DEER IN A CHANGING ENVIRONMENT: THE ROLE OF GIS IN WILDLIFE MANAGEMENT

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ABSTRACT

A major responsibility of wildlife biologists is the management of wildlife habitat. This responsibility is becoming increasingly important as the pressure from development limits ranges of animals. Managers not only must understand how to conserve and manipulate food, water, cover, and living space for the benefit of wildlife, they also must be able to choose areas for manipulation where management would be most beneficial. The purpose of this project was to demonstrate how a Geographic Information System (GIS) could be used to evaluate available habitat for California mule deer (Odocoileus hemionus californicus) inhabiting the San Gorgonio District of the San Bernardino National Forest and how to locate various options for habitat management including road closures, water development, and prescribed fire.

INTRODUCTION

Management of habitat is becoming increasingly important as the pressures from an expanding human population limit space and habitat for wildlife. For instance, in San Bernardino County, California, where our study took place, the population has more than tripled in the past twenty years (San Bernardino County 1991) and there is no sign that this record rate of growth will diminish. This tremendous population growth has resulted in increased use of public lands such that in 1990, San Bernardino National Forest experienced over 4 million user days. Human development not only limits the range of deer on the Forest, but reduces the value of habitat for deer. Even nonconsumptive uses of wildlife can have adverse effects on animals (Albert and Bowyer 1991, Boyle and Samson 1985, Snepenger and Bowyer 1990).

Given limited budgets, managers not only must understand how to manipulate food, water, and cover for the benefit of deer, they also must choose areas for manipulation where management will be most beneficial. Geographic Information Systems (GIS) are computer tools that can be used to rapidly analyze and model the types of spatial data necessary for informed decisions about habitat management.

The purpose of this paper is to show how a GIS was used to evaluate available habitat for California mule deer (Odocoileus hemionus californicus) in the San Gorgonio Ranger District of the San Bernardino National Forest, California. We also discuss methods used to site various habitat management options including road closures, water developments, and prescribed fire.

STUDY AREA

The study area is located in the San Bernardino Mountains, one of the Transverse Ranges of coastal southern California. These mountains are oriented on an east-west axis and extend approximately 95 km from the Cajon Pass on the west to Yucca Valley, in the Mojave Desert, on the east. The mountain range is bounded on the north by the Mojave Desert and by Banning Pass, 40 km to the south. Elevations range from approximately 610 m to 3500 m at the summit of Mount San Gorgonio.

The area we modeled is the Upper Santa Ana River drainage, a 32,000 ha area that forms the major drainage system for the southwestern portion of the mountain range. Slopes associated with this drainage system generally are steep and topographically diverse. The vegetation of the study area primarily is Jeffrey pine (Pinus jeffreyi) forests on northern exposures, dense chaparral on southern slopes, and Canyon live oak (Quercus chrysolepis) in valley bottoms (Muntz 1974).

The climate within the Santa Ana River drainage is typical of cismontane southern California. Summers, particularly at lower elevations, are hot. Rainfall occurs primarily during the cooler winter months. During the summer at higher elevations, thunder showers become increasingly common and temperatures are somewhat cooler. Annual temperatures within the study area range from well over 40 C to below -20 C on the highest peeks. Average annual rainfall is approximately 50 cm, but varies with elevation. Above 1500 m, winter precipitation occurs primarily as snow.

DATA ACQUISITION

A vegetation map was developed for the area from a LANDSAT-TM scene. Using ERDAS (ERDAS Inc., Atlanta, GA) software, the drainage was classified into nine spectral classes representing various habitat types. The classified image was then transferred to ARC/INFO (Environmental Systems Research Institute, Redlands, CA), the GIS used in our analyses.

Other available data on deer and their use of habitat were collected and entered into the GIS. These data included 1,200 telemetry relocations for 22 radio-collared female deer, as well as vegetation, soils, fire history, available water, and human use of the area including dirt and paved roads and 200 special-use cabins and campgrounds.

THE MODEL

Using siting criteria (discussed later) based on deer habitat use, watershed management, and agency requirements, we used the GIS to identify: 1) areas where management is not an option because of legal restrictions or other mandates; 2) areas highly preferred by deer that should be conserved, 3) areas with medium to low preference that could be enhanced by management, and 4) low preference areas where management would be least effective.

No Management or Low Priority for Management

Cornett et al. (1979) observed that deer use of a meadow near cabins was 40% of the use in a similar, undisturbed meadow. Further, they reported a 70% decrease in deer use within 46 m of hiking trails. Finally, more recent work suggests that a 50% reduction in deer use occurs within 100 m of low-density housing (J. Davis, Calif. Dept. Fish Game, pers. comm.).

Clearly, houses and trails reduce the value of habitat for deer, and any attempt at improving that habitat would have limited benefits. Therefore, in siting management options we considered any areas < 100 m from cabins, campgrounds, highways, and highly used dirt roads to be low-value areas of low priority for management. Also, the study area includes wilderness and private property, two land-use classes we considered unsuitable for management because the model was designed for use by the U.S. Forest Service.

Preference Scores for Deer

The first step in ranking areas suitable for deer management was to determine deer preference ratings for each habitat type recognized. We accomplished this by combining data on deer location with vegetation data. We then calculated deer use of each vegetation type and total availability of each vegetation type on the study area, after controlling for autocorrelation of point samples (Solow 1989). Preference scores were then estimated as the natural log of use divided by availability. Where use equals availability, the score is zero; a negative score implies avoidance, and a positive score implies selection of habitat. Additionally, we used the method of Neu et al. (1974) to calculate whether preference or avoidance differed statistically from expected values based on availability. Those habitats that were significantly selected by deer were classified as high preference, those areas where deer use was not different from habitat availability were classified as moderate, and those areas that deer significantly avoided were classified as low preference. The above preference scores were then used to generate a map of deer habitat preference, which was our primary data layer for determining if management should occur. An alternative approach would be to examine habitat importance (use x availability) to evaluate extremely common habitats that still might be important for deer even though use is less than availability (Bowyer and Bleich 1984).

Areas to be Protected

High-preference areas, according to the model, are areas that should be conserved and our criteria for this was to identify any human use < 100 m from those areas and determine if that use could be reduced or eliminated. When data on deer preference and human use were combined, we identified several areas of conflict. Over 80 special-use cabins occurred within these 100 m buffers. Several roads of all types also occurred within the protection buffer including state highway 38. We recommended that those dirt roads within protection zones be closed if possible, and areas of highway 38 occurring within the zone be identified for potential mitigation, such as fencing or reduced automobile speed.

Water Developments

Although some ungulates inhabiting arid environments may not require free water (Nicholson and Husband 1992), Bowyer (1984, 1986) reported that 77% of all mule deer observed during summer were < 500 m from water. Also, does averaged 351 m, while fawns averaged only 245 m from water.

When deciding if an area needs water to meet the requirements of mule deer, determining what Giles (1985) termed the zone of influence for water in the area is important. This zone is the distance a deer can reasonably be expected to travel to water given topography, energy costs, and water loss associated with locomotion. Determination of this zone of influence is difficult because simply measuring how deer distribute themselves with regard to water implies that deer do not have to expend excess energy to travel to water under existing conditions. Bowyer (1984) observed an average distance to water for bucks of 570 m; does during summer in the Santa Ana averaged over 1300 m from water. Clearly what is available to deer and the climate of the area will influence the distance they must travel to water.

The San Bernardino National Forest recognizes a zone of influence for water on deer of 900 m. This distance is likely too large for deer in southern California, we recognized that areas beyond 900 m from existing water definitely would be improved by developing water impoundments. Ideally, water developments should be planned to maximize coverage and minimize overlap with existing water. Unfortunately, previous water developments in the Santa Ana drainage were not necessarily planned this way. Fifty-four percent of the potential area that existing water developments could have benefited overlap the zone of influence for perennial streams and ponds (Fig. 1).

In the Santa Ana River drainage only 50% of the area has adequate water to meet the needs of deer. Using Giles (1985) formula for estimating the number water developments needed (N) for a given zone of influence (W) and a given area needing water (A)(Eq. 1):

$$N = \frac{A}{3.4641 * W^2} \qquad (1)$$

we estimated that fifty-three water developments are needed in the upper Santa Ana River drainage to have available water for deer on the entire watershed. Because this is such a large number, we prioritized the order for water development based on the existing value of habitat for deer. Therefore, higher priority was placed on areas where deer preference was moderate because high-preference areas already had water year round.

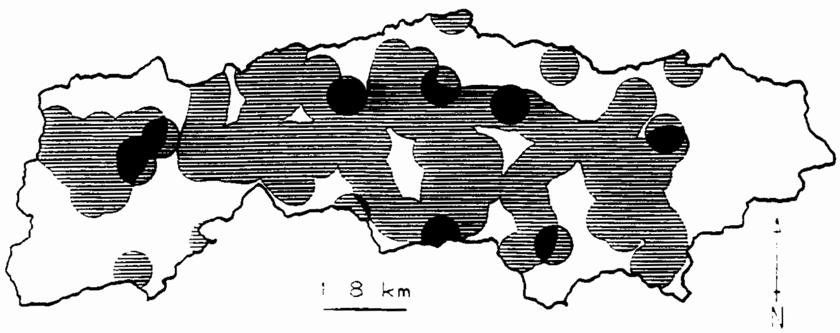

Fig. 1. Map of the upper Santa Ana River Drainage, San Bernardino Co., California, showing areas of influence (±900 m) for existing water sources (horizontal lines) on mule deer. Open areas depict zones without water; black areas show overlap in zones of influence between natural and developed sources of water.

Prescribed Burning

The primary means of habitat manipulation in chaparral is fire; between 1985 and 1988 67% of California State funds spent on deer were used for prescribed burning. The reason fire is beneficial for chaparral management is that old growth chaparral is nearly impenetrable to deer and fire can open up areas for deer (Bowyer 1986, Taber and Dasmann 1958). Secondly several authors (Kie 1984, Taber and Dasmann 1958) have noted marked increases in the availability of forbs and the dietary quality of chaparral for 3 years after fire. Fire is a natural part of chaparral ecosystems, and often, far less expensive than mechanical removal of brush. Therefore, management of chaparral is best accomplished via fire. Nonetheless, there are many constraints on the location of prescribed burns. We briefly discuss two aspect of prescribed burn placement in this model.

Various species of chaparral age at different rates and therefore begin seeding at different ages. Consequently, the Forest Service is mandated to limit fire frequency to no less than 20 or 50 years depending upon the species of chaparral present. Thus, fire history is essential in planning prescribed burns.

Also, the Forest Service is required to practice sound watershed management when planning burns. Currently, San Bernardino National Forest has a system for evaluating the potential for soil erosion after fire based on various soil parameters. A formula (D. Inmann, U.S. Forest Service, pers. comm.) classifies soils and slopes into 4 classes: low, moderate, high, and extreme. For prescribed burns, low to moderate-risk soils can be burned with only minor concern for erosion. High-risk soils should only be burned if all precautions are taken to minimize erosion, and extreme-risk soils should not be burned due to the dangers of excessive erosion. Combining erosion risk and extent of chaparral we developed a map of those areas of chaparral where fire is a viable option for management.

CONCLUSION

The simple model presented above only begins to address the complexity of natural systems. Deer choose habitats based not only on the types of habitats available but also their juxtaposition and interconnections. Environmental change, both natural and man made, add another layer of complexity to deer habitat management. As the speed of environmental change increases a multivariate GIS approach to management is essential.

Geographic Information Systems, like any computer tool, are as good as the data they use and outputs only can be as good as the questions asked of the data base. There is however one important thing to remember: the goal of GIS use is not the development of a high-quality database, rather in the case presented above, the management of deer. GIS cannot produce deer, but armed with quality data and enough desire and resources, GIS can help in the siting of projects to improve deer habitat and thus lead to more quality deer habitat for each dollar of management funds expended.

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