habit features provided to Focal Habitat Feature Identification Project, Teton County, Wyoming. Rocky Mountain ARMI Database - accessed October 2016. NPS Greater Yellowstone Network, Bozeman, Montana.

O'Brien, C.D., J.E. Hall, C.T. O'Brien, D. Baum, and L. Ballantyne. 2013. Impact of a natural pyrethrin biocide on two amphibians, common toad *Bufo bufo* and palmate newt *Lissotriton helveticus*, in Highland, UK. Conservation Evidence10: 70-72

Ouellet, M., C. Fortin, and M.J. Grimard. 2009. Distribution and habitat use of the boreal chorus frog (Psuedacris maculata) at its extreme northeastern range limit. Herpetological Conservation and Biology 4(2):277-284.

Pilliod, D.S., and E. Wind (editors). 2008. Habitat management guidelines for amphibians and reptiles of the Northwestern United States and Western Canada. Partners in Amphibian & Reptile Conservation, Tech Pub HMG-4, Birmingham, AL.

Pinder, A. W., K.B. Story, and G.R. Ultsch. 1992. Estivation and hibernation, pages 250-274 in M.E. Feder and W.W. Burggren (editors). Environmental Physiology of the Amphibians. University of Chicago Press.

Quarles, W. 2015. Pesticides and amphibian decline. Common Sense Pest Control XXIX (1-4) Special Issue: 3-19.

Relyea, R. 2005. The impact of insecticides and herbicides on the biodiversity of aquatic communities. Ecological Applications, 15(2): 618–627.

Semlitsch, R.D., and J.B. Jensen. 2001. Core habitat, not buffer zone. National Wetlands Newsletter: 23 (4): 5-11.

Semlitsch, R.E., and J.R. Brodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219–1228.

USDA, Natural Resources Conservation Service Iowa. (No date). Restoring and managing habitat for reptiles and amphibians. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/home/?cid=nrcs142p2_008529

Watling, J. I., C. R. Hickman and J. L. Orrock. 2011. Invasive shrub alters native forest amphibian communities. Biological Conservation. 144: 2597-2601.

Werner, E. E., R. A. Relyea, K. L. Yurewicz, D. K. Skelly, and C. J. Davis. 2009. Comparative landscape dynamics of two anuran species: climate-driven interaction of local and regional processes. Ecological Monographs 79:503–521

Werner, J.K., B.A Maxell, P. Hendricks, and D.L. Flath. 2004. Amphibians and reptiles of Montana. Mountain Press Publishing, Missoula, MT.

Habitat Characteristics

No known habitat model exists for Boreal Chorus Frog in Teton County, WY.

The scale of habitat for amphibians is obviously significantly smaller than the scale of habitat for larger animals. Nonetheless, there are landscape features which we are likely able to map that will construct a potential habitat map for the Boreal Chorus Frog. However, in addition to the map, the information contained within this narrative could be immensely helpful when developing land development regulations as they apply to wetland areas. Of primary concern with the variables listed below is breeding habitat and the surrounding terrestrial zone.

For the purposes of evaluating riparian and wetland habitat and development impacts adjacent to Boreal Chorus Frog habitats on private lands in Teton County, a site-specific assessment is recommended.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Breeding	Cover Types	NWI, NHD, TC Veg Cover	Wet areas including ephemeral areas if possible	NPS, 2016
Breeding	Flood Zones	Flood maps	10 year flood-zones	D Patla, *pers commun.*
Breeding	Highest value habitat	Create	>100 m from wetland edge	COSEWIC, 2008
Summer and Winter	Non-breeding Habitat	Create	Buffer breeding habitat patch by 200 m	COSEWIC, 2008

Contributors

Narrative Author: Debra Patla has conducted amphibian surveys and monitoring annually since the mid-1990s in Yellowstone, Grand Teton, and the National Elk Refuge, in addition to survey work on the Bridger-Teton National Forest and other land management units. She received her MS in Biology from Idaho State University in 1996; with thesis research on the habitat-related decline of a Columbia Spotted Frog population in central Yellowstone National Park. She has written and co-authored numerous reports and publications on amphibians in the Greater Yellowstone Ecosystem. She is a Research Associate of the Northern Rockies Conservation Cooperative and is employed as field coordinator of the long-term amphibian monitoring project in Grand Teton and Yellowstone national parks, which is led and managed by the National Park Service Inventory and Monitoring Greater Yellowstone Network (Bozeman, MT). http://science.nature.nps.gov/im/units/gryn/monitor/amphibians.cfm

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Secondary Reviewer: Renee Seidler, NRTAB

Secondary Reviewer: Amy Girard, NRTAB

GIS Methods – Summer & Breeding/ Year-round Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, GRTE, BTNF & CTNF layers, select lakes, ponds, wetlands, herbaceous aquatics From NWI Wetlands select based on flooding regime (4th letter in code) all that are not temporarily flooding (A) or seasonally saturated (B). F, G and H are the most important.	See Definition Query Selection Below	Definition Query for each source then Merge Layers; Dissolve	All summer and breeding veg covers
Limit Cover layers to the Project Area	Clip to Project Area		Clip	Refined Breeding Areas
Veg within 150 m of Important Veg Cover	Buffer wet patches by 150m	Buffer full, planar, dissolve	Buffer and Dissolve	Breeding and non-breeding habitat
Remove Deepwater Habitat	Remove Jackson Lake deepwater habitat	Digitize deep water and remove	Editor; Digitize; Clip	Refined breeding and non-breeding habitat
Convert Shapefile to Raster	Convert breeding and non-breeding habitat shapefile to a raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Important Habitat
Elevation below 9,400 ft	Retain elevations below 9,400 ft (~2,865 m)	VALUE <=2865	Extract By Attribute	Elevations
Extract Important Habitat by Elevation	Important habitat below 9,400 ft	Extract by elevation	Extract By Mask; Reclassify so No Data = 0	Breeding and non-breeding habitat
Compare with WOS and NMJH observations to Output	Compare observations with output.			

Veg Cover Definition Query Categories

Breeding and Summer Cover Type Definition Query
Teton County Map Codes:
Lakes, Ponds and Reservoirs - NLP
Herbaceous Aquatics - HA

Grand Teton Nation Park Map Codes:
Lakes and Reservoirs - NLP
Herbaceous Aquatics - HA

Bridger-Teton National Forest MU CODE:
Water - WA

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Water - WA

NWI Def Query: Removing Fourth Letter As and Bs
Included all but the following were removed: PEM1A, PEM1B, PEMA, PEMB, PEMBb, PFO1A, PFOA, PFOAh, PFOB, PFOBb, PSS1A, PSSA, PSSB, PSSBb, PUSA, PUSAh, PUSAx

Metadata

Title

BCF_Yrd.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Boreal Chorus Frog Year-round, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

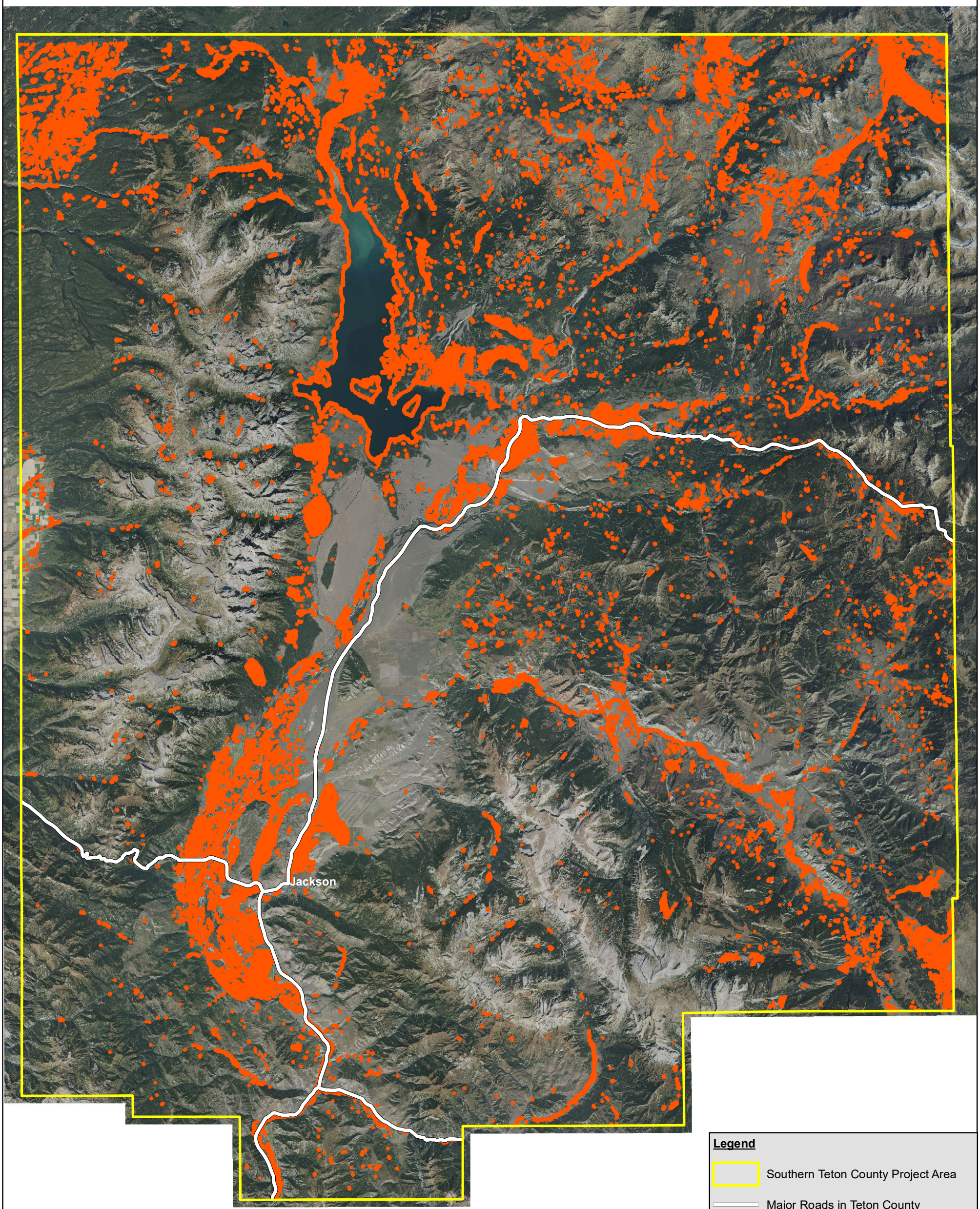
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the boreal chorus frog is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 21:

Boreal Chorus Frog Year Round Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

ALDER ENVIRONMENTAL, LLC
Water • Wetlands • Ecological Consulting
P.O. Box 6519, Jackson, Wyoming 83002
(307) 733-5031 www.alderenvironmental.com

WESTERN TOAD

Year-round resident in Teton County.

Important Habitat Characteristics

Wetland Breeding Habitat

Western toads (*Anaxyrus boreas* formerly *Bufo boreas*) breed in a variety of wetland types containing shallow water. Despite their apparent flexibility in breeding habitat, Western Toad are the least common of the four widespread amphibian species of the Greater Yellowstone Area, with relatively few known breeding sites (Koch and Peterson, 1995; NPS, 2016). Western Toad are thought to have declined in the area since the 1950s and declines in breeding site occupancy have been reported for the years 2002 to 2011 in Grand Teton and Yellowstone National Parks (Koch and Peterson, 1995; Hossack et al, 2015).

In Teton County, the most likely breeding habitat and active breeding sites are along the Snake River and Gros Ventre River, including oxbows and backwater channels and in wetlands of the flood plain near the rivers. This is based on recently documented Western Toad breeding at the R Park (M. Graham and W. Estes-Zumpf, *pers. comm.*) along with observations of toadlets north of the site along the Snake River (reported to B. Raynes and D. Patla in August 2016); on documentation of Western Toad breeding sites in the Snake River floodplain in Grand Teton National Park (Ray and Patla, 2016 and supporting information); on frequent observations of toads along the Snake River south of Wilson (S. Patla, *pers. comm.*) and breeding sites adjacent to and near the Gros Ventre River on the National Elk Refuge (Patla, 2016).

Western Toads congregate at aquatic breeding sites starting in May in Teton County; mating and egg production can extend into June and even July (Patla, 2001). Males lack vocal sacs and produce only soft and sporadic vocalizations, which are not useful as a technique for observers to find breeding sites (compared to Boreal Chorus Frogs). Females extrude eggs while swimming or walking through shallow water; these are fertilized externally by the male clinging to her back. The eggs are in long gelatinous strings, often entangled in vegetation but not purposefully attached to it. Hatching occurs within about 2 weeks. The larvae (tadpoles) inhabit the water body until metamorphosis, about 4 to 14 weeks after hatching (Patla, 2001; Werner et al., 2004), depending on water temperatures. After metamorphosis, the small toads (about 0.5" long or less) promptly emerge from the water at breeding sites and move to other habitats.

Dominant Vegetation: Emergent vegetation (sedges, rushes and grasses) is often present at breeding sites, but is sometimes sparse or absent. No particular species have been identified as important. Egg strands are often entwined around fine-stemmed sedges and rushes, but also are found strewn across the silt, mud, or gravel-covered bottom of shallow water bodies (Koch and Peterson, 1995; D. Patla, *pers. observ.*)

Health Indicators: Loss of shallow water habitat might be indicated by shrinkage or disappearance of emergent vegetation patches.

Canopy Cover: Due to the requirement of sun-warmed water for eggs and tadpoles, low canopy cover from adjacent trees and shrubs is typical. The percent cover in the water body by emergent and aquatic vegetation was found to be >50% at the majority of sites (about 58% of 71 surveyed sites) hosting Western Toad tadpoles in Grand Teton and Yellowstone national parks (NPS, 2016).

Minimum Patch Size: There is no evidence that Western Toads select breeding habitat with respect to size of the water body (Keinath and McGee, 2005). However, habitat data collected in Grand Teton and

Yellowstone National Parks during long-term amphibian monitoring suggest that substantially larger water bodies are used compared to the size of sites used by Boreal Chorus Frogs. The minimum size of a water body with Western Toad tadpoles in June (typically prior to summer shrinkage of wetlands) was 570 $m^{2;}$ (approx. 0.14 ac); however, there are only 22 records in this time frame for the years 2006 -2015 (NPS, 2016). In another data set, where some small pools were occupied by Western Toad tadpoles (e.g., 10 m^2), the pools connected to much larger water bodies including lakes and streams (D. Patla, personal observation and unpublished data).

Disturbance Interactions: This species exhibits very high site fidelity at stable sites; for example, Western Toads have been documented breeding annually since the 1990s at several sites in the Greater Yellowstone Ecosystem, including Nowlin Pond on the National Elk Refuge (D.Patla, unpublished data; Patla, 2016).

On the other hand, Western Toads are known to quickly colonize disturbed wetland sites in a variety of settings; including newly constructed ponds (Pearl and Bowerman, 2006); pooled-water features (e.g., backwater channels and oxbows) along rivers that are created or altered by high flows; gravel pits and quarries; and ponds in dense conifer forests after wildfire (Hossack et al, 2012). Western Toad tadpoles were found in an altered pond in the new R Park near Wilson in 2016 (M. Graham and W. Estes-Zumpf, *pers. comm.*)

Drought conditions causing breeding pools to dry up prior to metamorphosis results in the death of tadpoles and failed reproduction. Rapid decline in water levels can strand eggs and tadpoles and both stranding and freezing temperatures after egg deposition can result in high or total mortality of the embryos (D. Patla, *pers. observ.*).

Abiotic Factors: Breeding sites include a large variety of types, all with shallow stagnant or very slowly moving water including stream and river edges, oxbow ponds and backwater channels, beaver impoundments, ponds and lakes, thermal pools, flooded meadows, seasonal pools and man-made impoundments including reservoirs, ditches and gravel quarries (Patla, 2001; Keinath and McGee, 2005). Riverine wetlands and adjacent wetlands are particularly important for Western Toads in Jackson Hole, along the Snake and Gros Ventre Rivers. Beaver-impounded wetlands are also known to be important, with Western Toad exhibiting increased breeding occupancy and colonization of sites influenced by beavers (Hossack et al, 2015).

Slope: Water bodies used for breeding are on flat or gentle topography due to the requirement of stagnant or nearly-stagnant water. The slope structure of the water body are typically: shallow, slightly sloping shorelines at breeding sites (Bull, 2009).

Aspect: South-facing shorelines at breeding sites are critical, providing the warmth needed by developing and metamorphosing tadpoles (Bull, 2009).

Elevation Range: Breeding sites are found from the valley floor (about 6000') to over 9000' elevation. Most of the known breeding sites on federal lands in Teton County are below 8,000' (NPS, 2016; D. Patla, unpublished data).

Stream Order: Wetlands in proximity of any stream order may be suitable.

Water Temperature: Water temperature governs development and growth rates of eggs and tadpoles. Daytime water temperature at breeding sites in the area ranged from approximately 9° to 33°C (NPS, 2016). Tadpoles seek out the warmest portions of the water body.

Water Depth: Eggs are deposited in shallow water (5 to 50 cm, but mostly less than 20 cm) and typically near shore, within 6 m (Patla, 2001). Tadpoles occupy the shallowest possible water on sunny days, even

at the risk of becoming stranded. Deeper water is occupied by tadpoles at night and during cold weather. Most breeding sites have maximum depths of 0.5 m to 2 m (NPS, 2016).

Water Chemistry: Toad breeding sites typically have relatively high conductivity and high pH (>8.0) (Koch and Peterson, 1995; Klaver et al, 2013).

Summer habitat (after breeding and after tadpole metamorphosis)

Adult toads mostly disperse away from aquatic breeding sites after breeding, particularly the females (Patla, 2001; Keinath and McGee, 2005 and sources therein). Adult Western Toads occupy diverse habitats in summer, including forested and nonforested, wet, moist and even dry areas. They often use underground burrows. Young of the year Western Toads typically leave the breeding site immediately after metamorphosis is complete, dispersing overland or along streams.

Vegetation Type: No particular vegetation type or species have been identified as summer habitat. Toads are found in a wide variety of areas including: wetlands, riparian areas, stream-sides, wet and moist meadows, sagebrush meadows and conifer forests (Koch and Peterson, 1995).

Age Class: Western Toads require areas that protect them from dehydration such as a complex understory with coarse woody debris and underground cavities. Recent clearcuts (<10 years old) are used much less than other habitats by adult toads (Bartelt et al, 2004).

Canopy Cover: Open forests and breaks in the shrub or tree canopy allowing sunlight to reach the ground are regarded as important features since Western Toads prefer habitats that are neither excessively shaded nor sunny (Bartelt et al, 2004; Keinath and McGee, 2005).

Minimum Patch Area: Western Toads travel extensively and the size of the home range post-breeding is thought to be related to habitat quality, number of toads in the population and gender of adults (Keinath and McGee, 2005). A minimum patch size has not been identified.

Disturbance Interactions: Disturbances that remove and simplify ground cover and/or reduce moisture adversely affect post-breeding summer habitat. Spring and early summer flooding that increases moisture would be beneficial. Summer drought probably stresses Western Toads by reducing suitable habitat.

Abiotic Factors: Rather than aspect and other factors, of most relevance is the existence of suitable habitats (in terms of ground cover and moisture) within range of breeding sites. Slope does not appear to deter toad movements in upland habitats (Keinath and McGee, 2005). Adult Western Toads travel large distances relative to their size. Researchers variously report average or median distances moved in summer by radio-tracked adults as between 580 m and 2.9 km (Bartelt et al, 2004; Schmetterling and Young, 2008). Juvenile Western Toads can also disperse far from breeding sites in the few weeks between metamorphosis and hibernation. Young-of-year toadlets traveled 800 m or more (straight-line distance upstream) in Grand Teton National Park in August-September 2016 (D. Patla, unpublished data) and up to 1250 m downstream of a breeding site on the National Elk Refuge (Patla, 2016).

Winter habitat

Western Toads do not tolerate freezing. They hibernate below the frost zone in a variety of places, including rodent burrows, in and under root systems of conifer trees, in cavities and chambers along streams, under natural debris piles (such as rockslides and downfall trees), in man-made wood slash piles and possibly in beaver dams and lodges where flowing water would keep the air above freezing (Muths and Nanjappa, 2005 and sources therein; Keinath and McGee, 2005).

Vegetation Type: Vegetation type is non-specific. Characteristics of vegetative communities that provide winter habitat may include large amounts of woody debris, large trees (standing or down) that provide accessible root systems, occupation by burrowing rodents and non-compacted soils.

Abiotic Factors: General proximity to the breeding sites for adult Western Toads, in combination with suitable micro-sites, are likely the most important factors. Abiotic factors relating to non-compacted soils and underground refugia such as cracks in the substrate, rock piles, underground cavities and stream channels with natural (not degraded) banks may benefit Western Toad survival through the winter.

Migration Corridors

This highly mobile species exhibits several kinds of migration. Adults move from winter sites to wetland breeding sites in spring, from breeding sites to summer foraging areas and from summer range to winter sites. Young of the year migrate or disperse from the breeding sites where they metamorphose to winter refugia. While adults migrate individually rather than in groups, mass migrations of toadlets (many hundreds or thousands of animals) have been observed in late summer, both in terrestrial areas and along stream corridors (D. Patla, unpublished data; Patla, 2016). Stream corridors appear to be particularly important for young toads (Bull, 2009).

Barriers: Inhospitable conditions present barriers to migrations, such as disturbed areas lacking vegetative ground cover, managed landscapes with fertilizer or herbicides toxic to amphibians and frequently trafficked roads and parking areas. Some kinds of bridges and culverts present barriers, particularly if toads are moving upstream, because high velocity water and even small cascades can prevent movements if the animals are unable to travel next to the stream or river (D. Patla, personal observ). Vertical structures such as smooth walls, pipelines and plastic erosion barriers installed for construction projects can obstruct migratory movements. Pits and holes with vertical sides can lethally trap Western Toads unable to climb out. Research on landscape genetics of Western Toads in Yellowstone National Park revealed that connectivity for Western Toad populations was negatively affected by roads and development, low moisture conditions and major topographic features such as ridge lines (Murphy et al, 2010).

Risk Factors to Habitat/ Habitat Function

Habitat loss and degradation due to urbanization and agriculture are seen as leading cause of amphibian population declines occurring in the US and worldwide. To conserve semi-aquatic species such as the Western Toad in areas subject to land use changes, core habitat must be protected.

Core habitat consists of aquatic breeding sites surrounded by terrestrial habitat used for summer foraging for hibernation. The biological interdependence of aquatic and terrestrial habitats is regarded as essential for amphibian population persistence, but terrestrial habitat for amphibians is often overlooked by managers and conservation planners, partly because it is harder to define and map (Semlitsch and Jensen, 2001; Semlitsch and Brodie, 2003).

Researchers recommend protecting 150-200 m of terrestrial habitat surrounding Western Toad aquatic breeding sites, measured from the edge of the wetland (Bartelt et al, 2004; Semlitsch and Jensen, 2001). While this zone will not protect all individuals, it may protect the majority. Bartelt et al. (2004) found that 60% of adult Western Toads remained within 200 m of the breeding pond in an eastern Idaho (Targhee NF) population. Furthermore, a buffer zone around the core terrestrial habitat, generally recommended as 50 m, could be sized with respect to the adjacent land uses (Semlitsch and Jensen, 2001).

Connectivity with public lands managed for natural environments (e.g., national forest and park lands) and with Teton County's streams and rivers would be extremely valuable for this species, particularly where aquatic breeding sites are hemmed in by private land uses that restrict the amount of terrestrial core habitat available.

Most of the risk factors described below can be avoided by identifying and protecting aquatic breeding habitat (ponds, pools, etc. used for egg deposition and by tadpoles) and the surrounding terrestrial zone used by juvenile and adult Western Toads.

Risk factors in wetland breeding habitat

1. Wetland fill and conversion. This is the most common and destructive risk factor in urbanizing environments.

2. Loss of active breeding sites in Teton County. Because known breeding sites are few in number, loss of one or more major breeding (source) sites could adversely affect the probability that the species will persist on non-federal lands in the County.

3. Reduced number of wetlands with suitable characteristics for Western Toad breeding. Drought and water diversions or other hydrological alterations can shrink the aquatic water bodies or cause them to dry prematurely.

4. Pollutants inadvertently entering the water body from adjacent land uses (Pilliod and Wind, 2008). Of particular concern are runoff of nitrogen-based fertilizer, herbicides and pesticides not intended for use in aquatic areas and illegal dumping of petroleum products (e.g. motor oil) and waste materials (such as recreational vehicle holding tanks). Nitrogenous fertilizers can exert a spectrum of adverse impacts, from directly lethal to indirect ecological effects (Murphy et al, 2000). The risk of contaminants can be avoided or minimized by protecting upland terrestrial Western Toad habitat (200 - 300 m) surrounding breeding sites.

5. Application of pesticides to kill mosquitos. Products used by Teton County Weed and Pest (A. Girard, *pers. comm.*) include the following:

a. The larvicide *Bacillus thuringiensis var. israelensis* (Bti) has been used in Teton County for several decades and worldwide for over 50 years and is regarded as benign for amphibians at levels expected in treated wetlands (A. Girard, *pers. comm.*). Researchers caution that further investigation is needed to understand the eco-toxicological risk of frequent application in urban/suburban water bodies (Lajmanovich et al, 2015)

b. The product used to control mosquito pupae, Agnique (a surfactant film), has no information or data available about ecological effects (Material Data Safety Sheet for Agnique)

c. The product used to control adult mosquitos, Aquahalt, contains natural pyrethrin, which may or may not have adverse effects on amphibians, depending on the limited research available (O'Brien et al, 2013). Piperonyl butoxide, the other main ingredient of Aquahalt, is known to be toxic to amphibians at relatively low concentrations (EPA, 2006). Direct application of pyrethrin/piperonyl butoxide to water is not used by the Teton County Weed and Pest District (A. Girard, *pers. commun.*). However, adult and juvenile amphibians in terrestrial habitats are vulnerable to mosquito pesticide applications, as are tadpoles in wetlands, where unintentional aerial drift of pesticide occurs (Quarles, 2015).

6. Herbicides. Many different herbicide formulations are approved for use in wetland environments (A. Girard, pers. comm.). In addition, pesticides not approved for aquatic use frequently find their way into wetlands via wind and runoff, with lethal and sublethal effects to amphibians (Quarles, 2015 and

sources therein). Aquatic glyphosate (i.e. Rodeo) is recommended for use in wetlands by Teton County Weed and Pest District on rare occasions (A. Girard, pers. comm.). Glyphosate itself appears to be benign, but surfactants added to some glyphosate formulations are a major concern, with lethal effects to toad tadpoles (Battaglin, *pers. commun.*; Relyea, 2005). Toxic effects of glyphosate formulations are disputed by industry researchers, complicating the task of determining risks (Quarles, 2015).

7. Removal of emergent and aquatic vegetation (by non-chemical means). Aquatic vegetation eradication results in the loss of food resources (tadpoles graze on organisms growing on plant surfaces) and hiding cover. Eradication or reduction of algae adversely affects tadpole growth and development by diminishing food and oxygen. The decay of algae and plants killed by herbicides can result in lethal hypoxic or anoxic conditions for tadpoles (Murphy et al, 2000).

8. Aquatic diseases affecting amphibians that are spread by humans working in wetlands. Of particular concern for Western Toads are chytrid disease and ranavirus (Patla et al, 2016). This risk can be avoided or minimized by cleaning and disinfecting foot wear and gear between visits to wetlands.

9. Extirpation and removal of beavers. Beavers create and maintain aquatic wetland habitats that are highly favored by breeding Western Toads (Hossack et al, 2015).

10. Introduction of fish to manmade ponds and natural water bodies. Western Toads are not very palatable to fish, but diseases can be introduced by hatchery fish (Patla et al, 2016).

11. Isolation from other wetland breeding habitat patches. This prevents colonization of suitable, unoccupied habitat and re-colonization if the local population is extirpated.

12. Livestock risks include lethal trampling by cattle and sheep around the edges of breeding sites plus the loss of vegetative cover, fecal contamination and soil compaction (Keinath and McGee, 2005).

Risk factors in summer habitat:

1. Roads, pathways and parking areas. Western Toads are easily killed when they try to cross areas used by wheeled vehicles. Risk increases with traffic volume. Roads fragment habitat and pose migration barriers. Mortality of toads on roads has been observed in Teton County (a picnic area near Jackson Lake in Grand Teton National Park, Missoulian 2014), on the National Elk Refuge (Patla, 2016) and elsewhere in the western U.S. (Bull, 2009).

2. Bridges and culverts can pose barriers to Western Toads migrations and movements. For example, a mass migration of Western Toads young-of-the year upstream on Arizona Creek in Grand Teton National Park was partially blocked by water flow in a box culvert in late summer 2016 (D. Patla, personal observation and unpublished data). Amphibian-friendly designs are available from Ontario Ministry of Natural Resources & Forestry (2016) and the USDA (2008).

3. Vegetation treatments. A wide variety of chemicals are likely in use by Teton County landowners. Herbicides and nitrogen-based fertilizers applied to upland habitat can be directly toxic to amphibians and have indirect adverse effects (Murphy et al. 2000). Sublethal effects from pesticides include changes in amphibian growth and development, reproductive failures, increased predation, endocrine system disruption and depressed immune systems (Quarles 2015 and sources therein). Adult amphibians in terrestrial environments are particularly vulnerable to chemicals (compared to other vertebrates) because of their permeable skin, but exposure and toxicity information for amphibians is remarkably scarce (Bruhl et al, 2011). Furthermore, combinations of chemicals present in the environment and interactions with environmental variables (such as pH or the presence of disease organisms) pose yet more challenges to amphibian populations (Bruhl et al, 2011; Murphy et al, 2000). Recent research

findings emphasize the benefit of reducing pesticide use on land surrounding amphibian habitat to protect the health of amphibian populations (Battaglin et al, 2016).

4. Lawns and other artificial landscape maintenance. Mowing can kill Western Toads and reduce habitat quality (Pilliod and Wind, 2008; USDA, 2008).

5. Invasive and non-native plants can have adverse impacts on amphibians due to declines in arthropod (prey) abundance and changes in microclimates (Maerz et al, 2005; Watling et al, 2011). Limiting introductions of invasive species in addition to preserving native plant/shrub communities in Teton County can reduce this risk.

6. Pets (dogs). Western Toads are attractive as prey or play things to off-leash dogs and are easily killed or injured by dogs. Toxic excretions in the skin of toads pose a risk to dogs that bite them and can result in an expensive trip to the vet and stressful experience for dog owners witnessing the distress of their pets (which includes foaming at the mouth).

7. Fuels management. Western Toad foraging areas and micro-refuges are lost due to the removal of trees, understory, shrubs and woody debris and conversion of moist areas to dry areas (Keinath and McGee, 2005).

Risk factors in winter:

The micro-sites needed for overwintering under the frost zone can be eliminated by land uses that compact or simplify natural soil conditions (affecting rodent burrows, underground cavities, rock piles and downfall trees) or that modify stream bank structure in ways that eliminate bank cavities. Examples of such land uses are recreational developments, landscaping, livestock grazing in riparian areas, logging and prescribed fire. This risk can be avoided or minimized by maintaining natural vegetation conditions in upland core habitat surrounding potential breeding sites and by providing connectivity from breeding sites to blocks of land where natural conditions prevail.

Literature Sources

Bartelt, P, C Peterson and R Klaver. 2004. Sexual differences in the post-breeding movements and habitats selected by Western Toads (*Bufo boreas*) in southeastern Idaho. Herpetological 60(4): 456-467.

Battaglin, W, K Smalling, C Anderson, D Calhoun, T Chestnut and E Muths. 2016. Potential interactions among disease, pesticides, water quality and adjacent land cover in amphibian habitats in the United States. Science of the Total Environment 556-557: 320-332.

Battaglin, W. Personal Communication. Research Hydrologist, U.S. Geological Survey, Denver. Emails 2016.

Bruhl, C, S Pieper and B Weber. 2011. Amphibians at risk? Susceptibility of terrestrial amphibian life stages to pesticides. Environmental Toxicology and Chemistry 30 (11): 2465 2472.

Bull, E. 2009. Dispersal of newly metamorphosed and juvenile western toads (Anaxyrus boreas) in northeastern Oregon, USA. Herpetological Conservation and Biology 4(2):236-247.

EPA. 2006. Reregistration Eligibility Decision (RED) Document for Piperonyl Butoxide (PBO). List B Case No. 2525. Date: June 14, 2006 https://archive.epa.gov/pesticides/reregistration/web/pdf/piperonyl_red.pdf

Estes-Zumpf, W. Personal Communication. Wyoming Game & Fish Department. Emails 2016.

Girard, A. Personal Communication. Mosquito Program Coordinator, Teton County Weed and Pest. Emails 2016.

Graham, M. Personal Communication. Teton Conservation District. Emails 2016

Hossack, B, W. Lowe and P Corn. 2012. Rapid Increases and Time-Lagged Declines in Amphibian Occupancy after Wildfire. Conservation Biology, Volume 27, No. 1, 219–228.

Hossack, B, W Gould, D Patla, E Muths, R Daley, K Legg, and P Corn. 2015. Trends in Rocky Mountain amphibians and the role of beaver as a keystone species. Biological Conservation 187:260-269.

Keinath, D and M McGee. 2005. Boreal Toad (*Bufo boreas boreas*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. http://www.fs.fed.us/r2/projects/scp/assessments/borealtoad.pdf

Klaver, R, C Peterson and D Patla. 2013. Influence of water conductivity on amphibian occupancy in the Greater Yellowstone Ecosystem. Western North American Naturalist 73(2): 184–197.

Koch, E and C Peterson 1995. Amphibians and Reptiles of Yellowstone and Grand Teton National Parks. University of Utah Press, Salt Lake City, UT.

Lajmanovich, R, C Junges, M Cabagna-Zenklusen, A Attademo, P Peltzer, M Maglianese, V Márquez , and A Beccaria. 2015. Toxicity of Bacillus thuringiensis var. israelensis in aqueous suspension on the South American common frog *Leptodactylus latrans* (Anura: Leptodactylidae) tadpoles. Environmental Research 136:205-12.

Maerz, J, B Blossy and V Nuzzo. 2005. Green frogs show reduced foraging success in habitats invaded by Japanese knotweed. Biodiversity and Conservation 14: 2901-2911.

Missoulian. 2014. Toad migration underway at Jackson Lake. September 4, 2014. http://missoulian.com/news/state-and-regional/toad-migration-underway-at-jackson-lake/article_98b44a16-345b-11e4-afdd-0019bb2963f4.html

Murphy, J, C Phillips and V Beasley. 2010. Aspects of amphibian ecology. Pages 141- 178 *in* D.W. Sparling, G. Linder, C.A. Bishop, editors. Ecotoxicology of amphibians and reptiles. Pensacola, FL: Society of Environmental Toxicology and Chemistry (SETAC).

Muths, E and P Nanjappa. 2005. *Bufo boreas*. Species account, pages 392-396 *in* M. Lannoo (editor). Amphibian Declines: the conservation status of United Stated Species. University of California Press, Berkeley, CA.

National Park Service (NPS). 2016. Summary of amphibian habit features provided to Focal Habitat Feature Identification Project, Teton County, Wyoming. Rocky Mountain ARMI Database - accessed October 2016. NPS Greater Yellowstone Network, Bozeman, Montana.

O'Brien, C, J Hall, C O'Brien, D Baum and L Ballantyne. 2013. Impact of a natural pyrethrin biocide on two amphibians, common toad *Bufo bufo* and palmate newt *Lissotriton helveticus*, in Highland, UK. Conservation Evidence 10: 70-72.

Ontario Ministry of Natural Resources and Forestry. April 2016. Best Management Practices for Mitigating the Effects of Roads on Amphibians and Reptile Species at Risk in Ontario. Queen's Printer for Ontario. 112 pp. Available at: http://www.raqsb.mto.gov.on.ca/techpubs/eps.nsf/0/450bcba9edd3a9a885257fdb004d9e07/$FILE/Environmental%20Guide%20for%20Wildlife%20Mitigation%20Final%202015%20-%20ENGLISH.pdf

Patla, D. 2001. Conservation Assessment for the boreal toad (*Bufo boreas boreas*) on the Bridger-Teton National Forest, Wyoming. Idaho State University.

Patla, D. 2016. Amphibian Monitoring on the National Elk Refuge, 1998 – 2014. Final report for the Meg and Bert Raynes Wildlife Fund.

Patla, D, S St-Hilaire, A Ray, B Hossack and C Peterson. 2016. Amphibian mortality events and ranavirus outbreaks in the Greater Yellowstone Ecosystem. Herpetological Review 47(1): 50-54.

Pearl, C and J Bowerman. 2006. Observation of rapid colonization of contructed ponds by Western Toads (bufo boreas) in Oregon, USA. Western North American Naturalist 66(3): 397–401.

Pilliod, D and E Wind (editors) 2008. Habitat management guidelines for amphibians and reptiles of the Northwestern United States and Western Canada. Partners in Amphibian & Reptile Conservation, Tech Pub HMG-4, Birmingham, AL.

Quarles, W. 2015. Pesticides and amphibian decline. Common Sense Pest Control XXIX (1-4) Special Issue: 3-19.

Ray, A and D Patla. 2016. Greater Yellowstone Network amphibian monitoring: 2012-2013 biennial status report. Natural Resource Report Series NPS/GRYN/NRR—2016/1140. Na-tional Park Service, Fort Collins, Colorado.

Relyea, R. 2005. The impact of insecticides and herbicides on the biodiversity of aquatic communities. Ecological Applications, 15(2): 618–627.

Schmetterling, D and M Young. 2008. Summer movements of boreal toads (*Bufo boreas boreas*) in two western Montana basins. Journal of Herpetology 42(1): 111–123.

Semlitsch, R and J Jensen. 2001. Core habitat, not buffer zone. National Wetlands Newsletter: 23 (4): 5-11.

Semlitsch, R and J Brodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17:1219–1228.

USDA, Forest Service Stream-Simulation Working Group. 2008. Stream Simulation: An ecological approach to providing passage for aquatic organisms at road- stream crossings. Available at: http://stream.fs.fed.us/fishxing/aop_pdfs.html

Watling, J. I., C. R. Hickman and J. L. Orrock. 2011. Invasive shrub alters native forest amphibian communities. Biological Conservation. 144: 2597-2601.

Werner, J.K., B.A Maxell, P. Hendricks, and D.L. Flath. 2004. Amphibians and reptiles of Montana. Mountain Press Publishing, Missoula, MT.

Habitat Characteristics

No known habitat model exists for Western Toad in Teton County, WY.

The scale of habitat for amphibians is obviously significantly smaller than the scale of habitat for larger animals. Nonetheless, there are landscape features which we are likely able to map that will construct a potential habitat map for the Western Toad. However, in addition to the map, the information contained within this narrative could be immensely helpful when developing land development regulations as they apply to wetland areas. Of primary concern with the variables listed below is breeding habitat and the surrounding terrestrial zone. For the purposes of evaluating riparian and wetland habitat and development impacts adjacent to Western Toad habitats on private lands in Teton County, a site-specific assessment is recommended.

Season	Habitat Characteristic	GIS Data Source	Selection Criteria	Source
Breeding	Patch Size	NWI, TC Veg Cover	Wet areas > 0.14 acres	NPS 2016
Breeding	South-facing Shorelines	Aspect	South-facing shorelines are critical (emphasize if possible)	Bull, 2009
Breeding	Highest value habitat	Create	150 m from shore/ wetland edge	Bartelt et al, 2004; Semlitsch and Jensen, 2001
Summer and Winter	Non-breeding upland Habitat	Create	Buffer breeding habitat patch by 200 m from edge of wetland	Bartelt et al, 2004; Semlitsch and Jensen, 2001
Summer and Winter	Barriers	Create/ analyze using TC Roads	Lesser value habitat or potential location for movement corridor protection where habitat is crossed by a road	D. Patla, pers. observation and unpublished data

Contributors

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Primary Reviewer: Dr. Adam Sepulveda, Research Zoologist, Northern Rocky Mountain Science Center

Secondary Reviewer: Amy Girard, NRTAB

GIS Methods – Summer & Breeding/ Year-round Habitat

Habitat Characteristic	Process	Selection & Processing	GIS Tool Used	Output
Important Veg Cover	From TC, GRTE, BTNF & CTNF layers, select lakes, ponds, streams, rivers, wetlands, herbaceous aquatics, exposed shorelines From NWI Wetlands select based on flooding regime (fourth letter in code) all that are <u>not</u> temporarily flooding (A) or seasonally saturated (B). F, G and H are the most important.	See Definition Query Selection Below	Definition Query; Merge Layers; Dissolve	All summer and breeding veg covers
Limit Cover layers to Project Area	Clip to Project Area		Clip	Refined Breeding Area
Wet Area Patches	Merged Layer and Explode Multipart to Singlepart	Split to single part features, calculate area	Multipart to Singlepart; Add Geometry Attributes	Patches
Wet Areas > 0.2 acres	Select patches >0.2 acres.	Select patches >0.2 acres	Select by Attribute; Copy Features	Wet Patches >0.2 acres
Veg within 200 m of Important Veg Cover	Buffer wet patches by 150m	Buffer full, planar, dissolve	Buffer and Dissolve	Breeding and non-breeding habitat
Remove Deepwater Habitat	Remove Jackson Lake deepwater habitat	Digitize deep water and remove	Editor, Digitize, Clip	Refined breeding and non-breeding habitat
Convert Shapefile to Raster	Convert breeding and non-breeding habitat shapefile to a raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field, Calculate Field, Polygon to Raster	Important habitat
Elevation below 9,200 ft	Retain elevations below 9,200 ft (~2,800 m)	VALUE <=2800	Extract By Attribute	Elevations
Extract Important Habitat by Elevation	Important habitat below 9,000 ft	Extract by elevation	Extract By Mask; Reclassify so No Data = 0	Breeding and non-breeding habitat Raster
Compare with WOS and NMJH	Compare observations with output.			

South facing aspect was removed as a variable because these areas should be emphasized as most important not be used as a limiting factor.

Veg Cover Definition Query Categories

Breeding and Summer Cover Type Definition Query
Teton County Map Codes:
Streams and Rivers - NST
Lakes, Ponds and Reservoirs - NLP
Herbaceous Aquatics - HA
Exposed Shore - Stream Deposit Sparse Vegetation - VSL
Non-vegetated Cobble Bars - NVS

Grand Teton Nation Park Map Codes:
Streams - NST
Lakes and Reservoirs - NLP
Herbaceous Aquatics - HA
Exposed Lake Shoreline - Stream Deposit Sparse Vegetation - VSL
Non-vegetated Sand Bars - NVS

Bridger-Teton National Forest MU CODE:
Water - WA

Caribou-Targhee National Forest MU CODE BT:
Caribou-Targhee Water - WA

NWI Def Query: Removing Fourth Letter As and Bs
Included all but the following were removed: PEM1A, PEM1B, PEMA, PEMB, PEMBb, PFO1A, PFOA, PFOAh, PFOB, PFOBb, PSS1A, PSSA, PSSB, PSSBb, PUSA, PUSAh, PUSAx

Metadata

Title

WT_Yrd.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Western Toad Year-round Habitat, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

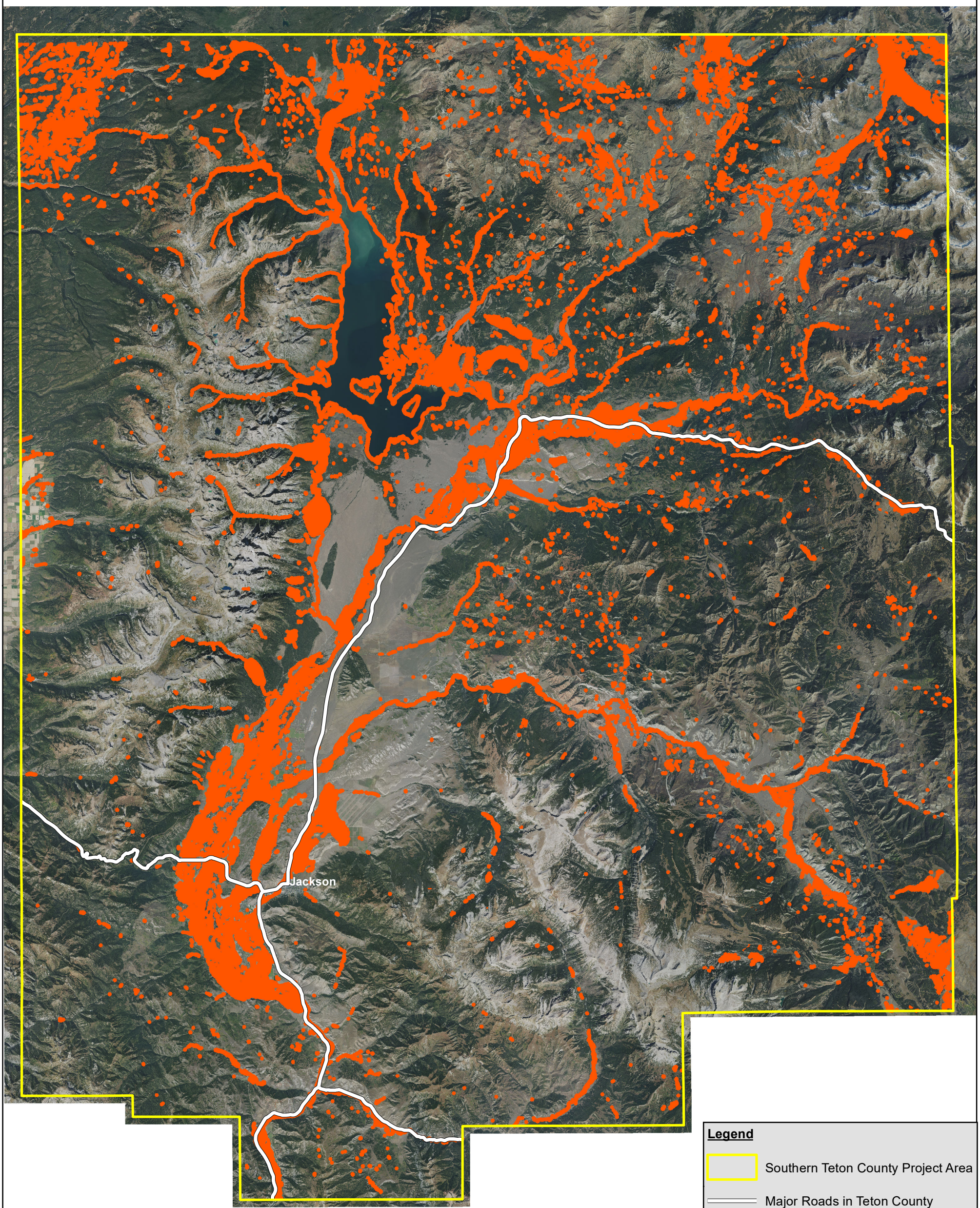
The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the western toad is one. The focal species habitat layers identified potential habitats and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats for a species within Teton County, WY. Rather, this layer is a map of species potential habitat within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please reference the project's final report for information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for any unintended or improper use of these data, misinterpretation or alterations. Both entities should be consulted for questions regarding appropriate use of these species specific potential habitat layers. These species specific potential habitat layers are not intended to be a definitive assessment of important habitat in Teton County. The intent is to display potential habitat for a species and season within Teton County. These potential habitat layers are only as accurate as the source data used. Alder Environmental, LLC, the Teton County Planning and Development Department and the Natural Resources Technical Advisory Board are not responsible for derived conclusions or analysis generated from these data by third parties. The burden of determining appropriateness for use lies with the user.



Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 22:

Western Toad Year Round Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

1 inch = 5 miles

0 1 2 3 4 5 Miles

NORTH

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MIGRATION

Pronghorn are not a focal species therefore the WCS/ USFS Path of the Pronghorn corridor shapefile was not included as an input. This is the one major known ungulate migration corridor in Teton County that was not included.

The Wyoming Migration Initiative is working on developing GIS layer for Teton County elk, moose and mule deer high use migration corridors using GPS collar data. This information was not be available for this version of the Teton County Focal Species Habitat Mapping Project but should be incorporated in the future. Dr. Matt Kauffman is expecting that the results should be available by October 2017 (Dr. Matt Kauffman, *pers. communication*).

GIS Methods – Migration Habitat

Habitat Characteristic	**Process**	**Selection & Processing**	**GIS Tool Used**	**Output**
Important Migration Routes	All focal species from WGFD. Including mule deer, elk, moose. Identified migration routes for non-focal species were not included.	Buffer WGFD routes by ½ mile (.25 mi each side), Clip to Teton County	Buffer; Clip	WGFD Migration Routes
Merge all Polygons	Merge all migration route polygons	All	Merge	All routes in one polygon
Convert Shapefiles to Raster	Convert WGFD Migration Routes Shapefile to a Raster	Add Values Field, Calculate Field to 1, Convert Polygon to Raster	Add Field; Calculate Field; Polygon to Raster	Migration Route Raster
Important Migration Routes	WMI and Sawyer mule deer, Riginos (2013) mule deer.	Use all, clip to Teton County	Clip	Non-WGFD migration routes
Mosaic with Raster migration routes	Combine all migration route rasters	All	Mosaic to New Raster	All Migration Routes Raster
Standardize Values	Standardize all values to 1		Reclassify; 1 and No Data = 0	Final Output

Metadata

Title

Migration.tif

File Type

Raster, NAD83 UTM Zone 12N

Tags

Migration Routes for Moose, Mule Deer and Elk, Teton County Focal Species Habitat Mapping Project, Alder Environmental

Summary

The purpose of this project was to provide the Teton County Planning and Development Department with a relative weights habitat map of Teton County, WY based on focal species habitats. This layer is one of the focal species habitat input layers employed in the creation of the relative weights habitat map.

Description

The Focal Species Habitat Mapping project's intent is to identify potential important habitat for 17 focal species in Teton County, of which the moose, elk and mule deer are the three identified focal species with land migrations. The focal species habitat layers identified migration routes and are intended to inform a relative values habitat map of Teton County, WY for use in development of land use regulations. This layer is not to be construed as a definitive map of crucial or important habitats or migration routes for species within Teton County, WY. Rather, this layer is a map of mapped migration routes within Teton County, WY and is, as stated above, not definitive. The accuracy of this mapping exercise is based solely on the accuracy of the inputs. The project's final report should be consulted for methods and data inputs used for the creation of this habitat layer.

Credits

Alder Environmental. 2017. Focal Species Habitat Mapping for Teton County, WY: Final GIS Data & Report. Project completed by Alder Environmental, LLC under contract for Teton County, WY Planning and Development Department. Please consult the project's final report for appreciation of others' past work that was used as inputs to this GIS layer, information on and acknowledgement of contributing authors and expert reviewers.

Use limitations

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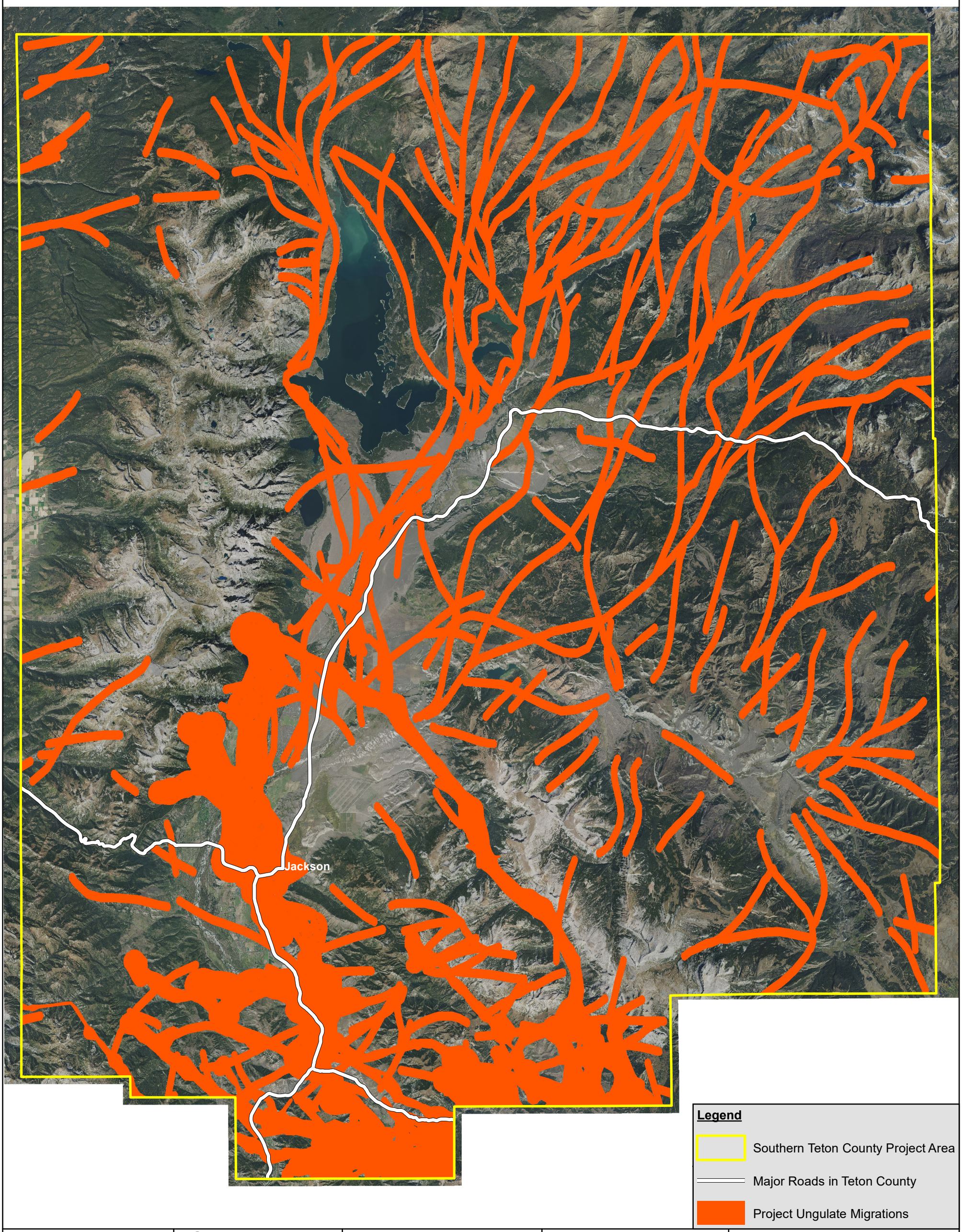

Teton County Focal Species Habitat Mapping Project

Teton County, WY

FIGURE 23:

Migration Spring & Fall Habitat

April 21, 2017

This potential habitat map is not to be construed as a definitive map of crucial or important habitat within Teton County, WY.

NAIP
- 2015 1-m Aerial Photography
NRCS
- Teton County Boundary

2017/TC/TCFSHMP/TaskBSppLayers.mxd

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