Appendix F: Working Group D—RISK ANALYSIS

Leaders:	*Dave Jessup and Melanie Woolever*
Facilitator:	*Susan Hayman*
Recorder:	*Nikole Pearson*
Participants:	*Nancy East* *Keith Aune* *Tom Stephenson* *Kyle Meintzer* *Colin Gillin* *Ray Lee* *Helen Schwantje* *Margaret Wild* *Scott Kelley*

Working Group D was tasked with four objectives: 1) provide an overview of disease risks facing wild sheep and their consequences; 2) define risk, relative risk, and conduct very simple risk calculation exercises; 3) define very basic risk assessment or analysis and give examples of their limitations and how they may be used in the management of bighorn/domestic sheep; 4) consider basic options for management of disease risks facing wild sheep.

Desired outcomes for workgroup D included the following: access to historic and foundational literature of disease risks facing wild sheep; recognition of the limitations of current knowledge regarding disease transmission between bighorn and domestic sheep and between different bighorn populations, how much interaction or contact may be required, and difficulties in measuring this; access to basic information on two approaches that have been taken to do risk analysis specific to bighorn/domestic sheep disease; and an appreciation for the complexity and challenges facing managers due to limitations on data, vast time and space, and serious consequences.

An important product for this group would be the identification of the knowledge gaps and research that would help advance the understanding of risk analysis.

Exercises

Dave Jessup acknowledged that all participants, regardless of affiliation, would benefit by understanding risk. Government agencies are usually responsible for calculating risk and, despite a lack of understanding, management decisions need to be made everyday. It is the

task of workgroup D to focus on the risks facing bighorn sheep. Risk is a variable and changes with time, place, and activities and is not easy to define in a way that is universally acceptable.

Several methods for calculating risk currently exist. Jessup suggested reviewing some of these methods to better understand their potential strengths and weaknesses.

Exercise 1

Using data provided, the group was to calculate the strength of association, or relative risk (RR), of a pneumonia outbreak in bighorn sheep following contact with domestic sheep. RR is the ratio of the frequency of occurrence of disease in the proportion of the population exposed to the putative factor to that in the proportion that has not been exposed. Such a relatively simple approach is not as easy as it looks. Data are not always complete and many points of datum are not comparable. In the wild, the original and ending number of animals in a herd cannot be calculated and the final result depends on the definition of incidence. Is incidence the number of outbreaks or the number of new cases within a group at risk during a specified period of time? Finally, bighorn respiratory disease is complex and influenced by factors other than contact with domestic sheep.

Exercise 2

A more appropriate way to determine RR may be to experimentally expose bighorn sheep to domestic sheep, observe the outcome, and calculate RR. The group was asked to calculate RR using sample data and the following equation:

$$RR = A/A + B \div C/C + D$$

Where:

A = bighorn sheep that developed fatal pneumonia after exposure to domestic sheep

B = bighorn sheep that did not develop fatal pneumonia after exposure to domestic sheep

C = bighorn sheep that developed fatal pneumonia and were not exposed to domestic sheep

D = bighorn sheep that did not develop fatal pneumonia and were not exposed to domestic sheep

Exercise 3

Some bighorn sheep may carry pathogenic organisms that will predispose them to disease outbreaks if they are mixed with other bighorn sheep. In exercise 3, RR was calculated as the incidence of disease in bighorn subsequent to mixing animals from different bighorn populations divided by the incidence of disease in bighorn without contact with other bighorn.

Discussion

All of the exercises made the assumption that disease is caused by the introduction on a novel pathogen, yet some bighorn sheep get pneumonia without any contact at all. Contact is difficult to determine since both domestic and wild sheep wander out of the herd and young bighorn sheep rams can travel great distances.

In conclusion, a solid calculation of RR of pneumonia in bighorn sheep is very difficult.

Risk Factors

Several current bighorn management policies may increase the risk of disease in bighorn sheep:

- Relocating stray bighorn into herd areas when the status of their contact with domestic sheep or goats is unknown (several states have made it the policy to shoot stray rams to decrease the risk of disease transmission)
- Establishing new herds in mountain ranges with nearby active or temporarily dormant domestic sheep allotments, such that immediate or future contact between domestic and bighorn sheep is likely
- Supplementing remnant or dwindling bighorn sheep herds with bighorn from other locations
- Releasing pen-reared bighorn into free-ranging bighorn herds

The group compiled a list of risk factors other than disease transmission:

- Translocation,
- Habitat quality and quantity, including improvements (use of fire and manipulations to provide better quality or quantity), habitat degradation, habitat fragmentation
- Harvest (hunting and relocating)
- Weather (access, exposure, long term/short term)
- Nutrition (forage quality and micronutrients)
- Interspecies competition
- Predation
- Human disturbance
- Herd demographics
- Genetic variability
- Herd behavior (losing the memory of migrating, especially when the herd has been translocated)
- Parasites/bacteria/virus
    - endemic/novel

Wildlife managers need to think about health in a very broad context; in terms of herd health (holistic health); disease is only one risk factor.

Many of the factors mentioned above will influence the outcome of a disease outbreak, but it is easy to get bogged down by the details and avoid discussing disease at all. The cause of a disease does not have to be known to know that there is a potential problem. The real questions are what is the probability, given all of the available data, that there is risk from contact and what is the probability that sheep *X* will do well in environment *Y*. A statistical model using all available data could answer those questions.

There has never been a comprehensive ecological risk assessment conducted for bighorn sheep. An ecological risk assessment needs to be regional and ecological data need to be collected in a common way so that they can be inserted into a model.

The following issues were discussed concerning risk factors and research needs:

- Helen Schwantje asked if members of the group would be interested in looking at the remote populations of bighorn sheep in her area that have had no exposure to domestic sheep and comparing them to populations that have been exposed.
- Assumptions must be carefully considered when modeling and levels of uncertainty must be built into the model.

- Contact is difficult to observe, so surrogates such as range overlap are used. If disease is the central issue, how is contact quantified? A numerical scoring can't be applied over large areas. If the product is a risk model, contact must be quantified.
- Researchers for many other wildlife diseases are having these same discussions. Do other models exist that could be used as a surrogate to respiratory disease in bighorn sheep?
- Research is occurring in different geographical areas, in little microcosms. A central clearinghouse is needed to gather information about all research being done and the results.
- Social science, such as economics and social parameters, must be included in new research.
- Delivery of the results is very important and focus groups must include members from the domestic sheep industry.

Qualitative Risk Assessment—*Risk Analysis of Disease Transmission between Domestic Sheep and Bighorn Sheep on the Payette National Forest* (February 6, 2006)

Workgroup participants made the following statements concerning the content of the Payette National Forest risk assessment:

- The document contained a lot of opinions and the names of the authors were not included
- It was an old fashioned approach that seems to say "we are wildlife managers and we know what is best for you"
- The breadth of the experts was not comprehensive
- The panel was actually predicting the likelihood of contact, not analyzing the risk of disease
- Bighorn sheep behavior should have been included

Melanie Woolever provided background information concerning this particular risk assessment. Decisions within the Forest Service must be made every day with or without the necessary information. The original Payette National Forest management plan was written and submitted for approval. The plan was overturned and rejected because it did not provide for viability of bighorn sheep. The Forest Service assembled several experts and created the risk assessment that the workgroup is currently reviewing. The risk assessment is supporting documentation for the management plan that addresses bighorn sheep viability.

Names were not included on the document because employees of the federal government are not allowed to take ownership of the document.

Although some members believed that this type of risk assessment might have been appropriate if there had been a greater variety of attendees, others disagreed. A qualitative approach is geographically restrictive because the experts are only experts in a very specific geographic area. Scott Kelley maintained that a quantitative model does not have the same restrictions. A quantitative model is built using areas where a lot of data exist and then applied to areas where a lot of data have not been collected; a model would be built out of the best systems and applied to less known systems.

Schwantje suggested using a template, which would include the fact that demographics are unknown. A template would provide consistency and the ability to build data upon data.

Strengths

- Use of broad spectrum (multidisciplinary—stakeholders/producers, etc.) of expert resources
- Quick—don't have lost of data and lack of ability to quantify

- Practical—economical
- What you do because you've got to do it
- Allows you to look at risk on a relative basis

Weaknesses

- Subjectivity
- Can be easily criticized by those not involved
- Potential to apply to other areas not involved
- Different to update with new info
- Geographic-specific

Application

- Lack of data/little data
- Narrow focus—one or two questions it seeks to address
- Using people very familiar with area/situation
    - Where populations are
    - Where problems are
- Geographic-specific

Quantitative Risk Assessment—*Modeling Risks of Disease Transmission from Domestic Sheep to Bighorn Sheep: Implications for the Persistence and Restoration of an Endangered Ungulate* (full paper is included in the preparation notebook under Bleich)

Tom Stephenson was involved in the collection of the spatial data for this risk assessment. After struggling with the data, researchers decided to predict the probability of contact between domestic sheep and bighorn sheep using radio collar location data. Once the probability of contact was developed, they created a cross model to predict the probability of disease moving through the populations. The data used to predict disease outbreak was the most detailed data available. Table 5 within the paper summarizes the predictive accumulative probability of an outbreak that causes a certain percentage of mortality. The table further summarized how different sheep management practices affect the probabilities.

Not as much data as expected would be needed; the uncertainty (of the input data) would increase, but the model could still provide recommendations. The quantitative model described in the paper matches what the EPA uses for ecological risk assessments. Other comments concerning this type of risk analysis included the following:

- Information that helps decision makers is included
- It is very illustrative and useful because it states, if we do *x*, we can expect *y*
- This was the first attempt and the authors are already looking at different methods and new models that would incorporate additional data
- The model is extremely transferable; the model doesn't change, the inputs change
- Collecting the data is the most expensive part, but other researchers might already be collecting the data for other purposes
- Examining sensitivity models informs researchers which pieces of data are the most critical to collect

- Acceptable risk could be included in a model based on the number of sheep in a herd

Strengths

- Measureable, more defendable
- Modeling methodology transferable
- Can be easily updated with new info
- Helps to answer "what if" management questions, how to minimize risk
- Transparent—easier to track how conclusions made
- Repeatable

Weaknesses

- Need data (but maybe not as much as might think)
- More time and money up front
- Input data may be different or more defined from one area to another

Application

- If you good data, do it
- Special status species
- Narrow range of acceptable risk

Results and Action Items

- Several risk assessment considerations were agreed upon:
  - A hybrid approach may be appropriate—quantitative risk assessments for areas/factors with adequate data, and use a qualitative risk assessment for the interpretation and analysis of factors that can't be measured.
  - Behaviors of both species must be understood to minimize contact.
  - Good quality data must be available.
- Researchers need to develop a template model and organize workshops to teach agencies how to use the model.
- Kelley will present the report to a colleague who is an ecological modeler to get her opinion.

Summary of the Science Panel Discussion (November 2, 2006)

In November 2006, the Payette National Forest convened a panel of scientific experts to clarify the science-based concerns regarding the *Risk Analysis of Disease Transmission between Domestic Sheep and Bighorn Sheep on the Payette National Forest* and to allow panelists to provide additional science-based information regarding disease transmission and its risk of occurring on the Payette National Forest that the Forest Supervisor should consider in conjunction with the risk analysis.

Panelists focused on the concerns they had regarding the Payette National Forest risk assessment and developed a series of eight statements to address those concerns. These statements are listed on page 1 of the *Summary of the Science Panel Discussion*:

1a) Scientific observation and field studies demonstrate that "contact" between domestic sheep and bighorn sheep is possible under range conditions. This contact increases[1] risk of subsequent bighorn sheep mortality and reduced recruitment, primarily due to respiratory disease.
1b) The complete range of mechanisms/causal agents that lead to epizootic disease events cannot be conclusively proven at this point.
1c) Given the previous two statements, it is prudent to undertake management to prevent contact between these species.
2) Not all bighorn sheep epizootic disease events can be attributed to contact with domestic sheep.
3) Gregarious behavior of bighorn sheep and domestic sheep may exacerbate potential for disease introduction and transmission.
4) Dispersal, migratory, and exploratory behaviors of individual bighorn sheep traveling between populations may exacerbate potential for disease introductions and transmission.
5) There are factors (e.g., translocation, habitat improvement, harvest, weather, nutrition, fire, interspecies competition, and predation), some that can be managed and some that cannot, that can influence bighorn sheep population viability.
6) Pasteurellaceae, other bacteria, viruses, and other agents may occur in healthy, free-ranging bighorn sheep.

Jessup asked the workgroup participants to review these eight statements and asked if the members of the workgroup would be willing to endorse the statements and forward them to the rest of the workshop participants. Members of workgroup D suggested some minor changes in wording and agreed to endorse the statements and provide them as a workgroup product to the whole group. The minor changes they suggested include:

1) #1b: Change "cannot be proven" to "have not been identified/defined/delimited in all cases."
2) #5: This statement seems a little bit out of order with the others (but it needs to remain in the list!). Perhaps swap places with #6?
3) #6: Delete "may"

Research Opportunities

1. Quantify the contact required for disease transmission from domestic sheep to bighorn sheep.
2. Review modeling efforts with other diseases, human or otherwise, and the lessons learned about disease transmission.
3. Conduct a comprehensive risk assessment that includes ecology and disease:
   a. gather data in a systematic way
   b. build uncertainty into the model
   c. conduct a sensitivity analysis

[1] Refer to the concern that this should read "can increase risk…," Summary of the Science Panel Discussion, page 12, 2nd paragraph under comments 38 and 40.

4. Inventory and collect a list of what research is being conducted and what researchers are learning in a coordinated manner.
5. Conduct a social science analysis and determine how to bring in this aspect into risk assessments (decisions can't be made on biology alone).
6. Develop an effective outreach/delivery of risk assessment results and models
7. Build a model to identify problems:
    a. build a model that explains how to minimize risk when making future decisions (include a social component)

Final Recommendation

Consult with ecological risk assessment modelers using the Sierra Nevada model as a starting point to develop a template for decision makers.