CAPTURE AND TRANSPLANT

CHAIR: AMY FISHER, NEW MEXICO DEPARTMENT OF GAME AND FISH

CHRISTOPHER M. PAPOUCHIS - GUIDELINES FOR THE RESTORATION OF BIGHORN SHEEP INTO LARGE LANDSCAPES: REPORT OF RECENT FINDINGS.

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Abstract: With some notable exceptions, the restoration of bighorn sheep to their former range in the Intermountain west, Colorado Plateau and prairie badlands remains only partially completed. Only 41% of the 100 prior translocations into this 6-state area were rated as clearly successful (those that met the J. Berger-BLM criteria of >100 animals), a success rate far lower than for most large ungulates. In 1990, the National Park Service (NPS) enjoined with 2 other federal agencies (BLM, U.S. Forest Service) and 5 state wildlife agencies (Colorado, Utah, South Dakota, North Dakota, Nevada) to restore metapopulations of bighorn sheep to large areas in and near to 15 NPS units in a 6-state area. In order to establish guidelines, we first analyzed the factors associated with success or failure of 100 translocations, and second we assessed the suitable habitat using the Smith et al. GIS-based model for bighorn sheep for 32 of those translocations. We found that the success of translocations was associated with larger founder groups (>40 animals), when indigenous groups were used as a source stock ($P=0.04$), when domestic sheep were not present in the area and no known contacts occurred ($P=0.05$), when no domestic cattle grazed the same range ($P=0.04$), and when the translocated herd was migratory ($P=0.014$, logistic regression analysis). Translocations were more successful when placed into habitat patches containing >200 km2 of GIS mapped suitable habitat ($P=0.006$) and when >4% of the mapped suitable habitat was lambing habitat ($P=0.036$). The modified GIS procedure we used, the modified Smith model, predicted success of the translocation in 82% of cases versus the 41% success rate for all translocations. We conclude that the use of the modified GIS process for every 100 translocations, would save ~ 33 million dollars at 1999 costs for capture and moving animals ($3,000/animal), and would save ~ 1150 wasted animals from the unsuccessful translocations (± = 28 animals/translocation). The cost of applying the GIS process we followed was about $1,200 - 1,500 per translocation. We applied the process to a vast area of 39,117 km2, an area the size of Vermont and Connecticut combined: 31% of that total area was rated as suitable, of which 2,687 km2 was already occupied, but another 6,635 km2 was unoccupied, but suitable. When fully restored and occupied, we estimate the total suitable area could potentially support as many as 7,000 - 7,500 bighorn sheep. Fifteen separate translocations were conducted in 1995-98 by the joint efforts of the 3 federal and 5 state agencies.

Managers consider bighorn sheep (*Ovis canadensis*) an enigmatic species. At present, some large and secure bighorn populations provide source stocks to many new herds, but most are small, sedentary and stagnant. The species was widespread in the western U.S. until large scale declines over the past century, due to diseases contracted from domestic livestock, market hunting, overharvests, and human alterations of the landscape (Cowan 1940, Buechner 1960, Wishart 1978), eliminated the species from its historic range in 3 states and greatly reduced its presence in 4 others (Thorne et al. 1979).

Starting in the 1950s, several western states embarked on aggressive restoration programs. Some considerable successes were realized, such as in Colorado where bighorn populations approximately tripled and currently number about 6,000 animals (Bailey 1990). However, despite the successes, the restoration of bighorn sheep to large landscapes has been fraught with repeated setbacks and failures. Prior translocations suffered from a lack of detailed information and analysis of the factors relating to success, and a lack of replication and controls to test restoration techniques (Bailey 1990). Reviews of translocations in the U.S. West found only about 40% of prior translocations could be rated as clearly successful (Leslie 1980, Singer et al. 2000a). This low success rate results in waste of limited source stocks of animals and squandered dollars since the typical translocation costs about $2,600 per animal (Bleich 1990).

Partly as a consequence of these variable restoration successes, bighorn sheep populations are generally small, isolated, and fragmented. Three separate reviews concluded roughly two-thirds of populations number less than 100 animals, and about one-third precariously number less than 50 individuals (Thorne et al. 1979, Krausman and Leopold 1986, Singer 1994). The rapid rate of extinction of many bighorn sheep populations has recently received intense scientific scrutiny (Berger 1990, 1999, Bleich et al. 1990, Krausman et al. 1993, Goodson 1994, Wehausen 1999) and has been attributed variously to disease, small population size, predation, sedentariness, poor dispersal tendencies, and inbreeding (Bailey 1986, Jessup 1985, Risenhover et al. 1988, Berger 1990, 1999, Wehausen 1996, 1999).

In 1990, the National Park Service, Intermountain Region, and the U.S. Geological Survey, Midcontinent Ecological Science Center, became involved in a long-term restoration effort of bighorn sheep into 15 National Park Service units in a 6-state area of the Intermountain West (Singer and Gudorf 1999). The goals were to: (1) restore metapopulations of bighorn sheep into large landscapes on an interagency basis; (2) incorporate conservation biology paradigms into the review, analysis and testing of restoration procedures; and (3) to incorporate statistical probabilities, large samples and replication into the formulation of restoration protocols. This paper shares the key findings of this large, 9-year effort with managers. Many of the highlights presented here are available in greater detail in an upcoming special issue of Restoration Ecology (March 2000).

KEY FINDINGS: Founder Sizes: Success of translocations of bighorn sheep were positively associated with founder sizes. In a survey of 100 translocations, 66% of translocations with founder sizes $\geq$40 were highly successful, while only 35.6% of smaller founder sizes ($\leq$29) were highly successful (Singer et al. 2000a). Small founder sizes did result in some successes, but the probability of success decreased (Singer et al. 2000a, 2000b). Large founder sizes were also associated with success of translocations in a large number of mammals and birds (Griffith et al. 1989) and it is not surprising to find this same relationship holds for bighorn sheep. There are several potential benefits from large founder sizes, but it is not evident from the data which factors, alone or combined, explain the higher success in bighorn sheep. Larger founder sizes means the new population is more likely to survive unfortunate stochastic events that may occur in the first few months of the release as the animals learn about their new habitat, including early vulnerability to predators, falls from ledges, or others, leaving more animals alive at the end of the first year to breed. Finally, larger founder groups tend to have a larger amount of genetic heterozygosity, thereby introducing greater genetic heterozygosity into the new population, and giving it a better chance of persistence.

Selection of Source Herds: Translocations from indigenous source herds were twice as likely to be successful (48%) as translocations from previously translocated populations (24%) (Singer et al.

2000a). In particular, we do not recommend translocations come from multiply-translocated herds. Translocated populations pass through genetic bottlenecks during the process of translocation and this loss is additive in multiple translocations. Using simple calculations of the loss of initial genetic heterozygosity based on information on effective population sizes, we determined one population stemming from a prior translocation (south unit, Badlands National Park) should have lost 37% of the initial heterozygosity of the original, indigenous source herd. A second population that passed through 3 founding event bottlenecks (Beaver Creek, Colorado) was predicted to have lost 49% of the original heterozygosity. However, rapidly growing translocated populations stemming from large, indigenous herds might only lose 3-8% of original heterozygosity. These rough calculations are supported by the recent modeling of Vucetich and Waite (1999) and genetic analyses by Ramey et al. (2000) that also verified the populations had passed through large and recent bottlenecks.

The increased success of translocations utilizing multiple source stocks is generally supported by the available evidence. Bailey (1990) found some evidence for increased success of translocations in Colorado stemming from multiple source herds, but the sample sizes were small. One data set of translocated populations (n=31) indicated a positive association between success of translocations and mixing source stocks (Singer et al. 2000b), but a second, larger data set (n=100 translocations) indicated no association (Singer et al. 2000a).

This information taken as a whole, including the positive effects of larger founder size, more augmentations, and indigenous source herds, all suggest the benefits of greater genetic heterozygosity on success of translocations. Fitzsimmons et al. (1995, 1997) found greater genetic heterozygosity in indigenous versus translocated populations. The hard evidence for the benefits of higher genetic heterozygosity on fitness, or population performance, in bighorn sheep, however, is limited. There are several suggestions of such benefits. Lamb mortality was higher in inbred zoo lines of bighorn sheep (Sausman 1982), there was some evidence for the same in wild populations (Haas 1989), and horn growth rates were associated with higher individual heterozygosity (Fitzsimmons et al. 1995). More definitive research is needed in this area, especially since the mixing of source stocks presents several dilemmas to managers. Any mixing of source stocks increases the risk of the introduction of a novel pathogen. Also, policies of some agencies, such as the National Park Service, direct that conservation of the original form, or nearest surviving genetic resource, be used in restoration (NPS 1988).

Patch Sizes, Habitat Quality and Movements: Success of translocations was associated with larger patch size (Zeigenfuss et al. 2000). Movements were also associated with larger patch sizes (Singer et al. 2000c). Bighorn sheep introduced into larger patches of habitat, especially those $\geq$200 km^2 of suitable habitat (i.e. just the occupiable habitat in the patch), were more likely to be successful, to migrate seasonally, to have larger home ranges, and to display higher rates of dispersal and colonization (Singer et al. 2000c, Zeigenfuss et al. 2000). Bighorns released into patches of $\leq$40 km^2 were more likely to be unsuccessful, nonmigratory, and to exhibit lower dispersal rates (Figure 1). Seasonal migrations were associated with higher growth rates, greater dispersal rates, and greater rate of success and persistence (Singer et al. 2000a, 2000b, 2000c, Zeigenfuss et al. 2000). Seasonal migrations in other ungulates has been attributed to spacing out from predators (Sinclair 1985, Bergerud and Page 1987), and to larger body mass in reproductive females compared to nonmigratory females (Albon and Langvatn 1992).

As might be expected, dispersal and colonization rates were associated with fewer water barriers, more broken terrain, fewer human developments, and less dense vegetation in the intervening habitat between patches (Singer et al. 2000b). A higher proportion of suitable habitat that was also lambing habitat (>10% of the suitable habitat) was associated with success, but <4% lambing habitat was associated with a lower success rate

(Zeigenfuss et al. 2000). The persistence of translocations was also associated with a lower ratio of perimeter to area (i.e. perimeter of the entire patch:area of suitable habitat), which is an index to habitat effectiveness in the patch (Singer et al. 2000c).

A number of potential benefits have been attributed to larger patch sizes. Larger patches tend to have greater habitat diversity and greater topographic diversity and thus support a greater diversity of phenological stages and forages in peak nutrition stages. Larger patches, in general, support larger populations and thus maintain greater genetic heterozygosity than do populations in smaller patches (Saunders et al. 1991). Non-persisting translocated populations reached higher effective densities on the suitable habitat within a patch, prior to their extirpation (Zeigenfuss et al. 2000), i.e. they became overcrowded sensu Risenhover et al. (1988) and Bailey (1986). Populations placed into larger patches were less likely to become overcrowded. The populations placed into smaller patches were more likely to be sedentary and thus the animals might have been subjected to higher parasite loads and to repeated stalking by predators (Risenhover et al. 1988).

Presence of Domestic Livestock: Both the presence of domestic livestock and known contacts with domestic sheep, especially the presence of domestic sheep within 6 km, were associated with a lower success of translocations (Singer et al. 2000a, 2000b, 2000c, Zeigenfuss et al. 2000). When contact between bighorn sheep and domestic sheep was observed, 45.5% of translocations failed, compared with a 23.7% failure rate when no contact was observed (Singer et al. 2000a). While a study of 100 translocated populations indicated a minimum of 16km distance to domestic sheep was necessary for greatest success of translocations (Singer et al. 2000a), another study of 32 populations recommended a distance of 23 km. (Zeigenfuss et al. 2000). Contact with domestic sheep have been implicated in twenty-eight cases of a die-off or decline in free ranging bighorn sheep herds (Jessup 1981; Blaisdell 1982; Foreyt and Jessup 1982; Onderka and Wishart 1984; Clark et al. 1988; Sandoval 1988; McCarty and Bailey 1984). While the cause and effect relationship is ambiguous, our data points clearly towards a negative impact of domestic sheep on success of bighorn sheep translocations. We therefore recommend a minimum of 16 km from domestic sheep be required before reintroducing bighorns to an area, however, whenever possible a distance of 23 km should be maintained for greatest probability of success.

We also found a negative association between the presence of domestic cattle on the same range and the success of translocations. When cattle were present, 32% of translocations failed, compared to a 6.25% failure rate when livestock were absent (Singer et al. 2000a). This was surprising since habitat and diet overlaps between the two species are minimal (Tilton and Willard 1982, Cunningham and Ohmart 1986, Dodd and Brady 1986, King and Workman 1984) and since there is little evidence for any transmission of pathogens between the two species (Mouton et al. 1991, McCarty and Bailey 1994). But several authors report there is potential for such transmissions at shared water holes (Jessup 1985, Spraker and Adrian 1990), and the role of cattle was suspected in the decline of two desert bighorn sheep herds (DeForge et al. 1981, DeForge and Scott 1982). Clearly more research is needed on bighorn sheep-cattle relations before definitive conclusions can be made.

Minimum Viable Population Goals for Restoration: We conclude patch size, not population size per se, was the critical minimum goal to consider in restoration of bighorn sheep into large landscapes. Population size can be an important index since ultimately, patch size and population size are correlated, but there is a high degree of circularity in references to both patch size and population size to persistence. As evidence of this circularity, there was a positive association between largest population sizes at the end of our studies and greater persistence, higher success, higher growth rates, and greater colonization rates (Singer et al. 2000b). We concluded there were two areas of potential effect of population size alone on persistence and success. First, larger pre-epizootic population sizes increased the probability of surviving any epizootic. We investigated 41 epizootics and found only 5% of herds with <50 animals prior to the epizootic survived the disease, but 75% of herds with 51-100 animals survived, and 83% of herds of >100 survived (Singer et al. 2000c). Persistence was the highest for populations numbering >250 pre-epizootic. Not all populations are subjected to epizootics, but no population is without risk. Therefore, we suggest any errors be on the conservative side, and the largest populations feasible (i.e. >250) be planned for in restoration programs, whenever possible. Second, the threshold of group sizes for optimal vigilance and optimal foraging efficiency has been set at >10 bighorn sheep (Risenhover and Bailey 1985, Berger and Cunningham 1988). Since groups sizes were positively associated with census N (Singer et al. 2000c), smaller populations might fall below this optimum average group size for predator security and foraging.

CONCLUSIONS: Past translocations of bighorn sheep have been of variable success partly because of a limited understanding of the factors involved. After a 9-year effort in translocating bighorn sheep into historic range, we recommend translocating large initial groups of bighorn sheep (≥40) from multiple indigenous populations into large patches (especially >200 km^2) with no potential contact with domestic sheep or livestock and at least 16km (preferably 23km) from the nearest domestic sheep allotment. It is our hope that these guidelines will help maximize the success of future translocations of bighorn sheep.

LITERATURE CITED

Albon, S.D., and R. Langvatn. 1992. Plant phenology and the benefits of migration in a temperate ungulate. Oikos 65:502-513.

Bailey, J.A. 1986. The increase and die-off of Waterton Canyon bighorn sheep: Biology, management and dismanagement. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:325-340.

_____. 1990. Management of Rocky Mountain bighorn sheep herds in Colorado. Colorado Division of Wildlife, Special Report No. 66. Ft. Collins, CO. 24 pp.

Berger, J. 1990. Persistence of different-sized populations: An empirical assessment of rapid extinction in bighorn populations. Conservation Biology 4:91-98.

_____. 1999. Intervention and persistence in small populations of bighorn sheep. Conservation Biology 13:432-435.

_____, and C. Cunningham. 1988. Size-related effects on search time in North American grassland female ungulates. Ecology 69:177-183.

Bergerud, A.T., and R.E. Page. 1987. Displacement and dispersion of parturient caribou at calving as an antipredator tactic. Canadian Journal of Zoology 65:1597-1606.

Blaisdell, J.A. 1982. Lava beds wrap-up, what did we learn? Desert Bighorn Council Transactions 26:3233.

Bleich, V.C. 1990. Costs of translocating mountain sheep. Pages 67-75 *in* Krausman, P.R. and N.S. Smith, eds., Managing Wildlife in the Southwest. Arizona Chapter of the Wildlife Society, Phoenix, AZ.

_____, J.D. Wehausen, and S.A. Holl. 1990. Desert-dwelling mountain sheep: Conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.

Buechner, H.K. 1960. The bighorn sheep in the United States: its past, present and future. Wildlife Monographs No. 4. 174pp.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. American Midland Naturalist 24:505-580.

Clark, R.K., D.A. Jessup, M.D. Kock, and R.A. Weaver. 1988. Relocation of bighorn sheep within California. Proceedings American Association Zoo and Wildlife Veterinarians. Pages 121-129.

Cunningham, S.C., and R.D. Ohmart. 1986. Aspects of the ecology of desert bighorn sheep in Carrizo Canyon, California. Desert Bighorn Council Transactions 30:14-19.

Deforge, J.R., J.E. Scott, G.W. Sudmeier, R.L. Graham, and S.V. Segreto. 1981. The loss of two populations of desert bighorn sheep in California. Desert Bighorn Council Transactions 25:36-38.

_____, and _____. 1982. Ecological investigations into high lamb mortality. Desert Bighorn Council Transactions 25:36-38.

Dodd, N.L., and W.W. Brady. 1986. Cattle grazing influences on vegetation of a sympatric desert bighorn range in Arizona. Desert Bighorn Council Transactions 30:12-16.

Fitzsimmons, N.N., S.W. Buskirk, and M.H. Smith. 1995. Population history, genetic variability, and horn growth in bighorn sheep. Conservation Biology 9:314-323.

_____, _____, and _____. 1997. Genetic changes in reintroduced Rocky Mountain bighorn sheep populations. Journal of Wildlife Management 61:863-872.

Foreyt, W.J., and D.A. Jessup. 1982. Fatal pneumonia of bighorn sheep following association with domestic sheep. Journal Wildlife Diseases 18:163-167.

Goodson, N.J. 1994. Persistence and population size in mountain sheep: Why different interpretations? Biennial Symposium of the Northern Wild Sheep and Goat Council 8:617-618.

Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a conservation tool: Status and strategy. Science 245:477-480.

Haas, C.C. 1989. Bighorn lamb mortality: Predation, inbreeding, and population effects. Canadian Journal of Zoology 67:699-705.

Jessup, D.A. 1981. Pneumonia in bighorn sheep: Effects on populations. Pages 72-78 *in* California-Nevada Wildlife Society Transactions.

_____. 1985. Diseases of domestic livestock which threaten bighorn sheep populations. Transactions of the Desert Bighorn Council 29:29-33.

King, M.M., and G.M. Workman. 1984. Cattle grazing in desert bighorn sheep habitat. Desert Bighorn Council Transactions 30:18-22.

Krausman, P.R., R.E. Etchberger, and R.M. Lee. 1993. Persistence in mountain sheep. Conservation Biology 7:219.

_____, and B.D. Leopold. 1986. The importance of small populations of bighorn sheep. Transactions of the North American Wildlife and Natural Resources Conference 51:52-61.

Leslie, D.M. 1980. Remnant populations of desert bighorn sheep as a source for transplantation. Desert Bighorn Council Transactions 24:36-44.

McCarty, C.W., and J.A. Bailey. 1994. Habitat requirements of desert bighorn sheep. Colorado Division of Wildlife, Special Report No. 69, Ft. Collins, CO. 27 pp.

Mouton, R.J., R.M. Lee, and R.J. Olding. 1991. A desert bighorn sheep decline in Aravaipa Canyon, Arizona. Desert Bighorn Council Transactions 35:18-19.

National Park Service. 1988. Management policies. U.S. Government Printing Office. Washington, D.C.

Onderka, D.K., and W.D. Wishart. 1984. A major bighorn sheep die-off from pneumonia in southern Alberta. Proceedings Northern Wild Sheep and Goat Council 3:356-363.

Ramey, R.R., and G. Luikart. 2000. Genetic bottlenecks resulting from restoration efforts: The case of bighorn sheep in Badlands National Park. Restoration Ecology. (In review).

Risenhover, K.L., and J.A. Bailey. 1985. Foraging ecology of mountain sheep: implications for habitat management. Journal of Wildlife Management 49:797-804.

_____, _____, and L.A. Wakelyn. 1988. Assessing the Rocky Mountain bighorn sheep management problem. Wildlife Society Bulletin 16:346-352.

Sandoval, A. 1988. Bighorn sheep die-off following association with domestic sheep: case history. Desert Bighorn Council Transactions 32:36-37.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32.

Sausman, K.A. 1982. Survival of captive born *Ovis canadensis* in North American zoos. Zoo Biology 3:111-121.

Sinclair, A.R.E. 1985. Does interspecific competition or predation shape the African ungulate community? Journal of Animal Ecology 54:899-918.

Singer, F.J. 1994. Bighorn sheep in the Rocky Mountain National Parks. Pages 332-333 *in* Our Living Resources – Interior West, E.T. LaRoe, et al., eds. U.S. Department of the Interior, National Biological Service, Washington, D.C. 530 pp.

_____, and M.A. Gudorf. 1999. Restoration of bighorn sheep metapopulations in and near 15 national parks: Conservation of a severely fragmented species. U.S. Geological Survey Open File Report 99-102, Midcontinent Ecological Science Center, Ft. Collins, Colorado. 96 pp.

_____, C.M. Papouchis, and K.K. Symonds. 2000a. Factors contributing to the success of translocations to restore populations of a severely fragmented species, *Ovis canadensis* (bighorn sheep). Restoration Ecology. (In press).

_____, M. Moses, S. Bellew, and W. Sloan. 2000b. Dispersal and colonization rates by bighorn sheep: The role of disease, corridors, and patch size. Restoration Ecology. (In review).

_____, L.C. Zeigenfuss, and L. Spicer. 2000c. The rapid extinction of bighorn sheep populations can be explained by patch size, movements, and contacts with domestic livestock. Conservation Biology. (In review)

Spraker, T.R., and W.J. Adrian. 1990. Problems with multiple land use dealing with bighorn sheep and domestic livestock. Biennial Symposium of the Northern Wild Sheep and Goat Council 7:67-75.

Thorne, E.T., G. Butler, T. Varcalli, K. Becker, and S. Hayden-Wing. 1979. The status, mortality, and response to management of the bighorn sheep of Whiskey Mountain. Wyoming Game and Fish Department Wildlife Technical Report No. 7. 198 pp.

Tilton, M.E., and E.E. Willard. 1982. Winter habitat selection by mountain sheep. Journal of Wildlife Management 46:46-359-366.

Vucetich, J.A., and T.A. Waite. 1999. Erosion of heterozygosity in fluctuation populations. Conservation Biology 13:860-868.

Wehausen, J.D. 1996. Effects of mountain lion predation on bighorn sheep in the Sierra Nevada and Granite Mountains of California. Wildlife Society Bulletin 24:471-479.

_____. 1999. Rapid extinction of mountain sheep populations revisited. Conservation Biology 13:378-384.

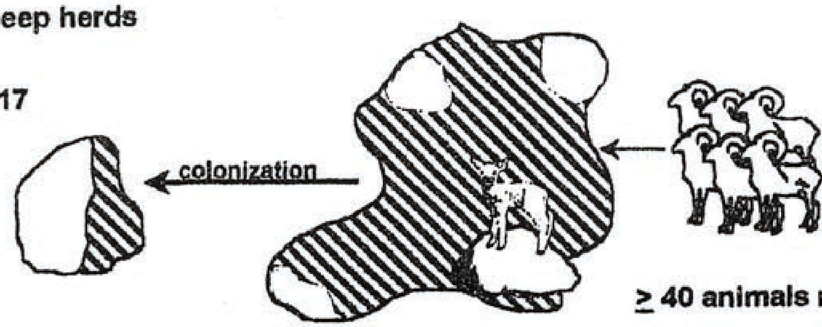
Wishart, W. 1978. Bighorn sheep. Pages 161-171 *in* J.L. Schmidt and D.L. Gilbert, eds. Big game of North America. Stackpole Books, Pennsylvania, PA. 494 pp.

Zeigenfuss, L.C., F.J. Singer, and M.A. Gudorf. 2000. A modified habitat suitability model for bighorn sheep: Test in 32 populations in mountain, prairie, and desert habitats. Restoration Ecology. (In press).

Figure 1

Successful translocations

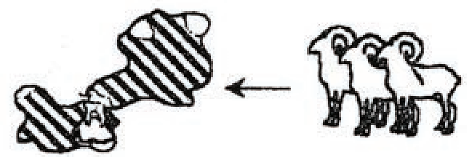
- Larger patches ($\geq$200 km^2)
- Colonizations, larger home ranges, seasonal migrations
- Smaller perimeter:area ratio ($\leq$0.003)
- $\geq$ 23 km from domestic sheep herds
- $\geq$ 10% lambing habitat
- Rapid growth rates, $\lambda \geq 1.17$



$\geq$ 40 animals released

Unsuccessful translocations

- Small patches ($\leq$ 40 km^2)
- Barriers to colonizations
- No colonizations, smaller home ranges, no seasonal migrations
- Static or declining populations
- Larger perimeter:area ratio ($\geq$0.024)
- Less than 6 km from domestic sheep herds
- $\leq$ 4% lambing habitat



$\leq$ 29 animals released

QUESTIONS, ANSWERS AND COMMENTS - CHRISTOPHER PAPOUCHIS PRESENTATION

PAUL KRAUSMAN, ARIZONA: Could you tell us what you're describing as lambing habitat?

CHRIS PAPOUCHIS: I'd need to refer to Tom Smith's model.

JIM BAILEY, NEW MEXICO: I think I can answer that.

PAPOUCHIS: Thank you. The question was how would I describe lambing habitat.

BAILEY: I'm pretty sure that in the Smith model suitable habitat had visibility constraints, but it also was something like 20 to 80 percent slope, that's suitable, and some proportion of that is at a higher slope (like 60 to 80 percent) and was defined as lambing range. It's misleading to say we need a greater proportion in lambing range because it will never be used as lambing range. We have a proportion of the better escape terrain.

PAPOUCHIS: I can't speak to the model. Like I said, that wasn't the work I was involved in.

VERN BLEICH, CALIFORNIA: Can you define migratory and nonmigratory as used in the model and its applicability to desert sheep populations in general?

PAPOUCHIS: What they defined as a nonmigratory population was a population that used only one area, and didn't migrate to other areas. With migratory or partially migratory populations, some of the sheep migrated, but not all of them were fully migratory. They actually used different summer and winter ranges. I don't know if I answered your question about the applicability to desert sheep areas in terms of movement between metapopulations or just within one particular range.

BLEICH: In my limited experience I've never really seen migratory behavior in desert sheep that you could really say were winter and summers ranges, and I was questioning the applicability of that parameter in the model.

PAPOUCHIS: Right. I wish Dr. Singer were here. He could answer this question better. I've been away from this data for a little bit. I would encourage anybody to ask him these questions.

CHRISTEN LAKE, YELLOWSTONE PARK: Why didn't winter range come up as a factor in the model?

PAPOUCHIS: I'm not aware of why it didn't. Again, I can leave the information and it can be discussed further. I do apologize for having limited knowledge of that aspect. I only got this information about a week and a half ago.

NIKE GOODSON, UTAH: Were the same data used to develop the models that were used to test the models and come up with the "success" percentages?

PAPOUCHIS: Are you referring to Tom Smith's original data, or the more recent data?

GOODSON: The new model. The original model was modified based on surveys of between 30 and 60 populations, and then there were 13 populations with habitat information.

PAPOUCHIS: Our model was tested on those 13 where there was specific GIS information produced by managers of those parks and of those other areas.

GOODSON: So the data that were used to test the model were not data that were used to modify the model? There was a different set of populations?

PAPOUCHIS: No, they were the same populations. The initial data used by Smith were not the same data that were used later, and Johnson and Swift made the modifications. Our study analyzed those modifications and tweaked them a little bit to hopefully improve success of defining what would really make a successful population.

GOODSON: I wanted to point out that if success and modification are based on the same data, then the success is not valid. You have to use independent data to come up with a success.

PAPOUCHIS: There are a couple of people here who can answer the question better.

LESLIE SPICER, COLORADO: I can help. The data I used to test against the model were new. They were not the same data originally used to produce the model.

GOODSON: Were they from different populations and different situations?

SPICER: It was partially the same population. Individual sheep weren't tagged or marked and sheep they used weren't identified. It was the same population, but the data were from different years.

HERB MEYR, IDAHO: Since most of the west is grazed by cattle, except for national parks, and recent studies have been done with bighorn sheep and cattle. It would be dangerous to leave here thinking we have to remove cattle so we can have bighorn sheep. I think that was a wrong conclusion that somebody came up with. The person who did the study is Elroy Taylor of BLM. There can be competition between bighorn sheep and cattle, but if you have the proper habitat, the cattle won't be in the same location.

PAPOUCHIS: Those were the same conclusions we reached from both of the studies, and I'm not going to backtrack from that. Obviously, there's a lot of controversy over that issue. What we found was, if you had cattle, it reduced the statistical likelihood of success of those bighorn herds. The presence of cattle was not a single determinant in affecting whether that population was successful or not. Both studies did find the presence of cattle had somewhat of a detrimental impact. Now, that may be refuted by other studies and I welcome that.

CRAIG FOSTER, OREGON: Were cattle grazing the same range? In a situation like Nike's down in southern Utah where you have impacts to riparian areas from cattle use, you can see it in the definition of cattle use. My sheep range is located within a cattle allotment and I've got a bunch of sheep ranges in my state where I've got a cattle allotment, but they don't use the same range. The cattle won't go on the steep ground.

PAPOUCHIS: As far as I know, the survey was originally set out the question of whether or not there are cattle grazing on the bighorn sheep range.