Appendix M

Occupancy, Risk, and the Potential for Contact Report

Table of Contents

List of Figures

Introduction

In 2003, the Payette National Forest (Payette NF) released its revised *Payette National Forest Land and Resource Management Plan* (Forest Plan) (USDA Forest Service 2003), which included direction on the management of bighorn sheep (*Ovis canadensis*) in Management Area (MA) #1 (Hells Canyon). The Forest Plan was appealed, in part due to the allegation that it violated the National Forest Management Act and the Hells Canyon National Recreation Area (HCNRA) Act by allowing domestic sheep (*Ovis aires*) grazing "within or near the range of bighorn sheep, thus threatening the viability of bighorn sheep through disease transmission" (USDA Forest Service 2005).

The Forest Plan includes one guideline for MA #1, which states: "Within bighorn habitat emphasis areas, close sheep allotments as they become vacant, or convert them to cattle where appropriate, to eliminate the risk of disease transmission from domestic to wild sheep. Do not convert cattle allotments to sheep allotments within occupied bighorn sheep habitat" (USDA Forest Service 2003).

The Chief of the Forest Service's (Chief's) remand to the Regional Forest states in part: "The Regional Forester is instructed to do an analysis of bighorn sheep viability in the Payette NF commensurate with the concerns and questions discussed above, and amend the SW Idaho Ecogroup Final Environmental Impact Statement (FEIS) accordingly. Changes to the management direction of the Payette NF LRMP for MA #1 (Hells Canyon) and adjacent areas shall be evaluated, and adopted as necessary to ensure bighorn sheep viability. The analysis and evaluation must be extensive enough to support determinations of compliance with applicable law and regulation, specifically the Hells Canyon NRA Act, 36 CFR 219.19, and 36 CFR 292.48" (USDA Forest Service 2005).[1] The Chief's remand for analyzing bighorn sheep viability is linked to the likelihood of contact and disease transmission between domestic and bighorn sheep.

"Occupied" Habitat and the Chief's Remand

The concept of bighorn sheep occupied habitat is referenced in the Chief's remand relative to the potential for contact and disease transmission between domestic sheep and bighorn sheep on five occasions, all in the "Discussion" section of the remand. Emphasis has been added in the following excerpts:

1) The Payette NF LRMP includes a Rangeland Resource 'Guideline' for Hells Canyon MA #1 that reads:

   > "Within bighorn habitat emphasis areas, close sheep allotments as they become vacant, or convert them to cattle where appropriate, to eliminate the risk of disease transmission from domestic to wild sheep. Do not convert cattle allotments to sheep allotments within **occupied** bighorn sheep habitat" (USDA Forest Service 2003 and 2005, p. 12).

[1] For a detailed account of the rationale and remand decision, see *Decision for the Appeal of the Payette National Forest Land and Resource Management Plan* (USDA Forest Service 2005).

This reference cites guidance from Forest Plan Guideline MA #1 (Hells Canyon) and refers to the Forest's use of the term "occupied habitat" in the Forest Plan.

2) "Payette NF LRMP direction pertaining to bighorn sheep in the Hells Canyon MA was described above. It is limited to a coordination objective, and a guideline for closing domestic sheep allotments should they become vacant. 'Guideline' is defined as 'a preferred or advisable course of action generally expected to be carried out' (Payette LRMP, p. GL-17). The Payette LRMP does not contain any direction for protecting or maintaining bighorn sheep or their habitat in the Hells Canyon MA, in particular for the protection of bighorn sheep from the documented current and likely future threat of disease transmission from domestic sheep. By permitting the presence of domestic sheep within **occupied** bighorn sheep range, the Payette NF does not appear to be managing the habitat to maintain viable populations of bighorn sheep" (USDA Forest Service 2005, pp. 13–14).

The focus of this discussion is on Forest Plan direction and the charge that the Forest Plan does not contain direction for protecting bighorn sheep from contact and disease transmission. The specific focus of this section is on MA #1 (Hells Canyon). The inference is that "occupied habitats" in Hells Canyon are needed to support viable populations of bighorn sheep per 36 CFR 219.19. No specific guidance is given for defining "occupied" habitats.

3) "Based on the above analysis, the viability of bighorn sheep populations within the Hells Canyon area, and across the Payette NF, appears to be threatened by allowing continued grazing of domestic sheep in or near **occupied** bighorn sheep habitat. As documented in the FEIS and relevant scientific literature, without immediate removal of domestic sheep from **occupied** bighorn sheep habitat, bighorn sheep within that habitat are likely at risk of extirpation. Bighorn sheep habitat is contiguous between the Payette NF and NFS lands to the north, east and south, and bighorn sheep appear to move between the two identified habitat areas (Hells Canyon and Snake River) within the Payette NF (FEIS Appendix A, letter #53; NOA #0021, Attachment A). Transmission of disease to bighorn sheep on the Payette NF that are part of the Hells Canyon population will place the entire Payette NF population at substantial risk". (USDA Forest Service 2005, p. 14).

In this section, the discussion is expanded from MA #1 to include the remainder of the Payette NF. The impetus is on removing domestic sheep from occupied bighorn sheep habitat, though the attributes for defining occupied habitat are not specified. The emphasis is on the risks of disease transmission from domestic sheep to bighorn sheep, specific to bighorn sheep population viability.

4) "While the Hells Canyon MA is thus not specifically included within the Hells Canyon NRA Act, it is clear that by permitting the presence of domestic sheep within adjacent **occupied** bighorn sheep range, and with the documented movement of bighorn sheep between the NRA and the Payette NF (see discussion above, and the specific citations in NOA #0018, p. 37), the Payette NF is not managing livestock grazing in the Hells Canyon MA in a manner compatible with the protection and maintenance of bighorn sheep or their habitat within the Hells Canyon NRA" (USDA Forest Service 2005, p. 14).

The use of occupied habitat in the above quote is specific to the Hells Canyon NRA and alleges that the Forest Service is not managing grazing in bighorn sheep habitat in a manner compatible with Hells Canyon NRA Act. No effort is made to define occupied habitat.

5) "Another appellant contends that '[t]he Forest Plans propose reviewing only 5% of projects within known **occupied** habitat to determine whether Forest management actions are affecting species habitats. This monitoring effort is insufficient to accurately monitor populations with any statistical certainty' (NOA #0018, p. 11). This is a reference to the first of two monitoring requirements for management indicator species (MIS) (Payette NF LRMP, p. IV-11). However, the monitoring frequency is stated as 'up to 25 percent' so this contention is incorrect. In addition, this item is for monitoring changes to habitat: the second MIS requirement is for monitoring population trends". (USDA Forest Service 2005, p. 26).

This section cites an appellant's contention with Forest Plan monitoring. No specific criteria are used to define occupied habitat.

In summary, the primary focus of the Chief's remand is to provide management direction that will provide habitats that support viable populations of bighorn sheep on the Payette NF per regulatory direction in 36 CFR 219.19. The emphasis on "occupied" habitat is viewed in light of this direction relative to implications of disease transmission between domestic sheep and bighorn sheep. No effort is made in the Chief's remand to provide specific direction that defines occupied habitat.

Habitat Occupancy and Bighorn Sheep

The delineation of occupied habitat is an important concept used by managers and researchers in understanding the distributions of species on landscapes and the implications of natural and anthropogenic perturbations on those species and their habitats. Researchers and managers also have a long history of developing models that infer habitat suitability based on species' habitat requisites and the potential for species to occur in, or occupy, these suitable habitats. Considerable effort has been placed on monitoring species and their habitats to this end. However, there is a great difference between identifying suitable habitat and inferring that such habitat is occupied. Relative to this issue on Forest Service administered lands, guidance from the 1982 planning regulations (36 CFR 219.19) state that "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area."

MacKenzie (2005) summarizes the long-standing issue of presence (occupied habitat) and absence of species on landscapes beginning with the well-known assertion that whereas presence can be confirmed, absence cannot. There have been numerous sampling schemes for the detection/non-detection of species, most of which include modeling efforts that assess the probability of detection or the estimation of occupied habitat patches (e.g., Johnson 1980; Gu and Swihart 2003; Manley et al. 2005; Stanley and Royel 2005; Hirzel et al. 2006; Vaughan and Ormerod 2006; Hockey and Curtis 2008; Long et al. 2009; Nichols et al. 2008). In the absence of specific modeling or sampling, and when data are limiting, Delphi (expert opinion) methodologies have also been used to assess the quantity and quality of habitats and even species occupancy (e.g., Johnson and Gillingham 2004; Seone et al. 2005).

Documenting bighorn sheep occupied habitat on the Payette NF has several challenges, and the availability of suitable habitat does not infer occupied habitat for a number of reasons. Substantial declines of bighorn sheep populations, contractions in the species geographical distribution, translocations for the recovery of bighorn sheep, population depressions as a result of disease epizootics, and bighorn sheep behavior all influence the likelihood that suitable habitats are occupied. These factors also influence the rate at which habitats are acquired and occupied and the likelihood of persistence once occupied.

Historically, bighorn sheep occupied suitable habitats over much of the western United States. Steep population declines followed Euro-American settlement from the mid-1800s through the early 1900s and were attributed to overharvest, habitat loss, forage competition with domestic livestock, and disease (Goodson 1982; Valdez and Krausman 1999). Currently, bighorn sheep are estimated at approximately 10% of historic numbers, occupying 30% of historic distribution patterns, and mostly occurring in small disjunct herds of less than 100 animals (Berger et al. 1990; Singer et al. 2000d).

The influences of disease epizootics on the geographic distribution and abundance of bighorn sheep has long been a significant factor influencing the occupation (and reoccupation) of historic habitats. An extensive body of scientific literature has accumulated on the effects of disease on bighorn sheep populations. The literature indicates the following: 1) numerous examples of bighorn dieoffs due to disease have been documented; 2) bighorn die-offs were documented as early as the mid-1800s and have been documented in every state in the western United States; 3) bighorn die-offs typically follow known or suspected contact with domestic sheep; 4) under experimental conditions, clinically healthy bighorn sheep have developed pneumonia and died within days to weeks following contact with clinically healthy domestic sheep; 5) a variety of diseases and pathogens have been implicated in die-offs, but most commonly the disease implicated in the die-off is bacterial pneumonia (Pasteurellosis) caused by *Mannheimia haemolytica* (formerly *Pasteurella haemolytica*) or other species of closely related *Pasteurella* bacteria; 6) there is consensus among wildlife biologists and veterinarians experienced in bighorn sheep management that domestic sheep and bighorn sheep must be kept separate in order to maintain healthy bighorn sheep populations (e.g., Foreyt and Jessup 1982; Goodson 1982; Onderka et al. 1988; Foreyt 1989; Desert Bighorn Council Technical Staff 1990; Callan et al. 1991; Cassirer et al. 1996; Martin et al. 1996; USDI BLM 1998; Bunch et al. 1999; Singer et al. 2000a, 2000b, 2000c, 2000d; Monello et al. 2001; Schommer and Woolever 2001; Singer et al. 2001; Dubay et al. 2002; Garde et al. 2005; Cassirer and Sinclair 2007; Clifford et al. 2009; George et al. 2008).

In Idaho's Hells Canyon, bighorn sheep populations were extirpated by 1945 (Cassirer 2004). Since 1971, reintroductions into Hells Canyon have resulted in the establishment of several herds in and adjacent to Hells Canyon (Cassirer 2004). Limited recolonization of historic habitats and expansion of bighorn sheep populations in Hells Canyon are largely influenced by recurring disease epizootics that impact adult survivability and lamb recruitment (Cassirer 2004; Cassirer and Sinclair 2007). Cassirer and Sinclair (2007) identify pneumonia as the primary factor limiting bighorn sheep population growth in eight Hells Canyon populations.

Bighorn sheep that have persisted above Riggins, Idaho, along the Salmon River, are Idaho's only native bighorn sheep population. There have been no transplants or augmentation of bighorn sheep originating outside of the Salmon River population into this population. Hence, these sheep represent a unique genetic and population base. Historic disease epizootics are documented in this population going back to

the 1870s (Smith 1954). As with the Hells Canyon population, disease epizootics have likely influenced both the abundance and distribution of bighorn sheep populations in the Salmon River drainage. Historically, source habitats likely connected the Salmon River and Snake River populations.

The analysis of suitable habitat, and the inference that suitable habitats are an accurate proxy for occupied habitats, is not useful in assessing the persistence of bighorn sheep populations. The distribution and abundance of bighorn sheep have been significantly reduced from presettlement conditions. Because disease epizootics are an integral factor in bighorn sheep persistence, analyses need to incorporate factors that contribute to the potential risk of these epizootics and address factors such as the availability and connectivity of suitable bighorn sheep habitats, bighorn sheep behavior and movement patterns, proximity of bighorn sheep to domestic sheep, likelihood of contact between the species, risk of disease transmission in contact events, and the perturbations in bighorn sheep populations as a result of disease transmission.

Clifford et al. (2009) utilized a contact and disease transmission model to assess potential implications of various grazing management strategies on the persistence of a Sierra Nevada bighorn sheep (*O. c. sierrae*) population. Building on concepts in that analysis, the Payette NF is conducting a similar analysis to assess the risks of contact and disease transmission between domestic sheep and bighorn sheep on the Payette NF. Per the Chief's remand, the primary purpose of this analysis is to provide a basis for the management of bighorn sheep habitats on the Payette NF such that habitats are maintained to support viable populations of bighorn sheep (36 CFR 219.19). A risk assessment approach that incorporates the species life requisites, the potential for contact between domestic sheep and bighorn sheep, and the influences of transmitted diseases on population dynamics provides a much better framework for management recommendations that will provide habitats to support viable populations of bighorn sheep.

The Payette NF built upon concepts in Clifford et al. (2009) to: 1) model bighorn sheep habitat suitability (source habitats assessment); 2) model the risks of contact between bighorn sheep and domestic sheep given bighorn sheep movement patterns and proximity to domestic sheep allotments (contact assessment); 3) infer disease transmission likelihood and rates; and 4) model the potential effects of diseases on bighorn sheep herd persistence (disease transmission assessment).

SOURCE HABITAT ASSESSMENT

Source habitats are those characteristics of macrovegetation (cover types and structural stages) that contribute to stationary or positive population growth for a species within its distributional range (Wisdom et al. 2000; Raphael et al. 2001). Further, source habitats contribute to source environments, which represent the composite of all environmental conditions that result in stationary or positive population growth in a specified area and within a specified time range (Wisdom et al. 2000; Raphael et al. 2001).

Source habitat by itself does not provide a meaningful metric for evaluating the impacts of domestic sheep on bighorn sheep viability. It does however provide a framework for assessing the potential for contact, and hence allows researchers to model the potential effects of disease transmission between domestic and bighorn sheep. This portion of the analysis focused primarily on the delineation of source habitats. The implications of contact with domestic sheep, disease transmission, and perturbations in

bighorn sheep populations are addressed in the contact assessment section below. Together these form the basis for source environment analyses.

For the Payette NF, source habitats for bighorn sheep were delineated utilizing LANDFIRE data (Keane et al. 2002) and incorporated other biophysical data considered important in bighorn sheep habitat selection and use from the literature (USDA Forest Service 2010). Figure 1 displays summer source habitats for bighorn sheep in the Snake River and Salmon River drainages on and adjacent to the Payette NF. Bighorn sheep source habitats in central Idaho are associated with large riverine systems and are thus well connected. A large telemetry data set (approximately 52,000 points from radio-collared bighorn sheep over 20 years) was used to assess the relationship between known sheep locations and modeled source habitats. The bighorn sheep data points and modeled source habitats show a strong correlation, as 92% of bighorn sheep telemetry points fall within identified source habitats. However, not all source habitats are occupied by bighorn sheep. Large areas of source habitat exist where bighorn sheep have not been detected, at least in recent years. Per previous discussion, this may be due to many reasons. Specific to Hells Canyon and the Salmon River, some possibilities are: 1) bighorn sheep may not have occupied historical habitats due to disease transmission events, 2) populations may need to increase before source habitats are more fully occupied, 3) exploration of transplanted bighorn sheep into adjacent unoccupied historic habitats may not have occurred.

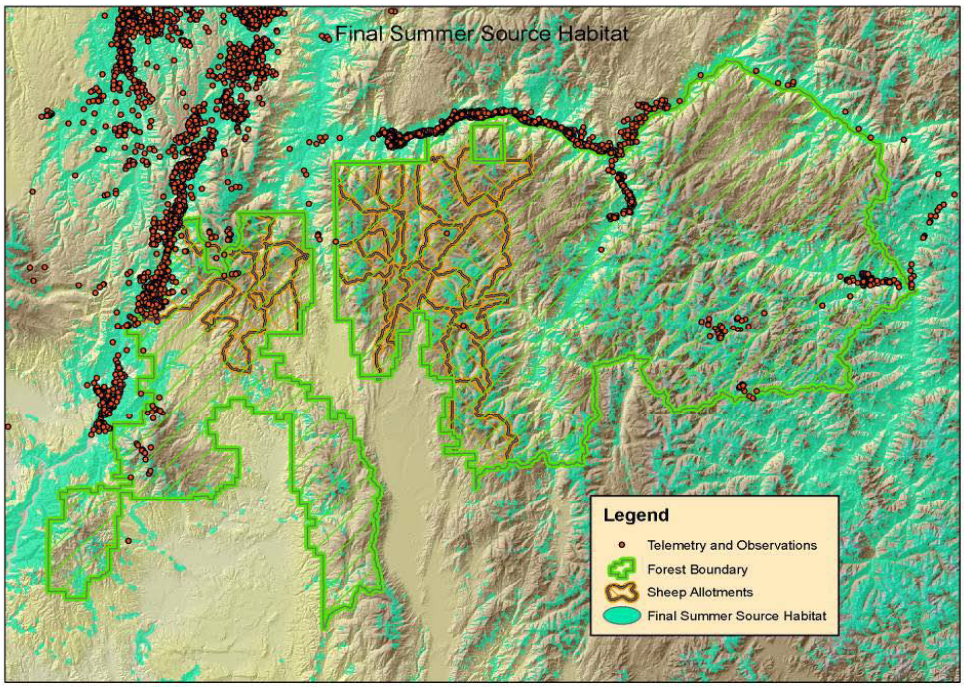

Figure 1. Summer source habitats for bighorn sheep on and adjacent to the Payette National Forest, with telemetry locations of radiocollared bighorn sheep

CONTACT ASSESSMENT

Assessing the potential for contact between bighorn sheep and domestic sheep involved a large telemetry data set (approximately 51,000 points). Data were used to develop individual home ranges within herds using a home range extension model developed for ArcView (Rogers et al. 2007). Individual home range models were coalesced into core herd home ranges for various bighorn sheep populations in Hells Canyon and the Salmon River drainage. The 95% isopleth was the outer boundary for bighorn sheep core herd home ranges. When a bighorn sheep herd 95% isopleth overlapped with domestic sheep allotment boundaries, researchers inferred a probability of interspecies contact at 100%. When analyzed for summer forays, 95.4% of the telemetry locations were within core herd home ranges. Of the 4.6% of the telemetry points outside of the core herd home ranges (forays), 4.4% were by rams.

Consistent with the bighorn sheep literature, bighorn sheep in Hells Canyon are capable of long-distance forays outside of core herd home ranges. This life history trait can put bighorn sheep at risk of contact with domestic sheep, particularly when suitable habitats are well connected and overlap with domestic sheep use areas (Gross et al. 2000; Singer et al. 2000d). The risk of contact between dispersing bighorn sheep (mostly rams) and domestic sheep is ostensibly related to bighorn sheep source habitats, the proximity of domestic sheep use areas (allotments), distance of bighorn sheep forays outside of core herd home ranges, and frequency of bighorn sheep forays outside of core herd home ranges.

Figure 2 displays the maximum distance of ram forays for the data set outside of core herd home range areas (95% isopleth) and the proportion of rams with forays from 0 to 35 kilometers (km) from core herd home range areas. All but one bighorn sheep telemetered forays were between 0 and 26 km. One ram had a foray documented at 35 km from its core herd home range. Foray distances were stratified into 1-km concentric rings emanating out from core herd home range areas and used as a basis for calculating the probability of contact. Along with the source habitats, foray distances allowed the analysis of potential contact with domestic sheep allotments.

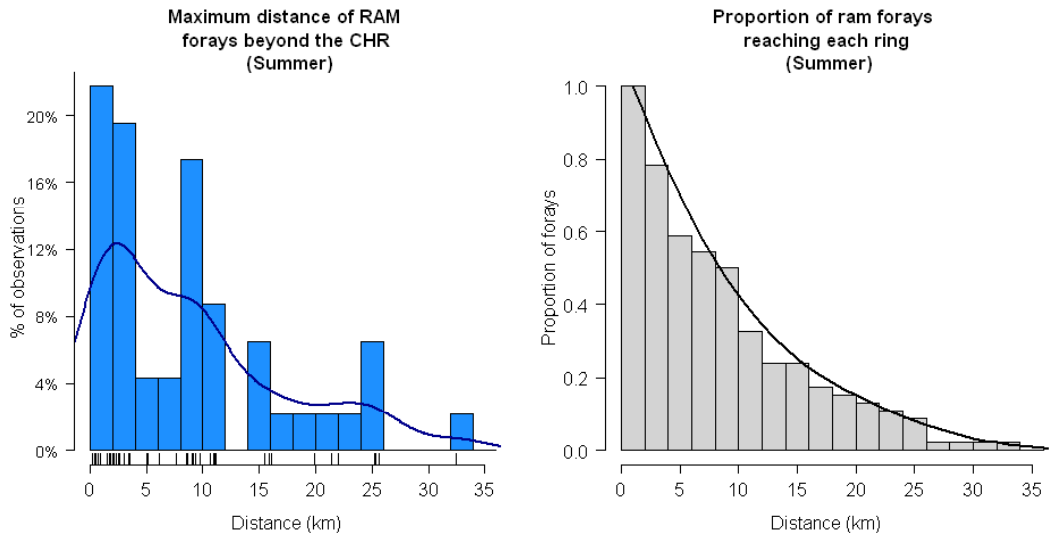

Figure 2. Maximum distance of ram summer forays beyond the core home range and proportion of ram summer forays reaching each ring. (Source: USDA Forest Service 2010)

The likelihood of contact for each kilometer ring outside of the core herd home range area can be expressed by the following equation (USDA Forest Service 2010):

$$P(\text{Contact}_{\text{Ring\_k}}) = P(\text{Foray}) \times P(\text{Animal reaches ring k} \mid \text{Foray}) \times P(\text{Intersect allotment} \mid \text{Animal reaches ring k})$$

The overall probability of contact for each individual is:

$$P(\text{Contact}) = \max_{k} P(\text{Contact}_{\text{Ring\_k}})$$

The probability of a bighorn sheep foray contacting domestic sheep was based on the size and pattern of the domestic sheep allotment relative to the distance of the foray ring (1–35 km) and the quality of habitat based on the source habitat map in those respective rings.

$$P(\text{Intersect allotment} \mid \text{Animal reaches ring k}) = \frac{\sum_{h}(\text{Area}_h \text{ in allotments w/in ring k}) \times (\text{Pref}_h)}{\sum_{h}(\text{Area}_h \text{ in ring k}) \times (\text{Pref}_h)}$$

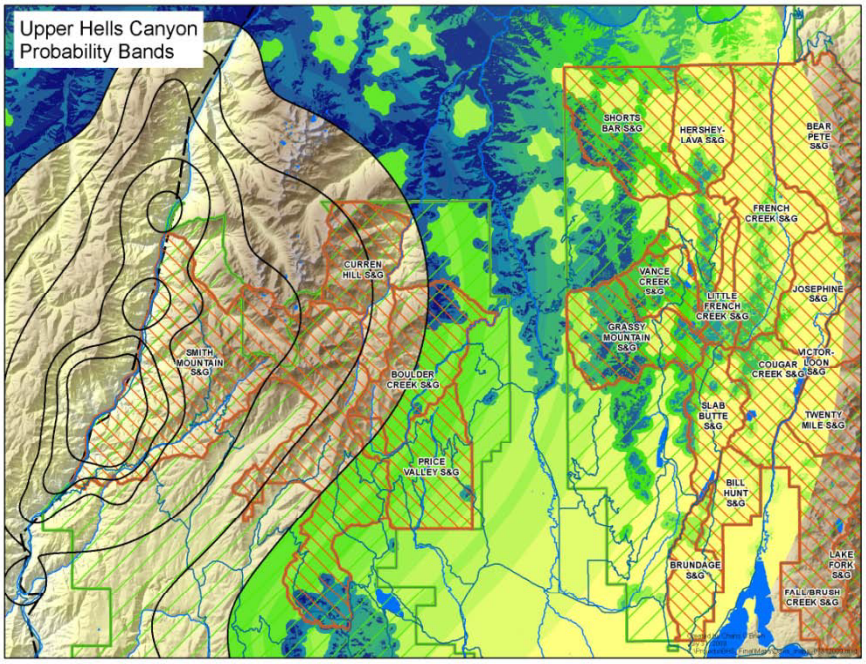

Figure 3. Example of probability of contact in the Upper Hells Canyon herd,where dark blue is the highest probability and light yellow is the lowest probability, based on source habitats in 1-kilometer rings outside of core herd home ranges (from 1 to 35 kilometers) and domestic sheep grazing allotments

The analysis allows for the integration of bighorn sheep source habitats, bighorn sheep behavior, and the proximity of domestic sheep allotments to determine the probability for contact between these species

(Figure 3). The probability of contact between these species is considered the key variable in determining the potential and extent of disease transmission. Relative to bighorn sheep, the use of source habitats are modified by these factors to reflect the potential effects of domestic sheep grazing on bighorn sheep. The contact assessment provides a foundation for assessing the potential for disease transmission between domestic sheep and bighorn sheep and the persistence of bighorn sheep populations within these source habitats.

Summary

In 2005, the Chief remanded the Forest Plan because management direction in the plan did not ensure that habitat management would maintain viable populations of bighorn sheep. The primary concern was the potential for contact, and disease transmission, between domestic sheep and bighorn sheep that would affect the distribution and viability of bighorn sheep populations on the Payette NF. The Chief instructed the Payette NF to conduct a bighorn sheep viability analysis that would lead to management direction compliant with agency regulation (e.g., 36 CFR 219.19). Since disease is likely the most significant factor influencing bighorn sheep habitat acquisition and occupancy, factors germane to this issue were a primary focus of the viability analysis.

The concept of occupied habitat is important in defining and delineating the distribution of species across landscapes and is often used as the basis for articulating how management will alter the abundance and distribution of species. Such analyses utilize species' habitat relationships to describe historic, current, and potential habitats and the implications of management on habitat requisites that potentially affect species.

Relative to bighorn sheep, there are problematic issues in defining occupied habitat on the basis of habitat suitability. Bighorn sheep currently occupy only an estimated 30% of historic habitats at population levels significantly diminished from pre–Euro-American settlement (approximately 10%). Source environments, and source habitats, should be components used in addressing "suitable habitats to support viable populations," but habitat alone does not equate to "population viability" for this species. Any viability assessment, and resulting management guidance for bighorn sheep, needs to address the potential for contact between domestic sheep and bighorn sheep and the implications for disease transmission between the species. This requires an understanding of bighorn sheep life requisites, how bighorn sheep move through and utilize habitats, and domestic sheep management (i.e., timing, location, densities, season of use, proximity of domestic sheep to bighorn sheep). Recent literature (e.g., Clifford et al. 2009) focuses on risk assessments that incorporate these principles into viability analyses.

The process being used by the Payette NF offers a risk analysis approach that couples a significant telemetry database with habitat analyses to provide a reasonable basis for analyzing the likelihood of contact between bighorn sheep and domestic sheep. This basis is used as a key construct in modeling the potential outcomes of such contact on the persistence of bighorn sheep populations.

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