MANAGING BIGHORN HABITAT FROM A LANDSCAPE PERSPECTIVE

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Abstract: Three levels of bighorn (Ovis canadensis) habitat management
address (1) metapopulations, (2) herds that comprise metapopulations,
and (3) local projects. Projects are implemented to enhance specific
seasonal ranges, migration corridors, or inter-herd corridors. There
has been an emphasis on projects in the management of sheep. Developing
comprehensive long-range plans for maintaining or enhancing herds and
metapopulations has been neglected. Three types of bighorn
metapopulation structures are proposed. Management needs and
constraints for each of the 3 levels of management are discussed. State
wildlife departments are in the best positions to provide needed
leadership in developing and coordinating management that will identify
and achieve long-term goals for metapopulations and for local herds.

Conservation of bighorn sheep and their genetic resources requires
strategies for maintaining local populations, and for maintaining their
interconnections as metapopulations. Ideally, these strategies are
implemented in a series of prioritized and coordinated management
projects. There has been an emphasis on projects in bighorn sheep
management. Meanwhile, developing comprehensive long-range plans for
maintaining or enhancing local populations and metapopulations has been
neglected. My objective is to emphasize the limitations of this
situation, and to stimulate discussion and development of more
comprehensive management.

MANAGEMENT OF METAPOPULATIONS

Metapopulations of bighorn sheep consist of local populations
(herds) interconnected by movements of animals across inter-herd
corridors. Movement between 2 herds may be totally, or mostly, one way;
or may approach being equal in both directions. Movements may be
frequent or occasional. Exchange of animals and their genes among
herds:

(1) may be necessary to maintain small herds having poor
    demographic characteristics. Berger (1990) concluded that
    herds of <50 sheep were not viable, and herds <100 sheep
    probably were not viable, for >50-70 years. Persistence of
    such small herds would be enhanced by periodic immigrations
    from nearby herds.

(2) may be necessary to avoid serious inbreeding depression
    of reproduction and survival. Geist (1975:105) arbitrarily
    selected 125 sheep as the number necessary to avoid this level

of inbreeding. Franklin (1980) concluded that 50 "effective breeders" would be necessary to avoid an arbitrarily selected 1% level of inbreeding. Fitzsimmons (1992) calculated that a herd of about 150 sheep is needed to provide the equivalent of 50 effective breeders.

(3) allows the spread and persistence of genes, including genes that may be relatively rare, thereby maintaining the genetic diversity and adaptability of the species in the long term. Recommendations (Franklin 1980, Thomas 1990) are that >>1000 animals are needed for long-term maintenance of genetic diversity in large vertebrates.

These 3 benefits of metapopulations are important to the wise use, including preservation, of bighorn sheep and their genetic resources.

Metapopulation Structure

Identifying and managing metapopulations are needed to preserve genetic diversity within regional aggregations of bighorn sheep. It may also be desirable to preserve the genetic purity of sheep within a region. If this is assumed, each managed metapopulation should exist within only 1 major ecosystem, such as the Mojave Desert, or Central Rocky Mountains, to preserve 1 ecotype of bighorn.

A widely distributed metapopulation will require management coordination among many landowners and agencies. Too many landowners and agencies may confound and perhaps preclude coordination. Also, a widely distributed metapopulation may have multiple risks of exposure to disease, especially from domestic sheep (Desert Bighorn Council Technical Staff 1990). Thus, there are both practical and theoretical considerations in choosing the size of a metapopulation for management purposes. This topic needs further discussion. I arbitrarily propose that management plans should recognize bighorn metapopulations having at least 1000 sheep, or the potential for at least 1000 sheep.

Metapopulation structure may vary with 1) the mean and variance of local population sizes; 2) the proportion of local habitat patches occupied at one time; and 3) the amount and frequency of movement among local populations. At least 5 types of metapopulations have been proposed (Hanski 1991:27, Harrison 1991:78). It is not clear how many types apply to bighorn sheep because long-term studies of interherd movements have been rare, and because metapopulations of bighorns in pristine North America have been fragmented by herd extinctions and habitat loss - and have not been reestablished. Within a species, metapopulation structure will vary with the number and spacing of suitable habitat patches, barriers between patches, and the sizes and qualities of patches. For managing bighorn sheep, I propose 3 types of metapopulations be considered. This classification is arbitrary and intermediate combinations occur:

Megapopulations of bighorn sheep contain >1000 animals distributed rather continuously over a large area. Bighorn megapopulations are organized into herds that use different seasonal ranges, such as lambing

areas and winter ranges; but barriers between herds are inconsequential and movements of sheep among herds occur annually. Bighorn in the Canadian Rocky Mountains and in the Black Mountains of Arizona are examples of megapopulations. If habitat is lost or degraded, megapopulations may decline into either core-satellite or patchy metapopulations.

Bighorn core-satellite metapopulations contain >1000 animals, distributed in >1 large, persistent core herd(s) and several smaller satellite herds that depend upon the core herd(s) and may be transitory. Core herds are expected to occupy relatively large, continuous areas of quality habitat, with populations of >150 sheep. Satellite herds occupy lesser and/or poorer areas. Consequently, satellite herds occasionally fluctuate to very low numbers of sheep, and may become extinct, especially in times of stress such as drought or severe winter. Animals may move both ways between core and satellite herds, but the preponderance of movement is to the satellite herds. Satellite herds depend upon this immigration for demographic persistence and genetic diversity. (However, relatively isolated satellite herds in unique environments may develop locally-adapted genotypes that, in time, could influence evolution of the metapopulation.) Megapopulations may also have satellite herds. If habitat is lost or degraded, core-satellite populations may decline into patchy metapopulations.

Patchy metapopulations of bighorn sheep contain >1000 animals distributed in interdependent herds of <100 sheep. Size and persistence of herds may vary, but several herds should approach 100 sheep and be persistent ("primary-patch" herds). In patchy metapopulations, each herd (and its inter-herd movements) plays an approximately equal role in maintaining the metapopulation and its genetic diversity. Many herds are "stepping-stone" populations, facilitating movement of animals between other pairs of herds. Bleich et al. (1990) described a bighorn patchy metapopulation. If habitat is improved or expanded, patchy metapopulations may increase and become core-satellite metapopulations.

Management Needs

Although a need for managing metapopulations of bighorn sheep has been noted (Bur. of Land Manage., n.d.; Bleich et al. 1990; Ramey 1991), there appear to be few, if any, metapopulation management plans. Meanwhile, plans and projects affecting local herds and ranges, and inter-herd corridors, are being developed and implemented without considering existing or potential metapopulation roles of the herds or lands. Among these are federal agency plans for multiple-use and wilderness areas, and state transplant projects.

Most metapopulations of bighorn sheep traverse lands managed by many owners and/or agencies. Consequently, metapopulation management requires interagency agreement and cooperation. Often, a state wildlife department will be the only agency with responsibility across an entire metapopulation. Occasionally 2 state departments will be involved. State departments should lead in convening interagency discussions of bighorn metapopulation goals and in developing interagency agreements for management plans. Plans should identify all local participating

herds and establish goals for each herd and its range. Goals will relate to a metapopulation role designated for each herd and range (core, satellite, primary-patch, and/or stepping-stone herds). Goals should specify the desired number of sheep, the habitat conditions needed for immigration and emigration, and desired habitat conditions on herd ranges. Most goals should be measurable so that failure to achieve or maintain them will trigger a response from management agencies. Metapopulation management plans should (1) designate agencies responsible for monitoring all herds, seasonal ranges and movement corridors; (2) designate an agency that will maintain a complete record of the metapopulation; and (3) be updated periodically as knowledge and habitats change.

Particular attention should be paid to core herds and primary-patch herds because: 1) they comprise major proportions of metapopulations; 2) other herds are at least somewhat dependent upon them; and 3) political uncertainties and demands from other land uses will increasingly threaten herd ranges and corridors, while resources for managing bighorn sheep will always be limited, forcing difficult choices and a need for priorities.

Management Constraints

A state wildlife department with broad responsibility for a metapopulation usually manages little land. Rather, many landowners and agencies with diverse, perhaps conflicting, objectives manage local bighorn ranges and inter-herd corridors. Interagency coordination and compromise are most difficult at this level of bighorn management.

The benefits, and failures, of managing or neglecting metapopulations will accrue slowly, especially in relation to the tenures of biologists and administrators in their jobs. Also, the credit or blame for metapopulation conditions will be distributed among several agencies. The resulting lack of agency commitment to metapopulation management may provide little incentive or reward for participating in this management, and personal identification of individual wildlife biologists with metapopulation management may be limited.

COMPREHENSIVE MANAGEMENT FOR BIGHORN HERDS

The year-round range of a bighorn herd may include up to 6 seasonal ranges and connecting migration corridors (Geist 1971). However, many herds are sedentary because of limited habitat and/or because they are transplanted herds that have not established long movements. Movement across a diversity of seasonal ranges will benefit bighorn sheep in 2 ways. First, a diversity of habitats provides a herd with options for responding to variable weather conditions or to harassment, thereby maintaining security and access to quality forage. Second, altitudinal migration provides prolonged access to green forage, as the seasons change, thereby enhancing animal quality (Geist 1987). Maintaining or enhancing seasonal ranges and migration corridors, and maintaining or reestablishing migratory movements, may be necessary for achieving

either optimization goals or wilderness goals (Bailey 1992) for a
bighorn herd.

Management Needs

Bailey (1986) and Risenhoover et al. (1988) discussed management of
bighorn herds. They recommended that existing and potential seasonal
ranges and migration corridors be identified and managed. Despite their
recommendations, there appear to be few such management plans
established and approved in agency documents. Rather, documented goals
are often vague (i. e. maintain at least 100 sheep) and usually specify
nothing about maintaining movements of sheep, or maintaining the
specific ranges and corridors that support these movements. Sometimes,
comprehensive management plans exist in the heads of biologists, and are
lost when they transfer among jobs.

Once the existing or potential seasonal ranges and migration
corridors have been identified, habitat conditions on each range unit
should be assessed. Several methods for evaluating bighorn habitats are
now available (Hansen 1980, Armentrout and Brigham 1988, Smith et al.
1991) and are being tested and improved. Habitat evaluation will allow
prioritization of habitat-improvement needs, so that the most critical
needs are addressed first (and resources are not wasted treating habitat
conditions that do not limit herd size or movement). Lastly, there
should be a realistic assessment of the constraints and of the resources
needed, in the long term, to achieve the plan's goals. If the goals are
truly impossible, more realistic goals are needed, or agencies and
publics should be advised that resources are not adequate for their
expectations. We may have to abandon some seasonal ranges, or even some
herds, in order to maintain other ranges, or herds, with the resources
and constraints that are likely to prevail. Comprehensive planning for
bighorn herds will produce confrontations with budgets and reality, and
will demand difficult choices. However, without such plans, habitat
management projects may be inefficient or even worthless, in the long
run. (We may be just nibbling around the edge - even the wrong edge -
of a problem with unknown and large dimensions).

Where bighorn herds migrate across administrative boundaries,
coordination and compromise among landowners and agencies will be needed
in developing comprehensive, long-range management goals and strategies.
Usually a small number of landowners and/or agencies will be involved.
Leadership should rest either with a state wildlife department, or with
an agency responsible for the major portion of the herd's range. In
either case, state involvement will be needed to coordinate herd
management plans with regional metapopulation goals.

Management Constraints

There is limited tradition for the level of inter-agency
coordination needed in comprehensive management. A common situation
involves state management to optimize a bighorn herd, while much of the
herd's range is in a wilderness where optimization is not a goal and
wilderness management plans have not been done (Bailey 1992). In
addition, conflicts with the desires of private landowners may be

difficult to resolve. An interspersion of private land on a seasonal range may greatly limit options for habitat maintenance or management (for example, with prescribed ignition of fire).

Agency priorities and incentives for biologists may emphasize management projects at the expense of comprehensive planning. The result of planning is a document. The results of projects are numbers: numbers of animals moved or treated, numbers of acres burned or fertilized, etc. Numbers are needed for year-end reports. Projects also create positive, although sometimes naive, publicity; and attract funding from private foundations. The rewards and incentives favor implementing more projects, while delaying comprehensive, long-range planning.

HABITAT MANAGEMENT PROJECTS

Habitat management projects include vegetation manipulation, soil fertilization and artificial water developments. Projects are numerous in bighorn management. Agencies requested funding from the Foundation for North American Wild Sheep for 25 habitat improvement projects in 1992. Other foundations also support habitat projects, and other projects are funded entirely with agency monies. Habitat management may be used on seasonal ranges and migration corridors of bighorn herds, or on inter-herd movement corridors.

Management Needs

Factors limiting the achievement of goals for bighorn herds must be identified to assure effectiveness of management. Otherwise, habitat management may not treat limiting factors and may be either inefficient or worthless. Identification of limiting factors should be part of comprehensive planning for bighorn herds.

Few management projects for bighorn sheep are evaluated for their effectiveness in achieving goals (Bailey 1990). At least some projects should be conducted as management experiments with suitable experimental designs. Confounding of multiple projects on one herd should be avoided so that effects of individual projects may be evaluated.

Management Constraints

Developing comprehensive plans for bighorn sheep, and testing the effectiveness of management projects, requires a personal and public admission of 1) the limitations of agencies and resources in solving complex problems, and 2) some degree of ignorance of bighorn populations, their habitats, and limiting factors. The tradition in wildlife public relations is not to admit limitations or ignorance. Administrators, and the public, are more easily seduced by (unproven) claims of effective management. Career advancement for wildlife biologists should depend more upon producing bighorn sheep; and less upon merely attracting funding and completing projects. In this regard, wildlife professionalism and administrative leadership are lacking.

CONCLUSION

There is a need for coordination of habitat management for bighorn sheep across seasonal ranges and migration corridors of local herds, and across inter-herd corridors of metapopulations. Comprehensive planning is needed to deal with long- and short-term problems of local herds. Bureaucratic inertia, numerous constraints, funding mechanisms, and lack of incentives for individual biologists are delaying the management of bighorn sheep on such a landscape basis (Fig. 1). Biologists who will question current practices and provide a broader, more realistic, view of bighorn management are needed. Agency leadership in developing and coordinating management to achieve long-term goals is lacking. State wildlife departments are in the best position to provide this leadership.

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┌───────────┐       ┌──────────────┐       ┌──────────────┐
│           │       │ Comprehensive│       │    Meta-     │
│  Project  │ ───►  │    Herd      │ ───►  │ population   │
│           │       │  Management  │       │ Management   │
└───────────┘       └──────────────┘       └──────────────┘
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COST/ACRE ($, Time)
GOALS REALIZED SLOWLY
CREDIT, PUBLICITY, DISPERSED
NEEDED INTERAGENCY COORDINATION
POLITICAL, LEGAL, LAND-USE CONSTRAINTS

──►

PERSONAL: IDENTIFICATION WITH PROJECT, SUCCESS
                REWARDS, RECOGNITION
PUBLIC AND AGENCY RECOGNITION OF NEED
AVAILABLE FUNDING

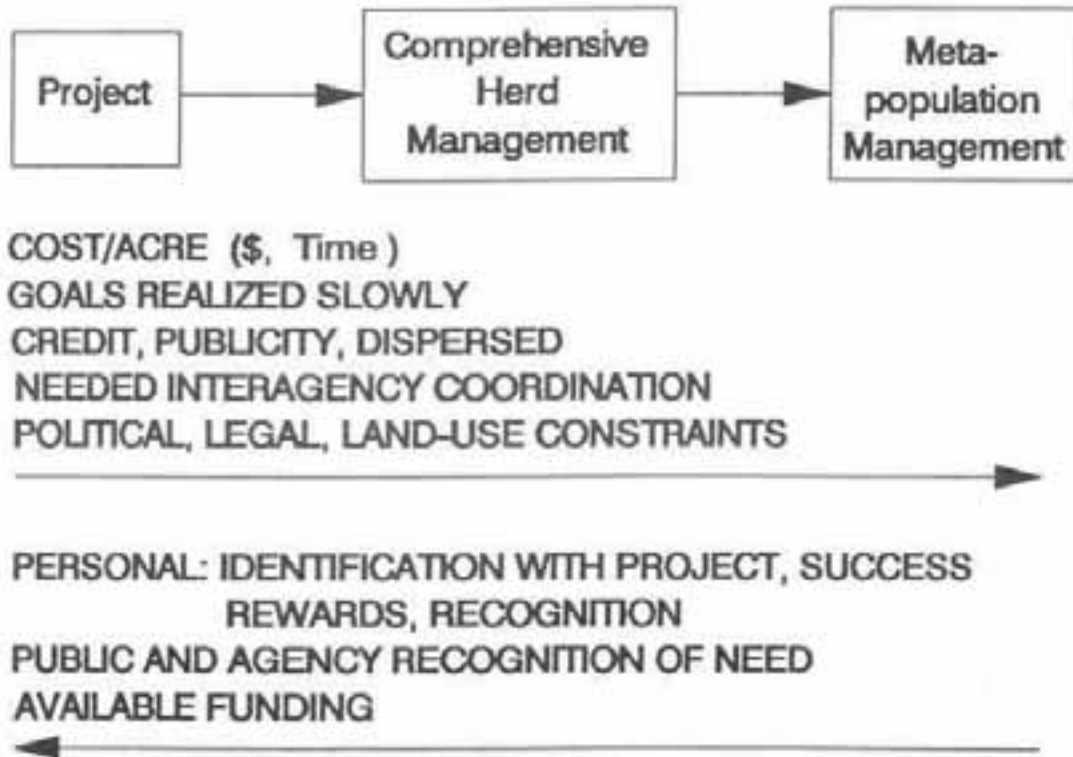◄──

Fig. 1. Some fiscal and political factors differing among 3 levels of bighorn sheep management. They favor an emphasis on completing projects that are not prioritized or coordinated within comprehensive long-range plans for herds or metapopulations.

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