The Landscape Of Fear And Its Implications To Sheep Reintroductions

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Abstract: The record for bighorn sheep (*Ovis canadensis*) reintroductions is not stellar; recent analyses indicate a less than 50% success rate. Most models to evaluate potential release sites center on assessing the amount of "escape habitat" available. Escape habitat has been defined as steep, rocky areas where sheep can outmaneuver their predators. This may be a good definition for predators that chase their prey such as coyotes (*Canis latrans*) or even wolves (*C. lupus*). However, in most areas of sheep reintroductions, the main predator is the puma (*Puma concolor*). Pumas stalk their prey and the definition of escape habitat overlaps substantially with what definitions of excellent hunting habitat for pumas. This indicates that a possible reassessment of escape habitat, especially in reference to sheep reintroductions, might be warranted. Many studies have shown that vigilance behavior is a good indicator of predation risk. Based on this, we are assessing predation risk of different habitat types relative to vigilance levels sheep exhibit. We are conducting this study in southern Idaho on a newly reintroduced California Bighorn Sheep (*O. c. californiana)* population that is preyed on by pumas. We monitored vigilance (head up and alert) of sheep for 20 minute time blocks in different habitat types, e.g. rock, cliff, open grass, etc. We found significantly higher vigilance rates in rocky (32.3 $\pm$ 3.1 %) and cliff habitats (30.1$\pm$ 4.5%) than in sage (16.7 $\pm$ 1.8%) and grass/sage (22.1 $\pm$ 2.8 %) areas. Our data indicate sheep perceive defined escape habitat as highly risky while open grass slopes as relatively safe. Results of our final analysis should help us assess the landscape of fear for sheep relative to puma predation and provide a more realistic assessment of potential release sites.

Key words: Bighorn sheep, pumas, predation risk, vigilance.

Bighorn sheep (*Ovis canadensis*) were once widely distributed in their range (Krausman 2000). However, during the last century, they have declined dramatically (Enk et al. 1998, Krausman 2000) for a variety of reasons (Gross et al. 2000). To try and reverse this trend, numerous agencies and organizations began an extensive effort to reintroduce bighorn sheep into historic range. Since the initiation of those efforts, 100's of translocations have occurred. However, various assessments of these transplants indicate they are often not very successful, ranging from 41 to 53% (Leslie 1980, Singer et al. 2000a). Considering the tremendous time, effort and money involved in transplant efforts, an approximately 50 % success rate is not very good. Additionally, the number of transplanted sheep and their potential offspring involved in these failed efforts represents a staggering loss of animals.

The reasons for this low success rate are varied, with epizootic outbreaks of bronchopneumonia considered the greatest

contributing factor (Singer et al 2000b). Apart from the impact of diseases, likely the second most commonly recognized factor is predation, specifically by pumas (*Puma concolor*) (Enk et al. 1998, Hayes et al. 2000, Logan and Sweanor 2001).

To counter these problems, the various models to evaluate release sites incorporate minimum distance from domestic sheep to reduce the transmission of diseases and maximum distance from "escape terrain" to reduce the threat from predators. With regards to escape terrain, however, its definition has been somewhat ambiguous. Van Dyke et al. (1983) described it as "Cliffs, rock rims, rock outcroppings and bluffs…." Later, Smith et al. (1991) expanded the definition to include "… slopes greater than 60% that have occasional rock outcroppings whereon bighorn can outmaneuver predators." This definition not only gives a physical aspect to escape terrain but also indicates how we think it functions in the avoidance of predation. However, being able to better "outmaneuver predators" is only reasonable if the predator primarily chases its prey, e.g. wolves (*Canis lupus*) or coyotes (*C. latrans*).

Pumas, however, are the prime predators on bighorn sheep and they stalk their prey. Not only do they stalk their prey, various studies have demonstrated pumas need specific "stalking habitat" to be successful. Such habitat consists of "…canyons, draws and steep ridges…." (Logan and Irwin 1985). Additionally, Koehler and Hornocker (1991) observed "…mountain lions, commonly associated with areas (of) cover for stalking, occupied…rocky terrain….". Finally, Enk et al. (1998) added "…they (lions) relied on… topographic complexity (i.e. rocky reefs and steep terrain for traveling and stalking prey".

Consequently, "escape terrain" for sheep and "stalking habitat" of pumas have many characteristics in common. Not surprisingly, it is in this type of habitat where pumas are successful at killing sheep. Rechel et al. (1997) found "…mortality locations of mountain sheep… (had) a strong positive relationship with proximity to …escape cover". Enk et al. (1998) reported "all sheep kill sites were located either in riparian corridors or adjacent to escape terrain". And finally, Jalkotzy et al. (2000) stated "kills were found… in areas with greater terrain ruggedness". Essentially, these data suggest that far from being safe, "escape terrain" may actually represent one of the riskiest habitats available. In fact, Enk et al. (1998) at the 11th NWSGC symposium concluded that escape terrain likely did not provide adequate protection from predation by pumas and advised that "it may be necessary to re-evaluate "escape terrain" and sheep-predation dynamics…." This re-evaluation is especially urgent considering that escape terrain has become and still is the most important element in assessing the adequacy of an area for sheep (Smith et al. 1991, Johnson and Swift 2000, Singer et al. 2000c). It is essential to determine if we are releasing sheep in the most secure habitat possible or into the jaws of their predators.

However, how do we evaluate the predation risk faced by sheep in escape or other habitat types? We propose to let the sheep tell us their perception of predation risk. There are ample studies demonstrating that prey are aware of the predation risk they face in different habitat types (Mech 1977; Edwards 1983; Stephens and Peterson 1984; Altendorf et al. 2001). Additionally, they respond to this predation risk by being more alert (Laundré et al. 2001). Thus, we used the level of vigilance sheep exhibited as an

estimate of the predation risk they faced in different habitat types. Additionally, we demonstrate how to map the resulting landscape of fear (Laundré et al. 2001) for sheep relative to pumas. Finally, we suggest how such a map could be useful in evaluating the overall level of predation risk of potential release sites.

STUDY AREA

This study area was the Jim Sage mountain range located in southern Idaho (Fig. 1). This range historically contained sheep which were extirpated in the early 1900's. In 2000 and 2001, various agencies and organizations participated in the reintroduction of 45 California bighorn sheep (*O. c. californiana*) into the area. The area is also part of a long term study of puma ecology and behavior.

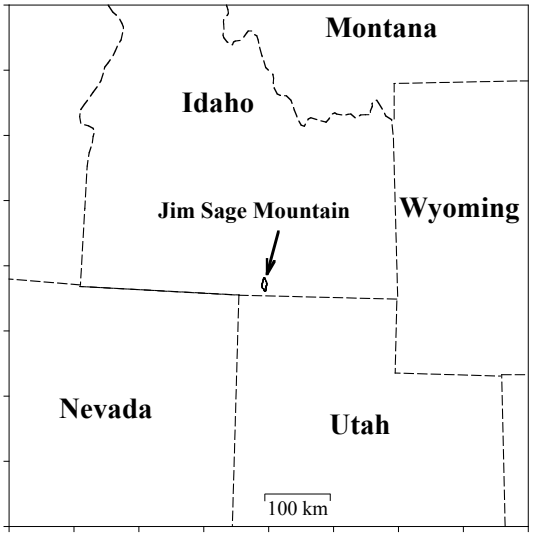

Fig. 1. Location of Jim Sage study site in southern Idaho.

METHODS

We observed vigilance behavior (head up and alert) in the released sheep during the summers in 2000 and 2001 and in the winters of 2000-2001 and 2001-2002. We made the observations with spotting scopes from existing roads. We maintained sufficient distance from the animals (>1.0 km) to minimize our influence on their behavior.

Observations consisted of 20 minute long focal samples in which we recorded to the second changes in the animal's behavior, e.g. feeding, surveying, etc. We limited the samples to animals that were actively feeding. We then calculated the total time of each behavior and then expressed it as a percentage of the total time observed. We also recorded the habitat type the sheep were using during the sample blocks. We identified 5 different habitat types: grass/sage (mainly open slopes with low growing grass and sagebrush; *Artemisia* spp.), sage (draws between slopes with higher growths of sage); scree (areas of loose small rocks); rocky (areas with varying amounts and sizes of rock outcrops); and cliffs (areas of 90^0 rock faces).

We compared arcsine transformed percent vigilance sheep exhibited within the different habitat types with a one-way ANOVA design. All means are $\pm$ standard error and the rejection level was set at $P \leq 0.005$.

RESULTS

We found significantly higher vigilance rates in rocky (32.3 $\pm$ 3.1 %) and cliff habitats (30.1 $\pm$ 4.5 %) than in sage (16.7 $\pm$ 1.8 %) and grass/sage areas (22.1$\pm$ 2.8 %; Fig. 2).

DISCUSSION

Based on our findings, sheep perceive open grass slopes as relatively safe. These results correspond to the observations of Risenhoover and Bailey (1985) and reinforce the concept that sheep prefer open habitats with short vegetation (Van Dyke et al. 1983). However, contrary to the existing perception, our data indicate

sheep find traditionally defined escape terrain to be highly risky.

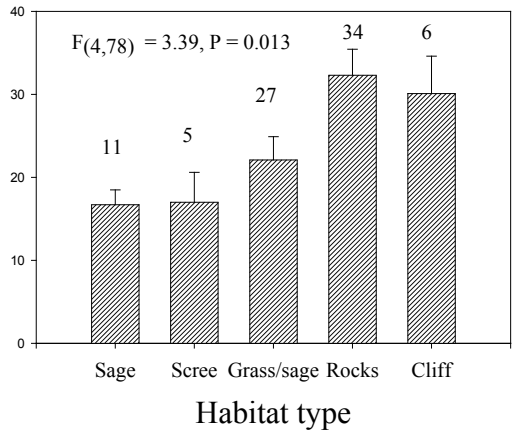

Fig. 2. Percent vigilance of sheep while foraging in the 5 habitat types of the study area.

MANAGEMENT IMPLICATIONS

Because our data indicate escape terrain represents areas of high predation risk, evaluating potential release sites may not be as simple as putting a 300 m buffer around identified escape habitat (Smith et al. 1991). Escape habitat is not safe and more is not better. We suggest we need to discard the concept of escape terrain from evaluation procedures. In place of escape terrain, we need to evaluate levels of predation risk sheep perceive in different habitat types. To do this, first we need to identify the different habitat types (Fig. 3). Once we have this information, we couple these habitat types with their appropriate risk levels and we can map the landscape of fear relative to this predation risk (Fig. 4). We can then add the other features of importance, i.e. distance to water, etc. (Singer et al. 2000c). Based on the final amount and configuration of the various habitat types (= risk levels) we can then assess if the area has adequate habitat safe from puma predation. All of this analysis should lend itself well to traditional modeling of sheep habitat with only substitution of risky habitat for escape terrain. We suggest such a change in evaluation is essential if we want to improve our success rate for sheep transplants.

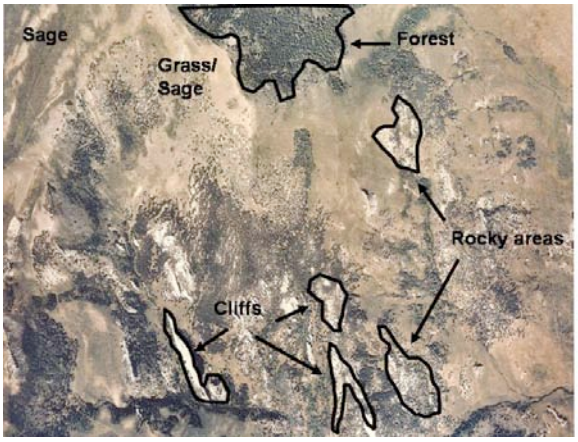

Fig. 3. Example of outlining some of the different habitat types from an aerial photo of sheep range.

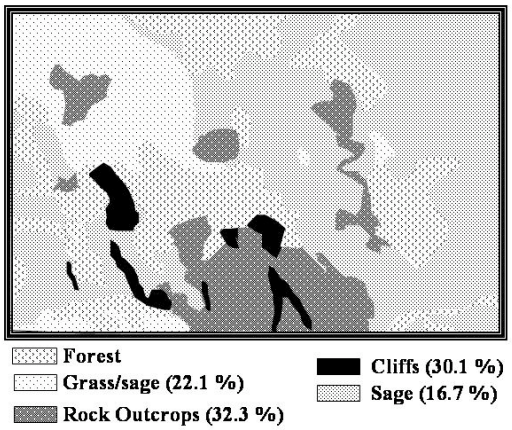

Fig. 4. Map of the landscape of fear where the different habitat types are represented by the corresponding levels of vigilance sheep exhibited in each area.

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