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Re: Comments on the Supplemental Draft Environmental Impact Statement High Uintas Wilderness Domestic Sheep Analysis.

Submitted Electronically To:

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To The Forest Service:

Gallatin Wildlife Association, Western Watersheds Project, Wild Earth Guardians, Wilderness Watch, and Yellowstone to Uintas Connection are providing these comments on the SDEIS. We have previously submitted scoping comments and comments in response to the Draft Environmental Impact Statement (DEIS) for the High Uintas Wilderness Domestic Sheep Analysis Project which was released June 25, 2019. We understand from the June 2023 cover letter for the SDEIS that, you will "still be considering and incorporating them in the preparation of the final EIS." Therefore, we are not repeating those comments here, but are updating and supplementing them in response to the SDEIS.

Gallatin Wildlife Association has submitted separate comments (August 15, 2023) on the SDEIS addressing bighorn sheep, climate change and cumulative effects, insufficient alternatives, and habitat conditions. Sage Steppe Wild also submitted separate comments (August 9, 2023) on policy issues, including compliance with NFMA, NEPA, Forest Service Manual and Handbook, Forest Plans, and others. We are incorporating the comments by both organizations herein by reference.

We begin by outlining the major points from our prior comments, followed by discussion updating our prior analysis of grazing impacts, bighorn sheep, Canada lynx, wilderness, and policy issues. Links are provided to references.[1]

Summary of Past Comments

1. Scoping comments submitted by Yellowstone to Uintas Connection dated June 27, 2014.
    a. Described our history of observations and data describing degraded conditions in the project allotments and adjacent sheep allotments.
    b. Provided a report documenting these conditions and comparing ungrazed and grazed allotments.
    c. Pointed out degradation of wilderness values.
    d. Described sheep bedding impacts and the need to document these.
    e. Referenced Mont Lewis' 1970 report documenting sensitivity of these alpine systems to grazing on steep slopes and erodible soils and the need for site specific suitability determinations, determination of plant community production, available forage, and current rates of forage consumption.
    f. Provided a report "Updating the AUM".
    g. Requested that soil scientists' reports and documentation from the West Fork Black's Fork EIS be included in the analysis as sheep alternately trail in and out of both West Fork and East Fork Black's Fork allotments.
    h. Opposed renewing permits.

2. Scoping comments submitted by Western Watersheds Project, Wilderness Watch and Yellowstone to Uintas Connection dated July 13, 2014.
    a. Provided comparison between grazed and ungrazed allotments showing recovery in the ungrazed allotments and continued degradation in the grazed allotments.
    b. Challenged the idea that gophers and tie hacking were causes for degraded conditions.
    c. Pointed out the damage from trailing and grazing sheep on steep slopes and passes.
    d. Asked for comparisons between current grazed and ungrazed areas with historical monitoring data such as the 1960's analyses.
    e. Asked for a determination of the historical range of bighorn sheep and pointed out the suitability of the entire wilderness to be bighorn habitat.
    f. Asked for an equivalency calculation for the forage consumption of domestic sheep in these allotments to the numbers of other animals that could be supported without domestic sheep.
    g. Asked that the West Fork Black's Fork allotment also be analyzed due to the trailing and cumulative impacts in common with the East Fork Blacks Fork.
    h. Pointed out the watershed and erosion effects which are evident in current grazed areas compared to the recovery in long term ungrazed areas.

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[1] Reports and publications referenced in our past comments are found at: https://app.box.com/s/60hra81c2mqdxc6mjnlh

i. Asked that the impacts on predators and carnivores be analyzed due to loss of their prey base (competition for forage with domestic sheep), and the effects of trapping and killing by herders, wildlife services, and DWR.
j. Provided a review and some data on gopher ecology and the effects of forage removal and trampling on visible gopher activity showing in the absence of livestock, visible gopher activity was low.
k. Provided data and a chart showing the percent bare ground in grazed and ungrazed locations showing potential is nearly 100% ground cover while in grazed locations it was about 50% bare ground.
l. Asked for analysis of disease vectors (pathogens) related to domestic sheep grazing these watersheds and the potential risk to recreational users.
m. Asked for cumulative effects analysis to include the Regionally Significant Wildlife Corridor and other projects such as timber and salvage projects.
n. In conjunction with that cumulative effects analysis, to analyze the effects of habitat fragmentation on Canada lynx habitat and linkage and loss of prey base from competition with livestock.
o. Asked for updated analysis of goshawk capable and suitable habitat and the effects of projects such as the timber harvests and roads on distribution and population of goshawks.
p. Pointed out the conflict between bighorn and domestic sheep, the Payette decision, the 11/25/2008 Forest Service Chief instruction to Regional Foresters to provide "effective separation" between the two.
q. Asked for updated capability and suitability analysis for domestic sheep.

3. Comments by Yellowstone to Uintas Connection on "An Alpine Community Classification for the Uinta Mountains, Utah" dated February 18, 2015.
    a. Expressed concern over the use of areas that are being grazed by livestock as reference areas and thereby accepting degraded conditions as a baseline or reference for the potential state of the communities.
    b. Areas with reduced ground cover were described as "pristine" or "undisturbed".
    c. The report was biased in hardly mentioning livestock or sheep, while gophers were a dominant theme indicating that the author and advisors from the Forest Service "can identify gopher activity (while ignoring gopher ecology) but cannot recognize sites that are grazed by domestic sheep or impacts from domestic sheep grazing."
    d. Requested the document be withdrawn and revised by incorporating more detailed analysis which was outlined.

4. Scoping Comments submitted by Gallatin Wildlife Association dated December 21, 2015.
    a. These comments raised the question of reanalysis of the sensitive species list for the Region.
    b. Requested an analysis of the history of NEPA and permit renewal for the allotments and allotment plans.

c. Requested an analysis of the history of bighorn sheep in and near the project area, population estimates, management interventions, and costs.
d. Requested analysis of the seven allotments closed in 2003 and the response of bighorn sheep and vegetation to these closures.
e. Requested a summary of bighorn herds, which are considered sustainable, viable at population or genetic level, and defines genetically effective as influenced by natural selection rather than human intervention.
f. Consider limitations on existing bighorn herds or the ability for new populations to be established on historic or suitable habitats within or near the allotments.
g. Note where these National Forests are now providing habitat for viable populations of bighorn sheep as required by NFMA.
h. Analyze disease issues and address how the presence of domestic sheep affects the suitability of bighorn habitat in the Uinta Mountains and map the historic and suitable habitat in the area.
i. Cites Forest Service rules to limit bighorn sheep contact with domestic sheep and requests copies of the herder reports needed to keep accurate records of grazing use and dates, stocking numbers, bighorn sheep sightings, and animal losses.
j. Asked if closing these allotments to domestic sheep would make the habitat suitable for bighorns and allow them to establish?
k. Asks for suitable bighorn habitat to be mapped within 14 miles of the allotments.
l. Expresses concern over connectivity for bighorn sheep, fences as barriers and requests a map of any fencing within the allotments.
m. Asks for all locations and activities to remove, control, or kill wild native carnivores and the involvement of Wildlife Services or the State of Utah.

5. Scoping Comments submitted by a coalition (Gallatin Wildlife Association, Western Watersheds Project, Wild Earth Guardians, Wilderness Watch, Yellowstone to Uintas Connection and others dated December 30, 2015.
    a. We incorporated earlier comments identified in the letter.
    b. Re-emphasized the negative impacts of the action on bighorn sheep, wilderness, TES species and habitats, effects of sheep grazing on watershed function and soil cover.
    c. Expressed the need to compare native plant biodiversity, pollinators, increaser species between long-term livestock exclusion areas and currently grazed areas.
    d. Global warming effects on high elevation vegetation, bighorn sheep.
    e. Need to analyze the impact of forage competition from domestic sheep with native grazers, including numbers equivalent and displacement from preferred habitats.
    f. Include West Fork Black's Fork allotment in the analysis due to its presence in bighorn habitat, its use for trailing to and from the Ashley NF and also trailing into the East Fork Black's Fork.
    g. Analysis of trail register comments is needed.
    h. Analysis of predator/carnivore losses due to conflicts with domestic sheep, requiring predator friendly management and a means of tracking mortality.

i. Cumulative impacts of other projects, road densities, noise, and incursions into roadless areas and other human activities on the Uinta Mountains and the Regionally Significant Wildlife Corridor.

6. Scoping comments submitted by Gallatin Wildlife Association dated March 11, 2016.
   a. Calculated that 25,700 domestic sheep would be grazing the 10 allotments while only 136 bighorns are present. Viability allowed for domestic sheep but not for bighorns.
   b. Do not support the proposed action.
   c. Reviewed bighorn population history in which the former population in the west was 1.5 to 2 million bighorns and have declined by 98% noting that in Utah they were nearly extirpated.
   d. Because of declining bighorn numbers, in 2009 the Forest Service designated them a sensitive species for the Intermountain Region. That designation carries with it the responsibility to protect and enhance habitat to prevent listing under the ESA. Domestic sheep presence is in direct conflict with these responsibilities.
   e. Bighorn populations in the Uinta Mountains have been largely extirpated and the numbers at 136 are the only population on Forest Service lands that exceeded the minimum viable population of 125 animals.
   f. Describe the extent of the High Uintas Wilderness that includes UDWR mapping of significant amount as bighorn habitat.
   g. Notes that most of the bighorn herds are targeted for augmentation. Concerned that presence of domestic sheep and trailing is a serious threat to viability and suitability of bighorn sheep and their habitat.
   h. Requested mapping of domestic sheep allotments and trailing routes and overlap with bighorn herds, identify the amount of bighorn habitat encompassed by domestic sheep allotments and within 9 miles of those allotments.
   i. The presence of domestic sheep within these bounds, based on the best available science, will adversely impact the suitability of bighorn habitat and viability of bighorn populations.
   j. Alternatives predetermined the outcome by not closing these allotments and citing the UWCNF Forest Plan identifying allotments for closure to expand bighorn habitat yet leaving closure to the discretion of the permittees.
   k. Requested ROC model mapping and analysis validating the Minimum Viable Population of 125 or more animals, provided review of MVP indicating much greater numbers are needed.
   l. Reviewed attempts to restore bighorns to the Uinta Mountains and reasons for failures. The grazing of domestic sheep on these ten allotments and the West Fork Black's Fork significantly limits the USFS ability to provide enough interconnected habitat to ensure long term viability.
   m. Note that the South Slope has no bighorn sheep and none of the individual herds on the north slope meet the MVP number.
   n. Reviewed Forest Service goals, standards, guidelines, and sensitive species management direction.

o. Described history of cumulative effects leading to demise of bighorn sheep in Utah, including habitat degradation and competition with livestock for forage and space, human disturbance, and stress citing DWR (2013). Requested analysis of suitable habitat on both Forests to determine if it is sufficient to maintain minimum viable populations.
p. Reviewed bighorn/domestic sheep science on competition and disease. Cited Ninth Circuit ruling that disease transmission from domestic sheep poses a sufficient risk to bighorn sheep viability to merit separation of the bighorns from domestic animals.
q. Cited research supporting interconnected populations and genetic bottlenecks of isolated populations.
r. Support allotment retirement to achieve viable, interconnected herds of bighorns in the Uinta Mountains.

7. Letter from Yellowstone to Uintas Connection to the Region 4 Deputy Director and Regional Range Management Staff Officer dated October 5, 2016.
    a. Reported on a prior meeting with Co-project leads for the UWCNF and ANF to discuss our collection of vegetation data and how that data would be used in an analysis of stocking rates.
    b. Included West Fork Black's Fork allotment in the presentation.
    c. Pointed out how the capable lands determined by the Forest Service are patchy and in some allotments are minimal and that their analysis did not consider soil erosion hazard.
    d. Pointed out our surveys in the early 2000's showing the uplands and slopes had extensive bare soil affecting hydrology and destroying fish habitats.
    e. Restated the Regional capability criteria provided to us by former Regional Forester and how these evolved from the R4 Range Analysis Handbook from the 1960's.
    f. Cited Mont Lewis report (1970) in which he called for grazing capacity to be based only on suitable range (now called capable). His suitable range excluded slopes >20%, soils with high or moderately high erosion index, and areas where ground cover could not be maintained under grazing use. We noted the Forest Service capable lands included large areas of wet meadows which Lewis had indicated are not preferred by sheep, so they concentrate on the drier adjacent upland areas.
    g. Referenced our prior meeting with the Co-project leads, we pointed out the failure of the current effort to validate stocking rates due to the lack of quantitative data.
    h. Pointed out the inadequate forage to support the sheep resulting in the current degradation.
    i. Symptomatic of this we documented the accelerated filling of Lake EJOD from denuded adjacent uplands grazed by sheep and cited a paper in which the author found that the watershed disturbance was detectable in the lake sediments.
    j. We then proposed some modified capability criteria to reflect Mont Lewis' recommendations.

8. PowerPoint presentation to Forest Supervisors for the ANF and UWCNF, Range Staff and Forest Ecologist on July 26, 2018. This was followed by a formal report in September, 2018.
    a. Examples of degraded conditions resulting in bare soichannelseep slopes, ridges and passes, alpine basins heavily grazed, braided stream channels, active head cuts, (compared to those healing in ungrazed watersheds), scoured stream banks, accelerated sediment deposition in lakes were provided.
    b. Comparison of soil cover in grazed and ungrazed uplands showing near 100% soil cover in ungrazed areas while those continuing to be grazed averaged approximately 50%.
    c. Cited suitability, utilization recommendations from Mont Lewis' 1970 report.
    d. Provided current data on forage consumption by domestic sheep and 30% recommended utilization rate.
    e. Reported results of our forage production sampling that showed 294 lb/acre average with wetland samples included, 211 lb/acre without. Presented Forest Service 1960's data showing average of 240 lb/acre.
    f. Presented Region 4 grazing capability criteria.
    g. Presented our forage production map and model and that for Forest Service 1960's data.
    h. Presented our grazing capability model and analysis showing few capable acres in the ten allotments.
    i. Analyzed the current Forest Service capable acreage.
    j. Calculated stocking rates for a series of scenarios showing that current stocking rates are greatly over capacity.

9. Comments submitted on the DEIS by Western Watersheds Project dated August 2, 2019.
    a. Incorporated comments provided by others by reference.
    b. Cited Forest Service handbook and manual guidance on recovery of sensitive species and FSH 2209.13 grazing permit administration Chapter 90 Rangeland Management.
    c. Desired Conditions are designed to continue degraded conditions below the level needed for proper biological and physical function. Examples of Forest Plan desired conditions provided which do not implement wilderness management requirements, instead are designed to benefit, and enable livestock grazing.
    d. Wilderness guidance from the FSM was cited, "Maintain wilderness in such a manner that ecosystems are unaffected by human manipulation and influences so that plants and animals develop and respond to natural forces."
    e. Also, among others, "Where there are alternatives among management decisions, wilderness values shall dominate over all other considerations except where limited by the Wilderness Act, subsequent legislation, or regulations."
    f. "Provide an environment where the forces of natural selection and survival rather than human actions determine which and what numbers of wildlife species will exist."
    g. Pointed out how the DEIS failed to comply with these, and other related requirements related to wilderness. In particular, noting that the DEIS failed to

assess impacts from domestic sheep grazing against the higher resource protection needed for wilderness areas.

h. Then cited the lack of consideration of predacious animals and birds and their benefits to the ecosystem.
i. Other citations from Departmental Regulations and the FSM providing requirements to provide habitats to maintain viable populations throughout their geographic range on NFS system lands, avoid impacts to species with viability concerns, avoid actions leading to ESA listing, and develop management practices to accomplish this.
j. Other cited provisions of the FSM require recovery strategies, quantifiable objectives, and management strategies.
k. Provisions of the Ashley NF Plan are cited such as reestablishing native species classified as sensitive, threatened, or endangered, by 1988 place all allotments under management designed to protect the wilderness resource, manage livestock within present capacity of the allotment, complete aquatic inventories of all streams, allow activities that will not adversely affect sensitive or T and E species.
l. Cited the High Uintas Wilderness Amendment requirement that, "The ability of soils to support naturally occurring vegetation communities is not significantly impaired by human activities.", and the need to collect data to show that permitted sheep grazing is not impairing vegetation communities.
m. The DEIS acknowledges that problems exist and that sites in harsh climatic conditions take time to heal while the WCNF Forest Plan requires improving habitat conditions. Yet, permitting domestic sheep in bighorn habitat prevents this from being achieved.
n. The Forest Plan requirements for wilderness include that natural ecological processes are dominant, and habitat needs of species at risk are protected.
o. Other Forest Plan requirements regarding pollinators, maintaining tall forb communities, and monitoring elements were discussed. Citing guideline G24 on protecting pollinators by not allowing activities that negatively affect them occurring during the flowering period. The DEIS does not recognize the effect of livestock grazing on this removal of flowering plants.
p. Reviews the Bighorn Conservation Assessment and its focus on eliminating potential for contact between bighorns and domestic sheep. In particular citing research that "Areas that have been grazed by domestic sheep may not be suitable areas for wild sheep for up to four years after grazing has been discontinued".
q. Cites RMRS-GTR-209 and a court ruling stating that, "Scientific research supports a finding that when bighorn sheep intermingle with domestic sheep, large numbers of bighorn sheep die… there is no way to avoid the incompatibility other than to keep the domestics and the bighorns separate." Where management objectives include maintenance or enhancement of bighorn sheep, spatial or temporal separation must be created.
r. The comments also pointed out the need to update the capability of the area to provide forage for livestock, ground truth the capability determination and complete

a suitability analysis that considers conflicts of use and resource damage resulting from livestock grazing. The DEIS was lacking in the needed analysis.

s. NEPA and the defining of a project purpose and need can be manipulated into being narrowly defined, thus limiting reasonable alternatives as is the case with the DEIS.
t. States that the DEIS analysis for most species does not contain population data trends or habitat conditions. Using CRCT as an example, the DEIS notes they are in decline but will "persist" and that increased sedimentation, trampling etc. will not increase this trend toward federal listing. This is a violation of the "hard look" under NEPA and the viability mandate of NFMA.

10. Comments submitted on DEIS by a coalition (Gallatin Wildlife Association, Western Watersheds Project, Wild Earth Guardians, Wilderness Watch, Yellowstone to Uintas Connection and others dated August 5, 2019. Major topics and related points are outlined below.
    a. The relationship of domestic sheep grazing in the Uintas to climate change.
        i. Expect an analysis of the cumulative effects of Forest Management in these Forests on climate to include other activities in addition to domestic sheep grazing just in the ten allotments.
        ii. Reviewed livestock industry contributions to GHGs, effects on stored carbon in soils and vegetation, motorized vehicle emissions, protection of forests for carbon storage.
        iii. Discussed the Forest Service Roadmap to address climate change and the need to provide connectivity, restore habitats, sequester carbon.
        iv. Discussed the National Fish, Wildlife and Plants Climate Adaptation Strategy that stresses conservation of habitats and reduction of non-climate stressors such as habitat degradation by livestock.
    b. Bighorn sheep risk due to contact with domestic sheep.
        i. Addressed the project and risks to bighorn sheep and Forest Service obligations to conserve sensitive species along with the agency philosophy that risks on other land ownerships exist, therefore the Forest Service need not mitigate the risk.
        ii. Pointed out flaws in the analysis of the cyclic nature of bighorns in the Uinta's which the BE attempted to assert as natural in spite of die-offs and that they remain below carrying capacity.
        iii. Explained that DWR augmenting bighorn herds is not legitimate in order to waive its obligations on sensitive species.
        iv. Pointed out the inconsistencies with both Forest Plans and NFMA regarding viability of sensitive species and continued presence of domestic sheep.
        v. Pointed out flaws in the Biological Evaluation such as the State's MVP not being valid, the Region 4 presenting differing values for MVP, disease likely causing losses and population numbers below the MVP.
        vi. The cumulative effects area is too limited.
        vii. The project risk assessment sets a prior impact date of 3 years, but bighorn population impacts can last more than ten years from exposure to pathogens.

viii. There is no guarantee the permits will undergo NEPA at the end of the ten-year term and the timeline for determining future effects should reflect that.
ix. An updated grazing capability and suitability assessment is needed to account for TES habitats and incompatibilities with domestic sheep.

c. Wilderness qualities.
   i. The High Uintas Wilderness is the most heavily grazed Wilderness and suggests this is why the likely best bighorn sheep habitat in the Wilderness Preservation System has struggling populations.
   ii. The DEIS fails to state grazing in Wilderness is a nonconforming use that harms wilderness character and biases the NEPA analysis.
   iii. This ignores that wilderness must be administered that leaves it "unimpaired for future use and enjoyment..protected…preservation of wilderness character.. "
   iv. The wilderness definition includes that it is "untrammeled by man…retaining its primeval character...is affected primarily by the forces of nature".
   v. Grazing livestock in wilderness is an exception where it is allowed to continue if in place prior to September 3, 1964, but must be regulated.
   vi. The DEIS leads the reader to conclude the proposed action would not harm Wilderness but fails to recognize agency policy to "close the gap" between the attainable level of purity and that which currently exists.
   vii. The DEIS biases the NEPA analysis by incorporating condition classes described in an earlier plan, therefore an analysis of No Grazing is not needed.
   viii. Those seeking a true primitive recreation experience would likely be most harmed by the presence of domestic sheep, while reliance on trail registers can be misleading.
   ix. Cites the misapplication of Landres et al 2008 and Keeping It Wild that downplays the essence of Wilderness and how KIW2 has been used to justify trammeling actions in wilderness.
   x. Critiques DEIS characterization of naturalness that presumes domestic sheep impacts are transient while ignoring the forage consumed, watershed degradation, and disease organisms left in feces.
   xi. Predator control was not mentioned yet the FSM emphasizes the critical role they play in maintaining integrity of natural ecosystems while the area is within lynx habitat, a recent wolverine sighting was made, while bears and coyotes are not mentioned.
   xii. Sheep driveways are sacrifice zones lacking plant diversity and severely eroded.
   xiii. The DEIS recognizes there has been no grazing since 1977 on the Fall Creek allotment, while the High Uintas Wilderness was designated in 1984 and the DEIS does not detail impacts from grazing this allotment.

d. Domestic sheep grazing and lynx habitat.

i. Lynx is threatened but there is no designated critical habitat in Utah although there are vast expanses of habitat where lynx were historically present.
ii. The reintroduction of lynx in Colorado led to forays into Utah and the Uinta Mountains while to the north in Wyoming there are naturally occurring populations.
iii. The Uinta Mountains are part of a regionally significant wildlife corridor connecting to the Greater Yellowstone ecoregion through SE Idaho.
iv. The highest concentration of lynx locations from the Colorado reintroductions is in the Uinta Mountains.
v. Habitat modeling has identified the Uinta Mountains as core lynx habitat and part of this Regionally Significant Wildlife Corridor, so why are there no lynx in the Uinta Mountains?
vi. The most obvious and most probable reason is that "following an initial extirpation due to trapping, hunting, poisoning, logging and livestock grazing, natural recolonization of the Uinta Mountains by Canada lynx is prevented by ongoing anthropogenic disturbances. One major continuous disturbance to consider is the domestic sheep trailing and grazing in the Uinta Mountains that has gone on every year for over 100 years."
vii. Forest Service hypotheses to explain absence of lynx lack consideration of impacts of domestic sheep grazing, neither of their two hypotheses is plausible and cannot support the Alternative 2 conclusion that "is not likely to adversely affect Canada lynx".
viii. Because lynx surveys since 1999 have not found lynx presence, the FS concludes there was never a resident population in the Uinta Mountains and therefore the Uinta Mountains are not good habitat.
ix. The lack of lynx could be due to human uses of the forest.
x. The 10 verified records of lynx occurrence in the Uinta Mountains in the 20th century underestimate the record. There are a total of 37 records including reliable records.
xi. The question is how many records would be needed to establish that there was a resident population in the 20th century? No one knows, but the premise that there was never a resident population begs the question by presupposing there never was a resident population.
xii. The premise that cyclic highs in lynx populations supports the hypothesis that lynx in the Uinta Mountains were transient rather than part of a resident population also begs the question since only 4 of the verified records correlate with those cyclic highs.
xiii. The comments analyzed the snowshoe hare situation using the West Fork Blacks Fork example from the 2006 FEIS in which the Forest Service found 42% of the allotment to be lynx habitat, while this DEIS then states there are only 574 acres of lynx habitat in LAU34.

xiv. By downplaying the amount of lynx habitat, the DEIS is able to discount sheep grazing and trailing effects on lynx habitat by defining less than 2,000 acres of lynx habitat in the project area.

xv. Case law supports consideration of biological corridors and their functionality, thus the corridors within the analysis area and linkages need to be examined as part of the larger corridor system between ecosystems.

xvi. Cited RFP G18, "In lynx analysis units design all management activities to maintain, restore, or protect desired lynx and lynx prey habitats including foraging, denning and movement."

e. <u>Grazing impacts on the Uinta Wilderness ecosystem.</u> These comments are more broadly summarized due to the level of detail contained therein.

i. These comments included the input from a retired Ashley NF soil scientist.

ii. It is noted that the DEIS fails to admit any damage or impacts on soils, vegetation, streams, or watersheds by grazing tens of thousands of domestic sheep on this sensitive, steep, and erodible landscape.

iii. Pocket gophers are blamed for reduced soil cover in spite of evidence we submitted.

iv. The DEIS discounts damage to sensitive and erodible areas by claiming sheep have equal access to those with low ground cover as well as high ground cover, while failing to acknowledge the areas with high ground cover can include wet meadows which sheep do not prefer.

v. The Forest Service limits its monitoring to these less sensitive areas and then claims that conditions are satisfactory.

vi. We pointed out the cumulative impacts of sheep bedding, salting, watering, trailing and camps over the century of use has led to sheep accessing and damaging the entire project area as opposed to the small area described in the DEIS.

vii. The monitoring studies and conclusions found in records we obtained by FOIA present a picture of an ecosystem without significant impacts, yet the 1970 report by Mont Lewis who was a Range Conservationist on the Ashley NF described the lack of suitability of these alpine areas for grazing and illustrated the grazing impacts.

viii. Lewis' photographs and descriptions also pointed out the erosion caused by sheep grazing on steep slopes and increasing sedimentation of the lakes and severe erosion caused on the red shale type from grazing.

ix. Lewis' photographs illustrated alpine turf in poor condition from a history of heavy use.

x. Mont Lewis provided recommendations for grazing capacity and suitability determination.

xi. We provided photos illustrating the conditions on steep slopes resulting from grazing and trailing sheep, resulting in accelerated erosion and loss of soil stabilizing vegetation.

xii. Darlene Voerner's (ANF soil scientist, retired) analysis included photographs of broken turf from sheep grazing leading to increasing soil loss, loss of soil covering lichens, barren areas created by this loss of the shallow soil cover, pedestaled vegetation, and the need for a detailed Level 2 soil survey.

xiii. We pointed out flaws in the data received in our FOIA in that there was no utilization data which means utilization standards are meaningless. Our analysis of 1,565 study sites in the Ashley NF found that only 69 reported ground cover from line intercept or ocular estimates in the past 20 years.

xiv. We provided photos from the FOIA files illustrating the minimal capable acres, the proximity of steep slopes and the drier upland sites which are preferred to the valleys with their forest cover, wetland, and willow areas.

xv. Those photos also illustrated the late snowpack and growth barely starting before sheep enter in their thousands to graze and trample these sensitive soils in such a stressed environment with harsh growing conditions.

xvi. Photos from the long ungrazed Fall Creek allotment showed meadows lush and green with 100% ground cover, trails and headcuts vegetated and recovering, wet meadow with adjacent uplands fully vegetated, absence of streambank scouring, and areas of streambank trampling recovering, also snow beds with full cover of lichen and other plants covering the soil.

xvii. An illustration of the preference of sheep from the FOIA files is in Ottoson where sheep are seen grazing and occupying the drier uplands adjacent to the stream and wetland area. Another photo of Ottoson showed severe erosion that is not healing, bare grazed slopes adjacent to wetland area, and broken turf.

xviii. An Ottoson wet meadow photograph with a notation by Sheryl Goodrich that "Sheep are very reluctant to use these areas."

xix. The Rorripa Snowbed photo with the statement that "Snow release date was prior to August 29 this year." These areas remain snow covered until late in the season yet are grazed and trampled so there is no chance of recovery. This photo showed large bare soil with no evidence of gophers, indicating it is not gophers creating the bare soil.

xx. An Ottoson gopher activity photo showing gopher activity in uplands adjacent to a wet meadow, but this is also a site that would be selected by sheep which would concentrate in the upland to avoid the wet meadow.

xxi. An Oweep sheep trail with a headcut and the Range staff admitting sheep trailing contributes to the headcut.

xxii. A photo in Painter Basin showing denuded uplands adjacent to a wetland area with the statement, "Had livestock grazing been so intense as to cause the conditions on the far side of the stream, similar conditions could be expected on the near side of the stream." Here the Forest Service makes the comparison with a wetland that according to their own statements would be avoided by sheep. Yet it is used to claim that the bare uplands are not degraded by sheep in the very areas they typically would graze.

xxiii. Sample Point analysis of a Forest Service monitoring photo showed that a ground cover data sheet reporting 2% bare soil was actually 40%.

xxiv. We cited a lichen study that illustrated the disruption of lichen communities and ground cover by sheep grazing.

xxv. A report of a visit to Bald Mountain stated, “"I spent the long weekend in the Uintas, my husband and I climbed to the top of Bald Mountain in the Red Castle allotment. There was so much sheep sh.. we couldn't put our packs down. In most places the ground was so saturated the melt was creating overland flow, so the feces was in standing water that was running off into the creeks. We hiked all the way back down without water, because gross. I trust my filter but that was just disgusting." This ridgetop location was heavily grazed by sheep and the ground littered with feces.

xxvi. We presented our analysis of Forest Service monitoring locations. Many monitoring points had no location data. We found that 75% of the monitoring sites were in “capable” areas that did not include consideration of a number of factors such as soil erosion hazard, forested cover, forage production and does not represent the complete set of criteria that should determine capability.

xxvii. The analysis showed the majority of sites were in areas of <10% slope indicating the more sensitive erodible or steep slopes were monitored less with wet and willow dominated sites dominating those monitored. These are the less preferred sites.

xxviii. We presented maps of the Forest Service monitoring sites showing their concentration in valleys and also a map of the range capability for cattle and sheep as determined by the Forest Service showing the very minimal areas capable for sheep.

xxix. We concluded the comments noting the heavy bias of the Forest Service monitoring and the lack of acknowledgement of domestic sheep impacts, that recovery is happening in the Fall Creek allotment, which is ungrazed, and there is no comparison of grazed and ungrazed areas.

Purpose and Need

The SDEIS (p5) describes the Purpose and Need for this project.

> The primary purpose of this project is to comply with the November 7, 2013 settlement agreement resolving Western Watersheds Project et al. v. United States Forest Service, Case No. 10-cv-612 ELJ-REB. In conjunction with the primary purpose, the other main purpose of this project is to provide forage for permitted domestic livestock grazing in a manner that maintains or moves conditions toward achieving Forest Plan objectives and desired conditions.

This is a purpose and need that is clearly defined to perpetuate the status quo, i.e. a "decision already made" which is counter to the intent of NEPA for a fact-based objective analysis. Prioritizing wilderness qualities, watershed health, protecting soils, sustaining native plant communities, and meeting the needs of fish and wildlife are omitted as a priority, that includes threatened, endangered, and sensitive species.

As outlined at the beginning of these comments, we have provided a great deal of input on all aspects of this project over ten years. We can find nothing that sincerely addresses this input and can only conclude that this SDEIS, its alternatives, and its upcoming decision document are merely "justifying a decision already made." (NEPA 1502.2). The courts have held that in defining a very narrow purpose and need, the agencies run afoul of NEPA. [2] (See Sage Steppe Wild comments on the SDEIS for more discussion on agency obligations in selecting alternatives.)

> The "purpose" of a project is a slippery concept, susceptible of no hard-and-fast definition. One obvious way for an agency to slip past the strictures of NEPA is to contrive a purpose so slender as to define competing "reasonable alternatives" out of consideration (and even out of existence). The federal courts cannot condone an agency's frustration of Congressional will. If the agency constricts the definition of the project's purpose and thereby excludes what truly are reasonable alternatives, the EIS cannot fulfill its role. Nor can the agency satisfy the Act. 42 U.S.C. § 4332(2)(E).[3]

The SDEIS (p24) notes that the determination of alternatives for analysis was made by "resource specialists from both Forests, and some of the cooperating agencies that represented agriculture and some that had jurisdictional authority over wildlife… ." This does not mention the input from interested publics and amounts to an internal livestock-centric group of interests. We note that the MOU for Management of bighorn sheep on NFS lands in Utah is a joint agreement among the Forest Service, Utah Dept of Agriculture and Utah Division of Wildlife Resources.[4] The Forest Service Handbook FSH 2209.10 Chapter 10 describes public involvement. It is supposed to:

- "Involve the permittee and interested publics in management of the range allotment." (Par. 11.3).

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[2] See Sage Steppe Wild "Comments on the High Uintas Sheep DEIS" for a full description of policy requirements and flaws in the analysis for the DEIS/SDEIS. https://app.box.com/s/la5v8o0mtj4ynnl4wia3vsqbw1dt66i1

[3] Simmons v. U.S. Army Corps of Engineers, 120 F.3d 664, 666 (10th Cir. 1997). https://caselaw.findlaw.com/court/us-7th-circuit/1089603.html

[4] Memorandum of Understanding for the Management of bighorn sheep on National Forest System (NFS) lands in the State of Utah. 2019. FS Agreement Number: 19-MU-1 1046000-028. https://wildlife.utah.gov/pdf/bg/plans/bighorn_uinta_mountains.pdf

- "Obtain ID team, interested publics, and permittee assistance in securing the necessary inventory and monitoring information and establish criteria for determining allowable use levels." (Par. 12.2).
- "The interdisciplinary (ID) team, the permittee, and interested publics should assist in the rangeland inventory and analysis and in the preparation of environmental documents." (Par. 13).

Citing congressional intent "to allow livestock grazing on suitable lands" and the desirability of providing forage for permitted domestic livestock, the SDEIS (p6) also recognizes this is a discretionary action by the Forest Service. These points of providing forage for livestock and doing so on suitable lands is key to our opposition to this project.
Suitable lands must also be "capable" according to the criteria defined by the Forest Service and the forage on those capable lands must be sufficient to provide for wildlife and livestock while leaving sufficient residual vegetation to protect watersheds and sustain the plant communities. The SDEIS (p10) cites the UWCNF RFP by stating, "Manage livestock grazing levels and operations on suitable lands for sustainable forage use within properly functioning conditions."

The question then becomes is there sufficient capable and suitable lands and forage to support domestic livestock while also meeting the needs of wildlife and watershed function? The SDEIS has not answered that question.

Domestic sheep grazing

Capacity and Stocking Rate: While the SDEIS mentions capable acres within the allotments, it doesn't map those and analyze the relationship between individual blocks of capable lands and describe the trailing and grazing taking place on the non-capable lands. We have reported significant degradation of areas within the allotments including uplands, slopes, stream banks and trails. The lack of a current evaluation of forage availability, forage demand, and setting a stocking rate based on forage available on capable areas leads to this damage.

In 2016, we conducted a survey for available forage in the project area using locations in allotments that were not grazed prior to field sampling.[5] The goal was to determine forage production and stocking rates for the allotments using the full suite of Forest Service capability criteria. This was needed due to the failure of the Forest Service to determine current forage production and incorporate all of its capability criteria into the determination of capable acres for domestic sheep grazing. This results in the Forest Service overstating the capable acreage and stocking rate for the allotments. This full analysis was presented to the UWCNF and Ashley

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[5] Vasquez, E., Carter, J., and Jones, A. 2018. A Forage Capacity and Stocking Rate Determination for the High Uintas Wilderness Domestic Sheep Analysis.
https://app.box.com/s/2c8dgun6na1v71zlew9oczpzq3nb27mo

NFs in a meeting in July, 2018 and in report form in September, 2018. It has also been published in a journal.[6] That article is included as Exhibit 1 to these comments.

The locations surveyed for forage production were representative of the six major soil types in the project area within the UWCNF. These were mapped, and image analysis performed to derive a predicted forage production layer. In addition, USFS forage production data from the 1960's was digitized and analyzed to produce a forage production dataset which could also be mapped. A canopy density dataset was generated in order to exclude densely forested areas in accordance with Forest Service capability criteria. We then applied a model of the Forest Service capability criteria, our forage production data, canopy cover density, slope, and removed wetland areas and water bodies to determine capable acreage. Both our 2016 and the Forest Service's 1960's datasets could be applied. Table 1 shows that the mean production is about the same today as it was in the 1960s.

Table 1. Key Statistics for Forage Production (lb/acre)

Time Period	Median	Mean	Maximum
1960's	206	240	615
2016	166	294/211*	1431**

*If wetland samples are excluded, the mean forage production becomes 211 lb/acre.
**Includes wetland samples

The current Forest Service regional criteria for determining capable acres are:[7]

- Areas with less than 45 percent slope for domestic sheep, 30% for cattle.
- Areas producing or having the potential to produce an average of 200 lbs or more of forage/acre on an air-dry basis over the planning period.
- Areas without dense timber, rock, or other physical barriers.
- Areas with naturally resilient soils (not unstable or highly erodible soils).
- Ground cover greater than 60%.
- Areas within one mile of water or where the ability to provide water exists.

In the 2003 WCNF RFP only the slope, forage criteria (based in extrapolation from vegetation map) and distance to water were used. We obtained GIS files from the Forest Service representing capable acreage in the Forest Plans for the UWCNF and ANF. These were used to map capable acreage using the three criteria that did not exclude dense timber or wetlands and did not collect forage production data. The capable acres using the Forest Service abbreviated

[6] Carter, J., Vasquez, E. and Jones, A. (2020) Spatial Analysis of Livestock Grazing and Forest Service Management in the High Uintas Wilderness, Utah. Journal of Geographic Information System, 12, 45-69. https://doi.org/10.4236/jgis.2020.122003

[7] U.S. Department of Agriculture (USDA) (1998) Rangeland Capability and Suitability Determinations for Forest Plan Revisions R-4 Revised 2/20/98. Region 4 Forest Service, Ogden, UT. See also FEIS for the 2003 WCNF RFP Appendix B-9.

determination within the ten allotments was 53,399 acres, or 35.7% of the 160,410-acre project area. See Figure 1.

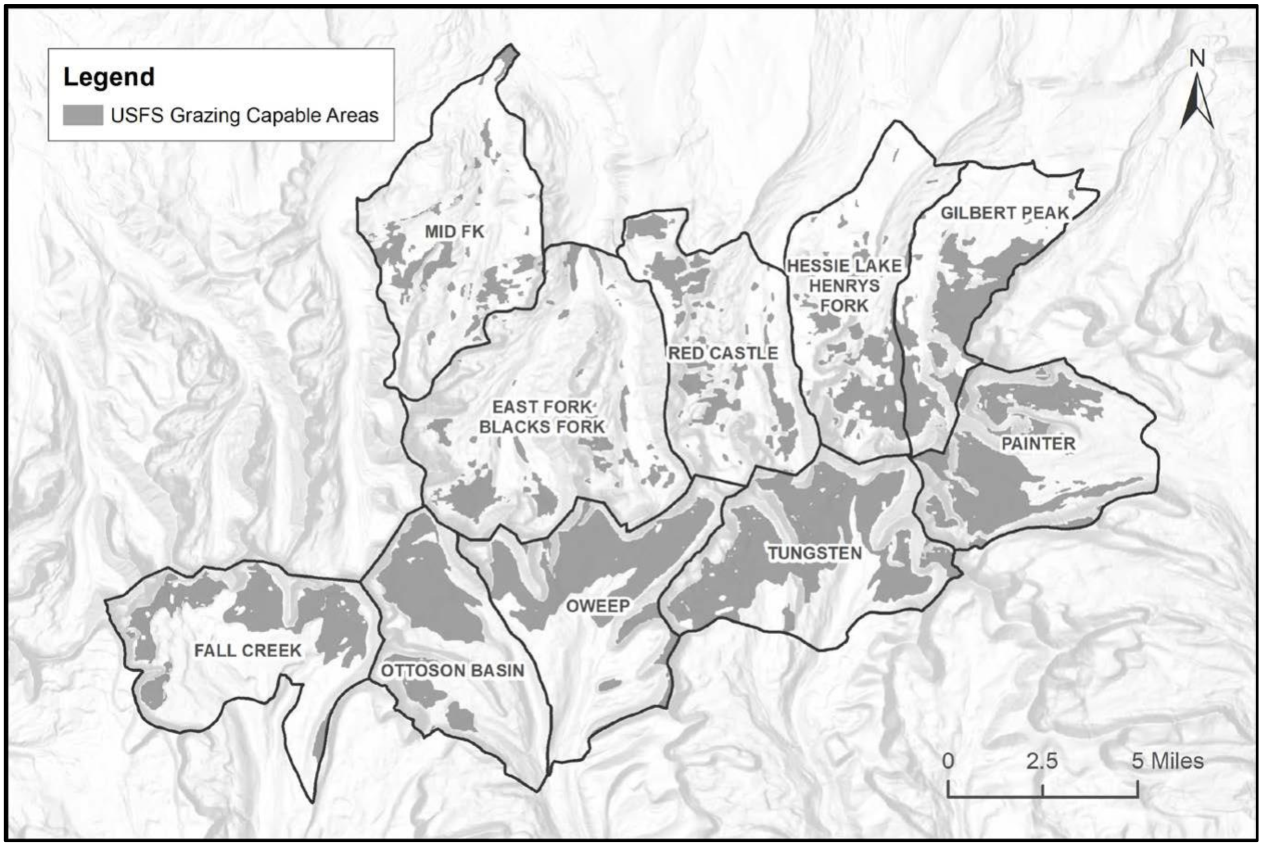

Figure 1. Ashley and Wasatch-Cache National Forest determination of capable acres = 57,399 acres, or 35.7 percent of total acres.

We calculated the capable acres using our forage determination and modeled forest canopy cover, while excluding wetlands and water bodies (The Forest Service has acknowledged that domestic sheep avoid grazing in these wet areas). Here we present the summary for two cases. In Case 1, we calculated the acreage of lands meeting the current regional criteria of ≤45% slope, 2016 forage production ≥ 200 lb/acre, and excluded areas of dense timber, water bodies and wetlands. In Case 2, since the most recent Forest Service forage production data was collected in the 1960s, we digitized the 1960's forage production data which was then used to determine acres with forage production ≥ 200 lbs/acre. This, along with slope ≤ 45%, while excluding dense timber, water bodies and wetlands were used to determine capable acres. Figures 2 and 3 illustrate the extent of capable acreage for these two cases.

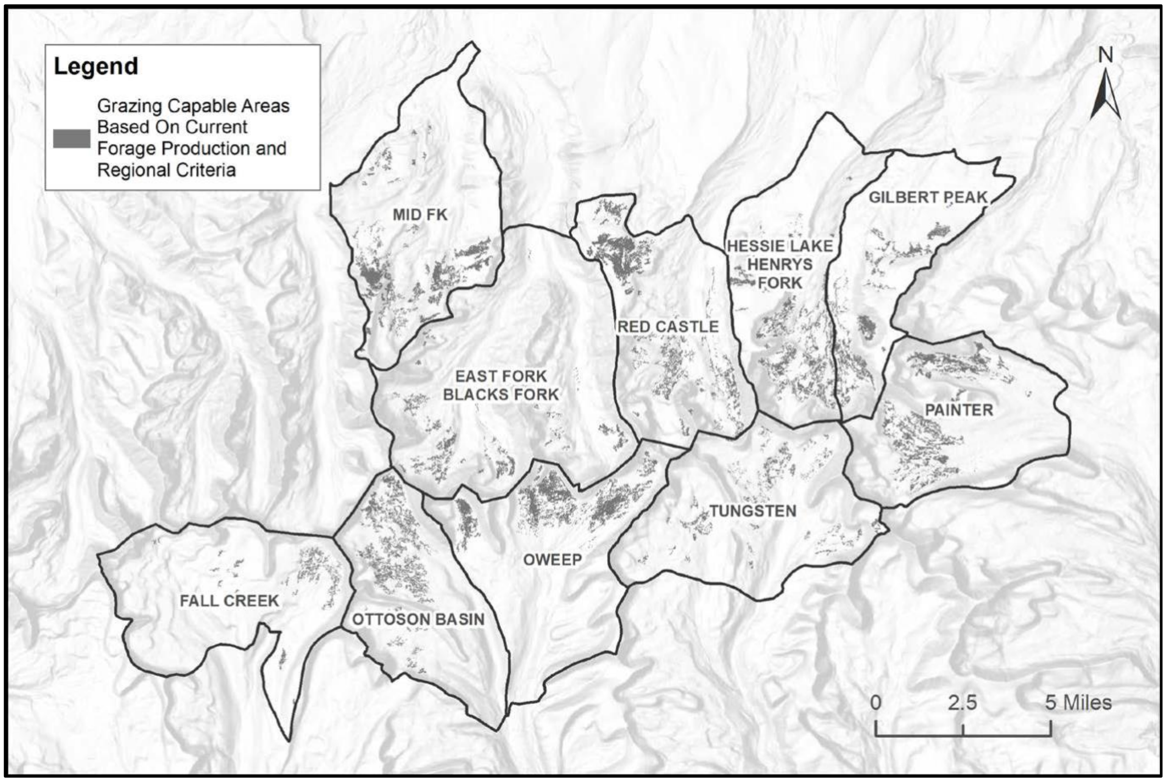

Figure 2. Capable acres determined from regional capability criteria and current forage production = 9685 acres, or 6.0 percent of total acres.

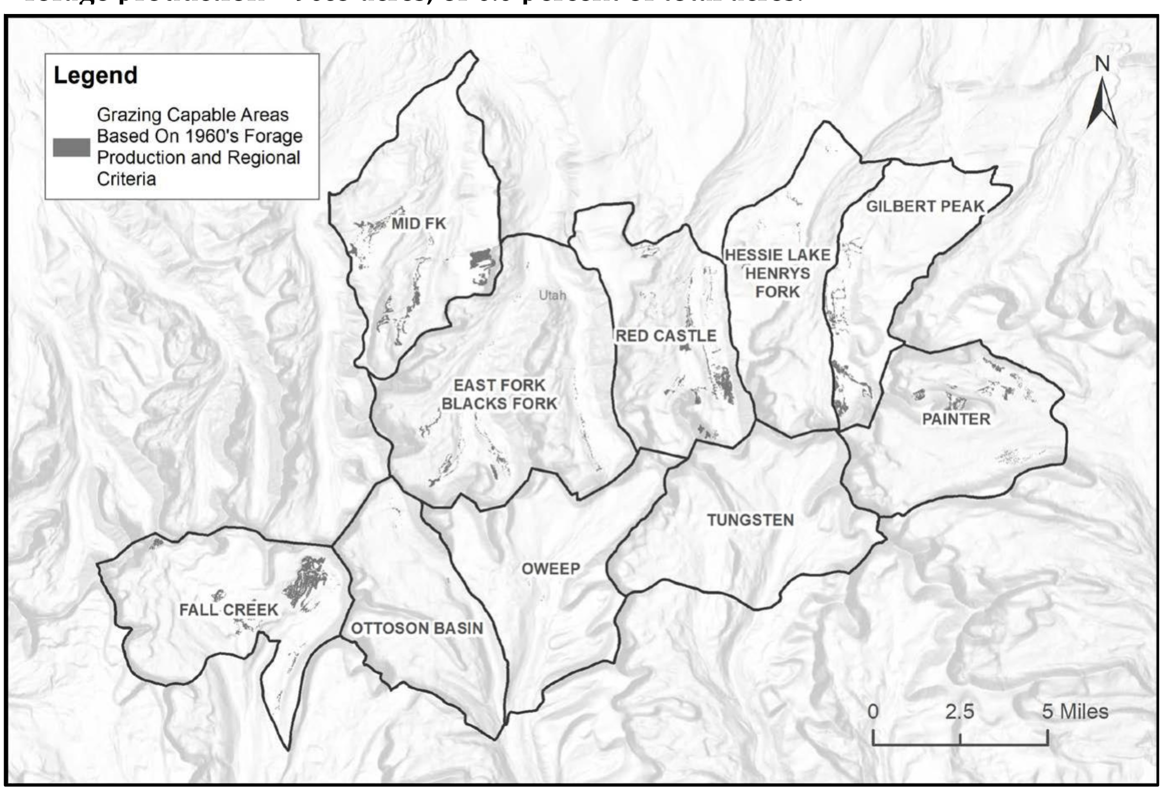

Figure 3. Capable acres determined from regional capability criteria and 1960's forage production = 2,887 acres or 1.8 percent of total acres.

This analysis determined there are only 9,685 capable acres for Case 1, or 6% of the project area and 2,887 acres for Case 2, or 1.8% of the project area. Clearly, an accurate determination of capability shows the lack of a full analysis by the Forest Service overstates the actual capable acres by factors of 6 and 20. (Table 2).

Table 2. Capable Acres by Allotment

Allotment	Case 1	Case 2
East Fork Blacks Fork	613	263
Fall Creek	319	734
Gilbert Peak	846	355
Hessie Lake Henry's Fork	1103	56
Middle Fork	1197	634
Ottoson Basin	1099	14
Oweep	1346	4
Painter	1186	317
Red Castle	1449	510
Tungsten	527	0
Total	9685	2889
Percent of Total Area (160,410 acres)	**6.0**	**1.8**

The total forage demand for the currently permitted 12,850 ewe/lamb pairs grazing these ten allotments based on their time in the allotments and a forage demand of 301 pounds per month per pair is 8,062,641 pounds. In Case 1, using the 2016 mean forage production of 294 lb/acre and 9685 capable acres gives total forage production of 2,847,390 pounds. Applying a 30% utilization rate to this amount gives 854,217 pounds available. This is 10.6% of the current demand by domestic sheep. In Case 2, using the 1960's mean forage production values on the 2887 capable acres is 848,778 pounds. Applying a 30% utilization rate to this amount gives 254,633 pounds available. This is 3.2% of the demand. The implication of this for current stocking rates is clear. In Case 1, a 90% reduction would be needed to balance domestic sheep use by the current permitted numbers to the available forage. In Case 2, a 97% reduction would be needed to balance domestic sheep use by the current permitted numbers with the available forage. The extra forage needed must come from grazing and trailing sheep throughout the non-capable areas on steep slopes, erodible soils, and sensitive alpine meadows resulting in the degraded conditions we have reported.

We have read the climate analysis for this project. It does not go far enough in accounting for climate effects and greenhouse gas emissions. The FEIS for the WCNF RFP (p3-351) gives the 10-year average AUMs permitted on the Forest. The total for cattle is 41,507 AUMs and for sheep it is 30,711 or overall, 72,218 AUMs. The climate analysis presents figures from INFRA for numbers grazed for each forest, but there are no total emissions generated on a Forest-wide basis. The ANF Forest Plan (pII-9) states the total AUMs is 75,000. While the Forests' climate analysis estimates the weight and forage consumption of the sheep grazing these allotments, they may be low based on observations of the sheep in the allotments. The Forest Service should request auction/sale records from the permittees to determine a more accurate representation of today's sheep weights as well as the numbers of lambs per ewe. The effects analysis (cumulative effects) should be couched in terms of the total emissions from the actions on the Forests, including logging, prescribed burns, livestock grazing and should include past, present, and foreseeable projects. A recent paper demonstrated the social carbon cost of public lands grazing. It was estimated to be $1.1 – 2.4 billion.[8]

It is also important to recognize that the capable areas are separated and patchy. This means that sheep are grazed, trailed, and bedded in non-capable areas which are more sensitive to disturbance. In addition, the capable areas would still need to be refined using the Regional Criteria for suitability. One of those factors which can result in the land not being suitable is in key wildlife habitats such as for bighorn sheep (See Sage Steppe Wild comments on the SDEIS).

<u>Closing Allotments:</u> The SDEIS did not analyze an alternative to reduce the number or size of allotments. It did not analyze reducing stocking rates to balance forage demand with available forage. Instead, it proposes to continue the status quo which will perpetuate the damage. It also did not consider closing the Fall Creek allotment which has not been grazed since 1977 (SDEIS p26). Given that the High Uintas Wilderness was designated in 1984, the SDEIS should propose closing this allotment since grazing was not occurring at the time of Wilderness designation. We note that there is no current AOI for the allotment. The SDEIS (p8) also cites a provision from the Ashley NF Plan that states, "Sheep allotments that remain unutilized for a period of 5 years may be considered for conversion to another class of stock or closed (IV-32)." The Fall Creek allotment meets this criterion many times over.

Bighorn sheep suitable habitat occurs throughout the 10 project allotments in addition to adjacent allotments. (Figure 4). The WAFWA 9-mile buffer[9] applied to the westernmost observations of bighorn sheep (data obtained from the Forest Service) show possible exposure of bighorn sheep that would extend into Painter Basin, Gilbert Peak, Hessie Lake/Henry's Fork, Red Castle, Tungsten, East Fork Black's Fork, and Oweep allotments. (Figure 5). The BE Figure 3 shows the likelihood of bighorn sheep forays into these same allotments and beyond.[10] The WCNF RFP ROD[11] (p19) references closing seven allotments to expand the area for bighorn sheep habitat if permits are waived. The WCNF RFP FEIS (p3-178) listed these: Gilbert Peak, Henry's Fork – Hessie Lake, Red Castle, East Fork Black's Fork, West Fork Black's Fork, East Fork Bear River, and Stillwater. These should be closed to protect the current distribution of

[8] Kauffman, J.B., Beschta, R.L., Lacy, P.M., and Liverman, M. 2023. Forum: Climate, Ecological, and Social Costs of Livestock Grazing on Western Public Lands. https://link.springer.com/article/10.1007/s00267-023-01853-6

[9] Wild Sheep Working Group. 2012. Recommendations for Domestic Sheep and Goat Management in Wild Sheep Habitat. Western Association of Fish and Wildlife Agencies. https://wafwa.org/wpdm-package/recommendations-for-domestic-sheep-and-goat-management-in-wild-sheep-habitat-2/

[10] Christensen, B. 2023. Terrestrial Wildlife Biological Evaluation for the High Uintas Wilderness Domestic Sheep Analysis.

[11] USDA. 2003. Record of Decision Revised Forest Plan Wasatch-Cache National Forest.

bighorn sheep and to provide for expansion of bighorn sheep into other suitable areas, all domestic sheep grazing should be terminated in the High Uintas Wilderness.

The SDEIS (p175) claims that separation of bighorn sheep and domestic sheep is maintained in the open allotments by stating, "bighorn sheep generally use the ridge tops and steep slopes for foraging, whereas domestic sheep generally use the valley bottoms. Thus, foraging competition between domestic sheep and the Uintas BHS is likely relatively limited." The problem with this theory is it does not reflect reality. We commented on the presence of heavy domestic sheep droppings on Bald Mountain, the denuded conditions on Red Knob and Dr. Carter has hiked many of the long ridges in the project area, finding that domestic sheep have heavily grazed and trampled the ridges. In addition, they are trailed back and forth between the ANF and UWCNF across the ridges.

These additional allotments should be included in the analysis. For example, we have mentioned the West Fork Black's Fork allotment in past comments. Historically, sheep have been trailed through the WFBF allotment to the south slope on the ANF.[12] This would likely be the Ottoson allotment. From the WFBF DEIS (Chapter 3, p19) " Sheep Trailing – A sheep herd is permitted to trail across the allotment in the early summer as it travels to an allotment on the Ashley National Forest; this same herd trails across the allotment again in the fall as they travel home from the Ashley National Forest." The current AOI for the Ottoson allotment shows trailing through the East Fork Black's Fork allotment. However, during the time we were addressing the WFBF, we recall being told by the Forest Service that sheep trailed up through the WFBF over Red Knob into the Ashley NF and that these herds would then return through the EFBF. So, the history of trailing through these allotments and by which herds needs to be disclosed to ensure that all connections are addressed and analyzed.

The Ashley NF Plan states, "Manage Bear Top Mountain in giving preference to Rocky Mountain bighorn sheep." (pIV-29). "Resource management activities will be allowed if they will not adversely affect any T and E or sensitive species." (pIV-30). "Authorize the introduction of bighorn sheep in the Bear Mountain vicinity following determination that any significant adverse environmental effects can be avoided or mitigated." (pA-38). Many comments in the FEIS for the ANF Forest Plan urged reintroduction of bighorns, consolidation of sheep allotments, closure of Fall Creek and Chepeta allotments, reintroduction into places such as Lake Fork, Rock Creek, Grandaddy Basin, Yellowstone and Uinta River drainages, and others. Many areas were described as suitable for bighorns. Here, the ANF describes its intent to provide bighorn sheep habitat.[13]

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[12] Wasatch Cache National Forest. 2006. Draft Environmental Impact Statement West Fork Black's Fork Grazing Allotment.

[13] USDA. 1986. Final Environmental Impact Statement for the Ashley National Forest Land and Resource Management Plan.

Figure 4. Project Allotments, Adjacent Sheep Allotments and DWR Modeled Suitable Habitat

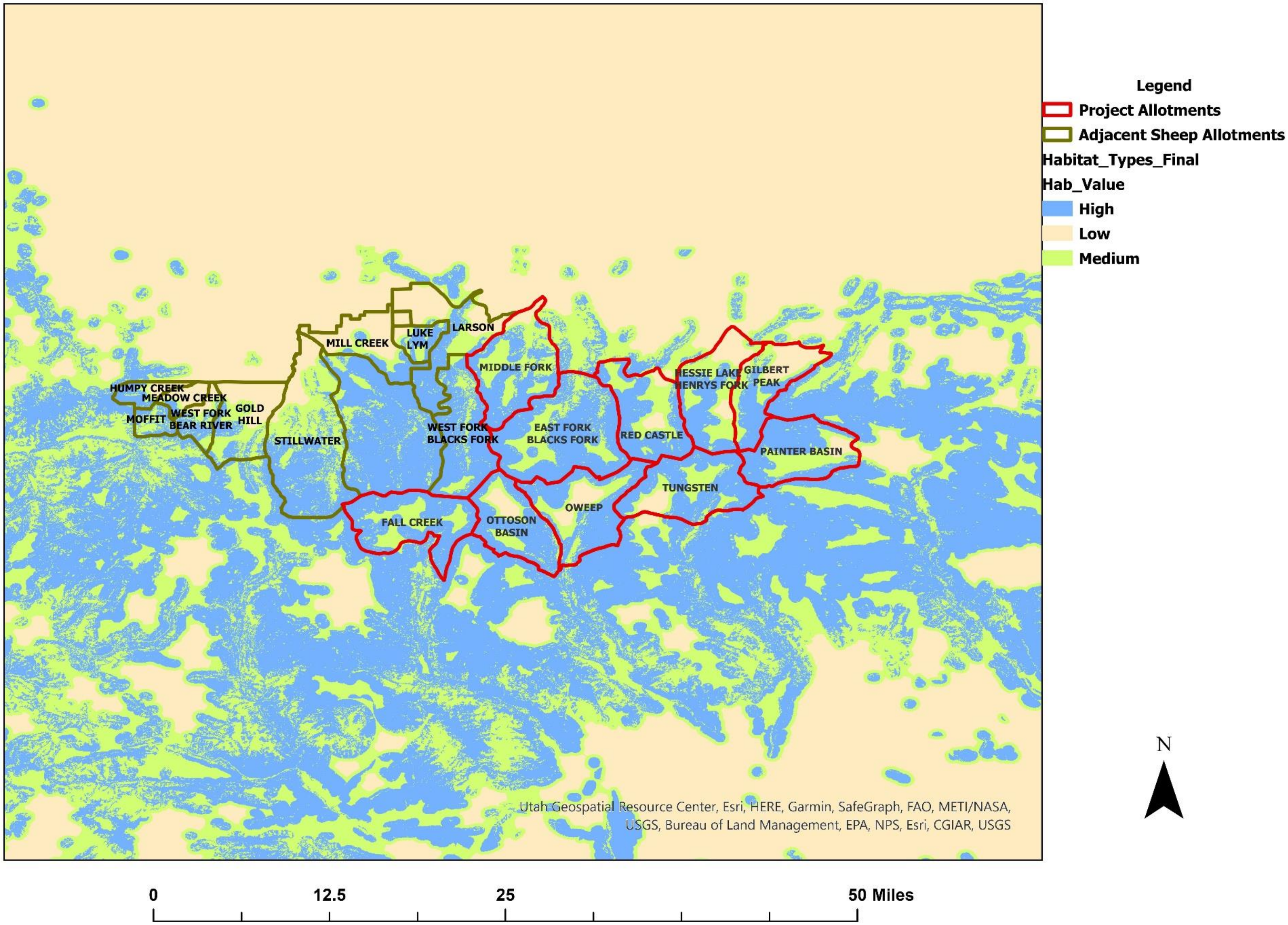
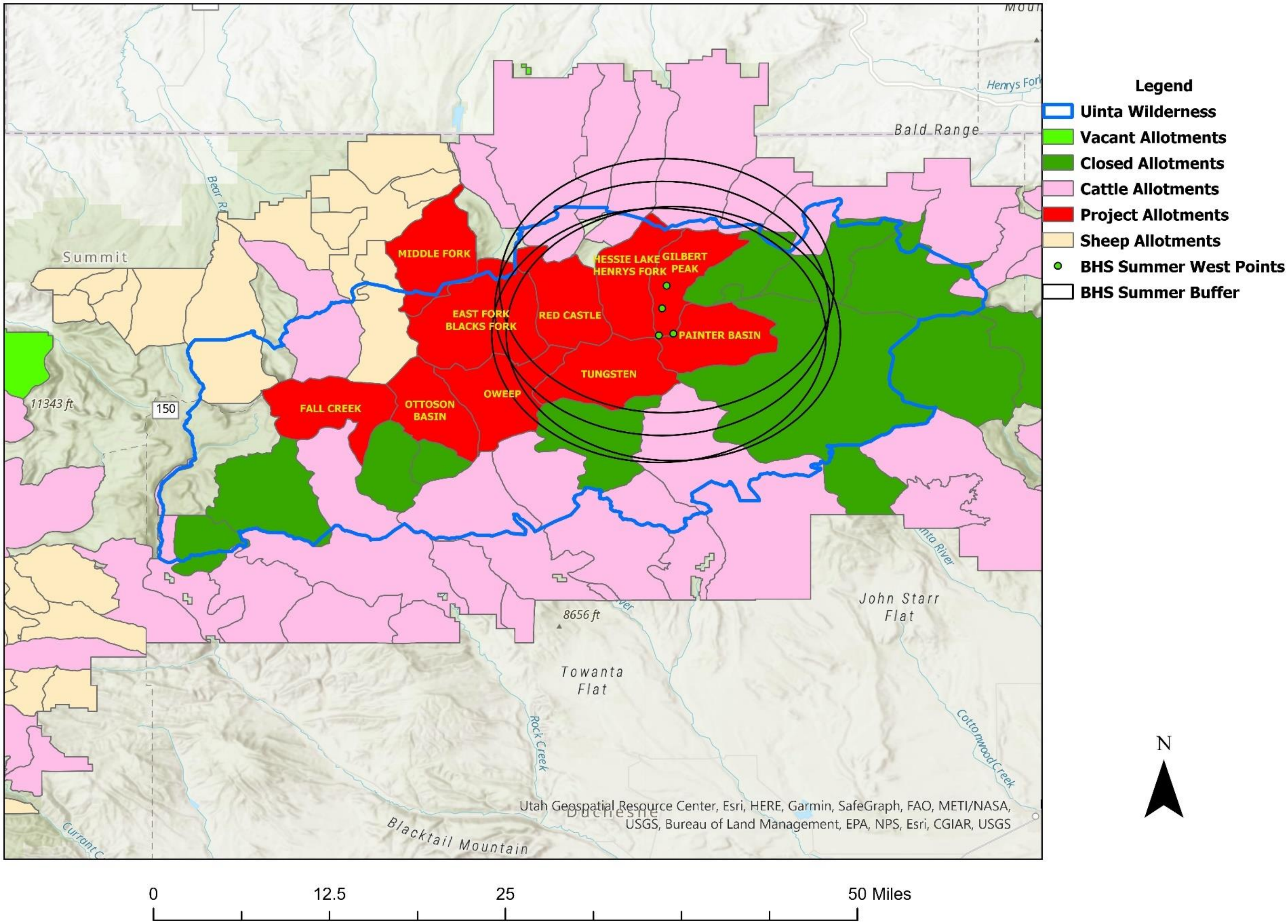


Figure 5. **Bighorn Sheep Summer Observations Westmost Points Buffered 9 Miles**



The SDEIS (p45) Range Vegetation section provides descriptions and photo examples of plant community types and cites the Brown (2006) description of these plant communities.[14] We have commented on the Brown report and its potential for incorporating degraded conditions as a baseline by his collecting data in allotments that are being grazed by livestock and are degraded. We analyzed the data provided in that report for the sheep allotments. (Table 3). Throughout the SDEIS, utilization is indicated to be low to moderate and has been measured for more than 60 years (SEIS p141) yet no tabulation or description of this data is provided and related to current or reference conditions. Neither are trend data provided as most monitoring appears to be opportunistic, not systematic. The Forest Service Handbook emphasizes the use of reference areas and the need to use monitoring of those to determine progress towards DFCs. "Monitoring can then tie to these reference areas as a means of determining progress toward meeting the desired conditions." (FSH 2209.13).

Table 3. Ground Cover Characteristics in Sheep Allotments

Community ID (Brown 2006)	**No of Sites**	**Exposed Soil Min %**	**Exposed Soil Max %**	**Exposed Soil Median %**	**Exposed Soil Mean %**
Dry	20	0	20	3	5
Ivesia and Barren	15	2	84	26	37
Low and Dwarf Shrub	4	4	10	5	6
Meadow	32	0	45	3	6
Mesic Carex	11	1	40	4	11
Snowbed	36	0	65	20	23
Wet	10	0	5	0	1

This table illustrates several important points.

- The minimum amount of exposed soil in all communities is near zero. This comports with Lewis (1970) which indicated potential ground cover is near 100% and also with our report[15] comparing grazed and long term rested allotments in the Uinta Mountains.
- The maximum exposed soil in wet communities of 5% and average of 1% comports with the acknowledgement by the Range Specialists such as Sheryl Goodrich that sheep avoid wet plant communities therefore these are not capable.
- The maximum exposed soil in all other communities ranged up to 84%.

[14] Brown, G. D. 2006. An Alpine Plant Community Classification for the Uinta Mountains, Utah. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 140 p. https://app.box.com/s/vt5obbo9tt2cd6ucesai9xjx046pu71y

[15] Carter, J. 2006. Watershed Conditions Uinta Wilderness. Western Watersheds Project. https://app.box.com/s/944957604b8618539585

This data indicates that severely degraded conditions of high amounts of exposed soil exist across these allotments. This argues against the supposition that conditions are "satisfactory" which the SDEIS (52) defines as "Meeting desired conditions or trending towards desired conditions." Yet we have not seen a quantitative measure or reporting of exactly how those conditions are met. Our review of historical monitoring data and reports revealed a minimum amount of data that could be used to make these determinations. This was addressed in our comments dated August 5, 2019 which emphasized the bias in the Forest Service monitoring.

Canada Lynx

The SDEIS (Table 23) concludes for Canada lynx that they are "Considered dispersers and no evidence of lynx reproducing in Utah. Track surveys 1999-2017 did not find hard evidence of lynx in the Uinta Mountains. Project would not change vegetation layers or remove snowshoe hare habitat. May affect, not likely to adversely affect." In our prior comments, we addressed the supposition that there are not now, or never was a resident population of lynx in the Uinta Mountains. We also addressed the location of the Uinta Mountains in the Forest Service's Regionally Significant Wildlife Corridor[16] connecting the Yellowstone ecosystem and Northern Rockies to the Uinta Mountains and Southern Rockies, in particular the Colorado population. Since those comments we have reviewed the history and regulatory status of lynx for comments on the Species Status Assessment being conducted by the US Fish and Wildlife Service. Those are included in Exhibit 2 of these comments. Important points from those comments follow.

A review of the regulatory history and science involved in the ESA listing for Canada lynx and subsequent land management on National Forests reveals that much of the science is misinterpreted to favor human activities that degrade and fragment lynx habitat, while absence of evidence due to lack of studies is used to claim these activities either have little effect, or in the case of timber manipulations, can even be beneficial.

This "unoccupied" status results from failing to find current evidence of lynx long after habitats have been fragmented by mines, high road density, an explosion in motorized recreation, timber projects and including habitat alteration by livestock grazing.

The use of "verified" records to determine occupancy or historical populations ignores reliable reports of lynx indicating that rather than 10 records there are up to 37 records/observations in the Uinta Mountains if "reliable" records are included. In the Uinta Mountains there are also records of lynx on the North Slope reported by a former Forest Service employee, Harold Wadley, who worked in the Uinta Mountains in 1957 and 1958. Traveling by snowshoe, he used dogs to track and tree lynx. His records show he treed 20 Canada lynx in those two years,

[16] Map shows the north-south linkage between large landscapes connecting forests from the northern Rocky Mountains in Canada to the southern Rocky Mountains of the United States referenced in the Wasatch-Cache Revised Forest Plan page 4-70, 4-120, and 4-143.

and he estimated there were 15 Canada lynx on the north slope of the Uinta Mountains between the West Fork of the Bear River and the Little East Fork of the Black Fork River.

The FSM 2670.31 provides guidance for T&E species. (1) *"Place top priority on conservation and recovery of endangered, threatened, and proposed species and their habitats."* (2) *"Establish, through the Forest planning process, objectives for habitat management and/or recovery of populations."* (4) *"Avoid all adverse impacts on threatened and endangered species and their habitats, except when it is possible to compensate adverse effects totally through alternatives identified in a biological opinion."* (6) *"Identify and prescribe measures to prevent adverse modification or destruction of critical habitat and other habitats essential for the conservation of endangered, threatened, and proposed species. Protect individual organisms or populations from harm or harassment as appropriate."*

The Forest Service and other agencies are not analyzing and characterizing the habitat structures and current degraded state of potential lynx habitat in lynx linkage and peripheral areas. Note that the regionally significant wildlife corridor is a lynx linkage to the UWCNF and ANF in the Uinta Mountains where the landscape has been divided into numerous LAUs. Those LAUs are not analyzed in terms of habitat characteristics, structural alterations, degradation, and threats. The NRLMD states, "When National Forests are designing management actions in unoccupied mapped lynx habitat they should consider the lynx direction, especially the direction regarding linkage habitat." However, the same NRLMD states that the objectives, standards, and guidelines "do not apply to linkage areas."

Our comments for the SSA also used the example of habitat degradation of this regional corridor from mining and livestock grazing. Even though this corridor was mapped by the Forest Service and included in the WCNF RFP, the habitat, its fragmentation and degradation are never analyzed.

Regulatory inadequacy was the reason for listing lynx as threatened. Our analysis shows that there has been a gradual diminution of consideration or analysis of the factors negatively affecting lynx which renders so-called protections in the Northern Rockies Lynx Management Direction[17] and Forest Plans nearly meaningless, and where livestock grazing is addressed, there is nothing to hold agencies accountable for habitat degradation.

For example, the interagency Conservation Agreement[18] indicated that "The Science Report, prepared by an international team of experts in lynx biology and ecology, is a compendium and interpretation of current scientific knowledge about the Canada lynx, its primary prey and habitat relationships. This document serves as an important scientific reference for the various lynx activities of the cooperating Federal Agencies." The CA went on to discuss the Canada

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[18] USDA Forest Service and USDOI Fish and Wildlife Service. 2006. Canada Lynx Conservation Agreement. USFS Agreement #OO-MU-11015600-0 13.
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5160661.pdf

Lynx Conservation Assessment and Strategy.[19] "The LCAS builds upon this scientific base and identifies the risks to the species that may occur as a result of federal land management." The LCAS then identified risks to the species, including:

1. Timber harvest and pre-commercial thinning that reduce denning or foraging habitat or convert habitat to less desirable tree species.
2. Fire exclusion changing the vegetation mosaic maintained by natural disturbance processes.
3. Grazing by livestock that reduces forage for prey.
4. Roads and winter recreation trails that facilitate access to historical lynx habitat by competitors.
5. Incidental trapping and shooting.
6. Predation.
7. Being hit by vehicles.
8. Obstructions to movement such as highways and private land developments.

Then comes the Northern Rockies Lynx Management Direction that eliminates consideration of roads, mining, grazing, and over snow travel. In the NRMLD (p3) there is reference to a FWS *"Clarification of Findings"* in a Remand Notice which basically explains away most forest activities as impacting lynx or lynx habitat, i.e. a *"threat"* to lynx. The NRMLD puts it this way:

> *After the LCAS was issued the FWS published a Clarification of Findings in the Federal Register (FEIS, Vol. 1, Appendix P), commonly referred to as the Remand Notice. In the Remand Notice the FWS states, "We found no evidence that some activities, such as forest roads, pose a threat to lynx. Some of the activities suggested, such as mining and grazing, were not specifically addressed [in the Remand Notice] because we have no information to indicate they pose threats to lynx" (p. 40083).*
>
> *Further on in the Remand Notice they state, "Because no evidence has been provided that packed snowtrails facilitate competition to a level that negatively affects lynx, we do not consider packed snowtrails to be a threat to lynx at this time" (p. 40098).*

From an agency perspective, what's not to like? Unlimited recreation, grazing, high road densities, and no obligation to account for the effects? These are all activities that are well known to fragment habitat yet are excluded from any standards or analysis under the current NRLMD. For example, the WCNF RFP FEIS (p20) notes, "Potential impacts from roads and trails include fragmentation of habitat and displacement of wildlife. The amount is a function of the amount of use on the road or trail. The greatest potential for adverse impacts associated

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[19] Ruediger et al. 2000. Canada Lynx Conservation Assessment and Strategy. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Forest Service Publication #R1-00-53, Missoula, MT. 142 pp. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5199571.pdf

with roads is from construction for timber harvest or oil and gas exploration and development…". We recall that the prior Forest Plan for the WCNF included a 1 mile/sq.mi road density standard which disappeared in the current RFP. The 1986 Ashley NF Plan notes that existing road density, excluding the High Uintas Wilderness was 1.11 miles/sq.mi. We could find no current road density limitations in either Plan. We are requesting that the current and potential status of Canada lynx linkage, peripheral areas, LAUs in the Regionally Significant Wildlife Corridor in the ANF and UWCNF be analyzed. Some guidance for the analysis is found in several publications. This is provided in more detail in Exhibit 2.

A recent paper found that lynx exhibited decreasing use of stand initiation structures up to a minimum availability of 25%.[20] Another found that 50% of lynx habitat must be mature-undisturbed forest for it to be optimal lynx habitat and no more than 15% can be young clear-cuts, i.e. trees <4" dbh.[21] At the home range extent, the study found that "females with larger surviving litter sizes had less fragmented home range, lower moisture variance, young regenerating forest patches with low perimeter-area ratio, and lower percent composition of old regenerating forest than home ranges of females with smaller surviving litter sizes." That same study also noted that "At the southern extent of their range, Canada lynx habitat is historically patchy and is subject to loss and fragmentation by some forest management practices (i.e. regeneration harvests, pre-commercial and commercial thins, prescribed burns), wildfires and insect infestations, and climate change". These results provide a guide to evaluating current forest stand structure, fragmentation by roads, logging and whether connectivity between patches is adequate. Ruggierio et al (1999)[22] also discuss the effects of fragmentation on competition with lynx by other carnivores and the loss of connectivity.

Sophisticated, peer-reviewed modeling identified the Uinta Mountains as core lynx habitat.[23] The study used vegetation cover types, road densities and classified suitable vegetation types based on current science at the time. After all cells that surpassed both the vegetation suitability and road density suitability thresholds were identified, habitat patches were formed using ArcGIS. For the purposes of the model, the analysis considered large enough core patches for lynx to be those that are at least 1,600 km^2, the approximate area of eight

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[20] Holbrook, J. D., J. R. Squires, L. E. Olson, N. J. DeCesare, and R. L. Lawrence. 2017. Understanding and predicting habitat for wildlife conservation: the case of Canada lynx at the range periphery. Ecosphere 8(9): e01939.10.1002/ecs2.1939. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.1939

[21] Kosterman, Megan K., "Correlates of Canada Lynx Reproductive Success in Northwestern Montana" (2014). Graduate Student Theses, Dissertations, & Professional Papers. 4363. https://scholarworks.umt.edu/etd/4363

[22] Ruggerio, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., Squires, J.R. (Eds.), Ecology and Conservation of Lynx in the United States. University of Colorado Press, Boulder, CO. https://www.fs.usda.gov/rm/pubs/rmrs_gtr030.pdf

[23] Bates, W., and Jones. A. 2007. Least-Cost Corridor Analysis for Evaluation of Lynx Habitat Connectivity in the Middle Rockies. Wild Utah Project, Salt Lake City, UT. https://app.box.com/s/52au96m3hpsx3wx7pvophlqbethbg5j2

average home range sizes for male lynx in the American Rockies.

The authors further assumed that areas identified as core patches in their model would: (1) be of sufficient area to support more than two mated pairs of lynx to reside year-round, for multiple years; (2) provide necessary land cover types for denning and hunting; (3) contain necessary prey to support lynx year-round; and (4) sufficient safety from human persecution. The model indicated that there are nine clusters of relatively well-connected blocks of suitable landscapes of sufficient size to be considered core lynx habitat. These habitat concentration areas included the High Uinta Mountains Wilderness (plus adjacent forested lands), a core patch in the Bear River Range, and many core patches near one another in both the west slope of the Colorado Rockies and the greater Yellowstone region." All the habitat factors were then evaluated through a separate analysis to determine the suitability for lynx traveling throughout the study area. This provided a "least-cost" path for lynx traveling between core patches. It is shown in Figure 6.

Colorado Parks and Wildlife engaged in a similar effort to map predicted use areas in Colorado.[24] They used location data from reintroduced lynx fitted with transmitters, filtered those data to remove locations for the first six months to account for habituation, considered elevations above 8,000 feet, and included factors for housing and road density, slope, distance to forest patches and vegetation types. Summer and winter data were used to generate models for both seasons.

Olson et al (2021)[25] used lynx observations in the west, climate, and human induced factors to model lynx habitat. Using lynx GPS and tracking data from Idaho, Wyoming, Montana, Washington, and British Columbia, the study found that lynx habitat is made up of a complex array of environmental conditions, not primarily vegetation type and elevations as currently mapped. They included an index of summer vegetation production, percentage of tree cover, road density and night light intensity as indices of anthropogenic influences. One confounding issue is their assumption of boreal forest soil pH as a factor due to the wetter conditions in boreal forests. However, we know lynx use a variety of forested types in the southern portion of their range and this factor might disqualify habitats unnecessarily. The model provides insight and a basis for more detailed analysis of lynx potential habitat and its fragmentation within the Regionally Significant Wildlife Corridor, including the Uinta Mountains and the linkage to the north. Their resulting map is shown in Figure 7.

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[24] Ivan, J., Rice, M., Shenk, T., Theobald, D., and Odell, E. Undated. Predictive Map of Canada Lynx Habitat Use in Colorado. Colorado Parks and Wildlife. Accessed on January 20, 2023. https://cpw.state.co.us/Documents/Research/Mammals/Publications/CPWPredictiveLynxMapReport.pdf

[25] Olson et al. 2021. Improved prediction of Canada lynx distribution through regional model transferability and data efficiency. Ecology and Evolution 11:1667 – 1690. https://www.fs.usda.gov/research/treesearch/63384

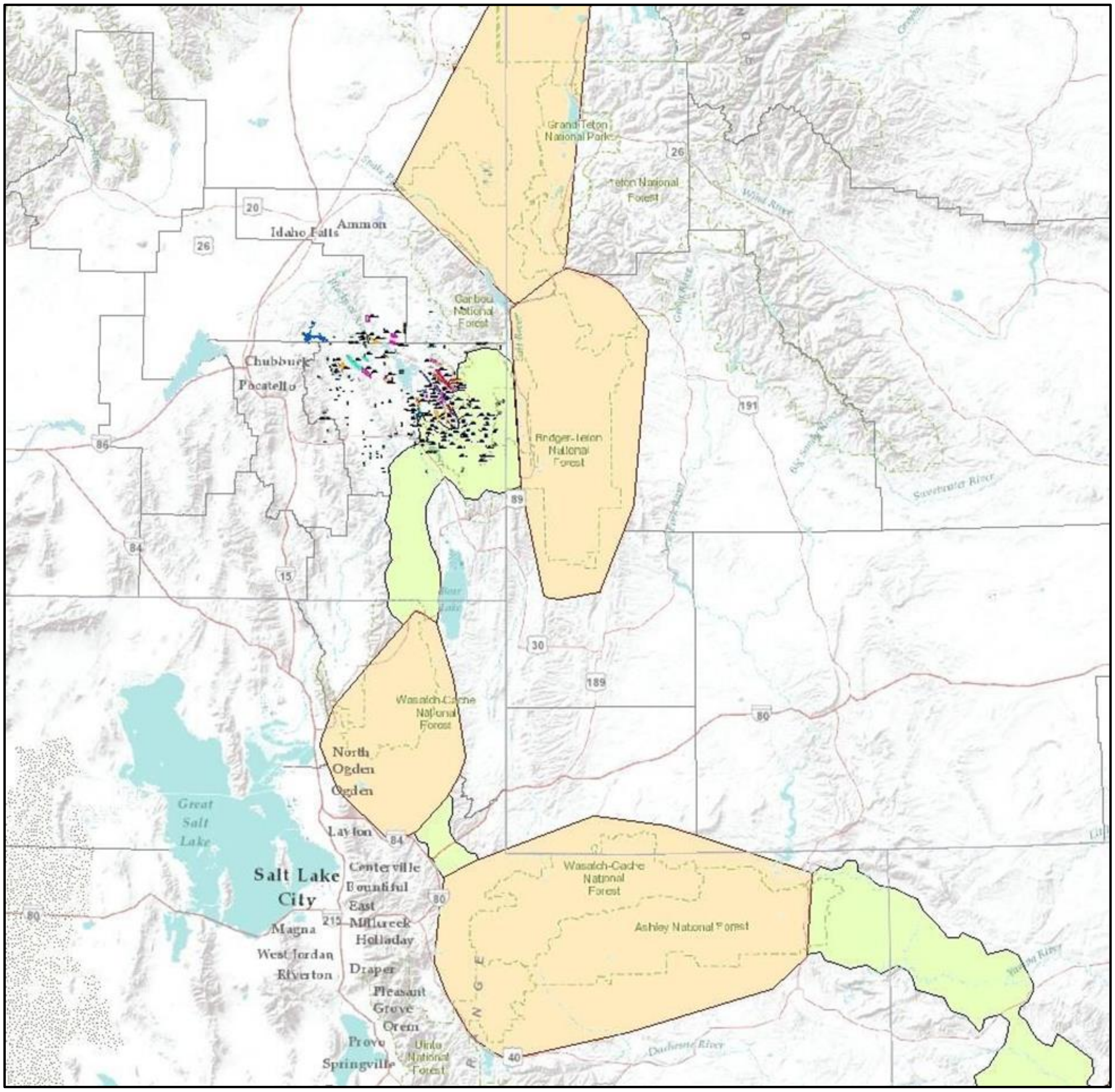

Figure 6. Modeled corridor from Bates and Jones. Orange is depicting a core area for lynx, while yellow are linkages. Mine leases in Idaho shown in various colors blue, red, orange depending on status.

The SDEIS and DEIS have not conducted a lynx population review and habitat analysis of sufficient detail to determine the effect of Alternative 2 on lynx and its prey. In addition, there is a lack of analysis of the current and potential state of habitat from the effects of other projects past and present. For example, consider the various North Slope timber projects and the recent Ashley NF projects that include the South Slope Fuels Reduction, Ashley Range Wide Improvement Project, Ashley NF Aspen Restoration Project, and the Ashley Forest Wide Prescribed Fire projects. That the Ashley NF deems these projects are needed indicates the ANF recognizes the apparently degraded ecological condition across the ANF. This argues against any Forest Service position that conditions in the Ashley NF are either "satisfactory" or meeting DFCs. We provided detailed comments on each of those projects addressing Canada lynx and other wildlife and hereby incorporate our comments by reference.

Recent court cases in Montana revolving around road density and habitats for wildlife have confronted the Forest Service over its flawed analyses that understate the effects of roads by omitting user-created and illegal roads, and by claiming their road closures are effective. Thereby illegal motorized use and impacts on wildlife are unaccounted for.[26] [27] A current article provides photo illustration of the effects of logging roads and the failure of attempted Forest Service closures. A cumulative effects analysis for Canada lynx and other special status species must include consideration of all activities that have, are or will fragment the habitat for these species be accounted for and this would include all roads whether open, closed, temporary, illegal and user created.

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[26] Alliance for the Wild Rockies v. Leanne Marten, et al. In US District Court for the District of Montana. CV 21-05-M-DLC. Filed 08/03/23. https://app.box.com/s/89u7tipvoenzln5hmvdobty4d33skk1i

[27] Native Ecosystems Council, Alliance for the Wild Rockies v Keith Lannom. In US District Court for the District of Montana. jCV 21-22-M-DWM. Filed04/04/22. https://app.box.com/s/u2srro4tdzuzlct63fhmjkojpu4c85uh

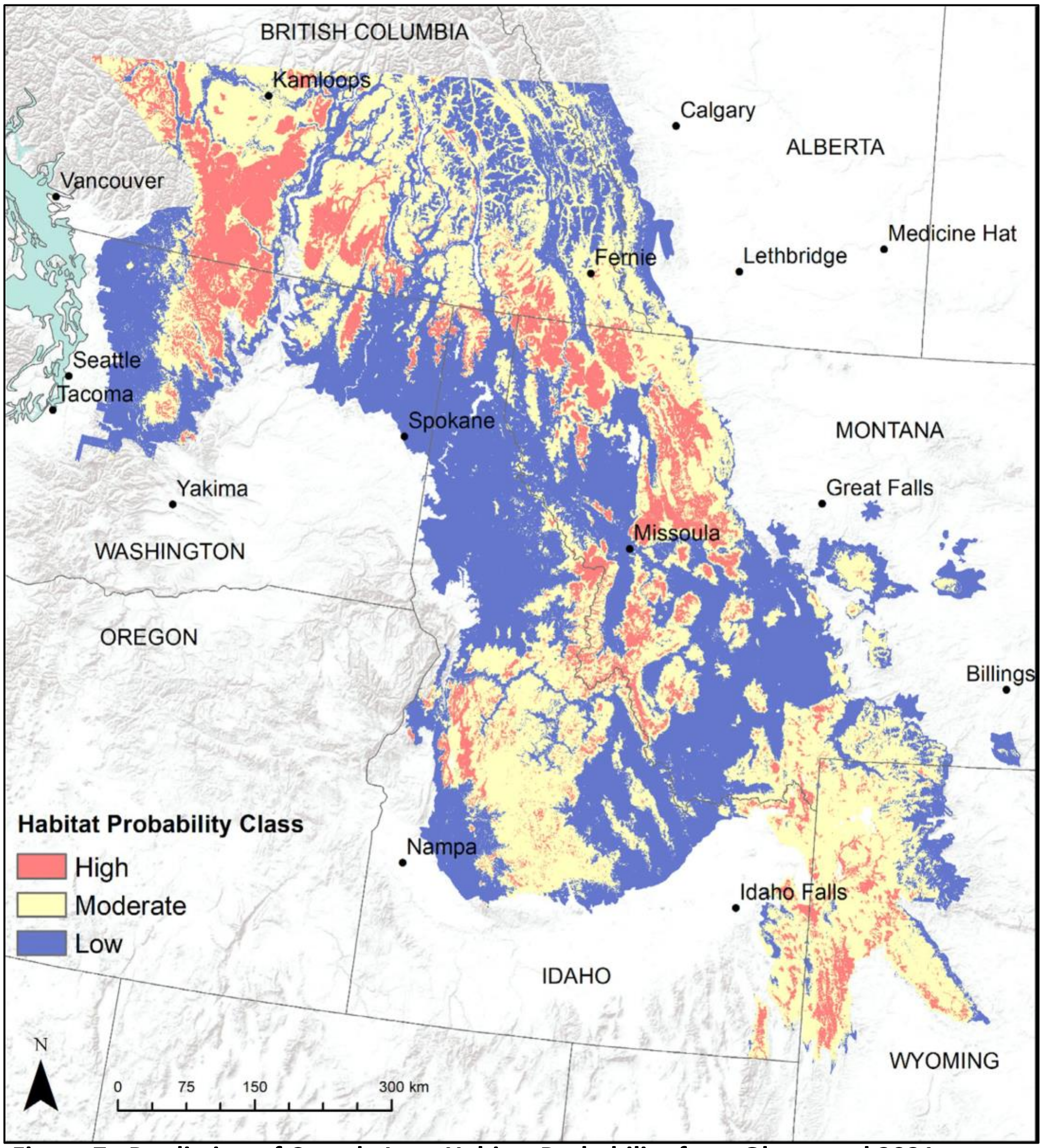

Figure 7. Prediction of Canada Lynx Habitat Probability from Olson et al 2021.

Wilderness

Introduction: Little has changed between the DEIS and the SDEIS. We summarized some key points at the beginning of this comment letter from our past comments. Since the SDEIS analysis is virtually identical to that of the DEIS, we refer you to our earlier comments, which address the flaws in significant detail. However, one issue in particular deserves mention again. The SDEIS repeats the mistake of the DEIS regarding grazing impacts from the proposed action. The SDEIS states that the proposed action "does not create new, additional, or amplified impacts to the wilderness resource." SDEIS at 213. But that statement is false, as the proposed action alternative would permit grazing in the Fall Creek Allotment, where grazing had not occurred and the allotment was in vacant status for many years prior to Wilderness designation and for the 40 years since. Opening the allotment to sheep grazing now would undoubtedly have significant impacts to wildlife and watersheds and to the experience of wilderness visitors. Access to that allotment would likely create the addition of a new stock driveway from the South Slope or from the North Slope within the Wilderness, depending on where the sheep would be coming from (see also SDEIS at 218).

Further, because grazing on the allotment has ceased long before wilderness designation, it would be unlawful to reestablish grazing at this point in time. The fact that grazing had occurred at sometime in the distant past doesn't meet the requirements of the Wilderness Act. If it did, the language in the law limiting where grazing is allowed would be meaningless, since virtually all public lands were grazed at some point in time.

The SDEIS on page 215 recognizes that 90% of the project area is in the Wilderness: about 143,971 acres of the 160,410 acres of the project area. Every single allotment under analysis in the SDEIS contains some acreage within Wilderness, and seven of the ten allotments are entirely within Wilderness. The impacts of thousands of domestic sheep in the Wilderness are significant.

Wilderness Analysis Questions and Concerns: To expound upon our previous comments, we have additional questions and concerns about the adequacy of the analysis in the SDEIS. The SDEIS states as follows:

> The wilderness system considers several factors when classifying an area of wilderness including the degree of being untrammeled, natural, undeveloped, opportunities for visitors to find solitude or primitive unconfined recreation; and other features of scientific or historic values. Grazing within the Wilderness is evaluated on how it impacts those factors (resource indicators).
>
> To address impacts on primitive recreation opportunities due to domestic sheep grazing, the forests estimated the amount of user visitation in the drainage, identified the high recreational use areas,

> determined when the domestic sheep would be using these same areas and evaluated the time of the recreational and grazing overlap (Appendix A – Wilderness/Recreation Resource Report [project record]).

SDEIS at 216. There are at least four problems with these paragraphs.

- As we explained in our earlier comments, the Wilderness impacts from the proposed action are not negligible, and parsing Wilderness out into discrete facets in order to narrow the lens and minimize acknowledgement of the projects effects stems from a misguided misinterpretation of the law. Scientific information has demonstrated that the sheep allotments are heavily overstocked because of fatal flaws in identifying suitable range. Evidence of the continuing deterioration of the grazed allotments has been provided in our previous submissions.

- The analysis completely ignores recreation displacement caused by domestic sheep grazing. Many visitors choose to ignore the areas where sheep graze, which the Forest Service is undoubtedly aware of, so the impacts to recreation aren't merely limited to those who visit the grazed areas, but also to all those who are displaced by the fact the areas are grazed. The analysis downplays the impacts of continued grazing by ignoring the impacts to those who have been displaced by grazing.

- There is an implicit bias in the SDEIS (and DEIS) toward narrowly focusing the analysis on impacts to recreationists. Aside from overemphasizing recreation as compared to other, and arguably more important, wilderness attributes, this narrowness is reflected in the conception that visitors are only affected if they physically observe domestic sheep in the visual sense. But even the most untrained visitor would probably detect signs of livestock grazing beyond encountering the sheep themselves. It would also appear the depauperate nature of the High Uintas Wilderness, in terms of large fauna as compared to other large Wildernesses in the West, is primarily due to the domestic sheep. That is an important negative impact itself, which secondarily has an impact on visitors who wish to see wildlife. At the same time, the SDEIS and DEIS admit there is great uncertainty about impacts to recreationists because assumptions in the SDEIS are based on anecdotal data or statistically incomplete data collected on the visitor registration/survey cards. The question needs to be asked, what percentage of visitors choose to write in the comment section at the end of the trip even if they registered?

- Why isn't the project record on the website? There are several references in the SDEIS, including the one noted above. Important information like this should be on the webpage.

One of the other problems with the SDEIS is its inconsistent redefining of the bighorn range. For example, when comparing the DEIS to the SDEIS, Figure 33 in the SDEIS and Figure 33 in the DEIS are different in that the SDEIS figure provides no buffer for bighorn sheep in the

Wilderness, as per the latest science. In essence, this biased analysis endangers the bighorn sheep that use the Wilderness.

Another failing of the SDEIS pertains to the range of alternatives considered. Nowhere does the analysis consider an option to close allotments when they become vacant. At the very least, this opportunity should be available for a rancher who wishes to waive (donate) an allotment back to the agency. This would have no impact on ranchers.

Wilderness and the 2022 MOU: One of the changes made in the SDEIS was to the 2022 MOU, which certainly seems to be driving the Forest Service's approach to this issue. But MOUs cannot supplant the Forest Service's statutory and regulatory obligations. We have several specific problems and concerns with the agency's reliance on such memoranda, including the following:

- The MOU was established without public input. It is a backroom deal, done before completion of the NEPA analysis, in which the state agency and the Forest Service appear to have privately agreed to prioritize domestic sheep grazing on public lands over the conservation of bighorn sheep (and other native wildlife) by agreeing that actions in pursuit of the latter won't restrict the former. This approach to decision-making betrays unlawful predetermination and undermines the public engagement and transparency goals of statutes such as NEPA.

- It is clear that the goal of the MOU and this SDEIS is to artificially maintain the bighorn sheep herd through continual augmentation from Antelope Island (SDEIS at 179), by killing cougars (SDEIS at 187), and even allowing ranchers to kill bighorns in the Wilderness if they come close to domestic sheep (SDEIS at 179) rather than make the logical decision to close the sheep allotments. The signatories to the MOU, including the Forest Service, agreed to help implement the State's 2018 bighorn plan (SDEIS at 33). Killing cougars is a disgustingly significant part of the 2018 Utah State bighorn plan. The SDEIS ignores the profound negative impacts to Wilderness and non-wilderness lands from this cougar killing pogrom and from the augmentation program (presumably done by helicopter if done in the Wilderness).

- Similarly, the MOU requires the Forest Service "to develop habitat projects" for bighorns to the east of sheep allotments and to "coordinate with UDWR" in efforts to collar and/or capture bighorns. SDEIS at 178. The SDEIS does not analyze the impacts of these efforts on Wilderness, assuming they might be contemplated in Wilderness. Given the proposal to capture bighorn sheep via helicopter in the Wilderness a few years ago, this seems likely to involve collaring and possibly augmentation. Helicopters and habitat manipulation are antithetical to Wilderness.

Summary: The High Uintas have the potential be one of the most outstanding Wildernesses in the entire National Wilderness Preservation System, but the continued and expanded program of grazing of domestic sheep, under the proposed action, severely hampers the recovery of native wildlife, native predators, and watersheds in the Wilderness, and will continue to significantly degrade the experience of wilderness visitors. In the SDEIS, the Forest Service falls short of its legal obligation to fully, and transparently assess, the environmental impacts of (and the legal problems with) this misguided action.

Bighorn Sheep

The entire premise of the SDEIS analysis of effects to bighorn sheep is based on the assumption that there is no need to address risks emanating from Forest Service-managed lands when there is additional risk present from BLM-managed and private lands. This assumption is both scientifically and legally faulty.

Scientific Flaws: The SDEIS analysis assumes that because there is (1) already *M. ovipneumoniae* (hereinafter *"M.ovi"*) in the High Uintas bighorn herds, and (2) the Forest Service has no control over the high-risk BLM and private land allotments, there is no additional harm from transmission of *M.ovi* from the National Forest allotments. But in fact, there are many strains of *M.ovi,* such that infection with one strain will not prevent future infection by another strain.[28]

In a 2017 study, the authors found that "… introduction of a new genotype (strain) of *M. ovipneumoniae* into a chronically infected bighorn sheep population in the Hells Canyon region of Washington and Oregon was accompanied by adult morbidity (100%) and pneumonia-induced mortality (33%) similar to that reported in epizootics following exposure of naïve bighorn sheep. This suggests an immune mismatch occurred that led to ineffective cross-strain protection."[29] Dr. Thomas Besser, one of the country's foremost experts on bighorn infectious disease research, goes on say about this study that "In this paper we documented introduction of a new *M. ovipneumoniae* strain that triggered a dramatic change in the pattern of disease: all adult ewes developed signs of pneumonia (morbidity) and 30% died (mortality). The lambs again experienced a fatal pneumonia outbreak, primarily triggered by lung infections with the newly introduced *M. ovipneumoniae* strain. The finding of lack of cross-strain immunity has since been repeated elsewhere, confirming that the limited immunity that bighorn sheep may develop to a strain of *M. ovipneumoniae* with which they have been infected for years fails to consistently protect them from genetically novel strains that they may encounter."[30]

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[28] Declaration of Dr. Thomas Besser, ¶ 40, February 26, 2021, filed in *WildEarth Guardians et al. v. Kristin Bail et al*., Case 2:20-cv-00440-RMP (E.Dist. WA). Attached as Exhibit 3.
[29] Cassirer EF, Manlove KR, Plowright RK, Besser TE. 2017. Evidence for strain-specific immunity to pneumonia in bighorn sheep. J Wildlife Mgmt 81(1)133-143. Attached as Exhibit 4.
[30] Declaration of Dr. Thomas Besser, ¶ 29.

Thus, despite claims to the contrary in the SDEIS, the additional risk caused by any Forest Service domestic sheep allotments does indeed increase risk to the High Uintas bighorn herds—regardless of any other risk posed by domestic sheep grazing in BLM and private allotments.

In addition, the SDEIS suggests that sources other than domestic sheep may be at play in transmitting *M.ovi* to bighorn sheep. The science does not support that supposition: "While *M. ovipneumoniae* has recently been reported in species other than sheep and goats (Caprinae), neither its ability to persist in these hosts for long periods of time, nor the ability of these non-Caprinae hosts to transmit the pathogen to bighorn sheep has been demonstrated, and the low carriage prevalence and the low genetic diversity of *M. ovipneumoniae* in non-Caprinae hosts are not consistent with them representing a separate reservoir for bighorn sheep infection."[31] "Domestic goats also pose a definite risk to bighorn sheep due to their *M. ovipneumoniae* reservoir status, although limited current data shows that goat sources tend to cause less severe and less persistent bighorn disease. In contrast, non-Caprinae species have not yet been shown to present any risk of transmitting *M. ovipneumoniae* to bighorn sheep."[32] Moreover, *M.ovi* is extremely common in domestic sheep: the USDA National Animal Health Monitoring Service Sheep 2011 project, a national survey of domestic sheep operations, detected *M.ovi* infections in approximately 90% of domestic sheep operations sampled, including in all operations larger than 500 head involved in the study.[33]

In sum, the science is clear that moderate and high-risk allotments on the two National Forests are seriously problematic for the High Uintas sheep herds irrespective of risks emanating from BLM-managed and private lands. And that risk cannot be downplayed through implications that bighorns might be contracting *M.ovi* from other animals.

Forest Plan Amendment Flaws: The Forest Service has not followed the required procedures under the 2012 NFMA regs. When doing a project specific forest plan amendment, the agency must identify which substantive requirements from their regulations are directly related to the plan direction being removed, and then apply those requirements within the scope and scale of the amendment. *36 CFR § 219.13(b)(5).* The Forest Service identified the substantive requirements directly related to the plan provision being removed in the attachment to the cover letter, but did not include that in the SDEIS itself. Nor did the FS properly apply those substantive requirements within the scope and scale of the amendment because it did not adequately analyze all relevant impacts to show that the plan amendment meets those substantive requirements, as set forth in 36 CFR §§ 219.8, 219.9.

The creative interpretation being attempted here—that the Forest Service does not need to maintain viability if any wildlife population also uses non-Forest Service lands and has threats on those lands—would conceivably apply to virtually all fish and wildlife populations. This

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[31] *Id.*, at ¶ 26.
[32] *Id.*
[33] *Id.*, at ¶ 24.

proposed forest plan amendment is an unreasonable interpretation that the Forest Service is only applying to bighorn sheep, and is contrary to prior long-standing interpretation by the agency. The Forest Service has the responsibility to ensure its own actions maintain viability even if other parties cause harm off the forest. By removing the plan provision, the Forest Service could take actions that would impair viability and yet wouldn't be inconsistent with Plan. That is a significant change that was not analyzed and does not meet the substantive requirements for ecological sustainability and diversity of plant and animal communities.

Viability requires enough animals for a self-sustaining population in the long-term, and constant augmentation does not qualify as self-sustaining in any way. Relying on the state to augment herds does not equate to viability.

We also find it interesting that the forest plan amendment was proposed for only the Wasatch-Cache National Forest and not the Ashley National Forest. The Ashley Forest Plan dates to 1986 and is thus subject to NFMA's viability rule. In addition, the Ashley Plan contains a standard to manage fish and wildlife habitat to maintain or improve diversity and productivity.[34] That standard is not addressed in the SDEIS.

MOU Flaws: The Forest Service cannot rely on the MOU between the Forest Service, the BLM, the State of Utah, and the domestic sheep permittees because the MOU was developed in violation of the Federal Advisory Committee Act (FACA), 5 U.S.C. App. II, §§ 2, 9-14. The inclusion of the permittees in the MOU discussions and as parties to the MOU removes any protections that would otherwise apply to intergovernmental communications.

Moreover, the overarching concept of the MOU is that Best Management Practices (BMPs) will adequately protect bighorn from domestic sheep. They won't. The Western Association of Fish and Wildlife Agencies (WAFWA) Guidelines, 2009, specifically state on page 15: "Effectiveness of management practices designed to reduce risk of association are not proven and therefore *should not be solely relied upon to achieve effective separation."*

And even if BMPs were effective at maintaining separation (they aren't), the Forest Service must provide in the SDEIS a scientific analysis of the effectiveness of the BMPs, which they haven't. Perhaps that is because it is not possible to do so. One U.S. District Court has already concluded that, in the absence of scientific analysis, BMPs could not be relied upon to maintain separation.[35]

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[34] USDA Forest Service. 1986. Ashley National Forest land and resource management plan, final environmental impact statement, and record of decision. At IV-32.

[35] *Western Watersheds Project v. Bureau of Land Management*, U.S. District Court for the District of Idaho, Civ. No. 09-0507-E-BLW, Decision and Order, October 14, 2009. https://casetext.com/case/western-watersheds-project-v-bureau-of-land-management-4

There is also the practicality of enacting the BMPs in such rugged and remote terrain. It takes a small herd of herders to watch every sheep at all times, and strays are common. In addition, the delays between infection and disease onset, and between disease onset and death, make it impossible to identify the specific moment of transmission or the specific animals involved in a *M.ovi* transmission event.[36] Therefore, tracing any disease transmission event back to its origin is virtually impossible.

In short, courts have found similar BMPs and MOUs that are not legally enforceable insufficient to protect bighorn sheep, lacking in scientific support, and thus not adequate to meet the Forest Service's legal duties to maintain viable populations of bighorns.

<u>Risk of Contact Analysis Flaws</u>: First, the risk analysis doesn't even mention, let alone take into account, stray domestic sheep. It is very common for strays to stay behind for days or even weeks after the primary domestic sheep herds are moved off the allotments. In one recent analysis on the Gunnison BLM District in Colorado, Colorado Parks & Wildlife documented 25 stray domestic sheep occurrences over just a few years. And those constituted only the documented occurrences. Unless the Forest Service is going to consider strays as an important factor in this analysis, we challenge the agency to demonstrate in the record and by searching UDRW records that strays are not an issue in this analysis area.

Second, the Uintas Bighorn Sheep Assessment from May 2021 indicates that the longest summer ram foray was 14.3 miles, while the longest winter ram foray was 5.6 miles. This data does not seem to have made it into the ROC analysis. Instead, the risk assessment somehow determined that the Hessie's Lake/Henry's Fork and Tungsten allotments are rated moderate and low risk even though bighorns are documented coming right up to the eastern edge of these two allotments.

We ran the bighorn location data using WAFWA's suggested 9-mile buffer from the western-most documented bighorns, and that map (Figure 5) indicates substantial overlap with most of the allotments under analysis here.

Keep in mind that our map uses a 9-mile buffer, not the 14.3-mile buffer that UDRW's own data indicates. The maps in the SDEIS at Figures 33 & 34 support our contention that the risk assessment artificially reduces the risk for all the but 2 eastern allotments. Based on those two maps, at a minimum we should be discussing closure of 5 allotments: Gilbert Peak, Painter Basin, Hessie Lake/Henry's Fork, Tungsten, and Red Castle. Anything else is inconsistent with the analysis in the SDEIS.

Third, the Wild Sheep Working Group has advised that results of the Risk of Contact Tool may be interpreted as follows: "Given the potential severity of die-off resulting from interspecies contact, we recommend management scenarios that allow for disease free intervals of at least 50

[36] Declaration of Dr. Thomas Besser, ¶ 34.

years. If we assume a moderate probability of contact with an allotment resulting in an interspecies contact that will result in a disease transmission outbreak event (0.25), then we would need to see a rate of contact of less than 0.08 contacts per year (or less than 0.8 contacts per decade)." (WSWG 2012).[37] In addition, the ROC Tool *as applied and approved by the court* in the years of litigation over the Payette National Forest decision to curtail domestic sheep grazing provides more support for using the WSWG rate of contact. In the Payette analysis, the ROC Tool was also run using the same rate of contact (that is, 0.25, or 1 in 4) indicating an average outbreak period of 50 years.

Instead, the analysis determines that a cumulative contact rate of 0.304—or almost 4 times higher than the WSWG recommended contact rate—is adequate to maintain these herds. (And again, we question these ROC numbers since strays were not considered and the SDEIS maps are inconsistent with the risk ratings.) The SDEIS conclusions rely on arbitrary contact rates of "high," "medium," and "low" that have no basis in the scientific literature. And even if one accepted these arbitrary labels, there is no attempt at justifying why only the "high" risk allotments are being considered for closure when one "medium" risk allotment demonstrates a contact rate of .106 (Hessie Lake/Henry's Fork), which is well above the 0.08 recommended by WSWG.

The 0.304 contact rate equates to one bighorn contact with an allotment approximately every 3.3 years. Compare this to the WSWG recommendation that management should allow for disease free intervals of at least 50 years. Viability be damned, this is clearly a plan to maintain constantly diseased bighorn herds through augmentation.

Fourth, the failure to use 80,000 bighorn location data points is suspicious. We do not comprehend how a collar can be placed on a bighorn without noting the sex of the animal, yet even if that is true those data points should've been tagged as female rather than deleted from the analysis.

Herd Analysis Flaws: The SDEIS only looks at risk at the meta-population scale by combining all herds into one, but the record indicates there is one herd that is most at risk: Hoop Lake. There is no map of individual herd locations but the SDEIS discusses 5 herds, and one that is closest to the allotments. That would be the herd with overlap with 2 allotments and very close to 2 more, which means it is at so highest risk of disease. The SDEIS does not discuss what the impact to meta-population would be from loss of that one herd in terms of reduction of geographic distribution and loss of genetic diversity. In addition, there is no viability analysis at the herd level, just at the overall meta-population level.

[37] See also Lyons et al. 2016. Final Report: Application of the Bighorn Sheep Risk of Contact Model on the Okanogan-Wenatchee National Forest. Washington Conservation Science Institute. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd512632.pdf

All the impacted bighorn herds are very small. Even though the meta-population has about 150 animals, each herd only has about 20-30. Hoop Lake, at highest risk, has only about 20. And assuming the Hoop Lake herd is on the western end of the CHHR closest to the Forest Service allotments, it is not close to BLM land or private land. Thus, the Forest Service allotments are the greatest risk to that herd and are likely the cause of its continuing disease issues. Maintaining low numbers of animals for long time puts herd at risk of inbreeding or loss during stochastic events. All herds have experienced recurring disease which keeps them small and prevents full recovery, yet as discussed above, a new strain of *M.ovi* could wipe out any of these herds.

The meta-population approach minimizes the impacts to the Hoop Lake herd in particular. That herd has had a stagnant growth rate and low numbers of animals for a decade because disease is likely suppressing growth. The Forest Service allotments are the main risk to this herd and closing those allotments would significantly reduce the risk, but this is not analyzed in the SDEIS.

Range of Alternatives Flaws: A third alternative that would address more of the risk to bighorn from Forest Service domestic sheep allotments was dropped using the same justification as appears throughout the SDEIS: why bother protecting bighorns on the National Forest when there is high risk from nearby BLM-managed and private lands. As noted above, the Forest Service has a legal duty to maintain viability of bighorns *on National Forests*. What happens outside of the National Forest boundary does not relieve the Forest Service of their duty. And science is clear that any risk to bighorns is cumulative, not redundant. The third alternative should be considered, and even then it is highly questionable whether it goes far enough to reduce risk to bighorns. Thus, we advocate for an analysis of two additional alternatives: the third alternative discussed at SDEIS pp. 181-2, plus an additional alternative that would encompass all allotments within the 9-mile WAFWA buffer.

Significant New Information: The bighorn sheep location data relied up on this analysis indicates that the 2009 NEPA analysis of the East Fork/Blacks Fork allotment should be reopened. It is clear from our map, above, that there is substantial overlap with the allotment when applying WAFWA's standard 9-mile buffer. This new information requires that either that 2009 NEPA be reopened, or that the allotment is considered in this analysis. In addition, there has been substantial new science on bighorn/domestic sheep disease transmission since 2009, as we have discussed above and is detailed in Dr. Besser's attached declaration.

Sincerely,

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EXHIBIT 1

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Spatial Analysis of Livestock Grazing and Forest Service Management in the High Uintas Wilderness, Utah

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Abstract

This case study addresses the Forest Service reauthorization for grazing of domestic sheep in Utah's High Uintas Wilderness, USA. It provides an approach using spatial analysis and aerial imagery to evaluate the lands capable of being grazed based on Forest Service criteria and field surveys. The resulting model and analysis demonstrated that the Forest Service has not applied its own criteria. This has led to the Forest Service overestimating the amount of land and numbers of sheep that can be supported in the study area. Past field studies show this has resulted in environmental damage by grazing sheep. Our analysis concludes that the numbers of domestic sheep should be greatly reduced to protect these lands and wilderness values. Limitations of the study include the lack of a suitably detailed soil survey to determine erosion susceptibility, a lack of ground cover data, a lack of Forest Service data for the level of grazing use, or utilization, and the lack of a Forest Service quantitative measurement of vegetation production in each plant community and soil type. In the end, our use of aerial imagery, GIS determinations of areas of steep slopes and dense forests, and our measurement of vegetation production in the dominant soil types showed most of the land is not capable for grazing domestic sheep even in the absence of this other data.

Keywords

Livestock, Capacity, Wilderness, Spatial Analysis, Remote Sensing

1. Introduction

In 2014, the Ashley National Forest (ANF) and the Uinta-Wasatch-Cache National Forest (UWCNF) in Utah initiated a scoping process for the High Uintas

Wilderness Domestic Sheep Analysis, followed by a Draft Environmental Impact Statement in 2019 [1] [2]. The purpose of the project is to reauthorize grazing of 12,850 ewe/lamb pairs of domestic sheep on ten grazing allotments totaling 160,410 acres within the High Uintas Wilderness which lies in NE Utah's Uinta Mountain Range.

Due to the importance of these watersheds, their associated water supplies for the public, wilderness qualities, and concerns for the effects of this proposal on these values as well as native fish and wildlife, the authors engaged in a study and Geographic Information System (GIS) analysis to inform the Forest Service environmental analysis. The goal of the study was to evaluate the capacity of the allotments to support domestic sheep grazing using Forest Service criteria, field data collection and image analysis combined in a GIS analysis. Using such a technique offers a means of reducing or eliminating many of the negative impacts of livestock grazing by balancing livestock use with available capacity and avoiding placing livestock in sensitive areas such as steep slopes, unstable or highly erodible soils. This can lead to healthier watersheds, reduction of soil erosion, restoration of fish and wildlife habitat and their associated populations across not only wilderness areas, but all livestock-grazed public and private lands.

1.1. Livestock Grazing Extent, Effects and the Need for a Systematic Approach to Management

There are approximately 3.4 billion ha worldwide that are grazed by livestock, with 73% estimated to be suffering soil degradation [3]. In the western USA, livestock are permitted to graze on over 103 million acres within the National Forest System and 168 million acres of public lands managed by the Bureau of Land Management [4], including 13 million acres of designated wilderness [5]. These BLM and Forest Service managed lands suffer degradation with over 50% in poor or fair condition [6].

Regionally important rivers such as the Bear, Green and Colorado are supplied water from the High Uintas Wilderness area watersheds and provide water to regional populations for agriculture, municipal and industrial use, power and recreation [7]. These rivers and their watersheds are also important to native fish such as Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) and Bonneville Cutthroat trout (*Oncorhynchus clarki utah*). Wildlife, including bighorn sheep (*Ovis canadensis*), Rocky Mountain elk (*Cervus canadensis nelsoni*) and many other mammals and birds also depend on these watersheds [2]. The High Uintas Wilderness is a core area for Canada lynx (*Lynx canadensis*) [8] and historically significant numbers occurred here [9]. It is part of a Regionally Significant Wildlife Corridor (Corridor) connecting the Greater Yellowstone Ecosystem and Northern Rockies to the Uinta Mountains and Southern Rockies. This Corridor is recognized by the Forest Service as well as regional conservation organizations [10] [11] [12]. It is important to maintain habitat integrity and productivity in these watersheds for these purposes, so overstocking of livestock or grazing livestock in areas susceptible to accelerated erosion and degradation must be avoided.

A meta-analysis of the effects of cattle grazing on arid ecosystems in western North America found reductions in rodent species diversity and richness; vegetation diversity; shrub, forb and grass cover; total vegetation cover and biomass; seedling survival; biological crust cover; and litter cover and biomass while soil bulk density increased, soil erosion increased, and infiltration rates decreased in grazed areas when compared to ungrazed areas [13]. A comprehensive review of ecosystem effects of livestock grazing in western North America found that livestock grazing reduces levels of biodiversity, leads to decreased population densities for a wide variety of taxa, disrupts ecosystem functions, including nutrient cycling and succession, changes community organization, and changes the physical characteristics of both terrestrial and aquatic habitats [4]. A similar review of livestock effects to streams and riparian ecosystems determined that livestock grazing negatively affects water quality and seasonal quantity, stream channel morphology, hydrology, riparian zone soils, instream and streambank vegetation, and aquatic and riparian wildlife. No positive environmental effects of grazing were found in this comprehensive survey of the literature [14].

Field surveys by the Forest Service in the 1960s in the High Uintas Wilderness documented erosion damage on highly erodible soils and steep slopes which had developed gullies, and which was exacerbated by sheep grazing and trampling [15]. Mont Lewis, a Forest Service range conservationist working in the Uinta Mountains in the 1960s, documented accelerated erosion, alpine turf in poor condition, and lakes being filled with sediment from grazing sheep in areas that were sensitive to erosion damage [16].

A recent study using sediment cores from Lake EJOD in a grazing allotment in the High Uintas Wilderness found increased nutrient and sediment loading in the past century, coincident with the period livestock have grazed here. This is a departure from rates of deposition going back 5300 years [17] (**Figure 1**). Lewis (1970) noted that these non-suitable areas (today these are called non-capable) should not be grazed [16]. Many of the soils were determined to have a very high erosion hazard. Surveys in the late 1990s and early 2000s showed grazed uplands had suffered loss of plant cover with upland grazed areas having bare soil averaging over 50% while areas that had not been grazed for decades had almost no bare soil. Streams were damaged from high runoff events creating bank scouring (**Figure 2**) and steep slopes were being grazed and trampled [18] (**Figure 3**). Surveys by soil scientists working for the Ashley National Forest in the 1980s described severe erosion and loss of soil cover and biological crusts [19]. In recent decades Forest Service monitoring has been sporadic and focused in areas of low erosion hazard in more level terrain such as valleys, wet or mesic meadows, and riparian areas, finding conditions to be satisfactory [2] [15].

This evidence of degradation as a result of grazing livestock at levels exceeding capacity and in areas of high susceptibility to erosion is what the straightforward

Figure 1. Lake EJOD, High Uintas Wilderness, deposits of sediment entering the lake from its grazed watershed [18].

Figure 2. Stream bank scouring, High Uintas Wilderness [18].

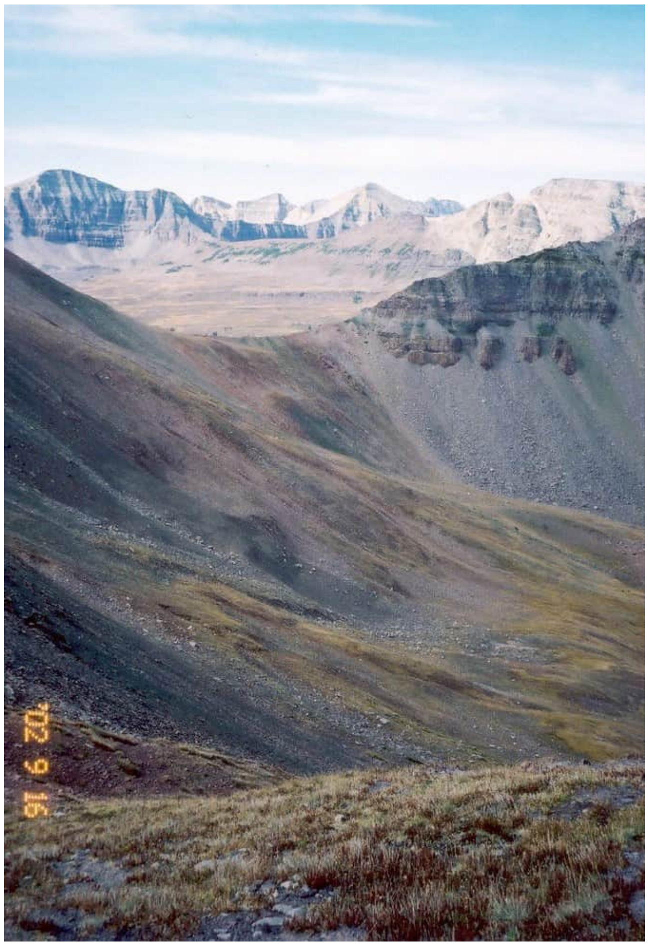

Figure 3. High Uintas Wilderness steep slopes grazed by domestic sheep [18].

use of GIS analysis techniques we provide here, combined with systematic data collection to fill data gaps, could reverse.

1.2. Grazing in Wilderness

In 1964, Congress passed the Wilderness Act and defined wilderness: "A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain". Wilderness is "land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions…." In addition, wilderness should be "affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (16 U.S.C. § 1131(c)). The law provided statutory protections for wilderness areas and established the National Wilderness Preservation System. The Act, among other things, mandated that wilderness areas be administered in a manner that will leave them "unimpaired for future use and enjoyment as wilderness" and provide for "the protection of these areas" and "the preservation of their wilderness character" (16 U.S.C. § 1131(a)).

The provision allowing livestock grazing in the Wilderness Act is an exception to the general premise of the Act, which directs agencies to manage wilderness areas to preserve their wilderness character and natural conditions. "Within wilderness areas in the national forests designated by this Act...the grazing of livestock, where established prior to September 3, 1964, shall be permitted to continue subject to such reasonable regulations as are deemed necessary by the Secretary of Agriculture" (16 U.S.C. § 1133(d)). Thus, livestock grazing which existed in wilderness areas when the Wilderness Act was enacted, has continued. Livestock grazing is an exception to normal wilderness protections. We have pointed out the various impacts on the land which show the degradation of ecosystem and natural values, which would also be inconsistent with the intent of the Wilderness Act.

2. Methods

2.1. Study Area

The study area is the ten grazing allotments at issue and their watersheds that occur in the ANF and UWCNF within the High Uintas Wilderness (**Figure 4**). Allotment boundaries align with watershed divides in most cases. The study area occurs in the Middle Rocky Mountain Physiographic Province [20]. Elevations range from about 8000 feet to 13,528 feet above sea level at the summit of Kings Peak. The land consists of steep canyons, U-shaped glaciated basins and river valleys, alpine tundra, lakes, streams and wetlands, mountain peaks, and large open meadows (**Figure 5**). Forested areas consist of sagebrush (Artemesia spp.), quaking aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), Douglas fir (*Pseudotsuga menziesii*), subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*) [12] [21].

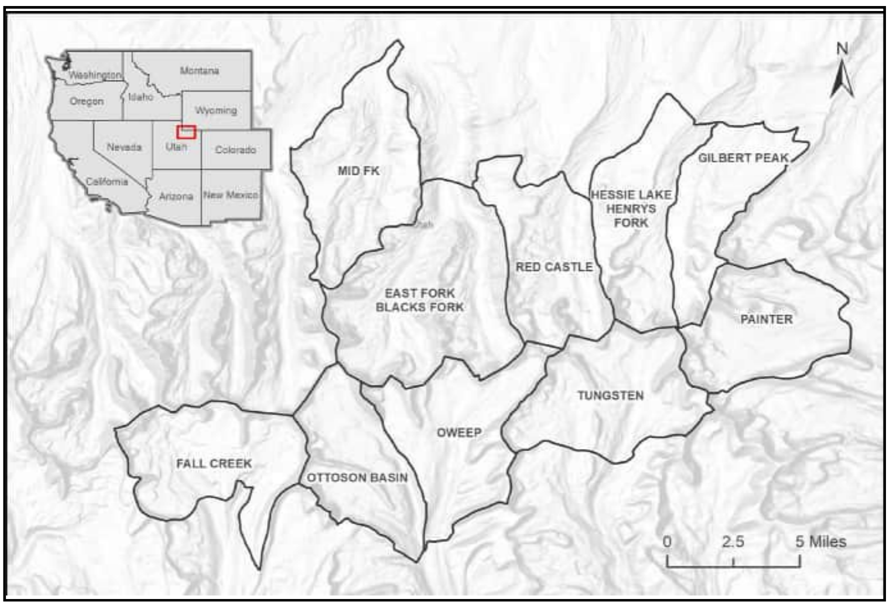

Figure 4. Study location and map of allotments.

Figure 5. Forest Service photo showing topography, dense forested areas, mixed wetland and upland areas and adjacent steep slopes [15].

The ten grazing allotments cover a total of 160,410 acres and have a near summer-long grazing season [2]. At this high elevation, the grazing season occupies most of the snow-free period with some areas retaining snow into August [15] (**Table 1**). The Forest Service describes the climate for this alpine area as having annual precipitation between 33 and 50 inches per year with most occurring in the form of snow [16]. Summer thunderstorms are also an important factor [20].

2.2. Forest Service Capability Criteria

The concept of "capability" for livestock grazing is a core concept directed at limiting soil erosion and degradation of grazing allotment watersheds and plant communities. It does so by factoring out areas of steeper slopes, highly erodible soils, and barren areas, in order to reduce risk of soil erosion and degradation of plant communities which leads to loss of productivity. It also is used to determine stocking rates based on forage consumption rates of livestock and allocates an appropriate proportion of the available, preferred or desirable forage species on the capable acres to livestock so that stocking rates are sustainable and reduce the risk of degradation [22]. The capable lands and stocking rates on the High Uintas Wilderness allotments have not been updated to reflect more recent guidance from the Region 4 Forest Service that oversees the ANF and UWCNF that manage these ten grazing allotments.

The current USFS regional criteria (Criteria) for range capability were described in a 1998 memorandum by the Forest Service [23]. These were:

1) Areas with less than 45 percent slope for domestic sheep, 30% for cattle.

2) Areas producing or having the potential to produce an average of 200 lbs. or more of forage/acre on an air-dry basis over the planning period.

Table 1. Numbers of permitted sheep and length of grazing season.

Allotment	Permitted Ewe/Lamb Pairs	Season	Allotment Acres
East Fork Blacks Fork	1350	7/6 - 9/10	25,440
Fall Creek	1100	7/1 - 9/30	16,612
Gilbert Peak	1400	7/11 - 9/10	11,896
Hessie Lake Henry's Fork	1400	7/11 - 9/10	14,539
Middle Fork Black's Fork	1200	7/11 - 9/10	16,855
Ottoson Basin	1300	7/15 - 9/10	12,620
Oweep	1400	7/15 - 9/10	16,686
Painter	1200	7/12 - 9/6	14,756
Red Castle	1300	7/6 - 9/10	14,857
Tungsten	1200	7/12 - 9/6	16,149
Totals	12,850		160,410

3) Areas without dense timber, rock, or other physical barriers.

4) Areas with naturally resilient soils (not unstable or highly erodible soils).

5) Ground cover greater than 60%.

6) Areas within one mile of water or where the ability to provide water exists.

In its 2003 Forest Plan Revision, the WCNF used only Criteria 1, 2 and 6 [20]. It evaluated the slope of the land using a digital elevation model to determine where the lands of less than or equal to 45 percent slope were located. Lacking current forage production data, the WCNF used a vegetation layer as a surrogate for forage production. While forage production had been determined in the 1960s and was their most recent data, it was not used. The Final Environmental Impact Statement for the Wasatch-Cache Revised Forest Plan [20] described it thusly: "The vegetation layer was used as a surrogate for minimum forage production. In general, coniferous-forested vegetation types (spruce, fir, pine, Douglas-fir), oak, and barren areas were said to not produce the minimum 200 lbs/acre of forage. All other types were included as potential forage-producing types." The Forest Plan for the ANF was produced in 1986 prior to the publication of these recent Regional criteria. According to the ANF, the capability analysis done in the 1960s was used in the Forest Plan [24]. It does not incorporate the current Criteria. Neither Plan relied on current forage production data.

2.3. Grazing Capability Model

Due to the lack of a dataset for ground cover and sufficiently detailed soil surveys, our model did not exclude highly erodible soils and areas with ground cover less than 60% (criteria 4 and 5). It is of note, however, that excluding slopes greater than 45 percent by the very nature of soil erosion/slope relationships defined in the Universal Soil Loss Equation [25] would inherently exclude many areas of unstable soils or soils with high erosion hazard. Criterion 6, distance to water, was evaluated and was not a limiting factor as all areas meeting slope, forage production and lack of dense timber criteria 1, 2 and 3 were within one mile of water. Small, isolated capable areas were removed from the final map as these are inaccessible (within dense forest) or surrounded by non-capable areas that are impractical to graze without placing the non-capable areas at risk. In sum, the model determined capable acres based on land less than one mile from water, less than or equal to 45 percent slope, producing 200 lb/acre or more of forage (based on actual forage surveys, described below), and lacking dense timber.

The model used ESRI's ArcGIS 10.5.1 [26] and ModelBuilder [27] as the modeling environment. As the main output, we obtained a dataset in polygon format that described the landscape according to the areas capable of supporting domestic sheep grazing. Water bodies were excluded. Wetlands are not grazed by sheep, so were excluded in the model [16]. **Figure 6** illustrates the steps implemented for the sheep grazing capability model by a stepwise removal of acreage > 45% slope, areas with forage production < 200 lb/acre, and areas with dense forest canopy. The resulting areas which meet Forest Service capability criteria were further reduced by removing isolated areas of land meeting capability criteria due to the need to use non-capable areas for access. Then water bodies and wetlands, areas which are not grazed or are not preferred by domestic sheep, were removed. This provided a final acreage of land which the model determined is capable of being grazed without risk of excessive damage. We would qualify this by saying this depends on having stocking rates that are within the forage capacity of the areas grazed. Datasets used or generated in model development are listed in **Table 2**. We requested and received GIS data from the Forest Service [28] and their historic monitoring data [15] in order to perform the analysis.

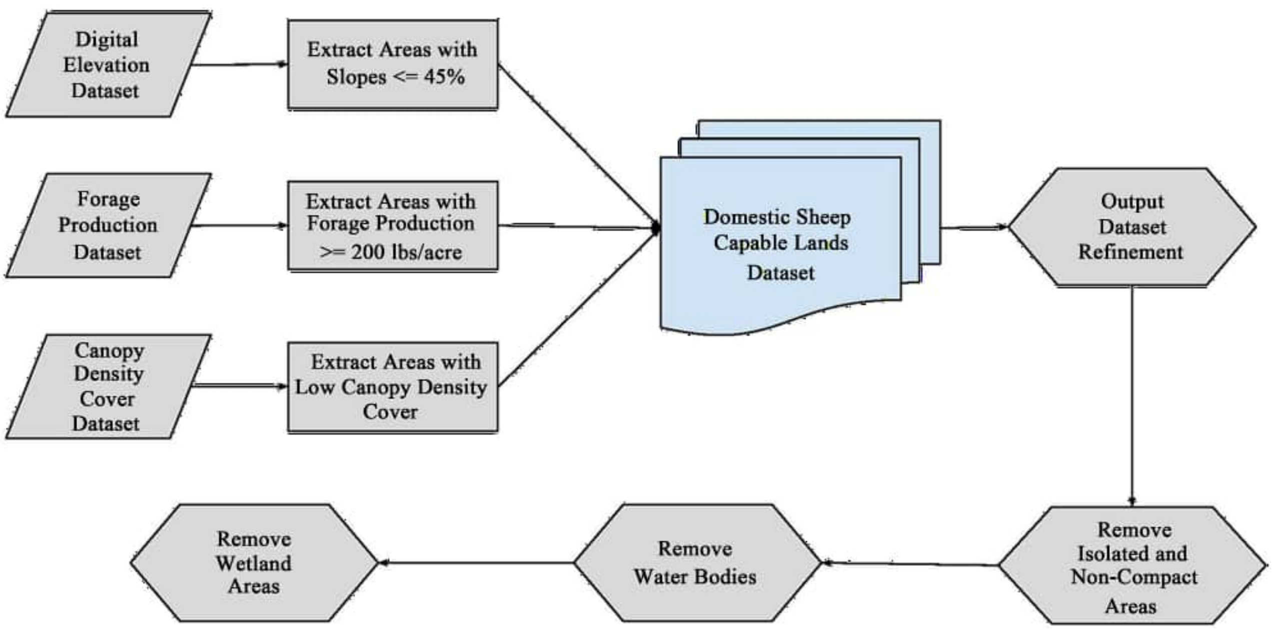

Figure 6. Flowchart of the domestic sheep grazing capability model.

Table 2. GIS datasets.

Dataset Name	Format Type	Version	Resolution	Source
NED Digital Elevation Model	Raster	2013	10 meters	US Geological Survey [29]
Slope	Raster	2018	10 meters	Derived from NED Digital Elevation Model
NAIP Digital Ortho Photo Images	Raster	2016	1 meter	USDA National Agriculture Imagery Program [30]
Canopy Density Cover	Raster	2018	1 meter	Wild Utah Project
National Wetlands Inventory	Polygon		Version 2.0, 2016	US Fish and Wildlife Service [31]
Predicted Forage Production	Raster	2018	10 meters	Wild Utah Project
Forage Production Maps	Digitized PDFs	1960-1967	1:17,000	US Forest Service [32]
Digitized Forage Production	Polygon	1960	1:17000	Digitized by Wild Utah Project
Grazing Allotments and Pastures Boundaries	Polygon	2016	1:24,000	US Forest Service [33]
NHD Water Bodies	Polygon	Version 1.07	1:24,000	US Geological Survey [34]
Grazing Capability (Forest Plan Revision)	Polygon	2001	1:24,000	US Forest Service [35] [36]
Forage Production Survey Sites	Point	2016	N/A	Wild Utah Project
Soils	Polygon	2011, 2016	1:24,000	US Forest Service [37] [38]

2.4. Development of Model Parameter Inputs

Slope: Criterion 1 as interpreted in the WCNF Revised Forest Plan [20] defines areas with slope ≤ 45% as capable for domestic sheep grazing. Determination of such areas was made using the Slope Analysis tool within the ESRI ArcGIS software [26]. As the chief input dataset, the NED Digital Elevation Model was used to derive the slope raster file [29] (**Table 2**). In a follow-up process, the output slope raster was filtered in order to generate a raster dataset containing areas with slopes ≤ 45%.

Forage Production: To refine the vegetation production estimate used by the Forest Service, we obtained field data for actual forage production. In order to get a representative sample of available forage in the project area, our team relied on areas that were not grazed by livestock prior to field sampling which occurred in August, 2016. Using soil map files [37] [38] and soil descriptions [39] obtained from the Forest Service, we determined that seven soil types were most common in the UWCNF portion of the project area which was not grazed prior to sampling. These occurred in the ungrazed areas and could be sampled to determine forage production. Of these soil map units, the Rubble and Rock Outcrop type covers 17,219 acres or almost 22% of the UWCNF study area, and is largely barren high county, so would not be expected to contain enough forage to factor into a grazing capacity analysis. Therefore, this soil type was not sampled and was assigned a value of zero for forage. The six remaining soil types were then visited by field teams in August, 2016 to collect forage production samples. Sites were inspected for signs of current sheep use such as droppings, tracks, bedding areas, and visible grazing use, in order to exclude these from the forage capacity samples if they were determined to have been grazed that season.

Sample site locations for collecting forage data were determined from locations of Forest Service monitoring sites and complemented with random locations generated with GIS to ensure coverage of all soil types. The number of locations was distributed equally among the soil types. Thirty-six locations were sampled across the 6 common soil types. At each pre-determined location within each soil type, plot clippings were collected along a transect heading due north [40]. To collect plot clippings, 24 × 24-inch sample frames were placed at 25', 50', 75' and 100' along each 100' transect. All herbaceous species in each sample plot were clipped to one inch above the ground, placed in Ziploc bags and brought back to camp, where they were kept open to air out until transported to the lab where they were air dried and weighed on an electronic balance. The amount of air-dry forage per acre was then calculated.

The forage production samples were then correlated with the aerial ortho-photos of the study area. Figure 7 illustrates the process of correlation and

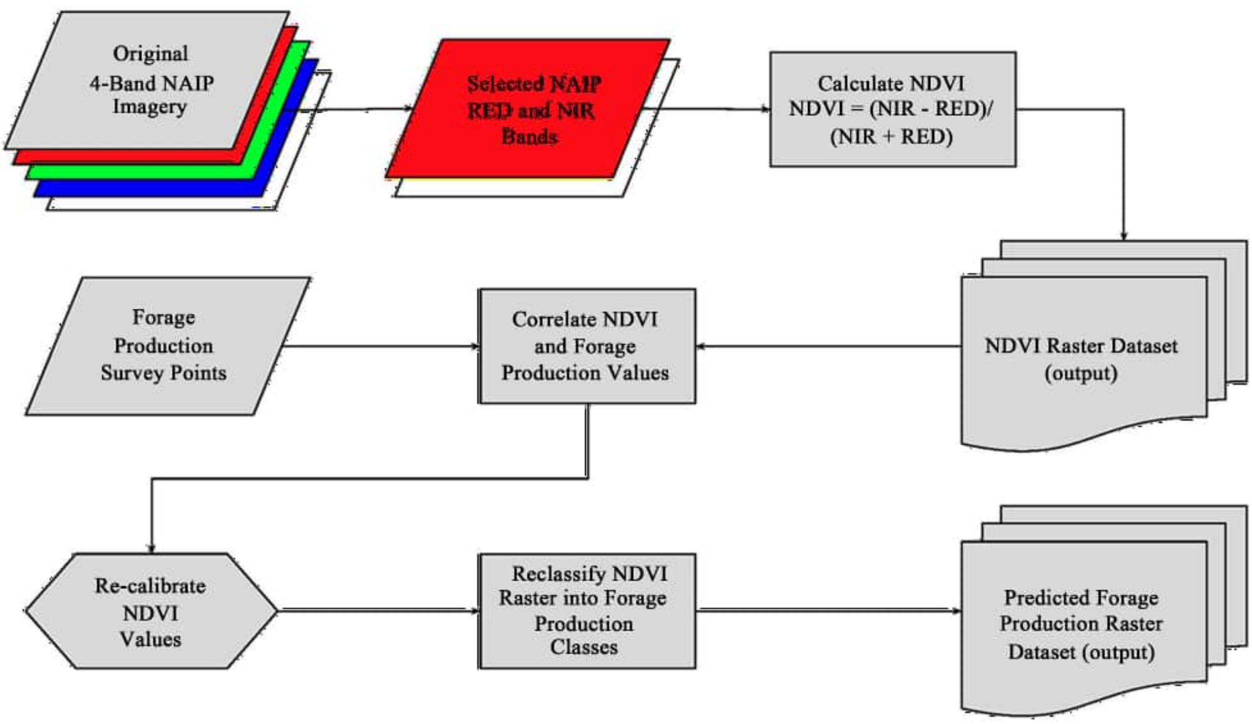

Figure 7. Image analysis process for the estimation of NDVI values, correlation of NDVI with forage production survey points, and image classification to derive a predicted forage production raster dataset.

NAIP image classification that was applied to derive a predicted forage production raster layer, using the Image Analysis tools within ESRI ArcGIS [20]. In the first step, we utilized NAIP imagery from August, 2016 to estimate Normalized Difference Vegetation Index (NDVI) values across the study area [30] (**Figure 8**). NDVI is estimated based on a ratio between the red and near-infrared (NIR) optical bands embedded in the NAIP imagery. The equation for NDVI is presented as NDVI = (NIR − RED)/(NIR + RED). This mathematical operation was completed by using the Raster Calculator in ArcGIS which generated a raster file. In the next step, the forage production survey points were used to correlate those values to the NDVI values from the previous step (**Figure 9**). These two datasets were correlated to each other by using the pixel values in the NDVI raster dataset and the forage production values determined at each survey location. By using the data correlation, we were able to re-calibrate the NDVI values to forage production values and confidently conduct a raster classification into different forage production classes based on the differential raster values of those vegetation classes (**Figure 10**).

Dense Timber: Areas of dense timber are considered not capable in the Forest Service Criteria because livestock generally avoid grazing in areas of thick conifer cover, either due to lack of forage or access limitations. In the model, areas with high and medium canopy density were excluded from capable areas since those canopy density categories are associated with areas with dense timber, a large number of fallen trees, and areas with restricted access to livestock. In order to achieve a reliable dataset that would describe areas of dense timber throughout the study area, we revisited the NDVI raster dataset from the previous

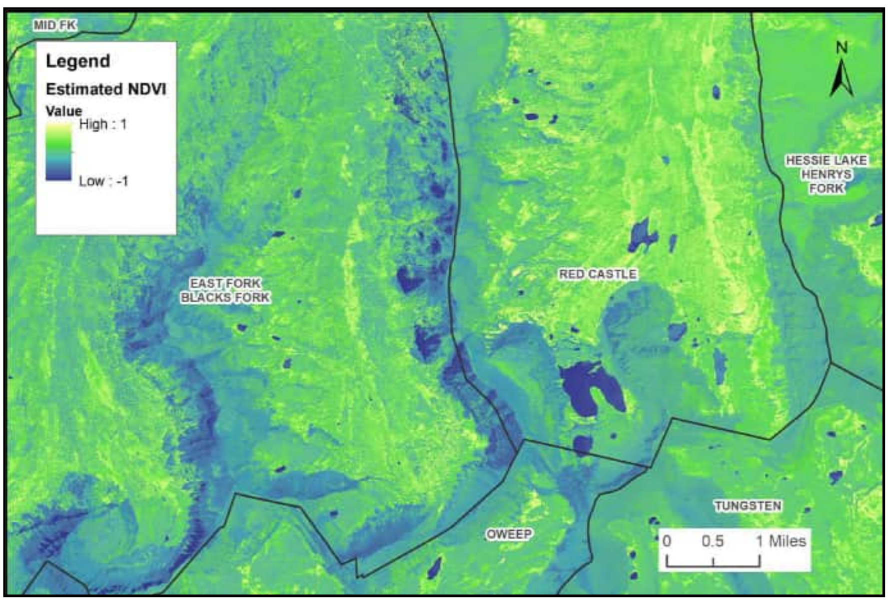

Figure 8. NDVI raster obtained from image analysis operation by estimation of a ratio between the green and near-infrared bands in NAIP ortho photo images [30]. (Areas shown in blue represent water bodies and areas shown in various shades of green represent vegetation in various NDVI values).

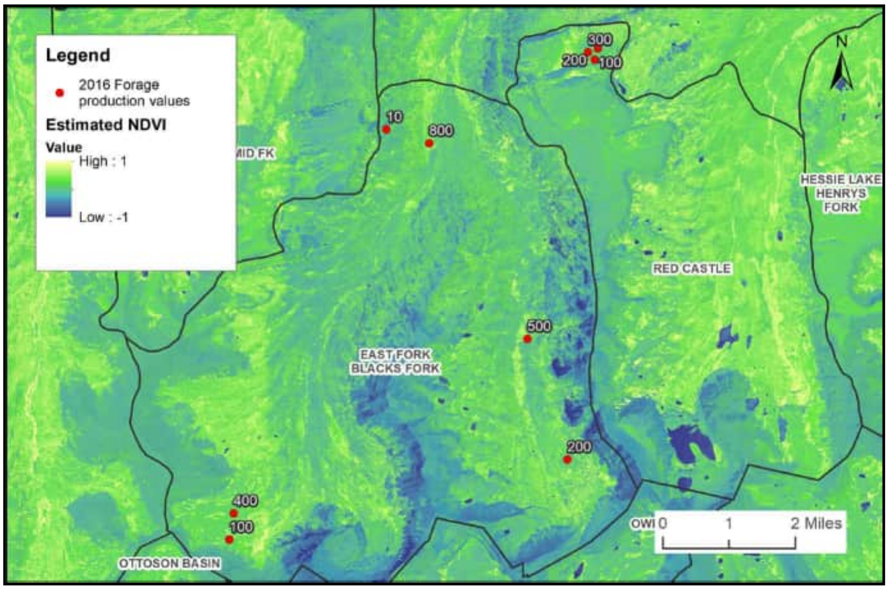

Figure 9. NDVI raster and forage production values estimated from the survey conducted in 2016.

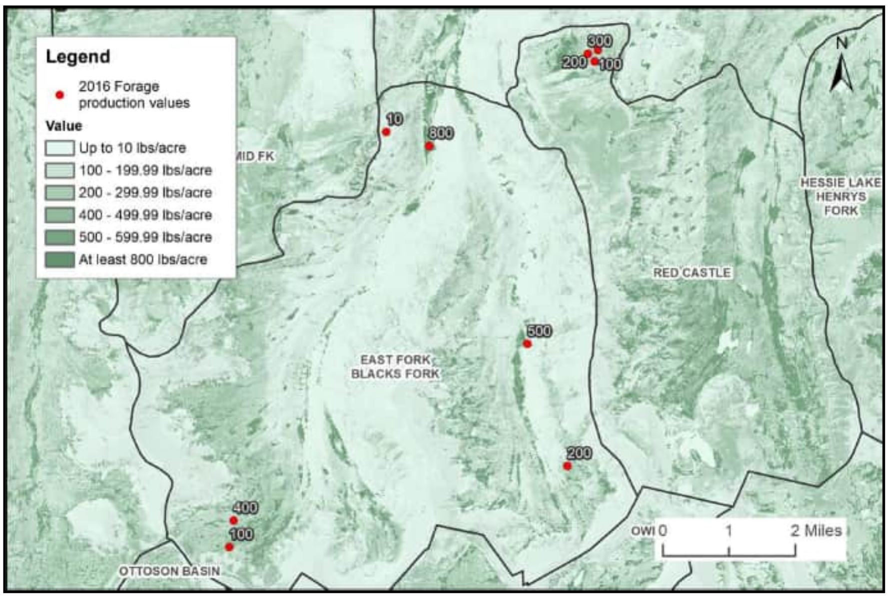

Figure 10. Predicted forage production raster from image classification of forage production data.

process and adjusted the raster classification process by targeting the different levels of forest canopy density. The resulting dataset describes the study area in terms of canopy density levels (*i.e.* high to low). **Figure 11** illustrates the data transformation process to obtain the canopy density cover dataset. **Figure 12** shows the resulting forest canopy density raster dataset.

Comparisons Using Model Outputs: Once these model outputs were derived, we made two comparisons to the Forest Service determination of capable lands. In Case 1, we calculated the acreage of lands meeting current Criteria of ≤45% slope, 2016 forage production ≥ 200 lb/acre, and excluded areas of dense timber,

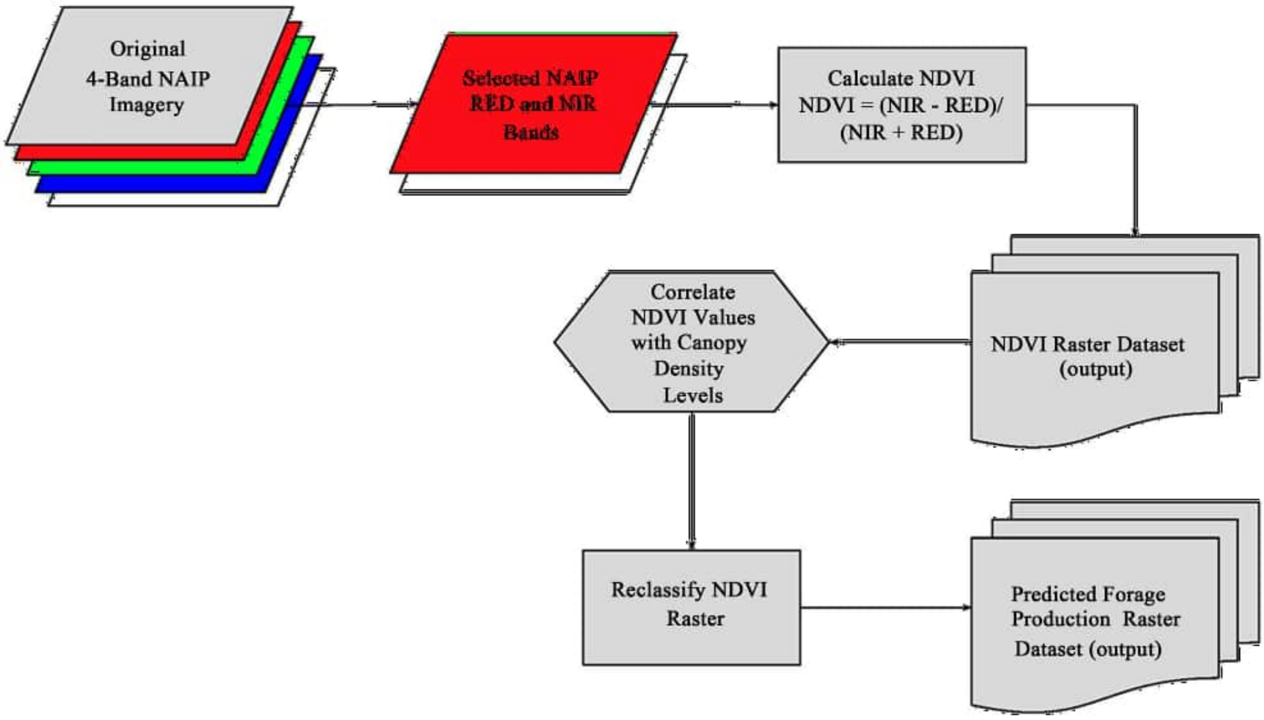

Figure 11. The data transformation process to obtain the canopy density cover dataset.

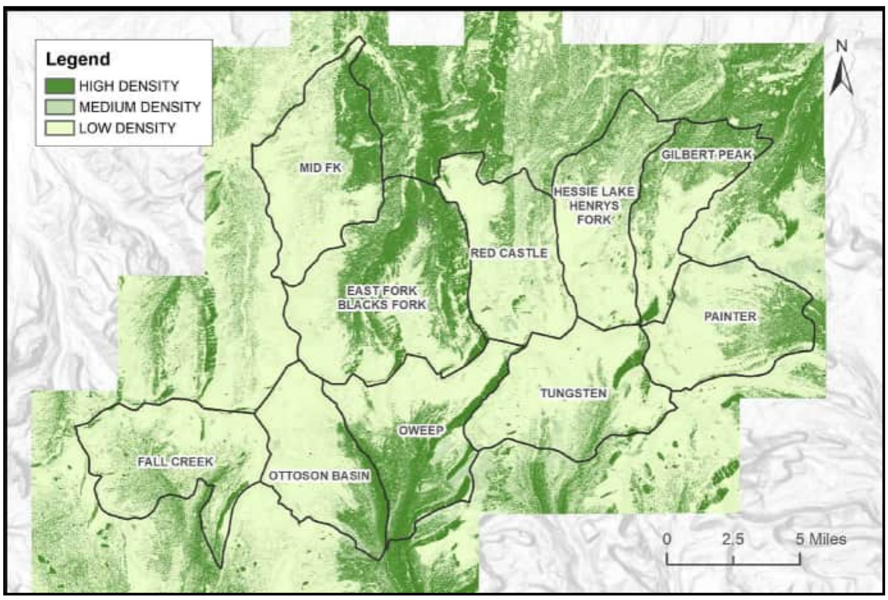

Figure 12. Canopy density raster dataset using NDVI values from NAIP imagery and the resulting classification into density categories.

water bodies and wetlands. In Case 2, since the most recent Forest Service forage production data was that collected in the 1960s, we digitized the 1960's forage production data which was then used to determine acres with forage production ≥ 200 lbs/acre [32] (**Table 2**). This, along with slope ≤ 45% and excluding areas of dense timber, water bodies and wetlands were used to determine capable acres.

2.5. Stocking Rate Determination

Forage Consumption: A forage consumption rate for sheep was provided in the USFS Region 4 Range Analysis Handbook showing forage consumption for a 125 lb ewe to be 4.1 lb/day air dry weight while an 80 - 90 lb lamb would consume 2.9 lb/day [22]. Since permits allow two lambs per ewe, we used 9.9 lb/day (301 lb/month) as a forage consumption rate for each ewe/lamb pair applied to the permitted numbers for each allotment. According to government statistics, in 2017, the average live weight of sheep and lambs for slaughter was 132 pounds [41]. This indicates our estimated forage consumption rate for a ewe and two lambs could be an underestimate if full permitted numbers of ewes and lambs are being grazed.

Utilization: Recommended utilization rates are 20% for alpine ranges grazed during the growing season or in poor condition, while for ranges in good condition and grazed during the dormant season 30% is recommended [42]. Lewis (1970) recommended 30% utilization for all areas except wetlands [16]. He recommended 40% in wetlands, while acknowledging these are not preferred by sheep, are not suitable for grazing and that the drier uplands nearby will be preferred. For this analysis we used a 30% utilization rate even though past work has shown these alpine and subalpine upland areas to be in poor condition with depleted ground cover, gully erosion, stream bank scouring and heavy grazing in non-capable areas such as uplands and steep slopes, indicating that they are most often in poor condition [16] [18] [19].

3. Results and Discussion

3.1. Current Forage Production and Comparison to 1960's Data

The 1960's forage production data excluded non-forage species in grazing capacity determinations [15] [16] [22]. **Table 3** summarizes key statistics from the 1960's determinations and our 2016 forage production data set.

The median sample weight was less in 2016 than in the 1960s while the mean was greater in 2016. This is logical since the 2016 data included all herbaceous species whether forage or non-forage, while the 1960s' data did not include non-forage species. The 2016 maximum values were samples from wetlands. The highest non-wetland sample was near the 1960's maximum.

3.2. Comparison of Capable Acres

Table 4 summarizes the capable acres determined for the ten allotments applying the current Criteria. These are contrasted with those determined by the ANF and WCNF in their Forest Plans. The Forest Service determination of capable

Table 3. Key statistics for forage production (lb/acre).

Time Period	Median	Mean	Maximum
1960s	206	240	615
2016	166	294	1431

lands was represented in the GIS data they provided [35] [36]. Their determination was that 35.7% of the land area was capable (**Table 4** and **Figure 13**). They did not exclude areas of dense timber or wetlands and did not collect forage production data, while relying on assumed production from their vegetation layer. Case 1 resulted in only 6% of the total allotment area being capable (**Figure 14**). Case 2 resulted in only 1.8% of the total allotment area being capable (**Figure 15**). The Forest Service determination of capable lands overestimates the actual amount by nearly 6 times based on applying their current Criteria and our 2016 forage production data (Case 1) and nearly 20 times when the 1960's

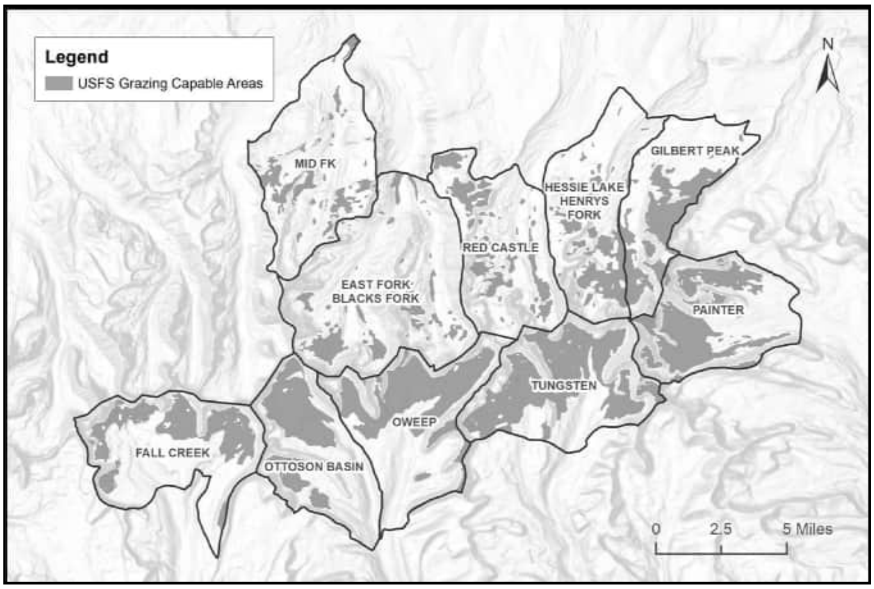

Figure 13. Ashley and Wasatch-Cache National Forest determination of capable acres = 57,399 acres, or 35.7 percent of total acres.

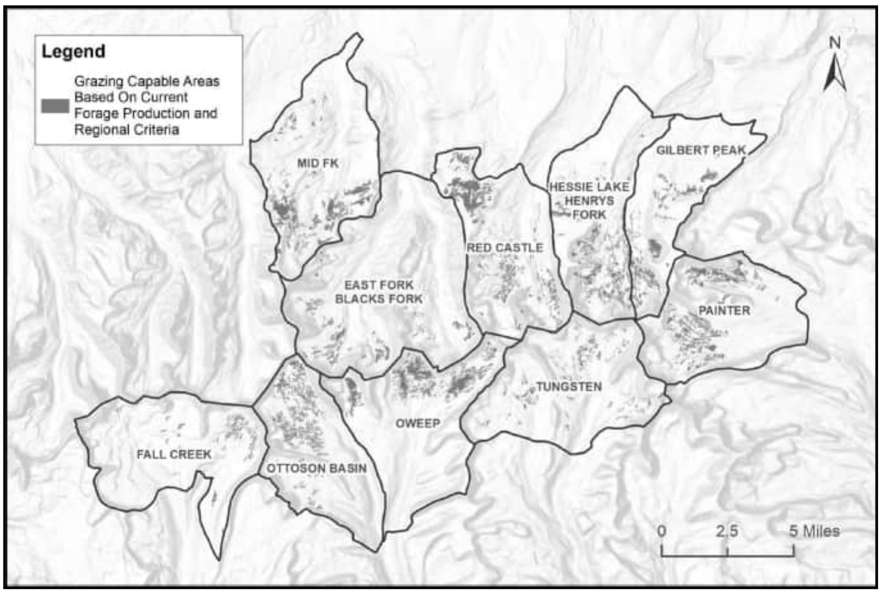

Figure 14. Capable acres determined from regional capability criteria and current forage production = 9685 acres, or 6.0 percent of total acres.

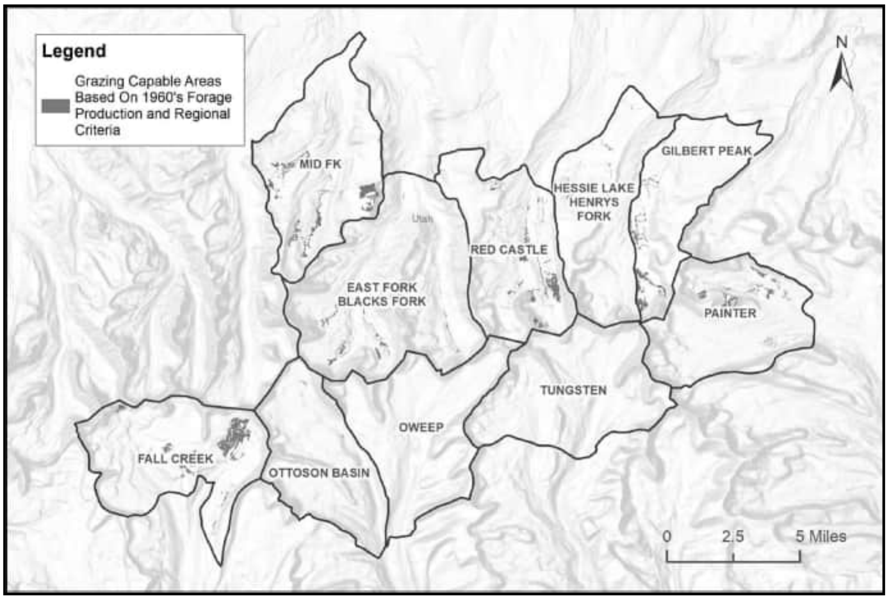

Figure 15. Capable acres determined from regional capability criteria and 1960's forage production = 2.887 acres or 1.8 percent of total acres.

Table 4. Summary of capable acres.

Total Allotment Acres	Forest Service Capable Acres	Total Capable Acres Current Forage: Case 1	Total Capable Acres 1960s Forage: Case 2
160,410	57,399	9685	2887
Percent of Total	35.7%	6.0%	1.8%

forage production data were applied (Case 2). If sufficiently detailed soil survey information and ground cover data were available, more areas would likely be found not capable as indicated by past surveys [16] [18] [19]. However, even in the absence of these data, our model demonstrates that the allotments lack land capable for grazing domestic sheep.

3.3. Evaluation of Forage Demand, Available Forage and Stocking Rates

The total forage demand for the currently permitted 12,850 ewe/lamb pairs grazing these ten allotments based on their time in the allotments and a forage demand of 301 pounds per month per pair is 8,062,641 pounds (**Table 5**). In Case 1, using the 2016 mean forage production of 294 lb/acre and 9685 capable acres gives total forage production of 2,847,390 pounds. Applying a 30% utilization rate to this amount gives 854,217 pounds available. This is 10.6% of the current demand. In Case 2, using the 2016 mean forage production values on the 2887 capable acres is 848,778 pounds. Applying a 30% utilization rate to this amount gives 254,633 pounds available. This is 3.2% of the demand. The implication of this to current stocking rates is clear. In Case 1, a 90% reduction would be needed to balance domestic sheep use by the current permitted numbers to

Table 5. Forage demand compared to available forage.

Total Forage Demand for 12,850 ewe/Lamb Pairs for the Current Grazing Period	8,062,641 lbs.
Case 1: Available Forage on 9685 Capable Acres	854,217 lbs. or 10.6% of Total Demand
Case 2: Available Forage on 2887 Capable Acres	254,633 lbs. or 3.2% of Total Demand

the available forage. In Case 2, a 97% reduction would be needed to balance domestic sheep use by the current permitted numbers to the available forage.

Where does the additional forage to support these 12,850 ewe/lamb pairs of permitted sheep come from? The domestic sheep are grazed and trailed throughout the non-capable areas on steep slopes and highly erodible soils and in the sensitive alpine meadows, where sheep consume whatever small amounts of edible plants they can find. This management has caused and continues to cause accelerated erosion, high flood forces during runoff events, changes in plant communities, and erosion of streambanks [16] [18] [19].

3.4. Impact on Wilderness Values

Cole and Landres (1996) delineated the threats to wilderness ecosystems to include: 1) recreation; 2) livestock grazing; 3) fire management; 4) invasive species; 5) diversion and impoundment of water; 6) atmospheric pollutants; and 7) management of adjacent lands [43]. Here we are considering only the livestock grazing effects, which they delineate as trampling, grazing, defecation, death of plants, compaction and destabilization of soils, redistribution of nutrients, changes in geomorphology, gully formation, and lowering of water tables, reduced water quality and impacts on wildlife populations. They considered the most significant effect at the species level is the indirect effects on wildlife. They point out that many of these wilderness areas are located at high elevations or in the desert, are naturally stressed and not resilient.

We have described the ecological degradation of plant and soil communities occurring in the High Uintas Wilderness due to grazing in non-capable areas. In addition, the current large-scale removal of vegetation by domestic sheep grazing in the High Uintas Wilderness reduces food and cover for native wildlife that depend on herbaceous plants. Snowshoe hares (*Lepus americanus*) are a principle food source for Canada lynx (*Lynx canadensis*), a Threatened species. Grazing by domestic sheep may be playing a role in the current absence of lynx from the High Uinta Wilderness [44]. Bighorn sheep populations today are a small fraction of historical numbers, with a loss of over 98 percent of historic numbers [45]. Domestic sheep compete with native bighorn sheep for food, space and water. They are also asymptomatic carriers of diseases such as pneumonia that result in sick and dead bighorn sheep if the two come into contact with one another [46].

The ANF and UWCNF have monitored many locations in these ten grazing allotments and, in recent years, have not identified impacts of domestic sheep grazing. For example, the Forest Service notes that "over 99% of the studies show ground cover is in satisfactory condition" and plant communities are dominated by plants of high value for watershed protection [2]. We reviewed the data files, photographs and data sheets provided by the Forest Service [15] and analyzed the Forest Service monitoring locations [28] to determine why they failed to find the problems documented by earlier Forest Service range and soil scientists and one of our own authors which documented severe erosion, active gully progression or headcutting, streambank scouring, and lack of ground cover in the drier uplands and on steeper slopes [16] [18] [19] (**Figure 16** and **Figure 17**). When long term ungrazed areas were compared to areas that continue to be grazed by domestic sheep, ground cover was high in the ungrazed areas, gully erosion and headcuts were healing, and streambanks were healthy and not eroding [18]. Lewis (1970) showed definitive improvements in plant community composition with improved vigor in an area where sheep had been excluded for 11 years leading to a change in condition assessment from fair to good [16].

Using GIS, we compared the Forest Service monitoring locations to percent slope and found that 59% of monitoring locations were in areas < 10% slope, and 83% in areas < 20% slope. This indicated that Forest Service monitoring was focused in areas that are less likely to be unstable and are less sensitive to sheep grazing impacts. Few sites were monitored in areas > 40% slope which would be on the slopes more subject to erosion and instability. Eighty three percent of locations were in riparian areas, alpine wet and dry meadows and willow complexes which are the less sensitive areas and many that are least preferred by sheep and which also correspond to more level terrain. Forest Service ground cover data is rarely collected. If casual observations noted in their files as well as on data sheets are all counted, only 10.8% of the monitoring sites since 2000 noted a ground cover estimate. The satisfactory conditions the Forest Service noted in their Draft Environmental Impact Statement appear to logically follow, given these measures were taken in the areas less sensitive to domestic sheep impacts [2].

Figure 16. Upland adjacent to riparian area showing bare soils and trailing damage [18].

Figure 17. Result of sheep grazing on steep slopes leaving loose, erodible soil and sparse plant cover [18].

Cole and Landres (1996) [43] note: "We can, however, attempt to identify those places where grazing is most inappropriate and develop grazing management objectives and guidelines that are more compatible with the goals of wilderness than the goal of maximizing sustainable animal production (the most common goal outside wilderness)". Wilderness is "land retaining its *primeval character and influence*, without permanent improvements or human habitation, which is protected and managed so as to *preserve its natural conditions*…." In addition, wilderness should be "*affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable*. By these definitions alone, domestic sheep grazing is incompatible with the Wilderness Act. The degradation documented in the Uinta Wilderness over the decades is clearly not compatible with the Wilderness Act's intent.

4. Conclusions

The GIS analysis we have conducted for the High Uintas Wilderness Domestic Sheep grazing reauthorization indicates that only a small fraction of these allotments are capable of supporting domestic sheep grazing. The capable acres identified in our forage capacity model for this mountain range are scattered, small areas disconnected from each other to a large extent and require sheep to be trailed between them. Historically, nearly every acre sheep can access has been grazed across the Uinta mountains, regardless of slope, ground cover, elevation, soil erosion hazard and vegetation condition. Previous monitoring has identified that large-scale erosion is occurring in the High Uintas Wilderness due to this practice of trailing and grazing domestic sheep in non-capable areas.

This analytical process using GIS provides a framework for evaluation of other grazed lands and an evaluation of the costs and benefits of livestock grazing versus other values such as wildlife, native plant communities and water supplies. It shows that current and proposed Forest Service management is based on lack of compliance with its own Regional Capability Criteria, inadequate monitoring and insufficient analysis. Limitations of the study include the lack of a suitably detailed soil survey to determine erosion susceptibility, a lack of ground cover data, a lack of Forest Service data for the level of grazing use, or utilization, and the lack of a Forest Service quantitative measurement of vegetation production in each plant community and soil type. In spite of these limitations, the use of slope, forest cover and forage production as derived in our study reduced field work necessary to do this evaluation and showed that these were the dominant factors needing to be addressed.

Forest Service management can address the problems in the High Uintas Wilderness by applying the analytical process we have provided and adjusting stocking rates and grazing periods based on the capable acres, current forage production and forage consumption rates, while applying a sustainable utilization rate. Sheep should be managed to remain within the capable areas and away from steep slopes. Monitoring should include trend in ground cover and utilization. It should be standardized, quantitative and performed annually. It should include capable and non-capable areas with a focus on those areas most preferred by domestic sheep such as the dry meadows and uplands in the valleys, uplands at the margins of wet areas and slopes at the valley margins. Sufficiently detailed soil surveys should be carried out for future evaluations. Only then will the Forest Service approach conditions where domestic sheep grazing in this wilderness may be sustainable and recovery of past degradation can begin.

Acknowledgements

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Dr. Carter has spent decades surveying and exploring the High Uintas Wilderness both at his own expense and while in the 2001-2010 time period he was an employee of Western Watersheds Project (WWP), also a 501c3 organization. Since retiring from WWP 2010, he has donated his time and expenses to this work. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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EXHIBIT 2

Vegetation Analysis of Grazed and Ungrazed Alpine Hairgrass Meadows[1]

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Highlight

Alpine hairgrass meadows in Colorado and Wyoming were examined for plant species differences related to sheep grazing history. Nine alpine areas were studied and three of these had not been grazed by domestic sheep for many years. Frequency values for eight plants were found to be useful in determining whether or not hairgrass meadows have been predominantly grazed over the years by domestic sheep. No additional information was obtained by including species cover data for classification purposes.

The first information on alpine vegetation of the southern Rocky Mountains came from botanical explorations made in the early 1800's. Only new or rare plants to the area were listed and few detailed accounts were given of the vegetation as a whole (Cox, 1933). Griggs (1956) agreed with Weaver and Clements (1938) in their conclusion that alpine communities are little understood, and ascribed the limited work in alpine areas to the complex nature of tundra communities. The heterogeneity found in alpine species groupings is such that some botanists have concluded that there is no sense at all to tundra vegetation. Polunin (1948) said the more he learned about alpine vegetation as a whole, the less he felt inclined to generalize about it.

A greater portion of alpine tundra of the southern Rocky Mountain Region was categorized as alpine grassland than any other community type by both Cox (1933) and Weaver and Clements (1938). This categorization is an important factor in grassland management since management principles are often based on the predominant vegetation type. Included in six grassland types described by Cox (1933) are three associations which contain tufted hairgrass (*Deschampsia caespitosa*) in abundance. These are: snowflush association, alpine-moor association, and wet-meadow association. In the alpine-moor association, hairgrass is said to form a transition from wet areas to upper slopes of the dry alpine meadows. Hairgrass was considered the dominant in wet-meadow associations and as an important species in the other two associations.

Tufted hairgrass is a well-known montane species but has received little specific attention in alpine tundra studies. The species is distributed throughout alpine regions of the world and include the Alps, Pyrenees, and the Himalayas. A favorable habitat for tufted hairgrass is indicated by sub-

[1] Appreciation is extended to the National Science Foundation (GB-11335) for partial support of this study. Received July 21, 1971.

stantial snow cover or by snow melt water influence. Additionally, late-lying snowbanks are known to offer protection against grazing. Hairgrass meadows are also recognized as being the best developed of true grass meadows in alpine tundra (Marr, 1961). Lawrence (1915) observed that hairgrass requires permanent ground moisture and relatively cool to cold climates in order to survive. Cooper (1908) described hairgrass as being a secondary species in his classification of dry grassland tundra meadows. Holm (1908) on the other hand, included hairgrass as being more important in swamps of the aspen zone.

Tufted hairgrass has been observed to be the most important forage species occurring on alpine sheep ranges (U.S. Forest Service, 1956). Its importance is recognized because of its ecological range, abundance, amount of herbage produced, and use by domestic sheep. Moist to wet sites in alpine hairgrass meadows have been observed to produce 0.7 tons of air-dry plant material per acre, with at least 85% of this consisting of plants which were palatable to domestic sheep. In contrast, turf-sites which are well drained and located on ridge tops are known to produce about 0.4 tons per acre of air-dry material with approximately 65% palatable for sheep (U.S. Forest Service, 1956). The importance of tufted hairgrass as a component of other vegetation types of the alpine tundra has also been noted by several researchers.

A study was made of alpine tufted hairgrass meadows in the southern Rocky Mountain Region to determine if plant composition differed in historically grazed areas as compared to that of ungrazed areas. Some studies of a local nature have been conducted in alpine hairgrass meadows and to date no comparisons of any characteristic of phytosociological structure have been made for geographically separated areas. Furthermore, no reports have been made comparing alpine hairgrass meadows which have not been grazed for many years to those grazed by domestic livestock.

Methods and Procedures

Nine areas were selected from alpine regions located in southern Wyoming and throughout Colorado (Fig. 1). Criteria for selection of an area for study included: accessibility, geographic relationship to other areas in the study, past use by domestic sheep, and timberline relationships. All study areas were located well above timberline and included a geographical representation of the southern Rocky Mountain Region. A stand size 7 × 10 meters was selected as a macro-plot representing hairgrass meadow vegetation. Each stand was sampled by placing 50 quadrats (10 × 40 cm) at random within. Presence for all species encountered in quadrats was noted and frequency computed. Density of hairgrass only was recorded for all 50 quadrats in each stand. Cover values were visually estimated for each species that occurred in every fifth quadrat. Thus, a total of 10 samples for species cover values were obtained for each stand. Data

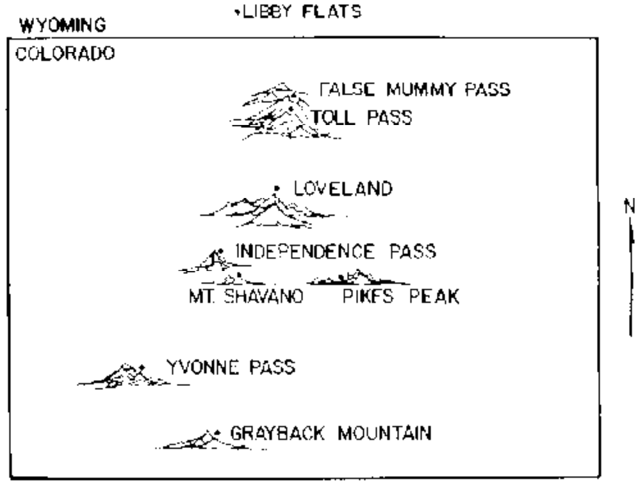

FIG. 1. Location of study areas containing alpine hairgrass meadows.

were obtained from three ungrazed areas having a total of 28 stands. These areas were False Mummy, Trail Ridge Road, and Pikes Peak. Grazing by domestic sheep has not been permitted for many years in the three areas and hopefully, an indication of hairgrass meadow vegetation differences due to continuous grazing can be assessed.

Cover data for species were available only for the two latter areas. The remaining six areas had a long history of use by domestic sheep and were represented by 49 stands. Generally grazed meadows were easily accessible and free of snow during the season of use by sheep. Relative soil moisture levels were determined for all stands, and included the following: very wet, wet, mesic, and dry mesic. A total of 77 stands were sampled with the number of stands within areas ranging from 6 to 12.

Bonham and Ward (1970) reported that 20 species were found consistently throughout alpine hairgrass stands. These species were selected for use in this study. Multivariate analysis of variance in combination with step-wise discriminant analysis was performed on frequency and cover data in order to determine the set of species giving the largest significant difference between group means. This procedure was also used to evaluate the power of species occurrence to discriminate between grazed and ungrazed areas.

Results and Discussion

The abundance of hairgrass in alpine meadows was found to vary both within and between grazed and ungrazed areas. Density of hairgrass ranged from 18 plants/m² to 48 plants/m², in grazed and ungrazed areas respectively. However, at least 40 plants/m² were observed for one meadow in a grazed area while the greatest range in hairgrass density occurred in ungrazed areas. The range of hairgrass frequency, on a meadow basis, was from 10 to 100% occurrence in ungrazed areas while that of grazed areas ranged from 18 to 98%. The overall percentage frequency of hairgrass for areas ranged from 49 to 85%. The lower frequency values occurred in southern sample areas while the higher values occurred in northern areas (Fig. 1).

Table 1. Important species and their frequency (%) of occurrence in grazed and ungrazed alpine hairgrass meadows. Only eight species were significantly ordered.

Species	Frequency		Importance level as discriminator	Discriminant coefficient
	Ungrazed	Grazed		
Phleum alpinum	0	17	1	−0.126
Potentilla diversifolia	1	30	2	−0.115
Polygonum bistortoides	44	30	3	0.167
Poa alpina	0	11	4	−0.156
Caltha leptosepala	28	6	5	0.131
Geum rossii	60	38	6	0.130
Senecio dimorphyllus	9	14	7	0.058
Oreoxis alpina	1	12	8	0.011
Achillea lanulosa	2	22		
Androsace septentrionalis	3	11		
Arenaria obtusiloba	14	10		
Artemisia norvegica	38	18		
Erigeron simplex	20	24		
Festuca ovina	28	24		
Lewisia pygmaea	4	12		
Ranunculus adoneus	12	6		
Sibbaldia procumbens	16	38		
Taraxacum ceratophorum	0	8		
Trifolium parryi	32	18		

Alpine hairgrass meadows are known to be associated with heavy snow accumulation (Marr, 1961). It was evident from this study that late lying snowbanks prevented grazing of some meadows even in areas used by sheep. Thus, responses of vegetation to long-term grazing exposure have been confounded with snowmelt. However, it was generally noted that snow receded earlier in the southern part of the study region and subsequently hairgrass meadows were opened to grazing earlier. Correspondingly, more species of palatable forbs occurred in these hairgrass meadows, which gave a higher species diversity for grazed compared to ungrazed areas. Important forbs and their distribution in grazed and ungrazed meadows are listed in Table 1. Western yarrow (*Achillea lanulosa*) was the most widely distributed species throughout grazed areas and was a common species in several of these hairgrass meadows. In contrast, marshmarigold (*Caltha leptosepala*) was observed to be common in ungrazed regions and occurred sparingly in a few meadows of grazed areas.

The importance of alpine avens (*Geum rossii*) as a component of ungrazed areas is evident from this study. Smith and Alley (1966) observed that alpine avens was an important member of several alpine vegetation types, and often dominated specific types. Furthermore, this species was recognized in their study as being unpalatable to sheep and other grazing animals. In contrast, Strasia et al. (1970) found that alpine avens made up 10% of sheep diets consistently throughout the summer on alpine ranges. In the present study, alpine avens occurred abundantly in hairgrass meadows of ungrazed areas and was found to dominate in meadows with mesic to wet habitats regardless of grazing history.

The common grasses occurring in alpine areas, for example Patterson bluegrass (*Poa pattersoni*), alpine bluegrass (*Poa alpina*), alpine timothy (*Phleum alpinum*), and sheep fescue (*Festuca ovina*) are more abundant in the drier habitats of alpine tundra. It was noted that these important grass species never occurred with hairgrass when density of the latter species exceeded 40 plants/m². Since it was suggested by Holway and Ward (1963) that hairgrass density is influenced by snow accumulation in alpine areas of Colorado, a covariance analyses was conducted on the data with hairgrass density as the covariate. No significant effect of the occurrence of other species with respect to hairgrass density was observed in this study.

Multivariate analysis of variance using all species, indicated that a significant difference existed in species mean occurrences for grazed versus ungrazed areas ($P < .01$). Step-wise discriminant analysis was then performed on the variance-convariance matrix for species listed in Table 1. This procedure yields coefficients for each species which are then used to classify the species group into grazed or ungrazed meadows. Eight species were found to be important discriminators for detecting significant differences in grazed versus ungrazed meadows. Alpine timothy was determined to be the most important discriminator for detection of ungrazed hairgrass meadows. It was obvious that two criteria were important: (1) the variance of the occurrence for the species and, (2) the absence of alpine timothy in ungrazed hairgrass stands. This species used alone as an indication of grazing history, correctly classified all ungrazed meadows, but misclassified 43% of the grazed meadows. Research on the management of alpine sheep ranges has indicated that alpine timothy is second only to hairgrass in importance according to its range, abundance, amount of herbage produced, and use by sheep (U.S. Forest Service, 1956) while bluegrass species were listed third. Neither alpine timothy nor bluegrass species occurred in hairgrass meadows of ungrazed regions.

Cinquefoil (*Potentilla diversifolia*) in addition to alpine timothy, increased classification accuracy to 70%. The former species was also more abundant in grazed areas than in ungrazed areas. The power to discriminate between grazed and ungrazed conditions concomitantly was reached only by using all eight species in order of their importance as indicated in Table 1.

The species coefficients give relative contrasts of the eight species and their importance as predictors of grazing relations in hairgrass meadows (Table 1). Approximately equal amounts of these species imply the existence of an intermediate stage between grazed and ungrazed conditions, historically. Two of the three species with positive coefficients were included by Strasia et al. (1970) as being important in diets of sheep. Furthermore, these two species, alpine avens and American bistort (*Polygonum bistortoides*) occur more abundantly in ungrazed hairgrass meadows.

Only three of the eight discriminator species occurred more frequently in ungrazed areas. Although alpine avens is an important species in ungrazed areas, its value as an indicator species was lowered by the fact that it occurred as the most frequent species in one of the grazed areas, Mt. Shavano. Snow accumulation on hairgrass meadows in this area however, indicated little or no grazing of these meadows early in the season.

Alpine timothy and alpine oreoxis (*Oreoxis alpina*) did not occur in meadows with hairgrass densities greater than 25 plants/m^2, while marsh-marigold did not occur when hairgrass densities were less than 12 plants/m^2. The remaining five indicator species occurred at all levels of hairgrass densities encountered.

Only five species were found to have cover values greater than one percent in ungrazed areas compared to only three species having in excess of one percent cover for grazed areas. The analysis of cover data using these procedures indicated that only three species were significant in distinguishing grazed areas from those ungrazed. Two of the three species were important both for cover and frequency of occurrences. American bistort was the most important discriminator using cover data. Previous studies have indicated that this forb is preferred early in the grazing season and make up a significant proportion of the diet of sheep (Strasia et al., 1970). The second most important species was found to be sandwort (*Arenaria obtusiloba*), followed by marsh-marigold.

It is obvious from this study that the absence of other major grass species in hairgrass stands is ecologically significant and indicates that grazing history has affected the species composition of alpine hairgrass meadows. Furthermore, important forbs such as American bistort, which are eaten by sheep during the early part of the season were much more abundant in ungrazed areas. Additionally, forbs having low palatability such as western yarrow, were observed to be more abundant in grazed hairgrass meadows than in ungrazed hairgrass meadows. Forbs are preferred by sheep early in the season and those that are not preferred by sheep can be predicted from this study. Forbs classified as not used by sheep include: cinquefoil and western yarrow. In contrast, marsh-marigold, alpine buttercup (*Ranunculus adoneus*) and alpine sage (*Artemisia norvegica*) are forbs which have not been reported as important in sheep diets, yet this study suggested that they might be (Table 1). Further studies need to be carried out in order to determine more fully the relationship of species composition and abundance in hairgrass meadows with regard to the grazing affects of domestic sheep.

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EXHIBIT 3

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The Influence of Grazing and Other Environmental Factors on Lichen Community Structure along an Alpine Tundra Ridge in the Uinta Mountains, Utah, U.S.A.

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Abstract

This study examined the influence of snowmelt, vascular plants, grazing, substrates, and soil characteristics on the distribution of lichen communities along an alpine tundra ridge in the Uinta Mountains of Utah. Percent cover of lichens, rocks, snow, and vascular plants were estimated at 18 study sites along an altitudinal transect. Vascular plant cover and species diversity were greatest at the lower elevation sites, and differences in plant communities were related to differences in rock cover and grazing. Lichens showed a similar trend, with rock cover, grazing, vascular plants, and timing of snowmelt all defining community structure. We hypothesize that domestic sheep have dispersed fragments of two lichen species from western Wyoming to grazed sites along the study transect. Generally, terricolous and epiphytic lichens differed between the lower and upper sites in species composition and growth-form distribution. Distribution of lichen growth forms was positively correlated with increasing rock cover. Late snowmelt areas were also distinguished by a defined group of lichens.

Introduction

There has been very limited research on the distribution and structure of tundra lichen communities. Creveld (1981) organized an extensive list of lichen species into 382 relévés and then arranged the relévés into vegetation types according to the Braun-Blanquet method of vegetation analysis. More recently Türk and Gärtner (2001) published a review paper examining biological soil crust communities in the subalpine and alpine habitats of the European Alps, including some information about lichens. Phytosociological studies of lichen communities in Greenland have also been published (Daniëls, 1982; Hansen, 1978), along with a more recent review paper concerning lichen-rich soil crusts (Hansen, 2001).

Knowledge about alpine lichens in the Western United States is limited and generally floristic in nature. Anderson (1964) published a comprehensive survey of the lichen genus *Lecidea* in Rocky Mountain National Park, Colorado; many of his collections were from true alpine tundra sites. Egan (1969) described the alpine lichen flora of Mount Audubon, Colorado, and later expanded his research to include three additional sites in New Mexico (Egan, 1971). Komárková (1979) published the results of an extensive phytosociological survey of the alpine zones of the Indian Peaks area of the Colorado Rocky Mountains, which included a comprehensive list of the lichen species. Flock (1976, 1978) evaluated the effects of snow cover and soil moisture on the distribution of lichens and bryophytes on Niwot Ridge in central Colorado. The only previous study dealing specifically with alpine lichens in Utah is a floristic survey of eight alpine tundra sites in central and eastern Utah that resulted in a list of 14 macrolichens (Imshaug, 1957).

More recently, research in alpine tundra zones in the Olympic Mountains of Washington has focused on the structural and functional attributes of lichen communities (Glew, 1997; Gold et al., 2001). Glew (1997) researched the effects of specific types of vascular plant communities on lichen community structure and observed that the structure of the epiphytic lichen community was directly related to the structure and composition of the vascular plant community. Glew (1997) also reported that specific types of vascular plant communities (e.g., krummholz and late snow) tended to support less diverse lichen communities, a phenomenon related to, either directly or indirectly, specific abiotic conditions (e.g., soil moisture, limited light, late-lying snow). Gold et al. (2001) examined several functional parameters of different kinds of alpine soil crust communities including a crust dominated by a thick layer of fruticose lichens. Compared to other sites in their study, soils at the lichen dominated site had the highest organic matter content, soil moisture, and concentrations of soil nitrogen and phosphorous. Although these studies have contributed significantly to our understanding of alpine tundra lichen communities in the Western United States, there is still a need for research that characterizes biotic and abiotic influences on the structure of alpine lichen communities.

Many of the alpine tundra areas of the Western United States having been extensively grazed since the mid to late 1800s (Marr, 1964); however, there have only been a limited number of studies investigating the impact of grazing, herding, and bedding of domestic animals on alpine tundra habitats (Johnson, 1962; Lewis, 1970; Paulsen, 1960; Smith and Johnson, 1965; Strasia et al., 1970; Thilenius, 1979). Data from these studies document the effects of domestic grazers on vascular plant vegetation, but lack any specific reference to lichens. In most cases, grazing-related damage to the vascular plant community was minimal except in bedding or watering areas or along driving trails (Thilenius, 1979). One study suggested that light to moderate grazing by sheep may even increase vascular plant cover (Strasia et al., 1970). It was also noted that grazing precipitated changes in the overall composition of the vascular plant community, with certain species increasing in abundance while others decreased slightly (Strasia et al., 1970). Similar reports are available for Arctic tundra areas where both

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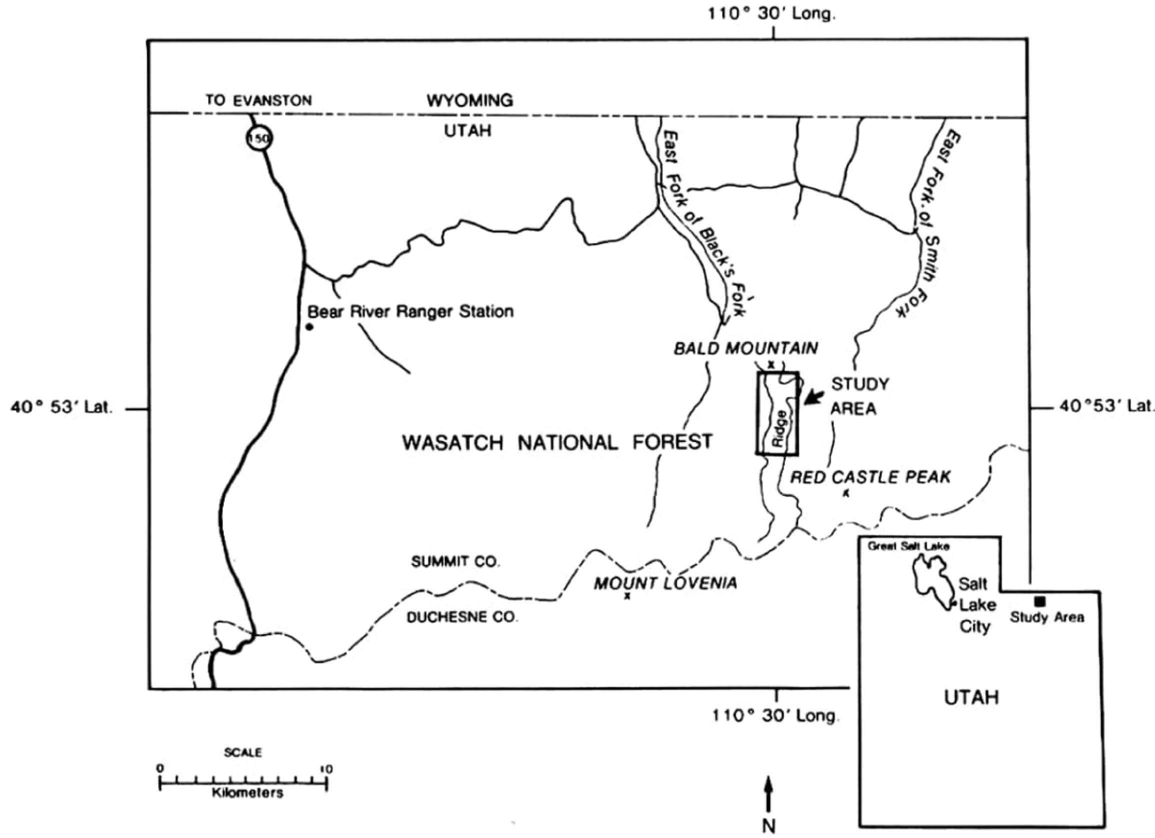

FIGURE 1. Map of study area in reference to the Wasatch National Forest and Bald Mountain. Inset shows location of study area in reference to the state of Utah.

domestic reindeer and wild caribou are the major grazers (Moser et al., 1979; Olofsson, 2006; Pegau, 1969, 1970; Polezhaev, 1980; Skuncke, 1969). These studies and others (Andreev, 1975; Utkin, 1974) show conclusively that when grazing animals are herded extensively, there are significant changes in both the lichen and vascular plant communities; specifically, the total lichen cover was reduced, some sensitive species were completely eliminated, and there was a proliferation of grass species (Olofsson, 2006; Polezhaev, 1980).

Several studies have examined the effects of trampling by humans, particularly along trails, on tundra landscapes (Bell and Bliss, 1973; Grabherr, 1982; Willard and Marr, 1970, 1971). These studies generally showed that tundra habitats are extremely sensitive to the effects of persistent trampling by human beings. Recovery of tundra landscapes following damage related to human activity was also shown to be extremely slow (Willard and Marr, 1971). Lichens, especially fruticose species, were noted to be particularly sensitive to human-related perturbations. Conversely, crustose and squamulose species on soil and rock substrates were generally less sensitive to human-related impacts (Willard and Marr, 1971).

The overall intent of our research was to obtain both quantitative and qualitative data for biotic and abiotic factors potentially influencing lichen community structure along an altitudinal gradient in the alpine tundra of the Uinta Mountains. We hypothesize that domesticated grazers (sheep) and vascular plant communities measurably influence the composition of alpine lichen communities. We further predict that abiotic factors such as soil chemistry, habitat rockiness, and snowmelt patterns also shape lichen community structure. This initial data set will be particularly crucial in light of the sensitivity of many lichens to various kinds of human-related perturbation compounded by the inherent vulnerability and slow recovery rates indicative of alpine tundra habitats.

Materials and Methods

SITE DESCRIPTION

The Uinta Mountains are located in northeastern Utah and northwestern Colorado. The north-south axis of the range averages between 48 and 65 km wide, whereas the east-west axis is approximately 240 km long. This study was conducted along an alpine tundra ridge that extends south of Bald Mountain and ranges from 3508 to 3938 m a.s.l. (Fig. 1). A transect, 4.5 km in length, consisting of 18 sites, was established along the ridge in 1983 (Fig. 2). The study transect was separated by vegetation type into three sections. The lower meadow sites (1–9) ranged between 3500 and 3600 m a.s.l. Sites 10–18 represented a gradient of increasing elevation from 3630 to 3880 m a.s.l. Sites 1–6, starting at the lower south-facing slope of Bald Mountain, consisted of an open alpine meadow dominated by *Carex rupestris* and *Geum rossii*. Sites 7–9 were located in a broken hummock area with *Carex rupestris*, *Geum rossii*, several *Salix* species, and some *Picea engelmannii*. Sites 10–18 were exposed, windswept, rocky areas with notably lower vascular plant cover. The upper sites were also dominated by *Carex rupestris* and *Geum rossii*, along with *Festuca ovina* and *Selaginella densa* as important subdominants.

FIELD METHODS

Lichen community structure was evaluated along gradients in elevation, vascular plant community composition and structure,

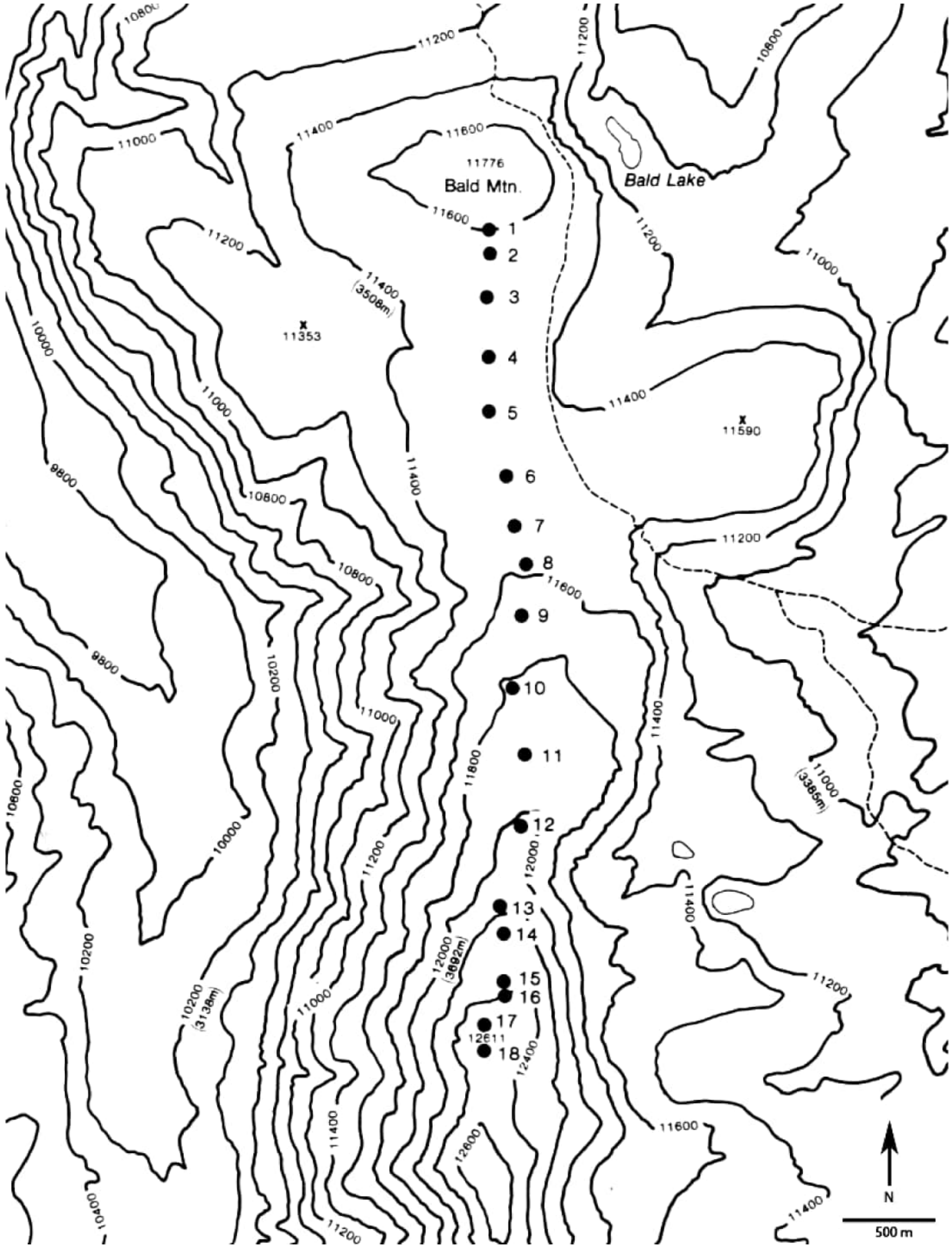

FIGURE 2. **Detailed map of the study transect showing meadow sites (1–6), hummock sites (7–9), and rocky ridge sites (10–18). Talus slopes that provide barriers to grazing sheep are located between sites 9 and 10, as well as at sites 14 and 16. Contour interval is 200 m.**

rockiness, snowmelt, various soil parameters, and grazing impact. The major vegetation types and physical features of the ridge were identified during the summer of 1982 after thorough examination of aerial photographs followed by detailed on-site investigations. A total of 18 distinctive areas were identified along the length of the ridge.

Following documentation of basic vascular plant community types and physical features along the study transect, permanently marked 10 × 10 m macroplots were established at each site. A random numbers table was used to locate ten 1 m^2 quadrats within each macroplot. A 0.25 m^2 square quadrat was then used to visually estimate percentage cover of lichens, vascular plant species, and rocks (large rocks with any dimension >10 cm in diameter and small rocks with all dimensions <10 cm in diameter) in one randomly identified quadrant of each square meter. Substrate notations were also made for all lichen species. General grazing effects by sheep were qualitatively estimated at each site on the basis of observed herding, grazing, and bedding patterns, a review of historical grazing allotments, and discussions with land managers and local sheep herders. Finally, snowmelt patterns along the study transect were documented using aerial photography. Photographs of the study transect were used to determine whether a site was snow free by the last week of May, June, July, or August of 1983; these data were then used to specifically evaluate lichen species distribution patterns as related to late snowmelt areas.

During the summers of 1980–1983 lichens and vascular plants were collected from each of the 18 transect sites. In addition, two surface (5 cm) soil samples were collected from each transect site for chemical and physical analysis of soil properties.

LABORATORY METHODS

Lichen and vascular plant specimens were processed in the laboratory, and voucher specimens were prepared. Secondary chemistry of lichens was determined using standard chemical spot tests (Huneck and Yoshimura, 1996; Orange et al., 2001). Thin-layer chromatography techniques (Culberson and Kristinsson, 1970; Culberson et al., 1981) were also used as needed to clarify lichen secondary chemistry for select species groups.

For species-level identifications, thin sections of lichen fruiting structures were prepared to determine ascospore size, shape, and color; number of spores per ascus; as well as the dimensions and characteristics of the various hymenial tissues. Voucher specimens of both lichens and vascular plants have been deposited in the Brigham Young University Herbarium.

A Utah Flora (Welsh et al., 2003) was used as the taxonomic authority for all vascular plant species. Lichen taxonomy was based on "A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada" (Esslinger, 1997).

All soil samples were analyzed for macronutrient concentrations and compositional properties using standard soil analysis procedures (Page, 1982). Calcium, magnesium, and potassium were extracted using a 1 N ammonium acetate solution. Phosphorus was extracted using a 0.2 N acetic acid solution, and total nitrogen was determined using standard Kjeldahl methods. Concentrations of nutrient elements were determined using atomic absorption techniques. Organic matter content was determined by wet oxidation using potassium dichromate (Page, 1982). Soil pH was measured using a saturated soil paste and a pH meter. The hydrometer method was used to determine soil particle size distribution and abundance (Page, 1982).

STATISTICAL METHODS

Transect sites were ordinated with respect to soil chemistry variables using the Multivariate Statistical Package (MVSP) statistical software. Centered, standardized Principal Components Analysis (PCA) was run with nine soil parameters for 17 sites (site 16 had no soil). Sites were clustered based on lichen species data. An unweighted pair-group method (UPGMA) was used to agglomeratively and heirarchically build the cluster based on Ruzicka's Similarity Coefficient (Ruzicka, 1958). Sites were additionally ordinated in MSVP with Canonical Correspondence Analysis (CCA), using lichen species data and soil chemistry data as species and environmental data files, respectively. Lichens occurring in at least 3 of the 18 sites were included in this analysis. Rare species were down-weighted. Niche overlap values for lichen species were determined following the method of Colwell and Futuyma (1971) and clustered following an UPGMA algorithm. Important Species Indices (ISI) were calculated for vascular plants and lichens using the methods of Warner and Harper (1972). Student's *t*-test for two independent samples was used to compare average percent lichen cover between the lower, grazed, meadow sites and the upper, ungrazed, rocky sites.

Results

ENVIRONMENTAL VARIATION AT THE SITE

The general pattern of snowmelt along the transect is likely consistent from year to year. In May only a few areas, none within the plots, were snow free. By the end of June, a number of areas in the higher elevation sites were snow free, whereas, the lower meadow sites were still under snow (Fig. 3). We attribute this pattern to the higher sites being windswept, while the lower sites are areas of snowdrift and accumulation. By the end of July, snow cover was patchy, but notably still present at site 9, and adjacent to sites 13 and 17. All sites were snow free by the end of August.

The higher elevation sites had significantly more large rock cover than the lower sites (Fig. 4). Sites 11–18 were especially rocky and included a talus slope site that had 100% rock cover (site 16). Among the lower meadow sites, site 1, located on the lower, southern slope of Bald Mountain, also had greater rock cover (Fig. 4). Decreasing vascular plant cover was associated with increasing rockiness in the upper portion of the transect (Fig. 4).

Based on physical characteristics, sites were divided into three groups: (1) meadows; (2) hummocks; and (3) rocky. Principal Components Analysis of nine soil variables (percent clay was eliminated as it was constrained by percent sand and silt) showed separation of some exceptional sites (17 and 15), but the remainder of the sites were not clearly separated based on groups or elevation (Fig. 5). Some of the meadow sites had higher silt concentrations (sites 3–6), but neither principal component axis separated these sites from the others.

The vascular plant community in the lower meadow sites was dominated by *Carex rupestris*, *Geum rossii*, *Festuca ovina*, and *Artemisia scopulorum*. The frequency of *Salix cascadensis* generally increased with increasing elevation. Another significant change in the vascular plant community, with increasing elevation, was the occurrence and increasing abundance of the cryptogam, *Selaginella densa* (Fig. 4). This low-growing vascular plant typically serves as an important substrate for a large number of lichen epiphytes. Other dominant vascular plants in the upper sites included *Draba cana*, *Paronychia pulvinata*, and *Lychnis apetala*.

Transect sites 1–5 had been continually grazed and often used as a bedding area for sheep since at least 1916, while sites 6–9 had only been lightly grazed, and sites10–18 had been essentially ungrazed (Zobell, personal communication). Furthermore, there is a talus slope that effectively separates sites 1–9 from sites 10–18. This talus area acts as a natural barrier to sheep movement, and only occasionally do sheep stray from the herd into the upper elevation sites above the talus slope (Redden, personal communication).

LICHEN SPECIES DISTRIBUTION PATTERNS

A total of 65 lichen species in 38 genera were identified from the study transect (Table 1). Dominant species included (in order of decreasing ISI—Important Species Indices) *Lecidea atrobrunnea* (ISI = 1.09), *Aspicilia calcarea* (0.90), *Umbilicaria virginis* (0.89), *Sporastatia testudinea* (0.88), *Lecanora thomsonii* (0.86), *Rhizocarpon geographicum* (0.39), *Lecidea auriculata* (0.35), *Xanthoria elegans* (0.26), and *Allocetraria madriporiformis* (0.26). There was a clear and marked increase in the abundance of lichens at the rockier sites, which were also higher in elevation and ungrazed (Fig. 6). Most of the lichens were crustose in growth form (37 species), with several foliose lichens (17 species). Fruticose (6 species) and squamulose (5 species) growth forms were much less

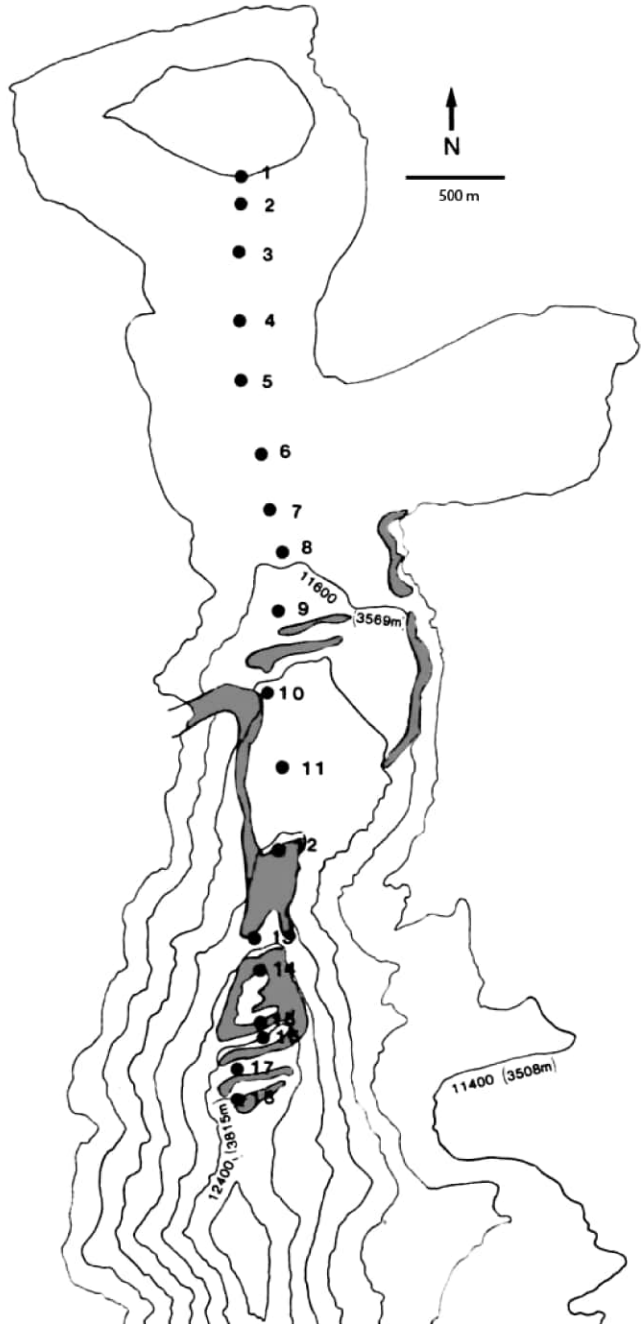

FIGURE 3. Transect map showing snow melt patterns as of the end of June 1983. Shaded areas represent snow-free locations. Contour interval is 200 m.

represented. Crustose lichens also had higher percent cover across all sites than all other growth forms combined, and showed a particularly marked increase in the upper, rocky sites (mean percent cover 14%). Foliose-umbilicate lichen species were restricted to the upper area.

Both the CCA analysis and cluster dendrogram of the study sites revealed two main clusters (lower sites, and higher sites plus site 8) and did not support separation of the lichen community into three distinct sub-communities as we saw with the vascular plants, but rather into two different communities separated by the talus slope between sites 9 and 10. The two analyses showed nearly identical topologies, with the same similar sites clustering together in both analyses. We show the CCA biplot (Fig. 7) because it shows the relationship of soil parameters. The relationship of soil parameters is highly similar to that in the soil chemistry PCA (Fig. 5); however, the sites separate more cleanly because of the addition of lichen species data. In the remainder of the analysis we will discuss the distinct communities in the context of the two areas (rocky upper sites, lower meadow sites). Total lichen cover was significantly ($t = 5.52$, $p < 0.0001$) higher in the upper, rocky sites (mean = 19.6%) than in the lower, meadow sites (mean = 6.0%).

The lichen cluster dendrogram, based on niche overlap measurements, revealed several lichen species associations (Fig. 8). We assigned these to categories based on characterizations of the sites given above. In the rocky upper sites there was a sharp contrast between those species that were terricolous and saxicolous. Another group was primarily associated with the meadow sites. Broad-ranging species occurred across the entire transect, while rare species were too rare to determine clear patterns of distribution. A few species appeared to be associated with late snowmelt (e.g., site 9). Many species were markedly more abundant in the rocky upper sites, including *Allocetraria madreporiformis*, *Aspicilia calcarea*, *Dimelaena oreina*, *Lecanora thomsonii*, *Lecidea atrobrunnea*, *Lecidea tessellata*, *Rhizocarpon geographicum*, *Sporastatia testudinea*, *Umbilicaria virginis*, *Xanthoparmelia cumberlandia*, and *Xanthoria elegans*. Not surprisingly, all but one of these taxa (*A. madreporiformis*) was saxicolous, and most were crustose (Table 1).

The grazed sites (1–5) had distinctly different groups of lichen species. Most of the terricolous lichens in this area were crustose or squamulose, with only one fruticose species (*Aspicilia hispida*) and three foliose species (*Cladonia* sp. 3, *Xanthoparmelia chlorochroa*, and *Peltigera rufescens*). The ungrazed/lightly grazed sites (with the exception of the late snowmelt site 9 and talus slope sites 14 and 16) had two fruticose, terricolous species: *Allocetraria madreporiformis* and *Cetraria aculeata*; and three foliose, terricolous species: *Cetraria ericitorum*, *Physconia muscigena*, and *Vulpicida tilesii*. Grazing activity was directly related to the lower elevation occurrence of the two vagrant species (*Aspicilia hispida* and *Xanthoparmelia chlorochora*), both of which were absent from the upper sites.

Epiphytic lichens were also less common at the grazed sites, but this is apparently related to the availability of suitable plant substrates. In particular, *Selaginella densa*, a common vascular plant substrate for epiphytic lichens in alpine tundra habitats, was consistently present in ungrazed or lightly grazed plots (Fig. 4), but absent in the lower sites. Only two epiphytic/humicolous lichens (*Caloplaca tiroliensis*, *Candelariella aurella*) were collected from the lower sites, whereas a total of nine epiphytic/humicolous lichens were collected from the upper sites.

Discussion

Data from this project demonstrated that lichen community distribution and structure are directly influenced by several factors, including domestic sheep grazing, degree of rockiness, nature of the vascular plant community, and snowmelt patterns. Grazing activity had a double impact on lichen community structure at the lower transect sites by "adding" new species while eliminating species sensitive to trampling. In contrast, soil data did not contribute to our understanding of lichen community distribution or structure.

The vagrant (unattached) lichen species *Aspicilia hispida* and *Xanthoparmelia chlorochroa*, found only at the heavily grazed and sheep bedding sites (1–5), are common components of short grass steppe and grazed shrub lands between 1500 and 2300 m in the

TABLE 1

Substrates on which lichens were found growing in this study included soil (S), pebbles and small rocks (P), large rocks (LR), and plants (E). Growth forms included crustose (Cr), fruticose (Fr), foliose (Fo), foliose with umbilicate attachment (Fo-um), and squamulose (Sq). The Important Species Indices (ISI) are calculated as frequency times mean percent cover. Mean percent cover for combined lower sites (1–9) and combined upper sites (10–18) is reported; a dash indicates that a species was not detected along that portion of the transect.

Species	Substrate	Growth form	ISI	Sites 1–9	Sites 10–18
Acarospora smaragdula	P, LR	Cr	0.03	0.18	<0.01
Acarospora sp.	P, LR	Cr	0.01	—	0.04
Allocetraria madreporiformis	S	Fr	0.26	0.19	0.87
Arthronia glebosa	S	Cr	0.01	0.05	—
Aspicilia calcarea	LR, P	Cr	0.90	0.47	1.42
Aspicilia hispida	S	Fr	0.02	0.12	—
Aspicilia sp.	LR, P	Cr	0.19	0.18	0.39
Brodoa oroarctica	LR	Fo	<0.01	—	<0.01
Caloplaca arenaria	P	Cr	0.02	0.09	—
Caloplaca epithallina	E	Cr	<0.01	—	0.04
Caloplaca jungermanniae	E	Cr	<0.01	<0.01	—
Caloplaca tiroliensis	E	Cr	0.02	<0.01	0.07
Calvitimela armeniaca	LR	Cr	0.02	—	0.12
Candelariella aurella	E	Cr	0.02	0.01	0.07
Candelariella rosulans	LR, P	Cr	0.15	0.17	0.17
Catapyrenium cinereum	S	Sq	0.09	0.22	0.06
Cetraria aculeata	S	Fr	0.05	0.09	0.22
Cetraria ericetorum	S	Fr	<0.01	<0.01	—
Cladonia sp. 1	S	Fo	0.11	0.41	0.01
Cladonia sp. 2	S, E	Fo	0.05	0.18	0.21
Cladonia sp. 3	S	Fo	0.11	0.81	—
Dimelaena oreina	LR	Cr	0.19	—	0.97
Evernia divaricata	S	Fr	0.01	—	0.09
Fulgensia bracteata	S	Cr	0.03	0.03	0.06
Lecanora argopholis	LR	Cr	0.01	0.12	—
Lecanora bicincta	LR	Cr	0.01	—	0.12
Lecanora epibryon	E	Cr	<0.01	0.01	<0.01
Lecanora hagenii	E	Cr	<0.01	—	<0.01
Lecanora marginata	LR	Cr	0.01	—	0.06
Lecanora polytropa	LR, P	Cr	0.08	0.20	0.05
Lecanora rupicola	LR	Cr	0.01	—	0.04
Lecanora thomsonii	LR	Cr	0.86	<0.01	2.89
Lecidea atrobrunnea	LR, P	Cr	1.09	0.78	2.44
Lecidea auriculata	LR, P	Cr	0.35	0.24	0.46
Lecidea tessellata	LR, P	Cr	0.18	0.07	0.49
Lecidea sp. 1	S	Cr	<0.01	<0.01	<0.01
Lecidea sp. 2	E	Cr	0.01	0.01	0.11
Lepraria vouauxii	S	Cr	<0.01	0.07	—
Megaspora verrucosa	E	Cr	<0.01	—	0.01
Melanelia tominii	LR	Fo	<0.01	—	0.02
Mycobilimbia berengeriana	S	Cr	<0.01	<0.01	—
Ochrolechia upsaliensis	E	Cr	0.02	0.10	0.06
Peltigera rufescens	S	Fo	0.02	0.13	<0.01
Phaeorrhiza nimbosa	S	Sq	<0.01	—	<0.01
Physcia sp.	LR	Fo	<0.01	<0.01	<0.01
Physconia muscigena	S	Fo	0.07	0.16	0.13
Placidium squamulosum	S	Sq	<0.01	<0.01	—
Protoparmelia badia	LR	Cr	<0.01	0.04	<0.01
Psora decipiens	S	Sq	<0.01	0.02	0.01
Psora luridella	S	Sq	<0.01	0.05	—
Pseudephebe minuscula	LR, P	Fr	0.01	—	0.13
Rhizocarpon disporum	LR, P	Cr	0.12	0.27	0.09
Rhizocarpon geographicum	LR, P	Cr	0.39	0.16	1.02
Rhizoplaca chrysoleuca	LR	Fo-um	<0.01	—	0.03
Rhizoplaca melanophthalma	LR, P	Fo-um	0.08	0.10	0.09
Solorina bispora	S	Fo	<0.01	—	<0.01
Sporastatia polyspora	P	Cr	<0.01	—	<0.01
Sporastatia testudinea	LR, P	Cr	0.88	<0.01	3.17
Staurothele drumondii	LR, P	Cr	0.02	0.07	0.02
Umbilicaria decussata	LR	Fo-um	<0.01	—	0.05

(continued)

TABLE 1

(continued)

Species	Substrate	Growth form	ISI	Sites 1–9	Sites 10–18
Umbilicaria virginis	LR	Fo-um	0.89	<0.01	2.90
Vulpicida tilesii	S	Fo	<0.01	0.02	0.01
Xanthoparmelia chlorochroa	S	Fo	<0.01	0.02	—
Xanthoparmelia cumberlandia	S, LR, P	Fo	0.15	0.03	0.57
Xanthoria elegans	LR, P	Fo	0.26	0.02	0.53
Mean percent lichen cover				6.01	19.57

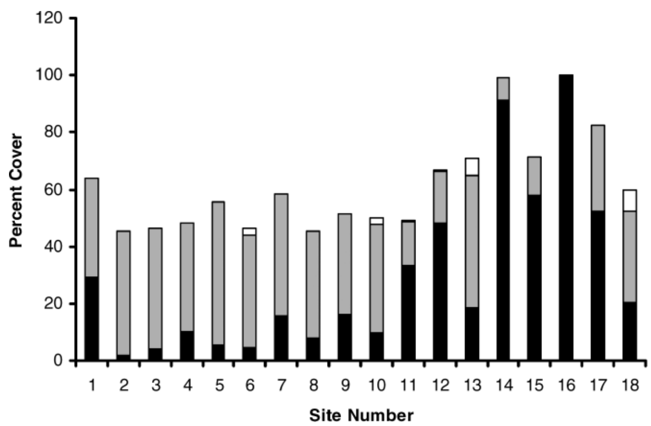

FIGURE 4. **Rock cover (black), angiosperm cover (gray), and *Selaginella densa* cover (white) for all 18 sites. Remaining cover was in the categories of bare ground, plant litter, lichens, and mosses. Percent sum cover could exceed 100% in the instances where rocks were overtopped by lichens or angiosperms.**

intermountain Western United States (Looman, 1964). Vagrant lichens typically associated with these habitats have been shown to be generally tolerant of grazing impact (MacCracken et al., 1983; Warren and Eldridge, 2001). Examination of the winter grazing sites (western Wyoming) for the Uinta sheep herds showed that both *Xanthoparmelia chlorochroa* and *Aspicilia hispida* were abundant in those locations. We hypothesize that during the grazing history of the Uinta sites unspecialized, small fragments of these two taxa have been transported from the winter range up to the grazed alpine tundra sites on the wool of sheep. In contrast, the more common tundra soil lichens, *Allocetraria madreporiformis*, *Cetraria aculeata*, *Cetraria ericetorum*, *Physconia muscigena*, and *Vulpicida tilesii*, were restricted to the ungrazed and lightly grazed portions of the transect because of their greater sensitivity to grazing (Olofsson, 2006). It has been reported that lichen growth form correlates with susceptibility to grazing impact with fruticose and foliose species generally more susceptible to grazing while crustose and squamulose species, with a much lower vertical profile, are not as impacted (Warren and Eldridge, 2001). The obvious exception to this pattern is the two "introduced"

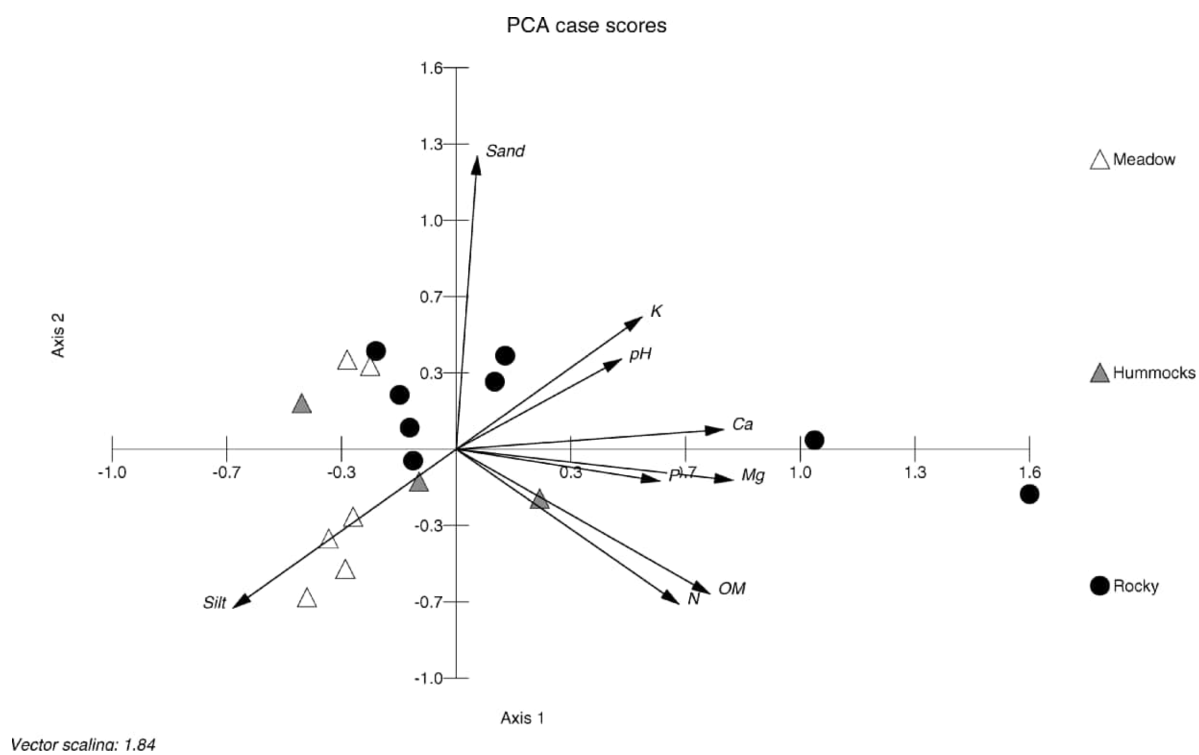

FIGURE 5. **Euclidean biplot of centered and standardized Principal Components Analysis (PCA) of soil data. Eigenvalues were 53.2 and 20.0 for the first and second axes, respectively, and thus this figure explains 73.2% of the variability in the data. Meadow sites fall into two groups, the upper group contains sites 1 and 2, the lower group contains sites 3–6. The two outliers in the rocky sites (high positive values on PCA axis 1) are sites 17 and 15 (left to right). Note that the three areas are not separated into discrete groups on either axis.**

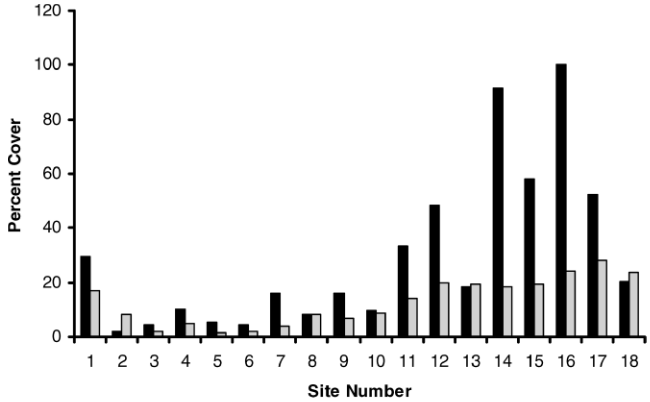

FIGURE 6. Relationship of rock cover (black bars) to lichen cover (gray bars) along the transect.

vagrants—*Xanthoparmelia chlorochroa* (foliose) and *Aspicilia hispida* (fruticose). However, unlike most other fruticose and foliose species, these two taxa are uniquely adapted to domestic grazing activity with sheep effectively fragmenting and dispersing both species (MacCracken et al., 1983). Interestingly, these two species reproduce almost exclusively by unspecialized thallus fragments with sexual reproduction rare to essentially nonexistent. Differences in lichen species and growth form patterns between the lower and upper sites further document the effects of domestic sheep on lichen communities. The potential sensitivity of the vascular plant *Selaginella densa* to grazing impact may also help to explain differences in lichen community structure between the upper and lower transect sites.

Observed differences in the number of epiphytic lichens between the lower and upper sites (2 and 9 species, respectively) appear to be directly related to the distribution of the low-growing vascular cryptogam *Selaginella densa*. This plant, which commonly supports a diverse group of epiphytic lichens, was absent from the lower elevation sites (1–5) but sporadically abundant at sites 6–19 (Fig. 4), thus accounting for the significant difference in the diversity of epiphytic lichens between the lower and upper sites. In alpine habitats, *Selaginella densa* typically occurs with other low-growing vascular plants on rocky ledges with thin soils (Welsh et al., 2003)—conditions uncharacteristic of the lower elevation sites.

Increasing lichen cover was also related to increasing rockiness with decreasing vascular plant cover and increasing elevation along the transect (Fig. 4). This pattern of increasing rockiness, especially larger rocks, was also associated with increasing lichen species diversity. Rocks are common lichen substrates, often supporting a diversity of species and growth forms. Specifically, higher percent cover and diversity of crustose and foliose-umbilicate species at the upper elevation sites were correlated with the increasing availability of rock surface area. The lichen cluster dendrogram, based on niche overlap measurements, further documented this pattern (Fig. 8), with species from the upper rocky sites clustering together (Group I) and the lower elevation meadow species grouping separately (Group II).

The lichen cluster dendrogram also showed a distinct cluster of late snowmelt lichen species (Group IV). Specifically, three species, *Psora decipiens*, *Rhizocarpon disporum*, and *Cladonia* sp., were consistently associated with late snow sites—a species pattern observed by the authors at other late-snow areas in the Western United States. Group III included a group of ubiquitous, broad-ranging species that occurred across the entire study transect. In contrast, Group V contained a group of rare species with very narrow distribution.

The similarity of the lichen community at site 1 (south-facing slope of Bald Mountain) to the upper elevation communities was generally related to the number of larger rocks at that site, which in turn supported a more diverse group of lichen species. Furthermore, higher lichen cover (16.7%) and similar growth-form distributions (more crustose species) also reflected the rockiness at that site in general and the abundance of larger rocks in particular (Fig. 6). However, the relatively smaller number of epiphytic lichens, and a soil community dominated by crustose and squamulose species suggested grazing impact and thus a closer fit with the rest of the lower elevation, grazed sites.

This research contributes to our understanding of how both biotic and abiotic factors influence lichen community distribution

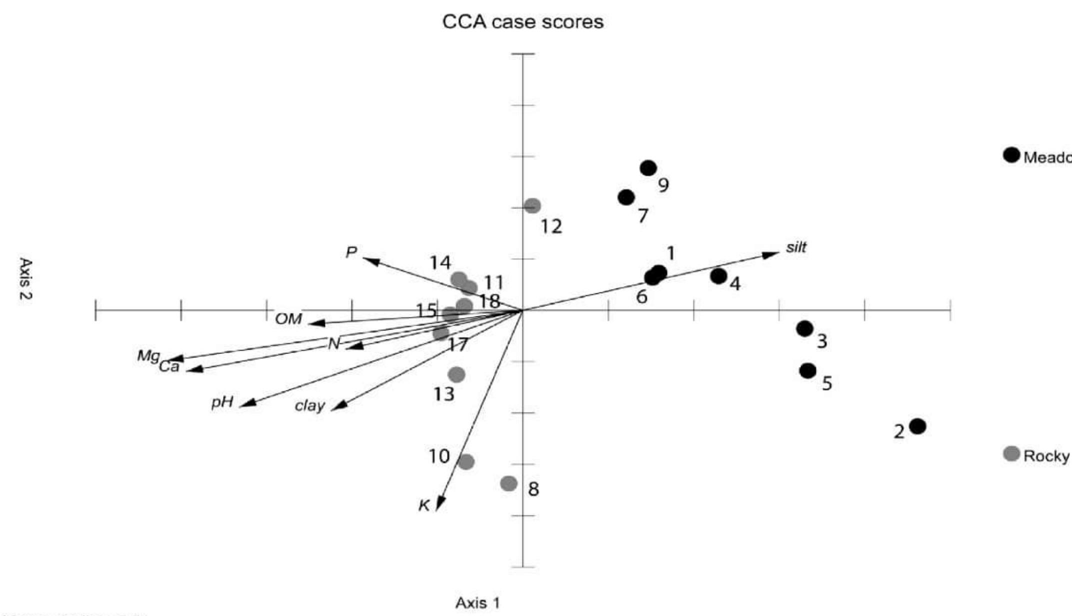

FIGURE 7. Canonical Correspondence Analysis (CCA) of lichen species data. The percentage of variation in the data explained by axis 1 and axis 2 was 26.4% and 12.3%, respectively.

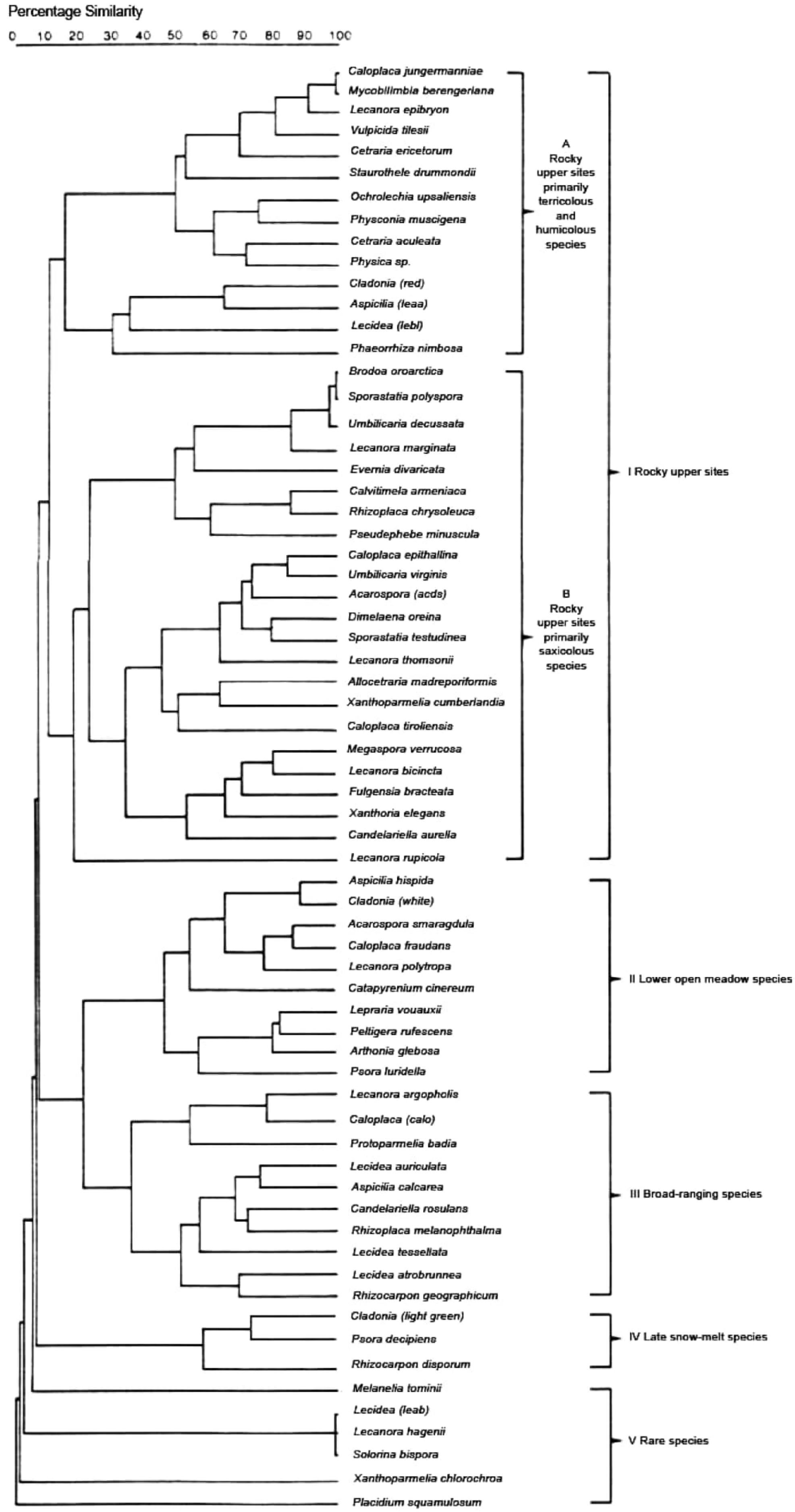

FIGURE 8. Cluster dendrogram of lichen species based on niche overlap values.

and structure in alpine tundra habitats. This information will prove particularly useful as we seek to restore and reclaim fragile, alpine tundra sites that have been historically impacted by human-related activity, such as grazing. Furthermore, these data will provide critical insights into the potential role of alpine tundra lichens as sensitive, early indicators of grazing impact on tundra ecosystems.

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EXHIBIT 4

2021-07-29

Monitoring Domestic Sheep Energy Requirements and Habitat Selection on Summer Mountain Range Using Low-Cost GPS Collar Technology

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Brigham Young University

Monitoring Domestic Sheep Energy Requirements and Habitat Selection on Summer Mountain Range Using Low-Cost GPS Collar Technology

Elizabeth M. Baum

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

Todd F. Robinson Chair
Steven L. Petersen
Randy T. Larsen

Department of Plant and Wildlife Sciences

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ABSTRACT

Monitoring Domestic Sheep Energy Requirements and Habitat Selection on Summer Mountain Range Using Low-Cost GPS Collar Technology

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Master of Science

With the advent of global position system (GPS) collar technology, we have developed a much greater understanding of the temporal and spatial distribution of livestock and their associated grazing patterns. While significant research using GPS collars has been reported for cattle, little research is available describing collar use in understanding the behavior of domestic sheep. The purpose of our research was to evaluate the energy requirements of sheep with the use of GPS collars. To accomplish this, we adapted a low-cost i-gotU GPS tracking device that is typically designed for cattle and modified it to fit sheep. Each collar was programmed to record sheep movements within four grazing habitat types during different times of the year. Habitat typesincluded spring pasture (SP), spring low hill habitat (SH), summer mountain habitat (MH) and winter desert habitat (DH). We divided our research into two studies: 1) to track and compare energy expenditure of domestic sheep between four habitats using collars for recording sheep movements, and 2) to model summer mountain selection by sheep using the collar derived coordinate positions and environemtal variabls in an RSF model process. We hypothesized that there would more energy expended while out on desert habitat in comparison to other range habitats and sheep would select for sites on summer mountain habitat that were close to water, gentle in terrain, and higher in elevation. We used sheep energy equations to determine the energy requirement. Collar derived coordinates were used to measure the horizontal distance traveled on flat terrain or verticle distances both upslope and downhil across variable terrain. Our results found that total distance traveled was not different between SP, SH and MH at 6.7, 7.1 and 6.9 km/d, respectively, however, total movement was different ($P<0.05$) on DH at 10.5 km/d. Sheep movement was greater ($P<0.05$) on slopes (altitude change in 3m between waypoints) versus flat terrain (movement between waypoints >20m). For example, sheep spent 65% of movement on slope and 39% on flat movement for SH, 86% of movement was spent on slope and 16% on flat terrain for MH, and 89% of movement was spent on slope and 11% movement was on flat for DH. Total energy required between the four habitats was different ($P<0.05$) at 5.9, 8.6, 7.1 and 13.9 Mcal ME/d for SP, SH, MH and DH respectively. While on summer MH sheep avoided slopes and rugged terrain, but selected for sites close to water, northern facing aspects and areas higher in elevation. We found that sheep expend the most energy on DH and sheep on MH will select for gentle terrain, areas close to water, northern facing slopes, higher elevation and avoid slopes. With this insight, sheep managers can better meet energy requirements needs and understand habitat utilization of their flocks.

Keywords: Sheep, grazing habitat, habitat selection, GPS, energy

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And finally, thanks to my wonderful husband Shad for his love and support throughout this project. As well as thanks to my beloved mother and father for enstilling in me at an early age a love for nature, exploring, and learning.

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CHAPTER 1

Monitoring the Energy Requirements of Sheep on Four Different Rangeland Habitats Using Low-Cost GPS Tracking Collars

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ABSTRACT

The movement and energy use of livestock, in particular sheep, can be used to better understand forage requirements, maintain healthy sheep herds, and promote ecological sustainability. GPS collars have been developed to monitor livestock movement, grazing patterns, and animal behavior across heterogeneous landscapes. Our research objectives are to effectively characterize the temporal and spatial movement, energy use, and distribution of sheep in relation to habitat type. To achieve this objective, we used a low-cost GPS tracking collar to record sheep movements and energy use while rotating between four different range habitat types. As sheep were moved between four different grazing habitats (spring pasture, SP; spring low hill habitat, SH; summer mountain habitat, MH and winter desert habitat, DH), environmental factors, distance traveled, vegetation intake, and stage of reproduction were used in energy equations to determine energy expenditure of sheep while out on each different range habitats. GPS derived coordinate locations were used to determine the distance traveled by sheep on flat surfaces or up and down hilly terrain. Total distance traveled was not different between SP, SH and MH at 6.7, 7.1 and 6.9 km/d respectively, but they were different ($P<0.05$) from DH at 10.5 km/d. Sheep movement was greater on sloped terrain (9 km/d) than on flat surfaces (1.22 km/d; $P<0.05$). Sheep spent 65% of movement on slope and 39% on flat movement for SH, 86% of movement was spent on slope and 16% on flat terrain for MH, and 89% of movement was

spent on slope and 11% movement was on flat for DH. Total energy required between the four habitats was different ($P<0.05$) at 5.9, 8.6, 7.1 and 13.9 Mcal ME/d for SP, SH, MH and DH, respectively. Three iterations of the i-gotU GPS collars were created in efforts to 1) improve issues with the jostling of the GPS unit components within the collar enclosure because of excess animal wear, 2) minimize moisture condensation and dust accumulation, and 3) improve battery life. We found that sheep expended most energy on DH, which was likely due to time spent searching for available forage. We found that the most effective GPS collar configuration had a larger memory, the i-gotU 600, which decreased joslting and improved ability to intake more waypoints and improved sealing, which kept at bay the moisture and dust. Battery life did continue to be an issue and still needs further investigation. This style of collar effectively recorded sheep movements and energy measuremnts by creating a cost-effective collar for sheep producers to utilize in order to better understand the temporal and spatial movements of their flocks. This information can be used in future research and management by informing managers while sheep are out on different range habitats and the amount of time spent on activity (i.e. movement on slope, movement on flat) has the most profound affect on energy expended. As well as grazing sheep out on DH has a tremendous drain on the energy requirements of sheep and may require additional supplements in the last trimester of gestation to assure healthy ewes coming off desert in preparation for lambing.

INTRODUCTION

Domestic sheep (*Ovis aries*) production is considered the oldest organized industry in the world (Aaron and Ely 2014; Chessa et al. 2009). Utilized for their meat, wool, and milk, sheep have long been favored for their multifaceted uses (Aaron and Ely 2014; Chessa et al. 2009).

Research has been conducted on maximizing the production of sheep through an improved understanding of their energy requirements (Cannas et al. 2004; Chessa et al. 2009). These requirements have been found to be significantly influenced by a number of factors including topography, weather, feed quality and reproductive stage (Cannas et al. 2004). These factors can now be taken into account when considering energy requirements with the aid of GPS tracking devices and maintenance equations (Bailey et al. 2017).

Recently, the advent and improvement of GPS tracking technology has been used to track both temporal and spatial grazing distribution and activity patterns of livestock (Anderson et al. 2012; Augustine and Derner 2013a; Bailey et al. 2017; Knight et al. 2018). Anderson et al. (2012) monitored the spatial distribution of free-ranging collared cattle to provide a greater understanding of how to better manage herds. Bailey et al. (2017) used GPS collars to evaluate cattle behavior, distribution patterns, and energy use to validate the possibilities of these findings being used in genetic selection.

Of the 5 million sheep being raised in the United states, 300,000 of those are in the state of Utah, ranking it 5th nationally (Utah Wool Growers Association 2017). Located in the Intermountain West of the United States, Utah's land is 80% rangeland that is too dry, rocky and mountainous for raising farm crops. Even in areas where cultivation is unsuitable, sheep can utilize plant biomass and convert that energy into profitable commodities (i.e. wool, milk, meat; Aaron and Ely 2014). These conditions favor a traditional system of rotating herds through different range habitats throughout the year due to the variation in climate, vegetation availability and terrain (Holechek 1983). While research has been published describing the energy requirements of sheep, the literature lacks information on the range of ewe energy expenditure as they transition between different production stages and range (habitat) types (i.e. gestation and lactation; ecological sites).

There are three major contributors to energy expenditure in livestock: maintenance, environment, and stage of production (Cannas et al. 2004). A portion of maintenance is defined as activity spent on resting, locomotion (flat or sloped terrain) and grazing (Lachica et al. 1997). With the recent affordability of GPS tracking devices and the advances in tracking and distribution, GPS trackers are becoming more accessible to the public (Allan et al. 2013; Augustine and Derner 2013a; Karl and Sprinkle 2019). Therefore, maintenance can be closely monitored with the aid of GPS collars as it tracks the movements of livestock across a heterogenous landscape.

The second major contributor to energy expenditure is climatic conditions (i.e. wind, snow, rain) that negatively affect the homeostasis of sheep. These conditions play a major role in how metabolizable energy is used (NRC 2007). Even though the sheep are equipped with wool, wind and rain can greatly reduce the thermal regulation that wool provides for the animal (Cannas et al. 2004; Cottle and Pacheco 2017). The combined effects of cold temperatures, wind, and precipitation can increase the maintenance requirements up to three times (Cannas et al. 2004). Thus, thermal stress caused by extreme temperatures, wind and rain, negatively affects the profitability of sheep production due to increased maintenance requirements resulting in a reduction in total body weight gain and a decrease in the efficiency of feed utilization (Pluske et al. 2010).

The various reproductive stages a ewe undergoes throughout the year greatly impacts energy expenditure (ASI 1996). Early gestation takes place after breeding in the fall. As winter sets in, they enter mid to late gestation. Ranchers will then remove sheep from the desert range to begin the lambing season. After ewes have lambed, they are placed in paddocks to allow for lamb and ewe to bond before being released out on range habitat to prevent ewes from losing lambs amongst the entire herd of ewes and lambs. During this time, ewes are beginning the early stages of lactation. After bonding time is allowed, ewes are placed out on spring lambing pastures. From the lambing pasture, ewes and lambs are moved initially to the spring low hills range for short-term grazing and then to the summer range where they remain throughout the summer. From gestation to lactation, each stage requires different amounts of energy in order to maintain homeostasis (ASI 1996; Cannas et al. 2004). For example, gestation requires greater amounts of energy towards the end of the gestational period, when the majority of foetal growth occurs in the final 60 days (Paganoni and Roberts 2018). As well as the energy requirements of lactating ewes is much higher than those of gestating ewes (Cannas et al. 2004). It becomes evident that in order to determine energy requirements of sheep, understanding the different stages of life and different habitats energy demands a ewe experiences throughout a year cycle, is imperative.

The purpose of our study was to characterize the movement of sheep and determine their energy requirements as they transition between different life stages and range habitats. To accomplish this, we equipped sheep with a GPS tracking device to monitor their movements and detect energy expenditure. We predicted their energy requirements would be different between the range habitats.

MATERIALS AND METHODS

GPS collars

The GPS collars were developed by modifying and adapting cattle collars described by Knight et al. (2018) to fit sheep. The collars were constructed using an enclosure (#BT2310 Polycase, Avon, OH, USA) attached to a 1" x 27" nylon dog collar using 73mm wide black Gorilla tape (Gorilla Glue, Inc, Cincinnati, OH, USA). An i-gotU GT-600 GPS unit (Mobile Action Technologies, New Taipei City, Taiwan) was modified by removing the back of the unit, leaving the electronic board in its case, and removing the internal battery at the battery terminals. The leads from a JST PH 2-pin 200mm male header cable (#3814 Adafruit, New York, NY, USA) were fed through a 0.5mm hole in the end of the enclosure and soldered to the leads from the GPS unit. The back of the GPS unit was then reattached. A 6600 mAh 3.7V lithium-ion battery pack (#353 Adafruit, New York, NY, USA) that has a JST PH 200mm 2-pin female header attaches to the GPS unit leads (see Fig. 1.3). The batteries were charged using a Sabrent 60 W 10 port charger (#HB-BU10, Sabrent, Los Angeles, CA, USA). The battery pack was also attached to the collar using Gorilla tape. With the GPS unit and battery attached, both were wrapped twice using 44mm duct tape (Shuretape Technologies, Avon, OH, USA; Fig. 1.2).

The GPS unit was programmed to collect waypoints every 5 minutes. At the end of the collection period the collars were removed from the ewes and the GPS unit removed from the enclosure. The data was downloaded using @Trip software (Mobile Action Technologies, New Taipei City, Taiwan) then exported as a csv file. The data file was inspected and waypoints that were out of the grazing perimeter were removed along with movement values greater than 72 m/minute (Agostinho et al. 2012). As an example of waypoint numbers, most data files had approximately 27,327 GPS waypoints recorded from each collar.

Sheep flock

A commercial sheep flock consisting of Rambouillet crossbreed white-face ewes (600 ewes; 4.2±0.9 years of age) was used as the basis for this study. Collars were attached to the ewes prior to the flock being moved to individual grazing habitat and then removed when the sampling period was complete. Sheep flocks were moved sequentially through the four different grazing habitats which included spring pasture (SP), spring low hills (SH), summer mountain habitat (MH), and winter desert habitat (DH).

Spring pasture

Two weeks post-lambing the ewes and lambs were moved from the lambing pens through three pastures (SP) from mid- April to the end of May 2020 near Fountain Green, Utah, USA. The first pasture (39.67°, -111.643° N, 39.615°, -111.641° E), consisted of 15 acres at an elevation of 1,779 m (Fig. 1.3). The second pasture (39.666°, -111.674° N, 39.662°, -111.660° E) consisted of 61 acres at an elevation of 1,920 m (Fig. 1.3). The third pasture (39.666°, -111.661° N, 39.651°, -111.646°) was 80 acres at 1,880 m elevation (Fig. 1.3). The vegetation was similar between pastures and consisted predominantly of alfalfa (*Medicago sativa*), Kentucky bluegrass (*Poa pratensis*), western wheatgrass (*Pascopyrum smithii*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). The climate was characterized by cool summer temperatures (20°C mean air temperature) and cold winters (-4°C mean air temperature) with an annual precipitation of 38 cm. Average annual temperature ranged from 15 to 20°C during the summer and -5 to -3°C during the Winter (PRISM 2004).

Spring low hills

From the early spring pasture, the sheep were moved to a 3,000-acre private allotment on spring low hills habitat (SH) for June 2020 (39.705°, -111.590° N, 39.686°, -111.559° E; Fig.1.4). Elevation ranged from 2,150 to 2,506 m with hilly terrain. Ungulates on the property that could potentially compete with sheep included elk *(Cervus canadensis)* and mule deer *(Odocoileus hemionus)*. Vegetation included bluebunch wheatgrass, Indian ricegrass (*Achnatherum hymenoides*), antelope bitterbrush (*Purshia tridentata*), Wyoming big sagebrush (*Atremisia tridentata ssp wyomingensis*), Utah juniper (*Juniperus osteosperma),* and two-needle pinyon (*Pinus edulis).* The climate was characterized by cool summer temperature (15°C mean air temperature) and cold winter temperature (-4°C mean air temperature) with annual precipitation of 53 cm. Average annual temperature ranged from 13 to 18°C during the summer and -4 to -2°C during the winter (PRISM 2004).

Summer mountain habitat

From July to September 2020 the sheep were moved to mountain habitat (MH) near Scofield Reservoir (39.91°, -111.16° N, 39.88°, -111.12° E; Utah County, UT, USA) on 2,500 acres (Fig. 1.5). Elevation ranged from 2,191 to 2,550m with open meadows climbing to mountain ridges. Ungulates on the property that could potentially compete with sheep included elk and mule deer. Vegetation included quaking aspen *(Populus tremuloides),* subalpine fir *(Abies lasiocarpa),* gambel oak *(Quercus gambelii),* Wyoming big sagebrush, Utah serviceberry *(Amelanchier utahensis*), bluebunch wheatgrass*,* timothy grass *(Phleum pratense)* and broom snakeweed *(Gutierrezia sarothrae)* found in the open meadows. The climate was characterized by cool summer temperatures (15°C mean air temperature) and cold winters (-5°C mean air temperature) with annual precipitation of 50 cm. Average annual temperature ranged from 43 to 70°C during the summer and -11 to 1°C during the winter (PRISM 2004).

Winter desert habitat

From late December to late February 2020-2021, the sheep were grazing on BLM winter desert habitat (DH) located in the western desert of Utah (39.62°, -113.41° N, 39.45°, -113.33°

E) covering approximately 35,000 acres (Fig. 1.5). Elevation ranged from 1,400 to 1,700 m with open hilly terrain. Vegetation included, Indian ricegrass, squirreltail *(Elymus elymoides),* bud sagebrush *(Picrothamnus desertorum)*, shadscale saltbush *(Atriplex confertifolia)*, broom snakeweed, winterfat *(Krascheninnikovia lanata),* black sagebrush *(Artemisia nova),* and Utah juniper dotting the landscape. The climate was characterized by warm summers (24°C mean air temperature) and cold winters (-1°C mean air temperature). Average annual temperature ranged from 19 to 24°C during the summer and -1 to 1°C during the winter with annual precipitation of 22 cm (PRISM 2004).

Energy determination

The energy requirement of the sheep was calculated based on the environmental factors, habitat type, and lifestage. A weather station (Davis 6152C) was placed on each of the habitats to provide temperature, wind, and rain environmental measurements in order to calculate cold stress factors. Energy requirement was determined using equations from NRC (2007), Cannas et al. (2004) and Tedeschi and Fox (2020a and 2020b).

Equation 1

$$ME_m = ([SBW^{0.75} * a1 * S * a2 * \exp(-0.03 * AGE)] + (0.09 * MEI * k_m) + ACT + NE_{msc} + UREA) / k_m$$

Where,

SBW = shrunk body weight (96% of body weight (FBW; kg))

a1 = 0.062 Mcal * NE_m / $kg^{0.75}$

S = multiplier for gender; 1 for ewes and wethers, 1.15 for rams

a2 = effects of previous months temperature; 1 + 0.09 * (20 – (previous month temperature))

AGE = years 1 to 6

MEI = ME intake; Mcal/d

k_m = efficiency constant; 0.644

Equation 2

ACT = activity; (0.00062 * FBW * flat distance (km) + 0.00669 * FBW * slope distance (km)

Equation 3

NE_{msc} = cold stress, SA * (LCT – Current Temp) * k_m / IN

SA = 0.09 * $SBW^{0.75}$

LCT = 39 + E * EI – IN * HE / SA

HE = MEI – (RE + NEpr + NElr)

IN = TI (1 – 0.3 * (1 – exp(-1.5 * rf / WD)) * EI

EI = [(1.759 - 0.0707 * wind (km/hr) + 0.6095 * wool (cm)) * MUD * hide] * 0.239.

Urea = cost of excreting N as urea; [(g ruminal N balance – g recycled N + g excess N from MP) * 0.0073] * k_m

Equation 4

NE_{preg} = 36.9644 * exp[-11.465 * exp(-0.00643 * t) – 0.00643 – t] * (LBW/4)

Where,

LBW = birth weight of lambs combined

$ME_{preg} = NE_{preg} / 0.13$

Equation 5

$Ne_l = [(251.73 + 89.64 * MF + 37.85 * (MP / 0.95) * 0.001 * MY] / k_m$

Where,

MF = milk fat %

MP = milk protein %

MY = milk yield kg/d

Vegetation sampling

Vegetation samples were taken at every site to determine nutrient content. 100m transects were randomly placed throughout the habitat sites. A 1-square meter hoop was placed every 10 meters along the transect, alternating sides, and all vegetation within the hoop was clipped and placed into paper bags, stored in a freezer until all samples were collected. The number of transects per site was determined by area of habitat and vegetation type present. All vegetation samples were taken out of freezer and separated by site and type (i.e., forb, grass, shrub) and sent to DairyOne forage laboratory for a wet chemistry nutrient analysis for dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and metabolizable energy (ME) content analysis (DairyOne Forage Laboratory, Ithaca, NY, USA).

Data analysis

Latitude and longitude data were converted to UTM coordinates. UTM coordinates were then used to calculate distance traveled (m) between waypoints. GPS altitude differences were used to determine slope movement. Slope movement was counted as any increase or decrease of 3 m or more. The distance traveled on flat surfaces compared to slopd terrain was used to calculate activity (ACT; see equation 2). Energy requirement was determined for each ewe using the information collected. For each habitat, total energy required was calculated as the sum of NE_m, NE_{preg} and NE_l. Each habitat energy requirement was the addition of these three NE amounts depending on the life stage of the ewes while on each habitat; SP NEm + Nel, SH NEm + Nel, MH NEm + Nel and DH NEm + NEpreg.

Statistical analysis was conducted with the proc Mixed module in SAS (2002). Fixed main effects included habitat and day, while animal was random to account for repeated measures. Least square means for habitat were determined to be significant at $P<0.05$. Habitat main effect comparisons were analyzed and expressed as least square means.

RESULTS

Collar Data Collection

Collars placed on ewes on the SP and SH habitats resulted in two of the 6 collars not collecting data, one did not record any data and the other recorded 6 days. The units where data was downloaded ranged from 30 to 49 days of GPS waypoints. Average time difference between the waypoints was 5.0±2.7 minutes. Five of the six units deployed on the SH provided data. One unit did not collect waypoints. Twenty-seven to sixty-seven days of waypoints were collected from the five collars. Average time difference for waypoints for SH was 9.3±6.8 minutes. Because the percentage of collars deployed to provide data was less than desirable for SP, SH and MH, ten collars were deployed on the DH, of which, data was downloaded from nine collars. The tenth collar did collect waypoints, but the battery power ran out on day 3. Waypoints were collected between thirty-seven and fifty-nine days. The average time difference between waypoints for DH was 8.7±4.5 minutes.

Forage Measurements

Habitat forage samples are presented in Table 1.1. Forage types from each site were combined to provide grass, forbs and browse values. SP habitat contained majority of grasses such as Kentucky bluegrass mixed with few forbs. SH habitat was located on uncultivated higher hilly country containing bluebunch wheatgrass, Indian ricegrass, antelope bitterbrush and Wyoming big sagebrush MH contained stands of mix forested fir trees, maples, and aspen stands, with meadows of slender wheatgrass (*Elymus trachycaulus*), saline wildrye, timothy grass, broom snakeweed, and mountain sagebrush. DH vegetation included, Indian ricegrass, squirreltail, bud sagebrush, shadscale saltbush broom snakeweed, winterfat, and black sagebrush. Percent of each forage type consumed came from Taylor Jr (1994) for each habitat. The total ME consumed was based on the percentage of forage type multiplied by the ME of each type.

Movement, Distribution, and Energy Use

GPS files were downloaded were waypoints were divided into 24-hr periods. Latitude and longitude values were converted to Universal Transverse Mercator (UTM). Distance traveled between waypoints was determined using the UTM. The total movement was calculated and divided into slope or flat movement totals based on altimiter values. For each day, the Mcal ME was determined using values found in Table 1.2. The total ME was calculated with the addition of net energy of gestation (NE_{gest})and net energy of lactation (NE_l) to maintenance (NE_m). Weight and flock average age were provided by the owner of the flock. Environmental values were collected from the weather station that was placed at each habitat site. Milk values are table values from the NRC (2007).

Spring pasture (SP) sheep movement collected by the GPS collars is presented in Table 1.3. Since SP was flat, slope movement was not determined. There were differences ($P<0.05$) between the three SP pastures for total movement and ME. Between the three pastures, there were differences ($P<0.05$), where the 15-acre (P1) was 4.85 km, the 61-acre (P2) was 7.09 km and the 80-acre was 12.02 km (P3; Table 1.3). Maintenance Mcal/d was different ($P<0.05$) at 5.09, 5.23 and 5.54 for P1, P2 and P3 respectively. Adding NE_l to NE_m total ME was different ($P<0.05$) at 5.77, 5.90 and 6.22 Mcal/d.

Comparing the four habitats, DH total movement was different ($P<0.05$) from the other three, with no other difference noted among the other habitat sites. Personal observation by the herder, and corroborated by the data, the first four days the sheep were on DH, they moved more (between 2.5 and 3 km) than the rest of the time on the habitat. Slope movement was different ($P<0.05$) across the four habitats with SP at 0.0 because the habitat was flat (Table 1.4). Flat movement was highest at 6.7 km/d ($P<0.05$) on SP compared to 2.8 km/d for SH and both different from MH and DH at 1.1 and 1.2 km/d, respectively. Percent of movement up and down slopes was different ($P<0.05$) across all treatments, ranging from 0.0 for SP to 88.7% for DH. Flat percent was inverse to slope %.

The ACT value ranged from 0.27 to 4.5 Mcal ME/d with all habitats being different ($P<0.05$; Table 1.3). Metabolizable energy was different ($P<0.05$) between the treatments, ranging from

5.2 for SP to 13.6 Mcal ME/d for DH. Adding gestation or lactation NE increased ($P<0.05$) the total ME/d requirement for SP at 5.9 and DH at 13.9 Mcal ME/d, SH was 8.6 and MH at 7.1 Mcal ME/d.

DISCUSSION

We found the amount of time sheep spent moving across rangelands took a large toll on the amount of energy expended between each range habitat. While there has been research observing the activity and movement patterns of sheep, little research exists documenting differences in activity patterns across multiple diverse rangeland habitats during different seasons (Clapperton 1964a; Squires 1974; Warren and Mysterud 1991). Squires (1974), documented sheep distribution in Australia where temperatures ranged from 32-38°C, sheep averaged 14 to 18 km/d on hot summer range habitat. We found our sheep moved between 7 to 11 km/d on summer habitat where temperatures were not so servere. This could be due to the fact sheep in Australia spent more time walking to water sources to stay hydrated. SP had relatively flat ground with 0% of movement spent on slopes, there was an increase in movement as sheep were transferred to increasingly larger pastures (Fig. 1.3). We concluded the increase in movement was correlated to increase in size of pasture. This has also been observed in a study by Clapperton (1964b) where sheep kept in larger pastures moved greater distances than sheep in smaller pastures. P3 showed the greatest amount of movement (12.02 km) and was also the largest pasture. We also observed this on DH where the greatest total movement between range habitats took place on the largest allotment (35,000 acres). Though the pastures were similar in forage make-up, P3 biomass was less in comparison to P1 and P2, therefore possibly causing sheep to continusouly moving for forage consumption. These factors all could have contributed to the greatest movement occurring on P3 before they were taken up to SH. The total ACT of SP (0.27) accounted for only 5% of the total metabolizable energy expended. We attribute this to the easy terrain and readily available grasses and forbs. Sheep on the SP therefore did not need to as much time searching for forage and terrain allowed for easy movement.

SH, MH, and DH contained minimal movement on flat but majority of movement on slopes. Lachica et al. (1997) found net energy cost of slope movement is higher than for movement on flat terrain due to energy expended to work against gravity. This is congruent with our findings that all habitats that contained higher percentages of slope movement, required more energy to be expended (Table 1.4). A study conducted on mountain winter range in New Mexico found that sheep utilized slopes less than 45°, and slopes 50-75° decreased the utilization further (McDaniel and Tiedeman 1981). This is important to note that sheep will utilize slopes less when slope steepness increases. Though SH and MH had slopped terrain and steeper mountain sides when compared to the topography of DH, metabolizable energy was less on SH and MH in comparison to that of DH due to more slope movement taking place on DH. During mid to late summer while sheep were on SH and MH, forage was abundant and readily available, therefore sheep spent less time moving in search of food. Whereas sheep on DH, when snow was present, had to spend more time foraging to meet energy requirements needs and therefore possible utilizing unfavorable terrain in search of forage to meet energy requirement intake moving 10.5 km/d.

We found that movement on slope profoundly affected the amount of energy expended between range habitats. McDaniel and Tiedeman (1981) also showed sheep utilized sites located on tops of ridges. A similar observation was made in a study by Bowns (1971) who observed range sheep in Northern Utah preferred to utilize higher elevation sites for safer bedding grounds and sought valley bottoms to graze during the day. In the forests of Norway, Warren and Mysterud (1991) reported sheep moving uphill at night for resting and predator protection. We found sheep utilized slopes on all habitats that contained hilly terrain. As slope movement increased, the total metabolizable energy also increased (Table 1.4). SP contained 0 % slope movement and required only 5.9 Mcal/d in comparison to SH, MH, which showed no difference in total movement from SP, but did show a difference in increased slope movement which resulted in higher metabolizable energy expended in both habitats (Table 1.4). This was also observed in our results as the energy expended on slopes was the greatest on DH and resulted in highest total metabolizable energy being expended on DH (13.87 Mcal/d). The difference between the readily available grass on SP to the sparce DH vegetation resulted in the sheep moving approximately 4 km/d more. The increase in movement on DH was movement up and down hilly terrain. The Mcal ME associated with DH slope movement accounts for 88.4% of the ACT ME, with ACT NE accounting for 33% of total ME required per day. Whereas the ACT for SP accounted for 5% of total daily ME required. Comparing the four habitats and knowing the impact slope movement has on energy requirement, SP would have the lower requirement even though the ewe's lactation requirement was included. Spring low hill and MH, on a percentage, have more inclines requiring the sheep to move up and down the terrain even with more readily available forage present. This in comparison to sheep on DH spending more time in search of vegetation across hilly terrain and therefore expended more energy.

From previous research we were able to adapt existing GPS units used in cattle research to create a low-cost GPS tracker for sheep movement. instead of cattle. Augustine and Derner (2013b) studied grazing patterns in cattle by combining Lotek 3300LR GPS collars with activity sensors that recorded up and down and side-to-side movements of the head, to classify if the animal is grazing versus, traveling, bedding, or resting. They found rather than simply quantifying the distribution of cattle, they were able to examine foraging distribution. From this we can see the potential GPS collars have in improving understanding of animal behavior. Knight et al. (2018) created a low-cost alternative to the Lotek 3300 GPS tracking collar using the i-gotU GT-120 GPS tracking collar and compared the performances of both. He discovered there was no difference for slope, location, and distance to water, but distance traveled was lower for Knight collars than for Lotek collars. Karl and Sprinkle (2019) developed a "commercial off-the-shelf (COTS) electronic components," low-cost GPS unit and compared it to the Knight collar for accuracy. Both studies proved it possible to manufacture low-cost GPS tracking devices that best facilitate tracking more domestic animals in a herd for short durations of time. By adapting the Knight et al. (2018) i-gotU configuration to sheep we were able to track the movements of sheep across diverse landscapes to understand their energy expenditure between ranges.

CONCLUSION AND MANAGEMENT IMPLICATION

With the use of GPS trackers, our predictions were confirmed that sheep grazing the four different habitats did affect energy requirement of the sheep. Energy requirement was greatly affected by the amount of time spent moving on hilly and sloped terrain. Activity had the greatest impact on total energy requirement between habitats. When compared to the other four habitats, SH, MH and DH had movement on slope resulting in higher amounts of Mcals/d. The total movement traveled was the greatest on DH, due to the lack of readily accessible and palatable forage on the DH. Sheep consequenctly spent greater amounts of energy searching for food which possibly caused them to utilize more sloped terrain.

Due to the tremendous drain on energy requirements of the ewe while grazing on winter desert habitat in Utah, we advise additional supplements be given to sheep in their last trimester of gestation to assure healthy ewes coming off the desert and preparing for lambing and lactation. Energy supplementation is most useful under conditions of drought or heavy snow (Holechek and Herbel 1986). Due to the recent drought in the western United States, rangelands are struggling to provide enough forage for flocks and as a result, less animals have been allowed to graze. With challenging forage conditions, ewes are also challenged with energy demands imposed by the growing lamb in utero. Producers are highly advised to supplement ewes diet with grain during the last 4 weeks of gestation (ASI 1996). By offering energy supplments on DH before lambing, milk production can be maximized as well as heavier lambs born resulting in higher prices during fall lamb sale (ASI 1996).

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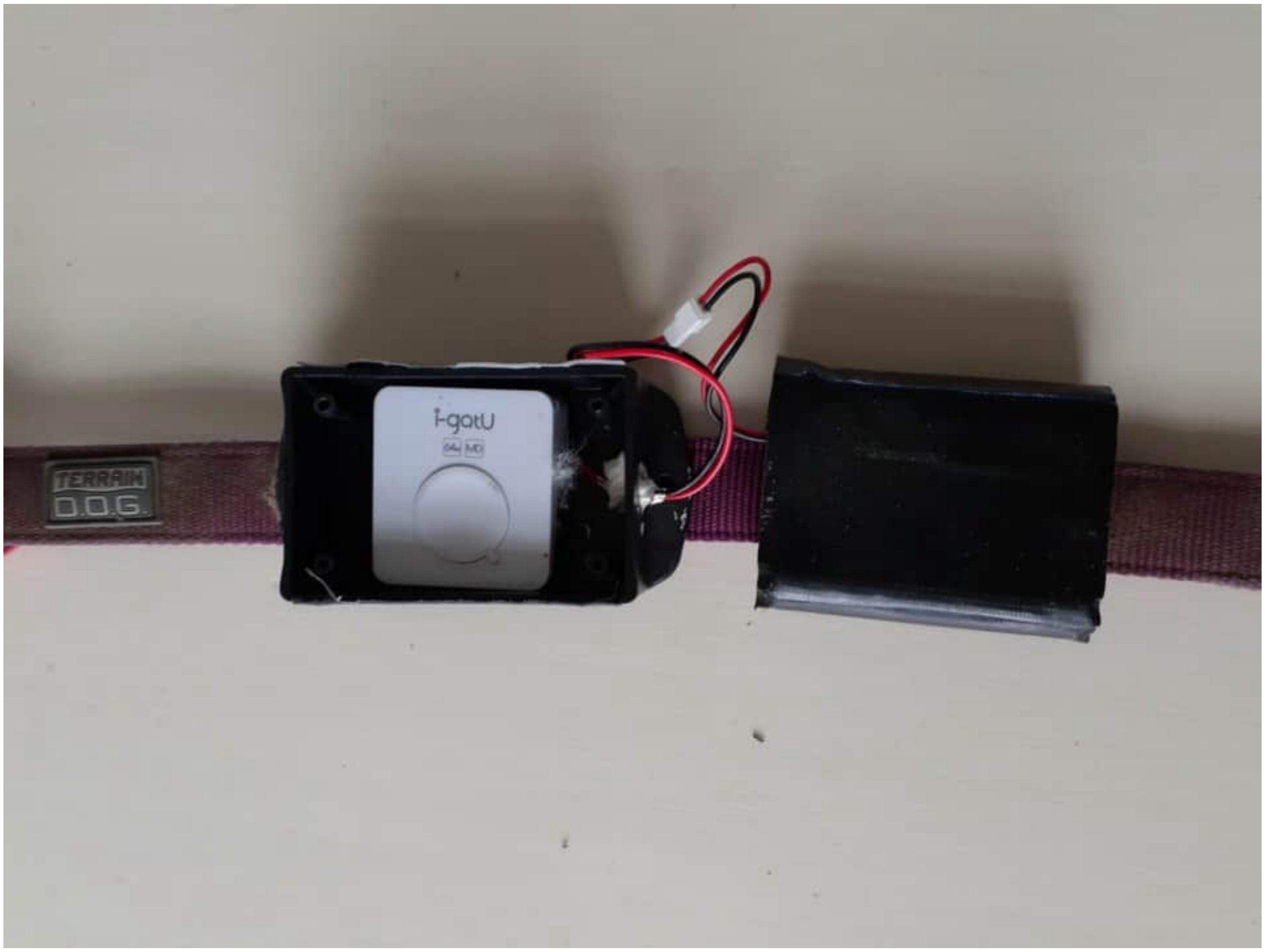

Figure 1.1 Constructed collars with i-gotU GT-600 powered by a 6600 mAh lithium battery

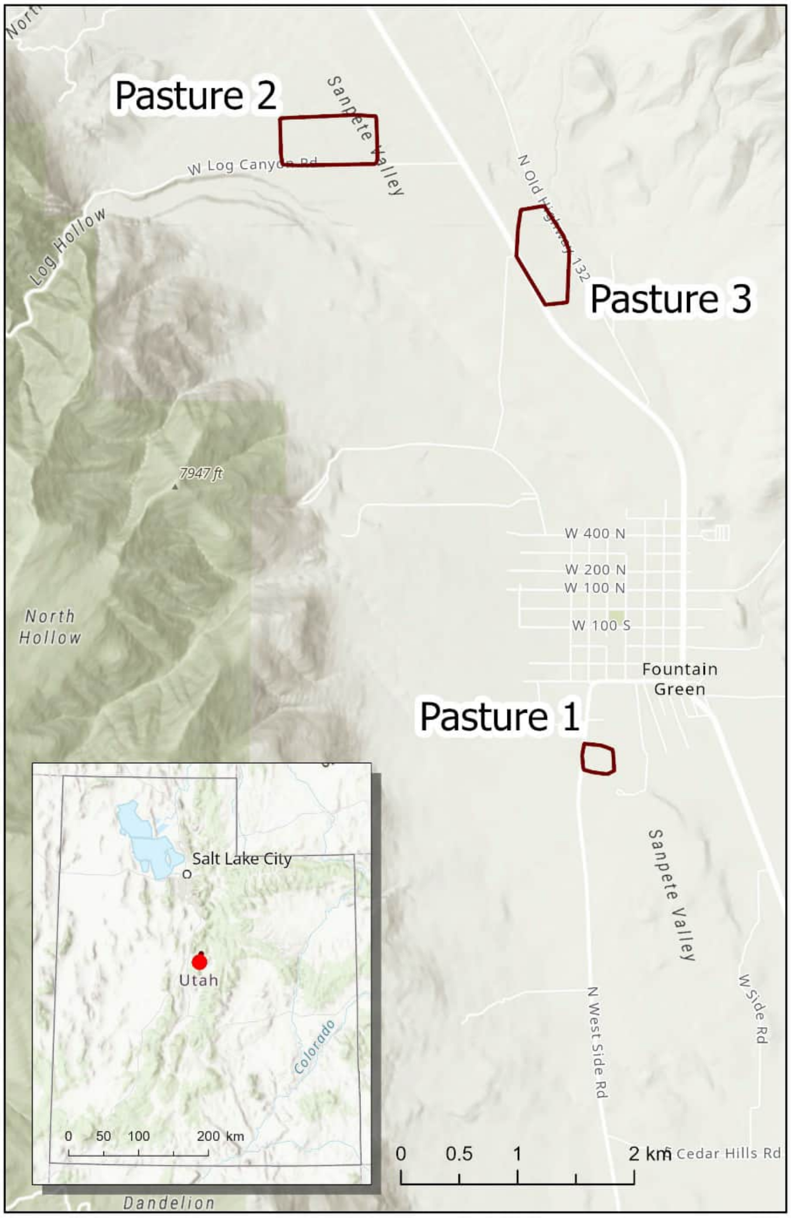

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Figure 1.2 Spring pastures. First pasture (P1) (39.617°, -111.643° N, 39.615°, -111.641° E), second pasture (P2) (39.666°, -111.674° N, 39.662°, -111.660° E), third pasture (P3) (39.666°, -111.661° N, 39.651°, -111.646°). Pastures surround Fountain Green, UT. Cultivated land covered mostly with Kentucky bluegrass and alfalfa.

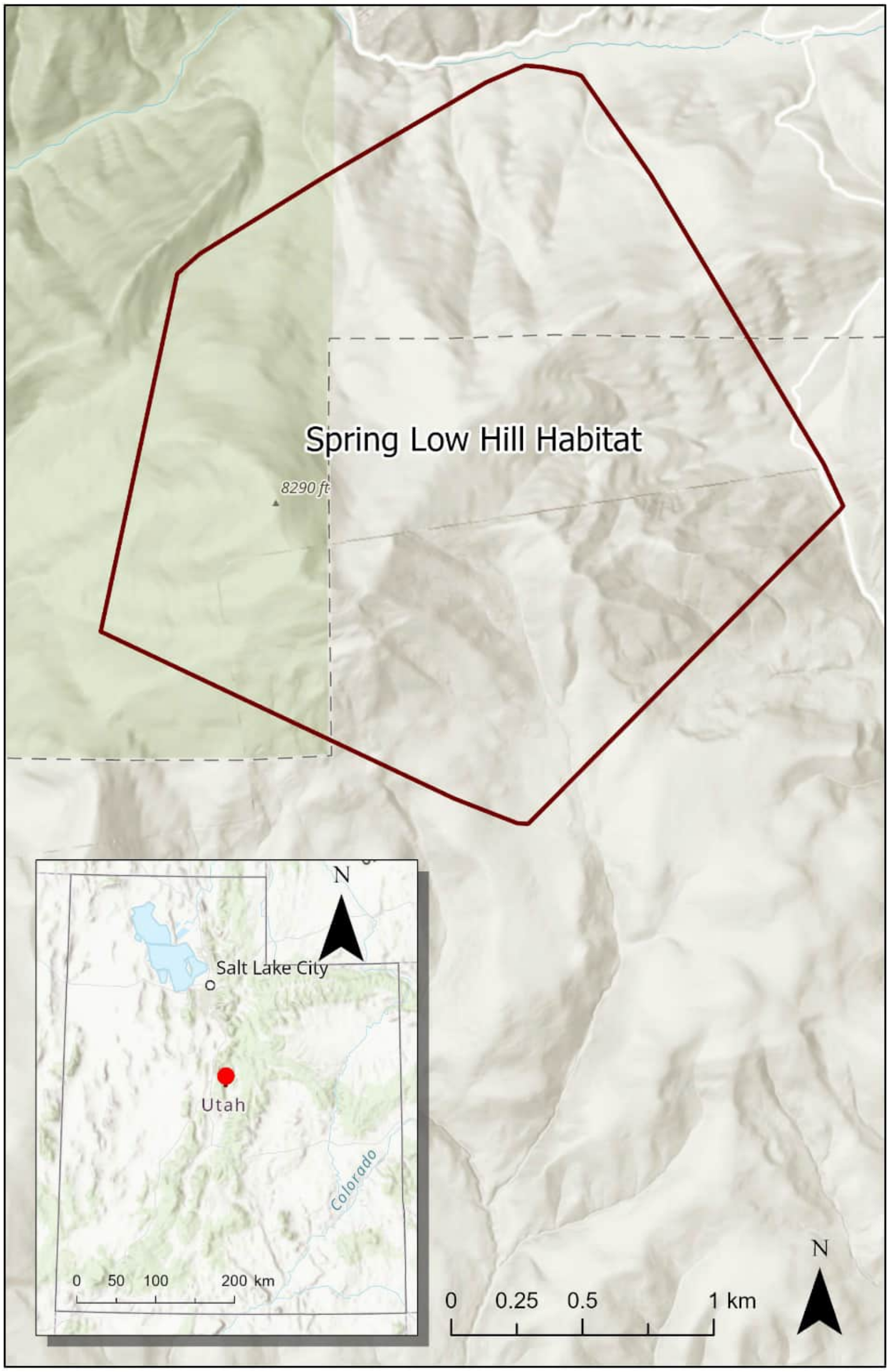

Figure 1.3 Spring low hill pastures (SH) (39.705°, -111.590° N, 39.686°, -111.559° E) located Northeast of Fountain Green, UT. Vegtation includes: scrub oak, Utah juniper, mountain big sagebrush, and indian rice grass.

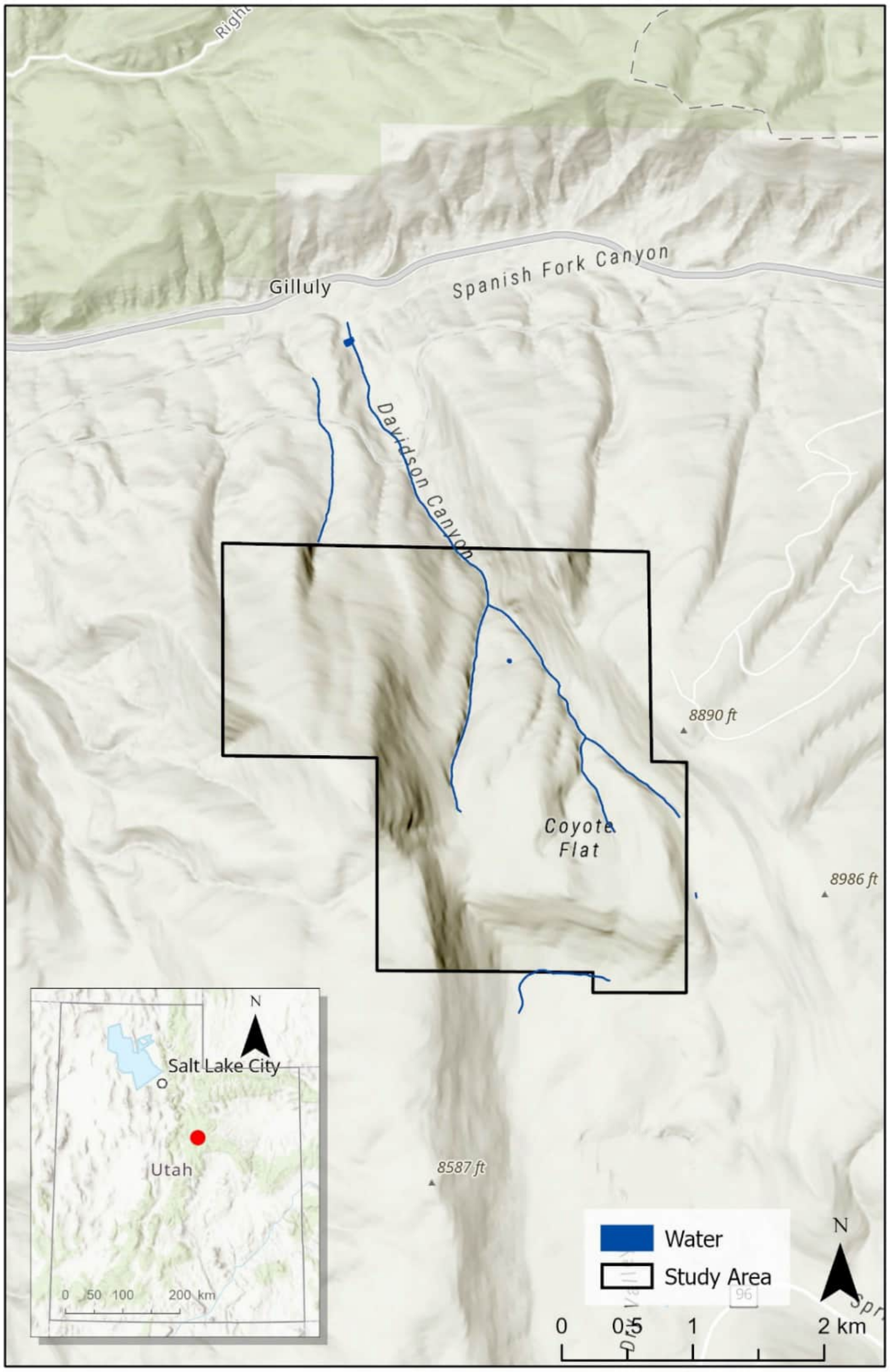

Figure 1.4 Mountain summer range (39.91°, -111.16° N, 39.88°, -111.12° E) located North of Scofield reservoir. Vegetation includes: mountain big sagebrush, aspen, gambel oak, broom snake weed, and Indian rice grass.

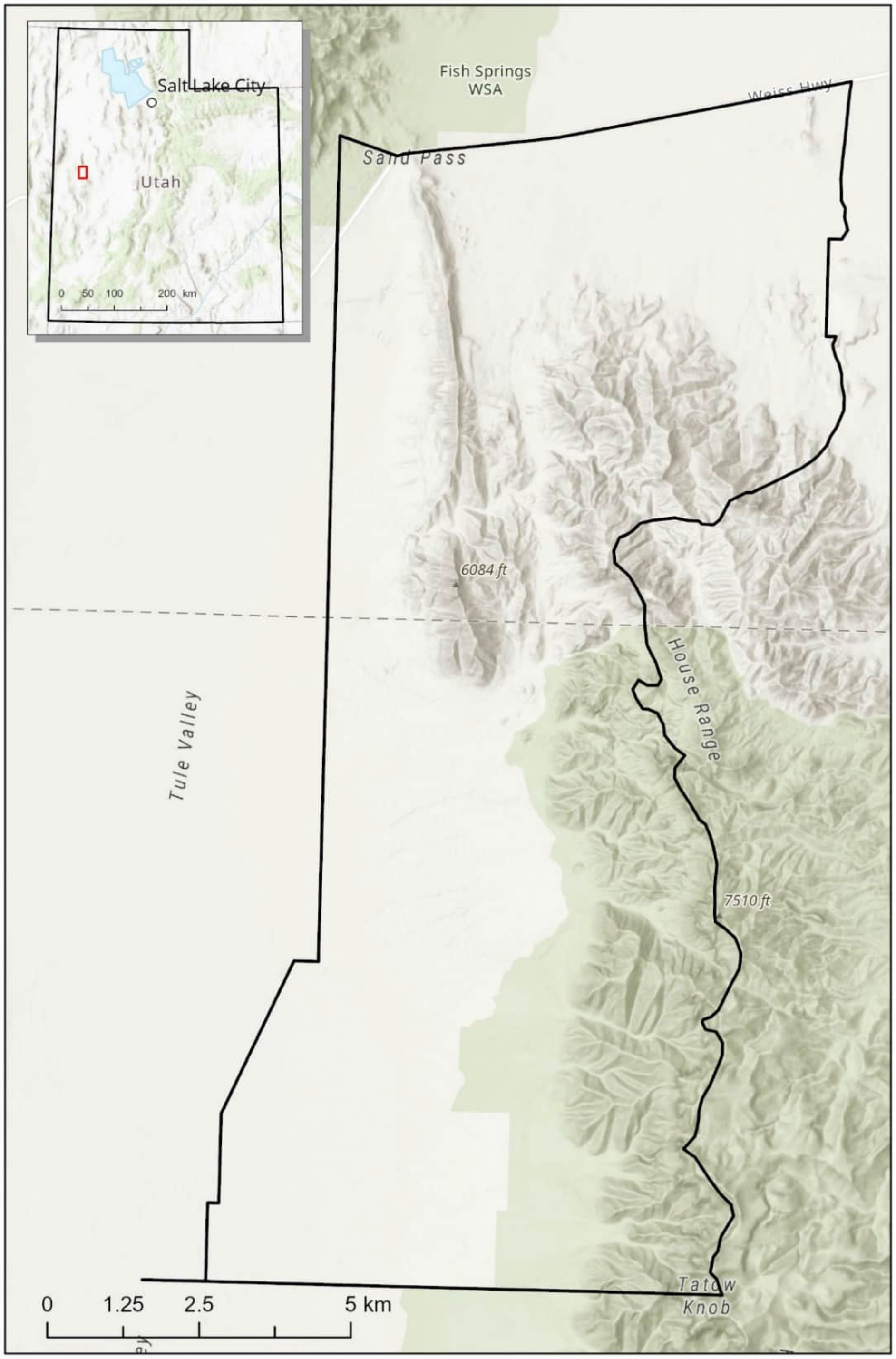

Figure 1.5 Winter Desert Range (39.62°, -113.41° N, 39.45°, -113.33° E) located in on BLM land in the West deserts of Utah. Vegetation includes: shadscale saltbush, bud sagebrush, black sagebrush, winterfat, indian ricegrass and Utah juniper.

TABLES

Table 1.1 Forage analysis of feeds on each grazing habitat

	DM, %	CP, %	NDF, %	ADF, %	NFC, %	ME, Mcal/kg
Spring pasture, SP						
Grass	47.1	12.5	51.1	36.1	26.7	2.42
Forbs	47.9	24.0	27.1	20.1	38.4	2.68
Spring low hills, SH						
Grass	45.9	9.0	55.6	31.9	25.7	2.32
Forbs	39.3	11.3	46.9	36.7	21.4	2.23
Browse	68.3	9.9	36.9	28.5	42.7	2.33
Mountain, MH						
Grass	83.9	6.5	66.1	42.8	18.2	1.99
Forbs	73.5	9.6	32.5	25.7	47.5	2.39
Browse	69.8	9.9	32.3	25.2	47.4	2.40
Winter desert, DH						
Grass	87.1	5.4	75.0	50.1	10.5	1.88
Forbs	84.6	5.6	64.2	52.1	20.9	2.00
Browse	64.0	8.5	50.3	41.8	30.8	2.15

Table 1.2 Input values for energy equations

	Grazing Habitat[a]			
	SP	SH	MH	DH
Weight, kg	66	66	69	70
Age, years	4.2	4.2	4.2	4.2
ADG, g/d	40	40	40	40
Previous Temp	6	12	16	4
Current Temp	12	16	13 (9.9)	-0.6
Rain, mm	0	2	0	0.25
Wind, km/h	8.0	3.1	3.3	5.9
Wool Depth, mm	12	14	20	51
Milk yield, l/d	1.7	0.75	0.25	0.0
Milk fat, %	2.85	2.85	2.85	0.0
Milk protein, %	2.53	2.53	2.53	0.0

[a]Sp = spring pasture, SH = spring low hill habitat, MH = mountain habitat, DH = winter desert habitat.

Table 1.3 Movement and energy requirements of ewes on spring lambing pastures (SP) of different sizes.

	Pasture[a]			
	P1	P2	P3	SEM
Total movement, km	4.85[e]	7.09[f]	12.02[g]	0.22
ACT, ME Mcal/d[b]	0.20[e]	0.28[f]	0.49[g]	0.01
NE_m, Mcal/d[c]	5.09[e]	5.23[f]	5.54[g]	0.01
Total ME, Mcal/d[d]	5.77[e]	5.90[f]	6.22[g]	0.01

[a]Pasture P1 = 15 acres, P2 = 61 acres, P3 = 80 acres.

[b]ACT= distances traveled on slopes and flat surfaces.

[c]$NE_m = ([SBW^{0.75} * a1 * S * a2 * \exp(-0.03 * AGE)] + (0.09 * MEI * k_m) + ACT + NE_{msc} + UREA) / k_m$

[d]Total ME = $NE_m + NE_l$.

[efg]Rows values with differing superscripts differ at $P<0.05$.

Table 1.4 Energy requirements needed for each grazing habitat.

	Grazing Habitat[a]				
	SP	SH	MH	DH	SEM
Total movement, km	6.66[f]	7.09[f]	6.89[f]	10.52[g]	0.19
Slope movement, km	0.00[f]	4.46[g]	5.91[h]	9.30[i]	0.14
Flat movement, km	6.66[h]	2.82[g]	1.12[f]	1.22[f]	0.14
Slope %[b]	0.0[f]	64.7[g]	85.6[h]	88.7[i]	0.92
Flat %[b]	100[i]	38.7[h]	16.3[g]	11.3[f]	1.07
ACT, ME Mcal/d[c]	0.27[f]	2.06[g]	2.76[f]	4.49[i]	0.07
NE_m, Mcal/d[d]	5.20[f]	7.91[h]	6.92[g]	13.55[i]	0.11
Total ME, Mcal/d[e]	5.88[f]	8.59[h]	7.08[g]	13.87[i]	0.11

[a]Sp = spring pasture, SH = spring low hill habitat, MH = mountain habitat, DH = winter desert habitat.

[b]Percent of total movement on slope or flat terrain.

[c]ACT= distances traveled on slopes and flat surfaces

[d]$NE_m = ([SBW^{0.75} * a1 * S * a2 * exp(-0.03 * AGE)] + (0.09 * MEI * k_m) + ACT + NE_{msc} + UREA) / k_m$

[e]Total ME = $NE_m + NE_{preg} + NE_l$.

[fghi]Rows values with differing superscripts differ at P<0.05.

CHAPTER 2

Resource Selection of Domestic Sheep on Mountainous Summer Pasture

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ABSTRACT

Past research has documented livestock grazing patterns and dynamics across pastoral landscapes. We used domestic sheep locations derived from coorniate positions obtained from GPS collars to study sheep habitat selection on summer mountain habitat North of Scofield Reservoir Utah, USA. Data was collection between the months of July to September, 2020. We developed a resource selection function (RSF) model to determine the influence of slope, distance to water, aspect, ruggedness, elevation, and vegetation types on sheep habitat selection while grazing on summer mountain habitat. We found sheep selected for sites closer to water, with more gentle terrain, higher in elevation and north-facing slopes. Vegetation types were less reliable due to the lack of species composition information and the possibility of sheep being herded to avoid areas of overuse. Although it is often assumed that sheep utilize slopes more than their heavier and larger cattle counterparts, they overall tended to avoid steep slopes compared to all other predictor variables. While remaining in relatively close proximity to water, seeking high elevation sites with gentle terrain and on north-facing slopes, this information regarding sheep summer grazing selection can be used to improve livestock management practices including flock management that increasessheep foraging patterns and energy effeciciency.

INTRODUCTION

Effective livestock management requires an understanding of the temporal and spatial distribution of livestock on pastoral landscapes (Liao et al. 2018). Factors that affect the distribution of livestock include both abiotic factors (i.e. slope, ruggedness, elevation, aspect, distance to water) and biotic factors (i.e. vegetation types; Bailey et al. 1996; Cook 1966; Senft et al. 1987; Squires 1974; Warren and Mysterud 1991). The selection for or against these factors can determine the temporal and spatial distribution of livestock across a heterogenous landscape. By understanding habitat selection by livestock, managers can better meet the resource needs and energy requirements of their animals.

Several studies have identified general relationships between domestic sheep (*Ovis aries*) foraging patterns and habitat characteristics (i.e. ruggedness of terrain, steepness of slope, availability of water). For instance, grazing can be influenced by both distance of vegetation from water and steepness of slope (Bailey et al. 1996; Senft et al. 1987; Squires 1974). Squires (1974) found that the highest grazing use and foraging patterns of Merino in Australia were less than 0.8km from water. Beyond this distance individual plants that remained ungrazed were significantly higher (Squires 1974). The distribution of livestock, in particular cattle, is limited by the steepness of the slope and unevenness of the terrain (Cook 1966; Mueggler 1965; Patton 1971). McDaniel and Tiedeman (1981) found sheep on mountain winter range in New Mexico, utilized slopes less than 45%, but utilization was reduced by 50-75% on steeper slopes. They discovered sheep normally utilize sites located on tops of ridges and tops of upper slopes before descending to the valley floor. Bowns (1971) found that an unherded flock of range sheep in

Northern Utah, USA preferred to bed on higher elevation terrain at night and sought valley bottoms to graze during the day. This behavior is congruent with moving and resting behavior of sheep in the coniferous forests of Norway where Warren and Mysterud (1991) reported sheep moving uphill at night for resting and sleeping on higher ground where they gain protection from predators. Abiotic factors such as slope, elevation, and distance to water have a major impact on the distribution and habitat selection of sheep.

Biotic factors, including the availability and quality of forage have been shown to affect sheep grazing distribution patterns (Bailey et al. 1996; Senft et al. 1987). Sheep are intermediate feeders which suggests they have a high capacity to adjust their feeding habits to meet forage availability to meet their energy and nutrient intake requirements (Holechek 1984). In the Intermountain West, sheep are considered the best adapted of all ungulate species at meeting their requirement needs due to their foraging adaptability, by utilizing the available forage resources (i.e. grasses, forbs, shrubs) and plant communities they come in contact with (Holechek 1984). In a recent study conducted on two separate range ewe herds in Wyoming, Scasta et al. (2020) found that sheep grazing on different allotments at different elevations, experienced shifts in diet selection and forage preference. A herd grazing at 1829-2438 m had a diet made up of 51% grass and 31% forbs while the other herd grazing at 2438-3048 m had a diet made up of 42% forbs, 14% shrubs and 13% grasses. Similar studies have also indicated that sheep diets are more varied than that of cattle, and when nonspecific diet is available, sheep will sustain a mixed diet of forbs, grasses, and shrubs (Grant et al. 1985; Parsons et al. 1994). It is reasonable to conclude that the diet of sheep is as variable as the heterogenous landscapes where they graze.

The use of geospatial tools has been valuable in quantifying the use and movement of animals across heterogenous landscapes. The development of geographic information systems (GIS) and GPS collars technology has been important in quantifying the resource selection of the greater sage-grouse *(Centrocercus urosphasianus)*, where Baxter et al. (2017), using geographic information system (GIS) and resource selection mechanism, revealed habitat preferences that allowed for better management of this species. Resource selection was used along with birth-site selection of American bison *(Bison bison)* to predict in greater accuracy of areas most likely to be the best habitat for birthing sites (Kaze et al. 2016). While resource selection has been commonly used in wildlife research, little has been done with using this method to analysis the habitat selection in domestic livestock.

Domestic sheep herds in the intermountain west have been utilizing rangelands since 1847, with approximately 300,000 sheep grazing Utah rangelands today (Utah Wool Growers Association 2017). Utah's landscape consists of 80% rangeland making it unsuitable for farming but ideal for raising domestic livestock. In the Intermountain West, sheep are commonly rotated through different rangeland habitats within a year cycle. GPS locations from GPS collars on range ewes grazing on summer mountain habitat to identify use areas, we analyzed environmental features within the habitat at multiple spatial scales and measured the influence of slope, aspect, ruggedness, distance to water, and vegetation types in relation to use sites of the sheep. We then used model-averaged coefficients to produce a GIS model of habitat selection for sheep on the mountain summer habitat. The purpose of our research is to identify the biotic and abiotic variables selected by sheep in a quantifiable way, in hopes of providing fundamental information for sheep managers to effectively improve livestock management. We hypothesize that sheep will select and show preference for high elevation, gentle terrain and close to water.

MATERIALS AND METHODS

Study Area

Our study was conducted on private land north of Scofield Reservoir (39.91° -111.16° N, 39.88°, -111.12° E) in Utah County, Utah, on 2,500 acres (Fig. 2.1). Elevation ranged from 2,191 to 2,550m and included a variety of terrain from gentle sloping meadows to steeper forested hillsides. Ungulates on the summer grazing allotment that could potentially compete with sheep included elk *(Cervus canadensis)* and mule deer *(Odocoileus hemionus)*. Vegetation included quaking aspen *(Populus tremuloides),* subalpine fir *(Abies lasiocarpa),* Gambel oak *(Quercus gambelii),* mountain big sagebrush *(Artemisia tridentata subsp. vaseyana),* Utah serviceberry *(Amelanchier utahensis*), bluebunch wheatgrass *(Pseudoroegneria spicata),* timothy grass *(Phleum pratense)* and broom snakeweed *(Gutierrezia sarothrae)*. The climate was characterized by cool summer temperatures (15°C mean air temperature) and cold winters (-5°C mean air temperature) with annual precipitation of 50 cm. Average annual temperature ranged from 43 to 70°C during the summer and -11 to 1°C during the winter (PRISM 2004). Human related activity was minimal except for the full-time sheep herder.

Sheep GPS Tracking

During the summer of July to September 2020, we placed six global positioning system (GPS) collars on six ewes from a herd of 600 adult Rambouillet crossbreed white-face ewes (71±1.2 kg; 4.2±0.9 years old; 1.65 lambs/ewe). The GPS collars were modified from Knight et al. (2018) as follows: An enclosure (#BT2310 Polycase, Avon, OH, USA) was attached to a 1” x 27” nylon dog collar using 73mm wide black Gorilla tape (Gorilla Glue, Inc, Cincinnati, OH, USA). An i-gotU GT-600 GPS tracker (Mobile Action Technologies, New Taipei City, Taiwan) was modified by removing the internal battery and attaching a JST PH 2-pin 200mm male header cable. A 6600 mAh 3.7V lithium-ion battery pack (#353 Adafruit, New York, NY, USA) that has a JST PH 200mm 2-pin female header attaches to the GPS tracker. The battery pack was also attached to the collar using the Gorilla tape. The GPS tracker was housed in the enclosure and sealed with silicone. With the GPS unit and battery attached, both were wrapped twice using 44mm duct tape (Shuretape Technologies, Avon, OH, USA; Fig. 1.3).

The GPS tracker was programmed to collect waypoints every 5 minutes. At the end of the collection period the collars were removed from the ewes. The data was downloaded using @Trip software (Mobile Action Technologies, New Taipei City, Taiwan) then exported as a csv file. The data was inspected and waypoints removed that were out of the grazing perimeter. In total 27,327 GPS coordinate points from all each collar were recorded.

Predictor Variables

Following the method used by Johnson (1980), a second order selection was used to conduct the resource selection function (RSF) by deliniating our study area and comparing the home range of the sheep to the total grazingland available within study area as defined by the property fencing was used. We obtained environmental data, (i.e. elevation, water location) from the Utah Automated Geographic Reference Center (AGRC 2021). ArcGIS to was used to generate slope, aspect, and ruggedness from elevation data (ESRI 2021). All environmental data was in raster format with a 10m spatial resolution. We binned aspect into seven different directions including: north, northeast, northwest, south, southeast, southwest, and west. Vegetation data was collected from landfire raster dataset (LANDFIRE 2016) and using the Society of American Foresters-Society for Range Management (SAF-SRM) cover type we grouped vegetation into 20 different groups based on dominant vegetation type. The raster layer for streams was taken from the Utah Automated Geographic Reference Center (AGRC 2021). A point feature was used to designate where the man-made pond was located within the allotment. No anthropogenic features were included in this study (i.e. distance to roads, power lines), because there were very few and unlike wildlife, domesticated animals, are less affected by human related features and activity. Using the ArcGIS Extract MultiValues to Points tool in the Spatial Analyst toolbox, we extracted cell values at locations specified in a point feature class from all rasters and recorded values to the point feature class attribute table (ESRI 2021). The vegetation vector was joined using the Spatial Join tool in the Spatial Analyst toolbox (ESRI 2021).

Resource selection functions and hotspot analysis

The RSF predictions were generated from a logistic regression which utilizes data from use and non-use sites and includes the set of predictor variables previously described to provide pixel or polygon resource unit probability (Boyce et al. 2002; Manly et al. 2007). To model habitat use of sheep on the allotment, we checked for multi-collinearity among the explanatory variables and found no evidence of collinearity between variables. The Create Random Points tool in the Spatial Analyst toolbox was used to generate the same number of random locations as there were use locations (n=20,958) in order to ensure adequate characterization of the study area (ESRI 2021). A 0 was assigned to random locations and 1 to use location sites in the attribute table (Boyce et al. 2002). With the "lme4" package in R, we used a linear mixed-effects logistic regression with a random intercept for individuals (Team 2021). We compared predictor variables at use locations versus random locations within the study area (Bates et al. 2014;

Gillies et al. 2006; Manly et al. 2007; Team 2021). Akaike's Information Criterion (AIC) was used to select the most parsimonious models that best fit the data using the R package 'MuMIn' (Akaike 1973; Team 2021). To create a raster heat map, we converted the 10m DEM to points and ran the Extract Multi Values to Points tool in the Spatial Analyst toolbox to create a sample grid and exported the attribute table with the coordinates and habitat variable measurements to a csv file. We then used the variable coefficients from our selected model and the variable values from the 10m sample grid (n= 110,615) to generate heat map that visually shows in different colors a prediction of utilization at each sample site (Fig. 2.3). A csv file containing the coordinates and prediction for each 10m cell was exported as a csv file and imported as a point layer in ArcGIS Pro using the XY Table to Point tool in the Data Management toolbox. The point layer was then converted to a raster using the Point to Raster tool in the Conversion toolbox.

RESULTS

Resource selection function

A total of 27,327 locations for ewes were collected on the grazing habitat from 5 of the 6 GPS collars from July to September 2020. We evaluated 20 models for habitat-use of the sheep (Table 2.1). The top model had an AIC weight of 0.819 and the delta score between the first and second model was 3.34, indicating that our top model was the best fit for our data. Based on AIC, our global model, which included every coefficient (i.e. vegetation types, aspect directions, slope, elevation, water proximity, and ruggedness), had the best fit data for summer use on Scofield (Table 2.1). Slope was highly significant in the best-fit model ($P<0.001$). The coefficient value for slope was negative and was estimated for each one degree increase in slope, with the probability of use by sheep declining by -0.9 (Table 2.2, Fig. 2.2). All three of our top models included water proximity as a significant variable ($P<0.001$; Table 2.1). Proximity to water had the second strongest negative beta estimate (-0.15) meaning that as distance from water increased by one meter, utilization of habitat decreased by -0.15 (Table 2.2). The ruggedness coefficient was significant ($P<0.05$) against rugged terrain and showed sheep avoided ruggedness (Table 2.2). Sheep showed preference for higher elevation sites, meaning as elevation increased by 1 meter, sheep utilization increased by 0.03 ($P<0.05$; Table 2.2). The ewes selected for north, northwest, southwest and west facing slopes ($P<0.05$; Table 2.2, Fig. 2.2).

The vegetation analysis compared every type to the intercept in preference selection. We selected the intercept "bristlecone" *(Pinus longaeva)*, due to the high avoidance sheep showed toward the bristlecone vegetation type. Compared to bristlecone pine, the significant (positive values) vegetation types that were selected for were herbaceous, engelmann spruce *(Picea engelmannii)*-subalpine fir, douglas fir *(Pseudotsuga menziesii),* white fir *(Abies concolor)*, aspen, mountain big sagebrush, tall forbs, alpine rangeland, chokecherry-serviceberry-rose, and juniper- *(Juniperus osteosperma)* pinyon *(Pinus edulis)* woodland vegetation types (Table 2.2). The most avoided vegetation type (negative values) was bigtoothed maple because it had the most negative beta estimate of -3.83 ($P<0.05$; Table 2.2). It is important to note that bigtoothed maple covered less than one percent of study area (0.53%; Fig. 2.4). Whereas the most common, mountain big sagebrush, covered 43% of the study area, aspen cover 33% and gambel oak 12% of total study area (Fig. 2.4).

SJ Plot and Hotspot analysis map

An "sjplot" was created in R showing all the predictor value estimates, including significant and non-significant variables at P>0.05 and sorting them in descending order with the highest selected variables on top to the most avoided variables on the bottom (Fig. 2.2; Team 2021). Further right from the neutral line indicates a strong selection for (in blue), while further left indicates a stronger avoidance (in red). The plot visually displays which variables were highly selected for (i.e. vegetation types, aspect types, elevation) to variables that were selected against (i.e. slope, distance from water, vegetation types, ruggedness, aspect types). Herbaceous, white fir, and douglas fir, were the top three vegetation types strongly selected for in comparison to bristlecone pine with small standard errors, all of which showed significance (P<0.05; Table 2.2; Fig. 2.2). The significant aspect variables show sheep using northern, northwestern, southwestern and western facing slopes (Table 2.2; Fig. 2.2). Variables such as ruggedness and elevation shown closer to the neutral line indicate strength of selection of use for elevation and avoidance of use for ruggedness (Table 2.2; Fig. 2.2). While bigtooth maple has a stronger avoidance by the ewes, being further from the neutral line (Fig. 2.2). Slope was highly avoided with a small standard error of 0.01 indicating slopes were avoided by sheep.

The raster heat map displayed hot spot analysis indicating the areas most likely to be used by the ewes in red and the areas most likely to be avoided in green (Fig. 2.3). For example, the steeper areas on the allotment are covered in green indicating a lack of usage by the sheep (Fig.

2.3). Whereas the gentler terrain on the allotment is generally covered in red and orange indicating higher usage sites (Fig 2.3).

DISCUSSION

Central to understanding sheep behavior, is understanding the way sheep utilize their environment (Johnson 1980). By using a resource selection functions (RSF) we were able to statistically analysize and identify the habitat features selected by sheep in order to provide understanding of resource usage by animals across a landscape (Manly et al. 2007). The results of our analysis support our hypothesis that sheep selected for higher elevations, avoided steep slopes, and preferred areas closer in proximity to water. Our model representing habitat use on mountainous summer rangelands found that slope was the most important continuous variable for characterizing sheep use. Slope had the highest negative beta estimate (-0.9, SE 0.01, $P<0.001$; Table 2.2) of all the continuous variables, meaning that, when compared to the other continuous variables, sheep strongly avoided steep slopes on the allotment (Fig. 2.2; Fig. 2.3). Other research has documented that sheep generally utilize steeper slopes more than cattle, and seek higher ground (Bowns 1971; Cook 1966; McDaniel and Tiedeman 1981; Mueggler 1965). Bowns (1971) and Glimp and Swanson (1994) found that sheep are less intimidated by steeper slopes than cattle and tend to prefer upland grazing sites. McDaniel and Tiedeman (1981) found increasing slope steeper than 45% negatively decreased utilization. Compared to other livestock species, sheep utilize steeper slopes more often, being less negatively impacted as slope increases (McDaniel and Tiedeman 1981). It is important to note that sheep were accompanied by a herder during their time on the summer mountain habitat. We acknowledge that the presence of a herder affects sheep movement across the landscape. While there are times when sheep movement is manipulated by the herder, majority of the time the sheep are left to make habitat selections uninfluenced. The RSF was performed to determine the habitat selection of sheep grazing on summer mountainous range located in central Utah, USA. While the strong selection against steep slopes could be partially attributed to the ewes being herded, sheep tend to take the path of least resistance if presented with one (McDaniel and Tiedeman 1981).

Distance to water is a consistent primary determinant in predicting livestock grazing distribution (Bailey et al. 1996; Senft et al. 1987; Squires 1974). Our model showed as distance from water increased, utilization decreased (beta estimate of -0.16, SE 0.01; $P<0.001$; Table 2.2; Fig. 2.2; Fig. 2.3). Our findings are corroborated by other published research regarding sheep use of habitat (El Aich et al. 1991; James et al. 1999; Squires 1974). Squires (1974) and El Aich et al. (1991) found that as distance from forage to water increased, forage intake decreased. James et al. (1999), observed merino sheep in Australia are normally found within 3 km of a water site. However, McDaniel and Tiedeman (1981) found distance from water did not limit forage intake. They found a similar amount of forage was consumed from 2,000 to 2,400 m from water as from 0 to 500 m from water. This could be a result of additional water sources supplied on the pasture and stock tanks located on the bottoms and tops of the mountain slope. As well as periodic snows that provided additional moisture. Habitat selection is clearly influenced by distance to water for our sheep grazing on the summer mountain habitat.

Sappington et al. (2007) defines rugged terrain as broken, uneven, rocky terrain. We predicted sheep would choose more gentle terrain that included less rugged habitat. Ruggedness had a negative beta estimate (-0.023, SE 0.01; $P<0.02$; Table 2.2, Fig. 2.2; Fig. 2.3), meaning the sheep on the allotment avoided rugged terrain. Ruggedness was found to be in the best-fit model but was not a significant variable in our second best-fit model that held 14% of the weight. McDaniel and Tiedeman (1981) documented when terrain becomes especially rough, sheep passed through the area leaving available forage untouched. While there is a deficiency in data for sheep utilizing rugged terrain, this behavior could be attributed to accessibility of gentler areas that allow for easier mobility and grazing. The sheep on our summer mountain habitat reflected this behavior and avoided rugged terrain.

Sheep have shown to select for higher elevation habitat where they graze on the tops of ridges, and upper slopes, and move uphill for bedding down at night (Bowns 1971; Glimp and Swanson 1994; McDaniel and Tiedeman 1981; Warren and Mysterud 1991). Even though the selection for higher elevation was not as strong as it was for slope avoidance (beta estimate of 0.04, SE 0.01; $P<0.004$; Table 2.2, Fig. 2.2; Fig. 2.3), this could be attributed to the lack of high elevation flat areas in our allotment for bedding down. Often, if left unmonitored, sheep will bed down in the same locations, on higher elevated ground, and overutilize rangeland vegegtation within the area (Bowns 1971; Warren and Mysterud 1991). The sheep in our study were herded, therefore the likelihood of overutilization of sites decreased, due to herders selecting different bedding locations. It has also been proposed that this uphill movement for higher-lying ground at night is not seen so much as a response to nutritional needs, but rather to provide other advantages, such as predator avoidance and offer safest bedding sites (Warren and Mysterud 1991). From our study and others, there is evidence for sheep to seek for higher ground.

The vegetation types selected for or against in this study were all in comparison to the avoided bristlecone pine vegetation type. The vegetation type sheep selected against was bigtooth maple, but they showed preference for herbaceous, Engelmann spruce-subalpine fir, douglas fir, white fir, aspen, mountain big sagebrush, tall forbs, alpine rangeland, chokecherry-serviceberry-rose, and juniper-Pinyon pine woodland type. It is important to note that these vegetation types describe the dominant vegetation and exclude several palatable species that could be the true attraction to sheep but are undocumented. A plausible explanation for the vegetation selection could also be attributed to the herder preference and pushing sheep through areas to avoid over utilization of other sites. Another important factor to consider is the percent each vegetation type covers on the study area (Fig. 2.4). Though bigtooth maple was strongly selected against, that could also be due to it covering less than one percent of the study area (0.53%). Therefore, it is not common on the landscape and the chance of sheep encountering this vegetation type is much lower than mountain big sagebrush which covers 43% of the landscape (Fig. 2.4). During the beginning weeks on the mountainous summer range, GPS points showed sheep predominantly grazing on open fields of herbaceous graminoids, forbs, and shrubs before being moved down into forest stands of douglas and white fir stands. Douglas fir *(Pseudotsuga menziesii)* is the third most common forest type in Utah (USU 2004). While sheep showed selection for douglas fir, it could be likely that douglas fir vegetation type was more dominant across our mountain habitat therefore sheep spent more time grazing in it and not necessarily due to selection. Sheep prefer to subsist on graminoids, but can adjust their feeding habits to available forages (i.e. forbs, shrubs; Holechek 1984). Therefore, even though there was selection for and against vegetation types on the allotment, it remains difficult to conclude the significance of our findings due to the variation in percentage of cover between vegetation types, sheep being herded, and a lack of knowledge of other types of vegetation within the dominate vegetation type.

The aspects on our allotment habitat that were variables in the best-fit model were northern, northwest, southwest and west facing slopes (Table 2.2). Aspect plays a critical role in influencing soil quality and vegetation patterns (Farzam and Ejtehadi 2017; Singh 2018; Yang et al. 2020). Differences in aspect can alter vegetation structure and composition by effecting air and soil temperature, moisture content, and evaporation (Farzam and Ejtehadi 2017; Singh 2018). North-facing aspects receive less sunlight and therefore retain moisture more effectively, giving life to thicker and denser vegetation (Farzam and Ejtehadi 2017). Whereas, sunnier south-facing aspect's vegetation is sparse and thin and therefore prone to erosion (Farzam and Ejtehadi 2017; Singh 2018). While the literature is lacking specific examples of sheep selecting for certain aspects, these studies give a possible reason our sheep selected northern aspects over southern aspects. Northern facing slopes provide sheep with better foraging habitat as well as protection from the hot summer sun.

Our results demonstrate sheep habitat selection on summer mountain range. However, additional improvements to this study could allow for further extrapolation of data. Our data is from one flock and the addition of more flocks would provide a more complete data set for habitat selection from other mountainous habitat sites. While we placed collars to represent 10% of the flock, increasing collar sample size to estimate herd movement would increase the validity and accuracy of our findings (Biau et al. 2008). Not only would increasing sample size improve our research but monitoring sheep throughout several years and on different rangelands would provide additional insights to habitat selection. By extending the length of time out on habitats and continuing to monitor sheep as they transferred between locations throughout a year, would allow data to be compared between sites and create a holistic view of sheep habitat selection throughout a regular grazing year. Another noticeable limitation when using RSF is the lack of existing data layers that also provide accurate information. For example, our vegetation layer describes dominant cover type but provides no further information of total species composition of area. Without a comprehensive knowledge of plant communities, it becomes difficult to draw any meaningful conclusions from this data layer. With improvements made to sample size, length of study and data layers, the study of habitat selection in sheep could be extrapolated for other similar range habitats for the improvement of livestock management.

CONCLUSION

Sheep grazing on our mountainous summer range avoided slopes, and preferred higher elevation, northern aspects, gentle terrain, and remained closer to water. Vegetation selected for and against, lacked reliability to make inferences, due to the GIS layer limitations in knowledge of species composition in areas and sheep being herded. Our results highlight what other studies have recorded in sheep habitat selection (Bowns 1971; El Aich et al. 1991; Holechek 1984; McDaniel and Tiedeman 1981; Squires 1974; Warren and Mysterud 1991). With the use of geospatial technology to generate an RSF for sheep grazing on mountainous summer range, we were able to quantify sheep habitat use in order to improve summer grazing management of sheep. Improvements could come by altering herding strategies to better utilize sheep friendly habitats and avoid those that are not beneficial. Further work using the tools outlined in this research and addressing outlined limitations is needed to look more closely at habitat selection of sheep.

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FIGURES

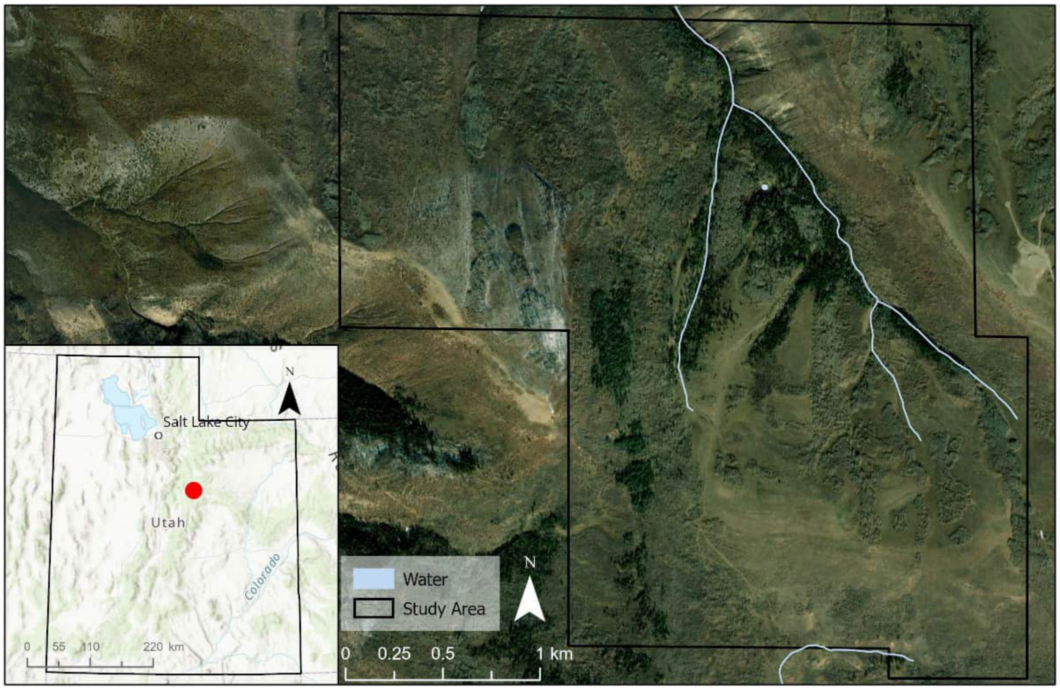

Figure 2.1 Study site location north of Scofield Reservoir, UT. Polygon represnet the mountainous range where sheep grazed from July 2020 to September 2020.

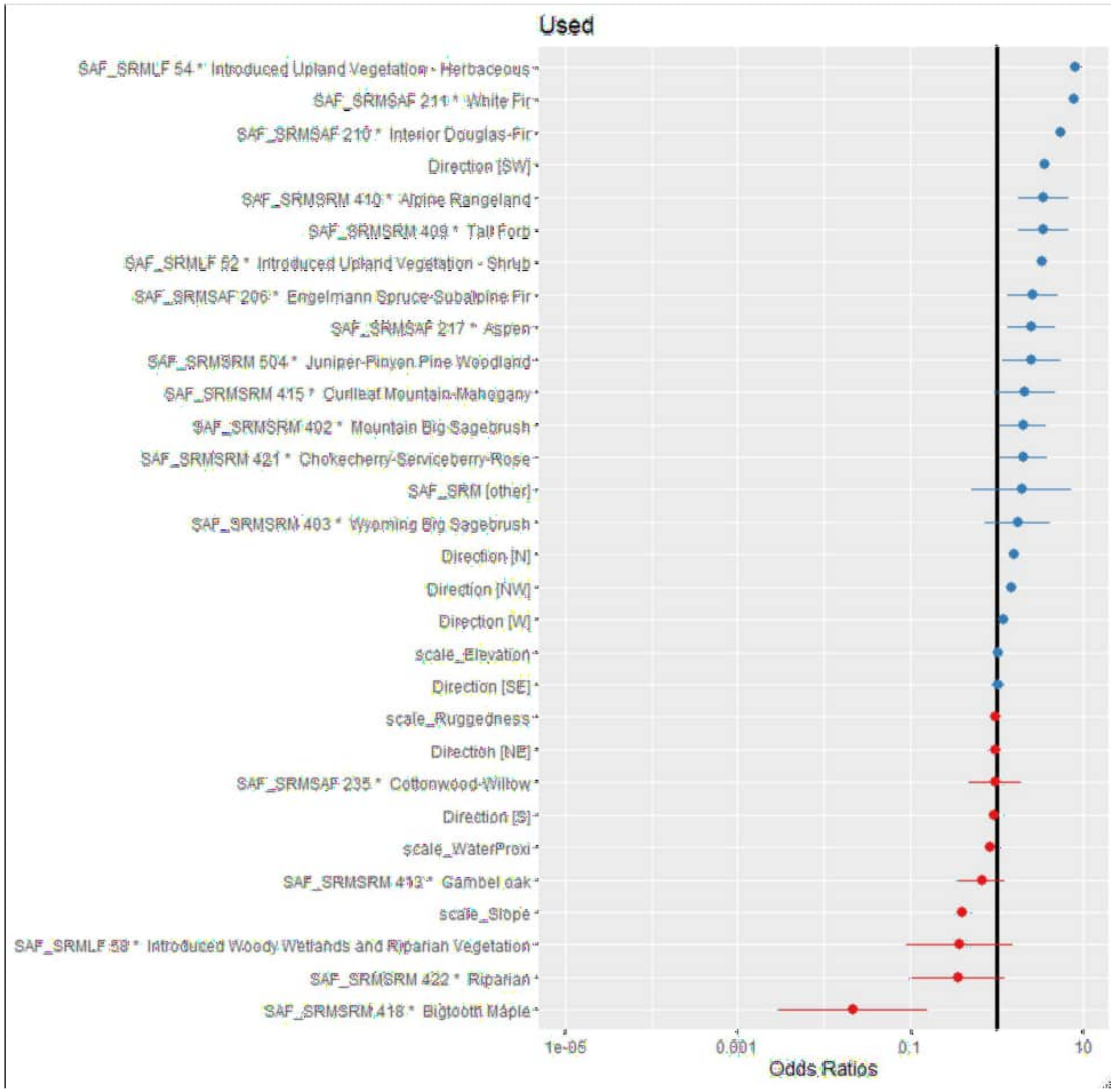

Figure 2.2 "sjplot" showing predictor value estimates with standard error bars in descending order with the highest selection on top in blue to the highest avoidance on the bottom in red. The "neutral" line, that is thicker than the rest indicates no effect. The vegetation types come from forest cover types of the United states and Canada (SAF) and the society for range management (SRM).

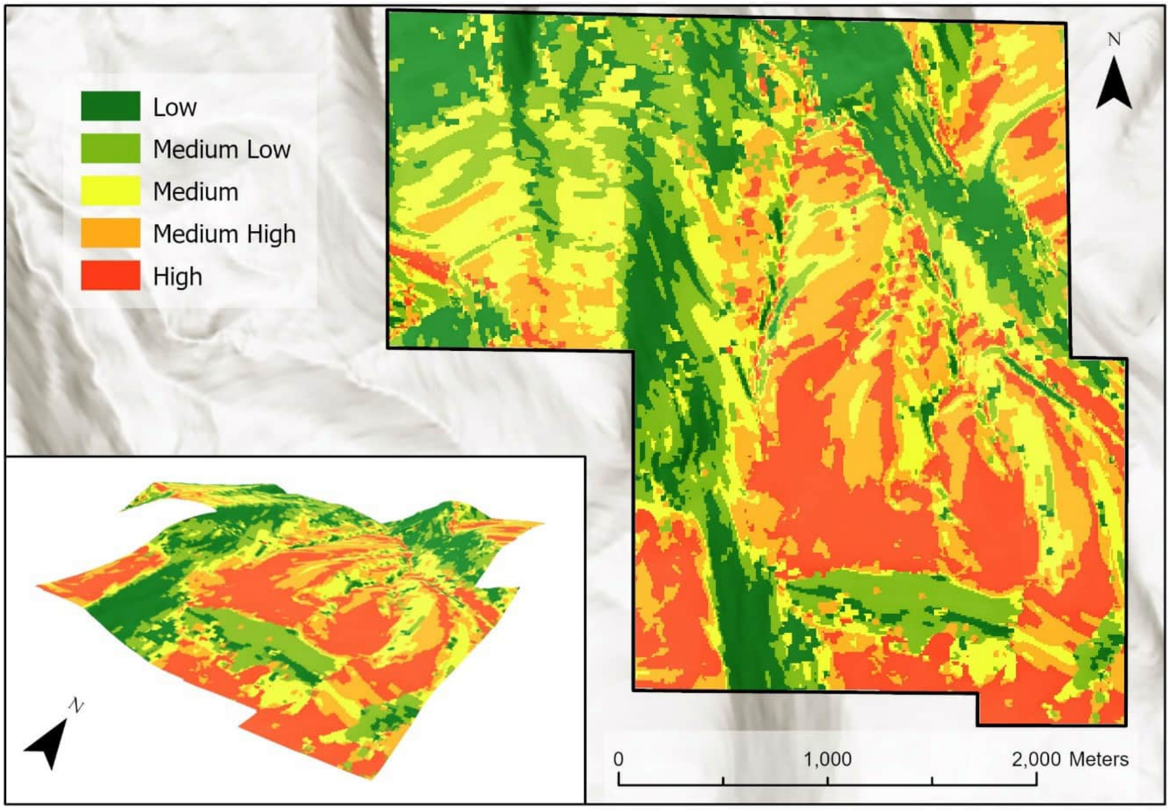

Figure 2.3 Heat map analysis of study area showing the relative probabilities of selection by domestic sheep binned into five categories from low (dark green) to high (red).

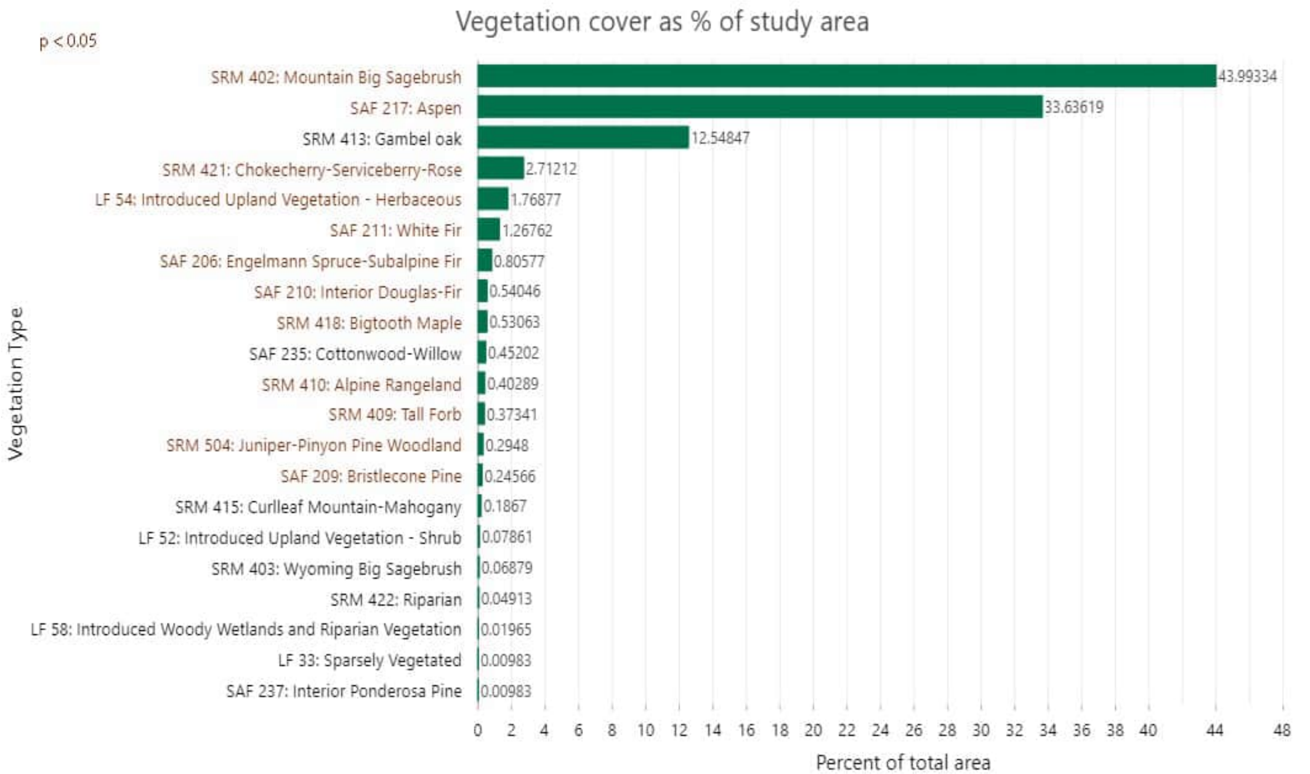

Figure 2.4 Vegetation cover as percentage of study area.

TABLES

Table 2.1 Model selection table showing 20 models, the number of parameters (k), the difference in Akaike's Information Criterion from the top model (ΔAIC), and the model weight for 20 a prioiri models for sheep habitat selection on mountainous summer range.

Model No.	**Model Structure**	**df**	**AICΔ**	**Weight**
M8	Vegetation+Aspect+Elevation+Ruggedness+Slope+ WaterProxi	32	0.00	0.819
M9	Vegetation+Aspect+Elevation+ Slope+ WaterProxi	31	3.45	0.146
M12	Vegetation+Aspect+Ruggedness+Slope+WaterProxi	31	6.26	0.036
M15	Vegetation+Aspect+Elevation+Ruggedness+Slope	31	174.47	0.00
M10	Vegetation+Elevation+Ruggedness+Slope+WaterProxi	25	1722.60	0.00
M11	Vegetation+Elevation+Slope+WaterProxi	24	1726.25	0.00
M13	Vegetation+Slope+WaterProxi	23	1764.94	0.00
M20	Aspect+Elevation+Slope+WaterProxi	12	2119.79	0.00
M14	Aspect+Elevation+Ruggedness+Slope+WaterProxi	13	2121.44	0.00
M16	Aspect+Eelevation+Ruggedness+WaterProxi	12	2653.03	0.00
M19	Aspect+Elevation+Slope	11	2657.22	0.00
M2	Slope	3	4873.91	0.00
M17	Vegetation+Aspect+Elevation+Ruggedness+WaterProxi	31	5397.86	0.00
M18	Vegetation+Elevation+Ruggedness+WaterProxi	24	7874.49	0.00
M7	Vegetation	21	8345.67	0.00
M3	Aspect	9	10431.73	0.00
M4	Elevation	3	13101.52	0.00
M5	Ruggedness	3	15622.73	0.00
M1	Intercept only model	2	15646.70	0.00
M6	WaterProxi	3	15647.90	0.00

Table 2.2 Model coefficients from best-fit model for habitat selection of sheep grazing on mountainous range located north of Scofield UT, USA.

Significant Coefficients	Beta Estimate	Standard Error	P Value
Topography			
Slope	-0.907542	0.013590	< 0.001
WaterProxi	-0.159241	0.012157	< 0.001
Elevation	0.039046	0.013579	0.004
Ruggedness	-0.022930	0.009817	0.019
Aspect			
Direction N	0.468430	0.045034	< 0.001
Direction NW	0.410669	0.043689	< 0.001
Direction SW	1.264073	0.046279	< 0.001
Direction W	0.172613	0.046250	0.000190
Vegetation Type			
Bristlecone Pine	-1.332760	0.331533	< 0.001
Bigtooth Maple	-3.836484	1.012389	0.000151
Herbaceous	2.089378	0.323017	< 0.001
Englemann Spruce-Subalpine Fir	0.959606	0.342799	0.005121
Interior Douglas-Fir	1.706320	0.348417	< 0.001
White fir	2.049769	0.328012	< 0.001
Aspen	0.926217	0.319575	0.003752
Mountain Big Sagebrush	0.708248	0.319086	0.026445
Tall Forb	1.243699	0.341405	0.000270
Alpine Rangeland	1.257119	0.344002	0.000258
Chokecherry-Serviceberry-Rose	0.696006	0.326403	0.032978
Juniper-Pinyon Pine Woodland	0.924872	0.391449	< 0.001

EXHIBIT 5

January 25, 2023

Jim Zelenak
Adam Zerrenner
Ben Conrad
US Fish and Wildlife Service
Ecological Services, Montana Field Office
585 Shephard Way, Suite 1
Helena, MT 59601.

Re: Canada lynx Species Status Assessment – Comment Submittal

Sent VIA Email to: jim_zelenak@fws.gov; Adam_zerrenner@fws.gov and Ben_conard@fws.gov

Dear Jim, Adam, and Ben:

Yellowstone to Uintas Connection is providing these comments as input to your current species status assessment for Canada lynx. Yellowstone to Uintas Connection is a 501c3 non-profit entity working to restore fish and wildlife habitat including the Regionally Significant Wildlife Corridor connecting the Greater Yellowstone Ecosystem to the Uinta Mountains and Colorado through the application of science, education, and advocacy. We named our organization and the Corridor from the Greater Yellowstone Area that passes through SE Idaho and SW Wyoming into NE Utah, the Yellowstone to Uintas Connection (Y2UConn) in order to bring attention to it across the West.

Y2U has been working to correct habitat fragmentation and degradation in the Y2UConn. Over the decades, we have documented the destruction and degradation of the natural character, water quality, and wildlife habitat integrity of the National Forests and BLM managed lands in this region, including the Y2UConn. Human developments including energy development, mining, livestock grazing, motorized recreation, and logging on public and private land have contributed to an apparent loss of function in this connection for Canada lynx. Our focus has been on restoring this corridor to function as a linkage for Canada lynx and wolverine. We review the literature, analyze and comment on agency actions such as phosphate mining and timber projects which fragment the habitat. Motorized recreation is a massive presence and largely unregulated and uncontrolled.

In recent years, we have been addressing the phosphate mining industry in SE Idaho on lands managed by the Caribou National Forest (CNF) and identified by the CNF as linkage habitat.[1] The phosphate mines typically dig up and destroy thousands of acres for each mine plus ancillary haul roads, powerlines, pipelines, and rail lines. To date, over 20,000 acres of forested habitats that are important to many wildlife species have been lost. Wildlife and habitat studies are minimal with no population data or trend analysis for viability assessments. Monitoring of project impacts on wildlife are scarce to non-existent. The typical outcome for lynx analysis is

[1] Caribou National Forest. 2003. Revised Forest Plan and FEIS. https://www.fs.usda.gov/detail/ctnf/landmanagement/planning/?cid=stelprdb5228906 Accessed January 21, 2023.

for the project proponents to acknowledge they may occasionally travel through the project or analysis area but will move around the periphery of the disturbance by way of other available habitat. While the project proponents, including the agencies, also acknowledge this area is part of the linkage area designated by the CNF and FWS, the habitat integrity of that area lynx are supposed to be able to access is never analyzed in terms of functionality for lynx. The CNF RFP linkage criteria lack any force or definition related to lynx habitat components, connectivity, or snowshoe hare needs.

What is lacking are adequate regulatory and land use planning criteria that require agencies such as the Forest Service and BLM to fully analyze and correct habitat fragmentation. In the following comments, we provide a summation of this Y2UConn as linkage habitat and an analysis of the failure of data interpretation, regulation and planning criteria to provide habitat and connectivity for lynx.

After years of providing input and analysis, the CNF remains unable or unwilling to fully analyze and implement habitat protection criteria for this linkage area, while consultations with U.S. Fish and Wildlife Service (FWS) are lacking in detail with FWS approving project after project without requiring any systematic and detailed analysis of lynx habitat functionality or connectivity. The 2017 FWS Species Status Assessment (SSA) continues to deflect to Forest Planning as protective of lynx and its habitat without providing any evidence this is the case.[2] While we expect the FWS is familiar with the principal documents relating to protection of lynx habitat, in the following, we briefly outline and comment on these as it is a good reminder of the state of knowledge and absence of effective regulation pertaining to lynx and its protection.

Dr. John Carter, Ecologist, and founder of the Yellowstone to Uintas Connection and Kiesha's Preserve, a wildlife preserve in the Y2UConn in SE Idaho, prepared these comments for input to the current Canada Lynx Species Status Assessment. Dr. Kirk Robinson, founder of the Western Wildlife Conservancy, has worked on this Regional Corridor and carnivore ecology for many years and assisted with input on the logic of lynx occupancy in Colorado and Utah.[3] The comments were reviewed by Dr. Barrie Gilbert, (retired) Utah State University.[4]

Respectfully,

John Carter, PhD Ecology
Yellowstone to Uintas Connection
Kiesha's Preserve
PO Box 363
Paris, Idaho 83261

[2] U.S. Fish and Wildlife Service. 2017. Species Status Assessment for the Canada lynx (Lynx canadensis) Contiguous United States Distinct Population Segment. Version 1.0, October, 2017. Lakewood, Colorado.
[3] Kirk Robinson, J.D., PhD Philosophy. Founder and current Executive Director of Western Wildlife Conservancy. https://westernwildlifeconservancy.org/mission-vision/ Accessed on January 24, 2023.
[4] Barrie K. Gilbert PhD, Department of Wildland Resources, (senior scientist retired), Utah State University, Logan Utah. Dr. Gilbert is a behavioral ecologist and recent author of One of Us: A Biologist's Walk Among Bears.

ABSTRACT

These comments provide a brief review of the regulatory history and science involved in the ESA listing for Canada lynx and subsequent land management on National Forests. The review reveals that much of the science is misinterpreted to favor human activities that degrade and fragment lynx habitat, while absence of evidence due to lack of studies is used to claim these activities either have little effect or in the case of timber manipulations, can even be beneficial. A review of the NRLMD and its application in linkage and peripheral areas as incorporated into Forest planning uses the Caribou NF as an example. The NRLMD provides limited guidance and protection to the Caribou NF as it is deemed "unoccupied" by lynx. This is in spite of evidence that lynx persisted in the area of the CNF over historical times. This "unoccupied" status results from failing to find current evidence of lynx long after habitats have been fragmented by mines, high road density, an explosion in motorized recreation accessing nearly every acre of land, timber projects and including habitat alteration by livestock grazing. The CNF Forest Plan includes recognition of lynx linkage, but the provisions in that plan for linkage habitat lack adequate quantification and standards.

Noting that there is a lack of emphasis on landscape connections between core areas of the DPS, analysis and mapping is provided showing the existence of long recognized regional wildlife corridors. A principal corridor is the Yellowstone to Uintas Connection linking the GYA to the Uinta Mountains and Colorado by passing through SE Idaho from lynx critical habitat in Wyoming. This is the most continuous high elevation, forested corridor making these connections. It also aligns with the CNF linkage to other areas. Protection and restoration of this and other corridors is essential to promote lynx connectivity and sustain meta-populations.

This review shows that regulatory mechanisms are inadequate to protect lynx habitat and connectivity. Monitoring of snowshoe hare habitat and populations as well as lynx presence in these southern areas of the DPS is lacking. While some habitat mapping and modeling has been done, it is not being applied or expanded to identify and describe in sufficient detail the habitats and migration corridors needed for lynx to persist. Land management plans must be updated and amended to provide data-based criteria and quantitative standards to ensure habitat for lynx and snowshoe hare are connected and functional.

REGULATORY ISSUES

The Programmatic Lynx BA. Canada lynx were listed as a Threatened species under the Endangered Species Act (ESA). In December 1999, the Forest Service and Bureau of Land Management completed their "Biological Assessment of The Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada

Lynx" (Programmatic Lynx BA).[5] The Programmatic Lynx BA concluded that the current programmatic land management plans *"may affect, and are likely to adversely affect, the subject population of Canada lynx."* The Lynx BA team recommended amending or revising Forest Plans to incorporate conservation measures that would reduce or eliminate the identified adverse effects on lynx. The Programmatic Lynx BA's determination means that Forest Plan implementation is a *"taking"* of lynx and makes Section 7 formal consultation on the land management plans (LMPs) mandatory, before actions are approved. The Lynx BA *"likely to adversely affect"* conclusion was based on the rationale that land use plans within the Northern Rockies have inadequacies, including:

1. Aggressive fire suppression may limit the availability of foraging habitat.
2. Allow levels of human access via forest roads that may risk incidental trapping, shooting, or access by competing carnivores.
3. Weak in guidance for new or existing recreation developments.
4. Allow mechanized and non-mechanized recreation that may pose a risk, by allowing compacted snow trails and plowed roads that facilitate competitors and predators.
5. Weak direction for maintaining habitat connectivity.
6. Weak in direction for coordinating management activities with adjacent ownerships to assure consistent management of lynx habitat across the landscape.
7. Fail to provide monitoring of lynx, snowshoe hares, and their habitats, making the detection and assessment of adverse effects from other management activities difficult or impossible to attain.
8. Forest management has resulted in a reduction of the area in which natural ecological processes were historically allowed to operate, thereby increasing the area potentially affected by known risk factors to lynx. The Plans have continued this trend. The Plans have also continued the process of fragmenting habitat and reducing its quality and quantity. Consequently, plans may risk adversely affecting lynx by potentially contributing to a reduction in the geographic range of the species.
9. Plan revisions are needed to incorporate conservation measures included in the Canada Lynx Conservation Assessment and Strategy.[6]

The LCAS *"was developed to provide a consistent and effective approach to conserve Canada lynx on federal lands in the conterminous United States. The USDA Forest Service, USDI Bureau of Land Management, and USDI Fish and Wildlife Service initiated the Lynx Conservation Strategy Action Plan in spring of 1998."* The LCAS was published shortly after the Canada lynx was listed as Threatened under the ESA. Risk Factors from the LCAS (2000) include:

[5] USDA Forest Service and DOI Bureau of Land Management.1999. Biological Assessment of the Effects of National Forest Land and Resource Management Plans and Bureau of Land Management Land Use Plans on Canada lynx.
[6] Ruediger et al. 2000. Canada Lynx Conservation Assessment and Strategy. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Forest Service Publication #R1-00-53, Missoula, MT. 142 pp.

1. Timber harvest and pre-commercial thinning that reduce denning or foraging habitat or convert habitat to less desirable tree species.
2. Fire exclusion changing the vegetation mosaic maintained by natural disturbance processes.
3. Grazing by livestock that reduces forage for prey.
4. Roads and winter recreation trails that facilitate access to historical lynx habitat by competitors.
5. Incidental trapping and shooting.
6. Predation.
7. Being hit by vehicles.
8. Obstructions to movement such as highways and private land developments.

All of these factors continue to operate within the National Forests and BLM lands within and surrounding the Y2UConn. They are not effectively addressed while degradation and fragmentation of habitat continues. Monitoring of these activities is minimal to non-existent.

Northern Rockies Lynx Management Direction. We reviewed the Northern Rockies Lynx Management Direction (NRLMD).[7] This direction *"applies to mapped lynx habitat on National Forest System land presently occupied by lynx, as defined by the Amended Lynx Conservation Agreement (CA)[8] between the Forest Service and FWS…When National Forests are designing management actions in unoccupied mapped lynx habitat they should consider the lynx direction, especially the direction regarding linkage habitat."* (NRMLD p1). [Emphasis added]. The FEIS for the NRLMD provided a map for the Northern Rockies Lynx Planning Area which is inserted as Figure 1. The CA provided this, *"As recommended in the LCAS, appropriate actions, including research, administrative studies, or monitoring, will be taken to verify the effectiveness of the lynx conservation measures."* (CA p7). We have seen none of these monitoring or other studies that have addressed effectiveness of lynx conservation measures, while monitoring of lynx and snowshoe hare occurrence and populations in the DPS is lacking.

In the NRMLD (p3) there is reference to a FWS *"Clarification of Findings"* in a Remand Notice which basically explains away most forest activities as impacting lynx or lynx habitat, i.e. a *"threat"* to lynx. The NRMLD puts it this way:

> *After the LCAS was issued the FWS published a Clarification of Findings in the Federal Register (FEIS, Vol. 1, Appendix P), commonly referred to as the Remand Notice. In the Remand Notice the FWS states, "We found no evidence that some activities, such as forest roads, pose a threat to lynx. Some of the activities suggested, such as mining and grazing, were not specifically addressed [in the Remand Notice] because we have no information to indicate they pose threats to lynx" (p. 40083).*
>
> *Further on in the Remand Notice they state, "Because no evidence has been provided that packed snowtrails facilitate competition to a level that negatively*

[7] USDA Forest Service. 2007. National Forests in Montana, and parts of Idaho, Wyoming, and Utah. Northern Rockies Lynx Management Direction Record of Decision.
[8] USDA Forest Service and USDOI Fish and Wildlife Service. 2006. Canada Lynx Conservation Agreement. USFS Agreement #OO-MU-11015600-0 13.

affects lynx, we do not consider packed snowtrails to be a threat to lynx at this time" (p. 40098).

In regards to timber harvest the FWS states, "Timber harvesting can be beneficial, benign, or detrimental to lynx depending on harvest methods, spatial and temporal specifications, and the inherent vegetation potential of the site. Forest practices in lynx habitat that result in or retain a dense understory provide good snowshoe hare habitat that in turn provides good foraging habitat for lynx" (p. 40083).

These findings by FWS narrow the focus from the concerns first published in the LCAS (discussed above) about what management direction is needed to maintain or improve Canada lynx habitat. We considered this information in the development of the selected alternative, and in our decision.

So, in one fell swoop, FWS and then the USFS thru the NRMLD adopted guidance that removes the majority of Forest Service actions or permitted activities from consideration as impacting lynx. We are to believe that lack of evidence is proof these activities have no impact on lynx or their habitat. Yet, the scientists who published the Science Report[9] which was used as the basis for the NRLMD had determined these activities adversely affect lynx and lynx habitat.

What we have observed is a gradual easing of requirements and population status of lynx over the years. Absence of lynx in SE Idaho is a foregone conclusion if you manage them out of existence by denying their presence thru history then deny impacts from logging, snowmobiles across the landscape, off road vehicles speeding thru forest roads, and that *"mining and grazing, because they were not specifically addressed … because we have no information to indicate they pose threats to lynx."* In this way, the agencies have relieved themselves of most responsibility to maintain or restore lynx, its habitat, and connectivity. We have reviewed the Science Report and find that the information in that report does not say roads, snowmobiles, timber harvest, mines and grazing do not impact lynx or lynx habitat. We discuss these as part of the narrative below.

Further in the NRLMD there are clarifying statements such as that standards and guidelines only apply to occupied habitat, while they can be considered for unoccupied habitats. (NRLMD p6). Regarding vegetation management direction, it *"conserves the most important component of lynx habitat: a mosaic of early, mature, and late successional stage forests, with high levels of horizontal cover and structure."* (NRLMD p21). The objectives, standards and guidelines do not *"apply to linkage areas"*. (NRLMD Att 1 p2). Livestock grazing *"may reduce or eliminate foraging habitat in areas that grow quaking aspen and willow in riparian areas….These localized changes in habitat may affect individual lynx; however, no information indicates grazing poses a threat to overall lynx populations…"* (NRLMD p21). Livestock management

[9] Ruggiero, Leonard F.; Aubry, Keith B.; Buskirk, Steven W.; Koehler, Gary M.; Krebs, Charles J.;McKelvey, Kevin S.; Squires, John R. 2000.. Ecology and conservation of lynx in the United States. General Technical Report RMRS-GTR-30WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. https://www.fs.usda.gov/research/treesearch/50623 Accessed on January 21, 2023.

objectives and guidelines do not apply to linkage areas. (NRLMD Att 1 p5). Over snow recreation *"Emphasizes not expanding snow compacting human uses into non-compacted areas."* Guideline G11 *"discourages the expansion of designated over-the-snow routes and play areas into uncompacted areas." "An alternative to drop all direction limiting snow compaction was not developed in detail because there is evidence competing predators use packed trails, suggesting a potential effect on individual lynx."* (NRLMD p23). Mineral and Energy Standard does not apply to linkage habitat. (NRMLD Att1 p5).

As these statements make clear, lynx habitat, including linkage areas have virtually no protections, standards, or guidelines under the NRLMD. While it does acknowledge that there is evidence of lynx competitors using packed snow trails it does not address landscape level snow machine access, the increase in motorized recreation with fast, high-powered machines, and landscape-level use such as occurs in 97% of the CNF since the Science Report data and information was assembled. A recent paper by Olson et al (2018)[10] acknowledges that lynx avoid areas of ski resort development and they altered their behavior to spend less time in areas of motorized recreation or used them at night when there was less use. The Forest Service Rocky Mountain Research Station has said, *"Lynx appear to have an upper threshold of recreation intensity which they can tolerate, and above this level, lynx may be less able to coexist. Managers, then, should keep in mind that developed or dispersed areas with very high use may displace lynx from habitat."*[11] We note that the phosphate mines in SE Idaho operate 24 hours per day, 7 days per week for up to 30 years at an individual mine with some 400 blasts of explosives each week at each mine.[12] Haul roads further fragment the habitat, operating continuously.

Since these studies used in the Science Report, three decades have passed with ever increasing snowmobile and off-road vehicle use. A report by Winter Wildlands Alliance for USDA noted that snowmobile use more than doubled between the early 1980s and 2004.[13] Cross-country skiing and snowshoeing experienced a similar increase. In the 1990s more powerful snow machines made access available to *"dominate terrain only accessible by backcountry skis or snowshoes."* High-marking and acrobatics are common in areas previously inaccessible. Highmarking is the "*recreational maneuver of attempting to reach the highest point of a snow-covered feature such as a mountain, on a snowmobile.*"[14] Groomed trails now are over 20,000 miles in the 11 Western Snow Belt States. Today, there are 1.3 million registered snowmobiles in the US and 601,000 in Canada.[15] As acknowledged above, this increased access allows

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[10] Olson, L.E.; Squires, J.R.; Roberts, E.K.; Ivan, J.S.; Hebblewhite, M. 2018. Sharing the same slope: Behavioral responses of Canada lynx to winter recreation. Ecology and Evolution. 1-18.
[11] USDA RMRS. 2023. Winter Sports and wildlife: Can Canada lynx and winter recreation share the same slope? https://www.fs.usda.gov/rmrs/winter-sports-and-wildlife-can-canada-lynx-and-winter-recreation-share-same-slope Accessed on January 16, 2023.
[12] USDA and DOI. 2019. Final Environmental Impact Statement Proposed Dairy Syncline Mine and Reclamation Plan. https://app.box.com/s/jmod5pcq1txhv4wmply3oxuazlm16tau Accessed on January 16, 2023.
[13] Winter Wildlands Alliance. 2006. Winter Recreation on Western National Forest Lands. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd528883.pdf Accessed on January 16, 2023
[14]https://en.wikipedia.org/wiki/Highmarking
[15] ISMA. 2022. Snowmobiling Fact Book. https://www.snowmobile.org/docs/isma-snowmobiling-fact-book.pdf Accessed on January 17, 2023.

trapping and hound hunting to occur across the landscape. In Idaho there were 1,830 trapping licenses issued for the 2017 - 2018 season[16], up from 638 in the 1995-1996 season.[17]

We looked up some brief history of ATV and UTVs. These come from industry websites. The first four wheeled atv was produced in 1982 by Suzuki.[18] This quickly turned to an emphasis on speed in 1987 with a model that could attain almost 80 mph. *"Naturally, as high-performance ATVs gained popularity, Quad Racing and ATV Motocross enjoyed massive growth and exposure in the late 1980s."* The first UTV, the Kawasaki Mule was introduced in the late 1980s.[19] A racing emphasis came about with the introduction of the Polaris RZR in 2007. Today, sales of these vehicles are around 800,000 annually with about half in the US. This is an estimate, since in many states they are not registered.[20]

The point of this is that there are millions of snowmobiles, atvs, utvs, and dirt bikes in the US today. Add to this the pickup truck and SUV market with their TV commercials emphasizing the backcountry and off-roading. These were present only minimally during the time of most of the studies in the Science Report. The implication of this is that conclusions about forest roads and snowtrails are out the window today since these are loud, fast, and powerful machines capable of accessing most terrain and are present in large numbers. For instance, in 2017, we funded a research project at Kiesha's Preserve to evaluate traffic on a CNF Forest access road in SE Idaho. Over 300 vehicles per day were using the road with many traveling at high rates of speed.[21] Sound levels were over 100 DbC. In winter, snowmobiles were creating noise levels of over 100 DbC. These roads today are not quiet, low frequency roads, but as we like to say, they have become an analog to a motocross where there is no enforcement of speed, noise or even checking registrations. How are lynx to occupy an area with this level of disturbance?

The Conservation Agreement (CA). addresses its scientific basis as:

> *In March of 1998, an interagency lynx coordination effort was initiated in response to the emerging awareness of the uncertain status of lynx populations and habitat in the conterminous United States and the onset of the listing process. The U.S. Fish and Wildlife Service (FWS), USDA Forest Service (FS), Bureau of Land Management (BLM), and the National Park Service (NPS) have participated in this effort. Three products important to the conservation of lynx on federally managed lands have been produced through this effort: (1) "The*

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[16] IDFG. 2018. Idaho Department of Fish and Game Furbearer. https://collaboration.idfg.idaho.gov/WildlifeTechnicalReports/Furbearer%20Statewide%20FY2018.pdf Accessed on January 16, 2023.
[17] Melquist, W.E. 1997. Idaho Department of Fish and Game Furbearers Study III, Job 1. https://collaboration.idfg.idaho.gov/WildlifeTechnicalReports/Furbearer%20PR94.pdf Accessed on January 16, 2023.
[18] https://www.hqpowersports.com/blog/history-of-the-modern-atv-and-utv/ Accessed on January 17, 2023.
[19] https://shocktherapyst.com/blog/a-brief-history-of-utvs/ Accessed on January 17, 2023.
[20] https://www.motorcyclesdata.com/2022/12/27/all-terrain-vehicles/ Accessed on January 17,2023.
[21] Unpublished data. 2017. Utah State University in Association with Kiesha's Preserve.

Scientific Basis for Lynx Conservation" (Ruggiero et. al. 2000)[22]*, hereafter referred to as the "Science Report"; the Lynx Conservation Assessment and Strategy (LCAS); and this Lynx Conservation Agreement (CA). Several States within the range of the lynx have contributed to this effort through interactions with participants and review of draft products.*

The Science Report, prepared by an international team of experts in lynx biology and ecology, is a compendium and interpretation of current scientific knowledge about the Canada lynx, its primary prey and habitat relationships. This document serves as an important scientific reference for the various lynx activities of the cooperating Federal Agencies.

The LCAS builds upon this scientific base and identifies the risks to the species that may occur as a result of federal land management. It recommends conservation measures that could be taken to remove or minimize the identified risks. It was developed to provide a consistent and effective approach to conservation of Canada lynx on federal lands in the conterminous United States.

The LCAS and Science Report constituted the best available knowledge and were incorporated into the CA. The Science Report (p12) addressed uncertainty by suggesting that *"the burden of proof be shifted so that uncertainty favors, or at least is not destructive to conservation…"*. As we pointed out above, the LCAS identified risk factors, which are now excluded by the NRLMD and Remand Notice. These exclusions have arbitrarily discounted nearly all activities as affecting lynx and lynx habitat. Lack of regulatory mechanisms was identified as a cause in the listing notice (FR Vol 65 No 58 p16052) stated as,

The contiguous U.S. Distinct Population Segment of the lynx is threatened by the inadequacy of existing regulatory mechanisms. Current U.S. Forest Service Land and Resource Management Plans include programs, practices, and activities within the authority and jurisdiction of Federal land management agencies that may threaten lynx or lynx habitat. The lack of protection for lynx in these Plans render them inadequate to protect the species.

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[22] Ruggiero, Leonard F.; Aubry, Keith B.; Buskirk, Steven W.; Koehler, Gary M.; Krebs, Charles J.;McKelvey, Kevin S.; Squires, John R. 2000.. Ecology and conservation of lynx in the United States. General Technical Report RMRS-GTR-30WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Available at: http://www.fs.fed.us/rm/pubs/rmrs_gtr030.html

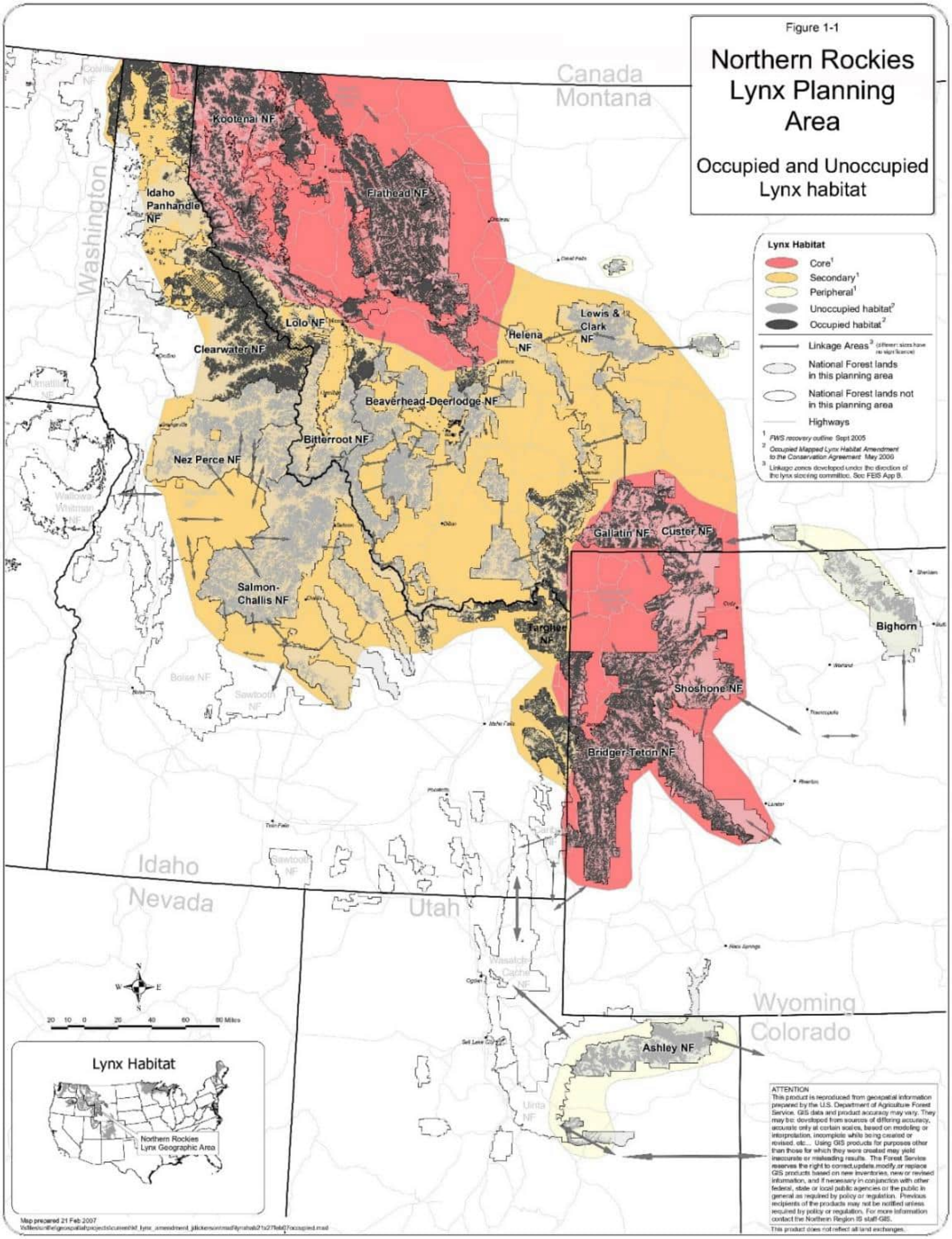

Figure 1. Map of Lynx Habitats from the FEIS for the NRLMD

The Science Report (SR) addresses fragmentation as *"reduction of total area, increased isolation of patches, and reduced connectedness among patches or natural vegetation…"* (SR p84*).* *"habitat fragmentation is the most serious threat to biological diversity and is the primary cause of the present extinction crisis."* (SR p85). *"rare species associated with wilderness, such as the lynx, generally are considered most susceptible to fragmentation."* (SR p86). *"generalist predators tend to dominate the predator guild in fragmented landscapes."* (SR p86). Coyotes and lynxes are separated by snow conditions, but *"this separation may break down where human modifications to the environment increase access by coyotes to deep snow areas. Such modifications include expanded forest openings throughout the range of lynx in which snow may be drifted, and increased snowmobile use in western mountains. Recreational snowmobile use has expanded dramatically in the United States in the past 25 years, with hundreds of thousands of km of trails (>19,000 km of groomed trails in Maine alone) within the pre-settlement range of the lynx…"* (SR p94). *"Fragmentation of habitats occupied by lynx (including increased openings, higher road densities, exurban residential development, and wider use of snowmobiles and devices that compact snow in areas with deep, soft snow) is a plausible mechanism for the questionable conservation status of the lynx in the contiguous United States."* (SR p95).

The data and information included in the Science Report had mostly been generated by the early 1990s, much in the 1970s and 1980s. The studies describing road density and snowmobile effects were very limited. The single study in the Science Report (p308) was based on data from the 1980s and stated that *"Road densities had no significant effect on habitat selection, and lynx crossed roads at frequencies that did not differ from expectation."* There was no data on use of these roads by vehicles in summer or snowmobiles in winter. Road density averaged 1.28 miles/sq.mi. As noted above, snowmobile use was expanding. The Science Report (p391) noted that *"Roads in the study area were of primitive standards that received little use in summer but were frequently used by snowmobilers in winter."* The Science Report (p295) said, *"Snowmobiles became readily available in the late 1950s and early 1960s, likely influencing trapper coverage, access, and attitudes."* Science Report (p391*), "Although legal harvest is no longer a conservation concern, human-caused mortality is believed to be additive in the low-density lynx populations characteristic of southern boreal forests (Koehler 1990; Table 13.3). If so, illegal or incidental harvest could significantly reduce population numbers of lynx in southern regions."*

2017 Species Status Assessment (SSA). The USFWS published a species status assessment (SSA)[23] for Canada lynx in 2017. The SSA recognized the lack of regulatory mechanisms was the reason for listing. (SSA p1). It stated:

> Factors affecting lynx that were evaluated in the SSA *"include the adequacy of existing regulatory mechanisms (the factor for which the DPS was listed); climate change, vegetation management, wildland fire management, and habitat loss and fragmentation (the factors considered by the Interagency Lynx Biology Team [ILBT] to have the potential to exert population-level effects on the DPS); and other factors that could influence the continued ability of particular geographic units to support resident lynx."* (SSA p3).

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[23] U.S. Fish and Wildlife Service. 2017. Species Status Assessment for the Canada lynx (Lynx canadensis) Contiguous United States Distinct Population Segment. Version 1.0, October, 2017. Lakewood, Colorado.

> *"The lack of regulations protecting lynx habitat from potential threats on Federal lands at the time of listing has been largely addressed by formal and binding amendments or revisions to most Federal land management plans within the DPS range. Although uncertainty remains about the efficacy of this improved regulatory framework, Federal lands are now being managed specifically to protect and restore lynx habitats, with the goal of supporting continued lynx presence on these lands."* (SSA p231).

This last statement is incredibly dismissive of the main cause of lynx habitat degradation, lack of adequate regulation, and instead, dismisses almost all actions that the Science Report acknowledged adversely affect lynx and lynx habitat. We searched online for evidence that the CNF has adopted the NRLMD or provided any Forest Plan amendments for lynx protection. There were none to be found. Y2U sent a letter to Mel Bolling, Forest Supervisor of the Caribou Targhee NF (CTNF) requesting updated analysis of the lynx status in the CTNF, including its historical occurrence, migration corridors and connections between habitats. The letter outlined our desired analysis and mapping to include human fragmentation and historical lynx habitat use.[24] The response from Mr. Bolling explained the current situation in the CTNF.[25]

Mr. Bolling explained some of the history of the lynx listing, the Science Report, LCAS and the 2013 revision of the LCAS which is now considered the primary guidance for land management agencies. His letter pointed out that the Targhee NF RFP was amended by the NRLMD in 2007. A National Lynx Survey was conducted on both the Forests in 1999 and determined that the Targhee NF met criteria for management as an occupied forest, but the Caribou did not. Therefore, the Caribou NF was not subject to the NRLMD and *"No LAU's or lynx habitat is mapped on the Caribou due to the designation of the Caribou NF as an unoccupied forest in 2002."* (p2). The conservation measures in the CNF RFP were *"deemed sufficient: by the USFWS through consultation on the RFP Biological Assessment to address threats to Canada lynx and provide regulatory mechanisms to ensure the continued persistence of Canada lynx on the Caribou National Forest."* Under this arrangement, therefore it appears that the provisions of the CNF RFP would be central to analysis of lynx habitat because other protections are dismissed due to what appears to be an arbitrarily determined occupancy status that ignored historical lynx observations and only relied on absence determined by the National Lynx Survey in 1999 which occurred long after historical reported occupancy. We address this further on.

Mr. Bolling's response included reference to a paper by Olson et al (2021)[26] which used lynx observations in the west, climate, and human induced factors to model lynx habitat. Using lynx GPS and tracking data from Idaho, Wyoming, Montana, Washington, and British Columbia, the study found that lynx habitat is made up of a complex array of environmental conditions, not primarily vegetation type and elevations as currently mapped. They included an index of

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[24] Carter, J., Garrity, M., Johnson, S., and Fite, K. 2021. Request for Response on Lynx Analysis in the CTNF. Letter on behalf of Yellowstone to Uintas Connection, Native Ecosystems Council, Alliance for the Wild Rockies, and Wildlands Defense. Dated August 15, 2021.

[25] Bolling, M. 2021. Response to letter requesting information on Canada lynx. Dated September 13, 2021.

[26] Olson et al. 2021. Improved prediction of Canada lynx distribution through regional model transferability and data efficiency. Ecology and Evolution 11:1667 – 1690.

summer vegetation production, percentage of tree cover, road density and night light intensity as indices of anthropogenic influences. One confounding issue is their assumption of boreal forest soil pH as a factor due to the wetter conditions in boreal forests. However, we know lynx use a variety of forested types and this factor might disqualify habitats unnecessarily. The model provides insight and a basis for more detailed analysis of lynx potential habitat and its fragmentation within the linkage in SE Idaho in the CTNF. We have included an Olson et al map from that paper as Figure 2 below. It illustrates a high probability of suitable lynx habitat in SE Idaho and the CNF. So, by this model, lynx habitat is present in SE Idaho. Why are there no lynx here? It is up to the FWS in its current Species Status Assessment and review to determine this.

Our review of the 2017 SSA finds a tenor of finding continued habitat fragmentation and degradation as unimportant to persistence of lynx, while only implicating climate change as problematic. But climate change is superimposed on all the existing insults to habitat and heightens their importance in the decline of lynx and lynx habitat. For example, the SSA contends that lynx only occurred in Colorado during *"irruptions from Canada…in the early 1960s and 1970s"* concluding that there is doubt that the population in Colorado *"will receive the demographic and genetic support from the north that is thought to be important to the DPS populations."* (p227).

There are two competing hypotheses operating regarding lynx presence in Colorado.

> H1. Lynx had been present in the Southern Rockies (south of Idaho-Wyoming) in a self-sustaining population for millennia but were slowly extirpated as a result of human activities, including trapping and livestock grazing, from early 19th century through mid-20th century.
>
> H2. The presence of lynx in the Southern Rockies in the 19th and 20th centuries prior to lynx reintroduction into the San Juan Mountains, was due mostly or entirely to periodic influxes of lynx from Canada.

Two bodies of evidence (I & II) support H1 as the correct hypothesis.

> I. There is a general lack of evidence of lynx population cycles in Canada being correlated with lynx population dynamics in the U.S., let alone in Colorado. The Science Report (p242) comments on the immigration hypothesis.
>
> *"In the Canadian provinces, Alaska, Montana, and Washington, we know that there are local reproductive populations, knowledge that invalidates a pure immigration hypothesis. For these areas, we can only state that they appear to be a part of a population in which lagged synchronous dynamics occur. Because we do not know why these dynamics occur, we cannot say to what extent they are affected by changes in local dynamics and the role that immigration might play.*
>
> *. . . the lack of lynx occurrence records associated with a large population peak occurring in the central provinces during the early 1980s. This population peak*

was higher than any recorded in the 20th century prior to 1959, but there was no evidence from museum specimens, verified mortality records, or anecdotal observations that unusual numbers of lynx occurred in any portion of its range in the contiguous United States."

II. Since lynx reintroductions in Colorado, lynx have reproduced and become established there. Prognostications of the eventual disappearance of lynx from Colorado are speculative and have nothing to do with whether Colorado was or is capable of supporting a self-sustaining population of lynx.

The Science Report in describing the population cycles made this observation regarding the Minnesota population: *"a three-year lag with data from the south-central Canadian provinces resulted in a strong correlation for the most recent period (r = 0.73, 1960-1983) but the pattern is out of phase in the previous 26 years… ."* (SR p238). We note that lynx were present in the DPS during large blocks of time other than in the 1960s and 1970s.

The 2013 LCAS. We reviewed the 2013 LCAS.[27] It emphasizes protection of core areas which support persistent lynx populations and *"less stringent protection and greater flexibility in secondary/peripheral areas…"* (p2). The only conservation measures provided for these peripheral areas were for vegetation management, which are general and unenforceable statements such as *"Vegetation treatments should be designed with consideration of historical landscape patterns and disturbance processes. Design timber harvest, planting, and thinning to include some representation of young densely stocked regenerating stands in the mosaic for snowshoe hare production areas"* (p95). The 2013 LCAS provided conservation measures for core areas and stated that projects *"must be consistent with the management direction contained in the forest plan."* (p89). This would mean the analysis would be consistent with the CNF RFP and its FEIS. Conservation measures for core areas included (only examples cited, for full list see the LCAS):

1. Delineate LAUs (p89)
2. Vegetation management (includes several measures including landscape evaluation to identify opportunities for adaptation to climate change). (p89)
3. Wildland fire management (p93)
4. Habitat fragmentation (promote or retain large contiguous blocks of lynx habitat, identify linkage areas to maintain connectivity, minimize large scale development, and others (p93)
5. Recreation management (direct recreational activities away from identified linkage areas (p94).
6. Minerals and energy (locate facilities and roads outside of lynx habitat and linkage areas where possible) (p95)
7. Backcountry roads and trails (Avoid Road reconstruction and upgrades that substantially increase speeds) (p95).
8. Livestock grazing (manage in riparian areas to maintain snowshoe hares) (p95).

[27] Interagency Lynx Biology Team. 2013. Canada lynx conservation assessment and strategy. 3rd edition. USDA Forest Service, USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Forest Service Publication R1-13-19, Missoula, MT. 128 pp.

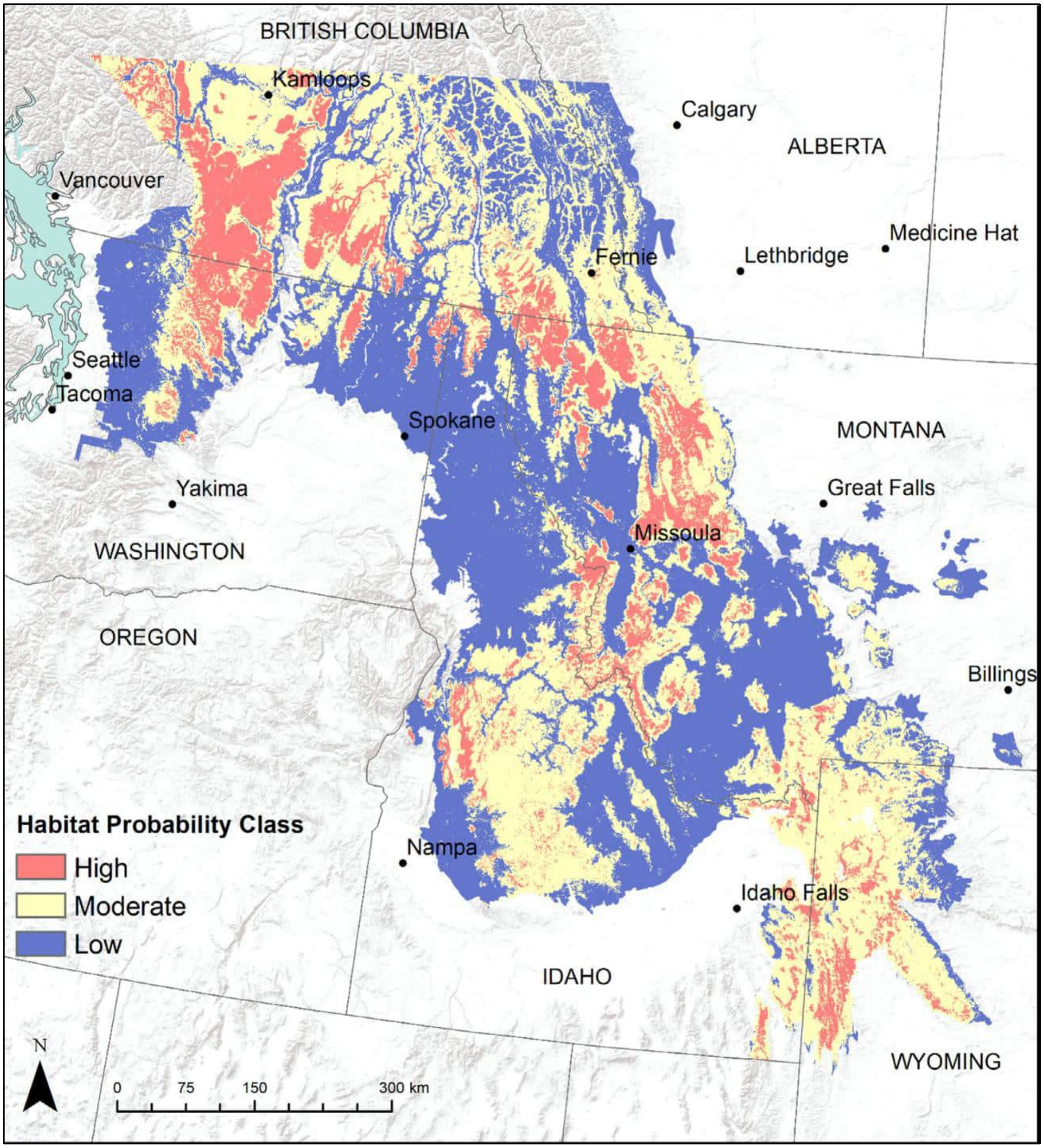

Figure 2. Prediction of Canada Lynx Habitat Probability from Olson et al 2021.

In the past two years we have seen several National Forests, the Caribou Targhee NF, the Ashley NF come out with prescribed fire and other forest manipulations that cover most, if not all, of the acreage within those Forests. These add up to nearly 2 million acres. This is happening across the West.

We have included Figure 3.1 from the 2013 LCAS here as Figure 3. That map does not show any linkage habitat. While it refers to the USFWS Recovery outline, there is no analysis of how to recover lynx. The 2013 LCAS does address factors that compromise lynx habitat and movement under the umbrella of *"anthropogenic influences"*(p68). It admits that not every human activity has been examined, but groups the activities into two tiers that can negatively affect lynx populations and habitat. The specialization of lynx on snowshoe hares and lynx *"low densities and in small populations throughout their range in the contiguous United States .. increase their susceptibility to local extirpations."* (p68). First tier factors include climate change, vegetation management, wildland fire and habitat fragmentation *"can directly effect (sic) both snowshoe hare and lynx population dynamics."* (p68).

"Federal agencies have amended or revised land management plans across much of the range of the lynx to provide direction to conserve lynx and lynx habitat. Thus, the impacts of anthropogenic influences have been substantially reduced." (LCAS p68). The Caribou NF has not demonstrated that its RFP has *"conserved lynx and lynx habitat"* or reduced *"anthropogenic influences"* while continuing to propose and approve projects across the CNF, including phosphate mines, timber and prescribed fire, and off-road vehicle trails. In no case have lynx protections or criteria been invoked or analyzed and no habitat analysis of the linkage capability has been performed, and in every case when consulted, the FWS has signed off on these projects. FWS must do a better review of these projects and their implications to lynx habitat, including requiring that land management agencies conduct the proper monitoring, quantitative habitat descriptions and analysis of habitat structure and function prior to approving future projects.

The 2013 LCAS describes how these first-tier factors affect lynx and lynx habitat. Climate change is a factor which is overriding other impacts and can cause shifts in distribution, changes in snowshoe hare cycles, reduction in lynx habitat and population, among other outcomes. (LCAS p69). Vegetation management alters stand structure, composition and arrangement and occurs across the range of the lynx. (LCAS p71). Wildland fire management can result in similar alterations. (LCAS p76). Habitat fragmentation, *"accentuates the viability risk inherent in a small population and increases its vulnerability to local extirpation."* (LCAS p76). Examples of fragmentation include, *"removal of forest cover, development of highways and associated infrastructure, and intensive minerals or energy development…"* (LCAS p77). Vehicle collisions are a factor in mortality. Here, the LCAS admits these activities have inherent risk to viability for small populations. In a direct contradiction to the Remand Notice, here *"intensive minerals development"* is a factor fragmenting habitats, yet this is excluded from any standards in the NRLMD for linkage habitats.

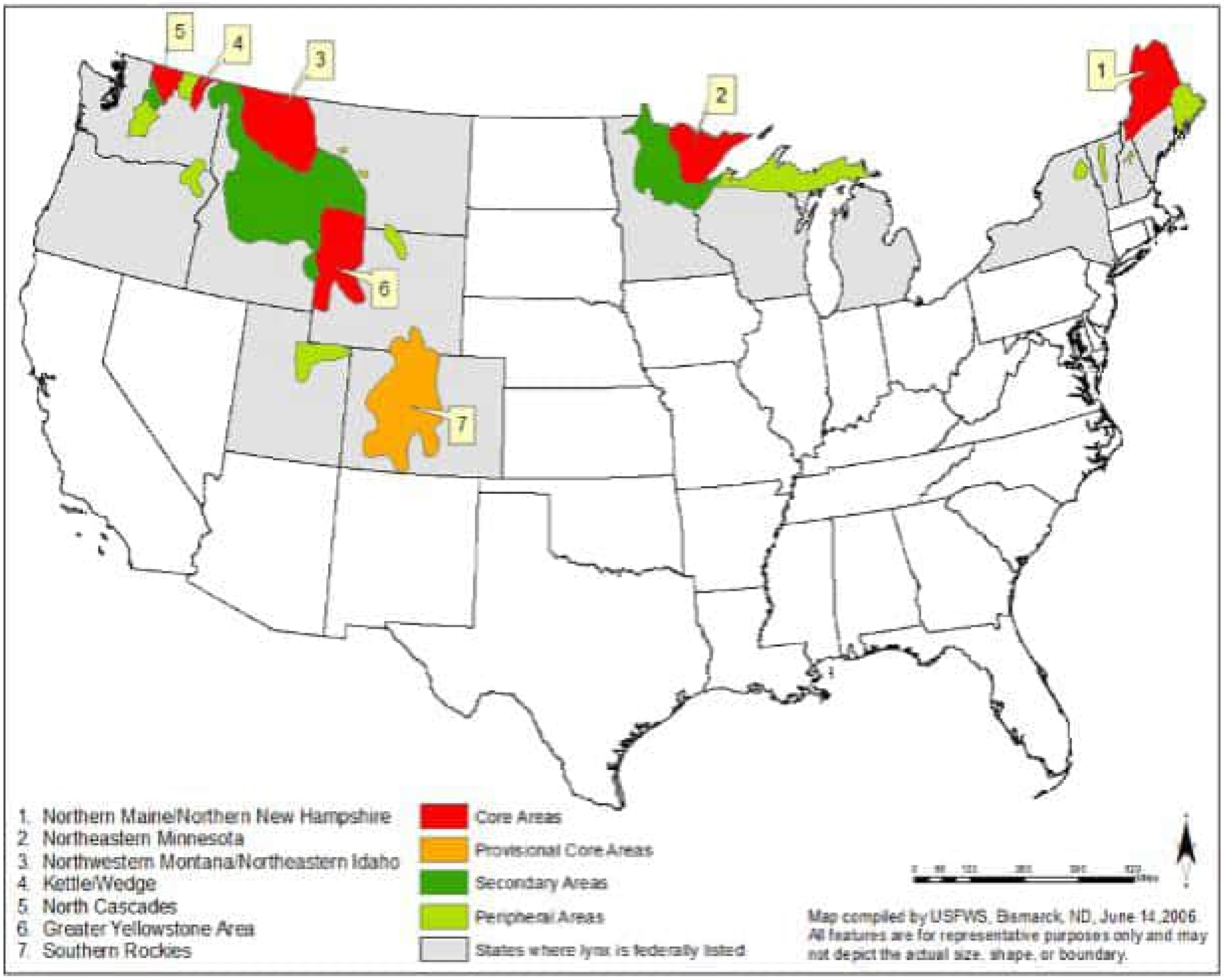

Figure 3. Taken from the LCAS Figure 3.1. Areas identified as core, secondary, and peripheral as depicted in the Canada Lynx Recovery Outline across the states where the lynx is listed (U.S. Fish and Wildlife Service 2005)

The second tier of anthropogenic influences include incidental trapping with rates of trapping *"positively related to average pelt value and appeared additive to nontrapping mortality."* (LCAS p79). It *"can occur in areas where regulated trapping for other species…overlaps with lynx habitats."* (LCAS p79). *"No conservation measures to address incidental trapping are included … because trapping is regulated by the states."* (LCAS p80). Idaho allows trapping of numerous species, hound pursuit and with snowmobile access and groomed trails, winter access is available throughout the CNF. Previously we have noted the increase in trapping licenses in Idaho. This effect is dismissed from consideration.

Recreation is noted to be increasing with millions of participants. (LCAS p80). The data reported in the LCAS is pre-2009. Recreation effects include habitat loss from construction of developed areas, disturbance from human presence with examples of den abandonment, use of compacted trails in the snow by competitors. (LCAS p80). Minerals and energy development *"could affect lynx habitat by changing or eliminating the native vegetation and contributing to habitat fragmentation. … development of associated roads, powerlines, and pipelines.. could also result in a loss of lynx habitat and contribute to fragmentation."* (LCAS p83).

An illegal shooting example from Colorado is provided, showing over 14% of reintroduced lynx were shot in the first 10 years. (LCAS p84). Forest/backcountry roads and trails with low vehicular or snowmobile traffic *"had little effect on lynx seasonal resource-selection patterns" and lynx traveled on roads "unplowed during winter". "Squires et al (2008) reported that lynx denned farther from all roads compared to random expectation. … occupy dens in early May when many forest roads are still impassable… snowmobiles no longer use the roads because of intermittent and unpredictable availability of sufficient snow."* Finally, *"fewer roads were located in denning habitat and higher road density occurred along forest edges and in managed stands, which lynx avoided…."* (LCAS p84). But these factors are all dismissed as affecting lynx in the Remand Notice and we find no regulatory standards regarding these activities relating to lynx and lynx habitat in the CNF.

Regarding livestock grazing, LCAS (p85) notes the summer diet of snowshoe hares is dominated by herbaceous food including *"forbs, grasses, and shrubs"*. Then claims that *"The habitats used by snowshoe hare that are most likely to be affected by livestock grazing are riparian willow and aspen communities."* The conclusion is that grazing by domestic livestock is *"unlikely to reduce the snowshoe hare prey base…"* This statement can only be produced by those who have never studied the impacts of livestock grazing on ecosystems in the Rocky Mountains. We have studied the effects of livestock grazing in SE Idaho and NE Utah and found extensive habitat degradation, over-utilization of forage, and overstocking. See Appendix 1 for a brief review with photographs showing some of the degraded conditions. Habitats in many of the National Forests in the southern portion of the DPS are terribly degraded by livestock grazing. Riparian areas and other snowshoe hare foraging areas are included.

By laying out these first and second tier anthropogenic effects for core areas, the 2013 LCAS inadvertently explains why lynx may not be found today in southern areas where they existed in earlier times. Lynx have *"low densities and in small populations throughout their range in the contiguous United States .. increase their susceptibility to local extirpations."* (LCAS p68). Almost every anthropogenic activity does have an adverse effect on lynx and lynx habitat as the science provided by the Forest Service and FWS have described in the preceding paragraphs. It is the omission of current monitoring and analysis along with the absence of adequate Forest Service standards that logic dictates is responsible for absence of lynx in places where it was observed in years gone by. We can find no monitoring or analysis of the effects of these activities to comply with the RFP and Travel Management Plan in the CNF. Lack of current data enables the CNF to deny impacts. Since our research has found an absence of recent monitoring and studies on Canada lynx habitat, populations and snowshoe hare habitats and populations across these southern Forests, it is incumbent on the current SSA effort to address this lack of information. **FWS must press for meaningful, ecological based standards, define linkages and corridors, and require they be addressed with detailed habitat, lynx, and snowshoe hare studies. Models such as we discuss later in these comments must be consolidated, evaluated, and applied to define and update core and linkage areas.**

Lynx Observations. The 2013 LCAS briefly describes lynx occurrences in the Northern Rockies. In Wyoming, lynx is a species of *"greatest conservation concern" and "has been documented historically and currently in western Wyoming…"* In Idaho lynx *"are classified as an S1 species of greatest conservation need."* Most of the 35 verified records in Idaho came from north of the Snake River with 2 from Caribou and Bonneville Counties along the Wyoming border. Recent snow tracking surveys have detected no lynx. (LCAS p57). Two lynxes were captured in traps in 2012 and 2013, one was released alive, and the other was shot due to being misidentified as a bobcat. In Utah, the LCAS reports only a few historical records from the early 1900s with later records all from northwestern Utah near the borders with Wyoming and Idaho. (LCAS p58).

Lynx observations were summarized in McKelvey et al (2000)[28]. McElvey et al used *"written accounts, trapping records, and spatially referenced occurrence data…"* (SR p207). They limited consideration of trapping records due to lack of constant effort and confusion with bobcats and where high reliability is needed, *"we used a subset of these data we call 'verified records"*. Verified records were those *"only if it was represented by a museum specimen, or a written account in which a lynx was either in someone's possession or observed closely….neither tracks nor sighting reports were considered to be a verified record."* (SR p209). Yet, today tracking surveys are used.

We have extracted McKelvey's data from Table 8.1 of their chapter and summarized the percent of observations that are *"verified"* and *"reliable"*. An extremely low percentage of total spatially referenced occurrences were *"verified"*. (Table 1). Hundreds to thousands of observations are not counted when determining lynx historical occupancy. Are we to believe they were all wrong? An example of this comes from a BLM report.[29] Of interest is an account by Harold Wadley, who was a Forester working for the U.S. Forest Service in Idaho and in the Uinta Mountains in Utah. Harold worked in the Uinta Mountains in 1957 and 1958. He used dogs and traveled by snowshoe to track and tree lynx. His records show he treed 20 Canada lynx in those two years. Harold encountered Canada lynx along the entire north slope of the Uinta Mountains. He estimated that there were 15 Canada lynx on the north slope of the Uinta Mountains between the West Fork of the Bear River and the Little East Fork of the Black Fork River. This essentially was the area within his ranger district. Was his report even considered? It is hard to tell. Do we just discount this as unreliable? After all, Harold worked for the U.S. Forest Service and knew lynx as do most trappers are likely to be able to do. His observations in the 1950s indicate a resident population occurred on a portion of the north slope of the Uinta Mountains at that time. This was prior to the irruptions from Canada in the 60s and 70s.

In the following paragraphs, we use an example of how one should approach these arguments surrounding whether lynx ever resided in the Uinta Mountains that was provided by Dr. Kirk

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[28] McKelvey, K.S., K.B. Aubry, and Y.K. Ortega. 2000. History and distribution of lynx in the contiguous United States. Pages 207-264. Chapter 8. In Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (Tech Eds). Ecology and conservation of lynx in the United States. Univ. Press of Colorado. Boulder, CO. 480 p.

[29] Lewis, L. and Wenger, C.R. 1998. Idaho's Canada Lynx: Pieces of the Puzzle. Idaho Bureau of Land Management Technical Bulletin No. 98 - 11 in cooperation with the U.S. Forest Service.

Robinson in one of our joint efforts to address domestic sheep grazing in the Uinta Mountains of Northwest Utah.[30]

Table 1. Spatially Referenced Occurrence Data from McElvey et al 2000.

State and time span	Total Spatially Referenced Occurrences	Verified Records	Verified as Percent of Total/Reliable
Colorado 1878 - 1974	196 Total 84 Reliable	17	8.7/20.2
Idaho 1874 - 1991	234 Total 228 Reliable	74	31.6/32.4
Utah 1916 - 1991	27 Total 17 Reliable	10	37.0/58.8
Montana 1887 - 1999	1,542 Total 1,169 Reliable*	84	5.5/7.1
Washington 1896 - 1999	765 Total 571 Reliable**	134	17.5/23.4
Wyoming 1856 - 1991	361 Total 288 Reliable	30	8.3/10.4

*Note that trapping records showed 3,012 reported between 1950 – 1997
**Trapping records show 215 between 1960 - 1989

Dr. Robinson's logical analysis examines the use of verified vs reliable accounts, or observations. He puts it this way:

> *There may have only been 10 verified records of lynx occurrence in the Uintas in the 20th century, but there have been an additional 17 reliable reports of lynx in Utah in the 20th century, based on physical remains (including photographs), visual sightings and track identifications, plus another 10 of unknown reliability. The total number of records is 37. Most of these lynx occurrences were on the north slope of the Uintas, in or near the West Fork of Blacks Fork. Even if we discount the 10 reports of unknown reliability, we still have 17 reliable reports and 10 verified records of lynx, for a total of 27, most of which located the lynx in the Uintas! In other words, the historical evidence indicates a minimum of 10-37 lynxes in the Uinta Mountains over the last 103 years (not counting dispersers from Colorado). Thus, there can be little doubt that the actual number of "sightings" was greater than 10. 30 would be much more probable.*
>
> *Why arbitrarily exclude the "reliable" sightings? What does "reliable" mean if you can't rely on what is reliable? Yet the FS chooses not to rely on them for the purpose of the DEIS—a decision that would seem to be based not so much on a desire for accuracy as a desire to minimize the presence of lynx in Utah in order to make room for Alternative 2.*

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[30] Coalition comments on the High Uintas Domestic Sheep Analysis Project. 2019. Provided to the Uinta Wasatch Cache National Forest. August 5, 2019. Access at: https://app.box.com/s/797x21rggtx1t6yayr0gi9kpbouis4sr

> *At this point we should ask ourselves how many records—verified records, if you like—it would take to establish that there was a resident population of lynxes in the Uintas during some part of the 20th century. Does anyone have even the slightest clue? Of course not. And the reason is that there are no empirical data for establishing a baseline on which to base a prediction. Surely all we can reliably say is that the more records (verified + reliable), the higher the probability. Thus, this premise commits the fallacy of begging the question by presupposing what is to be proved.*

As we review the table 8.1 from McKelvey, it is apparent that most historical observations and accounts are dismissed out of hand and have become the basis of today's claims by FWS and the Forest Service that there are not (and perhaps never were) resident lynx in Utah and Idaho, or Colorado for that matter even though the reintroduced population survives there today and appears stable or increasing according to the Forest Service website cited earlier.

McKelvey et al (2000) also provide a narrative describing lynx records in Idaho, totaling 73 records. Some records such as reported in Lewis and Wenger (1998), are apparently not included. The following are extracted from McElvey et al:

> From 1874 – 1917, there are 22 museum specimens from areas north of the Snake River Plain. In 1939 and 1940 specimens were collected in central Idaho in Valley County and Idaho County. In 1954 and 1955 specimens were located from Bonner and Shoshone Counties. Other verified records include one from Shoshone County in 1901, one from Boundary County in 1919, one from Idaho County in 1936, one from northwest Idaho in 1939, one from Clearwater County in1942, five from Caribou County in 1947, two from Bonneville County in 1955. (SR p225 - 226).
>
> *"There are 35 verified records from 1960 to 1991: four from 1962 to 1969, 18 from 1970 to 1979, 10 from 1982 to 1989, and three from 1990 to 1991; there are no verified records of lynx in Idaho since 1991 (Anonymous 1999, unpublished). Although most of these records are from the northern and central regions of Idaho where lynx occurred historically, six are from counties in the Snake River Plain, in areas where forest types occupied by lynx are absent or very fragmentary in extent (see "Lynx Associations with Broad Cover Types"). These include records from Blaine, Butte, Jerome, and Twin Falls Counties in 1972; one from Blaine County in 1984; and one from Power County in 1990"*. (SR p227).

The Lewis and Wenger (1998) report provided numerous accounts of lynx and lynx tracks in Idaho. They noted that little is known about Canada lynx in Idaho and that *"the lack of Canada lynx studies…only adds to the puzzling nature of the species"*. It was based on interviews with individuals *"familiar with Canada lynx habitat and local fauna in general."* (pi). These were individuals documented by Idaho Fish and Game as *"having harvested Canada lynx"*. While the report covers several areas of Idaho, it also includes Eastern Idaho accounts by 18 individuals. These are provided here for the SE Idaho area. They included accounts from residents in Island Park, St. Anthony, Rexburg, Georgetown, Ashton, Preston, Swan Valley, Paris, Montpelier, and Alta, Wy. The reports included those who observed lynx in SE Idaho in Georgetown Canyon, Tincup Creek, and Henry's Fork, many of whom killed lynx or observed their tracks. The report paints a broad picture of lynx across much of Eastern Idaho as well as other areas of the state. Here is one from Oliver Peterson of Montpelier who was trapping prior to the 70s when lynx sightings were claimed to be due to movement from Canada due to hare cycle lows. It appears very convenient today to claim there were never resident lynx in these areas.

> *Oliver Peterson, Montpelier, ID —Oliver began trapping in 1945 and did most of his trapping in the 1950s and 1960s. During a one-week period in 1947 or 1948, he caught five Canada lynx ten miles northeast of Soda Springs. He trapped four Canada lynx in the 1950s and 1960s, one in the same area where he caught the five Canada lynx. He caught three Canada lynx farther east near Georgetown. Except for one Canada lynx trapped near timberline, the remaining Canada lynx were caught in areas with a mosaic of aspen, conifer, and mountain brush. (p8). He speculated that during those years there were no snowmobiles and atvs and that the demise of lynx was due to increased access and by snowmobiles, atvs, and the lack of snowshoe hares. Traplines were accessed by snowshoe or skis and now (the 1990s) there is "intensive snowmobile and atv use". He believed this was a primary factor in the demise of lynx since the 1970s.* (p17).

The interviews provided information on lynx prey including jackrabbits, grouse, red squirrels, voles in addition to snowshoe hares indicating the use of alternate prey appears greater than in Canada and Alaska. The authors suggest scenarios relating lynx behavior to jackrabbit populations by lynx following jackrabbits into shrub steppe far from typical coniferous forest habitats and end up near other habitats occupied by snowshoe hares and/or may exploit jackrabbit population highs without leaving traditional habitats resulting from jackrabbits dispersing into those habitats.

They also discuss livestock grazing, noting that studies show that livestock reduce forage availability, that elk and livestock eat many of the same species as do black-tailed jackrabbits and reduce forage to the point it limits jackrabbit densities. *"Grazing of the same areas by both species may have cumulative effects on both snowshoe hare and jackrabbit habitats."* (p17). *"Utilization of forage by both elk and livestock may thus have a significant impact on hare habitats. This may be particularly true in the southern-most portions of the Canada lynx range where grazing becomes a more dominant use."* (p18).

In conclusion, Lewis and Wenger (p19) state, *"there is no 'smoking gun' factor in the decline of Canada lynx in Idaho. Many variables appear to limit Canada lynx numbers in this state. The most important of these appear to be timber harvest practices; high numbers of coyotes, mountain lions, and elk; increasing motorized and nonmotorized recreational use; incidental trapping; and reduced numbers of alternate prey, including species that are not documented as Canada lynx prey in existing research. These include jackrabbits, beavers, and porcupines."*

Lynx, the ESA and Forest Service Manual. The ESA promulgated regulations at 50 CFR § 402.12 delineate the purpose of a Biological Assessment (BA) as to *"evaluate the potential effects of the action on listed and proposed species and designated and proposed critical habitat…"*. It describes the contents as *"discretionary"* and depends on the nature of the federal action with consideration for including (1) results of on-site inspections; (2) views of recognized experts; (3) review of the literature; (4) analysis of the effects of the action on species and habitat, including cumulative effects and the results of related studies; and (5) analysis of alternate actions considered by the Federal agency.

In a recent typical example in the CNF in a Decision for a phosphate mine, the Husky 1 North Dry Ridge mine, the BA only based its brief analysis on the proposed action, not the suite of alternatives contained in the FEIS.[31] It included minimal analysis. The intent of the ESA was avoided and if one applied the NEPA standard for a hard look or cumulative effects to this aspect of the analysis, the analysis would fail. *"Discretionary"* cannot be used to avoid taking a hard look in the analysis. This project, combined with other projects that are listed in the FEIS for H1NBR in addition to roads, timber harvest, and recreation, occurs within a linkage area connecting to critical habitat for lynx immediately east of the project. Figure 4 illustrates this and shows some of the phosphate leases in the CNF lynx linkage for illustration. The loss of this connection due to habitat fragmentation means the loss of the genetic connection between the critical habitat and other peripheral habitat such as in the Uinta Mountains which then connect to the current Colorado population. **How can regulations or land use plans be effective when they are *"discretionary"* for the project proponents? This must be addressed.**

The Forest Service Manual[32] cites the ESA as *"the Act directs federal departments and agencies to ensure that actions authorized, funded, or carried out by them are not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of their critical habitats."* (FSM 2670.11). The FSM (2679.12) cites Departmental Regulation 9500-4 as (1*) "Manage 'habitats for all existing native and desired nonnative plants, fish and wildlife species in order to maintain at least viable populations of such species.'"* (2*) "Conduct activities and programs 'to assist in the identification and recovery of threatened and endangered plant and animal species.'"* (3) *"Avoid actions 'which may cause a species to become threatened or endangered'"*. The CNF provided guidance in its RFP FEIS to address this connectivity but has ignored its own guidance in approving the H1NDR and all the other projects we have reviewed. How can the CNF dismiss impacts to Canada lynx without actually conducting an analysis? The current analysis for H1NDR and other projects does not *"ensure"* that actions do not further endanger or adversely modify habitat. Only in the industry bias world of today's Forest Service could total destruction of habitat not be considered an "adverse" impact. Degrading and fragmenting this linkage habitat compromises lynx migration and habitat adjacent to and bordering lynx critical habitat and must be considered in that context.

FSM 2670.31 provides additional guidance for T&E species.

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[31] https://www.fs.usda.gov/project/?project=37878 Accessed on January 17, 2023.

[32] USDA Forest Service. 2005. Forest Service Manual National Headquarters (WO) Washington DC. FSM 2600 – Wildlife, Fish, and Sensitive Plan Habitat Management Chapter 2670 – Threatened, Endangered and Sensitive Plants and Animals (September 23,2005).

> (1) *"Place top priority on conservation and recovery of endangered, threatened, and proposed species and their habitats."* (2) *"Establish, through the Forest planning process, objectives for habitat management and/or recovery of populations."* (4) *"Avoid all adverse impacts on threatened and endangered species and their habitats, except when it is possible to compensate adverse effects totally through alternatives identified in a biological opinion."* (6) *"Identify and prescribe measures to prevent adverse modification or destruction of critical habitat and other habitats essential for the conservation of endangered, threatened, and proposed species. Protect individual organisms or populations from harm or harassment as appropriate."*

Once again, the CNF has not placed top priority on conservation and recovery, has not established meaningful objectives with enforceable standards for lynx habitat, has not designated LAUs with standards to protect preferred habitats and linkages, has ignored the effect of this linkage area on the adjacent critical habitat, thus compromising the integrity of that critical habitat and what remains of the core population in the DPS. The CNF by allowing snowmobile use on 97% of the Forest is not preventing harm or harassment of lynx, wolverines or other species which are affected by snowmobile use and the associated trapping, shooting and harassment. We have witnessed multiple snowmobiles trespassing on Kiesha's Preserve chasing and harassing a coyote and deer in an effort to "whack" the coyote and at other times, releasing dogs carried in their sleds to chase mountain lions while trespassing. With the groomed trails throughout the mountains, one hunter can cover a hundred miles in one day looking for tracks to turn out his dogs.

The FSM 2670.5 provides definitions of terms that are useful in interpreting the efficacy of the agency analysis. An **adverse effect** includes *"Any action that directly alters, modifies, or destroys, critical or essential habitats or renders occupied habitat unsuitable for use by a listed species, or that otherwise affects its productivity, survival, or mortality."* **Essential habitat** is defined as *"Those areas designated by a regional forester as possessing the same characteristics as critical habitat without having been declared as critical habitat by the Secretary of the Interior or Commerce. The term includes habitats necessary to meet recovery objectives for endangered, threatened, and proposed species and those necessary to maintain viable populations of sensitive species."* A **viable population** is defined as *"A population that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its existing range (or range required to meet recovery for listed species) within the planning area."*

The CNF has not designated Essential Habitat, but it has designated linkage for lynx. It has not identified recovery objectives or evaluated how a project leads to recovery of lynx. The analysis we have provided shows actions by the Forest Service have had an "adverse effect" as demonstrated by the lack of lynx observations and presence in SE Idaho. Given the lack of lynx observations in the recent decades, it is apparent that human activity is occurring in such a manner that lynx populations are being affected. Otherwise, why are lynx not being found here today? This example is illustrative of failures by both the Forest Service to comply with the intent of its RFP and FWS failure to require detailed analysis and protections in its role of consultation.

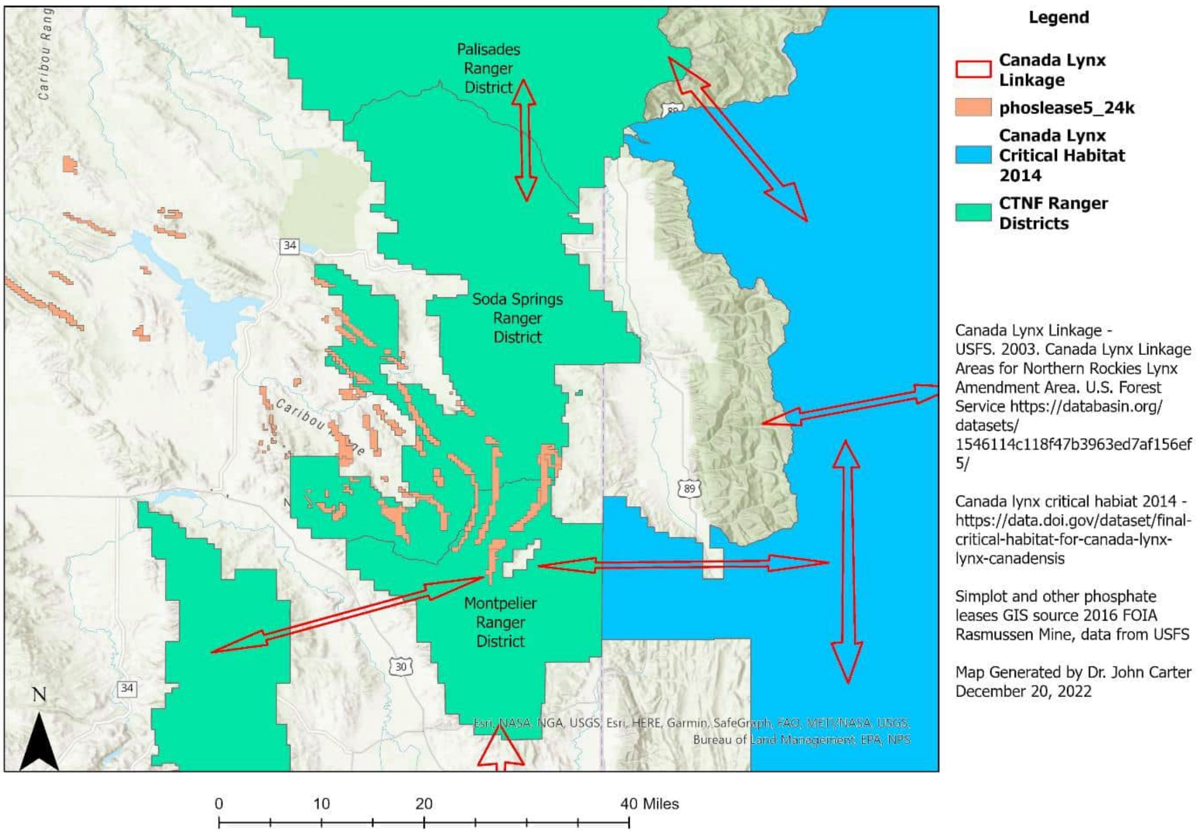

Figure 4. Canada Lynx Critical Habitat, Phosphate Lease Locations, Linkage Area including Soda Springs and Montpelier Ranger Districts Based on FEIS for 2003 Caribou Revised Forest Plan

FSM 2671.44 describes determination of the effects on listed species. Biological evaluations are to *"conduct and document the program and activities review necessary to ensure that any action … is not likely to jeopardize the continued existence of any listed or proposed species or to result in the destruction or adverse modification of critical or proposed critical habitat."* Internal *"biological expertise"* and *"informal consultation"* are to be used to reach *"supportable determinations of effect"*. Finally, *"Consider effects on suitable unoccupied habitat essential to recovery of the species when doing the biological evaluation."* We do not see CNF analysis of the linkage, or "suitable unoccupied habitat" or any effort to address its current vs historical condition as delineated in the CNF RFP FEIS. FWS is not addressing failures such as these.

The lack of adequate regulatory mechanisms to protect lynx habitat and connectivity has been implicated as a central issue for lynx being able to maintain populations.[33] (FR p16052). The FSM described above makes the point that the Forest Service should establish through planning,

[33]DOI USFWS. 2000. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx and Related Rule. Fed. Register Vol. 65, No. 58.

objectives for habitat management and/or recovery of populations and prescribe measures to prevent adverse modification of habitat essential to the conservation of T&E species. This remains to be done and the FWS should ensure that not only the CNF, but all Forests and BLM land management plans are quantitatively addressing lynx habitat and connectivity needs.

What the CNF provides for lynx linkage in its RFP is summarized below.

Caribou NF Direction for Canada Lynx. The Caribou RFP FEIS laid out a process for addressing connectivity. We have reviewed the RFP for standards or objectives relating to lynx and its habitat. Overall, these are quite generic and not specific to the habitat of lynx. The direction specified to maintain linkages for Canada lynx is found in (1) Vegetation Desired Future Conditions, (2) Vegetation Goals 1 – 4, (3) Vegetation Standard 2, (4) Wildlife Goals 2, 3, and 5, (5) Vegetation Goal 7, (6)Lands Objective 1, and (7) Lands Standard 1. (RFP 3-28) We reviewed each of these for specifics regarding lynx habitat. They are summarized below:

1. **Vegetation DFC** (RFP 3-17) to retain diversity of structure and composition, 30 – 40% of conifers in mature and old classes (FEIS notes this will not be attained), functional corridors are present, aspen managed to 20 – 30% mature and old, non-forested vegetation within site potential and within HRV, restoration of native shrub communities accomplished, woodland types are multi aged with balanced shrub/herbaceous understory and within HRV.

2. Vegetation Goals 1 – 4, 7 (RFP p3-17 – 3-18) to have diverse forested and non-forested ecosystems within HRV and/or restored through time, aspen managed to reduce or halt decline, forested ecosystems moving towards a balance of age and size classes in each forested type on a watershed or landscape scale, sage-steppe and mountain brush moving towards a balance of age, canopy cover, and size class on a watershed or landscape scale and within HRV, biodiversity maintained or enhanced.

3. Vegetation Standard 2 (RFP 3- 19*) "In each 5th code HUC which has the ecological capability to produce forested vegetation, the combination of mature and old age classes (including old growth) shall be at least 20 percent of the forested acres. At least 15 percent of all the forested acres in the HUC are to meet or be actively managed to attain old growth characteristics."*

4. Wildlife Objective (RFP 3-24) *"The Forest provides habitat that contributes to state wildlife management plans; Forest management contributes to the recovery of federally listed threatened, endangered, and proposed species and provides for conditions, which help preclude sensitive species from being proposed for federal listing."*

5. Wildlife Goals 2, 3, and 5 (RFP 3-24) states that wildlife biodiversity is maintained or enhanced by managing for vegetation and plant communities within their HRV, maintain multiple vegetation layers in woody riparian habitats, maintain, and *"where necessary and feasible, provide for habitat connectivity across forested and non-forested landscapes."*

6. Lands Objective 1 (RFP 3-8) *"Identify land adjustments and rights-of-way to improve management, public access, and/or wildlife connectivity annually."*

7. Lands Standard 1 (RFP 3-9) *"Priority shall be given to acquiring lands having special importance or unique characteristics such as riparian areas, historic sites, habitat for federally listed species, recreation sites, etc."*

There is no specific direction and no enforceable standards regarding lynx habitat and linkage (which the Forest Plan itself mapped). These appear as mere afterthoughts with no relation to research on lynx or hare habitat. We have seen no evaluation in any project as to whether these have any relation to the habitat needs of lynx. In our example, the H1NDR NEPA process did not analyze these provisions or reveal how they have been applied across the affected watersheds and landscape where lynx formerly have been found, or in the linkage shown in the CNF RFP FEIS. In our example of the H1NDR FEIS, the analysis did not use the guidance in the CNF RFP FEIS on connectivity and how to analyze it. It did not analyze the risk factors described in the LCAS and the combined impact of all the various uses and projects on this linkage area. A review of IRAs in the CNF finds they are rarely different in management than other forest lands, with many user-created roads and trails, past timber harvest, mining, and livestock grazing. For example in our comments on the Dairy Syncline DEIS (p43) we cited the Idaho roadless rule description of the Huckelberry Basin IRA which was to be fragmented for a tailings pond.[34] *"Remoteness and solitude rate as low, because of development." .. "Manageability of the area is considered poor, due to road intrusions and timber harvest activities."* (Idaho roadless rule FEIS C5-46). This is typical of the characterization of IRAs under the Idaho Roadless Rule. So, if IRAs are fragmented by all these activities, where are the intact habitats for lynx and other special status species in IRAs and other habitats presumed to have lower levels of protection? **A thorough review of the science on lynx habitat characteristics needed for recovery and connectivity should be completed and used to compare current conditions in the CTNF to those needed for lynx.**

LYNX REGIONALLY SIGNFICANT WILDLIFE CORRIDOR (Y2UConn)

The following discussion is about the need to define, protect and restore a corridor or corridors, and provide standards for habitat to provide connectivity to the southern population of lynx. This is focused on the Y2UConn (higher elevation) corridor passing through SE Idaho and NE Utah to connect critical habitat in the GYA to the Colorado lynx population.

The Colorado Division of Wildlife tracked radio-collared lynx released in Colorado. [35] According to the Rocky Mountain Research Station, *"By 2010, all indications were that the vast majority of animals relocated there had stayed in the state and they seemed to be surviving and reproducing well enough that the population was on a slight upward trajectory."*[36] That

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[34] USDA. 2008. Roadless Area Conservation National Forest System Lands in Idaho Final Environmental Impact Statement Appendix C.

[35] Devineau P, Shenk T.M., White, G.C., Doherty Jr., P.M. and R.H. Kahn. 2010. Evaluating the Canada lynx reintroduction programme in Colorado: patterns in mortality. Journal of Applied Ecology. doi: 10.1111/j.1365-2664.2010.01805.x 8 p.

[36] USDA RMRS. 2023. Winter Sports and wildlife: Can Canada lynx and winter recreation share the same slope?

link also noted that lynx were extirpated or greatly reduced in Colorado by the 1970s. The web report noted that *"managers really understand the need to provide for connectivity in these critical areas we've identified."* Do they? Are they? Where is the evidence? FWS should require evidence.

Devineau et al (2010) show that lynx telemetry records confirm that there is a *"hot spot"* of lynx occurrences at the western end of the Uinta Mountains, where collared lynx from Colorado remain for a time before moving on. As of 2009, at least 22 individuals had made at least 27 visits to the state of Utah, recorded by air telemetry and satellite.[37] The highest concentration of lynx locations in Utah, as identified by telemetry, is in the Uinta Mountains. *"The use-density surface for lynx use in Utah indicates the primary area of use being located in the Uinta Mountains."*[38] A recent report by Colorado Parks and Wildlife (CPW) using information from the tracking devices found that 19 males and 10 females reintroduced into Colorado between 1999 - 2006 were located in Utah.[39] Because some of these were single data points, CPW chose to evaluate 11 males and 6 females that were located in Utah between 2000 and 2010. Most of the individuals *"entered and exited Utah via the Uinta Mountains in the northeast, Abajo Mountains in the southeast, or the East Tavaputs Plateau in the east-central part of the state… ."* The report points out that a male and female occupied the same area in the Uinta Mountains for >200 days, but it is not known if there was denning or reproduction. *"Those that spent a considerable amount of time in Utah tended to find and traverse the high country running north – south through the central portion of the state*." *"There were likely other individuals who made the trip. Also, CPW stopped monitoring collared lynx in April, 2011. Movements into Utah may or may not have continued since then, but we have no documentation."* (p3).

The Science Report (Chapter 10) discusses the history of lynx occurrence in Colorado. "*… boreal forest habitat in Colorado is insular in nature and isolated from similar habitat in Utah and Wyoming by more than 150 km of lower elevation habitats in the Green River Valley and Wyoming Basin (Findley and Anderson 1956). All but a few specimen records are from the center of this island of boreal forest habitat in west-central Colorado."* (SR p230). There were 15 specimens found between the 1800's and 1936 with none thereafter until 1969, 1972, and 1974 when four additional specimens were identified. Despite snow tracking efforts, there have been no verified records in Colorado since 1974. (SR p231). As we summarized in Table 2, out of 196 records in Colorado between 1878 – 1974, there were 17 verified records, but 84 reliable records.

Figures 8.19 and 8.20 in the Science Report (p247) depicts lynx occurrences overlaid on Kuchler (1964) vegetation classes in the western U.S. It is noted that Rocky Mountain Conifer cover type enclosed 82% of lynx occurrences. Those Figures and Figure 8.17 show dense patterns of lynx occurrence in Colorado, western Wyoming and the GYA, western Montana, northern Idaho, and Washington bordering Canada. A pattern of occurrence also is shown in northeast Utah and

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https://www.fs.usda.gov/rmrs/winter-sports-and-wildlife-can-canada-lynx-and-winter-recreation-share-same-slope Accessed on January 19, 2023.

[37] Colorado Department of Wildlife (CDOW) Report, 2006-7, Tables 4 and 6, pages 23 and 24.

[38] Ibid. page 10; see also Figure 2, page 29.

[39] Ivan, J. 2019. Summary of movements of Colorado lynx in Utah. Colorado Parks and Wildlife, Fort Collins.

along the border between Idaho and Wyoming.   Connecting these populations is critical for the DPS to recover and maintain gene flow.

We have been addressing connectivity in the Yellowstone to Uintas Connection since our organization was founded.   The Y2UConn leg of the Regionally Significant Corridor is the high elevation, conifer dominated link needed to connect the GYA and northern Rockies to the Uinta Mountains and Southern Rockies. The CNF Forest Plan FEIS (pD-5)[40] summarizes the history/knowledge of this corridor through SE Idaho into NE Utah.

> *Most of the efforts to date to map corridors have focused on large-scale dispersal corridors generally from the Northern Rockies (Glacier NP) to the Greater Yellowstone Ecosystem. The USFWS, in efforts to conserve large carnivores in the Northern Rocky Mountains, has developed the concept of linkage zones. The linkage zone is an area between habitat fragments able to support both movement and low-density occupancy. The distinction between linkage zone and corridor is the width of habitat—that is the ability to support low density occupancy by species (Samson et al, 1997).*
>
> *Ruediger, et al, 2000 drafted a map titled "IGBC Wildlife Habitat Linkage in the Northern Rocky Mountains." This map also includes the northeastern portion of the Caribou in the mapped north-south linkage zone. Other agencies and groups have done mapping as well.*
>
> *In May 2000, a meeting was held with several state and federal agencies as well as other interested groups, to discuss developing common criteria to help identify linkages of highest importance (Ruediger, 2000). They recommended factors to consider when identifying wildlife habitat linkages; 1) consider all scales, 2) landforms and topography are important, mountain passes, river bottoms and major ridges are often natural movement corridors, 3) vegetation is important, many species use forested areas for cover, 4) quality of habitat is important, 5) areas with low road densities and low levels of human use are important, 6) need data and 7) maintain large intact blocks of habitat (Ruediger, 2000)*
>
> *The Wasatch-Cache National Forest in Utah looked at a north-south corridor passing through the Forest. They used McNab, et al, (1994) to identify Province M331 "Southern Rocky Mountain Steppe" as main north-south corridor (Williams, Forest Biologist pers. comm.) Part of this province (M331) passes through part of the Caribou NF in the Caribou/Webster/Preuss subsections. This same area has been mapped as part of the Greater Yellowstone Ecosystem and was included on Ruediger's "IGBC Wildlife Habitat Linkages" map.*

The 2003 Revised Forest Plan and FEIS for the Wasatch Cache National Forest provides this map along with a map of LAUs in the Wasatch-Cache NF, Uinta NF, and Ashley NF on its

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[40] USDA Forest Service. 2003. Final Environmental Statement for the Caribou National Forest Revised Forest Plan.

website.[41] Figure 5 illustrates this Regional Corridor and its connections. Figure 6 illustrates the Kuchler RMC type, and Figure 7 the topography. These maps show that the Science Report ignored this conifer dominated, high elevation connection in its claim that the Colorado boreal forest (Kuchler?) is *"isolated from similar habitat in Utah and Wyoming by more than 150 km of lower elevation habitats in the Green River Valley and Wyoming Basin."* Distances between higher elevation forested areas are much less in the western leg (Y2UConn) than across the Green River Valley and other northern areas from Colorado.

Colorado Parks and Wildlife summarized lynx movements from the reintroductions in Colorado to Wyoming.[42] Locations from 16 male and 15 female lynx that were released in Colorado between 1999 -2006 and were located in Wyoming between 1999 – 2010. (p2). It is interesting to note that the reintroduced lynx came from Canada populations to the north. Inspection of the maps in the report give the impression these lynx are attempting to find their way back north. As the report describes, *"Most of these individuals entered and exited Wyoming via the Medicine Bow Mountains or the Park Range and traveled no farther into the state than the northern extent of these ranges… . At least 8 lynx made it to the Greater Yellowstone Area and beyond. A few entered/exited via the Uinta Mountains in Utah… ."* The report notes that there were likely other individuals that made the trip, but there is no documentation since that time. (p3). Inspection of the figures in the report shows that some lynx apparently did cross the wide lower elevation valleys between the Medicine Bow Mountains and GYA, but there was no consistent path being followed and there were few conifer or high elevation areas. (Figure 6).

A least-cost path analysis of lynx connectivity between the San Juan Mountains in Colorado and the Greater Yellowstone Area reviewed the negative effects of habitat loss and fragmentation on wildlife populations and the resulting isolation of those populations.[43] The role of landscape linkages in providing connections and gene flow was addressed. Using GIS, current spatial data for habitats, human factors affecting lynx movement, and potential travel corridors between core patches of lynx habitat in the southern and northern Rockies were identified. Habitat suitability analysis identified the best core areas for lynx based on vegetation type and road density. Habitat types suitable for lynx were identified and scored. We have provided a general overview map in Figure 8 showing these core and corridor areas of the least cost path overlaid with the Y2UConn leg of the Regional Corridor. These are well aligned with each other. Detailed maps of vegetation classes, road densities, core areas, housing density, slope, habitat permeability, and least cost corridors are provided in the report. The analysis provides an assessment of the probability of successful dispersal for lynx as it assessed the entire landscape, while *"an animal traveling on the ground may not have prior knowledge of the territory it is crossing or obstacles it may come upon."* (p21). The model is suitable for making conservation and management decisions.

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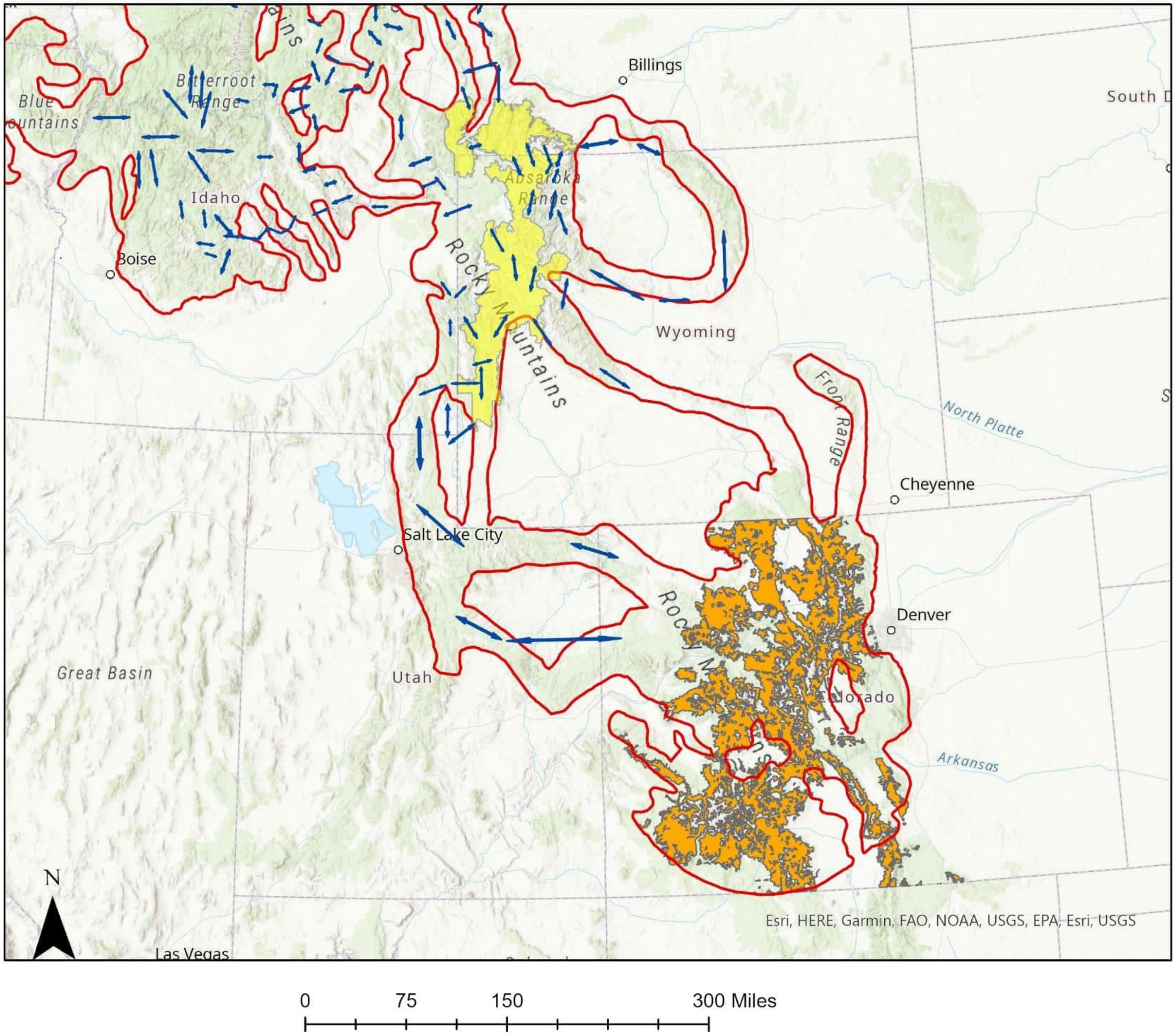
[41] https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/planning/?cid=stelprdb5076923&width=full

[42] Ivan, J. 2017. Summary of movements of Colorado lynx in Wyoming. Colorado Parks and Wildlife.

[43] Bates, W. and Jones, A. 2007. Least-Cost Corridor Analysis for Evaluation of Lynx Habitat Connectivity in the Middle Rockies. Report to the Nature Conservancy by the Wild Utah Project, Salt Lake City. https://app.box.com/s/0g8b1ryqg1iz6r1fd61rdkc8fso97oh5

Figure 5. **Regionally Significant Wildlife Corridor, Lynx Linkage and Colorado Potential Habitat**



Lynx Critical Habitat
Regional Corridor
Canada Lynx Linkage
Lynx Potential Habitat

Regional Corridor - Referenced in USDA. 2003. Revised Forest Plan Wasatch-Cache NF.

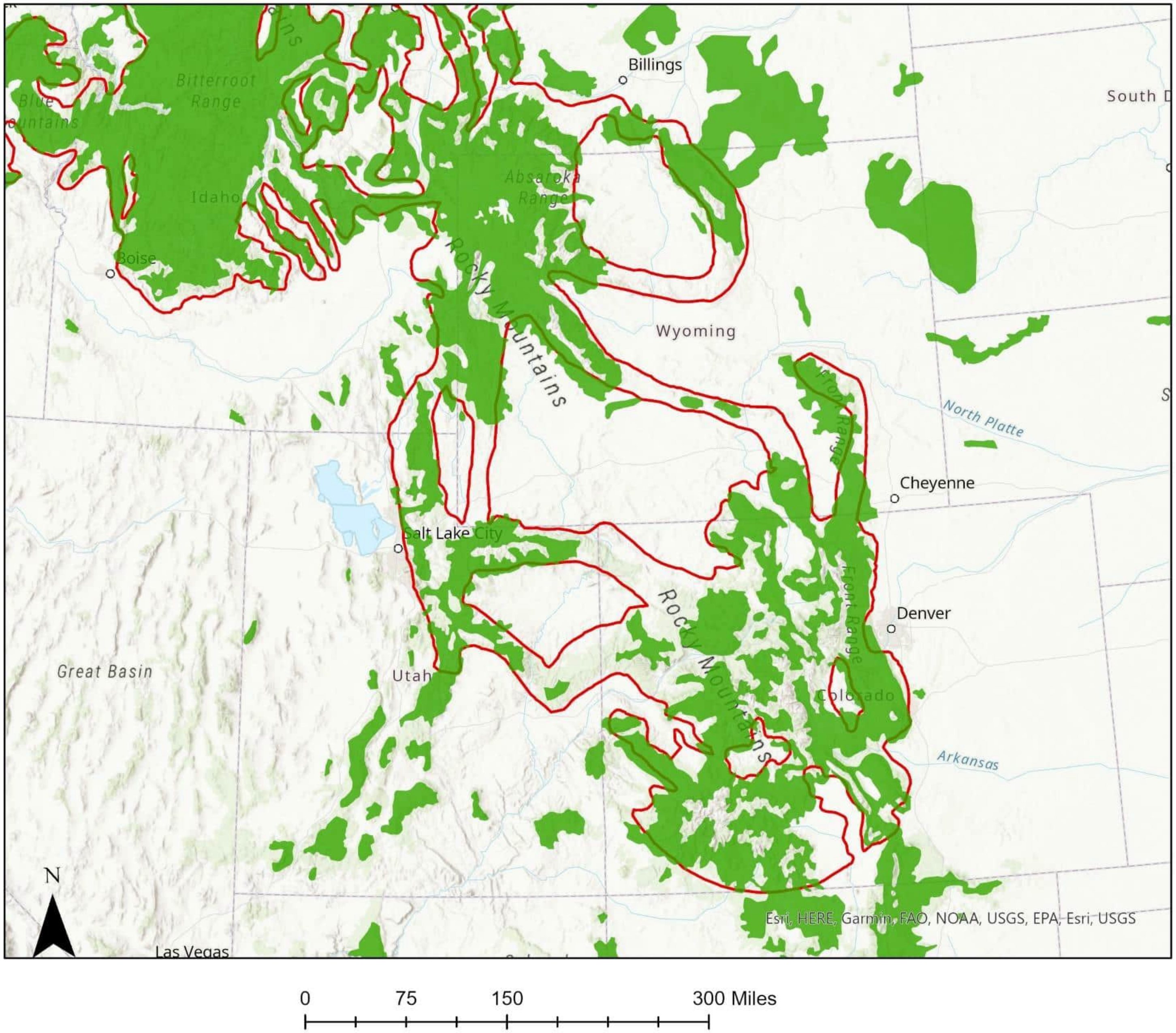
https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/planning/?cid=stelprdb5076923&width=full

Canada Lynx Linkage - USDA Forest Service Northern Region. November 13, 2003. Canada lynx linkage areas for the Northern Rockies Lynx Amendment.

Lynx Potential Habitat - Colorado Parks and Wildlife

Critical Habitat - Fish and Wildlife Service designation. See Federal Register Citation Number 79 FR 54782, published 20140912 for the legal critical habitat information.

Figure 6. **Regionally Significant Wildlife Corridor and Kuchler Rocky Mountain Conifer**



Kuchler Rocky Mtn Conifer

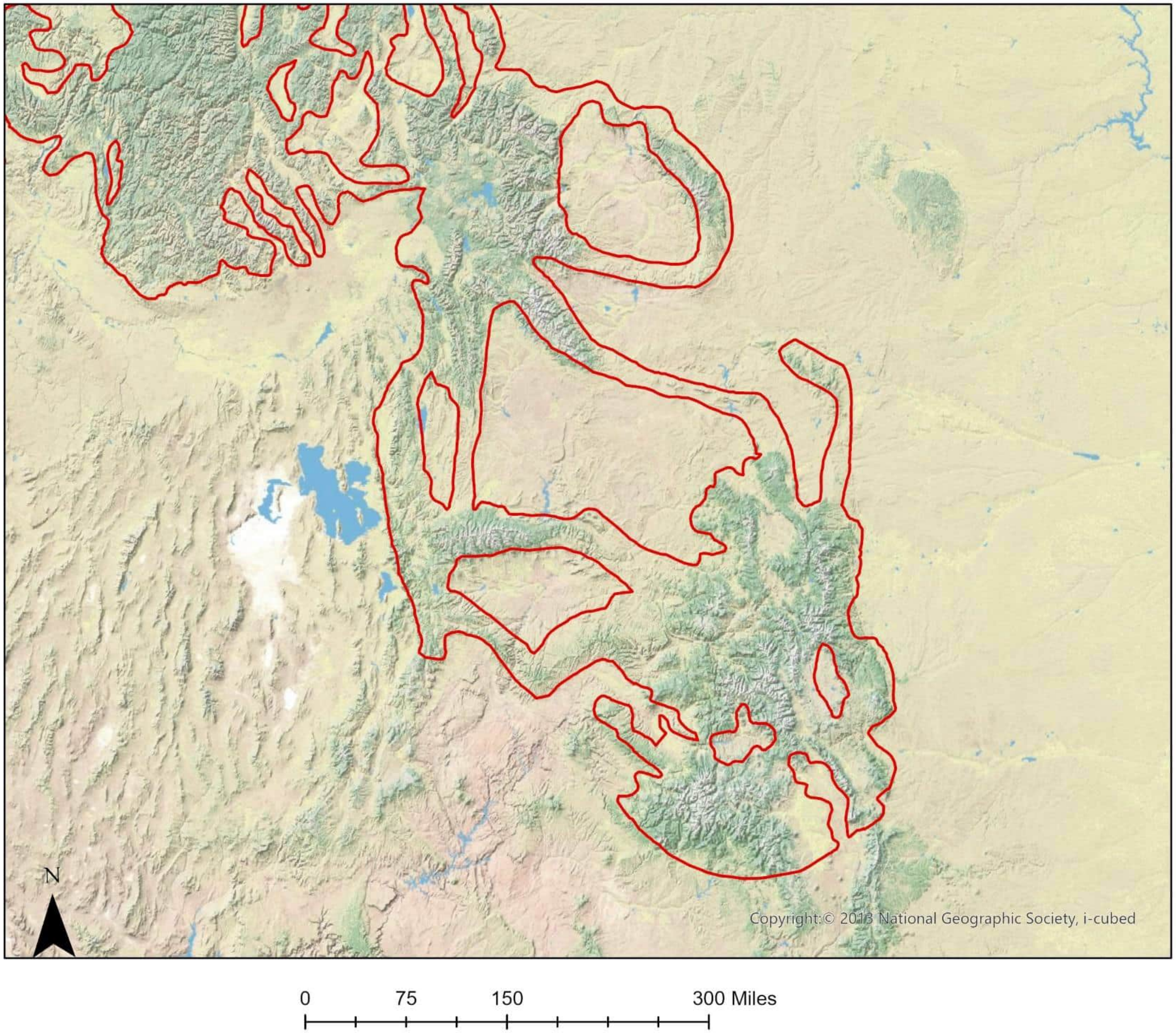
Regional Corridor

Regional Corridor - Referenced in USDA. 2003. Revised Forest Plan Wasatch-Cache NF.

https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/planning/?cid=stelprdb5076923&width=full

Kuchler type GIS files from Data Basin. http://app.databasin.org/app/pages/datasetPage.jsp?id=1c7a301c8e6843f2b4fe63

Figure 7. **Regionally Significant Wildlife Corridor Topographic Relief**



Regional Corridor

Regional Corridor - Referenced in USDA. 2003. Revised Forest Plan Wasatch-Cache NF.

https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/planning/?cid=stelprdb5076923&width=full

Topographic Map
ESRI land cover imagery for the world and detailed topographic maps for the United States

Colorado Parks and Wildlife engaged in a similar effort to map predicted use areas in Colorado.[44] They used location data from reintroduced lynx fitted with transmitters, filtered those data to remove locations for the first six months to account for habituation, considered elevations above 8,000 feet, and included factors for housing and road density, slope, distance to forest patches and vegetation types. Summer and winter data were used to generate models for both seasons. Figures 9 and 10 are reproduced from that report.

A map of the predicted distribution for Canada lynx in the 2050's based on modeled climatic conditions is provided in Figure 11.[45] This dataset represents the predicted distribution for Canada Lynx (Lynx canadensis) for the 2050's (ten year period average), based on the agreement (spatial average) of 5 niche modeling techniques (BIOCLIM, Climate Space Model, Envelope Score, Environmental Distance, SMV) and monthly precipitation and average temperature from 12 GCM's from the A2 emission scenario. Localities used to produce the model were resampled from the core area (highest probability) of the predicted distribution based on 48 Worldclim 1.4 climatic variables and BIOCLIM. CPW (Ivan) have also produced maps of summer and winter predicted habitat above 8,000 ft in Colorado.

Modeling and analysis such as these examples provide should be used to delineate the final configurations for regional corridors needed to maintain connectivity for these lynx populations. The Y2UConn leg of the corridor is a viable option for the higher elevations and snow cover needed by lynx. It also includes the potential core area of the Uinta Mountains where historical observations indicate a lynx population existed there in the early 1800's prior to trapping and exploitation by people. It connects to Critical Habitat in Western Wyoming where studies documented lynx present in 2004/2005 along with populations of snowshoe hares.[46] A follow-up effort in the winter of 2008/2009 also detected lynx in the Greater Yellowstone Area.[47]

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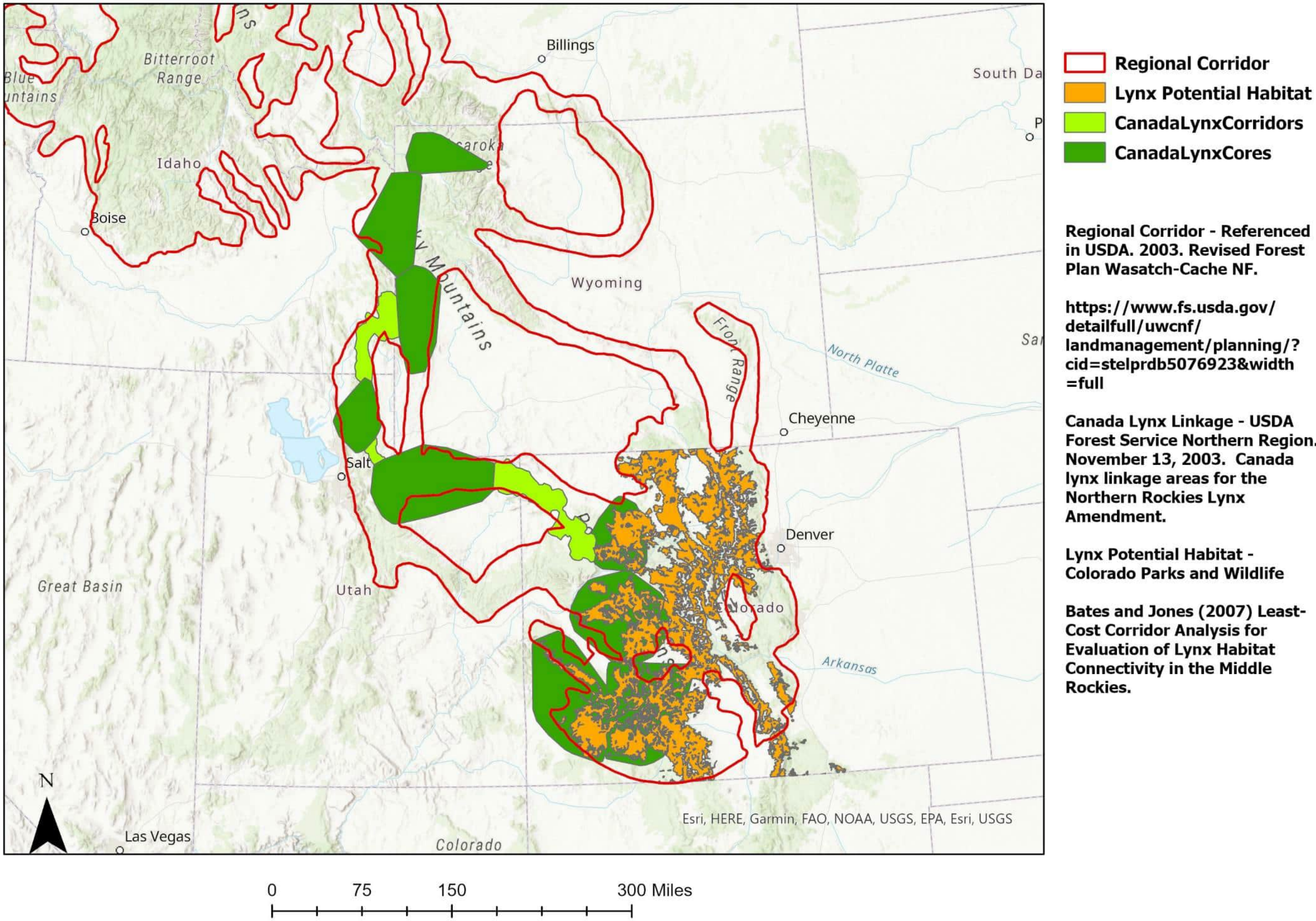
[44] Ivan, J., Rice, M., Shenk, T., Theobald, D., and Odell, E. Undated. Predictive Map of Canada Lynx Habitat Use in Colorado. Colorado Parks and Wildlife. Accessed on January 20, 2023. https://cpw.state.co.us/Documents/Research/Mammals/Publications/CPWPredictiveLynxMapReport.pdf

[45] Hamilton, H. 2008. Predicted Distribution of Canada Lynx (Lynx canadensis) - A2 emissions scenario - 2050's. California Academy of Sciences 07.29.2008. Map data from https://databasin.org/datasets/3674ed71-f5b7-45a3-a778-dfc2f0990235/ Accessed on January 20, 2023.

[46] Berg, N.D., Burghardt, J., Gray, R., and Smith, B. 2005. The Greater Yellowstone Lynx Study 2004/2005 Annual Report. The Endeavor Wildlife Research Foundation.

[47] Holmes, M. and Berg, N. 2009. Greater Yellowstone Ecosystem Lynx Study. Endeavor Wildlife Research Foundation. https://yellowstone.co/pdfs/lynxstudy2009.pdf Accessed on January 22, 2023.

Figure 8. **Regionally Significant Wildlife Corridor, Lynx Linkage and Colorado Potential Habitat**



Regional Corridor - Referenced in USDA. 2003. Revised Forest Plan Wasatch-Cache NF.

https://www.fs.usda.gov/detailfull/uwcnf/landmanagement/planning/?cid=stelprdb5076923&width=full

Canada Lynx Linkage - USDA Forest Service Northern Region. November 13, 2003. Canada lynx linkage areas for the Northern Rockies Lynx Amendment.

Lynx Potential Habitat - Colorado Parks and Wildlife

Bates and Jones (2007) Least-Cost Corridor Analysis for Evaluation of Lynx Habitat Connectivity in the Middle Rockies.

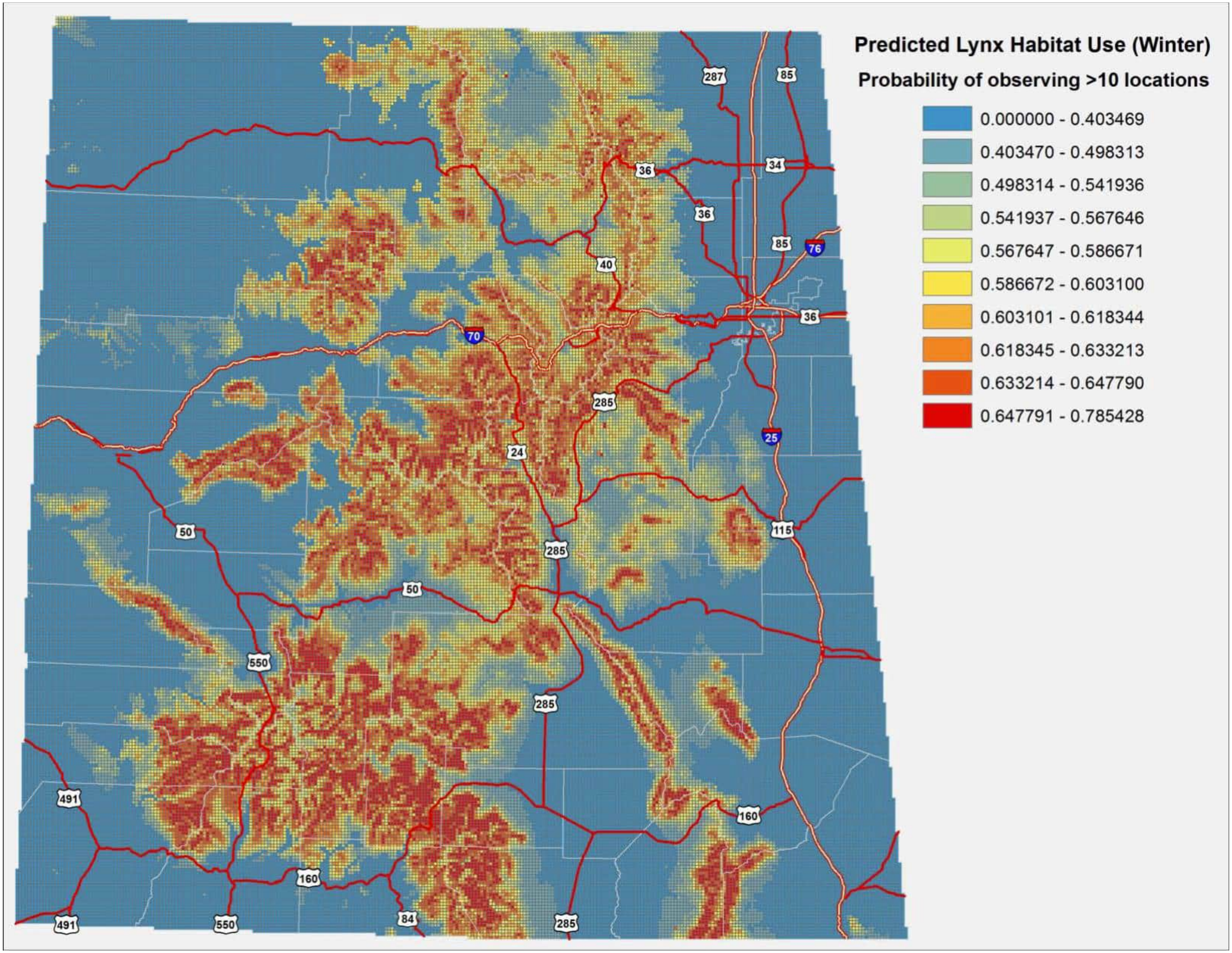


Figure 9 . Predicted winter use by Canada lynx in western Colorado. (From Ivan et al Figure 2)

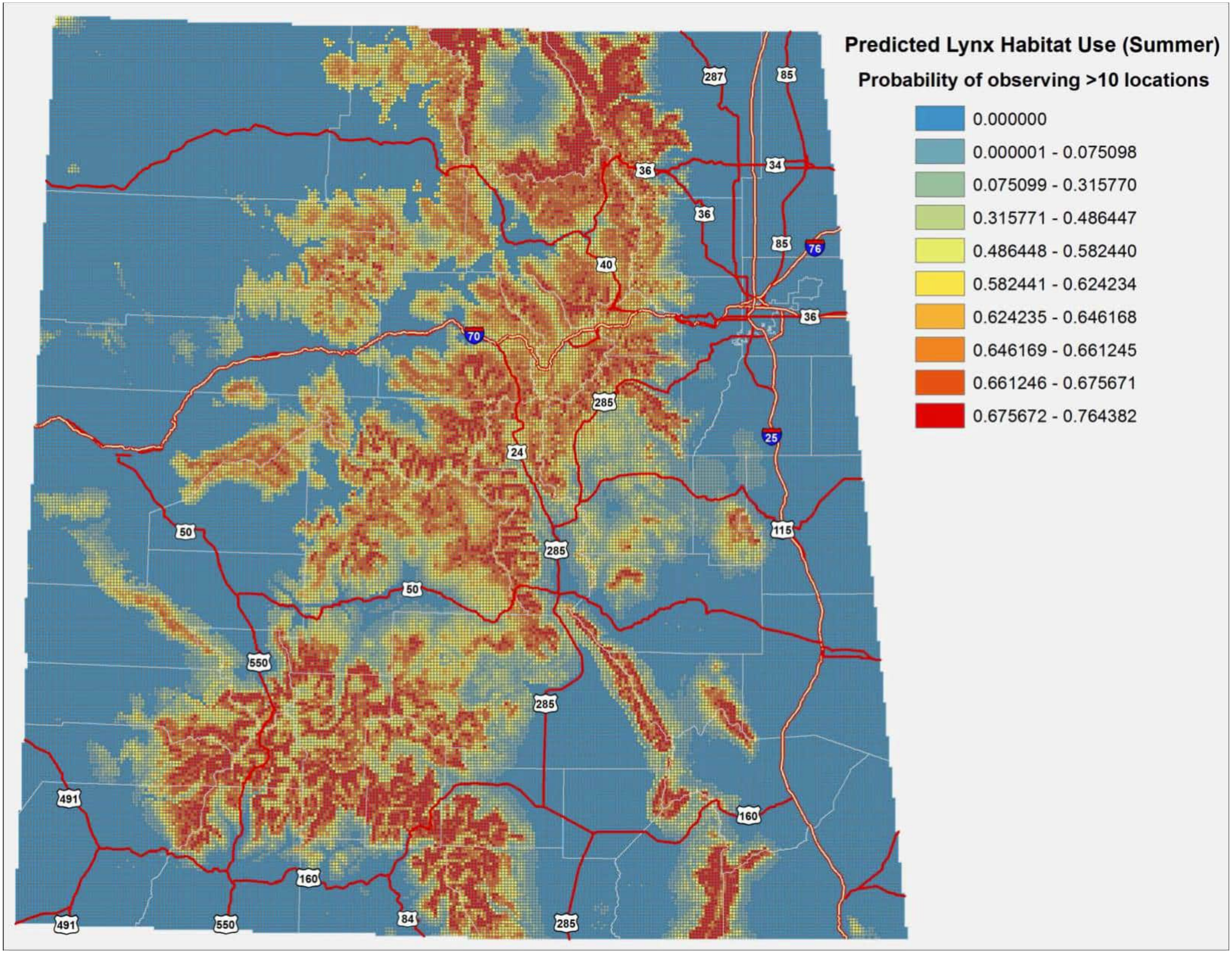
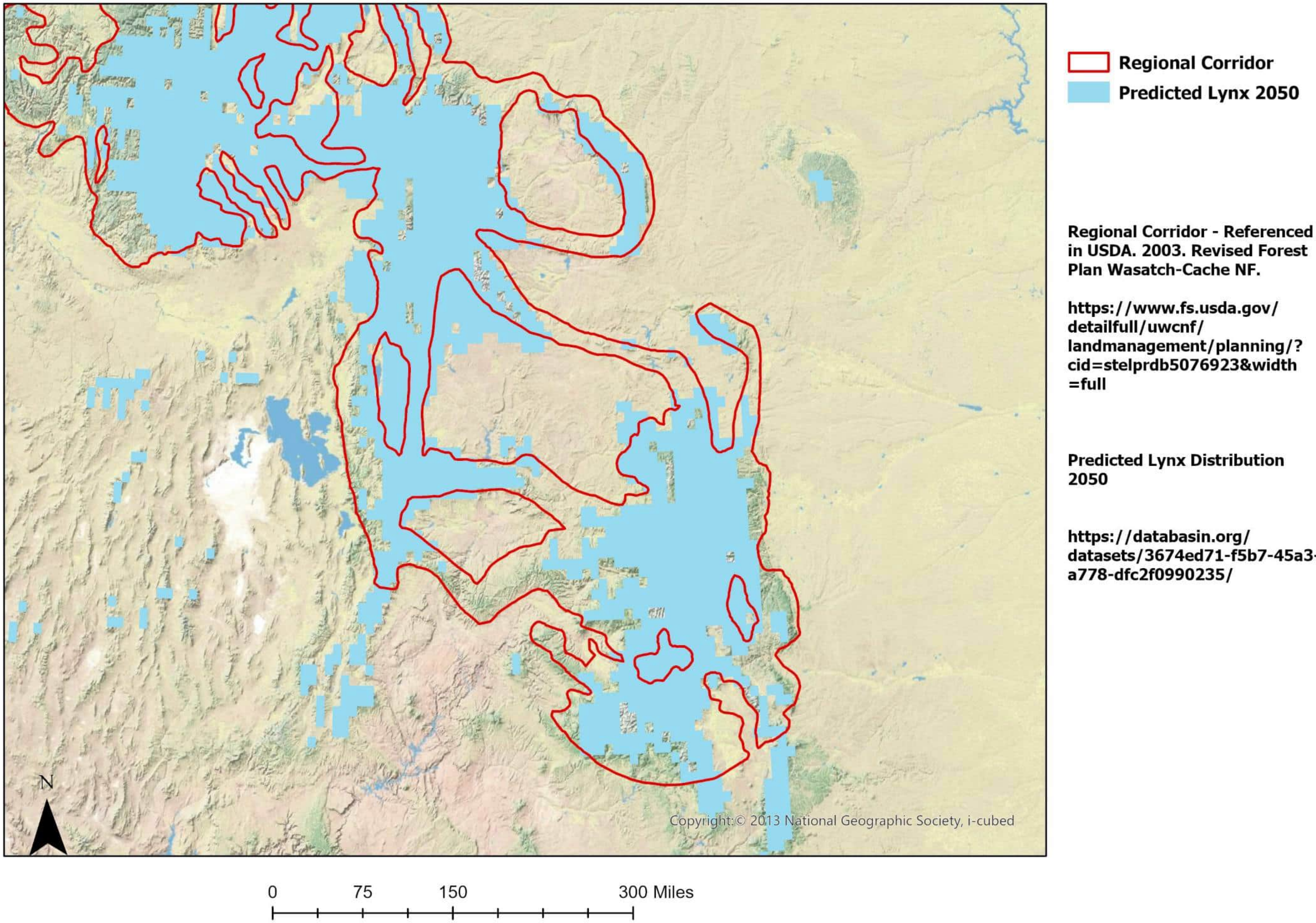


Figure 10. Predicted summer use by Canada lynx in western Colorado. (From Ivan et al Figure 3)

Figure 11. **Regionally Significant Wildlife Corridor Predicted Lynx Distribution in 2050s Using Climate Model**



PROVIDING FOR CANADA LYNX IN IDAHO, UTAH, WYOMING, AND COLORADO

These four states are those historically used or occupied by Canada lynx that do not border the Canadian Provinces (excluding northern Idaho) and the forested habitats where the larger populations of lynx have survived. Ensuring connectivity and habitat protection in these southern core and corridor areas that are disconnected from habitats in Canada is critical to maintain the isolated meta-populations in the south. The Colorado reintroductions show lynx can survive in this southern portion of the DPS, yet research and monitoring are lacking for these areas. The Science Report (SR p338) reported only seven studies with two of those being for bobcats. In the following, we just touch on a few parameters to place some degree of definition on lynx habitat, prey, and demographics for context to illustrate some of the quantitative parameters that need to be incorporated into agency requirements.

The Science Report Chapter 13 reviewed the ecology of lynx in these southern areas and compared them to the taiga in Canada. In both regions, lynx occurred where snowshoe hares were abundant. In the southern region, lynx were known to make exploratory movements prior to dispersal. The Colorado tracking data clearly illustrate these exploratory movements. Habitats in the southern region are patchier and lynx make more use of alternate prey. For instance, lynx scats collected in north-central Washington contained 79% snowshoe hare and 24% red squirrel. (SR p376 - 377). Snow tracking studies in the southern Canadian Rocky Mountains found prey consisted of 52% snowshoe hare, 30% red squirrels, and the rest were flying squirrels, martens, voles, and grouse plus unknowns. Snowshoe hare densities were estimated to range from 0.01 - 0.47 hares/ha. (SR p377). *"In southern boreal forests, limited data suggest that because snowshoe hares typically occur at low densities (Chapter 7), alternative prey may always be important components of lynx diets, especially in the western mountains."* (SR p378).

We previously referenced the association between lynx locations and habitat. The predominant association was with Rocky Mountain Conifer in these western interior states. Lynx use a variety of habitats and elevations between summer and winter. Generally, they use higher elevations in more southerly locations and between summer and winter. Most conifer types are included in areas used by lynx and can include Douglas-fir, western larch, lodgepole pine, subalpine fir, whitebark pine, and Engelmann spruce. Occasionally, they will occur in non-forested areas such as shrub-steppe. (SR p379). Snow tracking in Washington found that lynx traveled around meadows and used thinned stands that contained several hundred trees per ha. (SR p381).

Home ranges in these southern areas are larger than in the north. The average for males is 151 km^2 and females, 72 km^2. In west-central Wyoming they were smaller at 90 and 66 km^2. (SR p383 – 384). In Washington, home ranges were bounded by rivers, ridges, and major highways. (SR p385). Exploratory movements in Montana ranged from 17 to 38 km. (SR p386). Dispersal can take place over larger distances of several hundred km. (SR p386 -387). In the north-central Washington study, 8 kittens were documented in a population of 23 lynx during the three-year study. Estimates of total lynx density for the 1,161 km^2 area was 2.4 lynx/100 km^2. (SR p387). Comparisons are made to northern populations during the lows in hare cycles, indicating similar demographics occur in the southern populations compared to these lows. (SR p389).

Because lynx are highly dependent on snowshoe hares, we have looked for information on hare density in these southern states. Chapter 11 of the Science Report summarizes densities in Montana as well as the Wyoming Range. (SR p346). These ranged from 0.6/ha to 1.4/ha. Two studies cited from Utah gave densities ranging from lows in aspen with dense understory of 0.22/ha to 2.7/ha in spruce-fir habitat. Intermediate numbers occurred in Douglas-fir (0.57/ha and subalpine fir of 0.99/ha). These were estimated from pellet counts while the higher numbers from spruce-fir were from live trapping. Pellet plots in Colorado ranged from 0.26/ha in aspen, to 0.46 in Engelmann spruce. (p185).

These southern hare densities compare to population lows in areas of Canada with persistent lynx populations. For example, from the Science Report (SR p362), *"Hare densities in the southwest Yukon declined from 8.0 to 10.7/ha to 0.2 to 0.5/ha during one cycle (Ward and Krebs 1985), and another population fell from 7.5/ha to 1.3/ha during the next cycle (Slough and Mowat 1996). Similarly, a population in the Northwest Territories fell from 7 to 9/ha to 0.4 to 1.0/ha during the early 1990s (Poole 1994), and a northern Alberta population declined drastically from about 17/ha to 0.34/ha during the early 1970s (Brand et al. 1976)."* Apparently hare densities in these studies were sufficient to support lynx populations in the DPS, but the absence of recent hare studies leaves open the question as to the status and extent of current hare densities in the southern portion of the DPS. Whether snowshoe hares exist in sufficient numbers in these southern regions needs to be determined along with factors (deforestation, livestock grazing, predation, etc.) driving their population density.

A recent study looked at forest characteristics centered around lynx reproductive success.[48] Concerns were habitat fragmentation and loss of connectivity. In particular, the natural patchiness of lynx habitat at the southern extent of its range is *"subject to loss and fragmentation by some forest management practices (i.e. regeneration harvests, pre-commercial and commercial thins, prescribed burns), wildfires and insect infestations, and climate change… ."* (p2). There are data gaps on the abundance and arrangement of lynx habitat and how these relate to reproductive success. The research was conducted in the Swan, Mission, and Purcell Mountains in Montana and included low to mid-elevation ponderosa pine and Douglas-fir to high-elevation subalpine fir, spruce and lodgepole pine. (p3 - 4). Thirty - six female lynx were radio collared and monitored and produced 36 litters with an average of 2.46 kittens during the 14 year period 1998 – 2012. (p12 – 13*).* Mature forest was the dominant structure in core areas and home ranges with 49 and 50% of core and home ranges with young regenerating forest averaging 13 and 11% of core and home ranges, respectively. (p13). When the proportion of young regenerating forest reached 10 – 15% of the core area, the probability of producing a litter declines. (p14). Females with larger surviving litters *"had less fragmented home ranges, lower moisture variance, young regenerating forest patches with low perimeter-area ratio, and lower percent composition of old regenerating forest than home ranges of females with smaller surviving litter sizes"*. (p15). *"…connectivity of mature forest, percent composition of young regenerating forest and young regenerating forest patches with low perimeter-area ratio, and adjacency of mature to young regenerating forest types were the most important predictors for overall lynx reproductive success in our study areas."* (p16).

[48]Kosterman, Megan K., "Correlates of Canada Lynx Reproductive Success in Northwestern Montana" (2014). Theses, Dissertations, Professional Papers. Paper 4363.

The Northern Rockies Lynx Management Direction Record of Decision (NRLMD ROD) and its standards and guidelines provided no adequate standard for levels of mature forest habitat within LAUs and provided nothing for habitat not designated in LAUs. While it states that habitat connectivity will be maintained, there is no definition of what constitutes connected habitat, even though this can be defined by current science. The NRLMD ROD does not clearly define what qualifies as unsuitable lynx habitat, which is limited to no more than 30% of an LAU (VEG S1) with no more than 15% unsuitable habitat created in 10 years (VEG S2). The glossary at 12 also defines lynx habitat in an unsuitable condition as the stand initiation structural stage but notes that unsuitable habitat can also be created by shelterwood cuts and commercial thinning depending on the resulting stand composition and structure. The ROD at 9 defines lynx habitat in an unsuitable condition as those forests in a stand initiation structural stage that are too short to provide winter snowshoe hare habitat; these conditions are created by stand-replacing wildfires, prescribed burns that remove all vegetation, or regeneration timber harvest. The ROD at 10 states that the definition of VEG S2 was changed to clarify that it only applies to timber management practices that regenerate a forest, as clear-cut, seed tree, shelterwood, and group selection. The VEG S2 standard applies to all timber management projects that regenerate forests, including clear-cuts, seed tree, shelterwood and groups selective cuts. The NRLMD does not ensure persistence of lynx, since there are no restrictions on the amount of an LAU that can be converted to habitats that are avoided by lynx, and to habitats that reduce habitat connectivity via mature forests.

The 30% clear-cut standard for lynx habitat in the NRLMD is based on habitat recommendations published in 1989, while other key recommendations were ignored. Although these recommendations noted that monitoring was required to determine if they would be effective, we found no evidence such monitoring was ever done before they were partially included in the LCAS and the NRLMD. Currently, the best available science demonstrates that the 33% opening level allowed by these recommendations are invalid, while the unused recommendations of maintaining a high level of forest cover of 69% has been validated. The 1989 Brittell recommendations for lynx habitat defined a level of habitat connectivity for lynx, which included denning, travel, and stalking habitat as 66% of each square mile of lynx habitat, not an entire LAU of many square miles with no guidance as to where within that LAU habitat should be maintained.[49]

While clear-cuts and sparse forests may receive some lynx use, their suitability for lynx is significantly reduced for a significant amount of time. It has been shown not only that those clear-cuts and sparse forest are strongly avoided by lynx but that restoration of lynx habitat use in these logging areas to 50% of previous use takes 20 years in forest thinnings, and 34-40 years for selection cuts and clear-cuts. Also, all logging treatments are avoided by lynx for at least 10 years.[50] Predictors for lynx reproductive success within occupied female home ranges were the connectivity of mature forest, intermediate (10 - 15%) amounts of young regenerating forest, young regenerating forest patches with low perimeter - area ratios, and the adjacency of mature

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[49] Brittell, J.D., R.J. Poelker, S.J. Sweeney, G.M. Koehler. 1989. Native cats of Washington. Washington Department of Wildlife, Olympia.

[50] Holbrook, J.D., Squires, J.R., Bollenbacher, B., Graham, R., Olson, L.E., Hanvey, G., Jackson, S., Lawrence, R.L., 2018. Spatio-temporal responses of Canada lynx to silvicultural treatments within the Northern Rockies, U.S. For. Ecol. Manage. 422, 114–124.

forest to young regenerating types. Female lynx home ranges with greater than 50% mature forest and 10 - 15% young regenerating forest appear to be the optimum. [51]

More recent work has characterized habitat quality of Canada lynx at their "range periphery".

> *Our results indicated that the probability of a female producing kittens was most associated with the connectivity of mature, multistoried forests (composed of mostly spruce-fir). However, the variation among female lynx accounted for ≈62% of the total variation explained in litter production, suggesting substantial individual-level variation. Thus, managers can contribute to increased reproductive success of female Canada lynx by facilitating the development of mature forests but measuring that success will be difficult given the individual variation. In core areas of high-quality females (i.e., produced kittens frequently), mature forest was 17% more abundant (i.e., ≈60% of the total core area), more connected, less clumpy, and exhibited 2.25-times larger patch sizes than the core areas of low-quality females. At the home-range extent, patterns were less pronounced while the abundance of mature forests remained high (≈50%) for high quality females. Additionally, we demonstrated that the relative density of snowshoe hares was ≥2.8 times higher in advanced regenerating forests compared to all other structural classes, including mature forest. Advanced regenerating forests accounted for ≈18–19% of the core area and home range of high-quality female lynx. Combined, our results suggest that a high-quality mosaic for female Canada lynx contains ≈50–60% mature forest and ≈18–19% advanced regenerating forest. Furthermore, we used Forest Inventory and Analysis data to characterize the approximate age distribution of advanced regeneration and mature forest, which was relevant for rotation schedules of forest silviculture. Results indicated that advanced regeneration was ≈20 to 80 years old while mature forest was ≈50 to ≥200 years old.* [52]

In addition, lynx spend a significant amount of time at the interface between mature and advanced regeneration forest. This is likely because advanced regeneration forest provides the most hares, but mature forest habitat makes these hares more accessible. This indicates that advanced regeneration forest subsidizes the occurrence of hares in adjacent mature forest where they are more accessible to lynx.[53]

What is lacking today is the inclusion of current knowledge of what is known about lynx, snowshoe hare, red squirrels and their habitats into quantitative criteria that define these

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[51] Kosterman, M.K. 2014. Correlates of Canada Lynx Reproductive Success in Northwestern Montana.Graduate Student Theses, Dissertations, & Professional Papers. 4363. https://scholarworks.umt.edu/etd/4363 Accessed on January 22, 2023.

[52] Holbrook, J.D., Squires, J. R., Bollenbacher, B., Graham, R. O., Lucretia E., Hanvey, G., J, S., Lawrence, R.L., Savage, S. L. 2019. Management of forests and forest carnivores: Relating landscape mosaics to habitat quality of Canada lynx at their range periphery. Forest Ecology and Management. 437: 411-425. https://doi.org/10.1016/j.foreco.2019.01.011 Accessed on January 22, 2023.

[53] Holbrook, J.D., Squires, J.S., Olson, L.E., Lawrence, R.L., Savage, S., 2017. Multi-scale habitat relationships of snowshoe hares (Lepus americanus) in the mixed conifer landscape of the Northern Rockies, USA: cross-scale effects of horizontal cover with implications for forest management. Ecol. Evol. 7, 125–144.

habitats and their overlap in the southern DPS. The NRLMD and current Forest Plans are badly out of date and based on the omission of critical information. This is especially true in those areas not bordering the Canadian populations. While the Science Report has pointed out study and research needs, there has been a lack of definitive work in the southern-most states, particularly in SE Idaho, NE Utah, Colorado and the linkages or connections between these areas. Since these areas are heavily used by livestock as opposed to the situation further north, the effects of livestock on habitats important for cover and forage for snowshoe hares, and cover for lynx need to be determined. Also, the effects of over-snow travel, cross-country skiing, summer recreation and road density must be studied because the earlier data in the Science Report and the conclusions represented in the NRLMD, both LCAS, the 2017 SSA and the Remand Notice were based on earlier times in the absence of the levels of activity currently flooding throughout the western National Forests and BLM lands. We have regularly asked for data and maps of old growth forest residuals in these forests without success, apparently because these have not been developed. We have regularly asked for identification of the status of mined land reclamation, forest and vegetation manipulations, mapping of non-system roads and trails, temporary roads on National Forests without result.

It is in this vacuum of current data and information that the FWS must evaluate the status of Canada lynx in the DPS. Continuing to cast doubt on the historical presence of lynx in these southern areas cannot be used as a mechanism to reduce the area of potential lynx habitat, the habitat connections needed, or regulatory requirements. Instead, the current existing database and science must be applied to map and describe these areas of historical observations (not just verified records), their current habitat status and fragmentation by human uses as compared to what is known about the habitat needs of lynx. Studies and data collection need to happen to answer the questions and fill the data needs.

The criteria for identifying and managing LAUs needs to change to more specific, quantitative limitations on timber harvest, road density, mining, recreation use, perhaps using blocks of contiguous habitat and connections. Currently “unoccupied” or “peripheral” areas that had historical lynx observations must have potential lynx habitat mapped into LAUs, watershed areas, or blocks of habitat with definitive and quantitative criteria and standards reflecting what is known about lynx habitat. The parameters defining lynx habitat in places such as those studies we have cited in the contiguous states could be used to define current standards. Forest Plans and BLM Resource Management Plans must be amended with new standards to correct the current lack of regulatory requirements we have identified in our example of the Caribou NF. Corridors must be mapped and defined following the examples cited herein in which models have been used to identify lynx habitat, corridors, and connections. Those should have the same standards as occupied habitat.

Until these things are done, the Status Assessment for lynx must be that they are not only “threatened” in the western states DPS, but “endangered” and a recovery plan put in place to retain lynx in its historical habitat.

APPENDIX 1 -LIVESTOCK GRAZING STUDIES IN LINKAGE AND PERIPHERAL AREAS IN SE IDAHO AND NE UTAH BY DR. JOHN CARTER & ASSOCIATES

Since the late 1980s we have been engaged in collecting data on habitat in NE Utah and SE Idaho, particularly focused on the Bear River Range and Uinta Mountains. These are areas located in the linkage and peripheral habitat described for lynx in the CNF RFP and WCNF RFP. The 2013 LCAS (p68) stated that, *"Federal agencies have amended or revised land management plans across much of the range of the lynx to provide direction to conserve lynx and lynx habitat. Thus, the impacts of anthropogenic influences have been substantially reduced."* The presumption is that putting it in a forest plan means it will be so. The data and observations we have made over the past four decades and even earlier as we have backpacked and explored the national forests in Idaho, Utah, and Wyoming refute that presumption. Following are descriptions of some of our reports and data showing that livestock grazing management in this linkage habitat is abysmal. Figure A1 shows the National Forests occurring in the high elevation Regionally Significant Wildlife Corridor, which are where much of this data and observations have occurred. This corresponds to the linkage habitat and peripheral habitat.

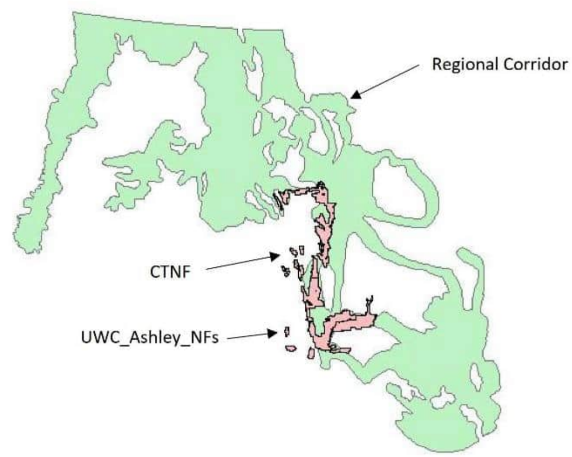

Figure A1. Forests in Which Livestock Grazing Studies Occurred

We completed a survey in the Caribou NF in 2001 with a report (Report) issued in 2002.[1]. This study showed tremendous degradation of plant communities and riparian areas. Monitoring in this and other areas in the Caribou and Targhee Zones and in NE Utah in the Uinta Wasatch Cache NF and Ashley NF since that time has shown no progress. When we measure use by livestock it is typically higher than sustainable levels and livestock are the base of the pyramid of damaging actions the Forest Service allows to continue. The photos in Figures A2-A6 below were taken during the 2001 survey and are from the Report. They show examples of the (a) impact of livestock grazing and water developments on vegetation, soils and aspen understory and recruitment, (b) conifer understory, and (c) riparian areas. Photo links are provided in the referenced Report for all locations surveyed.

In preparing this survey, we relied on Forest Service monitoring reports, the Draft EIS for the Revised Caribou Forest Plan[2] and literature characterizing livestock impacts on upland and riparian habitats. In the late 1990's, the Forest Service had prepared Regional and Sub-Regional

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[1] Carter, J., Chard,B. and J. Chard. 2002. Assessment of Habitat Conditions Bear River Range Caribou National Forest, Idaho. https://app.box.com/shared/5q2hazcnfu

[2] USDA. 2001. Draft Environmental Impact Statement for the Caribou National Forest Revised Forest Plan Draft Revised Forest Plan. Caribou-Targhee National Forest.

Reports characterizing departures from Proper Functioning Condition (PFC) for aspen, conifer, tall forb, sagebrush/grasslands, riparian, and wetland areas. They found livestock grazing and past timber harvest in conifer forest were fundamental issues leading to loss of PFC in these communities.[3] [4] Our Report (p18) described the structure and compositional characteristics of these habitats needed for PFC.

We assessed 86 locations for PFC in the Bear River Range including uplands, riparian areas, open basins/meadows, aspen and conifer stands. These were within one mile of water sources in areas considered "capable" for livestock based on slope and distance to water. Mapping analysis predetermined the locations at which we surveyed each habitat type present. We compared observable conditions to the Caribou RFP Draft EIS PFC guidelines. Table A1 below is reproduced from the Report and shows the number of locations of each habitat type assessed. A total of 310 individual habitats were assessed. As shown, a small percentage met the Forest Service guidelines for PFC, most did not.

Figure A2. Sheep watering and bedding area showing complete loss of understory, loss of aspen recruitment and high-lined aspen. The soil is completely exposed. Sheep are bedded in a different location each day throughout the season, leading to widespread damage that is not documented by the Forest Service.

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[3] USDA. 1996. Intermountain Regional Assessment: Properly Functioning Condition. USDA Forest Service, Region IV, Ogden, Utah.

[4] USDA. 1998b. Draft Sub-regional Assessment of Properly Functioning Condition for Areas Encompassing the National Forests of Northern Utah. USDA Forest Service, Region IV, Ogden, Utah

Figure A3. Aspen stand in valley bottom. Cattle have denuded the area, browsed suckers and essentially created a single aged stand that will die out unless livestock are excluded and recruitment allowed to occur. No understory cover or herbaceous vegetation is left.

Figure A4. Grazed conifer stand with little herbaceous vegetation present

Figure A5. Grazed riparian area with barren banks, little vegetation left in riparian zone

Figure A6. Sediment-laden stream substrate from trampled and eroding banks, adjacent roads

Table A1. Results of Bear River Range PFC Assessments

Habitat type	Number of locations	Number in PFC	Percent in PFC
Aspen forest	71	17	24%
Conifer forest	68	14	21%
Forb meadow	44	2	4.5%
Sage – grass	73	8	11%
Riparian	54	12	22%

We measured ground and canopy cover along transects at 55 locations in sagebrush-grassland and tall forb habitats. Tables A2 and A3 below are reproduced from that report. Bare soil averages above 50% show ground cover is well below potential. These averages included some ungrazed exclosures, which if omitted from the analysis, would have resulted in even lower soil cover values. The Sub-Regional Assessment by the Forest Service indicated ground cover potential ranges between 80 - 95%. In our surveys of un-grazed areas in the Bear River Range and on Kiesha's Preserve, potential ground cover is near 100% in all habitats. See our Kiesha's Preserve website for photographs of these ungrazed conditions.

Table A2. Cover Data for 45 Sagebrush Locations

Cover type	Range	Average	Standard Deviation
Bare Ground	86.2 – 10.7	51.6	19.0
Litter	68.2 – 2.0	31.5	15.2
Grass	23.2 – 0.3	5.1	5.3
Forb	14.7 – 0.5	4.5	3.4
Shrub	16.7 – 0	4.7	3.6
Rock	11.9 – 0	2.2	2.8
Crust/moss	10.4 – 0	0.4	1.6
Shrub Canopy	43.0 - 0	12.4	9.0

Table A3. Cover Data for 10 Locations in Tall Forb

Cover type	Range	Average	Standard Deviation
Bare Ground	78.8 – 5.5	54.1	22.6
Litter	55.0 – 4.9	24.2	15.5
Grass	16.5 – 1.0	6.0	5.6
Forb	21.1 – 2.8	11.6	5.2
Shrub	10.3 - 0	3.0	3.4
Rock	3.6 - 0	0.8	1.2
Crust/moss	1.9 - 0	0.3	0.6

Data collected in this 2001 study as well as other surveys we have conducted in the area demonstrate that all Forest habitats grazed by livestock are well below potential. Compared to the Draft Caribou RFP EIS and other PFC manuals for Riparian Areas the best we could say is they are functioning at risk with many in non-functioning condition

We have measured utilization by livestock in numerous locations in the Bear River Range and adjacent public lands such as BLM. Compared to Forest Plan or BLM land use plan standards allowing 30 – 50% use in upland and riparian areas, universally we find utilization in riparian areas and meadows near 100% and in uplands 70 – 80%. A summary of studies is listed:

1. Unpublished data for Bear River Range riparian areas (12) using paired plots found utilization rates averaging 81%.[5]

[5] Carter, J. 2009. Unpublished utilization data for Riparian Areas in the Bear River Range.

2. 2011 Monitoring Report 1st Hollows and Paris Canyon Allotments.[6] I found utilization ranges from 75 – 92% in meadows, riparian area use was 63 and 82.6% at two locations monitored, upland low sagebrush sites ranged from 49 to 69%, and upland big sagebrush sites ranged from 85 to 88%.
3. Multiyear study in the Bear River Range in northern Utah looked at livestock grazing effects on plant production, soil nitrogen and carbon.[7] That study documented losses in plant cover, plant production, soil carbon and nitrogen in areas grazed by livestock compared to long term ungrazed areas.
4. Summary of utilization data for riparian areas on the North Rich Allotment in the Bear River Range.[8] Over a four-year period these remained nearly constant at 83 – 93%.
5. A multiyear study on a BLM managed allotment (Duck Creek) in the lower elevation foothills adjacent to the Bear River Range in Utah. We evaluated government monitoring by collecting data on grazed and ungrazed paired plots and critiqued the government monitoring effort. We found the BLM understated utilization and native plant production was greatly reduced by decades of improper management.[9]
6. A paper illustrating upland and riparian outcomes from BLM management of the Duck Creek allotment showed the installation of upland water and a deferred rotation grazing system resulted in increased use on the riparian greenline, bank alteration by trampling remained at 80%, riparian utilization remained near 100%, and upland utilization increased to near 80%.[10]
7. A report summarizing multiple years of data collection in the High Uintas Wilderness.[11] This study documented depleted alpine ground cover in grazed areas compared to those that had been excluded from sheep grazing for decades. Grazed areas had over 50% bare soil compared to 0.2% in long term rested areas. Streambanks were scoured by high runoff events due to loss of stabilizing vegetation in the watershed and stream banks. Most of the soils in the allotment are considered as high to extremely high in erosion potential, resulting in loss of the productive upper horizon.
8. A paper on livestock grazing impacts in the High Uintas Wilderness which is in designated LAUs and Peripheral habitat.[12] While all lands in this 160,000 acre set of domestic sheep allotments are grazed by domestic sheep, we determined that only a small fraction of the area

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[6] Carter, J. 2012. 2011 Monitoring Report 1st Hollows and Paris Canyon Allotments. Report prepared for Western Watersheds Project and Yellowstone to Uintas Connection. Dated March 1,2012.
[7] Carter, J., Chard, B., and Chard, J. 2011. Moderating livestock grazing effects on plant productivity, nitrogen and carbon storage. In Monaco, T.A. et al. comps. 2011. Proceedings – Threats to Shrubland Ecosystem Integrity; 2010 May 18-20; Logan, UT. Natural Resources and Environmental Issues, Volume XVII. S.J. and Jessie E. Quinney Natural Resources Research Library, Logan Utah, USA.
[8] Carter, J. 2009. Allotment Summary North Rich Allotment Riparian Areas.
[9] Catlin, J., Carter, J., and Jones, A. 2011. Range management in the face of climate change. In Monaco, T.A. et al. comps. 2011. Proceedings – Threats to Shrubland Ecosystem Integrity; 2010 May 18-20; Logan, UT. Natural Resources and Environmental Issues, Volume XVII. S.J. and Jessie E. Quinney Natural Resources Research Library,
Logan Utah, USA.
[10] Carter, J., Catlin, J., Hurwitz, N., Jones, A., and Ratner, J. 2017. Upland water and deferred rotation effects on cattle use in riparian and upland areas. Rangelands 39(4):112-118.
[11] Carter, J. 2006. Watershed Conditions Uinta's Wilderness, Utah. Report for Western Watersheds Project. https://app.box.com/s/944957604b8618539585 Accessed on January 21, 2023.
[12] Carter, J., Vasquez, E. and Jones, A. (2020) Spatial Analysis of Livestock Grazing and Forest Service Management in the High Uintas Wilderness, Utah. Journal of Geographic Information System, 12, 45-69. https://doi.org/10.4236/jgis.2020.122003

(6%) is capable for grazing when we applied the Forest Service criteria for determining capable acres. The current forage on the allotments provides only 10% of the demand. The result of this is accelerated erosion, sedimentation of lakes and streams, depletion of the native plant community to below its potential. Based on the two scenarios we evaluated, the stocking rate would need to be reduced between 90 – 97%.

There were other surveys and reports with data provided to the Forest Service and BLM. No management changes have resulted from this input now decades after we first began monitoring and submitting data to the agencies. The habitats are depleted of the forage and horizontal cover needed by snowshoe hares and other wildlife. The Desired Future Conditions and Standards provided in the Forest Plans for these places have resulted in no positive change. Yet, the FWS and Forest Service claim that provisions in Forest Plans protect lynx habitat.