**Intermountain Region BHS/Domestic Sheep Management Framework -**
**Bighorn Sheep Risk Assessment for Region 4 National Forests**

**11-20-15**

**OBJECTIVE:** The objective of this framework is to establish a protocol for evaluating the status of summer bighorn sheep (BHS) habitats on each Intermountain Region national forest.  A Forest's ability to provide habitat that can support persistent BHS populations is assessed by evaluating where there is potential for contact between BHS and domestic sheep.   The data and analysis are used to inform management decisions regarding domestic sheep operations.  Individual reports summarizing the results of applying this framework will be prepared for Utah, Wyoming, Idaho, and Nevada.

**STATUATORY AND REGULATORY BACKGROUND**:
The National Forest Management Act (NFMA) 16 U.S.C. Section 6 (g)(3)(B) National Forest System Planning requires that National Forests "…provide for the diversity of plant and animal communities based upon the suitability and capability of the specific land area…"

The 1982 planning regulations (36 CFR 219.19), that interpreted NFMA, imposed requirements that forest plans include provisions to manage habitats to support viable populations of native and desired non-native vertebrate species on national forests.  The 1982 regulations include:

- "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area".
    - o Forest plans provide for management of habitat to meet species' requirements when those species utilize National Forest System (NFS) lands.
    - o Because most vertebrate species spend time (sometimes considerable) off of NFS lands, there are likely threats to species' viability over which the Forest Service has no jurisdiction or control.
    - o  Managing habitats to support persistent populations on the national forests is not the same as ensuring species range-wide viability.
    - o The scale of this requirement is the planning unit, which is generally considered a national forest.  Most national forests do not, on their own, contain habitat sufficient to meet all of the habitat requisites for vertebrate species scale.  The distribution of these species is generally much larger than an individual National Forest. Individual National Forests can, however, manage habitats that contribute to the viability of these species, and support the persistence populations of the species on NFS land for relevant life history periods.

- "For planning purposes, a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area".
    - o The emphasis is that habitats on NFS units should be managed such that they support both the number and distribution of populations necessary for species persistence within the planning area, for life history periods when the species is dependent on those lands.

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- "In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area."

    o Again, the enabling regulations emphasize the importance of species distribution within the planning area

- On April 9, 2012, new planning regulations were implemented, which superseded all prior planning regulations.   In accordance with 36 CFR 219.7(c), "no obligation remain from any prior planning regulation, except those that are specifically included in a unit's existing plan.  Existing plans will remain in effect until revised."  Therefore, it is the individual forest plan that will describe the extent of its obligation to provide habitat to support a viable population of existing native and desired non-native vertebrate species in the planning area.  As all plans in the Intermountain Region were developed under the 1982 regulations, the aforementioned language is likely referenced in those plans.

- BHS are currently designated as a sensitive species in the Intermountain Region.  Agency policy as defined in the Forest Service Manual (FSM) 2670.22 provides direction for Sensitive Species to maintain viable populations of all native and desired nonnative wildlife, fish, and plant species in habitats distributed through their geographic range on NFS lands.  Further, FSM 2670.32 and 2672.1 directs the National Forests to avoid or minimize impacts to species whose viability has been identified as a concern and listed by the Regional Forester as a sensitive species.

For BHS on Intermountain Region National Forests, the availability of habitat that is suitable in the sense of providing sufficient forage, shelter, and escape terrain for BHS is not generally a concern. Habitats historically used by wild sheep are abundant and well-distributed on all National Forests in the region. The primary issue of concern is the risk of contact with and the potential for disease transmission from domestic sheep (and, in some places, domestic goats).  Interspecies contact can result from BHS forays, defined as occasional long-distance exploratory movements from and returning to their core herd home ranges (CHHRs) (O'Brien et al. 2014, Singer et al. 2001), that are characteristic for this species.  When forays, primarily undertaken by rams, result in contact with domestic sheep, there is the potential for disease transmission to BHS that in turn can be transmitted and infect an entire BHS herd. Disease events can result in the deaths of 25-100% of animals in a population and long term reduction of fecundity (Singer et al. 2000a).

Because disease events in BHS populations often have severe repercussions that can last for decades, an understanding of BHS forays is instructive addressing potential risks of interspecies contact.  Data analyzed for the Hells Canyon BHS population in Idaho (the Payette Analysis) found that 14.1% of the rams, and 1.5% of ewes left CHHRs (forayed) during the summer months (O'Brien et al. 2014).   Of rams that made forays, 50% traveled at least 8.1 km and 10% of foraying rams traveled 21.7 km beyond the CHHR boundaries.  However, forays exceeding 50 km are documented.

In order to provide sufficient habitat to support a viable population of BHS on the National Forests, there must be sufficient habitat where there is not substantial risk for disease transmission from domestic sheep and goats.  In effect, domestic sheep allotments can create "sink" habitats – habitats

that are otherwise suitable for BHS, but in which BHS populations may be subject to disease transmission from domestics. In addition, once disease is introduced into BHS populations, they can transmit these diseases to other wild sheep populations. Identifying domestic sheep allotments that pose a risk of interspecies contact and disease transmission and identifying options to reduce this risk are key aspects of BHS management on national forests.

This assessment seeks to: (1) assess the distribution and quality of BHS habitat on NFS and adjacent lands; (2) identify BHS Core Herd Home Ranges (CHHR) on NFS lands; (3) evaluate the potential for BHS forays from (and back to) these CHHRs and estimate the rates of contact with Forest Service administered domestic sheep allotments adjacent to the CHHRs; and 4) evaluate the sufficiency of interspecies separation between CHHRs and domestic sheep allotments located on Forest Service lands. The results of this assessment will be used to inform management where the potential for contact between BHS and domestic sheep may represent an unacceptable risk to populations of BHS. Solutions and resulting management actions will address situations where the presence of domestic sheep may put the Forests at risk for not meeting the NFMA diversity requirement and implementing regulations pursuant to viable population requirements. This assessment provides a framework for evaluating risk and outlines potential management options, but does not make any management decisions.


**EFFECTS AND IMPLICATIONS OF INTERSPECIES CONTACT ON MAINTAINING VIABLE POPULATIONS OF BHS**
Although the mechanisms of disease transmission between domestic sheep and BHS are not fully understood, there is compelling evidence in the scientific literature indicating that BHS and domestic sheep should not concurrently occupy habitats where the goal is the management of BHS (See WAFWA 2012).

The effects of respiratory disease outbreaks on BHS populations are often severe (see Besser et al. 2012a, Table 1 and Besser et al. 2012b, Table 1). Numerous controlled pen experiments, referenced in Besser et al. 2012a, have resulted in complete or nearly complete die-offs of BHS following contact with domestic sheep. Besser et al 2012b, Coggins and Matthews 1992, and Foreyt 1990 also document that disease perturbations can affect lamb recruitment for several years following severe population declines resulting from disease epizootics. Hence, when BHS disease die-offs occur, there is a substantial immediate mortality (population decline) and subsequent delayed population recovery due to poor lamb recruitment, that follows in the aftermath for many years.

In wildland environments, the proximity of domestic sheep toBHS and the size of BHS populations, are contributing factors to the likelihood of persistence for wild sheep. There is a legitimate concern over the ability of small populations to sustain disease events, particularly when domestic sheep are in close proximity to BHS populations. Singer et al. (2000b) and Singer et al. (2001) suggest that populations falling below 30 animals have a high likelihood of extirpation, and that recovery of populations at or below this number is unlikely without management intervention. Singer et al. (2000b) considered populations of at least 100 animals as having a high probability of long-term persistence. Singer and Gudorf (1999) recommend translocations to sites capable of supporting at least 100–125 animals. This goal is consistent with population goals found in some state BHS management plans (e.g. Idaho, Utah). Cassaigne et al. (2010) regressed mortality rates against initial population sizes in BHS populations with epizootic disease die-off histories. Their analysis suggests that an initial population of at least 188 animals is required to ensure long-term persistence in epizootic events assuming a post die-

off population of at least 50 animals.

Singer et al. (2001) recommend focusing management for persistent BHS populations on large habitat patches ≥ 23 km from domestic sheep.  Monello et al. (2001) found significant differences in distances to domestic sheep in comparing non-die-off (39.61 ± 8.50 km) and pneumonia-induced die-off categories (24.13 ± 11.54 km) of BHS.   The largest Rocky Mountain sheep population is the Absaroka meta-population (comprised of 5 BHS herds), which is now around 5,000 animals.  As this is a disease free population with no adjacent domestic sheep, it might offer insight into how these populations historically functioned across large landscapes of suitable habitat prior to the incursion of disease epizootics involving this species.

Until recently, the primary management recommendation used for interspecies separation was the use of a standard buffer distance (e.g., 14.5km) to reduce the potential for contact (e.g. WAFWA 2012). Estimates of contact were deemed important: (1) because factors other than buffer distances alone (e.g. allotment shape, distance from the CHHR, habitat composition, and habitat connectivity) may affect risk of interspecies contacts; and (2) a precise and reliable estimate of contact rates formed a better basis for selecting between alternatives than a simple minimum buffer distance separation rule.

O'Brien et al. (2014) published estimates of BHS foray distances and frequencies using Hells Canyon telemetry data that can be used to address proximity and separation between the species.  Although its estimates are used to guide other investigations, foray behavior may differ among BHS populations. Where there is no better site specific data, foray probability values from the Hells Canyon data were used in this analysis.

Quantifying contact between the CHHR and domestic sheep allotments appears straightforward. Bighorn sheep foray probability data and habitat suitability provide the basis for calculating contact rates between the CHHR and domestic sheep allotments (contacts/year).   However, estimating the likelihood of interspecies contact required a more sophisticated analysis.  Accordingly, the Intermountain Region worked with the Payette National Forest to develop a modeling methodology designed to assess the risk of contact and potential for disease tranmission between domestic and BHS (Payette analysis).


**SUMMARY OF BHS ANALYSIS IN THE INTERMOUNTAIN REGION**

**Payette National Forest Analyses**

In 2005, the Payette Forest Plan revision was remanded to the Forest by the Chief because it had not adequately analyzed and addressed the potential impacts of contact and resulting disease transmission between BHS and domestic sheep on the allotments that it permitted**.**  The remand directed the forest to complete a BHS viable population assessment and to develop management direction that would provide interspecies separation to ensure compliance with NFMA regulatory requirements for maintaining viable populations of BHS on the forest.  The forest worked with a group of Cooperators that included the Governors Offices and State Game Agencies for the States of Idaho, Oregon and Washington, as well as the Nez Perce, Shoshone-Bannock, Shoshone-Paiute, and Confederated Tribes of the Umatilla tribal governments.

In its Final Supplemental Environmental Impact Statement (FEIS), the Payette National Forest (Payette NF) evaluated alternatives "based on their merits for providing separation and minimizing likelihood of contact between BHS and domestic sheep" (USDA-FS 2010). Separation was measured as an outcome using distances between a BHS population's CHHR and adjacent occupied domestic sheep allotments. It was considered a key metric of interspecies contact risk based on: (1) a broad consensus among BHS scientists and managers that maintaining interspecies separation is an important management goal (e.g. Desert Bighorn Council Technical Staff 1990, WAFWA 2007, Schommer and Woolever 2001, Singer et al. 2001) and (2) analyses showing that, for herds throughout western North America, distance from a BHS herd to the nearest domestic sheep is a significant predictor of pneumonia-induced die-off (Monello et al. 2001) and translocation success (Singer et al. 2000b). A thorough review of the process is found in the Payette FEIS Chapter 3, Appendix L and Appendix M.

The Payette NF's analysis included three model components: (1) a Source Habitat model; (2) a Risk of Contact (ROC) model; and (3) a Disease model. These models were used to evaluate an array of alternatives that assessed the degree of separation required to ensure habitats were sufficient to provide for viable populations of BHS well distributed on the Forest. *The FSEIS & Record of Decision Bighorn Sheep Viability LRMP Amendment* was published in July 2010.

Idaho Woolgrowers et al. litigated the Payette National Forest EIS/Record of Decision on four primary points:
1) Failure to support disease transmission assumption
2) Failure to take a "hard look" at other risk factors
3) Inadequacy of Models
4) Non-compliance with a Federal Court decision

On March 25, 2014, the Idaho Federal District Court rejected all of the Plaintiffs' allegations and granted the government's Motion for Summary Judgment upholding the Forest Service on all counts.

**Application of the Risk of Contact Analysis to Region 4 Forests**

In 2011, the Deputy Chief of the Forest Service provided direction on managing BHS in proximity to domestic sheep allotments: "*Where management objectives include maintenance or enhancement of bighorn sheep populations, the potential for disease transmission from domestic sheep/goats to bighorn sheep must be addressed. To meet these objectives, forests must conduct a bighorn sheep risk assessment using the enclosed viability analysis outline*" (USDA-FS 2011).

To implement the Deputy Chief's direction and address known areas of possible conflict between BHS and domestic sheep, the Intermountain Region initiated a framework in 2014 to evaluate the risk of contact between BHS and domestic sheep allotments on all National Forests in the region. The objective of this assessment is to analyze the potential for interspecies contact and sufficiency of interspecies separation on Intermountain Region National Forests and assess whether the Forest is managing conditions to maintain viable populations of BHS on the National Forest. The Payette NF's modeling framework was used as a basis for the development and use of a ROC model on other Region 4 National Forests where BHS populations occur.

A Forest Service/BLM BHS team contributed to the development of source habitat models for 11 western states with BHS populations and a geospatial risk of contact model adapted from the Payette analysis for application on other units. The ROC model has three primary components: a source habitat

model, a core herd home range (CHHR) model, and a foray model in a geospatial setting.  The overall model estimates probabilities and rates of contact between foraying BHS and occupied domestic sheep allotments.

The Source Habitat models were adapted from a habitat suitability model developed by the Hells Canyon Bighorn Sheep Restoration Committee (HCBSRC 1997) which uses topography and vegetation to identify BHS habitat (O'Brien et al. 2014).  Habitat models are tested using telemetry and observation data locations, and reviewed by state and federal biologists prior to their use in the Risk of Contact model.  For the CHHR modeling, the Region worked with the states to acquire and analyze BHS distribution data (telemetry and observation locations) which was used in the development of the CHHRs.  Source habitat maps were developed and reviewed with the states, and tested against BHS distribution data to ensure accuracy of the model.   Bighorn sheep foray probability data from the Hells Canyon data were used to model movements across landscapes and to estimate contact probabilities and rates with domestic sheep allotments.  The output of the Risk of Contact model provides estimates of contact probabilities and contact rates between BHS and domestic sheep allotments as a result of these forays.

The Forest Service/BLM BHS team also produced a User's Guide to accompany the model that includes a Frequently Asked Questions white paper that is available for ROC model end users and has conducted three training session webinars on the use of the models and management implications of model outputs. Two peer-reviewed articles (O'Brien et al. 2014 and Carpenter et al. 2014) document the computational details of and rationale for the model.  The Forest Service made the model available to, and advised, state and other federal partners (e.g. Fish and Game Departments, the Bureau of Land Management) involved in BHS management.  The model has since been used to inform management decisions relative to the Risk of Contact between BHS and domestic sheep allotments on National Forests (e.g. allotment analyses on the Rio Grande, San Juan, and Carson National Forests and the Blue Mountains Land Management Plan Revision).  The Bureau of Land Management has also used the model on lands in Idaho (e.g. Cottonwood Resource Management Plan, Owyhee Allotment Renewals, and Four Rivers Field Office Range Permit Renewal).

**Model Specifics and Applications Summary**
In summary, the ROC model has been subjected to considerable review and application.  The following illustrates the acceptance of the model:

1. Model is peer reviewed and published in the literature.  It is the considered as best available science (O'Brien et al. 2014).
2. Model was reviewed in a litigation challenge and was upheld in the Idaho District Court.
3. Model is one component in assessing agency compliance with NFMA and its enabling regulation pursuant to providing habitat to maintain viable BHS populations on each National Forest.
4.  Model provides a tool to assess risk as outlined in direction from the Deputy Chief of the Forest Service for BHS Analysis for NEPA documents (2011).
5. Model is part of a viable population assessment process being conducted by the Forest Service for BHS populations in the Intermountain Region.
6. Model outputs can be used as a basis for designing management that provides effective separation between BHS and permitted domestic sheep where the risk of interspecies contact is considered unacceptable.
7. Model is being used by other federal and state agencies in BHS planning efforts.

**Addressing Model Uncertainty**
Models used in the Region 4 assessment were developed following a careful review of the scientific literature, and are consistent with our understanding of interspecies contact between BHS and domestic sheep and the need to ensure separation of these species. Although the Source Habitat and ROC models provide a methodology for addressing separation, the authors recognize uncertainties associated with the models, and are working to improve our understanding of model performance.

**VIABLE POPULATION RISK ASSESSMENT PROCESS**

The purpose of this assessment is to provide decision makers with a means to evaluate whether the habitat available (quantity and quality) on individual National Forests is sufficient and the effects of management actions are acceptable to support viable BHS populations during those seasons when they use NFS lands. Bighorn sheep herd proximity to active domestic sheep allotments supplies a direct measure for interspecies separation, while the Risk of Contact model estimates the more directly relevant rates of contact between BHS and domestic sheep allotments. Both of these metrics of interspecies contact risk will help inform decision makers tasked with determining whether particular domestic sheep allotments pose an unacceptable risk to BHS populations, and with identifying those BHS populations considered important in meeting obligations identified in a forest's forest plan. The following steps describe the location and status of existing herds, documents outcomes of the Risk of Contact model relative to probabilities and rates of contact with domestic sheep allotments, interprets model outcomes relative to the risks of contact, and evaluates other factors contributing to interspecies contact.

There are caveats to the application of this assessment that influence its use and application:
- Many national forests do not have data to support the full array of model inputs. Where local estimates or data are not available, values collected from other similar national forests may be used. Where reliable data are not available, the model may be parameterized using the model's default values, which are based on the careful and extensive analyses described by the Payette National Forest in its FSEIS and in the Risk of Contact model User's Guide (USDA, Forest Service, March, 2015).
- State BHS management plans and local expertise are also considered important sources of information. The Forest Service has worked closely with state fish and wildlife agencies to assemble and review a large and robust set of telemetry and observational location data for BHS in Idaho, Nevada, Utah and western Wyoming. These data are critical in mapping CHHRs and have been used to inform the Source Habitat model, ensuring that modeled BHS habitat preferences match observed BHS habitat use.
- This assessment focuses on seasons when BHS utilize national forest lands during periods when domestic sheep can also occupy these landscapes. The source habitat, CHHR and foray models reflect summer use periods (roughly May 1 to October 31). Hence, the primary focus is the potential for BHS contact with domestic sheep allotments during the summer that are under the management purview of the Forest Service.
- Other considerations are needed to address BHS persistence at landscape levels. Disease transmission can occur between BHS, and inter-CHHR contacts by foraying BHS are expected when these are in close proximity. These contacts can take place during any season. Bighorn sheep also use federal and private lands adjacent to national forests during other seasons (e.g. winter). With a few exceptions, interspecies contact rates were not calculated off of NFS lands. A broader analysis would include cumulative effects off of NFS lands on other federal, tribal, and

private lands.  This would require the development of a winter source habitat map, winter CHHR delineations, and domestic sheep grazing areas on other land ownerships.  The combined summer and winter analysis would allow the more comprehensive modeling of contact between BHS CHHRs, and a hence a cumulative effects analysis for both inter- and intra-species risk of contact.  The present analysis focuses on summer BHS habitats on NFS lands and represents only one facet of overall risk to BHS populations.

For the Payette National Forest plan revision, the selected alternative in the FSEIS identified a Forest cumulative risk threshold of 0.08 BHS contacts/year as sufficient to provide long-term interspecies separation and to support viable (persisting) populations of BHS on that national forest in that forest plan revision effort.   The rationale used for this contact threshold is documented in the Payette's Record of Decision and the FSEIS (USDA-FS 2010).

This framework differs somewhat from the Payette process in that datasets for other forests in the region are less extensive than information garnered for the Payette.  Data are sufficient for applying the model and identifying areas of higher risk of contact between domestic and BHS, especially in the short term.  Many forests in the Intermountain Region expect to revise Forest Plans within at least the next 10 years.   Thus, BHS contact rates with active domestic sheep allotments should be evaluated in the context of managing risk of contact within a timeframe until a more thorough and cumulative risk assessment and decision framework is available upon completion of forest plan revision.   Allotments representing a risk of contact with key BHS core herds before a revision is completed should be carefully evaluated for addressing or mitigating the risk.  This could include acceptance of voluntary domestic sheep permit waivers and maintaining management options prior to revision.

### Step 1.  Overview and Description of BHS Populations on a National Forest

The analysis includes discussions of the amounts and distribution of BHS on and adjacent to NFS lands, BHS life history traits, and periods when BHS use NFS lands.

An important first step is to describe the location and size of BHS populations that occur on national forest units, and to identify those populations that contribute to providing viable (persistent) and well distributed populations on a given national forest.  Available demographic characteristics (e.g. Table 1) for these herds are used as inputs to the Risk of Contact Foray sub-model, but are also useful in describing the status, reproductive performance, and fitness of these populations.  As populations can be shared among national forests, consideration also needs to be given to the landscapes used by BHS that occur across forest boundaries.

### Table 1. Characteristics of Herds on a National Forest

| CHHR | Population Estimate | Adult Population | Lambs per 100 Ewes | Rams per 100 Ewes | RAM Ratio | Ewe Ratio |
|------|---------------------|------------------|--------------------|-------------------|-----------|-----------|
|      |                     |                  |                    |                   |           |           |

### Step 2 - Identify and Delineate CHHRs

CHHRs delineate the area typically used by BHS in a herd, and are the foundations for addressing the distribution of BHS populations on a national forest, as well as the first step in providing a basis for BHS movements associated with these areas.   CHHRs are generated by the Risk of Contact model using BHS telemetry and observation data, which are then reviewed by local experts prior to the selection of the "best-fit" boundary.  They represent that boundary that includes 95% of the animal locations in a herd. Bighorn sheep observations outside the CHHR boundary are considered foraying animals.   A detail description of the CHHR is found in the Payette NF EIS (Chapter 3 and Appendix L), the Bighorn Sheep Risk of Contact Tool User Guide, and referenced in O'Brien et al. 2014.

The CHHR can be defined using:
- telemetry data
- observation data
- expert delineation (e.g., from state biologists and WAFWA information)

Key inputs to the development of the CHHRs include:
- Telemetry and observation points used as inputs to calculate CHHRs
- Parameters involved in CHHR estimation (band width estimator and others)
- Expert generated CHHR polygons where specific data are not available

**Figure 1.  Example of CHHR options generated by the model and reviewed by local experts.**
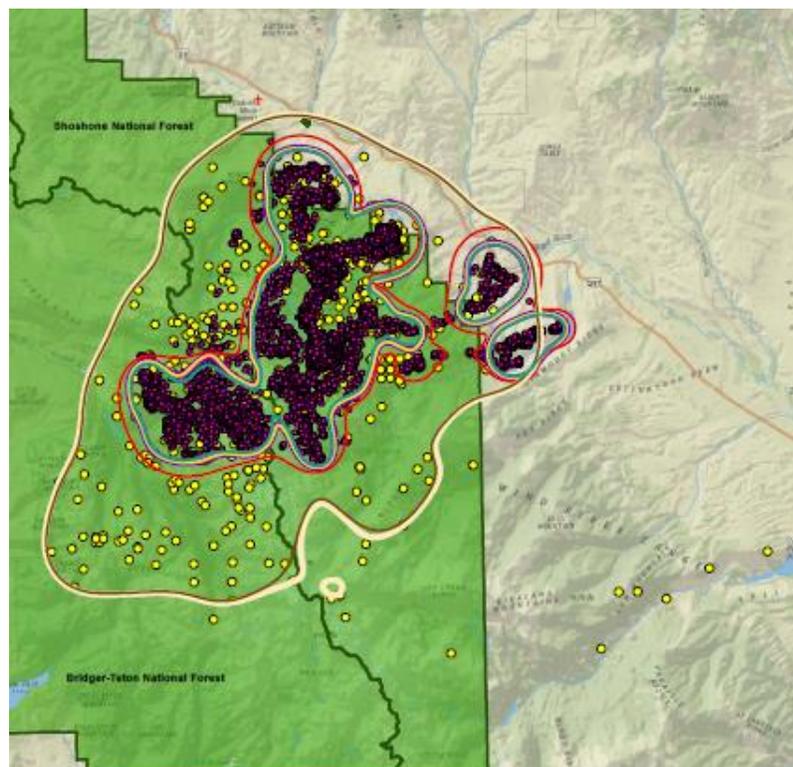


In this example, the yellow dots are observations of unmarked animals and the dark dots are from marked (telemetered) animals with satellite generated locations.  Several different CHHRs were generated by the model based on the various data aggregations.  A recommended CHHR was then selected after various data aggregations, expert knowledge of the area and population, and which CHHRs best represented the herd.

**Step 3– Compute Estimated ROC between CHHR and Active Domestic Sheep Allotments**
The ROC model uses the CHHRs identified in Step 2 and source habitat as a basis for assessing the BHS forays, contact probabilities and rates of contact with domestic sheep allotments.   Source habitats are those that include biophysical features considered important to BHS.  A detail description of the source habitat is found in the Payette NF EIS (Chapter 3 and Appendix L), the Bighorn Sheep Risk of Contact Tool User Guide, and referenced in O'brien et al. 2014.

The ROC model was designed to estimate rates of contact due to forays out from CHHRs to surrounding allotments for periods when sympatric use of landscapes by both domestic and BHS occurs. The Risk of Contact model provides the probability and rates of contact between BHS and allotments where they potentially can contact domestic sheep.  The Risk of Contact is a logical surrogate to address interspecies separation.

Data inputs:
- Ram and ewe foray probabilities
- Ram and ewe foray distance distributions
- Source habitat model

Data outputs will be derived for each CHHR relative to specific domestic sheep allotments and include:
- Single ram contact rates
- Single ewe contact rates
- All rams contact rates
- All ewes contact rates
- Whole-herd contact rates

**Table 2. Risk of Contact Output Table for each CHHR with Domestic Sheep Allotments**

| | Estimated annual contact rates via foray | | | | |
|---|---|---|---|---|---|
| Allotment | Single ram | Single ewe | All rams | All ewes | All animals (Herd) |
| | | | | | |

**Step 4 – Interpret ROC Results**

Step 4 provides interpretation and inference for the ROC model outcomes.   The herd contact rates are used to depict the degree of contact between foraying BHS and domestic sheep allotments.  This information can then be used to address the risk of contact between habitats occupied by both species, the sufficiency of separation between the two species, and provide insight into the potential risks of interspecies contact given the model outputs.

More frequent contacts with an allotment imply an elevated probability of interspecies contact and an increased potential for disease transmission.  Table 3 displays the contribution of individual allotments to herd contact rates.

State fish and wildlife agencies have a significant role in reviewing analysis results.  Much of the information used to inform the model is derived from state data.  Telemetry and observation data for BHS herds provides the foundation for modeling the CHHRs.  Herd demographic attributes including herd size and sex ratio are important inputs into ROC model, as well as providing direct indicators of

likely herd long term persistence.  State wildlife biologists can also help modify the source habitat models for specific geographical areas and use observation and telemetry data to calibrate modeled source habitats.  They may also provide other important information on BHS populations including transplant histories, disease involvement, management goals, etc.

**Table 3.  Sample CHHR – Contribution of allotments to contact rates between foraying BHS and domestic sheep allotments.**

| Allotment | Risk of Contact |
|-----------|-----------------|
|           |                 |

**Step 5 – Risk Evaluation and Management Options**
This step evaluates model outcomes and other information as a basis for providing considerations where risk of contact is considered high to provide assurances of adequate separation between bighorn and domestic sheep on national forests.   The following considerations are addressed:
- Identify herds that make an important contribution to BHS persistence (viable populations) at forest-wide scale
- Consider state management plan goals and objectives
- Review/discuss contribution of BHS herds to total population (population structure and sizes)
- Identify risks to persistence given mapped habitat and estimated rates of interspecies contact.
- Assess contribution of each allotment to estimated BHS contact rates
- Consider the potential for BHS from one CHHR affecting other BHS populations.
- Qualitatively address cumulative effects/off-forest considerations requiring further analysis
- Inferences for recommendations to assure interspecies separation that will allow for BHS persistence on NFS lands
- Region, Forest, and State work collaboratively to evaluate risk and potential mitigations

The states have developed management plans for BHS populations which can help inform the risk analysis process and Forest Service decisions regarding domestic sheep allotment use.  Management options to mitigate unacceptable risk in this framework have been derived from those listed in state plans.

Allotments representing a relatively high risk of contact should further evaluated with site-specific information for natural (e.g., landscape barriers such as rivers) or management (mitigation methods described below) conditions that may mitigate risk of contact.  Overlap of CHHR and domestic sheep allotments would normally pose an unacceptable risk.  Forest, State and Regional staff will collaborate to determine if and what potential mitigations or actions are needed to mitigate risk on individual allotments.  Site-specific factors and effects of mitigation (as outlined below) will be considered when evaluating the degree of threat to BHS on individual allotments.

Management options were derived from Wyoming, Utah, and Idaho BHS Recommendations and Plans.  Potential mitigations and resulting effect on contact risk for each actively managed allotment:

a. Incorporate cost-effective grazing Best Management Practices that have demonstrated success at providing effective separation such as monitoring and removing stray domestic sheep and BHS
b. Adjust allotment boundaries; re-model ROC after adjustment and calculate ROC
c. Remove domestic sheep from risk area (find alternate allotments if possible, or accept voluntary permit waivers where appropriate); effective ROC becomes 0
d. Convert domestic sheep with cattle; effective ROC becomes 0
e. Manage time and frequency of domestic sheep grazing on allotment to create temporal separation; effective ROC is proportional to the time on the allotment that domestic sheep presence is reduced
f. Consideration of potential federal and state management options when feasible (e.g., vaccines or newly devised techniques); effective ROC will be dependent upon the effectiveness of new techniques

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