A SYSTEM FOR EVALUATING POTENTIAL BIGHORN SHEEP TRANSPLANT SITES IN NORTHERN NEW MEXICO

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ABSTRACT: Six Santa Fe National Forest ranges were evaluated by quantitatively assessing several important habitat parameters, to determine their suitability for bighorn sheep (Ovis canadensis). Applications and limitations of this Habitat Evaluation System in determining suitability of ranges for bighorns and in developing strategies for management of bighorns in the potential release areas are discussed. Intensive range surveys were later conducted to help formulate specific plans for management of sheep in each area.

INTRODUCTION

Although reintroductions have become an important aspect of bighorn sheep management, few biologists have published methods used to determine suitability of bighorn transplant sites. Hansen (1971) devised a system to quantitatively evaluate suitability of desert ranges and Sands (1976) and Sandoval (1977) later modified this system for California bighorn (O. c. californiana) habitat in Nevada and desert bighorn (O. c. mexicana) habitat in New Mexico, respectively. This paper describes the methods used to determine the suitability of 6 potential bighorn transplant sites on Santa Fe National Forest ranges in northern New Mexico in 1978 and 1979. It was designed to be a practical evaluation method and remove some of the subjectivity in assessing suitability of ranges for bighorn sheep.

This system assessed suitability of habitat in vastly different ecosystems. Elevations ranged from 1,615 to 3,840 m (5,300 to 12,600 ft) and the following life zones were represented among the areas evaluated:

pinyon-juniper (Pinus edulis-Juniperus spp.), ponderosa pine-Gambel oak (Pinus ponderosa-Quercus gambelii), Douglas fir-aspen (Pseudotsuga menziesii-Populus tremuloides), spruce-fir (Picea engelmannii-Abies spp.), and alpine tundra (Elmore and Janish 1976).

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METHODS

Each study area was divided into 259 ha (1 mi^2) sections and each section was evaluated to help identify the range that was best suited for sheep. Partial sections along the study area boundaries were lumped with the nearest full section for evaluation purposes.

Habitat suitability was determined through the use of a modified version of Hansen's (1971) Habitat Evaluation System. The value of each range to bighorns was assessed by assigning numerical scores to 8 habitat parameters (Table 1). The overall suitability score was determined by adding together the scores for the various parameters. Each section was then placed in 1 of 5 suitability categories based on the total score obtained (Table 2).

Appendix 1 explains the scoring possibilities for the various evaluation tools. The breakdown in the Vegetation Type and Density component was left rather broad because of the variety of vegetative associations to be evaluated. The Range Condition and Trend component was assessed through a quantitative analysis of ground cover by the Parker Three-Step method and paced transects, and by ocular estimates

Table 1. Habitat parameters (tools) used to determine suitability of ranges for bighorn sheep in the Santa Fe National Forest, New Mexico.

Points	Tool Name	Subpoints
5 to 32	SUMMER RANGE	
	a. Vegetation Type and Density	1 to 7
	b. Range Condition and Trend	0 to 8
	c. Forage Production	1 to 5
	d. Escape Terrain	3 to 12
0 to 33	WINTER RANGE	
	a. Size	0 to 8
	b. Range Condition and Trend	0 to 8
	c. Forage Production	1 to 5
	d. Escape Terrain	3 to 12
0 to 20	HUMAN USE	
0 to 10	COMPETITION	
1 to 5	WATER[a]	

[a]Could receive up to 20 points (see Appendix 1).

Table 2. Suitability categories used to classify potential bighorn sheep transplant sites in the Santa Fe National Forest, New Mexico (from Hansen 1971).

Total Score	Suitability Category
0 to 50 points	Not improtant to bighorn, or of high value for human use.
51 to 64 points	Buffer zone or zone of deficienty for bighorn, or area of potential economic value or of moderate human use.
65 to 79 points	Periodic use of zone of deficiency for bighorn or area of potential economic value or for occasional human use.
80 to 100 points	Important to bighorn sheep.
101 and above	Vital to bighorn sheep.

following U.S. Forest Service methods (USDA 1979). Forest Service range condition data for each study area were analyzed and a browse condition survey was conducted following Forest Service methods (USDA 1979) in study area to further describe the range component. The Forage Production, Escape Terrain, and Winter Range Size components were subjectively assessed. Winter aerial and ground surveys were conducted to delineate snowfree areas to aid in the characterization of the Winter Range habitat component.

Recreational use data and information from people knowledgable of the areas aided in evaluation of the Human Use parameter. Fecal group surveys were conducted and data from New Mexico Department of Game and Fish permanent pellet transects were analyzed to obtain an index of the potential for competition with wild and domestic animals. Water resource data were obtained from Forest Service range allotment maps, field surveys, and Forest Service range personnel familiar with the areas.

All the areas that appeared to be of moderate to high value to bighorns from preliminary aerial and ground surveys were field evaluated. However, because of time limitations, portions of each study area that appeared to be of low value to sheep were evaluated primarily from aerial photos with cursory ground truthing.

Since this system is based on limiting factors, it indicated the limitations of each 259 ha section as bighorn habitat in addition to its overall suitability. In order to objectively assign limiting factors to each section, a minimum acceptable score was established for 6 habitat parameters (Table 3). If a parameter's score was below the accepted minimum the section was considered deficient in that parameter. Awareness of these deficiencies aided in establishing the prescription of management strategies for each study area.

Table 3. Guidelines used to determine the limiting factors of each section assessed by the Habitat Evaluation System in the Santa Fe National Forest, New Mexico.

Habitat Component	Range of Values Possible[a]	Minimum Acceptable Score[a]
Range Health[b]	1 to 13	8
Potential Escape Terrain	3 to 12	6
Winter Range Size	0 to 8	1
Isolation From Human Use	0 to 20	13
Competition-Free Range	0 to 10	4
Water Resource	1 to 20	4

[a]Score from the Habitat Evaluation System.

[b]Total score from condition + trend + forage production for summer range.

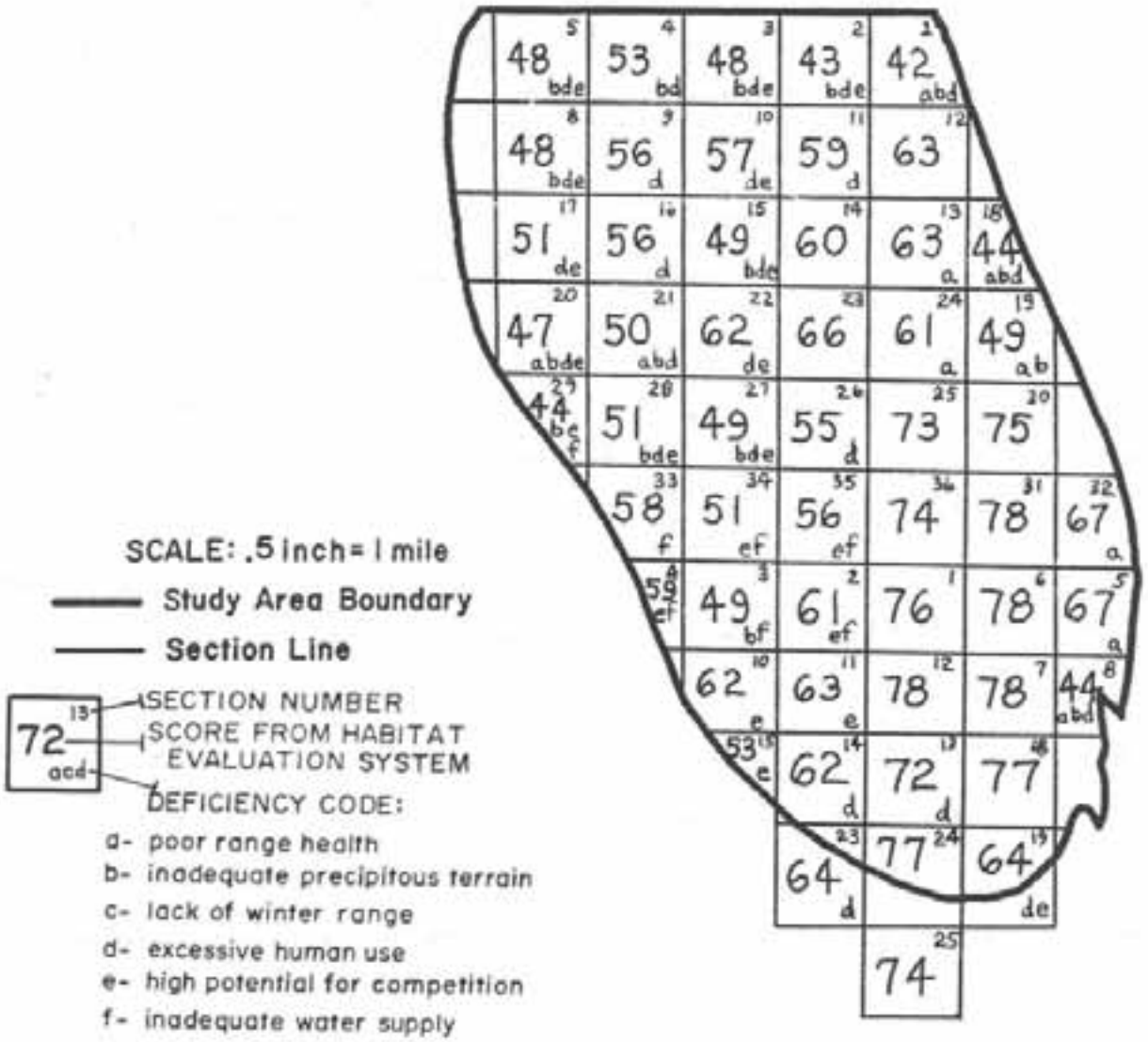
A graphic illustration of the major habitat components was completed in conjunction with the Habitat Evaluation System to aid in the assessment of each area's suitability and limitations for sheep. A map of each study area depicted the deficiencies and suitability score of all sections evaluated (Fig. 1). In addition, potential escape terrain, winter range, lambing areas, water sources, and mineral licks were delineated on overlays on 3 cm/km (2 in/mi) study area maps.

Potential escape terrain was denoted as low, moderate, or high value based on the score received in the Habitat Evaluation System (Appendiz 1). Snow free preciptious terrain and snowfree foraging areas were delineated on an overlay to illustrate the Winter Range habitat component. Also, the following water sources were recognized by type and dependability: perennial drainage, intermittent stream, spring, dam, well, and windmill. The last 4 types were depicted as being either "dependable" or "not-dependable".

To determine if the study areas were historic bighorn sheep habitat a literature review was conducted and people familiar with the areas were contacted. Bighorn bones identified from archeological diggings of nearby Indian ruins were also used as an indicator of historic use (Pers. Comm., Dr. Dick, Adams State College, Alamosa, Colorado).

During the first year of study, 4 of the 6 areas evaluated were found to have at least marginally suitable sheep habitat by the Habitat Evaluation System. These areas were intensively surveyed the following year to more accurately determine forage production and characterize the vegetation component. Forage production was estimated using Forest Service methods (USDA 1979) and vegetation condition was determined from line-intercept transects (Canfield 1941) in sparse vegetation, from Daubenmire's (1959) canopy coverage method in alpine areas, and from browse condition surveys

Figure 1. Illustration of the limiting factors (deficiencies) and habitat suitability score of each section in a potential bighorn sheep transplant site in the Santa Fe National Forest, New Mexico.



(USDA 1979). These data are currently being analyzed to determine carrying capacities and aid in developing management strategies for bighorns in the potential release areas. Vegetative composition and forage production data for 1 area are being compared with data from nearby occupied sheep habitat to determine similiarities and differences.

Refer to Table 4 for a summary of the procedures used in this study.

RESULTS AND DISCUSSION

After compiling and examining the data obtained from the Habitat Evaluation System, several limitations were found. Several sections with suitable bighorn habitat received low scores because unsuitable range made up the majority of these sections, thus the mean suitability score over the entire section was lowered. A more realistic suitability score could be obtained if evaluations were restricted to delineated sheep habitat rather than encompassing entire sections of land.

I also found that this system could not be used to accurately evaluate habitat in differing ecosystems without adjusting the scoring scheme. The water source component, for example, is of greater importance (relative to the other habitat components) in a semi-arid pinyon-juniper vegetation association then it is in a river canyon or alpine tundra association. Thus, adjustments must be made in the points available to each parameter relative to their importance in the particular ecosystem being sampled.

The system was not accurate enough to place all sections in correct suitability categories. Some sections classified "Important to Bighorn Sheep" appeared, from subjective assessment, to better quality as "Periodic Use" zones, and vice versa. This was probably due to an incorrect interpretation of the relative importance of the various habitat parameters

Table 4. Summary of the procedures used to determine the suitability of 6 potential bighorn sheep transplant sites in the Santa Fe National Forest, New Mexico.

1) Evaluated each 259 ha (1 mi^2) section of range.

2) Assigned numerical scores to each habitat parameter through aerial photo interpretation and field surveys.

3) Placed all sections into suitability categories based on the total of the parameter scores in each section.

4) Graphically illustrated limiting factors and suitability scores for all sections on study area maps.

5) Graphically illustrated important habitat components on study area map overlays.

6) Considered historic use of the areas by bighorn sheep.

7) Intensively surveyed potentially suitable areas.

   a. Conducted vegetation composition and forage production surveys.
   b. Compared data with information from nearby occupied bighorn habitat.

8) Determined carrying capacities and developed management strategies for each suitable area.

to bighorn sheep. In particular, the value of the Escape Terrain tool should be increased, relative to the other tools, because some sections had over 75 points (placing them in the "Periodic Use" category) even though they had no escape terrain.

Although this system has some weak points, it can be used to determine different levels of habitat suitability for bighorn sheep as well as reveal basic management strategies for the species. I hope this system will receive input from other researchers and eventually lead to a comprehensive and more objective habitat evaluation system which can be used by other wildlife biologists to determine the suitability of ranges for bighorns.

CONCLUSIONS

In conclusion, the merits of the system are:

1) It is a relatively objective means of evaluating habitat suitability and enables the worker to gather quantitative data, which carry more credence than qualitative assessments.

2) It is versatile in that it can be used for evaluations of almost any intensity from cursory to very intensive surveys. Thus, it can be adapted to fit almost any agency financial situation.

3) It quantifies specific limiting factors and therefore can serve as a firm foundation from which to develop management strategies.

4) It is flexible in that it can be adapted to evaluate suitability of habitat within different vegetation associations.

5) It has the potential to be developed into a comprehensive evaluation system that could be used objectively by many biologists.

The major limitations of the system are:

1) The accuracy of the scoring scheme is lower than was expected, but could be improved by more precisely weighting the various parameters

according to their relative value.

2) Since this is not a comprehensive evaluation system the parameter scoring must be adapted, by a qualified biologist, to the specific ecosystem(s) being assessed before it can be objectively used by field technicians. As an example, the water source component should be of higher value in a semi-arid exosystem than in an alpine tundra.

3) More of the subjectivity needs to be removed in making evaluations. For example, the forage production and winter range size components would be more objectively assessed by listing the number of points that would be received for specific biomass production values and potential winter range sizes based on knowledge of areas currently used by sheep as opposed to using relative values (i.e. low to high for forage production and small to large for winter range size).

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Appendix 1. Numerical scores possible for the habitat parameters (tools) used to classify potential bighorn sheep transplant sites in the Santa Fe National Forest, New Mexico.

Score	Habitat Parameter Description
	TOOL 1a: VEGETATION TYPE AND DENSITY
7 -	Alpine
5 -	Coniferous woodland: low density
4 -	Coniferous woodland: moderate density
3 -	Coniferous woodland: high density
2 -	Deciduous or coniferous forest: low density
1 -	Deciduous or coniferous forest: high density
	TOOL 1b: RANGE CONDITION AND TREND
	Condition:
3 - to 0 -	Vegetation (GOOD) and Soil (GOOD) to Vegetation (POOR) and Soil (POOR)
	Trend:
5 -	Static or both vegetation and soil UPWARD
3 -	One UPWARD and one DOWNWARD
1 -	Both vegetation and soil DOWNWARD (if the section has an acceptable management plan)
0 -	Both vegetation and soil DOWNWARD (if the section has an acceptable management plan)
	TOOL 1c: FORAGE PRODUCTION
5 -	High
3 -	Moderate
1 -	Low
	TOOL 1d: ESCAPE TERRAIN
	Quality:
3 -	High
2 -	Moderate
1 -	Low

Score	Habitat Parameter Description
	Quantity:
4 -	High (at least 410 m long and 365 m high)
3 -	Moderate
1 -	Low (the least acceptable is 91 m long and 182 m high)
	Juxtaposition:
5 -	High
3 -	Moderate
1 -	Low

High quality escape terrain would provide broken precipitous areas maneuverable by bighorns but not easily travelled by predators. It would also have few or no obstructions to view the surrounding terrain.

High value juxtaposition would provide a high interspersion of foraging areas and escape terrain (e.g. cliff-bench areas). Low value juxtaposition would have little or no interspersion or escape terrain seperated from foraging areas by areas of high vulnerability to sheep (e.g. level terrain or timbered areas).

Score	Habitat Parameter Description
	Overall Escape Terrain Value: Total of quality + quantity + juxtaposition.
10 to 12	High
7 to 9	Moderate
3 to 6	Low

TOOL 2a: WINTER RANGE SIZE

8 - to 1 -	Large to Small
0 -	No winter range

TOOLS 2b, 2c, and 2d: Use the same point system used for 1b, 1c, and 1d.

TOOL 3: HUMAN USE (from Hansen 1971)

0 -	High density human use and/or economic potential.

Score	Habitat Parameter Description
2 -	Medium to low density human use and/or economic potential (Unrestricted).
6 -	Medium density human use and/or economic potential.
7 -	High density human use unrestricted and low or no economic potential.
8 -	High density human use restricted and low or no economic potential.
9 -	Planned development for wildlife with some unrestricted human use and with some degree of economic potential.
10 -	Medium density human use with restrictions and no economic potential.
15 -	Low density human use unrestricted and low or no economic potential.
20 -	Relatively no human use and no economic potential.

TOOL 4: COMPETITION (from Hansen 1971)

0 -	Frequent livestock use.
2 -	Some livestock, feral animal, or native big game use.
5 -	Mostly big game use.
7 -	Some native big game use.
10 -	No native big game or livestock use.

TOOL 5: WATER SOURCES (from Hansen 1971)

1 -	Water present irregularly, mainly in summer.
2 -	Often dry when needed in spring and summer during dry years.
3 -	Dry half of the time when needed during dry springs and summers.
4 -	Seldom dry during the spring and summer.
5 -	Sufficient and always present.

Guidelines for evaluating water sources:

1) The section being evaluated will receive the value of the single most-dependable water source, except as outlined in #6 below.

2) If there is no water source within the section being evaluated, the section will receive the value of the best source within 4 miles.

3) If there is no water source within 4 miles of the section being evaluated, the section will receive 50% of the value assigned to the nearest water

source.

4) Any section that has a water source within it will receive twice the value of that source.

5) If the water source being evaluated is a river or creek that is sufficient and always present, and runs for more than .4 km (.25 mi) within the section, it will receive 20 points.

6) If there are 2 or more water sources within a section that are "sufficient and always present" the section will receive 20 points.