An Assessment of the Biological and Socioeconomic Feasibility of Elk Restoration in Virginia

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Thesis Submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science
in
Fisheries and Wildlife Sciences

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February 9, 2000
Blacksburg, Virginia

Keywords: Elk, *Cervus elaphus*, Reintroduction, Habitat Suitability Model, Geographic Information Systems, Human Dimensions, Nominal Group Technique, Mail Survey

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(ABSTRACT)

The biological and socioeconomic feasibility of restoring elk (*Cervus elaphus*) to Virginia was assessed. Biological feasibility was determined by evaluating habitat suitability for elk while considering potential impacts of elk on existing fauna and flora in Virginia. Suitability was assessed by creating a habitat suitability index (HSI) model that measured the availability and accessibility of open foraging areas and forested cover areas, the availability of permanent water sources, and the degree of fragmentation by roads. Eight areas were identified as potential elk habitat: 1 in Southwest Virginia, 4 in the Shenandoah Mountains (Shenandoah, Highland, Big Meadows, Peaks of Otter), and 3 in the Southern Piedmont (Danville, Brookneal, Rehobeth). The highest potentials for supporting an elk herd were found in the Highland and Big Meadows study areas, medium biological feasibilities were found in the Southwest, Shenandoah, and Brookneal study areas, and low biological feasibilities were found in the Peaks of Otter, Danville, and Rehobeth study areas. A restored elk herd could negatively affect indigenous fauna and flora by changing the structure and diversity of existing forested ecosystems, but impacts can be minimized by maintaining elk populations at or below cultural carrying capacity. The introduction of diseases during restoration and possible transmission of those diseases from elk to humans, livestock, and other wildlife also are concerns, but these issues can be addressed by following a risk minimization protocol.

Socioeconomic feasibility was assessed with a statewide mail survey of Virginia residents, 4 regional stakeholder workshops, an analysis of economic costs and benefits associated with elk restoration, and an assessment of the risks of elk-human conflicts in each of the 8 study areas. Overall, most (61%) respondents agreed that elk restoration would be good for Virginia. However, the low response rate (30%) and low confidence among respondents (49%) in their knowledge about elk indicated that most residents do not have the interest and/or necessary information to form a definitive opinion. Residents believe that the greatest benefits of restoration would be the value-based and indirect ecological benefits, such as returning an extirpated species to its native range, whereas the greatest perceived costs were the economic impacts to property, crop depredation, and public safety hazards. In contrast, local stakeholder representatives identified economic returns from increased tourism due to the presence of elk and

the creation of new recreational opportunities as the most anticipated benefits; important concerns were the potential for property damage by elk, the potential impacts on local ecosystems, and the costs of implementing and administering an elk restoration program and subsequent elk management. Proposed resolutions for these issues varied by region. Representatives from the Southwest and northern Shenandoah Mountain (Shenandoah and Big Meadows study site) Regions preferred not to restore elk, whereas those from the southern Shenandoah Mountain (Highland and Peaks of Otter study site) and the Southern Piedmont Regions preferred to start out small with a carefully controlled and monitored "experimental" population.

Economic benefits of elk restoration, as determined through analysis of data from other eastern states currently managing elk populations, are associated with tourism and the revenues brought to the community during elk hunting seasons, whereas economic costs are associated with crop damage, elk-vehicle collisions, and the administrative costs of managing an elk herd. Although the initial costs of transporting, releasing, and monitoring a founder population likely will exceed immediate benefits, once an elk population is established, benefits likely will exceed costs. However, an equitable distribution of costs and benefits must be devised so that the individuals who bear the costs are afforded a comparable or greater set of benefits.

Risk of landowner elk-conflicts was examined by comparing human population densities and growth rates, percent private versus public land, and agricultural trends across the 8 study areas. Highest risk for elk-human conflicts was identified in the Southern Piedmont Region and in the Shenandoah study site, risk was moderate in the Southwest, Big Meadows, and Peaks of Otter study sites, and risk in the Highland study site was low.

Overall, the Highland study site had the highest feasibility for elk restoration of all study areas examined; the Big Meadows and Southwest study sites both demonstrated moderate feasibility. Restoration in these areas is possible so long as management objectives remain flexible, plans are made in advance to address potential concerns, and the public is involved in the decision-making processes both before and after elk are released.

Acknowledgements

I would like to express my gratitude to all of the people who have assisted me in completing this project and bringing me to this point in my academic and professional career.

First, I would like to thank Dr. James Parkhurst, my graduate research advisor. Without Dr. Parkhurst's insight, experience, and encouragement, this project would not have been possible, and without his friendship and guidance. The time and effort that he put into both the completion of this project and my professional growth and enlightenment will be remembered throughout my career. I would also like to thank my graduate committee, Dr. Steve McMullin, Dr. Dean Stauffer, and Dr. Jim Fraser, whose advice, support, and commitment contributed to my professional growth and added to my overall enjoyment of the graduate experience.

I wish to acknowledge the Rocky Mountain Elk Foundation and The National Science Foundation for providing financial support for this project.

I am indebted to all the people currently or formerly at the Fish and Wildlife Information Exchange for their technical and moral support. Special thanks go to Jeff Waldon for his vision and generosity and Dave Morton, Scott Klopfer, and Blair Jones for their technical assistance.

I also would like to thank the individuals who have assisted me with various aspects of this project. Christina Swank was an immense help during both the habitat analysis and the mail survey implementation, and Dr. Mike Ellerbrock and Dr. Kurt Stephenson volunteered their time as facilitators during the regional workshops. I wish to thank Matt Knox of the Virginia Department of Game and Inland Fisheries, Roy Grimes of the Kentucky Department of Fish and Wildlife Resources, and Mike Cartwright of the Arkansas Game and Fish Commission for their help in acquiring information.

I wish to thank Mr. Robert Gross for inspiring me to seek out my dreams and directing me towards my current career path. The openhearted advice of my undergraduate academic advisor, Dr. Roland Roth, continued this inspiration and gave me the tools I needed continue down this road, and I am deeply appreciative of his efforts. I also must thank my undergraduate research advisor, Dr. Douglas Tallamy, for teaching me about the virtues of research.

My deepest appreciation goes to my family, who has supported and encouraged me in all ways possible. A special thanks goes to my parents, without whom I would not have had the desire or encouragement to grow in so many ways and strive for such great things. Finally, the love, support, encouragement, and understanding provided me by my husband, Mark, has been the enduring foothold that enabled me to complete this project.

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Chapter 1 -- Introduction and Justification

History of the North American Elk

The elk (*Cervus elaphus*), also known as the wapiti and red deer, once was one of the most widespread members of the deer family (*Cervidae*). Its range included most of North America, Europe, Scandinavia, and Asia, and portions of North Africa and South America (Bryant and Maser 1982). However, due to expanding human populations, increasing hunting pressures, and changing habitats, this range has been reduced drastically. In the United States, elk were extirpated from the East by the early and mid-1800's and reduced greatly in number and range in most western states by 1900 (Boyd 1978).

Today, 2 of the 6 recognized subspecies of North American elk are considered extinct. These are the Eastern elk (*C. elaphus canadensis* Erxelben 1777), which once inhabited eastern deciduous forests from New Hampshire to Georgia and west to Louisiana and Missouri, and the Merriam elk (*C. elaphus merriami* Nelson 1902), which occupied a limited range in Arizona, New Mexico, and northern Mexico (Bryant and Maser 1982). The remaining 4 subspecies – the Tule elk (*C. elaphus nonnodes* Merriam 1905), the Roosevelt elk (*C. elaphus roosevelti* Merriam 1897), the Manitoba elk (*C. elaphus manitobensis* Millais 1915), and the Rocky Mountain elk (*C. elaphus nelsoni* Bailey 1935) – occupy more restricted ranges than they did historically (Figures 1.1 and 1.2) (Bryant and Maser 1982).

Despite, or perhaps because of, this reduction in range and numbers, the North American elk remains popular among both consumptive and nonconsumptive users. Consequently, many state agencies have attempted to restore elk to its former range. Between 1892 and 1939, >5,200 elk from western states (primarily Yellowstone National Park) were transported to 36 states, the District of Columbia, Canada, and Argentina (Witmer 1990).

Although elk populations in most western states never were in jeopardy, their size and range have grown considerably since the turn of the century (Bryant and Maser 1982). Most attempts to restore elk to western ranges have been successful, chiefly because large areas of quality habitat still exist and human population densities remain relatively low. Successful translocations were conducted in Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, and Washington.

After extirpation of the Manitoba elk from the Plains region, attempts were made to repopulate that region with Rocky Mountain (RM) elk. Of the 8 states that attempted this, 3 were successful – Oklahoma, South Dakota, and Texas (Bryant and Maser 1982). Of the others (Arkansas, Louisiana, Minnesota, Missouri, and North Dakota), 2 states established herds that persisted for several years. Minnesota's introduced elk herd was eliminated because of the damage it inflicted to crops, and Missouri's enclosed herd was exterminated due to an overgrazed range and lack of funding for supplemental feed (Murphy 1963).

In the East, 10 states attempted to establish elk herds prior to 1980 using RM transplants (Bryant and Maser 1982). Of these 10 states, only the herds in Pennsylvania and Michigan remain today. Attempts in Alabama, Florida, Indiana, Kentucky, New Hampshire, New York, Virginia, and Wisconsin all failed. Explanations for the failure of so many restoration attempts include 1) lack of appropriate habitat, 2) over-hunting and illegal harvests, 3) excessive culling to curb crop damage, 4) disease/parasites, 5) poor condition of released animals, 6) lack of funds, and 7) elk/vehicle collisions (Witmer 1990).

History of Elk in Virginia

Eastern elk once inhabited the entire Piedmont and Allegheny regions of Virginia, but were most abundant in the mountainous areas of the state (McKenna 1962). The last population of Eastern elk in Virginia was extirpated in 1855 in Clarke County (Wood 1943), and for the next 62 years, wild elk were not known to exist within the Commonwealth. In 1917, the Virginia Game Commission transported about 150 RM elk from Yellowstone National Park and released them in small groups across the Commonwealth. Because little was known about the habitat requirements of elk at that time, the locations of many release sites were ill advised, and most releases quickly failed. One example of poor site selection was the sand dunes of Cape Henry in Princess Anne County, where elk immediately conflicted with adjacent land uses and compelled authorities to destroy the founder population (Wood 1943).

Elk released in the mountains of Virginia fared somewhat better, and by 1920, 2 herds were established – 1 in Botetourt/Bedford counties, and 1 in Giles/Bland counties. Conflicts arose quickly between elk and agricultural and development interests. The first elk hunting season was held in 1922 to reduce damage to agricultural crops, but many elk were killed illegally by frustrated farmers (Wood 1943, McKenna 1962). Following a 10-year suspension of elk hunting, a limited season was opened in 1956, closed in 1957, re-opened in 1958, and finally was discontinued in 1960. By this time, the herds had declined to only a few animals. Although these 2 herds persevered for >50 years, the last elk from the initial restoration effort vanished from central Virginia in August of 1970 (Gwynne 1977). Today, Virginia boasts only a few elk in east-central Virginia – the remains of a once captive herd owned by the late Arthur Godfrey (M. Knox, Virginia Department of Game and Inland Fisheries, personal communication).

Current Restoration Efforts in the East

The successful translocations between 1910 and 1930 have provided much needed knowledge about elk ecology east of the Rocky Mountains, and a growing interest in elk restoration recently has instigated several new attempts to reintroduce elk to states in the East. Below is a synopsis of both the early successes and most recent attempts.

The Pennsylvania Herd

Almost 50 years after the extirpation of Eastern elk from Pennsylvania, the Pennsylvania Game Commission (PGC) attempted to establish a population of RM elk. Between 1913 and 1926, 177 RM elk were released into 10 Pennsylvania counties. The current herd is descended from the 24 elk released in Cameron County in 1915. Ten more bulls were brought in from South Dakota and released in neighboring Elk County between 1924 and 1926 to reinforce the founding population (Forbes and Ferrence 1999). The herd since has increased to an estimated 450 animals on a 580 km^2 (58,000 ha) range (Forbes and Ferrence 1999).

Beginning in the 1960s, crop depredation became a major problem. A high of $13,000 in total crop damage was reported by farmers in 1982 (Parker 1990), and in the winter of 1989-1990, farmers shot 37 depredating elk out of a herd of <150 (Forbes and Ferrence 1999). The PGC's current elk management program includes habitat enhancement, land acquisitions, aerial surveys, fencing, trapping and translocating, and research and education. Between 1992 and 1999, only 4 elk were killed due to depredations – 3 of those 4 were shot by a farmer who refused free fencing materials (Stalling 1997). These management strategies have helped PGC alter the movements and distribution of elk, ultimately reducing the number of conflicts. Rawley Cogan, a wildlife biologist with PGC, believes the current elk range could be increased to >2,000 km^2 (200,000 ha) by connecting it to nearby State Forest lands, enabling the elk population to increase to about 1,200 animals at a density of 0.6 elk/km^2 (1 elk/167 ha) (Stalling 1997).

The Michigan Herd

Michigan's last Eastern elk disappeared in 1877. In 1915, 23 RM elk were placed in an enclosure in the north-central portion of the Lower Peninsula (Moran 1973). In 1918, 7 elk from this enclosure were released on free-range in nearby Cheboygan County and ultimately founded the herd that still roams freely today (Moran 1973). The Cheboygan County herd grew quickly; the population was estimated at 200 animals by 1925, 300-400 by 1939, 900-1,000 in 1958, and 1,200-1,500 by 1961. By the 1960s, the elk range covered approximately 1,000 km^2 (~1 elk/67 ha) (Moran 1973). By the mid- to late-1960s, elk densities in some areas had reached 4/km^2 (1 elk/25 ha) and human/elk conflicts began to arise. Elk were abundant enough to provide a foundation for a sizable tourist industry, but depredation damage to farm and forest crops and wildlife ranges also was occurring (Moran 1973). Michigan's Department of Natural Resources (MDNR) since has managed the elk population with hunting, high tensile electric fences, and food plots on state-owned wildlife openings. Conflicts between elk and farmers and foresters have been reduced significantly since these strategies were implemented (Phillips 1997, SEAFWA 1997), and the MDNR has been able to maintain the elk herd at approximately 900 animals and a density of about 1 elk/km^2 (1 elk/100 ha) overall (Moran 1973, SEAFWA 1997).

Recent Restoration Efforts

None of 200 elk released in Arkansas in 1933 survived; state game officials attributed this failure to illegal hunting, natural mortality, and loss of habitat. The state made a second attempt and brought 112 RM elk into the Ozarks between 1981 and 1985 (Cartwright 1991). Today, this herd consists of approximately 450 elk distributed over >100,000 ha (1 elk/222 ha) of a linear river valley where forage is abundant and movement is unrestricted (SEAFWA 1997). Officials in Arkansas held their first elk hunt in the fall of 1998; 18 resident licenses were issued in a lottery, and 2 licenses (1 resident, 1 nonresident) were auctioned off by the Rocky Mountain Elk Foundation (RMEF) (M.E. Cartwright, Arkansas Game and Fish Commission, personal communication). Both the lottery and auction were repeated for the 1999 hunting season.

Wisconsin's first attempt to re-introduce elk failed due to use of an enclosure that did not meet critical habitat criteria (Bryant and Maser 1982). Following a feasibility assessment and a recommendation to attempt a second restoration (Parker 1990), 25 elk were translocated in 1995 from Michigan and released in Wisconsin as an experimental free-ranging herd. These animals are now part of a comprehensive study to assess the feasibility of more extensive attempts at elk restoration in that state (SEAFWA 1997).

Kentucky recently established both captive and free-ranging elk populations. In February 1996, managers of the Land Between the Lakes National Recreation Area released 29 Manitoba elk into a 280-ha fenced wildlife viewing area (SEAFWA 1997). Kentucky's free-ranging elk population currently is in its infancy. A feasibility study (Phillips 1997) suggested that free-ranging elk could survive on >1,000,000 ha of forested lands in southeastern Kentucky. Since then, >400 elk have been released as part of the state's plan to release about 200 animals every winter over a 9-year period (R. White, Rocky Mountain Elk Foundation, personal communication). Their long-term population objective is 7,400 elk.

Feasibility studies for the restoration of elk recently were completed in New York (T. Toman, Rocky Mountain Elk Foundation, personal communication), and Illinois (Van Deelen et al. 1997), and for the Great Smoky Mountains National Park (GSMNP) (Long 1996). Results in Illinois indicated that current socioeconomic conditions would preclude a successful restoration. New York officials continue to evaluate the possibility of bringing elk into sections of the Catskill Mountains. Elk restoration in GSMNP was determined to be feasible and in agreement with the Park's mission, but a final decision on whether to proceed is pending.

A Third Chance for Virginia?

Witmer (1990) found that, although elk reintroduction can be a critical component of biodiversity conservation, many past attempts to restore elk in the East were hampered by 1) a lack of reliable information about historic biological and social characteristics of Eastern elk herds and 2) a failure to fully document the reasons why previous restoration attempts either succeeded or failed. Given that several states in the Southeast, including Virginia, currently are re-evaluating the feasibility of elk restoration (W. Smith, Rocky Mountain Elk Foundation, personal communication), specific and detailed information is needed on a variety of important issues relating to potential costs and benefits of restoring elk. Restorations conducted in Pennsylvania, Michigan, and Arkansas have helped improve understanding and knowledge about elk ecology and management. Yet, here in Virginia, considerable need remains for specific information on the historic range of elk, the type(s) of habitat elk use in Eastern states, how elk will interact with other species, human/elk interactions, socioeconomic and public relations issues, and how an elk herd ultimately will be managed if restoration is successful.

Thus, the focus of my research is to determine if and where suitable habitat for elk exists in the Commonwealth of Virginia, to conduct a socioeconomic determination of potential costs and benefits of elk restoration, and to provide recommendations for the management of elk, their habitat, and potential conflicts with affected communities should restoration proceed. Specifically, I evaluated the opportunities and risks associated with an elk restoration program in a step-wise fashion, as outlined in the following objectives:

Objective 1: To identify locations in Virginia that satisfy the biological needs of elk while maintaining the ecological integrity of existing faunal and floral communities.

Objective 2: To determine the socioeconomic constraints and beneficial opportunities presented to the local communities identified in Objective 1 and to the Commonwealth as a whole by a restored elk population in Virginia.

Objective 3: To identify management concerns and evaluate options for managing a newly established elk population in Virginia.

Chapter 2 -- Biological Feasibility

Introduction

I began my study by assessing the biological feasibility of elk restoration in Virginia. I first defined suitable elk habitat in simple, but realistic, terms and applied that definition to Virginia's landscape to locate potential elk ranges. I then considered the potential biological or ecological ramifications (e.g., competition with other species, disease) that may result from elk restoration.

Methods

To objectively define suitable elk habitat, I followed guidelines prepared by the U.S. Fish and Wildlife Service (1981) and constructed a habitat suitability index (HSI) model for elk in Virginia. Each component of my HSI model evaluates a critical aspect of elk habitat such that a change in that component is reflected as a proportional change in the habitat effectiveness (HE) score (also called a suitability index, SI, U.S. Fish and Wildlife Service 1981) for that component (Wisdom et al. 1986, Thomas et al. 1988). Then, each component score is mathematically combined into a single HSI.

Similar models have been developed for elk in Oregon (Wisdom et al. 1986, Thomas et al. 1988), Illinois (Van Deelen et al. 1997), Michigan (Beyer 1987), and Tennessee (Long 1996). However, each model included a different set of habitat parameters, measured these parameters in different ways, and/or applied different HE scales for each parameter. Because each model was designed for a specific geographic region and for use at a specific scale, I believed that a direct application of these models in Virginia was not advisable. Therefore, I created a unique model applicable to Virginia. I reviewed earlier models and extracted for use those components I deemed most pertinent based on how well supported they were by the literature, whether they represented a potentially limiting factor for elk in Virginia, and whether the spatial data existed in Virginia to implement them.

The Software and Data

I designed this HSI model for application in a computer-based Geographic Information System (GIS). I used Map and Image Processing Software (MIPS) produced by TNT-MicroImages, Inc.© for the GIS processing. MIPS is a comprehensive software package capable of analyzing both vector and raster data and converting between the 2 data types. It also supports a macro language, Spatial Manipulation Language (SML), that allowed me to create customized programs for executing complex commands. The SML programs I wrote to implement my HSI model in MIPS are included as Appendix 3.

I obtained data for roads and water features from the 1985 1:100,000 U.S. Geological Survey (USGS) Digital Line Graphs (DLGs), which include all transportation (e.g., roads, railroads) and hydrographic features (e.g., streams, lakes) in an hierarchical classification system. The files are distributed by USGS as 30x60 minute quadrangles for hydrography and as 30x60 minute "half sheets" (i.e., 2-30x30 minute sheets/quad) for roads. Both data sets were in Arc/Info format, so I converted them to MIPS format. I identified pertinent road and water features using USGS's classification system and then extracted those needed for my analysis.

Digital elevation models (DEMs), based on contour lines in USGS 7.5-minute quad maps, provided elevation data at a 30m resolution. I used MIPS to calculate the slope at each pixel using cubic convolution.

I obtained land cover data for Virginia from Morton (1998), which is a set of 14 1991-1993 Landsat Thematic Mapper (TM) scenes classified into land use categories and having a resolution (i.e., pixel size) of 30m x 30m and an overall accuracy of >80%. Morton's (1998) land cover classification scheme consisted of 7 broad land cover types including deciduous forest, coniferous forest, shrub, herbaceous, disturbed, coastal wetlands, and open water. I used this database because it provided a good baseline for determining dominant land cover types and assessing relative heterogeneity. However, for this study, I collapsed the land use categories into 3 classes: forest (deciduous, coniferous, and mixed), open (herbaceous, shrub, and wetland), and other (disturbed and water). I considered the "other" category as nonhabitat because elk likely would not find sufficient forage or cover in disturbed (e.g., urban, beach, barren) or open water (e.g., lake, river) areas.

Because Morton's (1998) land use maps are fine scale (30m x 30m), whereas elk are "large-scale" animals with large home ranges, I believed that the land use maps would discern landscape features not biologically meaningful to elk. In addition, the probability of an incorrect classification of land use (e.g., classifying shrub land as forested) increases at the single-pixel level; the probability that a forested pixel was classified incorrectly is likely to be high when all pixels surrounding it are classified as open. I concluded that these fragments might have an undue impact on my habitat assessment. Therefore, I wrote an SML program to "defragment" the land use data by reclassifying open or forested areas composed of <3 pixels (<0.27 ha) as the locally dominant land-use type. I considered fragments >0.27 ha (>2700m^2) to have biological significance to elk, and they were retained in this model. The SML adjustment program is explained further in Appendix 2.

Selecting Study Areas

Large blocks of undeveloped land would provide the best potential habitat for elk. A good indicator of development and habitat fragmentation is the network of major roads (Classes 1 and 2 under the USGS classification system) that spreads across the state. Where more people live and more development has taken place, many major roads come together. Even in less developed areas, major roads hinder elk movements. Ward et al. (1973) observed that, although elk regularly cross forest roads, only 1 elk was seen attempting to cross Interstate 80 (Class 1) in Wyoming – and that elk was hit by a truck and killed. Additionally, a small (~200 elk) herd in Colorado was so hesitant to cross a Class 1 that it remained on unsuitable habitat adjacent to extensive residential and commercial development until the disturbance ultimately forced them to seek better habitat (Buchanan 1998). Once this threshold was reached, the entire herd attempted to cross the 4-lane highway at once, causing >30 collisions and forcing officials to close the highway until all animals had crossed. Finally, Ward et al. (1976) noted that, although elk often are seen within 400 m of major roads, they seldom cross to the other side. Evidently, elk become habituated to steady, predictable traffic and carry out their daily activities undisturbed on 1 side of the road, but those same characteristics of traffic flow prevent elk from crossing to the other side. In Michigan, the elk range is bounded functionally on all 4 sides by well-traveled roads – 1 interstate (Class 1) and 3 major roads (Class 2) (Buss 1967, Moran 1973). Although elk are seen outside of this range (presumably after crossing the Class 2 roads) human disturbances outside of the range prevents colonization by elk and expansion of the elk range.

I used major roads to initially define the boundaries of potential elk restoration sites. From a digital road map, I created a 150-m buffer on each side of every major road to delineate polygons that might represent contiguous habitat patches. Because major roads have wide right-of-ways, large centers of traffic flow, and strips of disturbed gravel and mowed lawn on either side, much of this 150m buffer is nonhabitat (Ward et al. 1976). Remaining portions of the buffer are characterized by loud noises and a lack of visual barriers. Beyond this buffer zone, vegetation and topography ameliorate these effects, and normal habitat use by elk is possible.

From the buffered road map, I extracted only polygons ≥25,000 ha for further consideration. This approximates the size of the range that supported the small elk herd in Giles/Bland counties earlier this century (Baldwin and Patton 1938). Although there likely were other factors involved in the demise of that herd, I believe that range size was an important limiting factor. Murray and Leckenby (1985) and Christensen et al. (1993) similarly suggested that minimum analysis areas for elk habitat in the West be 12,000-48,000 ha. A preliminary GIS survey of major roads in Virginia produced a series of polygons that exceeded 25,000 ha in size (maximum size: approximately 55,000 ha).

Yet, a single 25,000 ha block of habitat likely would not support a viable elk population. Managers and elk biologists working with translocated eastern herds similarly suggested that ≥50,000 ha (500 km^2) of habitat are necessary to ensure the success of future elk restoration efforts (Witmer 1990, Long 1996, Phillips 1997, SEAFWA 1997). I therefore considered only those areas with ≥2 adjacent polygons of ≥25,000 ha each (or a combined area of ≥50,000 ha) in my model.

Model Development

The first stage in any modeling exercise is to define the objectives that dictate the format and breadth of the model (Farmer et al. 1982). My model was designed to fulfill several general objectives:

1) The model should produce an HSI score on a 0.0 (= Poor) to 1.0 (= Optimal) scale,

2) The model should encompass the major measurable habitat factors that potentially could be limiting to elk in Virginia,

3) The model should address year-round needs of elk because extensive migration by introduced herds in the East is unlikely, and

4) The model should use currently available digital landscape data, GIS technology, and/or simple field sampling techniques to minimize time expenditures while maximizing accuracy and resolution.

Elk have 4 basic life requisites: forage, cover (thermal and escape), water, and space. The model I developed (Figure 2.1) consists of 5 variables that address these requisites:

1. Landscape Composition (HE_C = open land : forest land ratio)
2. Landscape Interspersion (HE_I = open land / forest land interspersion)
3. Water Availability (HE_W = distance to water)
4. Road Density (HE_R = road density)
5. Topography (HE_S = navigability due to slope)

Below, I describe why each variable potentially is limiting in Virginia, the habitat relationships each variable expresses on elk habitat, and how the 5 variables fit together to produce a single habitat suitability measure. Finally, I review methods for interpreting the resulting index and review the basic assumptions that define the applicability of the model.

Component 1 – Landscape Composition

Justification

Elk are generalists regarding the types of food they eat and the variety of habitats and successional stages they use (Lyman 1963; Buss 1967; Irwin and Peek 1983*a*, *b*; Christensen et al. 1993). Optimal elk habitat consists of a variety of successional stages that provides year-round forage and cover for elk (Irwin and Peek 1983*a*). On western ranges, grass and shrub lands provide the primary forage base (Craighead et al. 1973, Edge et al. 1987, Zager 1989, O'Neil and Witmer 1991), whereas mature forests provide thermal cover during winter and escape cover year-round (Hillis et al. 1991, Christensen et al. 1993). On eastern ranges, successional diversity also is important, but with 2 key differences. In the Southeast, winter thermal cover is not as important because the temperature at which behavioral and environmental thermoregulation become necessary for elk ($^{-}16$-$^{-}19$ C, Nelson and Leege 1982) is below the region's normal winter low temperature. However, thermal cover may be vital to elk during hot, dry summers (Moran 1973, Peek et al. 1982, Merrill 1991, Long 1996) because the upper critical temperature for elk (25-30^{O} C, Parker and Robbins 1984) is well within the range of normal summer temperatures in the Southeast. Secondly, eastern forests play a major role in year-round forage production (Zager 1989) and can replace, at least partly, the role of western grass and shrub lands (Beyer 1987, Bender and Haufler 1996, Long 1996, SEAFWA 1997). Elk on ranges with large forest components use open areas <10% of the time during the hottest part of the summer and when forage on open ranges is less palatable or less available during both summer and winter (Waldrip and Shaw 1980, Edge et al. 1987, Bender and Haufler 1996, SEAFWA 1997).

Determining HE_C

Open forage areas used by elk are characterized by <60% canopy closure (Thomas et al. 1979, Wisdom et al. 1986). Western elk habitat is managed to maintain 40-60% open forage areas and ≥40% forest cover (Thomas et al. 1979, Lee 1984, Zager 1989, O'Neil and Witmer 1991). On eastern ranges, forests provide both forage and cover needs, and elk may not require as much open land (Long 1996). Established range requirements used in the west often have been adjusted here in the East so that optimal habitat would include 40-90% forest and 10-60% grass and shrub lands (Beyer 1987, Long 1996, SEAFWA 1997).

The lesser need for extensive grass and shrub (i.e., open) lands has been demonstrated by several eastern herds; in Pennsylvania, the primary range is 2-3% open, and Wisconsin's elk range is about 3% open (SEAFWA 1997). However, I believe such a small amount of open area does not represent optimal conditions. In the 2 cases cited above, both herds are small, and Pennsylvania's herd has experienced severe population fluctuations (SEAFWA 1997, Stalling 1997). Although specific reasons for these problems have not been determined, some speculate that sub-optimal habitat plays a major role (Cogan 1987, Stalling 1997). Further, even though few open areas are available, >50% of all elk activity occurs in these openings (Cogan 1987, Devlin and Tzilkowski 1986). Similarly, Michigan's entire elk range is approximately 10% open, but core range is 21% open (Bender and Haufler 1996, SEAFWA 1997).

I concluded that elk herds in the East do not require as much as 40% open areas, but habitat with ≤10% open would not provide optimal conditions. Therefore, I modified Long's (1996) HE curve to classify optimum habitat in Virginia as 40-80% forest and 20-60% open (Figure 2.2). At the extremes of the scale, regions with 100% open area receive an HE_C score of 0.2 (as opposed to 0.0) because open areas can include shrub lands capable of providing limited browse and hiding cover, and regions with 100% forest receive an HE_C score of 0.3 to reflect the multiple roles forests can serve.

I assessed landscape composition at a scale of 1 km^2, which I believe represents a tract of land that an elk can assess quickly. Although the percentage of open and forested area in a polygon is an important measure of gross resource availability, an elk is not likely to utilize the landscape at such a broad scale. I obtained the HE_C score by calculating the forest:open ratio for the region including and surrounding each pixel in the defragmented land use database using a 1 km^2 moving window (33 x 33 pixels), and assigning an HE_{Ci} score to each pixel according to the scale in Figure 2.2. The overall HE_C index is the average of the HE_{Ci} scores (Equation 2.1).

Equation 2.1

$$HE_C = \frac{\sum_{i=1}^{N} HE_{Ci}}{N}$$

where N = number of pixels in polygon

Component 2 – Landscape Interspersion

Justification

Like HE_C, landscape interspersion (HE_I) is concerned with the juxtaposition of open and forested areas. However, HE_I deals with the size, shape, and proximity of open and forested patches rather than their simple availability. Subdividing the spatial component into composition and interspersion variables ensures that all habitat needs can be met and available habitat can be used most efficiently (Edge et al. 1990). Forested and open areas of appropriate size and in close proximity to each other minimize the amount of energy elk expend while maximizing the energy available for maintenance, growth, and reproduction (Johnson 1951, Reynolds 1966, Irwin and Peek 1983*a*, Murray and Leckenby 1985, Cogan 1987, Zager 1989). As the core area of either open or forested patches becomes larger than optimal, elk cannot make full use of the total area, and the size of the range effectively is reduced (Wisdom et al. 1986).

Determining HE_I

Landscape interspersion can be calibrated 2 ways. Size of open and forested areas has been used in the past; generally, open areas <14-20 ha (Irwin and Peek 1983*b*) and forested areas of approximately 100 ha (Hillis et al. 1991) are most preferred. However, the shape of these areas is more important than size (Kramer 1983, Wisdom et al. 1986, Thomas et al. 1988). Optimal elk habitat occurs in the 270 m of forest closest to an edge and in the 90 m of an open area closest to cover (Collins and Urness 1983, Irwin and Peek 1983*a*, Wisdom et al. 1986, Zager 1989). This relationship has been used in other elk habitat models (Wisdom et al. 1986, Thomas et al. 1988) and is illustrated in Figure 2.3.

An example can further illustrate why I include both landscape variables (HE_C and HE_I) in my model. If 50% a 1 km^2 area (as used in HE_C) is forest and the other 50% is open, the center pixel is assigned an HE_C score of 1.0, regardless of how the cover types are arranged. However, the HE_I score can vary. If the eastern and western quarters of the area are forested, with a 500m wide strip of open area in the center, the center pixel would receive an HE_I of 0.25. If the eastern half were open and the western half were forested, then the pixel would fall exactly on the edge and receive a HE_I score of 1.0.

I calculated HE_I by grouping each pixel of the defragmented land use map into 90m bands representing the distance from an open/forest edge. I assigned each band an HE_{Ii} score according to Figure 2.3 and averaged the pixel scores to obtain the HE_I score (Equation 2.2):

Equation 2.2

$$HE_I = \frac{\sum_{i=1}^{N} HE_{I\,i}}{N}$$

where N = number of pixels in the polygon

Alternatively, HE_I can be found by determining the proportion of the polygon's total area classified into each band and calculating the average of these band scores (Figure 2.3) weighted by the proportion of the area they represent (Equation 2.3):

Equation 2.3

$$HE_I = \frac{\left[\sum_{i=1}^{N}(Open\ HE_i \times Open\ Area_i) + \sum_{i=1}^{N}(Forest\ HE_i \times Forest\ Area_i)\right]}{\left(\sum_{i=1}^{N} Open\ Area_i + \sum_{i=1}^{N} Forest\ Area_i\right)}$$

where i = each of the 90m band widths, and
HE = habitat effectiveness index derived from Figure 2.3

Component 3 – Water Availability

Justification

In addition to the year-round need for water by all elk, cows and calves have a special need for nearby water sources during the calving season when their mobility is reduced and lactation raises physiological water needs (Irwin and Peek 1983*b*, Bian and West 1997, SEAFWA 1997). This period coincides with the time when water often is least available.

Determining HE_W

Elk typically prefer areas ≤800 m from a permanent water source (Mackie 1970, Long 1996). During calving and lactation periods, this distance is reduced to ≤400 m (Slovkin 1982, Bian and West 1997). Because this shorter distance is a seasonal requirement restricted to a few months out of the year, Long (1996) considered areas within 800 m of water to be optimal. I modified Long's (1996) curve so that distances ≥1600 m are assigned a score of 0.2 rather than 0.0 (Figure 2.4). I do not believe that HE_W alone can reduce habitat suitability beyond this point, particularly for bulls that are known to roam widely.

To calculate HE_W, I divided each polygon into 400m distance bands away from permanent water sources, and assigned HE_{Wi} scores according to Figure 2.4. The final HE_W score is the average of each pixel's score (Equation 2.4).

Equation 2.4

$$HE_W = \frac{\sum_{i=1}^{N} HE_{W\,i}}{N}$$

where N = number of pixels in the polygon

Alternatively, HE_W can be calculated as the average sum of each band's score weighted by its proportion of the total area (Equation 2.5).

Equation 2.5

$$HE_W = \frac{\sum_{i=1}^{N} \left(HE_i \times Area_i \right)}{\sum_{i=1}^{N} Area_i}$$

where i = each of the 400m band widths, and
HE = corresponding habitat effectiveness from Figure 2.4

Component 5 -- Road Density

Justification

The detrimental effects of roads on elk habitat suitability have been illustrated repeatedly (Ward et al. 1973; Perry and Overly 1977; Lyon 1979, 1983; Witmer and deCalesta 1985, Cooper and Millspaugh 1999). Impacts of major roads were discussed earlier (see pages 9-10). Lower order (or "minor") roads also present potential problems for elk (Lyon and Ward 1982). The unpredictable, but frequent, traffic on these roads creates a "zone of influence" within which elk habitat suitability is decreased (Lyon 1979). Biologically, this disturbance causes elevated metabolism in elk leading to increased energy demands and reduced vigor. Behaviorally, elk avoid minor roads and concentrate on areas farther from roads, which effectively reduces the amount of preferred habitat available to them (Witmer and deCalesta 1985). Disturbances from nearby roads also alter daily activity patterns and decrease total foraging time (Schultz and Bailey 1978, Bender et al. 1991).

The influence of roads on habitat effectiveness for unexploited elk herds is uncertain. Wisdom et al. (1986) suggested that roads are not as detrimental for unhunted elk populations as for hunted populations that perceive human activity as a threat. Such reasoning was used by Beyer (1987) and Long (1996) to justify why roads should be ignored in the East. I believe, however, that roads should remain an important factor. Elk have habituated to roads and human activity in National Parks where hunting is prohibited and recreational activities are monitored (Lyon 1979, Wisdom et al. 1986). However, even in National Parks where elk often are seen near (<300 m) minor roads, any human out-of-vehicle activity (which often occurs near these roads) will cause elk to flee (Ward et al. 1976, Schultz and Bailey 1978). In Virginia, hunting (for other species), poaching, and other outdoor recreational pursuits likely will delay or prevent habituation from developing. Further, if elk successfully are reintroduced, elk hunting is likely to occur in the future. Finally, the presence of many lower order roads is an indicator of human encroachment and future development, which directly would affect habitat suitability and availability. For these reasons, I included a measure of habitat effectiveness that considers roads.

Determining HE_R

There are at least 2 ways to measure habitat effectiveness as it relates to lower order roads. The first is a "distance-to" function, where an HE score is assigned to each pixel based on its distance from the nearest road (Lyon 1979). Many HE scales based on distance to roads previously have been developed (Hershey and Leege 1976, Perry and Overly 1976, Lyon 1979, Kramer 1983, Witmer and deCalesta 1985). A second, perhaps more representative, method measures habitat effectiveness (HE_R) from road density (km/km^2) (Kramer 1983). One such HE_R scale (Figure 2.5) was developed simultaneously by Perry and Overly (1977) and Thomas et al. (1979) and validated by Lyon (1983) using different data sets. This scale closely fits observed patterns of elk use and has been used in other HSI models (Wisdom et al. 1986, Thomas et al. 1988, Long 1996, Van Deelen et al. 1997). I use it here with no revisions. The scale (Figure 2.5) illustrates a sharp decrease in HE_R up to 0.625 km/km^2 (1 mi/mi^2) with a more moderate decrease beyond that point.

I applied this scale to each polygon and included all improved roads and streets (Class 3 and 4 as defined by USGS), the type most detrimental to elk (Thomas et al. 1979, 1988). I calculated road density (km/km^2) for each pixel using a search area of 800 m in all directions, which represents the maximum distance that a road is likely to impact elk habitat use (Perry and Overly 1976, Lyon 1979, Witmer and deCalesta 1985). The calculation of road density presented a logistical problem in that I needed to perform a 2-dimensional analysis (density) on a 1-dimensional feature (roads). I rasterized minor roads using land use as a template (30m resolution) so that each road was represented by a 1-pixel wide line in the raster file. To calculate density, I calculated how much road was represented by each pixel. Using the standard properties of right triangles, if a road goes straight through a pixel (right to left or top to bottom), that pixel represents 30 m of road, and, if the road goes through the pixel diagonally, the pixel represents approximately 42 m of road. Assuming that, on average, roads generally will fall somewhere between these 2 ideal scenarios, I took the average of the 2 estimates (36m) as the length of road represented by each road pixel. This conversion allowed me to calculate road density using a moving window operation that simply counted the number of "road" pixels and converted the total to an estimate of length. I assigned HE_{Ri} scores to each pixel according to Figure 2.5 and calculated HE_R as the average of the pixel scores (Equation 2.6).

Equation 2.6

$$HE_R = \frac{\sum_{i=1}^{N} HE_{Ri}}{N}$$

where N = number of pixels in the polygon

Component 6 – Topography

Justification

If elk are to make full use of their habitat, navigability is an important factor and is affected by steepness of slope (Slovkin 1982, Irwin and Peek 1983*b*, Edge et al. 1987). In a multivariate analysis of elk habitat on a western range, Edge et al. (1987) found that slope was the most significant factor determining elk distribution and habitat use. Whether this is true here in the East has yet to be determined, so for now, I include slope in the model.

Determining HE_S

Elk prefer gentle slopes (Irwin and Peek 1983*b*, Edge et al. 1987). Hershey and Leege (1982) noted that slopes $<12^o$ were used most frequently, and slopes $>30^o$ were used much less than expected. Other studies (Slovkin 1982, Huber 1992, Sheehy and Vavra 1996) have shown that slopes $\leq 17\text{-}22^o$ are optimal and use declines sharply as slope further increases; very little use (<3% of elk observations) occurred on slopes $>42^o$. Long (1996) used a landscape-based HE scale and considered slopes $\leq 27^o$ optimal, slopes $27\text{-}54^o$ marginal, and slopes $>54^o$ of little value. Because there are few data to support Long's scale on areas with $>30^o$ slope, and because his scale was applied to average slopes calculated over large areas, I revised his scale to reflect elk use at a scale compatible with available satellite imagery using data from Hershey and Leege

(1982), Slovkin (1982), and Huber (1992). In the new scale (Figure 2.6), slopes $\leq 20^{o}$ are optimal, slopes $20\text{-}40^{o}$ are marginal, slopes $40\text{-}60^{o}$ are potentially nonviable, and slopes $>60^{o}$ are nonviable.

To determine HE_S, I calculated the slope for each pixel from a digital elevation model (DEM) and assigned HE_{Si} scores to each pixel according to Figure 2.6. Overall HE_S is then the average of the pixel values (Equation 2.7).

Equation 2.7

$$HE_S = \frac{\sum_{i=1}^{N} HE_{S\,i}}{N}$$

N = number of pixels in the polygon

[Note: After creating an HE_S map for each polygon, it was clear that slope would not be a limiting factor in any of the study areas; the lowest HE_S score any polygon received was 0.96. Though slope may be a limiting factor in other, more rugged, areas of the Appalachians, I concluded that it was not limiting in Virginia and left this variable out of my model when ranking study sites.]

Constructing the Index

When examining how other researchers combined the habitat components to create a single HSI score, I noticed that many previous models employed a simple geometric mean, based on the assumption that the variables are related in a compensatory manner (Wisdom et al. 1986, Thomas et al. 1988, Long 1996). This means that a high score on 1 variable partially compensates for a low score on another variable, but variables with low scores influence the final index more than variables with high scores. Beyer (1987) used a minimum index function where the variable with the lowest HE score was taken as the overall HSI. The latter method seems to ignore important habitat variables, and, given the generalist approach elk take to foraging and habitat use, I do not believe that any 1 habitat component should ever completely determine overall habitat potential (Lyon 1979, 1983; Wisdom et al. 1986; Thomas et al. 1988; Long 1996). Because I was unable to field test my model, I could not justify placing unequal weights on habitat components. Therefore, my model is based on a compensatory relationship expressed as a simple geometric mean (U.S. Fish and Wildlife Service 1981, Van Horne and Wiens 1991). I calculated HSI scores by referring back to the original HE_i maps and calculating the geometric mean of the 4 variables (not including HE_S) for each pixel (Equation 2.8) and then calculating the overall mean HSI (Equation 2.9).

Equation 2.8

$$HSI_i = [HE_{C\,i} \times HE_{I\,i} \times HE_{W\,i} \times HE_{R\,i}]^{(1/4)}$$

Equation 2.9

$$HSI = \frac{\sum_{i=1}^{N} HSI_i}{N}$$

where N = number of pixels in the polygon

Interpreting the Results

Once an HSI score is obtained, it can be used to assess potential habitat suitability within each study area and make comparisons among study areas. One way to do this is to assign suitability classes to each index. Wisdom et al. (1986) suggested a classification scheme (Table 2.1) after testing his model in different areas with divergent habitat conditions. Results of my model also can be evaluated this way. However, because this scale was developed using a model designed for the Blue Mountains of Oregon, it may not be the ideal scale for use in this situation.

Because the purpose of this assessment is to compare and rank the suitability of elk habitat in each study area, it is important to make valid comparisons. The HSI score alone cannot do this because it does not consider total area. To compare study areas, HSIs must be converted to habitat units (HUs) by multiplying the HSI by the area (ha) of the corresponding polygon (U.S. Fish and Wildlife Service 1981, Long 1996, Roloff and Hauffler 1997). This gives a relative measure of the habitat availability in each polygon. For example, an area of 25,000 ha with an average HSI score of 0.6 would have 15,000 HUs and ecologically would be equivalent to a hypothetical polygon with only 15,000 ha of optimal habitat (average HSI 1.0). Study areas then can be compared directly based on the number of HUs they contain.

I took this conversion even further by translating HUs into a predicted elk population size given an ideal elk density. An ideal elk density is impossible to determine for Virginia because a stable population of elk has not been present in the state for >150 years (Wood 1943, Long 1996), but elk populations in other eastern states may serve as examples. For instance, elk densities of >1 elk/26 ha were associated with high winter mortality and range degradation

(Murphy 1963) and crop depredation increased as elk densities rose above 1 elk/65 ha (Blood 1966, Moran 1973). Blood (1966) recommended that elk in the Riding Mountain National Park be maintained at approximately 1 elk/130 ha in order to minimize off-site conflicts with farmers. Upon examining 3 eastern reintroduced elk herds, I found that the current elk densities are 1 elk/202 ha Arkansas (SEAFWA 1997), 1 elk/230 ha in Michigan (SEAFWA 1997), and 1 elk/147 ha in Pennsylvania (Forbes and Ferrence 1999). Differences in densities likely are due to differences in habitat quality, degrees of human disturbance, and the types of management applied. Given an average of 1 elk/193 ha among these 3 herds and using the average HSI of 0.65 I calculated in this study, I calculated an optimal elk density of 1 elk/125 HU. This estimate assumes that habitat conditions in these 3 states are similar to those in Virginia. Because these figures were obtained from elk populations that are managed to minimize socioeconomic conflicts, I interpreted the results as estimates of cultural carrying capacity (CK), rather than ecological carrying capacity (EK). Both HUs and population estimates are per-area estimates and can be used to directly compare ≥2 polygons. Study areas can be compared directly by summing HUs and/or population estimates for adjacent polygons.

Basic Assumptions of the Model

Because habitat models simplify reality, a series of assumptions and limitations define the conditions under which the model is valid and applicable (Farmer et al. 1982, Van Horne and Wiens 1991). The assumptions underlying my model as described above are:

1. The methods of identifying initial study areas as potential elk habitat are realistic and provide an appropriate spatial scale for analysis.

2. Each component in the model is an important factor in determining habitat suitability for elk in Virginia, and no critical components have been left out.

3. The data bases used as input to the model are accurate and up-to-date with respect to the physical position of features and the attributes assigned to them.

4. The causal relationships between each component and habitat effectiveness are reflected correctly in the variables comprising the model.

5. The mathematical model used to obtain the final HSI score closely matches the actual relationships between the variables.

6. The final HSI score is related linearly to the potential for an area to provide elk habitat and is indicative of the carrying capacity when converted to habitat units.

Ranking the Study Areas

I used a 2-step process to rank study areas on a “high-medium-low” scale according to their ability to support an elk population. First, I ranked the areas according to their estimated carrying capacity of elk. Second, I used a perimeter:area ratio to obtain an index of shape for each study area and ranked them according to their shape. I combined the 2 systems to produce an overall rank using the lowest of the 2 partial ranks.

In the first step, I ranked study areas according to their CK: CK<400 = low; 400≤CK≥700 = medium; CK>700 = high. The break point of 400 elk represents my estimate of the minimum viable population size (Appendix 1). This also corresponds to the bottom of the 95% confidence interval for initial population sizes of extant ungulate populations in National Park reserves (Newmark 1986, as cited in Soulè 1987). Any area ranked low at this stage likely will not support a viable elk herd on its own. The break point of 700 elk between medium and high suitability was determined from a natural break in the data and by examining data on elk populations in other eastern states. A population of 700 elk may represent a threshold in the amount of management required to prevent population decline. Managers in Pennsylvania estimate a population of ~500 elk and are trying to increase the size of the range and the number of elk that inhabit it, primarily to ensure that population declines, such as occurred in the 1960s and 1970s, do not threaten the herd in the future (Stalling 1997). On the other hand, Michigan currently has a population of 800-900 elk, down from a maximum of >1000 elk (Bender 1996, Bender et al. 1991). Managers there are content with the current population size and manage at that level through sport hunting. I believe, therefore, that a threshold population size exists between 500 and 900 elk where managers consider the population secure. The estimate of 700 elk agrees with this notion, and corresponds to the median initial population size of extant ungulate populations in National park reserves (Newmark 1986, as cited in Soulè 1987).

The second ranking scale addresses both management and habitat accessibility issues. From a management perspective, a compact, contiguous range (i.e., high area/perimeter ratio) may be easier to manage than a more linear, fragmented range (more perimeter and more surrounding area to oversee). Second, a more compact range will allow more complete use of available habitat by elk. As the site becomes more linear and/or fragmented, it becomes more difficult for elk to reach all areas because either the distance from one end to the other is too great or barriers may obstruct movements.

I determined area/perimeter ratios for each study site according to an outside boundary joining all polygons in a study site into one larger polygon. I established breakpoints between ranks based on inherent breaks in the data. Indices <4.0 were assigned a low rank, indices 4.00 to 5.0 were medium, and indices >5.0 were high. This scale is sensitive to size of a study area in that smaller areas inherently have a lower area/perimeter ratio (and thus a lower rank). However, I do not feel this was a major concern because smaller areas already are considered less feasible, and this ranking scale was designed primarily to further distinguish among the higher ranked (and larger) study areas.

As the final step in ranking study areas according to overall habitat suitability and biological feasibility, I combined the 2 scales for each site and took the lower of the 2 ranks as the final rank. This allows either ranking scale to determine the highest rank a site is assigned. I believe this is realistic because habitat suitability, habitat accessibility, and ease of management are all primary concerns of wildlife managers.

Results

I identified 8 study areas (Figure 2.7) in 3 regions of Virginia: the Southwest Virginia Region, the Shenandoah Mountain Region, and the Southern Piedmont Region (Figure 2.8). I discuss each region and the study areas that comprise it below.

Southwest Virginia Region

The Southwest Virginia Region (total area = 209,974 ha) contains only 1 study area, but is composed of 6 polygons (Figure 2.9, Table 2.3). It includes portions of Pulaski, Bland, Wythe, Tazewell, Smyth, Russell, Washington, Buchanan, and Dickenson Counties. Public lands (including Jefferson National Forest, Clinch Mountain Wildlife Management Area, and Hungry Mother State Park) are prominent in the 4 eastern polygons, and private lands are exclusive in the 2 western polygons. Overall, 26% of the Southwest study area is owned publicly. In the 4 eastern polygons, roads are concentrated primarily on private inholdings, whereas, in the 2 western polygons, roads are most dense around the polygons' perimeters and where the landscape is less rugged. In the 4 eastern polygons, open areas are located primarily along polygon perimeters, but also are scattered through public lands and as private inholdings (such as Burke's Garden) located in mountain valleys. Open areas in the 2 western polygons are scarce and located mainly in mountain valleys. Streams located throughout this study area provide readily available water (e.g., the Clinch River flows through the west-central polygon).

Overall, this study area contains 126,975 HUs (Table 2.4). Areas of highest habitat quality (Figure 2.10) in the eastern polygons are located at the edges of large forested areas (such as at the edge of National Forest lands and surrounding Burke's Garden) and along mountain valleys. Availability of grass and shrub lands is a limiting factor in the western polygons, and poor interspersion of open areas is a concern throughout the entire study area. The high density of roads in western polygons may limit habitat suitability.

The Southwest study area received an overall biological feasibility rank of medium (Table 2.2), which reflects a high estimated carrying capacity ($N = 976$) and its irregular, fragmented layout. It clearly is capable of supporting a viable elk herd, but the irregular shape and inconsistent land stewardship pattern may present complex management issues (i.e., elk/landowner conflicts, habitat management needs; see Chapter 3).

Shenandoah Mountain Region

The Shenandoah Mountain Region is composed of 4 study areas: Shenandoah, Highland, Big Meadows, and Peaks of Otter. This region is located in northwest Virginia and stretches north-south from Winchester to Buchanan and east-west from the West Virginia state border to Charlottesville.

Shenandoah Study Area

The Shenandoah study area is the northern-most study area (Figure 2.11, Table 2.5). It contains 4 polygons totaling 158,078 ha situated along the West Virginia border and includes portions of Frederick, Shenandoah, and Rockingham Counties. The U.S. Forest Service (USFS) and the Virginia Department of Game and Inland Fisheries (VDGIF) collectively control 32% of the land in this study area. Open areas in the Shenandoah study site are found primarily in the northern polygon (especially near Winchester) and along the eastern boundaries of the 3 southern polygons. Road density is high throughout the private lands of this polygon, but declines in the National Forest. Lower-order permanent water features are common throughout this study site.

This study area contains 94,721 HUs (Figure 2.12, Table 2.6). Landscape composition is a limiting factor throughout much of the study area. However, landscape interspersion is less of a concern (i.e., the amount of open area is rather low, but it is well interspersed). High road densities also would be a limiting factor in parts of this study area. Highest suitability scores occur in mountain valleys where more open areas and water exist.

The Shenandoah study area received a final biological feasibility rank of medium (Table 2.2), which reflects a high estimated carrying capacity (N = 728) combined with a linear shape. The western boundary of this study site is formed by the West Virginia state border with Monongahela National Forest lying immediately to the west. If my assessment had not been limited by the state boundary and landscape data for West Virginia been incorporated, this study site likely would have continued well into West Virginia and biological feasibility may have been higher.

Highland Study Area

The Highland study area (total area = 222,875 ha) is located just south of the Shenandoah study area and contains 5 polygons (Figure 2.13, Table 2.7). It comprises portions of Rockingham, Highland, Augusta, Bath, and Rockbridge Counties. George Washington National Forest is prominent within this study area and represents a large strip of public land down the center and into the southwest corner of the area. Only the eastern polygon has no National Forest. Other public lands in this study area include Highland State Wildlife Management Area, and Goshen Little North Mountain Wildlife Management Area. Overall, 49% of this study site is owned publicly. Open lands are located sporadically in polygon interiors. Only along the eastern edge of the study site between Lexington, Staunton, and Harrisonburg, where the land is owned privately, do open areas become common. Other open areas occur along polygon perimeters or river valleys. Several small river systems (including Cowpasture, Bullpasture, Calfpasture, Little, and Middle Rivers) and their lower order tributaries provide readily available water. Roads are concentrated primarily on private lands, but several penetrate the forest interior (especially along rivers in southern polygons).

The Highland study area contains 124,038 HUs (Table 2.8, Figure 2.14). Landscape interspersion and road density are the 2 primary limiting factors for elk in this area. Throughout the National Forest, open areas are scarce, and, where they do occur, habitat suitability scores improve dramatically. On the other hand, along the eastern fringes of the study area where private lands predominate, forested areas are uncommon and roads are more prevalent, thereby lowering suitability scores. The largest patches of high quality habitat occur along the borders of the National Forest, along mountain valleys (usually near private in-holdings), and along larger water systems.

The Highland study area received a biological feasibility rank of high (Table 2.2), which reflects its high estimated carrying capacity (N = 954) and high area:perimeter ratio. The large size and contiguous shape of this area compensates for less than ideal landscape composition conditions. The Highland study site also is located along the West Virginia border. If the state border had been ignored in this assessment, the study site likely would have extended into the Monongahela National Forest of West Virginia.

Big Meadows Study Area

The Big Meadows study area (Figure 2.15, Table 2.9) contains 5 polygons between Luray and Waynesboro that total 195,467 ha and include parts of Shenandoah, Rockingham, Page, Rappahannock, Madison, Greene, Augusta, and Albemarle Counties. Public lands dominate much of the area and include parts of the Shenandoah National Park, a portion of George Washington National Forest, and the Rapidan State Wildlife Management Area. Private land is concentrated around the perimeter of the polygons. The southern polygons are managed almost entirely by the Shenandoah National Park. Overall, public lands make up 34% of this site. Open areas are limited almost exclusively to private lands at the perimeters of the polygons and along river systems. There are few open areas in the interior of the public lands. Water is abundant throughout the study area; the South Fork Shenandoah River, North Fork Shenandoah River, South River, Conway River, Rapidan River, Robinson River, Hazel River, Moormans River, Doyles River, and Roach River all flow through the study area. Road density is high throughout the privately owned portions of the study site (in the northern polygons), but much reduced on public lands.

The Big Meadows study area contains 109,195 HUs (Table 2.10, Figure 2.16). Landscape composition is the limiting factor on public lands whereas high road density is the limiting factor for elk on private lands. Areas of highest habitat quality exist in well interspersed private lands and at the edges of public land; HSI scores decrease as one approaches the core of public lands.

The Big Meadows study site received a biological feasibility rank of high for biological feasibility (Table 2.2) as reflected by its high estimated carrying capacity (N = 839), large size, and relatively contiguous shape. Habitat quality declines in the interior of the public lands, but sufficient interspersion is present at the edge of public lands and on private lands for overall quality to remain suitable.

Peaks of Otter Study Area

The Peaks of Otter study area (Figure 2.17, Table 2.11), located at the southern extent of the Shenandoah Region, is the smallest (total area = 67,994 ha) area in the region and contains only 2 polygons. It is located at the junction of Allegheny, Botetourt, Rockbridge, Bedford, and Amherst Counties. This study area occurs almost entirely within the USFS congressional boundaries, but actual Forest Service ownership is concentrated in the eastern polygon. Public lands make up 34% of this site. Most open areas are located along the James River and near Lexington. The James River and its tributaries intersperse the study site, so water is readily available. Few roads permeate the polygon interiors, but many roads are associated with private in-holdings along the James River.

The Peaks of Otter study site contains 37,685 HUs (Table 2.11, Figure 2.19). Landscape composition is the most limiting factor to elk in this study area. The highest quality habitat exists along the James River and the associated forest openings. Open areas in the northeast corner of the western polygon (nearest Lexington) raise habitat suitability in those areas as well.

This site received an overall biological feasibility rank of low (Table 2.2). This is one of the smallest study sites and is the most irregularly shaped. The narrow corridor (<5 km wide) connecting the 2 polygons will restrict elk movement and force elk to cross Interstate 81/U.S. Route 11. Peaks of Otter offers the fewest number of HUs of any study site examined, and its estimated carrying capacity (N = 289) is well below the MVP of 400 elk. This site would not support a viable elk herd on its own.

Southern Piedmont Region

The Southern Piedmont Region is composed of 3 study areas: Danville, Brookneal, and Rehobeth. It is located in south-central Virginia and stretches east-west from Martinsville to Charlotte County and north-south from Campbell County to Danville.

Danville Study Area

The Danville study area (total area = 65,400 ha) contains 2 polygons and comprises portions of Franklin, Henry, and Pittsylvania Counties (Figure 2.19, Table 2.13). Except for the Turkeycock Mountain Wildlife Management Area in the western polygon, the entire study area is privately owned (1.6% public). Open areas are well interspersed throughout this study area, except along Turkeycock Mountain where forest lands dominate. Landscape interspersion and composition are not limiting in this area, and water is available; several reservoirs and associated tributaries occur in the western polygon, and the Sandy River and its tributaries occur in the eastern polygon. Roads density, however, is high throughout the study area.

The Danville study area contains 47,848 HUs (Table 2.14, Figure 2.20). This study area boasts a higher HSI score than any area discussed previously. Despite the high road density, the landscape parameters (composition and interspersion) remain favorable. Areas with low suitability occur inside the wildlife management area where open areas are few. Despite the high habitat suitability, this study area is small, and human activity on surrounding lands may limit its overall suitability. Due to this constraint, the Danville study site received a biological feasibility rank of low (Table 2.2). It does not provide sufficient habitat units to support a viable elk herd on its own.

Brookneal Study Area

The Brookneal study area (total area = 88,757 ha) consists of 3 polygons located at the junction of Pittsylvania, Halifax, Campbell, and Charlotte Counties (Figure 2.21, Table 2.15). This study area is entirely privately owned. Open and forested areas are interspersed throughout the study area, and water is abundant (Banister River, Roanoke (Staunton) River, Bighorn Lake, Connor Lake and their tributaries). Roads density is high throughout the study area.

The Brookneal study site contains 68,653 HUs (Table 2.16, Figure 2.22). Roads are the most limiting factor for elk in this area, but landscape composition, interspersion, and water availability all scored high and countered the negative effects of road density. High quality habitat is distributed evenly throughout, but human disturbance surrounds the study area and limits the size of the range.

The Brookneal study site, with an overall biological feasibility rank of medium (Table 2.2), received the highest rank of the 3 Southern Piedmont study areas. This site is irregularly shaped, but appears capable of supporting a viable elk herd (estimated N = 528).

Rehobeth Study Area

The 56,909 ha Rehobeth study area (Figure 2.23, Table 2.17) contains 2 polygons and includes portions of Charlotte, Lunenburg, and Mecklenburg Counties, all of which are in private ownership. Open and forested areas are distributed throughout the Rehobeth study area, and water is abundant; the Meherrin River and its lower-order tributaries flow through the study area. As in other Piedmont study areas, road density is high.

The Rehobeth study area contains 42,851 HUs (Table 2.18, Figure 2.24). Roads are the major limiting factor to elk, but landscape composition, interspersion, and water availability all scored high and compensated for the high road density. High quality habitat is distributed evenly across the landscape, but human disturbance surrounding the site limits the potential range.

The Rehobeth study site received an overall biological feasibility rank of low (Table 2.2) due to its small size and low estimated carrying capacity (*N* = 329). This site likely would not support a viable elk herd on its own.

Discussion

The Model

During this study, I noted an interaction between natural and anthropogenic landscape features. Water features and roads frequently occur together in valleys and neutralize each other's effects on habitat suitability (water = positive impact, roads = negative impact). In highly forested landscapes, open areas (often on private inholdings) also follow these water/road corridors, producing a net positive effect on habitat suitability (high HE_I, high HE_W, low HE_R). In this way, human disturbance actually may increase habitat suitability by enhancing open:forest interspersion. However, excessive human disturbance can affect habitat suitability negatively by raising road densities and decreasing forest cover below 40% (lowering HE_C and HE_I). To achieve optimum elk habitat, it is critical to either carefully integrate human disturbances with naturally maintained areas or actively manage natural areas for a good open/forest mix.

The HE and HSI maps illustrate how the landscape and habitat change spatially. A single pixel value is not very informative, but as more pixels are included in the view, highly suitable areas can be discerned from less suitable areas. These distinctions may translate functionally to areas where elk may be more or less successful and to areas needing different amounts of habitat management. At the polygon or study area level, HE and HSI scores indicate the habitat's potential capacity to meet the needs of a group of animals.

The model I designed provides an objective, systematic procedure for the large-scale analysis of potential elk habitat and aids in identifying the most biologically feasible locations for elk restoration in Virginia. However, because I could not test this model directly, it should be reviewed critically before future use and revised if the assumptions are found to be violated.

Model revisions (such as adding new variables, removing unnecessary variables, or altering HE scales) may be necessary especially where smaller-scale studies are performed.

One possible model revision is to include smaller scale variables. The HE_C and HE_I variables in my model assume that available forest lands provide sufficient forage, as well as good hiding and thermal cover. However, not all forested areas meet these criteria. Many second growth stands have sparse understories that do not provide sufficient forage or hiding cover and thus qualify only as thermal cover (Irwin and Peek 1980). Wisdom et al. (1986) define a forest that performs all 3 roles simultaneously as “optimal” cover. The importance of this distinction depends on the scale of the study.

Landscape heterogeneity can be measured at several different scales with very different results (Davidson 1998). The variables implemented in this study measure large-scale variability. Given the large size of the study areas and the variety of land use patterns each area encompasses, I assumed sufficient forest structure variability was present inherently within the landscape to provide necessary cover and forage as long as the other landscape variables indicated suitable conditions. No differences between the study areas’ forest understory qualities would be detectable without in-depth and extensive field sampling, which proved to be impractical at the scale and with the resources with which I was working. In smaller scale studies (such as an in-depth study of 1 study area or polygon), the field sampling necessary to characterize understory patchiness may be justifiable. I discuss understory patchiness further and tentatively suggest a corresponding HE relationship in Appendix 4.

Elk Habitat in Virginia

Although I previously presented specific elk population estimates to facilitate my study area comparisons, these estimates serve as theoretical guides only. These numbers should not be used as concrete management objectives or as absolute minimums or maximums. Should management objectives need to be set, they may be higher or lower than these indices and will depend on the specific management program proposed, the socioeconomic climate, and ongoing changes in the landscape (e.g., forest clearing, farmland reforestation). These indices may be used as tentative starting points, but objectives should remain flexible.

The Shenandoah Mountain Region as a whole exhibits the highest biological feasibility (Figure 2.25). Within this region, the Highland and Big Meadows study areas received high ranks and would be logical places to begin a more detailed examination of potential release sites based strictly on biological parameters. Although ranked lower overall, the Shenandoah study area also might be favorable based only on biological parameters, and certainly could enhance the value of adjoining study areas if management objectives allow. The Peaks of Otter site by itself does not appear suitable for restoration attempts, but could play a role in future range expansion within the region.

The Southwest and Southern Piedmont Regions both have lower biological feasibility than the Shenandoah Mountain Region. The Southwest Region has significant amounts of land under public ownership whereas the Southern Piedmont is owned privately. Suitable elk habitat may be more accessible within the Southwest than in the Southern Piedmont, where habitat is patchy and discontinuous and human disturbance has a greater impact. I believe that the Southwest Region ranks second in terms of the quality and amount of habitat offered; the Southern Piedmont Region would rank third overall.

Other Biological Considerations

Potential Floral Impacts

In addition to the presence and suitability of elk habitat, it is important to consider the impacts elk may have on that habitat. Two primary factors determine what those impacts will be: 1) the size of the elk population in relation to the carrying capacity of the habitat, and 2) the migratory status of the elk herd (e.g., seasonal migrants vs. permanent residents).

Population Size

Before I discuss how elk affect the landscape, I must distinguish between EK and CK. At EK, an elk population has just enough forage to maintain its current population size (Houston 1982). At EK, preferred forage species are rare, and less preferred forage species show heavy use (Boyce 1998). When compared to populations below EK, the ecological effects of an elk population at EK can include a browse line ~2 m off the forest floor (Gaffney 1941), altered species composition and structure in the understory (Kay 1995, Putman 1996*a*,*b*), a reduction or elimination of shrub seed production and shrub and tree growth rates (Clutton-Brock and Albon 1989, Kay 1995, Case and Kauffman 1997), and a decrease in plant diversity (Clutton-Brock and Albon 1989). If heavy grazing continues, forested landscapes become more fragmented over time because forest openings fail to regenerate.

The ecological effects of elk populations at EK typically are viewed as overuse. Terms like “overgrazed” and “overpopulated” often are applied to these conditions and the effects are reported as economic losses by landowners and managers (Houston 1982). Cultural carrying capacity often is a more desirable objective. At CK, ecological impacts and property damage are maintained at or below a socioeconomically acceptable threshold (Houston 1982). Cultural carrying capacity generally is well below EK (often <½ EK), and can be maintained through hunting, culling, habitat management, and trap and transport.

Moderate browsing by elk (such as would occur at CK) also can impact forested systems, and can be a positive influence. At low to moderate population levels (i.e., ≤CK), elk browsing can maintain plant diversity and heterogeneous forest structure that many managers strive for (Putman 1996*a*). Moderate elk browsing can slow (rather than halt) forest succession, reduce canopy shade to allow the growth of shade intolerant species, stimulate the production of palatable growth, and limit the spread of a few dominant forage species (Clutton-Brock and Albon 1989, Kay 1995, Putman 1996*a*). In exclosure studies, moderate elk densities (6.8 elk/km^2 in winter, lower in summer) maintained grass-dominated understory patches by limiting shrub growth and prevented the dominance of ferns and other unpalatable species by stimulating the growth of palatable grasses and forbs (Woodward et al. 1994, Schreiner et al. 1996). Elk browsing may decrease shrub density and size, but diversity can be maintained in refugia that impede herbivory, such as around fallen trees and logs (Woodward et al. 1994, Schreiner et al. 1996).

Damage by elk to forested ecosystems tends to remain low, relatively constant, and tolerable until elk density reaches a threshold point (i.e., the cultural carrying capacity), when the impact abruptly increases (Putman 1996*a*). Moderate elk browsing is not likely to cause considerable damage, but a population irruption (as may occur when elk initially are introduced, McCullough 1997) could increase damage above tolerable levels (McShea and Rappole 1997).

The population size estimates I suggested earlier (Table 2.2) are approximations of CK because the reference "optimal" elk density (1 elk/125 HU, see pp. 21-22) was selected as a means to reduce the potential impacts of elk grazing to socially and economically acceptable levels. These estimates also are based on areas where deer are an important herbivore, which further supports their applicability in Virginia. Accordingly, management of elk populations at these densities may prevent them from causing significant ecological impacts.

<u>Seasonal vs. continuous foraging</u>

A second important determinant of ecological impact by elk is the seasonality of their activity. Western elk herds migrate between summer and winter ranges. This migration allows the ecosystem to maintain a continually sufficient forage base (Danvir and Kearl 1996, Werner and Urness 1996). Temporary high levels of herbivory on seasonal ranges are tolerated ecologically because vegetation has an extended recovery period each year. The ecological effects of intense, seasonal elk browsing mimic those of moderate, year-round browsing (Frank 1998). As a result, populations of elk can be sustained seasonally at very high densities -- as much as 20 elk/km^2 at EK (Huff and Varley 1999) or 2-6 elk/km^2 at CK (Clutton-Brock and Albon 1989, Woodward et al. 1994, Schreiner et al. 1996).

Virginia has a milder climate than most western elk ranges; extended periods of heavy snow cover normally do not occur, and herbaceous forage generally is available year-round. Therefore, seasonal migration by elk should not be anticipated. Maintenance of a dense, nonmigratory elk population quickly could break down the positive feedback loop (Frank 1998) and change forest structure in a way similar to an elk population at EK (Danvir and Kearl 1996). Forest regeneration may be hindered and portions of the habitat may, over time, revert to open fields maintained by continuously high levels of grazing by elk. Similar changes in vegetation structure in Yellowstone National Park have been linked to an elk herd that migrates less today than those that existed historically (Keigley 1997). Thus, elk carrying capacities (both EK and CK) on eastern ranges likely will be lower than those on western ranges.

My estimates of CK for elk in Virginia (Table 2.2) are based on data from predominantly nonmigratory eastern elk herds. As a result, my estimates of elk density (0.5-0.75 elk/km^2) are similar to those currently found in other nonmigratory eastern herds (e.g., Pennsylvania = 0.68 elk/km^2, Forbes and Ferrence 1999; Michigan = 1 elk/km^2, SEAFWA 1997; Arkansas = 0.45 elk/km^2, SEAFWA 1997). These densities also follow the conclusion that CK is significantly lower where elk are nonmigratory. Management to maintain elk populations at these levels should prevent damages associated with heavy year-round herbivory.

Potential Faunal Impacts

A reintroduced elk population may affect other endemic species. If elk alter the composition or abundance of vegetation in the ecosystem, other species that depend on that same vegetation also will be impacted (Putman 1996*b*).

<u>White-tailed Deer</u>

Elk occur sympatrically throughout most of its range with at least one species of deer, including white-tailed deer, mule deer (*Odocoileus hemionus hemionus*), black-tailed deer (*O. hemionus columbianus*), and roe deer (*Capreolus capreolus*), yet spatial and temporal resource partitioning among elk and deer often prevents competitive interactions (Wydeven and Dahlgren 1985, Sheehy and Vavra 1996). Elk and white-tailed deer have different food and habitat niches that preclude competition under normal conditions (Singer and Norland 1994). Elk primarily are grazers and spend more time in open foraging situations (Hobbs et al. 1983, Leslie et al. 1984, Jenkins and Wright 1988, Kingery et al. 1996, Kirchhoff and Larsen 1998), whereas white-tailed deer primarily are browsers and prefer more forest cover than elk (Cairns and Tefler 1980, Kirchhoff and Larsen 1998).

Elk may compete with deer 1) where elk densities are unusually high (≥ CK) (Nelson 1984, Latham 1999), 2) where extreme weather conditions (e.g., severe drought or long, cold, snowy winters) limit forage availability (Wydeven and Dahlgren 1985; Jenkins and Wright 1987, 1988; Kingery et al. 1996), and 3) in areas where elk must depend on forest browse for forage (Nelson 1982). Winters in Virginia generally are mild and forage remains available, but extended summer droughts may result in a decrease in available forage. Also, elk likely will depend on forest browse and possibly compete with deer when mast production is low or drought conditions limit new growth. Because elk are more generalist foragers than deer and can reach higher (>2 m) for browse than deer (1-1.5 m), deer may be at a competitive disadvantage (Nelson 1982, 1984; Trammel and Butler 1995; Latham 1999). Therefore, elk may predominate over deer in such competitive situations (Nelson 1984, Kirchhoff and Larsen 1998, Latham 1999). Elk densities in Europe often are an important determinant of roe deer densities (Latham et al. 1997, Latham 1999), but never vice versa. In areas where ungulates are at EK, elk typically outnumber deer at least 2:1 (Cairns and Tefler 1980, Leslie et al. 1984, Wydeven and Dahlgren 1985), which may indicate that the EK of deer is reduced by the presence of a dense elk population.

Conversely, deer have lower energetic needs than elk and are capable of using smaller, sparser food patches than elk. When maintained at CK, elk and deer may coexist without significant interaction because spatial and temporal landscape heterogeneity allows for the "repeated reversal of competitive advantage of one species over another" (Putman 1996*b*: 7). For this reason, even in competitive situations, elk probably will not displace deer completely as long as structural diversity is maintained in forested habitats (Jenkins and Wright 1988, Kirchhoff and Larsen 1998, Latham 1999).

To limit competition between elk and deer, both deer and elk populations should be monitored closely, and management objectives should be conservative (≤CK). Suggested population densities presented in this chapter are conservative estimates of CK and may serve well as preliminary management objectives.

Songbirds

The ecological impacts of elk browsing also may affect forest-dwelling songbirds. Although most studies on this topic have been performed relative to deer densities, those results are relevant to elk. Structural diversity (e.g., layers of vegetation, patchiness, interspersion of successional stages, edges, snags) in the forest understory is critical to maintenance of diverse and abundant bird populations (Bull and Slovkin 1982). Moderate grazing pressure (elk and deer combined at CK) generally increases structural diversity of the forest understory, which then increases songbird species abundance and density (McShea and Rappole 1997). As deer densities approach EK and structural diversity decreases, songbird foraging and nesting habitat degrades, especially within the 0-7.6m height interval of the understory (deCalesta 1994, 1997; McShea and Rappole 1997). Results likely would be similar if elk populations approach EK.

Other Sympatric Species

Predator-prey interactions may develop between a restored elk population and sympatric carnivores such as coyotes (*Canis latrans*) and black bears (*Ursus americanus*). Both species prey on newborn calves when available, and during severe winters (>50cm of snow on the ground, Jenkins and Wright 1987), adult elk also are vulnerable (Houston 1978, 1982). Low levels (<5%) of calf mortality among elk due to predation have been reported in Pennsylvania and Michigan, but population growth rates have not been affected (Bender et al. 1991, Forbes and Ferrence 1999). Predation inevitably will result in some calf mortality in Virginia, but it is unlikely to be a major mortality factor initially.

Reductions in the density of understory vegetation at high elk densities (approaching EK) also can affect both the diversity and abundance of invertebrates and small mammals (e.g., mice [*Peromyscus spp.*], voles [*Microtus spp.*], shrews [*Blarina spp.*]). These changes then could influence songbird populations that rely on invertebrates for food and mammalian (e.g., foxes [*Vulpes spp.*], bobcats [*Felis spp.*]) and raptor predator populations (Putman 1996b).

Domestic Livestock

Forage preferences of elk are related more closely to those of sheep and cattle than to those of deer (Kingery et al. 1996). However, elk and livestock grazing appears to have either neutral effects on both species or to be slightly commensal (positive for cattle, neutral for elk). When elk density is low to moderate (≤CK) and livestock density is kept within recommended animal unit ranges, elk and livestock grazing may complement each other. Elk may remove enough foliage and standing dead litter to stimulate increased production in pastures (Werner and Urness 1996). However, year-long grazing (by either livestock or elk) can become competitive. Rotation grazing systems or animal unit limits for livestock and the maintenance of conservative elk densities would prevent most competitive interactions (Beck et al. 1996, Hobbs et al. 1996).

Disease

Another concern associated with elk restoration is the potential for simultaneous introduction of diseases and parasites detrimental to other wildlife, livestock, or humans. It is impossible to eliminate this possibility, but the risks can be minimized. Nettles and Corn (1998) prepared a Model Health Protocol that addresses wild elk translocation from western to southeastern United States. They placed diseases into risk categories and developed a protocol to minimize the risk of importing high risk diseases during elk translocation. I summarize the high risk diseases below, and the high and unknown risk diseases in Table 2.19. Specific recommendations on minimizing risk are summarized in Chapter 4.

High-Risk Diseases

Chronic Wasting Disease – Chronic wasting disease (CWD) is threatening because little is known about what causes it or how it is transmitted. CWD is a type of transmissible spongiform encephalopathy (TSE) and is related closely to scrapie disease of sheep and goats, bovine spongiform encephalopathy (BSE, or “mad cow disease”) of cattle, and Crutzfeldt-Jakob disease (CJD) in humans (Nettles and Corn 1998). The infectious agent is a prion protein (Lantos 1992) that alters normal brain proteins to produce brain lesions and neurological disorder leading to progressive weight loss, excessive thirst, frequent urination, excessive salivation, behavioral alterations, weakness, and ultimate death (Williams and Young 1993, Spraker et al. 1997, Miller et al. 1998, Nettles and Corn 1998). CWD can infect elk, mule deer, and white-tailed deer, but the relationship between CWD and other TSEs is unclear (Nettles and Corn 1998). Because BSE in cattle has been shown to cause CJD in humans (presumably through the ingestion of infected meat), there is cause for concern (Lacey 1998). Little is known about the transmission of CWD between animals, but animal-to-animal transmission of other TSEs has been demonstrated in sheep, goats, and cattle (Spraker et al. 1997). Maternal transmission also may be possible (Schreuder 1994).

As of 1997, the geographic distribution of CWD in wild deer and elk was limited to north-central Colorado and south-central Wyoming, concentrated around an infected captive elk herd near Fort Collins, Colorado (Spraker et al. 1997, Nettles and Corn 1998). However, CWD also has been diagnosed in captive elk herds in various parts of the mid-western and western U.S. as well as in western Canada. Most reports have been traced to commercially transported animals from the original infected herd, but secondary and tertiary movements are difficult to track (Nettles 1998). A new immunohistology test recently was developed for CWD that indicates previous tests may have identified only 20-40% of the cases present, so CWD may be more prominent than originally believed (M. Knox, VDGIF, personal communication). Because CWD cannot be diagnosed without microscopic inspection of brain tissue, testing can occur only after the suspect animal is dead (Nettles and Corn 1998). Further, the incubation period of CWD can be quite long (i.e., months to years, Miller et al. 1998), which increases the chance for undetected infection among individual elk (Nettles and Corn 1998).

Brucellosis – Brucellosis, caused by the bacterium *Brucella abortus*, historically has been an important disease among cattle and other livestock. Brucellosis causes spontaneous abortion in cervids and livestock, and is transmitted easily among animals by mouth, during breeding, or during and after parturition when nearby animals consume aborted fetuses and expelled placentas (Kistner 1982). Brucellosis also causes “undulant fever” in humans and is characterized by recurring chills and fever accompanied by severe headaches. Prolonged antibiotic treatment will cure most human cases, but cannot prevent the arthritis that commonly follows the disease later in life (Kistner 1982). As a result of these public health risks, a national brucellosis eradication program has been initiated and states that successfully eliminate brucellosis among livestock receive certification from the U.S. Department of Agriculture (USDA) (Kistner 1982, Berger and Cain 1999). Cattle producers in certified states possess marketing advantages over those in states where brucellosis is present.

Brucellosis is prevalent among wild elk in Idaho, Montana, and the Greater Yellowstone Ecosystem area, especially in and around the National Elk Refuge (Dobson and Meagher 1996). Supplemental feeding during winter and the associated concentrations of elk are primary factors that help maintain brucellosis among elk herds (Nettles and Corn 1998). Where feeding occurs, approximately 1/3 of the female elk test positive. Otherwise, wild elk do not appear infected with brucellosis. Given the public health risks and potential effects of brucellosis on Virginia’s livestock, it is critical to avoid importing elk linked with brucellosis infected animals.

Bovine Tuberculosis -- Bovine tuberculosis (TB), caused by the bacterium *Mycobacterium bovis*, is another important livestock disease transmissible by elk. A long-term national TB eradication program nearly has eliminated TB, and most U.S. states, including Virginia, currently are accredited as being TB-free (Nettles and Corn 1998, M. Knox, VDGIF, personal communication). In the past decade, TB has been detected among captive ungulates and, as a result, some states (e.g., New York, Pennsylvania, Michigan) have lost their TB accreditation for cattle.

Generally, wild ungulates in the U.S. have resisted infection by TB (Rhyan et al. 1997, Nettles and Corn 1998), though TB may be endemic in red deer of New Zealand (Lugton et al. 1998). However, an outbreak of TB in wild white-tailed deer in a 5-county area of Michigan's lower peninsula (adjacent to the elk range) occurred in 1994, and transmission has occurred to several cattle herds, coyotes, raccoons (*Procyon loter*), and, most recently, black bear (Bruning-Fann et al. 1998, Nettles and Corn 1998, Fischer 1999). High densities of deer coupled with supplemental feeding efforts by residents have been important factors in maintaining this outbreak (Schmitt et al. 1997, Nettles and Corn 1998). Michigan's current TB eradication program involves a ban on supplemental feeding of deer and the liberalization of deer hunting regulations to increase harvest (Fischer 1999). Given these occurrences and the economic consequences to livestock should TB be introduced to Virginia, careful testing of elk should be performed prior to importation, even though bovine TB has not yet been diagnosed in wild elk.

Nonendemic tick species – Dermacentor andersoni is a tick not now present in Virginia that serves as an efficient vector elsewhere for several pathogens, including *Anaplasma marginal* (see anaplasmosis below), tuleremia, Colorado tick fever, and *Rickettsia rickettsii* (Rocky Mountain spotted fever). Even though other vectors for these diseases already are present in the Southeast, *D. andersoni* is viewed as being a more efficient vector, and its introduction should be avoided (Nettles and Corn 1998).

Ixodes pacificus serves a role in the West similar to the deer tick's (*Ixodes scapularis)* role in the East regarding the transmission of Lyme disease and tick paralysis. To avoid adding a new vector for an already serious disease in the Southeast, steps should be taken to avoid introduction of *I. pacificus* (Nettles and Corn 1998).

Psoroptic mange – Elk infested with mites (*Psoroptes spp.*) may experience severe mange and eventual death. These mites apparently are host specific to elk and possibly bighorn sheep so the risk to other endemic species in the Southeast is minimal. However, simultaneous introduction of this pathogen should be avoided to prevent infection in future elk populations (Nettles and Corn 1998).

Endemic Parasites

Parelaphostrongylus tenuis, a helminth known as the meningeal worm or brainworm, is carried by white-tailed deer throughout Virginia at a prevalence level of >70% (Dudak 1964; M. Knox, VDGIF, personal communication). In deer, *P. tenuis* generally does not cause any clinical signs of disease (Davidson and Nettles 1997), but elk may be affected more seriously. Infection in elk may cause severe neurological damage and death (Samuel et al. 1992, Nettles and Corn 1998). However, the full impact of *P. tenuis* on elk is unknown. Not all elk infected with *P. tenuis* show clinical signs of disease. An experimental study demonstrated that elk exposed to low numbers of *P. tenuis* larvae (≤15), especially as calves, appear to develop no signs of infection. Elk exposed to moderate numbers of larvae (25-75) may not develop any symptoms, may develop neurological symptoms and recover, or may develop severe disease and succumb. All elk exposed to high numbers of larvae (≥125) likely succumb (Samuel et al. 1992). Surviving elk with *P. tenuis* infections do shed larvae in the feces, so the life cycle of the parasite can be completed in elk without severe neurological impacts (Samuel et al. 1992). Because other successfully restored eastern elk populations sympatric with *P. tenuis* infected deer (e.g., Pennsylvania, Michigan) show similar patterns of infections, the impacts of *P. tenuis* on elk in Virginia may be minimal (Samuel et al. 1992).

Chapter 3 -- Socioeconomic Feasibility

Introduction

Elk restoration in Virginia potentially can affect many segments of the state's economy. State and federal taxes (e.g., sales, income, and property taxes) fund road maintenance, law enforcement, land use planning, economic development programs, education, and commodity subsidies. Because these programs may be affected, either positively or negatively, by elk restoration, Virginia taxpayers have a right to be heard. With the recent passage of Virginia State House Bill 38 (HB38), The Virginia Department of Game and Inland Fisheries (VDGIF) acquired a new funding source. Starting in 2000, HB38 will reallocate a portion of the sales tax collected on wildlife-associated recreation expenditures to VDGIF and increase their current annual budget by up to $13 million/year. Although this will provide much needed operating dollars, it also creates a new constituent base (i.e., wildlife watchers, campers, hikers, people who feed birds, occasional recreationists) who will now contribute funds to wildlife management. In return, these constituents also must have an opportunity to influence resource management decisions.

Aside from the economic and political issues surrounding elk restoration, there also are a range of ethical and ecological issues that the people of Virginia may wish to address. These are value-based, often intangible considerations (either positive or negative) that have no defined market value, but still are important aspects of natural resource valuations to many people. These concepts need to be identified as they relate to elk restoration in Virginia and considered along with the economic and political factors in the decision-making process.

Given that socioeconomic repercussions of elk restoration could occur at various scales (e.g., single landowner, local community, region, state), each level should be considered in the decision-making process. However, in this preliminary assessment, I concentrated primarily on statewide and regional socioeconomic feasibility. Although certain inferences can be made at the local community level from the results of my study, a more targeted assessment of impacts at the community/landowner level will be needed should restoration proceed and actual release sites be contemplated.

Statewide Assessment

I surveyed Virginia residents to determine their attitudes and beliefs about elk and elk restoration by conducting a mail survey that had 3 major objectives:

1) To assess the level of knowledge and interest among Virginia residents regarding elk and elk restoration,

2) To estimate the level of support/opposition that exists among Virginia residents toward elk restoration and various elk management options, and

3) To determine the motivating factors underlying their decisions to support/ oppose elk restoration.

Survey Methods

Names, addresses, and telephone numbers for 2,400 randomly selected Virginia residents (stratified by county) were obtained from Survey Sampling, Inc., in Fairfield, CT. I designed the survey (Appendix 5) using Survey Pro software (V. 2.0, Apian Software), and administered it following a modified version of Dillman's (1978) total design method. The survey consisted of 60 questions addressing participant demographics, knowledge and interest regarding elk and elk restoration, attitudes of and motivations for supporting or opposing elk restoration, and attitudes about management of a restored elk herd.

The draft survey instrument was reviewed for content and format by 4 faculty members in the Department of Fisheries and Wildlife Sciences, 3 VDGIF employees, and 2 Rocky Mountain Elk Foundation (RMEF) officials and then pre-tested on a subsample ($n = 25$) of potential survey participants (e.g., landowners, farmers, recreationists). I asked pre-test participants to make suggestions on how to improve the survey, facilitate its completion, and identify relevant issues that I may have overlooked. I considered comments from all reviewers and pre-test participants in preparing the final survey instrument.

The survey form, a cover letter, an informational brochure, and a postage-paid envelope were mailed to each address in the database. Each survey and return envelope were coded numerically to track response during the mailing process. The brochure (Appendix 6) was a tri-fold pamphlet that explained the purpose and approach of this feasibility study, a history of elk in Virginia, the life history of elk, and a summary of basic elk habitat requirements. I included the brochure to give participants information about the proposal before asking them to judge the desirability of having elk in Virginia.

I sent the initial mailing on March 8, 1999. Two weeks later, I sent postcards to all nonrespondents re-emphasizing the importance of their response. After 3 more weeks, I sent a second complete survey package to all remaining nonrespondents. Finally, 3 weeks after the second survey mailing, I sent a second postcard to nonrespondents announcing the pending closure of the response period (May 19, 1999) and again soliciting their participation. After the survey closed, I performed a nonresponse bias analysis because my final response rate was <65% (Dolsen and Machilis 1991). I conducted telephone interviews with 50 randomly selected nonrespondents and used a survey consisting of 8 questions from the original mail survey (numbers 1, 3, 9, 11, 15, 16/17, and 45; Appendix 5). I collapsed the original response options (i.e., “Strongly Agree” and “Agree” = “Agree”) to facilitate respondents’ rapid responses. I performed all interviews between 1900 and 2100 hours during July and August, 1999.

Data Analysis

I entered response data into Survey Pro where numerical scales were assigned to categorical responses. I obtained descriptive statistics using Survey Pro protocol, and performed inferential tests using Statistical Package for Social Sciences (SPSS 7.0, SPSS Inc., Chicago, Illinois) software and a probability value (P) of 0.05 to signify statistically significant relationships. For some analyses, I reclassified respondents into regional categories according to the management regions used by VDGIF.

I looked for relationships among variables using a 2-tailed G-test (log-likelihood ratio) with the Crosstabs procedure in SPSS (SPSS, Inc. 1996*a*) and a null hypothesis of no relationship (i.e., variables are independent of one another). Where contingency tables had ≥20% of cells with expected values <5, I collapsed similar categories (“Strongly Agree” and “Agree” collapsed to “Agree”) to raise the expected values and increase the validity of the test (SPSS, Inc. 1996*b*). When a significant G-value was obtained for ordinal variables, I used Goodman and Kruskal’s gamma (γ), a proportional reduction in error (PRE) measure, to explain the strength and direction of those relationships (Bohrnstedt and Knoke 1994; SPSS, Inc. 1996*b*). Gamma ranges from –1.0 (perfect negative relationship) to +1.0 (perfect positive relationship) with 0 representing no relationship. I report $\gamma \leq -0.2$ and $\gamma \geq 0.2$ as being significant here.

I tested for nonresponse bias using a chi-square (χ^2) goodness-of-fit test that compared responses given by telephone and mail respondents. Also, because participants responding late in the survey process are likely to express attitudes more similar to those held by nonrespondents than to those responding early in the process (Drane 1993), I compared responses received after each of the 4 respective mailings using a 2-tailed G-test.

Survey Results

Of the 2,400 surveys mailed out, 630 were completed and returned, 41 were removed from the sample by request, and 235 were returned as undeliverable by the U.S. Postal Service. My adjusted response rate was 29.7%.

Nonresponse Bias

I contacted 345 nonrespondents before reaching my goal of 50 complete telephone interviews. Goodness of fit tests revealed significant differences in the responses of telephone vs. mail survey respondents for all questions (Table 3.1). However, in each case, these differences were explained completely by an increase in “Don’t Know” responses among telephone respondents (or “Didn’t Read It” for Question 3, Appendix 5). When I removed these responses from analysis, all χ^2 values became nonsignificant (Table 3.1).

I found differences among participants responding to different mailing events, even when “Don’t Know” responses were removed (Tables 3.2 and 3.3). Late respondents were more likely to oppose elk restoration when forced to take a position (G = 22.239, df = 3, $P < 0.001$, γ = 0.311) and less interested in viewing elk (G = 24.06, df = 6, P = 0.001, γ = 0.236) than early respondents. When neutral and “Don’t Know” options were provided, later respondents were more likely to use these options than earlier respondents (G = 15.30, df = 3, P = 0.002, γ = 0.277) but still were equally as likely to support elk restoration.

Description of Respondents

The distribution of respondents to the mail survey mirrored the state’s population distribution. The 2 most represented regions were northeastern Virginia (35.6% of respondents) and eastern Virginia (19.4% of respondents). These percentages reflect the population centers in northern Virginia (near Washington D.C.) and eastern Virginia (Virginia Beach/Norfolk area) respectively. The northwest region made up 8.9% of the respondents, 17.6% came from the central region, and 18.5% came from the southwest region.

Respondents largely were male (71.7%, n = 452), middle aged, educated, and wealthy. The largest age group (44.1%, n = 278) was 46-65 years old; people 25-45 years old (32.9%, n = 207) were next most common. This age distribution differed (χ^2 = 142.10, df = 3, P < 0.001) from the age distribution among all Virginia residents according to the 1990 U.S. Census (Figure 3.1). Respondents were more likely to come from the 2 older age groups (45-65 and 65+) than the younger groups (18-25 and 25-45). Education level of respondents was high; 48.9% (n = 300) held at least a bachelor's degree, and 25.4% (n = 156) had a graduate degree. Only 4.2% (n = 26) held less than a high school diploma, and 15.4% (n = 94) held only a high school diploma. The income of respondents also was higher than that of the general population (Figure 3.2). Although a statistical test could not be performed due to the use of different income scales used in my survey and the U.S. Census, it appears that the lowest income level (<$30,000) was under-represented in my sample whereas the $60,000-$100,000 income class was over-represented.

Attitudes Toward Elk Restoration

Sixty-one percent (n = 374) of respondents agreed that "Reintroducing elk into Virginia is a good idea," 14% (n = 86) disagreed, and 25% (n = 140) were undecided ("Neither Agree nor Disagree" or "Don't Know," Figure 3.3). Younger respondents were more likely than older respondents to agree that elk restoration was a good idea (G = 37.31, df = 8, P < 0.001, γ = 0.303, Figure 3.4), and respondents employed in agriculture were less likely than others to agree that elk restoration was a good idea (G = 29.73, df = 8, P < 0.001). There were no differences in attitudes toward elk restoration due to gender, income, education, region, or previous or current living conditions (Table 3.4).

Later in the survey, I asked respondents their opinion about elk restoration again, but gave them only 2 options: "Support" or "Not Support." This question allowed me to ascertain 1) whether respondent attitudes were stable during the course of the survey and 2) the propensities of initially undecided respondents. Overall, 68% (n = 416) of respondents still supported elk restoration whereas 32% (n = 193) did not. These responses were similar to attitudes expressed earlier (G = 394.27, df = 4. P <0.001, γ = 0.941). However, 65% (n = 57) of initially neutral respondents ("Neither Agree nor Disagree") and 69% (n = 35) of respondents initially expressing no opinion ("Don't Know") indicated they would not support elk restoration based on their current knowledge (Table 3.5). Finally, 49% (n = 92) of respondents opposing elk restoration were neutral or gave no opinion initially whereas only 12% (n = 47) who supported elk restoration now were undecided initially.

I next presented respondents with a series of hypothetical conditions. If elk were to be kept in a permanent enclosure, 46% (*n* = 288) of respondents would be less likely to support elk restoration, and 35% (*n* = 225) would not change their attitude. However, respondents who initially opposed elk restoration were more likely to support it if elk were kept in an enclosure than respondents who supported restoration without the enclosure ($G = 31.11$, $df = 8$, $P < 0.001$, $\gamma = -0.199$, Figure 3.5). When considering an elk release near (<30 km from) their home, 57% (*n* = 358) of respondents would not change their attitude. However, when compared to initial attitudes, a potential elk release near respondents' homes polarized attitudes toward elk restoration ($G = 151.61$, $df = 8$, $P < 0.001$, $\gamma = 0.532$, Figure 3.6). Finally, respondents living in the northwest and southwest regions were more likely than respondents from the other 3 regions to support elk restoration if the release site was near their home ($G = 20.58$, $df = 10$, $P = 0.024$, Figure 3.7).

Sixty-three percent (*n* = 398) of respondents would be "Very Likely" or "Somewhat Likely" to make a special trip to view a restored elk herd. Respondents who supported elk restoration were more likely to travel ($G = 264.65$, $df = 12$, $P < 0.001$, $\gamma = 0.699$) and were willing to travel farther ($G = 215.06$, $df = 12$, $P < 0.001$, $\gamma = -0.658$, Figure 3.8) to view a restored elk herd than were respondents who opposed restoration. If a special viewing facility were provided, 45.7% (*n* = 288) of respondents would be more likely to visit the elk herd, but this attitude occurred primarily among respondents who initially agreed that elk restoration was a good idea ($G = 95.28$, $df = 8$, $P < 0.001$, $\gamma = 0.361$) and who already had an interest in viewing a restored elk herd ($G = 90.49$, $df = 6$, $P < 0.001$, $\gamma = 0.379$).

I asked respondents to predict how a series of hypothetical results of elk restoration would affect them personally (Table 3.6). Respondents who opposed elk restoration were more likely to respond "Don't Know" in response to increased agricultural damage ($G = 5.17$, $df = 1$, $P = 0.023$, $\gamma = 0.355$), increased biodiversity ($G = 26.75$, $df = 1$, $P < 0.001$, $\gamma = 0.582$), smaller deer herd ($G = 9.08$. $df = 1$, $P = 0.003$, $\gamma = 0.446$), negative effects on other wildlife ($G = 5.57$. $df = 1$, $P = 0.018$, $\gamma = 0.319$), increased recreational opportunities ($G = 26.79$. $df = 1$, $P < 0.001$, $\gamma = 0.716$), and economic benefits to communities ($G = 15.84$. $df = 1$, $P < 0.001$, $\gamma = 0.551$). Respondents who supported restoration expected positive effects from increased biodiversity ($G = 42.52$, $df = 4$, $P < 0.001$, $\gamma = 0.484$), increased recreational opportunities ($G = 113.01$. $df = 4$, $P < 0.001$, $\gamma = 0.666$), and economic benefits to communities ($G = 114.45$, $df = 4$, $P < 0.001$, $\gamma = 0.634$). Opponents of elk restoration anticipated more negative effects from the elk poaching than did those who supported elk restoration ($G = 23.62$, $df = 4$, $P < 0.001$, $\gamma = -0.237$).

Levels of Knowledge

I asked respondents how confident they were with their knowledge of elk and their ability to form an opinion about elk restoration in Virginia. Approximately half (51.1%, n = 312) of the respondents were "Very Confident" or "Somewhat Confident", whereas the other half (n = 298) were "Somewhat Uncertain" or "Very Uncertain" (Figure 3.9). Unemployed respondents were less confident than employed respondents (G = 18.90, df = 3, P < 0.001; Figure 3.10), and respondents who frequently participated in outdoor recreation were more confident than less active respondents (G = 68.98, df = 18, P < = 0.001, γ = 0.320; Figure 3.11). I did not find relationships between perceived knowledge level and gender, employment type, income, or education (Table 3.7).

Respondents who were confident with their knowledge of elk were more likely to agree that elk restoration was a good idea than were uncertain respondents (G = 172.63, df = 12, P <0.001, γ = 0.317). Confident respondents also expressed polar attitudes (i.e., "Strongly Agree," "Strongly Disagree"); uncertain respondents expressed moderate attitudes (e.g., "Agree," "Neutral," "Disagree," Figure 3.12). Less confident respondents also were more likely to respond "Don't Know" (G = 103.52, df = 3, P <0.001, γ = 0.886). Later in the survey, less confident respondents were more likely to oppose elk restoration (G = 51.82, df = 3, P < 0.001, γ = 0.341). Sixty-five percent (n = 121) of respondents who indicated they would "Not Support" elk restoration also indicated they were somewhat or very uncertain with their knowledge level, whereas 41% (n = 167) of respondents who indicated they would "Support" elk restoration were uncertain of their knowledge level (Figure 3.13).

Respondents found the informational brochure helpful, with 34% (n = 217) responding "Very Helpful" and 49% (n = 307) responding "Somewhat Helpful." However, uncertain respondents either did not read the brochure (G = 28.47, df = 3, P < 0.001, γ = 0.710) or found it less helpful (G = 88.53, df = 6, P < 0.001, γ = 0.451, Figure 3.14) than did confident respondents. Response to the brochure also varied with respondent attitude toward elk restoration. Respondents who agreed that elk restoration was a good idea were more likely to find the brochure helpful (G = 68.64, df = 4, P < 0.001, γ = 0.525, Figure 3.15) than respondents who disagreed.

Confidence levels led to different attitudes about elk restoration for respondents in different occupations. Respondents employed in agriculture who were confident with their knowledge were less likely to agree that elk restoration is a good idea (G = 17.069, df = 2, P <

0.001), whereas other confident respondents (employed: G = 39.49, df = 2, P <0.001; unemployed G = 18.74, df = 2, P < 0.001) were more likely to agree (Figure 3.16).

Respondents indicated that newspaper articles (73%, n = 458), news segments or TV programs (71%, n = 445), and informational brochures (58%, n = 367) would be the best ways to distribute information about elk restoration (Figure 3.17). An informational web site (n = 36), educational programs in schools (n = 10), and articles in *Virginia Wildlife* and other magazines (n = 6) also were suggested. Respondents identified 4 types of information that should be distributed: 1) specifics about the proposal (e.g., location and size of proposed ranges, number of elk to be released, management plans and objectives, associated costs), 2) reports from other eastern states that have elk (e.g., property damage, elk-vehicle collisions, management programs, size of elk tourist industries, reasons for success or failure of other elk restorations), 3) biology/ecology of elk (e.g., types of habitat, size of range, natural predators, aggressive tendencies, interspecific interactions, possibilities for disease transmission), and 4) a comparison of the costs and benefits of elk restoration (e.g., how benefits balance with costs, arguments given by major proponents and opponents).

Respondent Motivations

A series of questions in the survey (Questions 22-32 for supporters, Questions 33-44 for opponents, Appendix 5) asked respondents to indicate how strongly different factors motivated their attitudes toward elk restoration. Supporters of elk restoration appeared to base their decision primarily on ethical and ecological factors (Table 3.8); 4 of the top 5 ranked reasons to support elk restoration were unrelated to the desire for direct personal benefit. These included the desire to restore Virginia's natural history, return elk to historical native range, and increase Virginia's biodiversity. Factors involving direct personal gain (e.g., recreational opportunities, economic benefits) were less important, and the opportunity to hunt elk was least important. Other reasons given to support elk restoration included its compatibility with other wildlife conservation programs (n = 7), the educational opportunities it offers (n = 7), the possible impetus to expand current protected areas (n = 5), and the restoration of natural balance (n = 5).

Among those who supported elk restoration, the motivation for that support varied among demographic factors. For example, an elk's right to live on an historic range (G = 20.43. df = 3, P < 0.001) and the restoration of Virginia's natural heritage (G = 14.63, df = 3, P = 0.002) were more important in women's decisions than in men's (Table 3.8), whereas the opportunity to hunt elk (*G* = 30.54, *df* = 3, *P* < 0.001) was more important in men's decisions. Respondents with less formal education believed the chance to hunt elk (*G* = 36.27. *df* = 12, *P* < 0.001, γ = 0.229), additional recreational opportunities (*G* = 30.30. *df* = 12, *P* = 0.003, γ = 0.267), and economic benefits (*G* = 28.19, *df* =12, *P* = 0.005, γ = 0.242) were more important than did respondents with more education (Table 3.9). Respondents active in outdoor recreation indicated that the chance to see elk (*G* = 42.01, *df* = 9, *P* < 0.001, γ = 0.280), the chance to hunt elk (*G* = 68.23, *df* = 9, *P* < 0.001, γ = 0.430), additional recreational opportunities (*G* = 40.22, *df* = 9, *P* < 0.001, γ = 0.333), and elk restoration as a good use of funds (*G* = 32.65, *df* = 18, *P* = 0.018, γ = 0.211), were more important than did less frequent participants (Table 3.10). Finally, respondents raised in rural settings reported the chance to hunt elk (*G* = 37.44, *df* = 9, *P* < 0.001, γ = 0.305) as more important than did respondents raised in urban settings (Table 3.11), and respondents who currently lived in rural areas reported the chance to hunt elk (*G* = 35.00, *df* = 9, *P* < 0.001, γ = 0.269) and the opportunity to see elk (*G* = 19.31, *df* = 9, *P* = 0.023, γ = 0.247) as more important than did urban respondents (Table 3.12). Following from this last trend, respondents living in southwest Virginia were most likely to report the chance to hunt elk as motivation for their decision (*G* = 29.957, *df* = 4, *P* < 0.001, Figure 3.18).

Whereas respondents who supported elk restoration made a value-based decision, those opposing elk restoration made a need-based decision (Table 3.13). The top 5 reasons given for opposing elk restoration were based on either safety (e.g., automobile accidents, disease transmission) or economic (e.g., agricultural crop damage) issues. Value-based factors (e.g., inhumane treatment of elk, competition with deer) ranked low among opponents. Other reasons listed for opposing elk restoration included the extent of current deer problems (e.g., crop damage, Lyme disease, *n* = 12), a lack of habitat (*n* = 11), the presence of more important issues (e.g., education, environmental safety, *n* = 8), a lack of information (*n* = 7), an opposition to hunting (*n* = 8), and a lack of interest (*n* = 7). I did not detect any differences in the factors motivating respondents to oppose elk restoration due to gender (Table 3.13), education (Table 3.14), participation in outdoor recreation (Table 3.15), background (Table 3.16), or current living conditions (Table 3.17).

Respondents' attitudes toward elk restoration were related to their perception of VDGIF. Overall, respondents were satisfied with the performance of VDGIF's game (51% satisfied, *n* = 323) and nongame management (46% satisfied, *n* = 288) programs and overall agency performance (53% satisfied, *n* = 336, Figure 3.19). However, respondents who were satisfied with the game management program (*G* = 22.12, *df* = 4, $P < 0.001$, $\gamma = 0.304$, Figure 3.20) were more likely than unsatisfied respondents to agree that elk restoration is a good idea (Table 3.18).

Elk Management in Virginia

Fifty-four percent (*n* = 343) of respondents agreed that elk restoration would be an appropriate use of funds by VDGIF (Figure 3.21), although this was related closely to their attitudes toward elk restoration (*G* = 418.97, *df* = 4, $P < 0.001$, $\gamma = 0.938$). Respondents employed in agriculture were less likely than others to agree that elk restoration would be an appropriate use of funds (*G* = 25.073, *df* = 8, *P* = 0.002, $\gamma = -0.225$).

I asked respondents to express their agreement or disagreement with 4 hypothetical funding options that might be used to manage an established elk herd (Figure 3.22). The most preferred option (67% agreed, *n* = 423) was obtaining monies from outside private sources, such as nongovernmental organizations, followed by obtaining new money from general state funds (43% agreed, *n* = 269), and reallocating existing funds from other VDGIF wildlife programs (42% agreed, *n* = 267). Seventeen percent (*n* = 109) of respondents indicated that additional funds should not be obtained. Respondents who opposed elk restoration were more likely to disagree with all of the funding options (Table 3.19). However, this relationship was weakest for the use of funds from outside private sources (61%, *n* = 101, of opponents agreeing), indicating that this may an acceptable option even among opponents. Respondents who opposed elk restoration also were more likely to agree that new funding should not be obtained at all (53% agreeing, *n* = 83, *G* = 158.40, *df* = 4, $P < 0.001$, $\gamma = -0.703$).

I next asked respondents to rate 5 hypothetical management options for dealing with potential increases in crop damages. Sixty-two percent (*n* = 375) believed that people should be compensated for damage caused by reintroduced elk. The most popular compensation option was for the organizations who promoted elk restoration to contribute money (62%, *n* = 391, agreeing, Figure 3.23). Provision of free damage prevention tools (48.5%, *n* = 305, agreeing), obtaining money from general state funds (34.9%, *n* = 220, agreeing), and having local communities create a compensation fund (10.7%, *n* = 68, agreeing) were less preferred options. Respondents who opposed elk restoration were less likely to agree with using general state (G = 70.830, df = 4, $P < 0.001$, $\gamma = 0.419$) or community funds (G = 43.547, df = 4, $P < 0.001$, $\gamma = 0.343$), or to having compensation provided at all (G = 28.326, df = 4, $P < 0.001$, $\gamma = 0.303$). However, opponents were more likely to agree with outside private funding (G = 88.618, df = 4, $P < 0.001$, γ = -

0.566), and were equally as likely as supporters to agree with having free damage prevention materials provided ($G = 64.903$, $df = 4$, $P < 0.001$, $\gamma = 0.065$, Table 3.20). Other options suggested by respondents include channeling elk hunting fees ($n = 11$) and tourism revenues ($n = 5$) into a damage compensation program.

Survey Discussion

Nonresponse Bias

Mail survey respondents were more interested in and/or knowledgeable about elk and elk restoration than telephone respondents. Many telephone respondents had no interest in the issue, refused to participate, claiming they knew nothing about elk, or participated grudgingly, repeatedly referring to their lack of confidence in their responses. However, among telephone respondents who expressed an attitude other than "Don't Know," the direction of their responses did not differ from mail respondents. Similarly, when I compared responses among the 4 mailing events, late respondents were less confident, but their attitudes did not differ from earlier respondents. I concluded, then, that the impact of nonresponse bias on my qualitative analysis was negligible. The impact on my quantitative analysis may be greater (i.e., respondents may exhibit stronger attitudes than the general public), because uncertain respondents tended to express neutral attitudes. My analysis mirrored the findings of Lauber and Knuth (1997) concerning moose restoration in New York.

The higher interest in and/or levels of knowledge about elk restoration among survey respondents may be reflected in respondent demographics. Respondents to this survey were older, more educated, wealthier, and more predominantly male than the general population. These differences may result from varying interest or knowledge levels leading to nonrandom response (especially among different age, education, or income levels). The gender bias likely reflects varying interest and knowledge levels between males and females and a bias in the original sample due its telephone listing origin (males often represent their households in these listings). However, I found no differences in the direction of observed relationships between mail and telephone respondents (random with respect to age, income, and education), and I believe these effects were negligible.

Attitudes Toward Elk and Respondent Knowledge

The majority of respondents supported elk restoration in Virginia. However, nearly half of the respondents were uncomfortable with their ability to make an informed decision. Given that 70% of the original survey population failed to respond to the mail survey, I believe there is a broad lack of interest in and knowledge about elk among the general public.

The most confident respondents were young and recreationally active, and resided in rural areas or small cities. Increasing confidence as recreational activity increases and ties to urbanity decrease may be accompanied by an increase in interactions with wildlife, and because environmental education programs recently have been integrated into many public education curricula, younger respondents may be expected to have more knowledge about wildlife.

The effect of perceived knowledge levels on attitudes was evident throughout the survey. Less confident respondents were less likely to express definitive opinions on many topics and were more likely to give neutral responses. Confident respondents not only were more likely to express opinions, they also were more likely to express strongly polar opinions (e.g., “Strongly Agree”). Few confident respondents were neutral about elk in Virginia. This suggests that as residents become more informed about elk, they begin to take positions.

The propensity of undecided (i.e., uncertain) respondents to oppose elk restoration when forced to state a position creates an interesting dilemma. First, because most Virginians appear uninterested in and/or unknowledgeable about the issue, they may refrain from participating in the decision-making process. Second, the less people know and/or care about elk restoration, the more likely they are to oppose it when pressed to take a stand. A similar trend was observed concerning restoration of moose in New York (Lauber and Knuth 1998) and wolves in New Brunswick (Lohr et al. 1996) and Colorado (Bright and Manfredo 1996).

This creates a fundamental problem with using survey results from a largely uninformed public as a key factor in decision-making processes. The attitudes expressed by less confident respondents likely are based on scant or false information, and, therefore, may be ephemeral in nature (Lauber and Knuth 1998). Even among confident respondents, strong polar attitudes also can be based on false information. Although decision makers are required to involve the public, this should not be interpreted as an endorsement of uninformed public decision making (Decker and Chase 1997). In fact, the public is less likely to be satisfied with a decision they feel is based on poor information – even if reached by a majority (Lauber and Knuth 1997). While fairness dictates that citizen preferences be considered in the decision about elk restoration, these preferences do not necessarily represent the best public interest. Several aspects of most public attitude surveys (including this one) make them especially vulnerable to this limitation; they 1) target a random sample of the general population, 2) provide little information about the issue, and 3) encourage even unknowledgeable or uninterested individuals to participate (Lauber and Knuth 1998). My attitudinal survey was useful in providing preliminary information on the status of citizens' knowledge about elk restoration, measuring preexisting opinions about the issue, and identifying issues that need to be addressed in the decision-making process. Although not a sufficient base for final decision-making, this information is an important foundation for a more interactive and directed process.

If an elk restoration program is initiated in Virginia, education efforts targeting older and urban residents (who indicated they were less confident of their knowledge in this survey) may increase public support (Kellert 1991, Bright and Manfredo 1996). Articles in *Virginia Wildlife* and flyers provided at game check stations might be useful, but largely will reach an already educated and, perhaps, decided public. Other media outlets, such as news reports on local television and radio stations or newspaper articles (but not in the "Outdoors" section) will reach a larger constituent base. Information provided should be unbiased, factual, and represent all sides of the issue. Topics that might be covered include 1) an historical account of elk in Virginia, 2) a review of other elk restorations in the East, 3) an account of the expected effects of elk restoration on Virginia residents, and 4) specific details of the restoration and management plan.

Although education may increase support for elk restoration, it will not gain 100% support (Kellert 1991, Bright and Manfredo 1996, Lohr et al. 1996). First, because confident people were more likely to support elk restoration, I suspect that the percentage of people supporting it should increase more than the number of people who would oppose it. However, increased education actually may further polarize the general public by increasing the number of people with a strong opinion about elk restoration. Second, differences of opinion on expected positive and negative effects of elk restoration are based not only on respondents' knowledge of elk, but also on cultural values, personal interests, and past experiences with wildlife in general (Kellert 1991). In my survey, individuals employed in agriculture were less supportive of elk restoration than other respondents even when their perceived levels of knowledge were the same. It has been suggested that attitudes toward natural resource issues cannot always be driven by factual information because the internal value given to that information depends on the cultural value system and personal background that receives and processes it (Bright and Manfredo 1996). Because attitudes often are insensitive to new information, a more basic need exists that can be addressed only by fostering better communication and understanding between groups with differing attitudes (Kellert 1991, Lauber and Knuth 1998).

Each trend discussed above assumes that respondents accurately judged their own knowledge. However, these judgments may have been affected by a number of factors unrelated to elk. Attitude and level of knowledge can act as independent agents mediated by first-hand experiences or the lack thereof (Kellert 1991). My survey illustrated this in the effect of employment type on the relationship between perceived knowledge and attitudes toward elk restoration. Confident agricultural respondents were more likely to oppose elk restoration whereas other confident respondents generally supported elk restoration. Agriculturalists are exposed more often to the negative effects of wildlife (i.e., crop depredation, property damage) and may learn from these experiences that wildlife needs to be controlled, and that any potential increase in these impacts needs to be avoided. On the other hand, nonagriculturalists may obtain a greater proportion of their information from media or recreational experiences that lead to positive feedback, hence the belief that wildlife should be conserved rather than controlled.

Given these inherently different perspectives, it may be difficult to convince opposing positions to consider alternative arguments. Information considered valid and useful by one stakeholder may be ignored by other stakeholders (Kellert 1991, Lauber and Knuth 1998). I saw this in the response to the informational brochure I included with my survey. Respondents who supported elk restoration found the brochure helpful whereas opponents found the brochure less helpful. Although every effort was made to provide nonbiased information, the natural history and ecological information it contained was more appealing to respondents who favored elk restoration. Respondents who opposed elk restoration expressed a desire for more information about possible detriments of elk restoration. Although these issues were mentioned briefly in the brochure, it focused primarily on historical and ecological descriptions Therefore, it may have been partial to respondents already holding favorable attitudes toward elk.

Motivations

Respondents with different attitudes about elk restoration appear to act on very different motivations. Those who support elk restoration are motivated by value-based concerns, whereas opponents are motivated by need-based concerns. Kellert (1980, 1991) would classify the value-based motives as ecologistic (concerns for ecosystem integrity), humanistic (projection of human sentiments onto elk), or moralistic (concern for elk rights). Need-based concerns would be classified as negativistic (personal health and safety issues) or utilitarian (economic livelihood concerns).

This pattern in attitudinal motivations may be common. Primary reasons offered to support wolf restoration in New Brunswick included that they were present historically and that they are an endangered species (value-based motivations, Lohr et al. 1996). Primary reasons for supporting wolf restoration in Michigan were based on similar values (Kellert 1991). Reasons to oppose wolf restoration in both cases were the likely losses of livestock due to wolf predation and the concern for personal safety (need-based motivation; Kellert 1991, Lohr et al. 1996). Moose restoration in New York was supported because it would help restore the local ecosystem and because moose "belong" in their native habitat (both value-based); the proposal was opposed because it involved significant financial costs and because it was less important than many competing concerns (need-based, Lauber and Knuth 1997). Finally, the primary predictors of attitudes toward wolf restoration in Colorado were the strength of symbolic existence beliefs and the types of emotional responses (e.g., like, dislike) elicited by wolves (Bright and Manfredo 1996). Individuals with existence beliefs and positive emotional responses supported wolf restoration; those with weaker existence beliefs and negative emotional responses opposed it.

Burton (1990) identified 3 categories of motivations: those that are universal to the human species (needs), those that are cultural (values), and those that are transitory (interests). Interests refer to an individual's social, political, and economic objectives and can be negotiated or traded for gains in other interests. However, values and needs (those motivations found in my survey) are much more persistent. Needs are universal to all people and usually will be pursued by all means possible. In this case, needs represent desires for safety on roads, prevention of disease transmission, and avoidance of property damage that may affect one's livelihood. Values are deeply held, culturally ingrained ideas, habits, or beliefs that are resistant to compromise or change. Values represent desires for ecological conservation, the "repair" of human caused ecosystem degradation, and the "rights" of elk to live in former native range. Because this disagreement occurs at the needs and values level, reconciliation or resolution can be very difficult. When conflict occurs at this level, responses of individuals to opposing arguments tends to be nonrational, and rivals may resort to bringing up irrelevant past "injustices" (Burton 1990). Peripheral perceptions about the agency or other interest groups reinforce individual views and create an even more difficult situation. This link between public attitudes toward elk restoration and satisfaction with the management agency (VDGIF) was, indeed, demonstrated by my survey and the moose restoration proposal in New York (Lauber and Knuth 1999).

Differences in motivations between supporters and opponents of elk restoration in Virginia also follow Maslow's (1970, as cited in Muchinsky 1990) need-hierarchy theory. According to this theory, lower order needs (e.g., physiological, safety) must be met before higher order needs (e.g., social, self-actualization) become primary motivators. This explains why people motivated by need-based concerns (i.e., opponents) are unable to consider value-based motives worthy or justifiable. If elk restoration threatens the fulfillment of an individual's safety or economic livelihood, ecologistic and moralistic factors become much less important.

The public involvement strategy selected in the elk restoration decision-making process must reflect the special needs of this type of dispute. Public involvement must be open, informative, and noncompetitive to foster productive discussions and bring opposing groups together. This type of discussion among interest groups requires that the educational needs and value systems of individual groups are recognized and met as a means to encourage dialogue between groups. It is important to provide opportunities for groups to exchange ideas openly without judgment or hostility or, as Fisher et al. (1991) succinctly put it, to "separate the people from the problem" (p. 17) and "focus on interests, not positions" (p. 40). By encouraging individuals to recognize that all interests are equally valid and that the purpose of the discussion is to learn about those interests and create mutually agreeable solutions rather than to demoralize or defeat the opposing side, animosity can be reduced, and consent, if not consensus, can be reached.

Elk Management in Virginia

Respondents expressed a preference for a variety of methods to fund an elk management program, including the use of private and general state funds, and the reallocation of funds from other wildlife programs. This suggests that planners strive to use a combination of funding options. Such a plan also may create a more stable and well-funded program. However, because opponents of elk restoration mostly favored use of private funds, extra efforts should be made to ensure that private funds comprise a significant portion of any proposed budget.

Compensation programs are controversial issues. In Virginia, victims of damage caused by deer, beaver, or other wildlife are not compensated. Most respondents knew this, and it often was cited as a reason why victims of elk damage should not be compensated, even among those who opposed elk restoration. However, should compensation become necessary, the preferred options were for private organizations to supply the necessary funds and for victims of elk damage to receive free damage prevention materials.

Keeping elk in a permanent enclosure generally was not favored by most respondents. However, it may garner support from people who initially are opposed to elk restoration. Presumably, if elk were kept in an enclosure, the potential negative effects of crop damage and elk-vehicle collisions could be controlled or prevented. However, the decision to keep elk in a permanent enclosure would risk losing the support of many (over half) people who support elk restoration, especially those interested in ecological and/or moral aspects of elk restoration.

Regional Assessment

It was clear from my mail survey that many people believed elk restoration would have no impact on them and, therefore, were uninterested. Indeed, elk restoration would have few tangible effects on the majority of the public living in urban population centers. A closer look at people living in the regions where elk restoration was deemed biologically feasible was necessary. These people are most likely to both experience the material benefits of elk restoration and suffer the burden of any costs.

I focused the second phase of my socioeconomic assessment on the regions I identified in Chapter 2 as potential elk habitat. My objectives were to provide a noncompetitive atmosphere and engage stakeholders in a participatory discussion of elk restoration and the issues surrounding it. I sought to 1) obtain regionally specific information about the benefits and conflicts local residents anticipated, 2) identify possible opportunities for reconciling conflicts, and 3) help stakeholder groups obtain a better understanding of each others' interests.

Regional Workshop Methods

Whenever conflict is anticipated, it is important to provide a structured environment that fosters communication and understanding without further polarizing any differences (McMullin 1996, Curtis and Hauber 1997, Decker and Chase 1997). This should include a noncompetitive, unthreatening atmosphere where participants feel free to express themselves while respecting the rights of others to do the same. Encouraging participants to put aside their personal differences and concentrate on the issue, its ramifications, and potential resolutions can help to achieve this goal (Fisher et al.1991).

I held workshops in each region where potential elk habitat had been identified. I held 1 workshop in Abingdon to represent the Southwest Region, 2 workshops (1 in Verona, 1 in Winchester) in the Shenandoah Mountain Region due to its large size, and 1 workshop in Martinsville to represent the Southern Piedmont Region. For each meeting, stakeholder groups were identified to represent the unique land use patterns, socioeconomic culture, and management needs of the area. Representatives from each group were contacted and invited to participate. Although the specific organizations varied, each meeting targeted 3 general stakeholder types: agricultural producers (e.g., foresters, livestock producers, orchardists, vegetable growers, grain farmers); government agents (e.g., U.S. Forest Service, National Park Service, Virginia Department of Transportation, law enforcement); and user groups (e.g., hunters, conservationists, researchers, economic development agents). These stakeholder "clusters" represent interests with similar goals and values that are distinct from the goals and values of other "clusters" (Creighton 1981: 39). Participants at each meeting were divided equally between these 3 clusters for a total of 20-25 participants. Meeting participants and invitees are listed in Appendix 7.

Once representatives agreed to attend, I sent them a letter expressing our appreciation, an informational brochure (Appendix 6), a meeting agenda, and directions to the meeting site. If participants were not contacted until several days before the meeting, the necessary information (e.g., start time, meeting location) either was faxed to them or relayed over the phone. When participants arrived at the meeting, they received a folder with a name tag, another agenda and brochure, a participant list, a pre-meeting survey (see below), a pen, and notepaper.

Meeting Format

To start each meeting, the facilitators were introduced and the agenda was reviewed. Ground rules, such as "no soap-boxing" and "respect others' viewpoints, even if you don't agree with them," also were established at this time to ensure a cooperative, unthreatening atmosphere for the meeting. Participants were told that no decisions about elk restoration would be made during the meeting, and that the purpose for the meeting was for them to supply information they believe needs to be considered in an elk restoration feasibility study for their area. I next presented a slide show about the history of elk, current status of other restoration attempts, habitat needs of elk, life history and seasonal behavior of elk, and an overview of this feasibility study.

I divided each workshop into 3 discussion sessions following a nominal group technique format (Moore 1987) modified for larger groups. In the first session, I asked participants to consider the possible benefits of elk restoration in their area. The second discussion session asked participants to consider the possible costs and detriments of elk restoration in their area. Finally, in the third session, participants reviewed the products of the first 2 sessions and suggested ways to reconcile costs with benefits.

Each session was further divided into 2 phases. In the first phase, participants were divided into 2 or 3 sub-groups. The facilitator for each sub-group presented the topic to be addressed and allowed 3-5 minutes of silent brainstorming. Participants were asked to reflect on the topic and make notes for discussion about relevant issues. After the brainstorming session, discussion issues were listed on a flip-chart using a round-robin method until all participants had exhausted their ideas. Participants then discussed the listed items, combined related items, clarified unclear items, and added new items identified during the discussion. Once each sub-group was comfortable with its list, the larger group reconvened for the second phase, where a "master list" was compiled from the sub-group lists and discussed further. Finally, when the entire group was satisfied with the list of issues, each participant was given 10 "sticky dots" and asked to place them on those issues they considered important. These dots could be used in several ways: all 10 could be placed on 1 item, dots could be dispersed among several items, or dots (whatever was left) could be returned to the facilitator as abstaining votes. This process produced a ranked list representing the issues most important to the stakeholders. The ranked master lists are included in Appendix 7.

I assigned participants to sub-groups with color coded dots located on the front of their folders. I designed the first 2 meetings (those in Abingdon and Verona) so that sub-groups for the first 2 sessions comprised similar interests (i.e., commodity producers in one group, land managers in a second, recreationists and conservationists in a third). I believed participants would feel more comfortable if surrounded by similar interests and that a less competitive atmosphere would lead to more productive discussions. I then randomized participants in the third discussion session so that the different interest groups could work together toward resolutions. For the last 2 meetings (those in Winchester and Martinsville), I randomly assigned participants to sub-groups for all 3 sessions (each session randomized separately) to maximize the interaction that participants had with other interest groups. The only condition placed on this randomization was that the interest groups were distributed as evenly as possible (i.e., if 3 Forest Service officials were present, each was assigned to a different group). This resulted in 2 sub-groups in Winchester and 1 in Martinsville (where only 12 of 21 invited participants were present). I compared these 2 formats in terms of the outcome of the meetings and the quality of the participant experience.

Assessing the Participant Experience

I asked all participants to complete and return the pre-meeting survey included in their registration folder before the start of the meeting. I designed this survey (Appendix 8) to identify participant expectations about the meeting and their preliminary attitudes about elk restoration in their area. About 2 days after each meeting, I mailed a follow-up survey (Appendix 8) and business-reply envelope to each participant to assess 1) how well the meeting satisfied participant expectations and 2) the effect of the meeting on attitudes toward elk restoration.

Because sample sizes were low for these surveys (often >50% of cells had expected values <5), I was not able to apply reliable statistical tests. Instead, I used simple descriptive statistics. I first treated the 4 meetings as 1 to determine the effectiveness of the nominal group technique and identify the impact of the meeting experience on participants' attitudes. Second, I examined the results across meetings to determine regional trends in participant expectations, satisfactions, and attitudes toward elk restoration and to examine differences between the 2 group assignment methods (i.e., random vs. similar interest).

Regional Workshop Results

Each meeting had 20-25 participants except for the meeting held in Martinsville, for which only 12 of 21 invited participants were present. The 3 stakeholder clusters (agriculture, government, users) were represented at all 4 meetings. For this discussion, I have examined the master lists from each of the 3 discussion sessions (Appendix 7), compiled a classified list of items common across the 4 regions (Table 3.17, 3.18, 3.19), and identified uniquely important issues for each region. I created the classified lists by identifying broad issues raised in each meeting and combining items that fit under the broader topics (e.g., provision of both consumptive and nonconsumptive recreational opportunities fit under the broader topic of recreation).

Perceived Benefits

I classified benefits into 5 broad topics (Table 3.21): tourism, recreation, management, education, and biodiversity. The most important benefit identified in 2 of the 4 meetings (Abingdon and Verona) was the potential for economic returns from tourism generated by a restored elk population. Winchester participants ranked the creation of new/enhanced recreational opportunities as the most important benefit, and Martinsville participants believed that fostering biodiversity was the most important benefits of elk restoration. Other important benefits identified across the regions were the positive effects elk might have on existing wildlife and habitat management programs (elk restoration was perceived as an impetus and an aid for managers to improve large scale and multi-species habitat management), and the educational opportunities presented by a restored elk herd.

The lists of potential benefits created in the 4 regions are similar in content with only minor variations in the ranked order. Participants in Abingdon (Southwest Region) ranked tourism as the primary benefit of elk restoration (1^{st} and 2^{nd} in master list, 1^{st} in classified list). Other important benefits included educational opportunities (3^{rd} and 4^{th} in master list, 2^{nd} in classified list), enhancing multi-species habitat management (5^{th} and 9^{th} in master list, 3^{rd} in classified list), recreational opportunities (8^{th} and 10^{th} in master list, 4^{th} in classified list), and fostering biodiversity (11^{th} in master list, 5^{th} in classified list). Abingdon participants also identified the unique benefits of cultivating public/ private partnerships (ranked 6^{th}) and the creation of a philosophical existence value (ranked 7^{th}).

The most important potential benefits identified in Verona (southern Shenandoah Mountain Region) were the economic benefits of tourism (1^{st} and 5^{th} in master list, 1^{st} in classified list), the provision of new recreational opportunities (4^{th} and 9^{th} in master list, 2^{nd} in classified list), improvements in and facilitation of habitat management (2^{nd} in master list, 3^{rd} in classified list), and restoring a missing part of the ecosystem (3^{rd} in master list, 4^{th} in classified list). Other important benefits identified in Verona include the provision of educational opportunities (7^{th} in master list, 5^{th} in classified list), and the aesthetic beauty of elk and its role in creating a higher quality of life (6^{th} in master list).

Winchester (northern Shenandoah Mountain Region) participants identified recreational opportunities (3^{rd} and 4^{th} in master list, 1^{st} in classified list) as an important benefit of elk restoration. Participants also believed elk would allow managers to shift their focus towards the creation of forest openings and produce economic returns associated with timber harvest (1^{st} and

6th on master list, 2nd on classified list). Tourism (2nd in master list, 3rd in classified list), educational opportunities (5th and 8th in master list, 4th in classified list), and fostering biodiversity (7th in master list, 5th in classified list) were other benefits identified.

Because only 12 participants were present in Martinsville (Southern Piedmont Region), few dots were available during the ranking process, and most items were separated by only 0-2 dots. Therefore, it was difficult to rank benefits in order of importance. However, fostering biodiversity and restoring a native species (4th, 7th, and 8th in master list, 1st in classified list) appeared to be 1 of the most important benefits. Others included recreational opportunities (1st in master list, 2nd in classified list), tourism (3rd in both lists), improving and facilitating habitat management (6th and 9th in master list, 3rd in classified list), and educational opportunities (3rd in master list, 5th in classified list). Finally, increasing the quality of life through the aesthetic characteristics of elk (5th in master list) was a unique benefit identified in this region.

Perceived Concerns

The lists of concerns associated with elk restoration were longer and more varied than the lists of benefits, but regional similarities still were present. I identified 5 categories of concerns (Table 3.22). Private property damage was the most important concern in Abingdon, Winchester, and Martinsville (and 2nd in Verona). Participants were concerned with damages to crops and family garden and landscape plantings, fence damage and associated losses of livestock and hay stores, and property rights infringements when private landowners provide habitat for a public good. Verona participants ranked the potential impacts of elk on the local ecosystem, including habitat alteration through intensive foraging and associated impacts on sympatric wildlife and plant species, as the top concern. Other important concerns identified across meetings were the economic costs of elk restoration (including start-up costs, costs for property damage compensation, costs of elk monitoring, costs of habitat management, and the increased demands on already over-worked personnel), the risk of elk/vehicle collisions (including physical damage to vehicles and potential for human injury, fatality, and emotional trauma), and the possibility for disease transmission (e.g., from elk to livestock, wildlife, and humans; from wildlife back to elk).

Crop destruction and infringement of property rights were the most important concerns identified in Abingdon (1st, 4th, 8th, and 13th on the master list, 1st on the classified list). Crops of particular concern were hay, corn, tobacco, fruit trees, alfalfa, Christmas trees, family garden plots, and forage crops. The direct costs of elk restoration and management were second (2nd in both lists), and disease transmission from elk to humans and livestock was third (3rd and 9th in the master list, 3rd in classified list). Public road safety ranked 4th on both lists. No dots were given to items listed as potential ecosystem impacts, which indicates they were of little importance to participants from the Southwest Region.

The most important concern identified in Verona was the impacts of elk on the ecosystem (2nd, 4th, and 5th in the master list, 1st in classified list). Property damage and impacts of elk on agricultural lands (1st and 7th in master list, 2nd in classified list) also were important. No specific crops were listed, but fence damage and competition with livestock explicitly were identified. Other issues identified in Verona included disease transmission between elk, livestock, wildlife, and humans (3rd in both lists), public safety on roads (6th in master list, 4th on classified list), and the direct costs of elk restoration (9th, 11th, and 12th in master list, 5th in classified list).

Crop depredation was the biggest concern among Winchester participants (1st, 4th, 5th, 11th, and 13th in master list, 1st in classified list); >30 dots separated this concern from the rest of the list. Crops of particular concern included tree fruits (especially apples), vegetables, alfalfa, soybeans, clover, and ornamentals. Other concerns listed included ecological impacts (2nd and 9th in master list, 2nd in classified list), the additional workload placed on managers (8th and 12th on master list, 3rd on classified list), and elk-vehicle collisions (3rd in master list, 4th in classified list). Participants also identified the impacts of increased tourism on community integrity (6th in master list), and the lack of stated objectives relating to restoration (7th in master list) as important concerns.

Martinsville participants identified crop and property damage (2nd, 14th, and 20th in master list, 1st in classified list) along with public road safety as primary concerns (1st in master list, 2nd in classified list). Ecosystem impacts (6th in master list, 3rd in classified list) and direct costs of elk restoration (3rd in master list, 4th in classified list) also were important concerns. Other concerns identified in Martinsville were the potential that access to elk for recreational purposes would be “locked up” on private property (4th on master list) and the issue of equitable distribution of the costs and benefits (5th on master list). Again, the small number of participants in Martinsville and large number of ideas generated made it difficult to rank these issues.

Resolutions

I identified 6 categories of resolutions (Table 3.23). Abingdon and Winchester participants believed the best resolution was to not restore elk to those regions of Virignia. This resolution was not suggested at the other 2 meetings. Verona participants believed that it was most important to address the economic concerns (e.g., property damage, administration costs) by planning for and securing funding beforehand from corporate sponsors, partnerships, or tourism revenues. Participants also suggested that an expedient damage compensation program be developed and economic incentives (e.g., easements, tax adjustments) be offered to landowners whose land is to be used as elk habitat. Martinsville participants indicated that their most preferred resolution was to start out with a small, experimental herd for further studies before taking on a large-scale restoration project. Other important resolutions identified across the regions were to 1) further research the biological/ecological parameters and locate the best elk habitat based on land ownership patterns, 2) obtain information on direct costs, expected returns, and utility of various management procedures from other eastern states now managing elk, and 3) conduct an education program to inform the public about the history and biology of elk, the objectives of the program, the conflicts that could arise, and the proposals for managing a restored elk herd.

Abingdon participants indicated that their most favored resolution was to “forget the proposal” and not restore elk to Southwestern Virginia (1^{st} in both lists). If elk were restored in this region, participants want to clearly establish the potential costs and benefits (2^{nd} in both lists) and better define elk habitat needs and the likelihood of conflicts with private landowners (3^{rd} in both lists). The 4^{th} ranked resolution (in both lists) was to start with an “experimental” herd in a temporary enclosure to determine the economic and ecological impacts of a more extensive restoration. Finally, participants believed the objectives of a restoration program need to be defined clearly and publicized before elk restoration is attempted (5^{th} in both lists).

The most preferred resolution identified in Verona was to limit the size of an elk herd to a level that would minimize property damages. This idea was not ranked highly at any other meeting and, therefore, was not included in the classified list, but it clearly was preferred by participants in this region. Using tourism revenue to fund the restoration and compensate for property damage (3^{rd} and 5^{th} in master list, 1^{st} in classified list) also were important resolutions. Other resolutions identified in Verona were to enclose the elk permanently or perform a small-scale pilot project (2^{nd} and 6^{th} in master list, 2^{nd} in classified list), launch a public education program (6th in master list, 3rd in classified list), minimize the risk of disease introduction (4th in master list), and produce an Environmental Impact Assessment (7th on master list).

Winchester participants indicated that the most desirable resolution was to not restore elk and "forget the proposal" (1st in both lists). Establishing an experimental herd to monitor potential costs and benefits and keeping elk on public land also were important resolution (6th and 7th in master list, 2nd in classified list). Participants further believed the existing deer population should be controlled before elk are restored to the area (3rd in master list), and that better habitat with fewer conflicts could be identified elsewhere in the state (4th on master list, 3rd on classified list).

Martinsville participants believed the most important resolutions were that restoration begin as a small herd on public land surrounded by willing landowners or that elk be limited to public lands (2nd and 5th in master list, 1st in classified list) and funds are generated for damage compensation, program administration, and landowner incentives (4th, 7th and 8th in master list, 2nd in classified list). Participants also believed that the experiences of other eastern states should be reviewed (1st in master list, 3rd in classified list), that a more detailed habitat analysis that assesses at land ownership patterns should be conducted (3rd in master list, 4th in classified list), and an education program to inform the general public about elk and elk restoration should be established (6th in master list, 5th in classified list).

Participant Satisfaction

I collected 68 pre-meeting surveys for a 93% response rate. Meeting participants believed each item listed as desired meeting outcomes was important (Table 3.24). In order of importance, participants wanted to learn about the viewpoints of other interest groups, interact with other interest groups, formulate solutions to potential management problems, have their ideas and concerns heard, learn about elk biology and management, and influence the results of the feasibility study. They also stated that listed aspects of the meeting process were important, including (in order of importance) participant open-mindedness, interaction among opposing interest groups, facilitator fairness, the presence of a noncompetitive atmosphere, facilitator objectivity, group discussion of ideas, and the generation of a large number of ideas. When I asked participants to judge their knowledge concerning elk biology and management, they did not agree nor disagree that they were knowledgeable about either topic (Table 3.25).

Fifty-six follow-up surveys were returned for a post-meeting response rate of 60%. Participants generally were satisfied with the meeting outcome (Table 3.26). In order of satisfaction, participants received sufficient attention, were able to contribute satisfactorily, were able to interact adequately with other interest groups, generated a sufficiently large number of ideas, participated in high quality discussions, and generated high quality ideas. They were neither satisfied nor dissatisfied with the feasibility or potential effectiveness of proposed solutions. Participants also were satisfied with the meeting process. In order of importance, they were satisfied with the agenda's organization, meeting location, facilitator competency, meeting style, meeting time, presence of a noncompetitive atmosphere, and facilitator objectivity. Finally, participants indicated that the facilitators did a good job of providing information about elk history, biology and management and the importance and methodology of this feasibility study (Table 3.25).

I found no regional differences in participant expectations before the meetings began (Table 3.24). However, participants in Verona were more knowledgeable about elk biology and management than other participants, whereas Martinsville participants were less knowledgeable (Table 3.25). I also found no regional differences in participant satisfaction with the meeting outcomes (Table 3.26). However, Winchester participants were less satisfied with the meeting process than participants from other regions (Figure 3.24). Specifically, Winchester participants believed the meeting atmosphere was more competitive and threatening and were less satisfied with the competency of the facilitators than participants in other meetings.

Overall, participants' attitudes toward elk restoration generally did not change after participating in the regional meetings (Figure 3.25). Prior to the meeting, participants believed there were many disadvantages associated with elk restoration, but were neutral about potential advantages, whether mangers could deal with problems generated by elk restoration, and whether elk should be restored to their region (Table 3.27). After the workshops, participants agreed that disadvantages could be minimized by managers, but were neutral about the advantages and disadvantages of elk restoration and whether elk restoration was a good idea for their region. It is interesting to note that 17 of 34 participants who were neutral about elk restoration before the meeting, took a side at the end of the meeting. Ten of these 17 people decided that elk restoration was not a good idea.

Attitudes toward elk restoration varied by region (Table 3.27). Prior to the meetings, Winchester participants disagreed that elk restoration presented many potential benefits whereas other participants agreed with this statement. However, participants were largely neutral about whether elk restoration should occur in their area (Figure 3.26). After the meetings, Winchester participants disagreed that the advantages of elk restoration outweigh the advantages, whereas Martinsville participants agreed with this statement. Winchester participants further believed the disadvantages of elk restoration were too great to even consider elk restoration; Martinsville participants disagreed with this statement. Verona and Abingdon participants were neutral on both statements. Martinsville participants believed the disadvantages of elk restoration could be minimized by managers; other participants were neutral. Finally, Winchester and Verona participants were neutral about elk restoration after the meetings, whereas Abingdon participants believed it was not a good idea, and Martinsville participants believed that is was (Figure 3.27).

Regional Workshop Discussion

Consolidating the master lists of participants' issues allowed me to look at the magnitudes of potential costs and benefits across regions, but its utility in making comparison between regions has limitations; an artificially high score may have been created for some items. I am uncertain whether the broad topics I identified would have received the same number of dots had they been on the master list instead of the smaller components. Participants may have believed that the components of a particular issue were important and then been compelled to place more dots to boost their ranks. If a list of broader topics were ranked instead, fewer dots may have been necessary to satisfy participants that a particular issue would receive an appropriate rank. However, because participants were interested enough in the broader topics to identify their components and then emphasize that interest with more dots, it seems reasonable to combine dots as a measure of overall importance. Therefore, even though the grouping process may inflate some ranks, I believe that it was important in summarizing the relative strengths of participants' attitudes toward particular issues.

In many cases, the nominal group technique was limited by the large number of ideas and the availability of only 10 dots/person with which to prioritize those items. This was seen most clearly in Martinsville where only 12 participants were present and a large number of ideas were generated in all 3 sessions. It also was demonstrated in Winchester during 1) the discussion of concerns when the majority of dots were placed on the top ranked item and few were left for distinguishing the importance of other items and 2) the discussion of benefits when several participants abstained from the ranking process (79 dots returned). Many items on these lists received a similar number of dots with no clear breaks for a solid ranking scheme. When this occurred, I believe it is appropriate to interpret the ranked lists in segments. The top items were most important to participants, although it is difficult to say which is most important and which is next most important. The items at the bottom of the ranked list clearly were least important.

Potential benefits of elk restoration identified as important by workshop participants differed from those expressed by mail survey respondents. Workshop participants identified closely with potential economic returns of an elk restoration (e.g., tourism) whereas the general public identified most closely with less tangible benefits (e.g., fostering biodiversity). In fact, only in Martinsville was a noneconomic benefit ranked as most important; recreational opportunities (also leading to direct personal gain) received the highest rank there. Although benefits such as fostering biodiversity and ecosystem enhancement were listed by meeting participants and often considered important, they generally were outranked by economic or recreational benefits. This is a reversal of the pattern seen among survey respondents.

Creighton (1981) identified 5 ways in which people can identify with an issue: 1) proximity (living near a proposed project), 2) potential for economic gain or loss, 3) potential impacts on resource use, 4) social concerns (e.g., development), and 5) values. The majority of people in Virginia likely would not identify with the first 4 factors due to their physical distance from potential elk habitats. Therefore, opinions expressed by the general public likely are rooted in values. This may help explain the mail survey's low response rate and the reluctance of many respondents to express definitive opinions on elk restoration. People who believe the impact of a decision upon them is minor or indirect are less likely to express opinions or volunteer their time for public involvement programs (Creighton 1981). Workshop participants, on the other hand, often could identify with all 5 factors listed by Creighton, and the benefits concerning direct impacts to monetary and cultural resources took precedence over value-based issues.

This difference in motivations between survey respondents and meeting participants was not evident when I examined the identified concerns. People were concerned primarily with direct negative consequences (e.g., public safety, property damage) of elk restoration rather than value-based consequences (e.g., ecological degradation) regardless of where they lived (e.g., close to or far from potential elk range) and the types of benefits they anticipated. Although value-based concerns were identified by meeting participants, it was clear that unless the economic and safety issues are addressed, many people would not be able to experience or appreciate the benefits.

Meeting participants were concerned especially with the equitable distribution of costs and benefits. This particularly was evident among the agricultural groups. Even though many members of this group admitted that a variety of potential benefits were possible, most were reluctant to place any importance on those issues because, for them, potential costs were much greater. Specifically, agricultural producers believed that the burden of supplying habitat and forage to a restored elk herd would rest on them and unfairly concentrate the costs on the few landowners who operate within the elk's range. They further believed that benefits of restoration would be spread out over a much larger group of people and that agricultural producers would experience few, if any, of these benefits. Participants viewed this as 1) a property rights infringement in that private landowners would be expected to provide a public good, and 2) a demoralization of the agricultural community in that the interests of others would take precedence over the needs of farmers. It was important to these participants that, should elk restoration proceed, this inequitable distribution of costs and benefits be prevented.

When I compared the costs and benefits, I noted that, for many benefits listed, a corresponding concern also was listed. For instance, fostering biodiversity and facilitating large-scale management are countered by concerns about ecosystem degradation and loss of biodiversity. The economic gains from tourism were countered by the impact on community culture (e.g., undesirable growth, increased traffic). Although these appear inconsistent, they are important reflections of the values and interests of the people. Participants recognized that some benefits can only be experienced to a point, at which time the returns start to diminish, and costs become more intense. Resolutions were suggested for managing a restored elk population in ways that would maximize these benefits while preventing the costs from diminishing the gains.

Participant satisfaction with the meeting process varied more with the tone of the meeting than with the format used. Abingdon and Winchester meetings had a more competitive tone than the Verona or Martinsville meetings. In Abingdon, some members of the agricultural stakeholder group took an antagonistic stance and some members of the recreational stakeholder group took a defensive stance. This created a communication gap that may have been interpreted as threatening to other meeting participants. The negative tone at the Winchester meeting was due primarily to the hostile nature of 1 participant who repeatedly interrupted others and berated their input. Seven out of 12 respondents to the Winchester follow-up survey noted that this was the low point of the meeting, and several felt that it took away from their ability to benefit from the meeting. The problem encountered at these 2 meetings was identified by Porter (1997) as participant arrogance; a person or group of people with 1 set of interests refused to engage in or even consider as legitimate another set. Although Winchester participants were less satisfied with the meeting process other participants, I believe this was due to the disruptive individual because the participants in Martinsville (using the same grouping technique) did not express a similar dissatisfaction. However, because the competitive tone in Abingdon did not affect participant satisfaction, it is possible that by dividing participants into similar interests, they were not as exposed to the competitive atmosphere as were Winchester participants (where groups were randomly mixed) and, therefore, felt more positively about their experience. When conflict is unavoidable, the meeting tone may be improved by separating interest groups for at least a portion of the meeting, although it still is important to allow time for opposing interest to interact. Otherwise, either grouping technique appeared effective.

There also were clear differences in the regional attitudes toward elk as expressed during the meetings and in the pre- and post-meeting surveys. Participants in Abingdon and Winchester had more negative attitudes toward elk restoration than did participants in Verona or Martinsville. Whether these attitudes resulted from the competitive atmosphere in Abingdon and Winchester or the competitive atmosphere resulted from the prevailing negative attitudes is hard to tell. However, because the tone of the meeting did not affect participant satisfaction in Abingdon, and because these attitudes were evident before the meetings began, I concluded that the attitudes of participants largely determined the tone of the meeting. Abingdon and Winchester participants (especially from the agricultural stakeholder group) were more resolute in their opinions and less tolerant of other interest groups. These meetings ended on a negative level, fewer acceptable resolutions to potential concerns were identified, and many participants simply stated "don't do it." In Verona and Martinsville, participants tended to be open-minded and accepting of each others' ideas. This led to an overall positive experience and the ending sentiment that elk restoration would be possible as long as the identified concerns were addressed beforehand.

In each region, there exists a level of mistrust between those who wish to experience the potential benefits and those who fear the costs. The decision whether to restore elk, therefore, may have to be made through informed consent rather than consensus (Curtis and Hauber 1997). However, consent does not reduce the importance of equitably distributing costs and benefits. "If people see themselves as standing to gain or lose something they value as result of an agency action (particularly if they are losing while others are gaining), the agency must demonstrate the equity of its decision-making process" (Creighton 1981: 26). To be perceived as equitable, the decision-making process must be highly visible to affected individuals, and all stakeholders must have equal access and an equal voice in that process (Creighton 1981). I believe these regional workshops were a good first step. Based on the results of these meetings, it may not be possible to reach consensus in any of these regions. However, I do believe that, particularly in the southern Shenandoah Valley and the Southern Piedmont, it is possible to reach consent if it is demonstrated to the local residents how the major concerns will be addressed.

Analysis of Costs and Benefits

One of the first questions people ask when presented with the elk restoration issue is "Why?" Often, this question is followed by more specific questions, such as "What will it cost?" and "What will we get out of it?" I have attempted to identify some potential costs and benefits associated with an elk restoration in Virginia and estimate their values by citing experiences from other eastern states (Table 3.28). In making predictions for Virginia, I used an elk density of 1 elk/200 ha, which approximates the predicted densities calculated in Chapter 2.

Economic Commitments

The initial phase of elk restoration often is the most expensive. The Kentucky Department of Fish and Wildlife Resources' (KDFWR) elk restoration budget has ranged from $316,773 in the first year to a projected $589,950 in the third year, for a 3-year total of >$1.3 million (Table 3.29, Roy Grimes, KDFWR, personal communication). Because all elk released in Kentucky were equipped with either GPS or radio collars, telemetry expenses were quite high ($284,005 total). Personnel expenses are high ($289,128 total) because KDFWR sends employees to the source state to assist with elk trapping and handling while others remain in Kentucky to monitor elk already released. Of the >$1.3 million budgeted thus far, 64% has been funded by the Rocky Mountain Elk Foundation (RMEF), 27% has been funded by KDFWR, and 9% has been funded by the University of Kentucky (Table 3.29).

This funding pattern is representative of other elk restorations in the East. However, the absolute cost varies with the magnitude of the restoration effort (e.g., number of animals released, post-release monitoring methods) and the length of time the restoration requires. For example, Wisconsin's elk restoration budget has totaled ~$450,000 since its inception in 1995 (Ray Anderson, University of Wisconsin, personal communication). Telemetry equipment ($5,000), graduate student support ($96,000; 2 students/year, 12,000/year), and transportation for personnel ($64,000) were all major expenses. Wisconsin had predicted their expenses would be

≥$256,900/year the first 2 years and $444,700/year thereafter, for a total of ≥$1.4 million over the first 4 years (Parker 1990). This discrepancy ($1.4 million predicted, $450,000 actual) resulted from fewer law enforcement, habitat management, and damage compensation expenses than predicted in their feasibility study.

One major difference between these 2 projects is that Wisconsin released all their elk (25 total) in 1 year (Anderson 1999) whereas Kentucky is releasing many more elk over a period of several years (>300 from 1997-1999, plans for >1000 elk in 1999-2000). Wisconsin's lower expenses also may reflect the short distance that elk were transported; Wisconsin elk were obtained from Michigan, whereas Kentucky elk were obtained from Utah. However, transport costs were not a major part of either state budget; transport costs for elk obtained from Utah was ~$5,000 per trip for ≤80 elk (Cornicelli 1998). When compared to other expenses, this is minor.

Costs of elk management also vary with herd size. Michigan, currently managing a post-hunt elk population of ~900 animals, spends ~$240,000/year (including personnel time and travel expenses). The largest expenses are habitat improvement, administration of the elk hunt, and law enforcement (Table 3.30, Parker 1990). Arkansas spends $80,000-$90,000/year (not including personnel time and travel expenses) to manage ~450 elk (Table 3.31, Mike Cartwright, Arkansas Game and Fish Commission, personal communication). Their greatest expenses are habitat improvement and administration of the elk hunt (similar to Michigan). Because personnel expenses were not available for Arkansas, I estimated they would increase the total budget by ~50%, for a total Arkansas elk budget of $120,000-$135,000 annually. Both states hold annual elk hunts and conduct elk habitat improvement. Differences in these budgets largely can be accounted for by differences in the size of the elk herds (Michigan's herd is approximately twice the size of Arkansas' herd). Based on Michigan's budget of approximately $240,000/year and a population of 900 elk, total management expenses would be $266.67/elk or $1.33/ha of range.

Elk restoration can create additional economic costs through crop depredation and property damage. In Arkansas, damage has been minimal in the past, but is beginning to rise (hence the new hunting season). Damages reported by Arkansas landowners include broken fences, livestock harassment, and depredation of pastures, hay crops, orchards, gardens, and game feeders (including deer food plots) (SEAFWA 1997, Cartwright 1999*a*). Kentucky has received 2 reports of property damage due to elk to date: 1 on a university research plot, and 1 on a cemetery near the release site. Since then, both locations have been fenced to prevent future depredations (Grimes 1999). Michigan receives ~5 complaints/year totaling <$1,000 for damage to alfalfa, bean, and corn crops that border the primary elk range (SEAFWA 1997, Matthews 1999). Damage complaints in Michigan were more frequent in the 1950s and 1960s before institution of an annual elk hunt. Most complaints in Pennsylvania come from corn, hay, and oat farmers, although reports of fence damage occur. The highest reported damage in Pennsylvania occurred in 1982 and totaled $13,000 (or $45.33/animal and $0.23/ha of range), but since the institution of new management initiatives (e.g., fencing, trap and transfer, land acquisition), <$2,000 in damages/year due to elk have been reported (Parker 1990, SEAFWA 1997).

Elk-vehicle collisions are difficult to place a price on. Michigan reports an average of 5.3 elk-vehicle collisions/year, and a maximum of 8 in any year over the last 20 years, even though I-75 is adjacent to the elk range (SEAFWA 1997). Pennsylvania and Oklahoma also report elk-vehicle collisions, but the annual numbers are low, and only 7 (no personal injuries) have been documented in Arkansas since elk were reintroduced in 1981. Based on Michigan's report and a herd size of 900 elk, a maximum of 1 elk-vehicle collision/year can be expected per 113 elk. Based on an average cost of $3,000/impact in property damage (SEAFWA 1997), these collisions would cost $26.55/ animal or $0.13/ha of range.

Economic Returns

In western states with large elk populations, elk hunting generates substantial economic returns through the sale of hunting licenses, equipment, lodging, and food; many small towns depend on elk hunting for millions of dollars of annual income (Freddy et al. 1993). Although eastern states have smaller elk populations, considerable income through elk hunting has been generated. The Arkansas Game and Fish Commission (AGFC) held their first lottery elk hunt in 1998. Eighteen resident licenses (out of >16,000 applicants) were issued via lottery, and almost $63,000 were donated (free application, donations accepted). Two more licenses (1 resident, 1 nonresident) were auctioned off by RMEF for a total of $87,500, 85% of which was returned to AGFC. Overall, the 1998 Arkansas elk season brought AGFC >$130,000 (Cartwright 1999*a*). Both the lottery and auction were repeated in 1999; auction revenues totaled nearly $35,000 with total donation receipts still pending.

In Michigan, 30,000-40,000 applications/year are received for 350-450 elk permits (Matthews 1999). Applications generate ~$200,000/year, and licenses generate another $23,000 for a total annual agency income of $247.78/elk. Total annual expenditures by elk hunters in

Michigan, including guide services and related expenses (e.g., lodging, food) is estimated at $299.79/animal, or $1.50/ha of elk range (SEAFWA 1997).

Nonconsumptive use of elk also generates significant economic benefits. Michigan holds an annual elk festival that fills the town with tourists and brings a large influx of money. Recognizing this potential, Arkansas started its own elk festival in 1998. Canoe operators in Arkansas report an increase in business during elk viewing season (e.g., the rut), and a similar pattern is seen by other recreation-oriented businesses near the elk range (SEAFWA 1997). The viewable elk herd at Land Between the Lakes in Kentucky received >90,000 visitors during the rut in 1998 (Grimes 1999); visitors were charged a fee of $7/personal vehicle or $2/adult and $1/child for tours (Hanna 1995). These revenues are expected to exceed the operating costs of the viewing area and contribute to the general budget for the recreation area.

In Pennsylvania, thousands of tourists travel up to 400 miles (total of 73,500 visitor days) to visit the elk range each year – most (86%) for the primary purpose of viewing the elk herd (Shafer et al. 1993, Lord et al. 1999). The town of Benezette (human population = 350) receives ~1,300 visitors each day during the bugling season. Each visitor spends $10-20/day for lodging, transportation, food, photography, or tour guides, producing $955,000 of income for the community (Schafer et al. 1993, Lord et al. 1999). Value added return is estimated at $750,000 (multiplier = 1.79), for a total economic input of >$1.7 million/year into the local economy. This money has created 42 new jobs and helped establish new lodging facilities, craft/gift shops, restaurants, and tour guide services (Lord et al. 1999). Other eastern states could expect at least $284.40/animal or $1.42/ha of range per year in direct tourist expenditures from a restored elk herd, depending on how well developed the tourist industry becomes (SEAFWA 1997).

Total expenditures is the sum of hunting and tourism activity. In Michigan, this is estimated at $584.19/animal, or $2.92/ha of elk range (SEAFWA 1997). If a factor of 1.62 (U.S. Fish and Wildlife Service 1998) is applied to this figure as a multiplier for secondary expenditures and jobs created, elk could be expected to bring in $4.73/ha of range, and a 100,000 ha range could provide $473,040 to the local economy.

Total Economic Value of Elk

Based on figures in Table 3.28, it appears that the economic benefits of elk restoration outweigh the costs. I estimated a benefit:cost ratio of 1.69, for a primary economic value (given

100,000 ha of elk range and 1 elk/200 ha) of $119,413/year ($238.86/elk, $0.71/ha). This ratio is similar to Buhnerkempe and Higgins (1997) estimate (predicted ratio was 1.6:1) from a feasibility study conducted in southern Illinois. These ratios consider only primary expenditures by hunters and tourists. The value added ratios likely are much higher.

A restored elk herd in Virginia may experience some or all of these costs and benefits. A restored elk herd is unlikely to bring significant hunting revenues for a number of years, but initial tourist income attracted by the new elk herd may be greater than estimated due to the novelty of the herd. In addition, crop damage costs depend highly on the types and amounts of agriculture found on the proposed elk range and steps taken to prevent or mitigate damage.

One concern with cost/benefit analyses is that they emphasize only tangible economic values, but economic values are only a subset of social values. In fact, the actual income brought in by hunters and tourists often is a poor reflection of the total value of a wildlife resource (Phillips 1976, Brown and Manfredo 1987, Davis and Lim 1987). Other values include option (the possibility of future use), existence (the inherent value of a species), ecosystem (value placed on ecological services), aesthetic (visual and acoustical enjoyment), and educational (childhood experiences, scientific research) (Hair and Pomerantz 1987, McDivitt 1987, Rolston 1987, Talbot 1987, Norton 1988, Conover 1997). Because wildlife is a public good, its total value (economic + intrinsic) is difficult to determine (McDivitt 1987, Conover 1997).

Even when a market price does exist (e.g., hunting licenses, user fees), there is an extra-market component that individuals would be willing to pay above and beyond the set price. In Montana, while hunters paid an average of $185 per hunting trip ($66/day) for license fees, lodging, food, and travel, they were willing to pay an average of $260/trip. When the chance of seeing (but not necessarily shooting) a 6-point or better bull elk was doubled hypothetically, willingness to pay (WTP) increased to $345/trip (Brooks et al. 1991, Duffield 1991). Duffield (1991) also found that residents of Colorado were willing to donate an average of $78.00 (median = $17.72, 88% of respondents willing to donate ≥$1) to protect an area of important elk habitat. Only 15% of the average donation was attributed to an increased opportunity to see or hunt elk; 85% was associated with preservation and existence values. Despite the hypothetical nature of these estimates, it is clear that significant values are placed on elk and other wildlife outside of what is measured by market dynamics.

There also are social costs that cannot be assigned a market value. These include the impacts of increased tourism on local ambience. Large influxes of people into small towns that occur in and around elk ranges can create public safety and security issues for local residents, increased traffic volume, and an overall degradation in the local quality of life due to crowding, development, and commercialization (Cameron County Echo 1998).

A final concern in estimating the overall value of elk is that costs and benefits seldom are distributed equitably. The goal of wildlife management agencies often is to maximize values for society as a whole (McDivitt 1987, Conover 1997), but in many cases, benefits associated with the presence of elk accrue largely on those who do not bear the costs (Phillips 1976). While scientists, naturalists, recreationists, and society in general may benefit from elk restoration, a much smaller part of society (especially agriculturists) likely will bear the majority of the costs (Wade 1987). These groups often are mutually exclusive, and 1 group is viewed as a direct threat to the other (Phillips 1976). The negatively affected group, therefore, has little incentive to take the benefits into account when making their land use decisions. Clearly, ways to balance the costs and benefits associated with elk restoration both for society as a whole and among the different groups that comprise it must be identified (Phillips 1976, McDivitt 1987).

Equitability can be approached from 2 directions: decreasing the costs placed on any individual (see Chapter 4, Conflict Management), or increasing benefits experienced by those for whom the costs are highest. Some western states have increased benefits to local landowners through land acquisition, lease agreements to secure long-term government grazing rights (for use of land by elk) and/or public access for hunters and recreationists, and by encouraging free-market wildlife management (Phillips 1976, Long 1996). The last option has been used in California, Colorado, and Utah and provides incentives (e.g., longer hunting seasons, more liberal bag limits) to landowners in exchange for requisite habitat enhancement programs (McDivitt 1987). Some landowners look upon this program as an economically viable alternative to farming and livestock production (Guynn and Steinback 1987, McDivitt 1987, Long 1996). Similarly, the Texas Parks and Wildlife Department offers free elk permits to landowners who then control the distribution of those permits to hunters (Potter 1982). Landowners may not sell the permits, but can charge access fees and fees for services (e.g., lodging). Some landowners have concentrated on nongame wildlife and are seeing significant returns from watchable wildlife programs (Long 1996). These programs also present secondary benefits by allowing for better management of elk herds, providing more recreational opportunities, and increasing property values through the creation of multiple use benefits. Although the provision of special elk hunting privileges to landowners in Virginia may not be an option in the near future due to the small size and vulnerability of a restored herd, other incentives can be provided, such as recreationists' user fees or lease contracts for elk range utilization.

Risk Assessment

If elk restoration is to be successful, habitat availability and socioeconomic conditions must be favorable both now and into the future. Although it is impossible to predict exactly how the factors I examined in this study will change over time, a risk assessment offers tentative predictions about trends in human populations and resource use by humans. To predict the likelihood of continued habitat availability and future socioeconomic conflicts, I examined 1) recent trends in human population densities, 2) patterns of land stewardship (i.e., public vs. private land), and 3) regional trends in agriculture as an indicator of evolving land use patterns.

Population Trends

Recent trends in human population growth are important indicators of how likely potential elk habitat present today may change in the future. Unfortunately, these data cannot be used to make long-term predictions (i.e., >10-20 years). However, I believe they can be useful in comparing risks in different regions of the Commonwealth. In areas of rapid human population growth, elk habitat may undergo development and be converted to residential or commercial land unsuitable for elk in the near future.

Population trend data were obtained for counties within each of my 8 study areas (U.S. Census Bureau 1973, 1978, 1983, 1988, 1994, Table 3.32). Counties within a study area were combined to obtain an overall human population density and trend (Figures 3.28 and 3.29). Although there was a widespread population increase in the 1970s (U.S. Census Bureau 1983), growth rates during the 1960s, (U.S. Census Bureau 1973) and 1980s (U.S. Census Bureau 1994) varied among the study areas. Growth rates during the 1980s generally were greater than those in 1960s; however reported growth rates over the 1980s included 12 years of data (1980-1992) whereas those for the 1960s covered only 10 years (1960-1970).

The Shenandoah and Danville study sites both have dense (>25 people/km^2) and rapidly increasing human populations, which raises uncertainties about the sustainability of available elk habitat in those areas. Additionally, the potential for human/elk conflicts likely will increase with human growth and expansion. The Southwest study site also has a relatively dense human population (>25 people/km^2), and the potential for human-elk conflicts is high. However, because the human population density is decreasing (especially in the western counties of Buchanan, Dickenson, Russell, and Tazewell), elk habitat in this study area may remain stable. Human population densities in the Big Meadows and Peaks of Otter study sites, though currently at moderate levels (15-25 people/km^2), are growing steadily, which may lead to habitat degradation or loss in the near future. The Brookneal, Rehobeth, and Highland study sites appear to be the most stable. Brookneal has a moderate population density (15-25 people/km^2), but growth consistently has been low. Rehobeth and Highland have the lowest population densities (<15 people/km^2) and growth rates of all the sites; growth in Rehobeth is decreasing slowly whereas Highland's is increasing slowly. Thus, these latter 2 sites appear to have the lowest risk of both human/elk conflicts and future habitat degradation/destruction.

Land Stewardship

A second measure of risk is the proportion of total land area in public ownership (e.g., federal and state lands). In study areas with a high proportion of public ownership, the amount of land available on which conflicts with private land owners can occur is less. Public land also provides a greater opportunity for close monitoring and management of a restored elk herd. These activities likely would be more difficult on a range with little public land. I estimated the proportions of public to private lands for the 8 study areas using a land stewardship data layer developed for Virginia's Gap Analysis Program (S. Klopfer, Virginia Polytechnic Institute and State University, personal communication). I defined "public land" as any area owned by a government agency or conservation-oriented, nongovernmental organization.

The Shenandoah region has the lowest risk for conflict of the 3 regions, based solely on the public:private land ownership ratio. The Highland area contains the highest proportion (49%) of public lands of all the study areas. Big Meadows (34% public), Peaks of Otter (34% public), and Shenandoah (32% public) study areas present higher levels of risk for conflicts than the Highland site, but still have significant tracts of National Forest and/or National Park lands to help to minimize these risks. The Southwest site (26% public) is comparable to the latter Shenandoah study sites, but the stewardship pattern is different. Public land is dispersed uniformly throughout the Shenandoah study sites, whereas in the Southwest, public land is concentrated in the eastern polygons; the western polygons are entirely privately owned. The presence of large corporate landowners (e.g., coal companies) in the Southwest's western polygons may ameliorate this problem.

Within the congressional boundaries of the national forests, considerable acreage of privately owned, undeveloped (but often farmed) land currently exist. These “inholdings” often are targeted by the Forest Service as acquisition prospects. Inholdings especially are common in the Southwest, Highland, and Peaks of Otter study sites, and may present additional conservation opportunities for these areas in the future. However, until these sites can be acquired, they are especially vulnerable to elk/landowner conflicts due to their location within a large forest system and their isolation from other open foraging areas.

Finally, the Southern Piedmont sites are owned almost entirely by private landholders. Danville (1.6% public) is the only study site in this region that contains public land. Both the Brookneal and Rehobeth sites are 100% privately owned. Thus, the risk of conflicts between reintroduced elk and private landowners is high within this region.

Land Use Trends

A major concern expressed by people during both the regional workshops and the state-wide mail survey is the impact of elk on agriculture. To address this concern, I obtained trend data on the number of farms, total acreage of farmland, and the proportion of agricultural sales coming from the production of crops (as opposed to livestock products) for the counties in each study areas (U.S. Census Bureau 1973, 1978, 1983, 1988, 1994; Tables 3.33 and 3.34). I combined counties within study areas for comparison (Figures 3.30 and 3.31). I also identified the specific commodities produced (e.g., dairy cows vs. beef cattle, fruit vs. grain) in each area to further define regional risks for elk-landowner conflicts (Virginia Agricultural Statistical Service 1997). I have assumed that 1) appropriate precautions would be taken to minimize the risks of disease importation during elk restoration (see Chapter 4), 2) recommended animal unit limitations are heeded on pastures (particularly for dairy cows where consistently adequate forage is essential to maintain productivity), and 3) elk are managed at cultural carrying capacity. If any of these assumptions are violated, the risk of elk-landowner conflicts on agricultural lands will increase considerably.

In the Southern Piedmont Region, the Danville study area has the fewest farms (n = 2,941) and the lowest agricultural land area (222,000 ha) of all the study sites. However, this may be due to the small size of this site and probably does not reflect a lower risk of elk-landowner conflicts. Brookneal has a much higher number of farms (n = 3,981) and a high total farm acreage (331,000 ha), despite its relatively small size. Further, 50-80% of the agricultural production (primarily tobacco, hay, and alfalfa) in the Piedmont comes from the cultivation of economically important crops, and Franklin County (part of the Danville site) is the third largest diary producer (10,600 head) in the state. Even though both the number of farms and total farm acreage appear to be declining across the Southern Piedmont, the risk for elk-landowner conflicts remains high.

The Southwest study site contains the second highest number of farms and farmland acreage of all the study sites, and these numbers appear to be stable. This represents a high risk factor for elk-landowner conflicts on private lands. However, this risk is not consistent across the area. The 2 western-most counties (Buchanan and Dickenson) have very few farms (<150 each) and little farm acreage (≤5,000 ha each). Even though 40-75% of the agricultural production in these counties (primarily hay and tobacco) comes from crop cultivation, the risks of conflict are low because total production is so low. Pulaski, Bland, Wythe, and Tazewell counties have low to moderate numbers of farms (300-750 each) and farm acreage (30-60,000 ha each) and receive very little of their sales (4-7%) through crop production; farmers in these counties are important dairy producers (800-4,900 head each). The economic impact on nonforage crops may be low, but depredation on forage crops and competition with dairy cows may be a major concern. Smyth, Russell, and Washington counties have the most farms and highest farm acreage in this region and are among the highest examined in this study. This is coupled with a moderate reliance on crop production (30-50%, primarily tobacco and corn) and a prevalence of dairy production (700-5,300 head each). Thus, the risk of elk-landowner conflicts in these counties is high.

Agricultural trends in the Shenandoah Region are highly variable. The Shenandoah study site has the fewest farms (*n* = 3280) and least farm acreage (204,000 ha) of the 4 sites in this region. Most agricultural areas occur in Rockingham County (1,895 farms, 98,000 ha), where dairy production is highest in the state (>25,000 head). Frederick County relies heavily on crop production (>60% of total sales). Frederick County is the heart of Virginia's "apple country," and the 3 counties in this study area (Frederick, Shenandoah, Rockingham) are the biggest apple producers (644,624 trees, 244,149 trees, and 217,713 trees respectively) in the Commonwealth. Orchardists would be especially at risk for elk depredation and damage to trees, as deer are already considered major nuisances. Overall, a high risk for conflicts between elk and local farmers exists in this site.

The Peaks of Otter study site has a low number of farms (*n* = 3,012) and low total farm acreage (236,000 ha). Given the small size of the site, risk of elk damage per unit area likely is quite high. Nonforage crop production typically is <20% of total production, but dairy production ranges from <500 head to 3,300 head within the counties that compose this site.

The Big Meadows study site has the most farms (*n* = 6,476) and highest total farm acreage (477, 000 ha) of any study site examined. Rappahannock County relies heavily on crop production (~45% of total sales, primarily hay), but it has the fewest farms (*n* = 288) and very little dairy production (<500 head). This trend (i.e., more crop production, less total farm acreage, low reliance on dairy) also occurs in other counties east of the Blue Ridge Parkway. Counties west of the Parkway have more agricultural lands and more farms overall, but rely less on crop production (<10% of total production) and more on dairy production. Two of the 3 most important dairy producers in the Commonwealth, Rockingham (28,000 head) and Augusta (10,000 head) counties, are in this study area. Based on the high total farm acreage, moderate reliance on crop production in some counties, and prevalence of dairy production in other areas, the overall risk of elk-landowner conflicts probably is high in the Big Meadows study area.

Finally, the Highland study area has both a moderate number of farms (*n* = 4551) and total land acreage (344,000 ha). Given its large size, the per-area risk of elk-landowner conflicts is reduced significantly. Eastern counties (i.e., Rockingham, Augusta, Rockbridge) have more farms and total farm acreage than western counties (i.e., Bath, Highland). However, reliance on nonforage crop production is very low across the entire study site (<10%). Livestock production is predominant, but, in eastern counties, dairy production especially is important. Again, 2 of the 3 most important dairy producing counties in the state (Rockingham, Augusta) occur in this study area. Dairy production is minor in western counties (<500 head each). The combination of few farms, low reliance on crops, and little dairy production leads to a low risk of elk-landowner conflicts in western counties, but risk may be more significant on eastern counties where significant depredation on forage crops and competition with dairy cows could occur. It is worth noting that only a very small part of Rockingham County (where the most agricultural land and dairy production occurs) is included in this study site. The overall risk for this study site, therefore, may be lower than indicated by the totals given in Table 3.33. The Highland study site presents the lowest risk for elk-landowner conflicts of all the study sites.

Conclusions

My mail survey indicated that a large segment of the general population in Virginia lacks the information necessary to form an opinion about elk restoration, and many people are not interested enough in the issue even to consider it. Among those who expressed interest, there exists a high level of support for elk restoration. Although this could be viewed as an endorsement for an elk restoration project, care must be taken not to base any decision on the preferences of ill-informed or uninformed individuals. A final decision certainly should consider the preferences of Virginia residents, but it also should reflect the many other factors presented in this study (e.g., biological feasibility, economic ramifications, risk of elk-landowner conflict). Professional judgment is a critical component of this decision and should not be devalued or relinquished to satisfy the majority. On the other hand, the information received from this survey provides a useful foundation upon which other factors can be weighed.

Moralistic, humanistic, and ecologistic values are the primary motivating forces for supporters of elk restoration among the general public. The desires to return elk to its once native range, reverse human wrongs, and restore Virginia's native biodiversity all were important goals of people who supported elk restoration. Opponents of elk restoration are concerned with potential impacts on the economic livelihood and safety of residents of Virginia. If elk restoration is to proceed, individuals concerned about agricultural and property damage and disease transmission must be assured that their concerns are taken seriously and that plans are in place to mitigate these conflicts should they arise. A public education and involvement campaign that allows opposing interest groups to interact in a noncompetitive manner and work cooperatively towards mutually acceptable solutions can help do this.

The general public also expressed preferences for 2 management issues. First, a variety of funding sources, including private funds and funds reallocated from other wildlife programs, should be used to fund any proposed elk management program. Because use of private funds was the most preferred option (even among opponents), this should be prominent in the budget, particularly during the restoration and early management phases. Second, many people supported compensation for victims of elk damage through monetary compensation (using private organization funds) and the provision of free damage prevention materials.

These same attitudes were expressed to varying degrees in my regional workshops. However, unlike the general public, those people who live closer to areas where elk restoration was contemplated have a direct stake in the issue. Additionally, they are more concerned particularly with the equitable distribution of the economic costs and benefits of elk restoration within the community

The Southwest Region would benefit from elk as a tourist attraction and a means of increasing the economic input into local economies. However, concerns about crop depredation and property damage may override this potential benefit. Agricultural producers view elk restoration as a threat to their livelihoods and an unwanted burden. Assurances that these conflicts would be minimized may be received with wariness or distrust. This region has a high reliance on cropland and dairy farms, which elevates the potential for elk-landowner conflicts. Stakeholder attitudes indicate a low tolerance to accept this risk and interference, despite the presence of large tracts of public and corporate lands.

Attitudes in the Shenandoah Valley Region are remarkably different in the northern versus the southern half. The northern half of the Shenandoah Valley is dominated by apple orchards and other agricultural industries. People in this area recognized many potential benefits of elk restoration (e.g., increased tourism, enhanced recreational opportunities), but agricultural producers already are impacted harshly by white-tailed deer damage and fear the addition of a second, even larger, ungulate. Further, the northern Shenandoah Valley has the densest human population of all regions considered, and density is increasing rapidly. This region represents the most important fruit tree and dairy production region of the state and, even though large tracts of public land are present, it likely would be impacted negatively by elk restoration.

People in the southern half of the Shenandoah Valley do not view elk restoration with as much animosity. They foresee a wide range of potential benefits (both economic and noneconomic) associated with an elk herd in their region, but fear the impacts elk may have on the local ecosystem and the possibility of increased property damage. However, agricultural producers in this region may be satisfied with a demonstration of advance planning by the management agency to mitigate foreseeable conflicts and may be accepting of a small, experimental elk herd on which a more detailed cost/benefit analysis could be conducted. The facts that this region has a low human population density, high proportion of public lands, and low farm acreage (on a per-area basis) that relies on nondairy livestock production increases the socioeconomic feasibility of elk restoration in this part of the state.

Because many invitees were not present at the workshop in the Southern Piedmont (including several agricultural and economic development representatives), some viewpoints may not have been represented adequately. Participants identified many important benefits of elk restoration, including both economic and noneconomic factors, but public safety and property damage were primary concerns. Public safety concerns may be warranted due to the high road density in this region. Human population densities range from relatively low in the eastern portion to one of the highest examined closer to Danville. This region has almost no public land, but a great deal of agricultural land. With >50% of agricultural production in economically important crops and a large portion in dairy production, the risks for elk-landowner conflict is high.

I calculated an elk restoration benefit:cost ratio of 1.69 representing primary expenditures and costs. Elk restoration has the potential to bring significant economic returns to communities, both as a tourist attraction and as a future game animal. However, there also are costs associated with property damage, elk-vehicle collisions, and management expenses. The magnitudes of these costs and benefits will vary depending on 1) the size of the elk herd, 2) the land use patterns in and around its range, 3) the degree to which the elk tourist industry is developed, 4) whether an elk hunt is administered and how extensive it becomes, and 5) the extent of habitat improvement/management efforts. Further, a net economic return may not be realized until several years after restoration is initiated due to the high initial costs of obtaining, transporting, releasing, and monitoring the founder herd. Extra-market values (e.g., existence, option, educational) may, however, be realized immediately.

The socioeconomic feasibility of elk restoration reflects region-specific issues. Many possible concerns and potential benefits associated with elk restoration were identified I my assessment, and these issues will need to be addressed before an elk restoration program is attempted. The success of an elk restoration program will depend on both how well those issues are reconciled, and the effectiveness of the public involvement process used to reach that reconciliation. Chapter 4 discusses how these issues may be addressed.

Chapter 4 -- Management Implications

Introduction

Both biological and socioeconomic feasibility are important to the success of an elk restoration program. Advance planning by the responsible wildlife management agency on how restoration should proceed and how the restored elk herd should be managed is just as important. Although the specific management issues that might arise following restoration are impossible to predict, planning for a variety of anticipated scenarios can expedite the management implementation process. In this chapter, I synthesize the biological and socioeconomic feasibility assessments and discuss the overall feasibility of elk restoration in Virginia. I then examine possible management scenarios relating to the restoration of elk to Virginia and offer suggestions for dealing with these issues.

The Upshot: Is Elk Restoration Feasible in Virginia?

Evaluation of Study Sites

I consolidated the results of my region-specific biological and socioeconomic assessments into a matrix (Table 4.1) as a means to facilitate evaluation of the overall feasibility of elk restoration in Virginia. Each factor in the matrix is scaled so that a rank of "High" corresponds with high feasibility (e.g., a "High" score on the risk assessment scale would be interpreted as having low risk and thus enhance feasibility). I consider habitat suitability to be the primary factor in determining overall feasibility; the rating for habitat suitability determines the highest possible overall rank. Evaluation scores for regional attitudes and risk assessment can lower that rank, but cannot raise it. When all 3 factors are considered, if 2 out of the 3 are the same, the final rank is equal to the common rank so long as it is not higher than the habitat suitability rank. For example, if a study site received a medium rank for habitat suitability and regional attitudes, and a low rank in the risk assessment, the overall rank would be medium (2 out of 3 = medium). On the other hand, if a study site received a medium rank for habitat suitability and a high rank for the other 2 factors, the overall rank would be medium (habitat suitability is limiting).

The Peaks of Otter (Shenandoah Mountain Region), Danville (Southern Piedmont Region), and Rehobeth (Southern Piedmont Region) study sites all have low overall feasibilities; each site is limited by low habitat suitability, due primarily to the small size of these sites. None of these 3 sites are capable of supporting a viable elk herd (≥400 elk, see Appendix 1) on their own, but the high levels of regional interest and acceptance expressed in these regions may allow them to become part of a larger range if nearby study areas are targeted for elk restoration. Danville and Rehobeth, both have high risk for future development and elk-landowner conflicts. Danville has a high human population density and growth rate, and neither Piedmont study areas have significant tracts of public land. I do not recommend restoration in these 2 areas, even as part of a larger effort, unless risk factors can be addressed.

The Shenandoah study site (Shenandoah Mountain Region) also has low feasibility. Although it potentially is capable of supporting a viable elk herd (>700 elk), regional attitudes generally are negative, and my risk assessment supports concerns raised in the area. Agricultural interests are a dominant force in this region; the Shenandoah study area is the state's most productive dairy and orchard region. Both industries are at risk for conflicts with a restored elk herd (dairy through fence destruction and competition with livestock, orchards through depredation on and physical damage to fruit trees). The linear shape of this study area further increases the potential for conflicts with local landowners by raising the probability that elk will use habitat outside of the study area. The Shenandoah study site also has a high human population density and growth rate, which negatively will affect the availability/suitability of habitat in the future.

The Southwest study site (Southwest Virginia Region) received a final rank of medium. This is a large study site with the potential to support a large elk herd (>900 animals). The risk of elk-human conflicts varies across the study site (low risk for elk-farmer conflicts and future habitat degradation in the western portions, high risk for both types of conflicts in the eastern portions). The linear-irregular shape of this study area presents an additional risk factor in that the distribution of elk will be difficult to manage. The negative attitudes of regional stakeholders toward elk restoration in Southwest Virginia is cause for caution. If elk restoration were attempted in this area, concerns of local landowners must be satisfied and a specific plan for how the herd will be managed must be developed.

Because the Southwest Virginia site is such a large, linear study site, I found it difficult to place 1 feasibility score on the entire site. I did not specifically analyze feasibility for sub-parts of a study area, but here overall feasibility clearly is higher in Dickenson and Buchanan counties than in other eastern portions. Representatives from the extreme western part of the study area were not present at the regional meeting (although they were invited), but other participants suggested that stakeholders from the western section may have reacted more positively than those from the east. My risk assessment for the western counties also was lower than for eastern counties; human population size is low, population growth is negative, few farms are present, and beef cattle is the dominant agricultural practice. The western-most portion of the study area lies directly adjacent to Kentucky's elk range, and elk likely will colonize this portion of the study area on their own. If restoration is deemed feasible for this area, separate releases in Virginia likely will not be necessary unless to speed up the process.

The Brookneal study area (Southern Piedmont Region) also received a final rank of medium. A viable elk herd (>500 animals) potentially could be supported by this study area, but the site is small. The risk of elk-human conflicts is high due to agricultural activities and the heavy reliance of farmers on cultivation of economically important, depredation-sensitive crops (e.g., hay, alfalfa). This site is at risk from future land development (and associated habitat loss), even though the human population density and growth rate currently are low, because it has no public land. Because stakeholders expressed positive attitudes toward elk restoration, it may be possible to address the potential risk factors. However, the absence of almost half the invited participants at the regional workshop make this conclusion tentative. Overall, elk restoration may be feasible in this study area, but other areas should be considered first.

Big Meadows (Shenandoah Mountain Region) has an overall rank of medium. This site is large and potentially capable of supporting a large elk herd (>800 animals). Regional attitudes change as one moves north to south, with the northern half most like the Shenandoah study area and the southern half most like the Highland study area. The importance of agriculture, in particular, apples and dairy production, creates a high risk of elk-landowner conflicts on the northern portion of the site. Further, most of the agricultural lands are located in the valleys of the major river systems (e.g., North Fork Shenandoah River) and are surrounded by large tracts of public forest land. This creates an especially high risk factor for elk-farmer conflicts. The southern portion of this study area also is dependent on dairy production, but apple production is much lower. Even though large tracts of public land (i.e., Shenandoah National Park, George Washington National Forest) are present in the Big Meadows study site, the habitat quality generally is low due to the lack of forest openings. The rapidly increasing human population suggests that habitat currently available on private lands may not be available in the future. Therefore, although elk restoration may be possible in this study site, extensive management would be required to minimize the risk factors.

The Highland study site received a high rank on all 3 factors. This large, contiguously shaped site contains large tracts of public land. It potentially can support a large elk herd (>900 animals), and regional attitudes reflect cautious support for elk restoration. The human population density is the lowest of any site examined, and its growth rate remains low. Total farm land acreage for the Highland site is moderate, but given its large size, the amount of agricultural activity is relatively low. The potential economic impact on existing cropland is low due the region’s low dependence on crop cultivation, with only a moderate reliance on dairy production in eastern counties. Although damage to fences is a risk factor in this area, the risks for crop depredation or competition with livestock are low. Compared to other study areas, the Highland site has the highest overall feasibility, and I recommend concentrating on this area if an elk restoration program proceeds.

Habitat Relationships and Implications to Feasibility

The best elk habitat in all areas (except for the Piedmont Region) occurs at the interface between private and public lands where the best interspersion of open and forested lands usually occur. This increases the risk for elk-landowner conflicts, especially where public lands make up a significant portion of the total land area. By improving habitat on public lands, elk may be less attracted to private lands, and the risk of elk-landowner conflicts may be reduced. Even though overall suitability of large public lands may by reduced by the presence of large tracts of uninterrupted forest, public lands still are critical to the success of elk restoration. The ability to perform habitat improvements will be imperative to effective management of any elk population along these interfaces

Restoration Considerations

One of the most important factors needed to successfully restore elk in Virginia is having a sound release program, which includes 1) properly selecting animals for release, 2) properly handling animals during captivity, 3) using appropriate methods for the release. Each of these issues is discussed below.

Founder Population

Assuring that genetic diversity exists in the founder population is an important first step toward successful restoration of a population because this diversity represents the genetic resources available to the population in the future. Unfortunately, genetic variability in the founder population can be reduced greatly as animals are selected for transport, much like a genetic bottleneck. This especially is true for elk, which often are captured as related family units. If diversity within the founder population is low, the population’s adaptive abilities may be repressed. Sufficient genetic variability depends on both the number and genetic makeup of the individuals selected (Leberg 1990).

To estimate the number of founders needed to ensure genetic viability, I first turned to estimating the minimum viable population (MVP, Appendix 1). Lehmkuhl (1984) explains that MVPs are calculated under the assumption that "the original numbers must constitute a viable, stable, closed population forever…The genetic consequences of a small *founder* population are not necessarily serious **if the population is allowed to expand**" (p. 168, bold emphasis is mine). Inbreeding and drift generally are problems only in perpetually small populations or when very few founders are released. Otherwise, these forces can be avoided with a few generations of robust population growth. However, the question still remains – how many founders is enough?

Leberg (1990) determined the minimum founder population (MFP) by estimating the proportion of genetic heterozygosity present in the source population that is retained by the founder population (Equation 4.1):

Equation 4.1

$$\%H_s = [1-1/(2N)]$$

where H_s = % heterozygosity retained by the source population

N = the number of founders.

This relationship suggests that a founding population of ≥10 animals can retain most (≥ 95%) of the genetic variation of the source population given 3 major assumptions: 1) the sex ratio in the founder population must be 1:1, 2) all animals must breed successfully, and 3) all 10 animals must be selected randomly and independently.

A 1:1 sex ratio for elk would be both unrealistic and undesirable given their harem mating system. This dilemma was addressed by Leberg (1990) using an adjusted equation (Equation 4.2)

Equation 4.2

$$Hs = [1-(N_f+N_m)/(8 \text{ x } N_f \text{ x } N_m)]$$

where N_f and N_m are the numbers of females and males (respectively) in the founder population.

Using the more typical sex ratio of 1 male:5 females common to eastern elk harems (Schonewald-Cox 1986, Bender 1996), the MFP would be 18 (3 males, 15 females). However, this assumes that all founders will reproduce. In many restorations, individuals disperse from the release site, die before reproducing, or simply fail to reproduce. Therefore, this estimate must be corrected for potential post-release dispersal and mortality and to allow for social structuring within the founder herd (Leberg 1990). From prior reintroduction experiences with elk, mortality among founders can be ≥20% during the first 6 months post-release, and dispersal varies widely (Anderson 1999, Grimes 1999).

Other assumptions of Leberg's (1990) model cannot be quantified. The model assumes that founders are unrelated, which may be idealistic because elk often are captured as family units and may be more similar genetically than randomly selected elk. Nonoverlapping generations is assumed; therefore, no allowance is made for nonreproductive yearlings to buffer the growth rate until new calves become active reproductively. Finally, it assumes that the founder population will grow rapidly ($r \geq 0.1$, Gogan and Barrett 1987, 1988). These factors were discussed by Leberg (1990), but he offered no suggestions for their mitigation. In past restorations, founder populations of ≥20 elk have been most successful, but the more elk released and the more groups released (on adjacent habitat), the more successful the program tends to be (Griffith et al. 1989, Witmer 1990). The chance of successful restoration increases rapidly as the number of founders increases, but levels off as that number reaches 20-40 individuals, depending on the quality of the habitat (Griffith et al. 1989).

Based on these considerations, a founder population of <20 elk could jeopardize the success of the restoration. Thus, if resources permit and management objectives endorse, I recommend releasing several (3-4) groups of ≥20 individuals (more if extensive dispersal is expected, Rogers 1988) with a sex ratio of at least 1 bull:5 cows (more bulls if possible) captured from different locations. This would ensure that several genetically distinct family units are represented and can interbreed. Griffith et al. (1989) and Parker (1990) supported these recommendations. However, project objectives largely will decide the magnitude of the initial release. If a smaller scale project is desired (e.g., an experimental herd), then additional animals should be added after the initial release if and when a decision to establish a sustainable elk population is made.

Elk Capture, Handling, and Transport

Determining which source herd to select individuals from is important to the health of the founder population. Wild-caught animals from a robust, flourishing population likely will fare better than captive-raised elk and will increase significantly the chance of restoration success (Griffith et al. 1989). Also, the source herd should be free of known high-risk diseases (see Prevention of Disease Transportation, page 99).

Capturing, handling, and transporting elk can cause physiological trauma; they have a "flighty and responsive" nature that makes them vulnerable to stress and stress-related diseases (e.g., capture myopathy) (Waas et al. 1999). In a monitored translocation study (Waas et al. 1999), heart rate, lactate concentration, and hematocrit concentration all peaked immediately after each transition (e.g., movement from holding pen to trailer or trailer to holding pen), and cortisol and sodium concentrations increased steadily during the 17-day study. These responses were linked to stress caused by extensive handling, new environments, and confined quarters. Sodium increases are associated with dehydration, and an increase in cortisol of >40% is associated with impaired immune functions (Barnett and Hemsworth 1990). To minimize these impacts, the amount of direct handling should be minimized, plenty of food and water should be provided (stress raises metabolic rate), only healthy animals should be translocated, and translocation during the rut, parturition, or lactation must be avoided (Wass et al. 1999).

Late fall/early winter is the best time to transport elk; cows will have been bred, calves weaned, and the rut will be over. However, translocations should be complete before animals become physiologically stressed during late winter (Parker 1990, Grimes 1999). Optimal months for transport are late November through January, but this will vary with the severity of the winter. If translocations are made too late, captured animals are more vulnerable to stress-related illness. In Kentucky, elk captured in Utah and transported early in the season during an average winter (1997-1998) experienced 21% mortality (primarily due to capture myopathy), whereas 75% of elk transported in March died due to stress related illness. During the milder winter of 1998-1999, stress related mortality was <5%, even though animals were translocated well into March (Grimes 1999, Grimes and Maehr 1999, Larkin et al. 1999).

Before translocation, elk should be examined using a health risk minimization protocol (see next page). Blood samples from all elk to be transported should be collected and frozen for future reference and research (Cornicelli 1999, Grimes 1999). Vitamin B shots should be administered to bolster the elks' immune systems (Larkin et al. 1999).

Prevention of Disease Transportation

Transportation of diseased animals is a concern with any animal translocation, but especially with elk due to their close phylogenetic relationship to deer (Family Cervidae) and cattle and sheep (Order Artiodactyla) and the potential for disease transmission among these species. Below, I summarize Nettles and Corn's (1998) protocol for minimizing the risk of importing diseases and parasites (previously listed in Chapter 2) that are linked to elk.

1) Select a healthy source population. Elk populations linked to chronic wasting disease (CWD), brucellosis, anaplasmosis, tuberculosis (TB), or paratuberculosis infections should not be used as source herds. Sources of information to determined herd status include published literature, necropsy records, State Fish and Wildlife Agencies, academic departments, and State Veterinarian's Offices. An elk population with "Monitored Herd" status is preferred (see Nettles and Corn 1998).

2) Quarantine captured animals. A 93-day pre-transfer quarantine period is recommended for animals obtained from unmonitored herds. This includes the 90-day waiting period between 2 TB tests plus 3 days to read the second test. A negative test for brucellosis within 30 days of transport also should be obtained. If the source herd has "Monitored Herd" status, the quarantine may not be necessary, but negative test results still should be obtained.

3) Examine and test captured animals. A licensed veterinarian should inspect animals for symptoms including swelling, hair loss, emaciation, diarrhea, alertness, lameness, and injury. A Certificate of Veterinary Inspection should accompany all shipments, and animals should be identified permanently. TB and brucellosis tests should be performed following U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS 1996, 1997) guidelines.

4) Eliminate parasites with prophylactic treatment. Use of broad-spectrum parasiticides (e.g., ivermectin) on captured elk prior to translocation is recommended.

The Release

Either a "soft" release or a "hard" release can be used to place elk into their new range. Soft releases involve holding and feeding elk in a temporary pen before letting them roam free. Soft releases allow managers to monitor the post-translocation condition of the animals (Parker 1990, Phillips 1997) while helping to establish group cohesiveness and acclimate them to the local area. This may encourage the elk to stay together and lower the chances of extensive dispersal after the final release. Providing high quality forage (e.g., alfalfa, hay) at the enclosure site during containment and for a short time after release may further decrease the chance for extensive dispersal; elk will be encouraged to return continually to the holding area. Elk can be held in this temporary enclosure for up to several months, although the advantages of social cohesiveness and recovery from transport maximize after about 3 months (Gogan and Barrett 1988). Soft releases do have disadvantages, however. First, a soft release adds significantly to the total cost for translocation (Phillips 1997), although creating a simple enclosure with cattle paneling can minimize this cost (Parker 1990). Second, the location of the enclosure needs to include all the necessary habitat components (e.g., water, cover). Third, unless the enclosure's location is kept secret or patrolled, human visitation may further stress the animals and contribute to their domestication (Phillips 1997).

Hard releases are cheaper and faster than soft releases in that elk are allowed to roam free as soon as they step off the truck. However, dispersal often is greater after a hard release. Although 75% of the elk hard released in Kentucky remained within 20 km of the release site, some have traveled >60 km (Larkin et al. 1999). This extensive dispersal also has occurred with other hard releases of elk (Parker 1990). Monitoring of post-release mortality also is more difficult with hard releases. Although use of radio collars with mortality sensors may facilitate this, it often is difficult to locate free-ranging elk in time to perform a full necropsy.

Although Kentucky's Department of Fish and Wildlife Resources (KDFWR) used hard-release method, I do not recommend it for use in Virginia. The conditions present in Kentucky that made a hard-release possible (13-county area with little agriculture, large tracts of public land, low human population densities, and the desire to release large numbers of animals, Grimes 1999) are not present in Virginia except, perhaps, in the far western portion of southwest Virginia. I recommend using a soft release and keeping elk in a temporary enclosure for at least several weeks, preferably >1 month before final release.

For a soft-release, the release site must 1) be large enough to temporarily support the founder population with minimal feeding (~280 ha for 30 elk, Long 1995), 2) include both open and forested habitat with a mix of ≥20% open lands and ≥60% forested lands, 3) include a natural, permanent water source, 4) be on a large tract of public property, 5) be surrounded by large tracts of public property and/or private landowners who are willing to cooperate in the restoration attempt and support the herd as it grows, and 6) be accessible by cattle trailer for bringing elk in.

Regardless of the release method selected, post-release monitoring is imperative. This can be accomplished with radio collars placed on every released elk, or through a combination of radio collars and Global Positioning Systems (GPS) collars, though GPS collars would add considerable expense. Post-release mortality should be tracked to determine causes of mortality. Post-release dispersal should be tracked to anticipate or help predict (and hopefully avoid) elk-human conflicts and to monitor the herd's social organization and patterns of habitat use. The initial radio-collaring also will be important later for monitoring calving rates, population growth rates, and population sex ratios.

Management Implications

Before any decision to restore elk is made, it is important to consider the actions that need to be taken to prepare for elk restoration, management scenarios that may arise after elk are released, and management options available to deal with those issues. I discuss my recommendations by referring to pre- and post-release implications, depending on when action needs to be taken. It is critical, however, that each time periods be considered and planned for before a decision about elk restoration is made and before any animals are released.

Pre-release Management Implications

Public Involvement

A critical pre-release management need in any restoration effort is to get the public involved early in the planning process (i.e., pre-release) and to keep them involved during the management phase (i.e., post-release) (Reading et al. 1997, Lauber and Knuth 1997, 1998). Regarding elk, this includes informing people about elk, the objectives of and plans for elk restoration, the potential for elk-human conflicts, and the methods available to mitigate those conflicts. Although this educational campaign should target primarily the communities in and around the proposed elk range, the general public also would benefit. The future success of an elk management program will depend on complete openness and honesty; no pertinent information should be withheld. For instance, if the public is not made aware early in the planning process that hunting may be an important elk management tool, then it will be especially difficult to obtain public support for a proposed elk season when it becomes needed.

The public also should be involved in discussions related to setting restoration objectives, acquiring funds for the project's implementation, designing regulations pertaining to released elk, the siting, design, and operation of elk viewing facilities, and preventing and mitigating crop depredation and property damage. Management agencies, such as the U.S. Forest Service or National Park Service, and on whose land elk restoration likely would depend, need to be involved early. By getting community organizations involved, such as economic development agencies and tourism centers, the potential benefits of elk restoration may be realized early in the process. Partnerships with private conservation-oriented organizations will be critical both in securing funding for elk restoration and in implementing the educational campaign. Agricultural organizations must be partners in the planning process to help develop acceptable and effective conflict management programs.

Finally, it is imperative to communicate and cooperate with natural resource managers in neighboring states (e.g., West Virginia, North Carolina). Due to the constraints of this study, the size of my study areas were limited by the Virginia state boundary. In reality, the potential elk ranges I identified may extend well into neighboring states, and it is realistic to assume that elk released in these study areas (e.g., Southwest, Highland, Shenandoah) will disperse across the state line.. The concerns of managers in these states should be considered both in the initial decision-making process regarding elk restoration and in post-release management planning. Decisions must be made in advance as to what will be done if animals cross state boundaries

Regulatory Concerns

Under current wildlife regulations, elk are classified as deer and would be subject to the same hunting seasons, poaching regulations, and damage management programs. Thus, before any elk are released, separate regulations would have to be set for an elk population that address 1) its initial sensitivity to excessive mortality (Skubinna and Van Dyke 1991), 2) its attractiveness as a source of trophies for poachers, 3) its potential to damage private property and agricultural crops, and 4) its potential to serve as a game species in the future. Steps to limit human-induced mortality in released elk, including poaching, hunting, or molesting, must be enacted. Poaching is the primary source of nonhunting mortality in Michigan, Pennsylvania, and Arkansas, but stiff penalties and education programs have reduced poaching losses significantly (Parker 1990). Kentucky has given elk protected status and punishes elk poachers with 1) fines of $1,000-$5,000 and/or ≤6 months in prison and 2) fines equal to either the replacement costs of the poached elk or double the monetary gain received for the poaching activity, whichever is greater (Grimes 1999). Prior to March 1999, 2 elk had been poached in Kentucky (1 during deer season); both offenders received $5,000 fines and lost their hunting licenses for 3 years. Similar regulations could be adopted in Virginia. Second, managers must have the ability to establish seasons and regulate elk hunting seasons should the population reach a level that would sustain hunting. Third, provisions should be made for the controlled removal of elk (e.g., kill permits, agency removal) known to cause damage to private property within and outside of the delineated restoration area.

The last regulatory concern is a contingency plan. Despite the best advance planning efforts, it is possible that elk restoration will present unsolvable, unacceptable, or unforeseeable problems. Collectively, elk managers, public agencies, private organizations, and the general public may determine that continuation of the elk restoration program is undesirable. Using a soft-release and starting out with a small "experimental" herd would facilitate cessation of an elk restoration program, but it still will be necessary to establish how released animals will be removed. Although it will not be popular with a large segment of the public, it is necessary to recognize this possibility and involve the public in determining how the decision will be made and implemented before elk are released; it will be much more difficult to implement a contingency plan if the public is not aware of it until it is needed.

Post-release Management Implications

Conflict Management

Conflicts between landowners and elk likely will be the biggest problem in an elk restoration project (Sullivan et al. 1991). Affected landowners view elk damage as an unfair burden thrust upon them while the rest of the public enjoys the benefits. To amend this situation, benefits available to affected landowners must be increased and/or the costs that they experience must be mitigated (Wywialowski 1994). Specifically, the benefits of elk restoration experienced by landowners must exceed the costs incurred from elk damage (Baumeister 1996). Benson (1992) suggested that benefits to landowners may be increased by allowing them to control and charge access fees for recreational activities, such as hunting, that occur on their land (Benson 1992). Other ways to increase benefits to local landowners is through purchase of lands or the creation of conservation easements through contractual leases (Lyon and Ward 1982, Guynn and Steinback 1987, McDivitt 1987).

Elk-landowner conflicts also can be addressed by minimizing the economic impacts of elk damage on affected individuals. Direct monetary compensation is controversial, and few states offer such programs; it treats the outcome of elk depredation rather than the source and, therefore, is short-term and ineffective at reducing total damage (Sullivan et al. 1991, Wagner et al. 1997). Instead, damage prevention must be encouraged, and the management agency should help landowners acquire these materials. DeCalesta and Witmer (1994) and Curtis et al. (1994) review possible damage prevention/control measures, including fencing, repellents, sonic devices, diversional food plots, kill permits, and targeted hunting programs. Regulated hunting would apply to an elk herd that has grown large enough to sustain the desired harvest (Grimes 1999), and requires the involvement of affected landowners in setting regulations, determining the distribution of the harvest, and obtaining hunter access to private land (Sullivan et al. 1991). Fencing also may be a viable option (e.g., Benner 1999, Bryant et al. 1993, Knight et al. 1997, Bauman et al. 1999). However, fence maintenance costs generally are high, and unmaintained fences become vulnerable to damages as elk attempt to get through (Lyon and Ward 1982). If a fencing program is implemented in Virginia, it is important to provide not only for fencing materials and installation, but for fence maintenance as well.

Perhaps the most important action that can be taken to prevent elk-landowner conflicts from precluding a successful restoration is to involve landowners in decisions about elk management and to listen and attend to their concerns (Sullivan et al. 1991). If property damage becomes an issue, it may be helpful to assign 1 person the duty of interacting with the landowners, monitoring damage complaints, explaining potential management options, and assisting in the implementation of the chosen plans. Such an assignment may create a sense of consistency and foster trust between the landowner and the manager.

Elk-vehicle collisions are a second type of conflict that can be addressed. Concern for road safety is an important issue for the public due to previous experiences with deer and reflects the fear that elk-vehicle collisions likely will be more costly in terms of both property damage and human injury/trauma than are deer-vehicle collisions. Elk may be especially vulnerable to vehicle collisions during the early stages of restoration because animals are not familiar with the new area and are more likely to encounter roads during home range establishment and territory exploration (Grimes 1999). However, the frequency of elk-vehicle collisions once an elk population becomes established is likely to be low (≤1 collision/113 elk/year) and will depend largely on the density of roads within the elk range (SEAFWA 1997). There are few ways to reduce elk-vehicle collisions other than fencing along roads, posting and enforcing stricter speed limits, and posting “elk-crossing” signs to increase driver awareness (Reeve and Anderson 1993, Romin and Bissonette 1996, Lehnert and Bisonette 1997, Ujvari et al. 1998). In some areas, blinking “elk crossing” signs have increased speed limit compliance and reduced elk-vehicle collisions (Barber 1996).

Population Management

One of the primary ways to minimize conflicts between elk and landowners is to maintain the elk population at or below cultural carrying capacity. This also is an important means to minimize ecosystem impacts. Annual estimates of population size, young:adult ratios, and sex ratios are needed to determine the condition of the population and whether it is increasing, decreasing, or stabilizing (Gogan 1990, Lyon and Ward 1982, Bender 1996). Information on elk habitat use and distribution (e.g., public vs. private land, proximity to water sources, proximity to population centers) and movement patterns (e.g., highly mobile vs. well-defined home ranges) is essential. If the founder population is radio-collared, monitoring initially will be simple, but, as the unmarked portion of the population increases, other means of monitoring will be needed. Aerial techniques have been developed to census elk herds living in dense forest cover (Bear et al. 1989, Otten et al. 1993, Peterson and Page 1993, Weckerly and Kovacs 1998). These techniques generally are most effective during leaf-off seasons (e.g., winter, early spring) and when elk are most active (e.g., early in the morning).

Given that elk could become a significant tourist attraction for nonconsumptive wildlife users, potential conflicts with hunting interests may arise. If an elk hunting season is ever opened in Virginia, whether for damage management or recreational purposes, seasons should be set to maintain the viewability of the herd. This is a primary goal in Michigan, and the elk season there is designed to minimize the wariness of the elk herd (Bender et al. 1999). A season that lasts too long or occurs during a sensitive time of year (e.g., the rut) may increase elk wariness and decrease viewer satisfaction (Kuck et al. 1991, Bender et al. 1999). Michigan holds an early hunt in September (early in the rut) on private lands surrounding the primary elk range to curb conflicts with local landowners, and a later hunt in December (after the rut ends) to reduce population size on the primary elk range (and primary viewing area, Bender et al. 1991, 1999; Matthews 1999). Michigan hunters harvest 14-18% of the herd in December with >90% hunter success (Bender et al. 1999). Given this success rate, the number of permits issued must be controlled carefully, and herd size can be controlled within a narrow margin (Michigan's goal = 800-900 animals post-harvest, Matthews 1999). There has been no change in viewer satisfaction as a result of these hunting seasons, and the program is considered a success (Bender et al. 1999, Matthews 1999).

When elk hunts are conducted to maintain a particular population size, the sex ratio among harvested animals is critical. Both Michigan and Arkansas issue specific bull and cow (antlerless) permits so that cows make up ≥50% of the harvest (Cartwright 1999*b*, Matthews 1999). This mitigates the effect of hunting on the sex ratio of the herd by preventing an over-harvest of bulls. On some western ranges, over-harvest of bulls has resulted in bull:cow ratios of <10 bulls:100 cows (with a desired sex ratio of 60 bulls:100 cows) and <1 mature bull:100 cows (Demarchi and Wolterson 1991, Carpenter 1991). Maintaining a high bull:cow ratio in the herd will keep harems relatively small (1 bull:5 cows) and may minimize conflicts with landowners and damages to the ecosystem by keeping elk groups small during the rut (Bender 1996).

Elk hunting is likely to be controversial with some segments of the public at first. Education programs that encourage ethical hunting behavior can raise awareness and acceptance among the general public (Freddy et al. 1993). Elk and deer management units in Michigan have different boundaries to encourage the notion that deer and elk are different and require different management strategies (Matthews 1999). Arkansas has implemented an extensive elk hunter education program that requires all elk hunters to attend an orientation/training session where hunting techniques, elk identification, and hunter ethics are emphasized. When a hunter goes into the field, he/she must have an unarmed friend present to help retrieve downed elk. An Arkansas Game and Fish Commission (AGFC) staff member also must be present during each hunt to serve as a monitor (Cartwright 1999*a*, 1999*b*). Although these regulations raised the administrative costs of the hunt, they have produced high hunter success and satisfaction and public acceptance of early elk hunting seasons.

In addition to managing the size and composition of an elk herd, it may be necessary to influence its distribution. This can be done 2 ways: trap and transfer, and habitat improvement. Pennsylvania recently initiated a trap and transfer program to move elk from an area with large tracts of private lands, high elk population density, and high risk for elk-landowner conflicts to one about 40 miles from the capture site with few private lands (Mitchell 1998). Although a few animals have moved back toward the traditional elk range, most have stayed at or near the release site (Benner 1999).

Kentucky and Arkansas initiated habitat improvement/management programs that involve creating forest clearings, field maintenance (e.g., mowing), and food plot seeding and fertilizing (Michael Cartwright, AGFC, personal communication; Grimes 1999). In Virginia, distribution and habitat use data for elk, together with my habitat model (Chapter 2), could help identify where habitat improvements are necessary and what types of improvement should be made. Creation of forest openings in heavily forested areas and closure of roads, particularly in key habitat areas during critical parts of the life cycle (e.g., calving or rutting areas) are likely options. Creating new forest openings and/or planting existing forest openings with a mixture of warm and cool season grasses may lure elk off of high-risk private feeding grounds and onto public land (Devlin and Tzilkowski 1986). Forest clearing operations should be performed outside the rut and calving periods, the extent of road construction should be minimized, and constructed roads should be reseeded with grass cover after the clearing operation is complete. Size and shape of clearings should be planned so that edge is maximized and the core space is <180-270m (maximum width ~500 m) from forested cover (Lyon 1975, Lyon and Ward 1982, see Chapter 2 of this document).

Tourism

To experience the full benefits of elk tourism, viewing area(s) must be established where elk are likely to be seen during most of the year. These may be simple pull-off facilities with an overlook, or may be as complex as a park-like facility with walking trails, educational displays, viewing scopes, visitor centers, and interpreters. Pennsylvania currently has no formal viewing area, yet large numbers of tourists continue to look for elk along roadsides and established trails (Shafer et al. 1993). The lack of viewing areas has created overcrowding problems in small towns near the elk range and has contributed to resident dissatisfaction with tourist activities. An established viewing facility may minimize these problems. Pennsylvania currently has plans to open an Elk Heritage State Park with a visitor center, dining/lodging facilities, research and educational facilities, educational displays, and walking and driving tours (Cameron County Echo 1998). Arkansas also recently has added educational displays to their pull-off facilities (Cartwright 1999). The educational value can be enhanced with displays about elk biology, history, and management, safety issues for elk viewing, information about other area attractions, and the availability of brochures for viewers to take home and share with others (Barber 1996).

Conclusions

Many potential conflicts (i.e., property damage, ecosystem impacts) can be mitigated and/or prevented by carefully managing an elk's population size and distribution. Managing at or below cultural carrying capacity will minimize the impacts of an elk population on both the ecosystem and private property. The numbers I present in this study as preliminary population objectives are first approximations of cultural carrying capacity (see Chapter 2), but these numbers will need to be adjusted up or down as the elk population grows and the true impacts are realized.

Economic benefits of elk restoration can be realized through hunting and tourism and associated services; economic costs can occur through crop depredation, property damage, elk-vehicle collisions, and management costs. These costs and benefits will vary depending on the size of the elk herd, the degree to which an elk tourist industry is developed, the size and administration of an elk hunt, the amount of economically vulnerable agriculture in and around the elk range, the degree of fragmentation by roads, and the extent of the management program (e.g., habitat improvement). Elk restoration in the Piedmont Region likely would incur high costs in crop depredation and elk-vehicle collisions, but would have low habitat improvement costs. Elk restoration in the Highland study area likely would incur lower crop depredation costs but may require significant habitat improvement efforts. Although the start-up costs of restoration likely will outweigh the economic returns for the first several years, elk restoration is capable of returning significant economic returns to the community.

Besides selecting the most feasible location, the best way to ensure success in an elk restoration program is to work closely with the public and involve them in management decisions. Building partnerships through public involvement can instill a sense of ownership and pride in the project and encourage cooperation towards the goal of sustaining a restored population. For this to work, a forum must be provided where potential and actual problems can be discussed and solved, interest groups learn about the potential costs and benefits for other groups, and a mutual respect can be fostered between interest groups.

There clearly are many factors that must be considered before elk restoration is attempted. I have addressed what I believe to be the most critical factors in this study, but there undoubtedly are factors that have not been addressed and may not even be identified until well into an elk restoration program. Based on the factors addressed in this document I believe that elk restoration is feasible in parts of Virginia, and especially in the Highland study site, so long as efforts are made to involve the affected public in addressing potential concerns beforehand and the objectives of restoration (e.g., elk population size, range boundaries) remain flexible. It is now the decision of the managers and the community as to whether this can be accomplished.

Figures

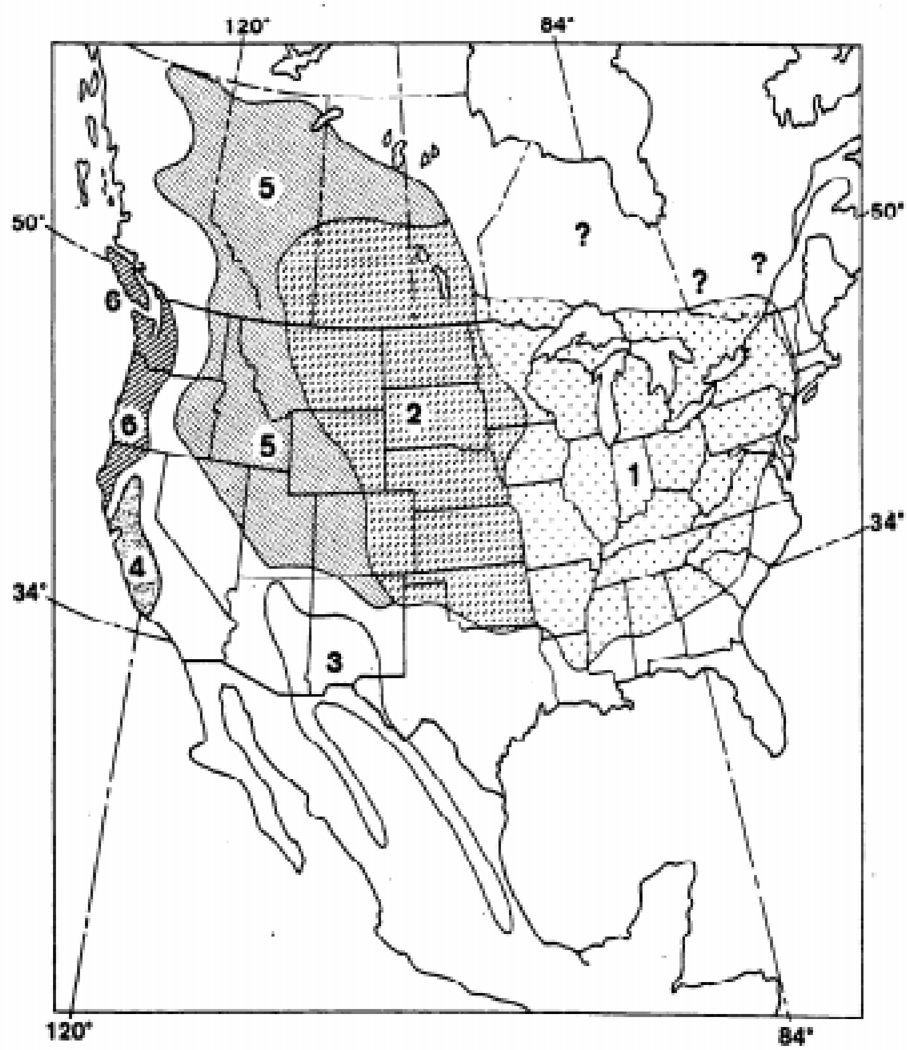


Figure 1.1. Historical distribution (prior to 1850) of North American elk subspecies, as depicted by Bryant and Maser (1982). Key to subspecies: 1-Eastern elk (Cervus elaphus canadensis Erxelben 1777), 2-Manitoba elk (Cervus elaphus manitobensis Millais 1915), 3-Merriam elk (Cervus elaphus merriami Nelson 1902), 4-Tule elk (Cervus elaphus nonnodes Merriam 1905), 5-Rocky Mountain elk (Cervus elaphus nelsoni Bailey 1935), and 6-Roosevelt elk (Cervus elaphus roosevelti Merriam 1897).

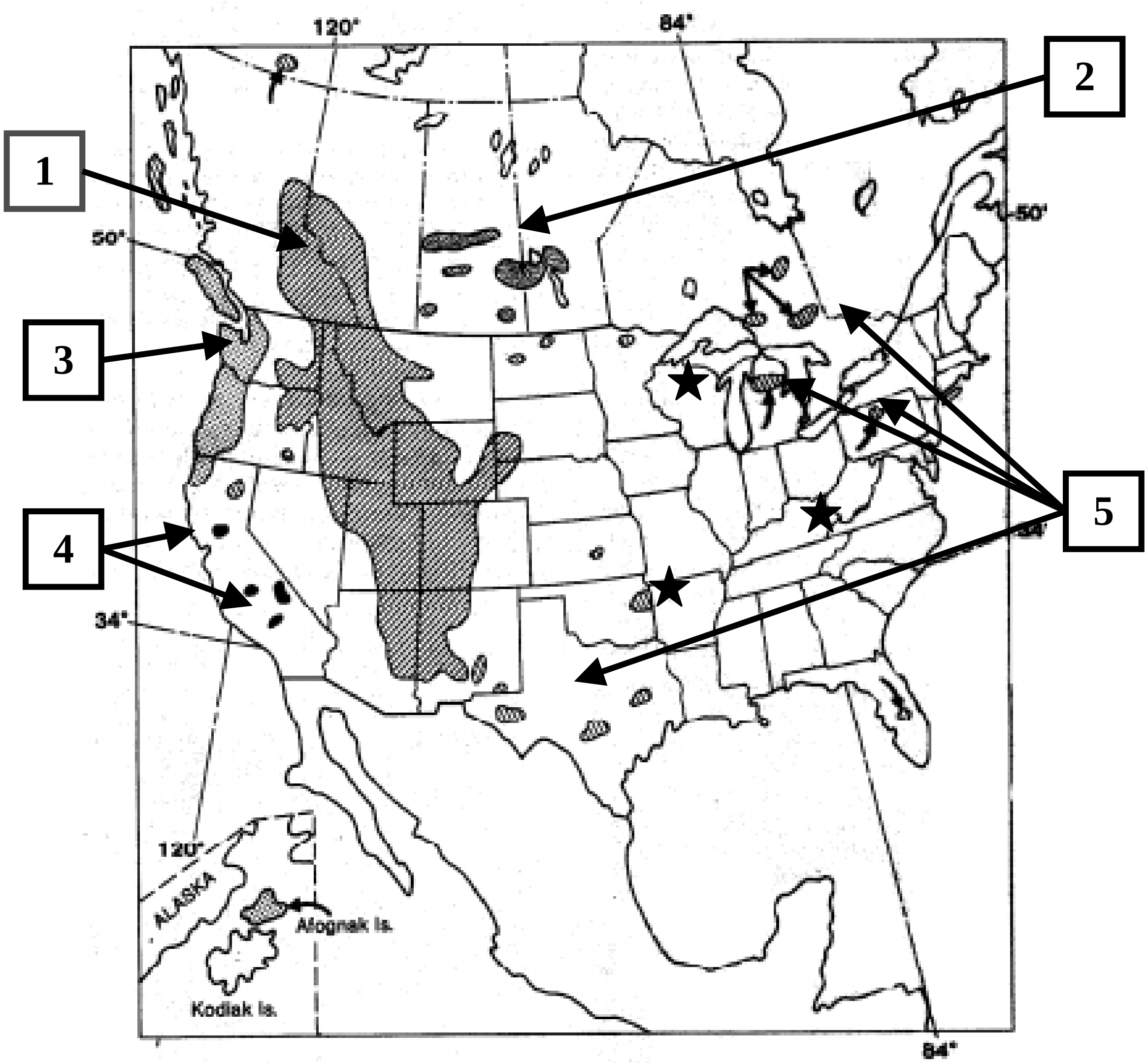


Figure 1.2. Current distribution of North American elk subspecies as depicted by Bryant and Maser (1982). Key to subspecies: 1-Rocky Mountain elk (Cervus elaphus nelsoni Bailey 1935), 2-Manitoba elk (Cervus elaphus manitobensis Millais 1915), 3-Roosevelt elk (Cervus elaphus roosevelti Merriam 1897), 4-Tule elk (Cervus elaphus nonnodes Merriam 1905), 5- populations of Rocky Mountain elk established prior to 1980, Stars indicate populations of Rocky Mountain elk established since 1980.

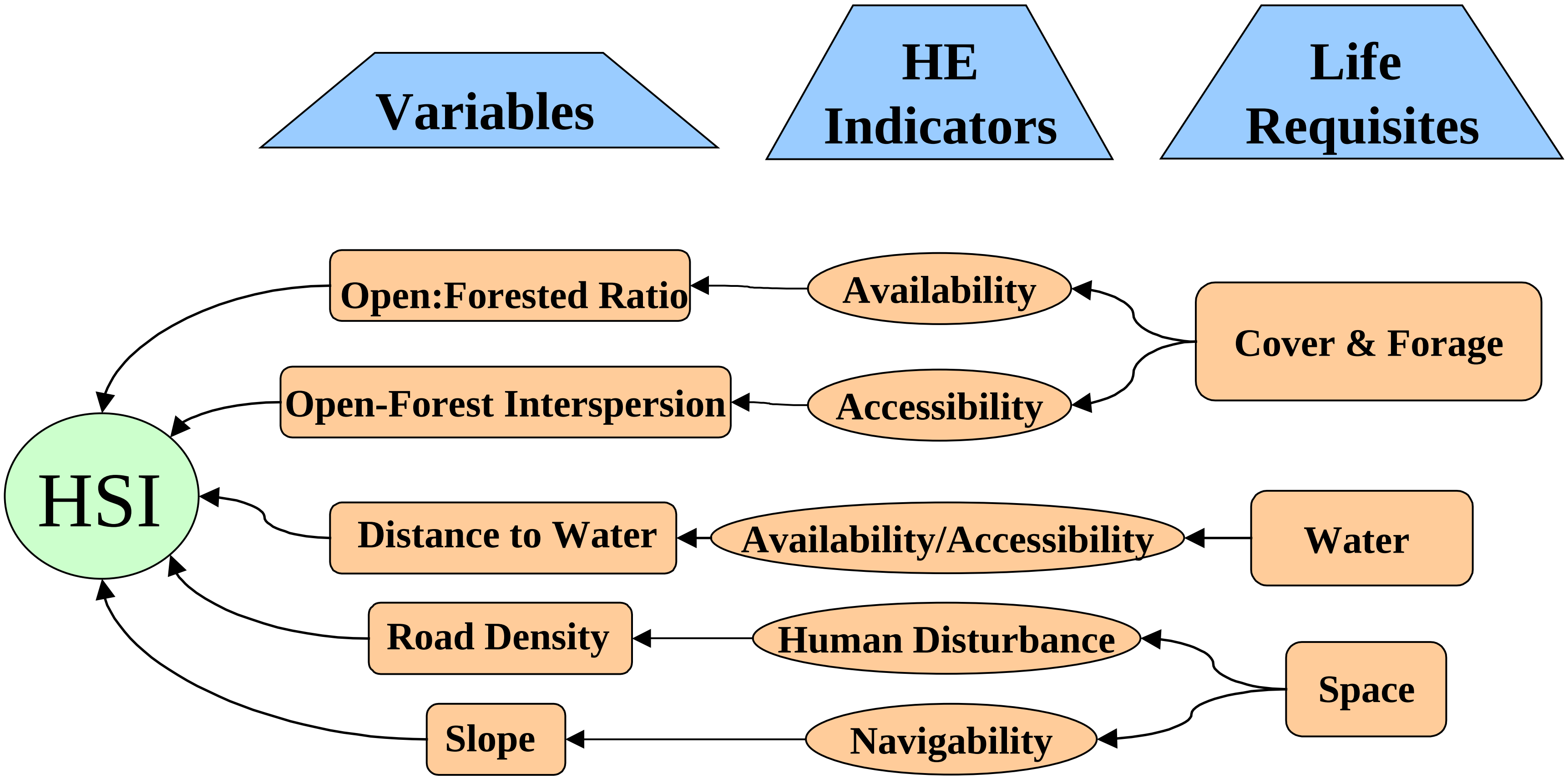


Figure 2.1. Structure of a habitat suitability index (HSI) model for elk in Virginia. Each life requisite corresponds to a measure of habitat effectiveness (HE) which is measured by 1 of 5 variables in the model. These 5 variables then combine to produce a single index of habitat suitability.

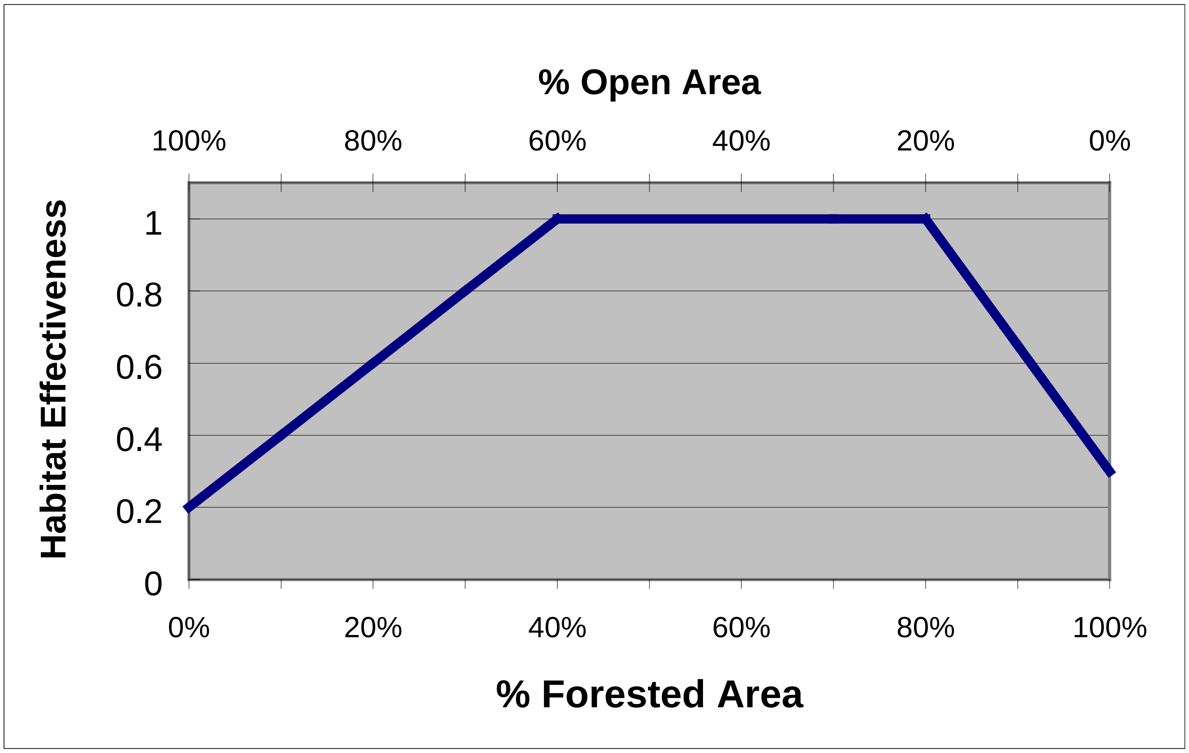


Figure 2.2. Scale used to determine the habitat effectiveness score for potential elk habitat as determined by landscape composition (HE_C) in Virginia. Scores are based on the proportion of forested and open area composing a unit of haibtat 1 km^2 in size. Open areas include any areas with <60% canopy closure (i.e., grass and shrub lands); forested areas include any areas with ≥60% canopy closure.

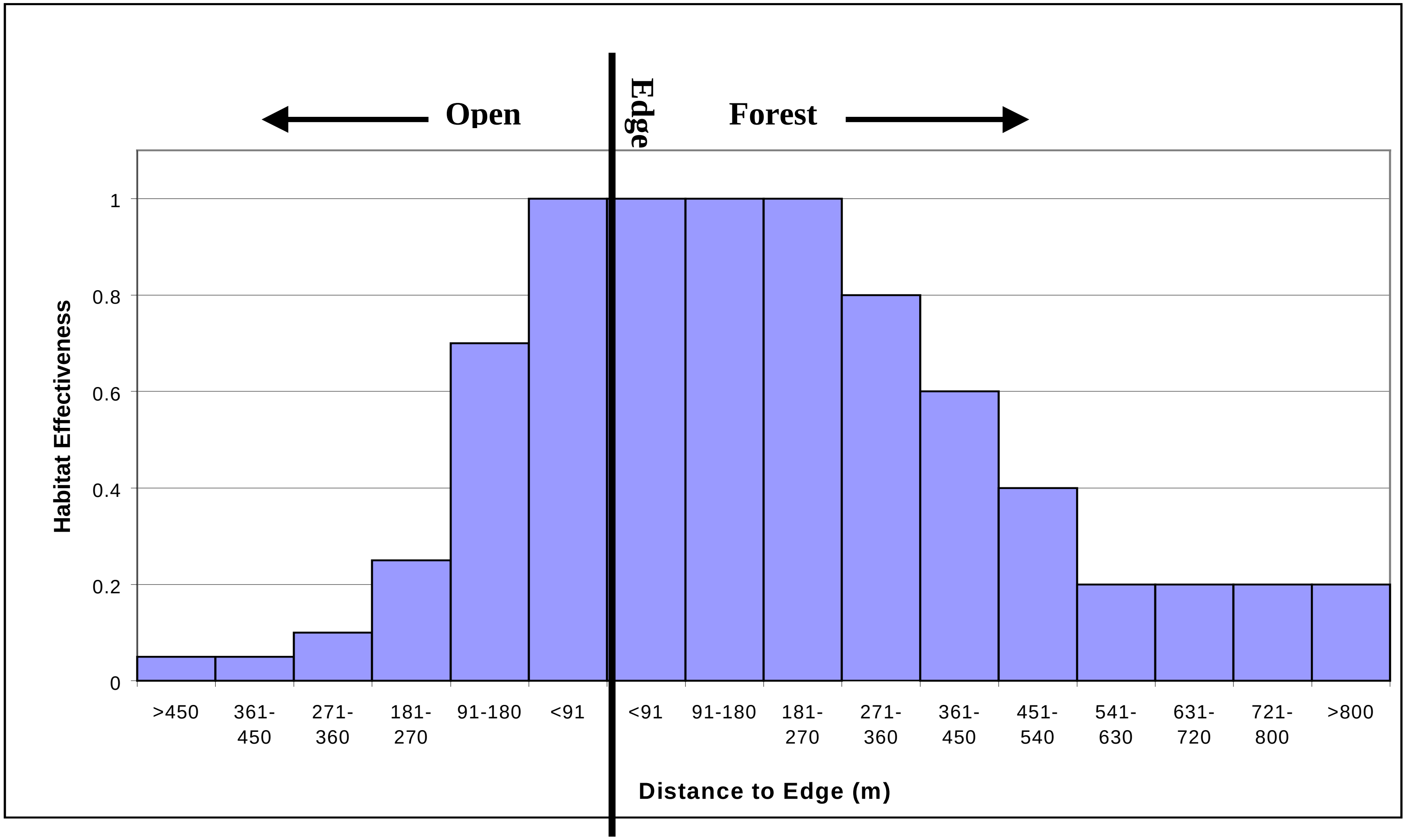


Figure 2.3. Scale used to determine the habitat effectiveness score for potential elk habitat as determined by landscape interspersion (HE_I) in Virginia. Scores are based on the distance of any given forested or open point in the landcscape to an open:forest edge. Open areas include any areas with <60% canopy closure (i.e., grass and shrub lands); forested areas include any areas with ≥60% canopy closure.

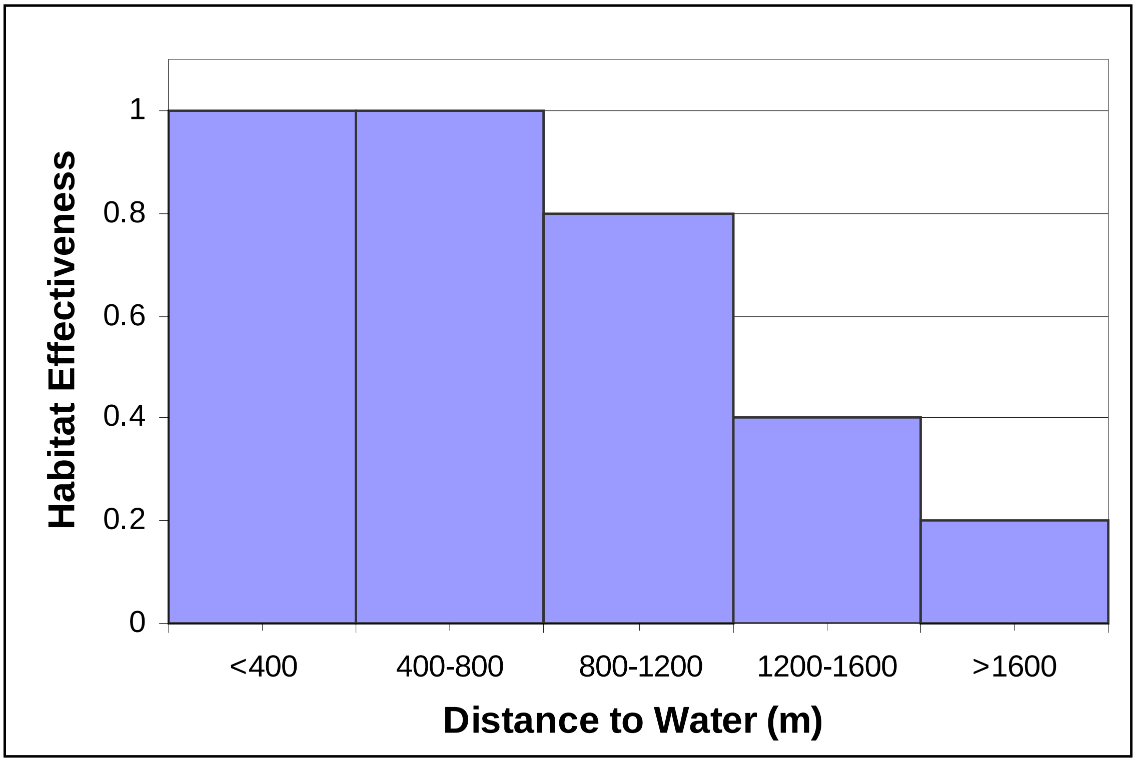


Figure 2.4. Scale used to determine the habitat effectiveness score for potential elk habitat as determined by permanent water features (HE_W) in Virginia. Scores are based on the straight-line distance (in meters) of a given point in the habitat from a permanent water feature.

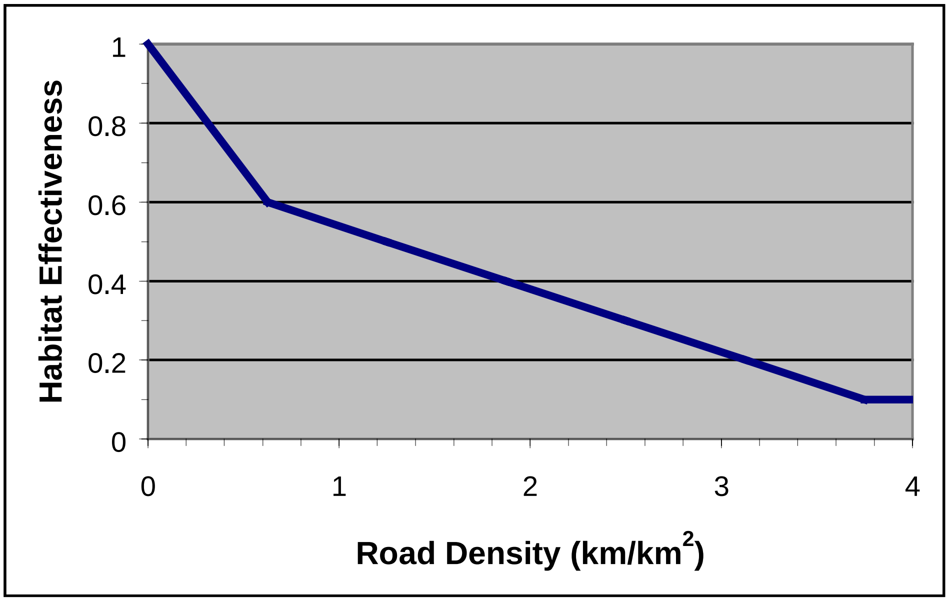


Figure 2.5. Scale used to determine the habitat effectiveness score for potential elk habitat as determined by road density (HE_R) in Virginia. Scores are based on the density (km/km^2) of minor roads (Class 3 and 4 as classified by the 1985 U.S. Geological Survey digital line graphs) occurring within 800m of a given point in the habitat.

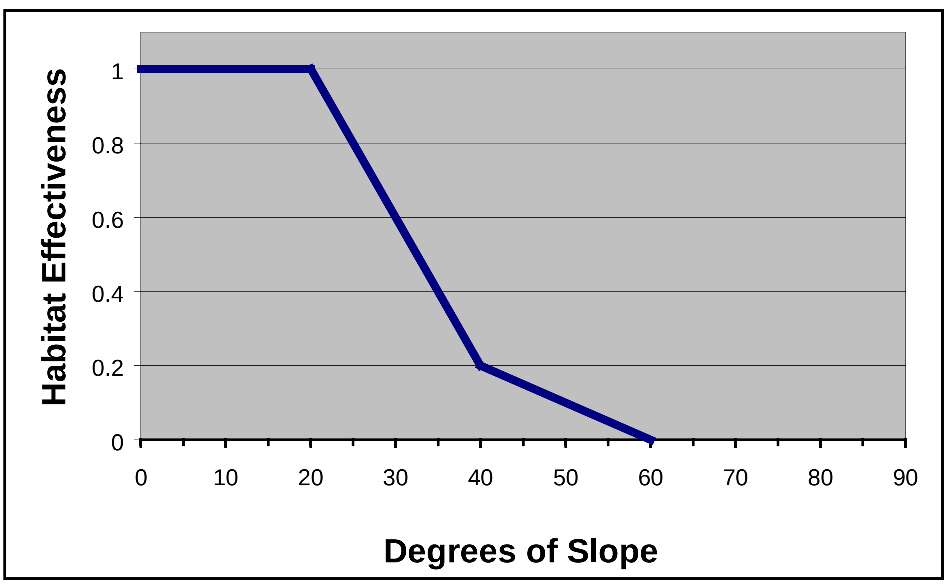


Figure 2.6. Scale used to determine the habitat effectiveness score for potential elk habitat as determined by slope (HE_C) in Virginia. Scores are based on the calculated slope of a given point in the habitat.

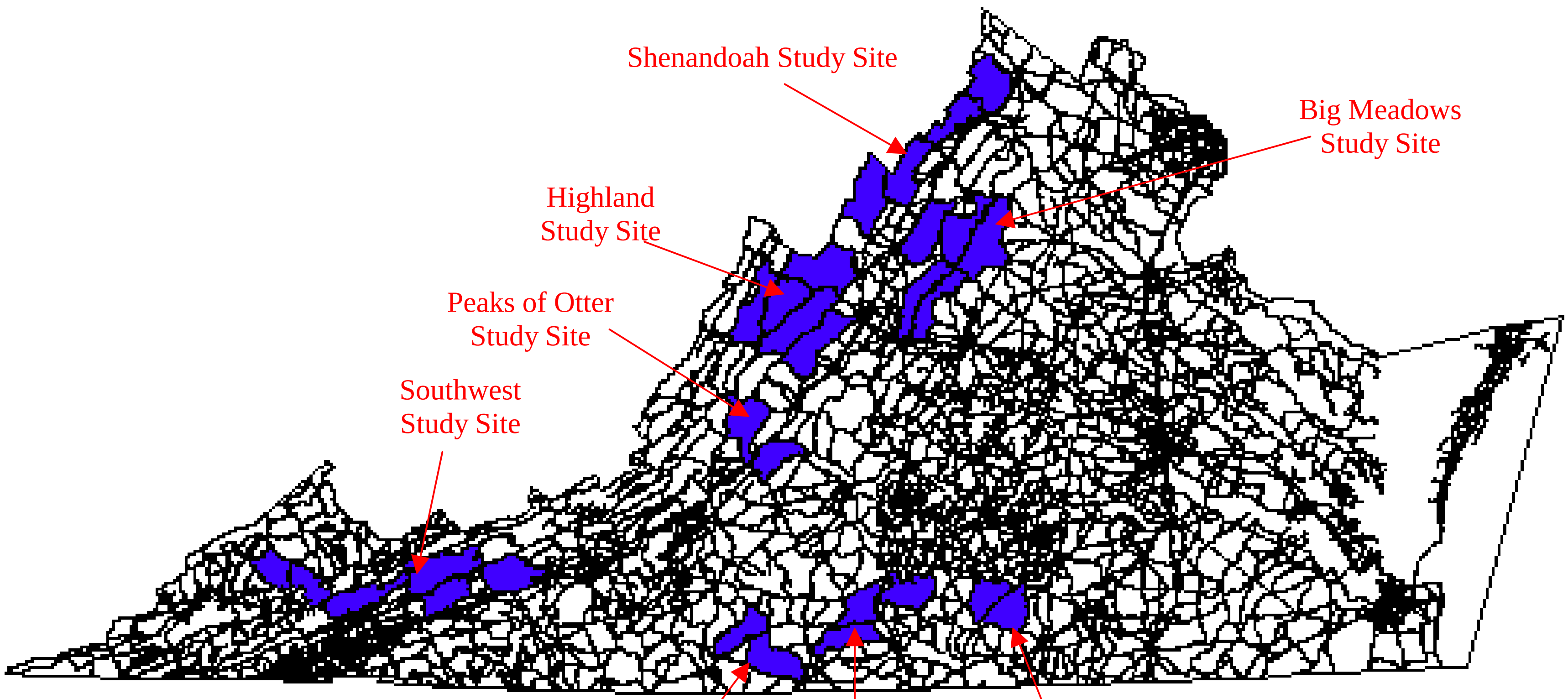


Figure 2.7. Location and physiographic relationship of potential elk habitat study sites in Virginia. Boundaries of polygons composing a study site were defined by major roads (Class 1 and 2 as classified by the 1985 U.S. Geological Survey digital line graphs). Polygons are ≥25,000 ha in size and must lie directly adjacent to ≥1 other polygon of ≥25,000 ha.

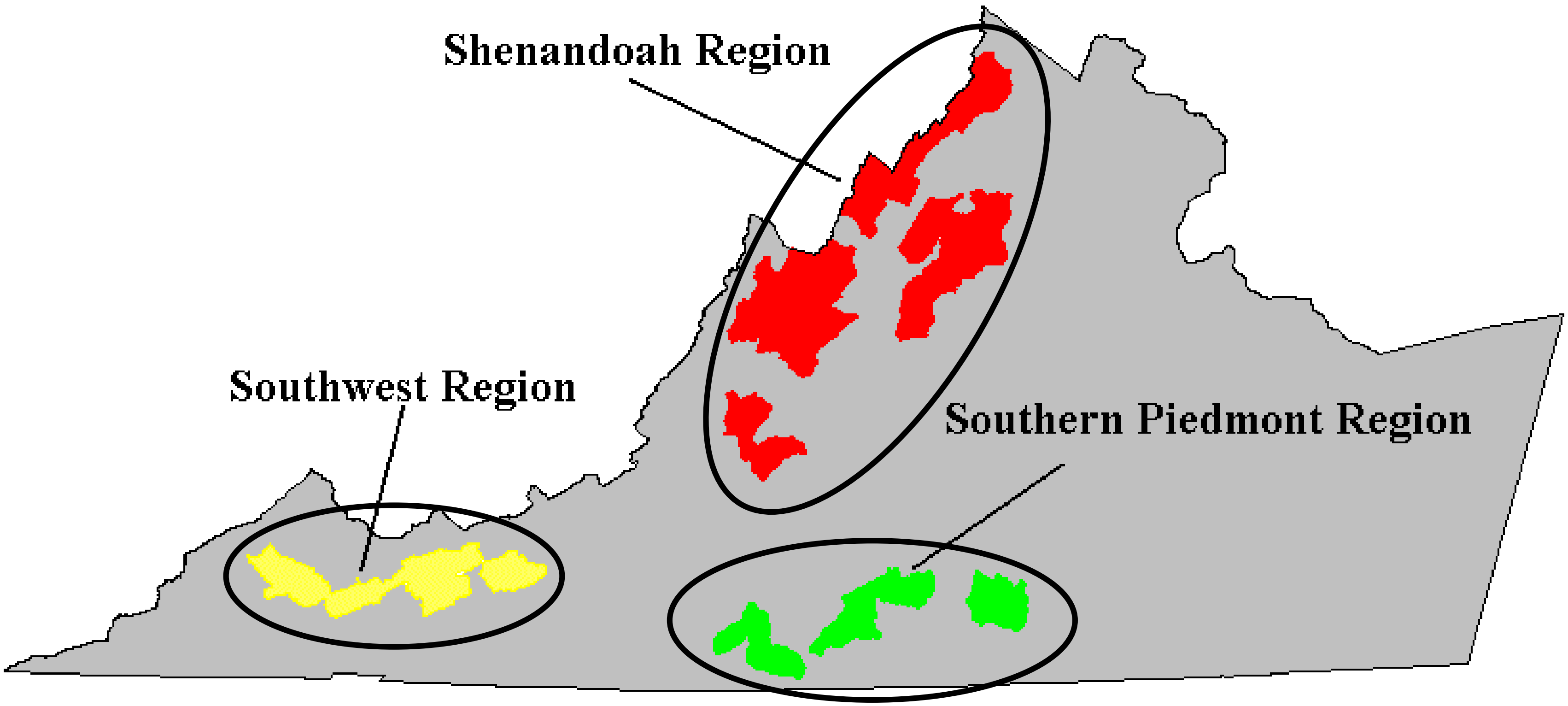


Figure 2.8. Potential elk restoration study sites, as consolidated into regions to facilitate the biological and socioeconomic feasibility assessment.

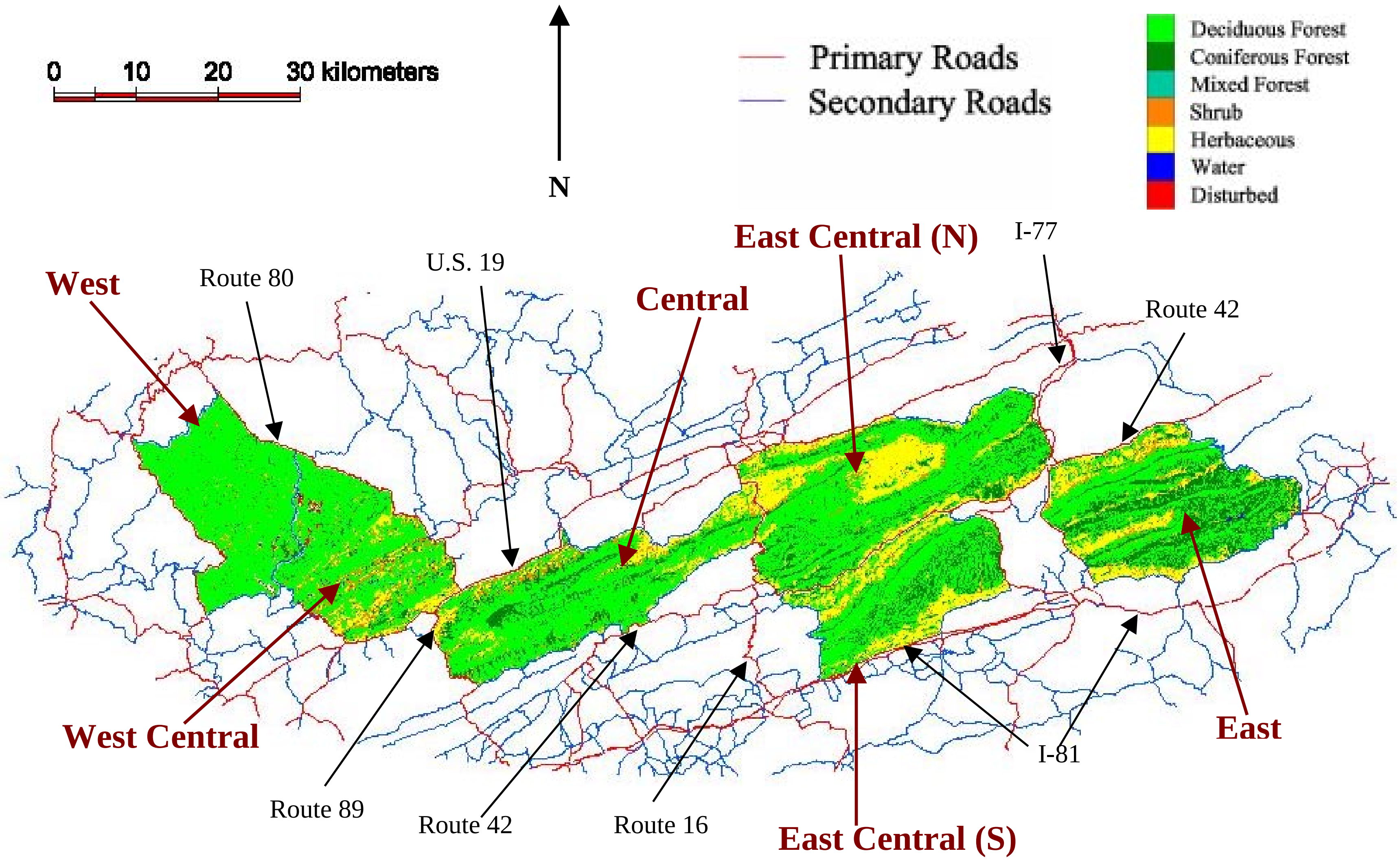


Figure 2.9. Location, boundaries, and existing land uses of the 6 polygons composing the Southwest Virginia study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

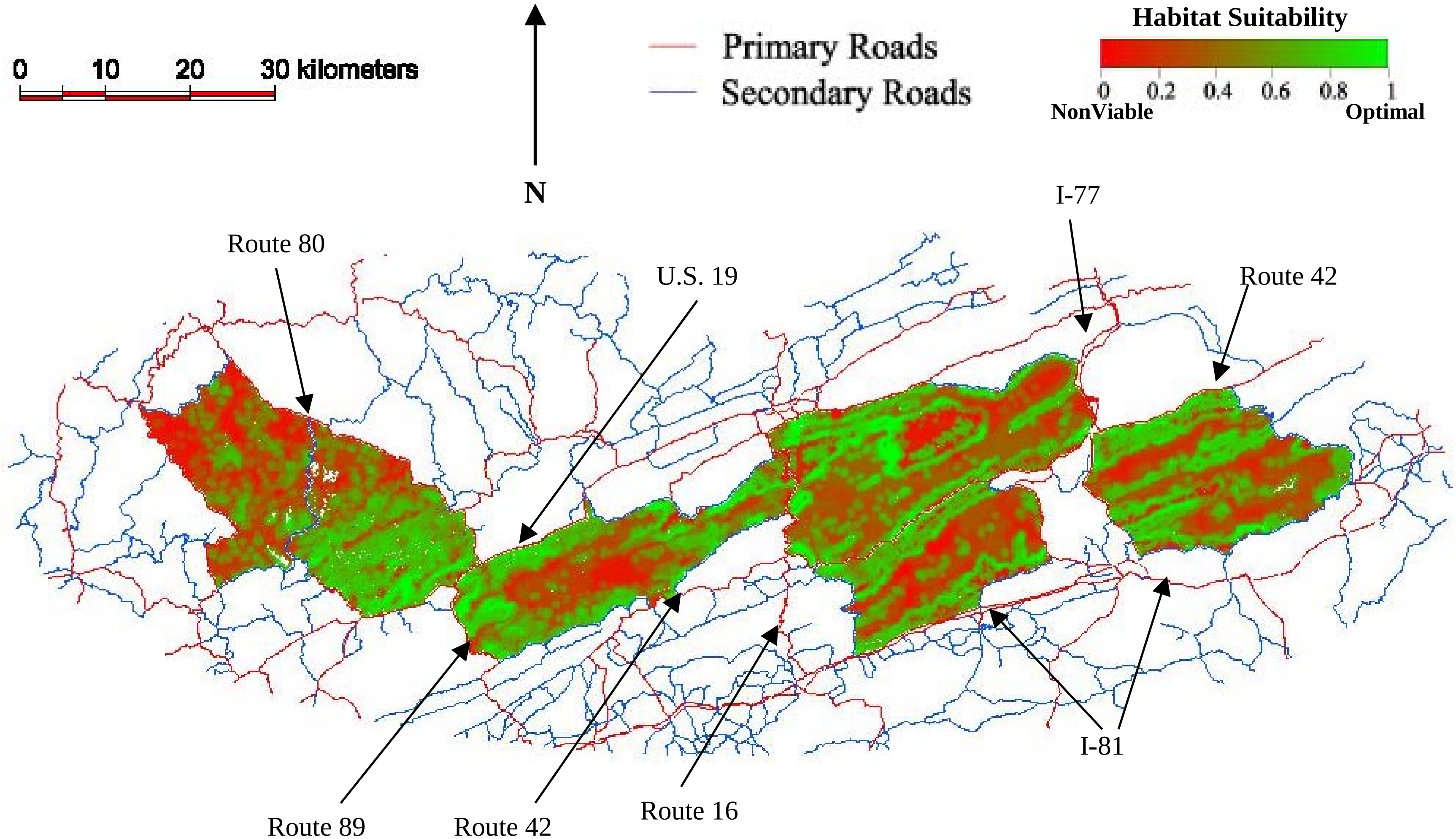


Figure 2.10. Pictographic display of habitat suitability for elk for the 6 polygons comprising the Southwest Virginia study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

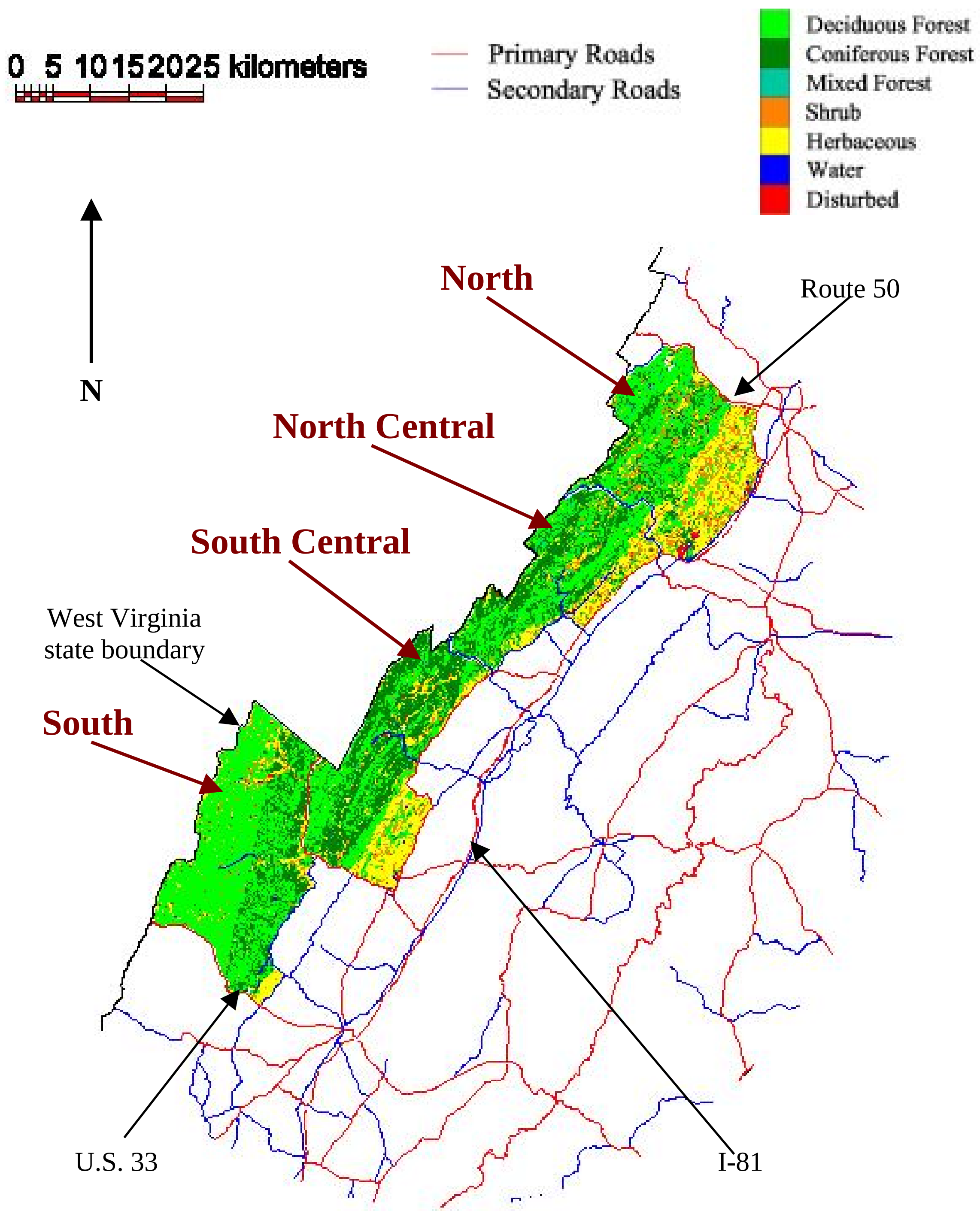


Figure 2.11. Location, boundaries, and existing land uses of the 4 polygons composing the Shenandoah study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

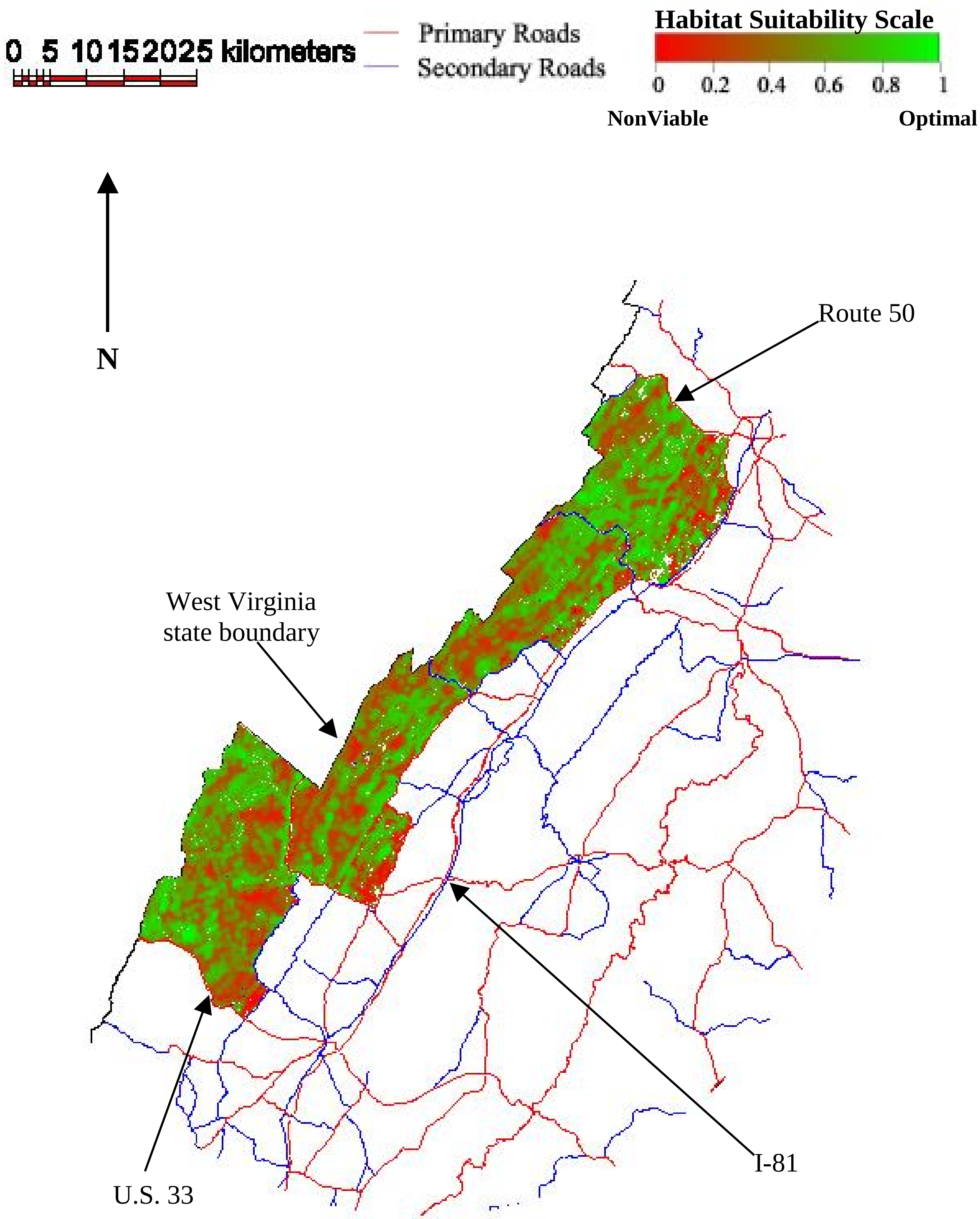


Figure 2.12. Pictographic display of habitat suitability for elk for the 4 polygons comprising the Shenandoah study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

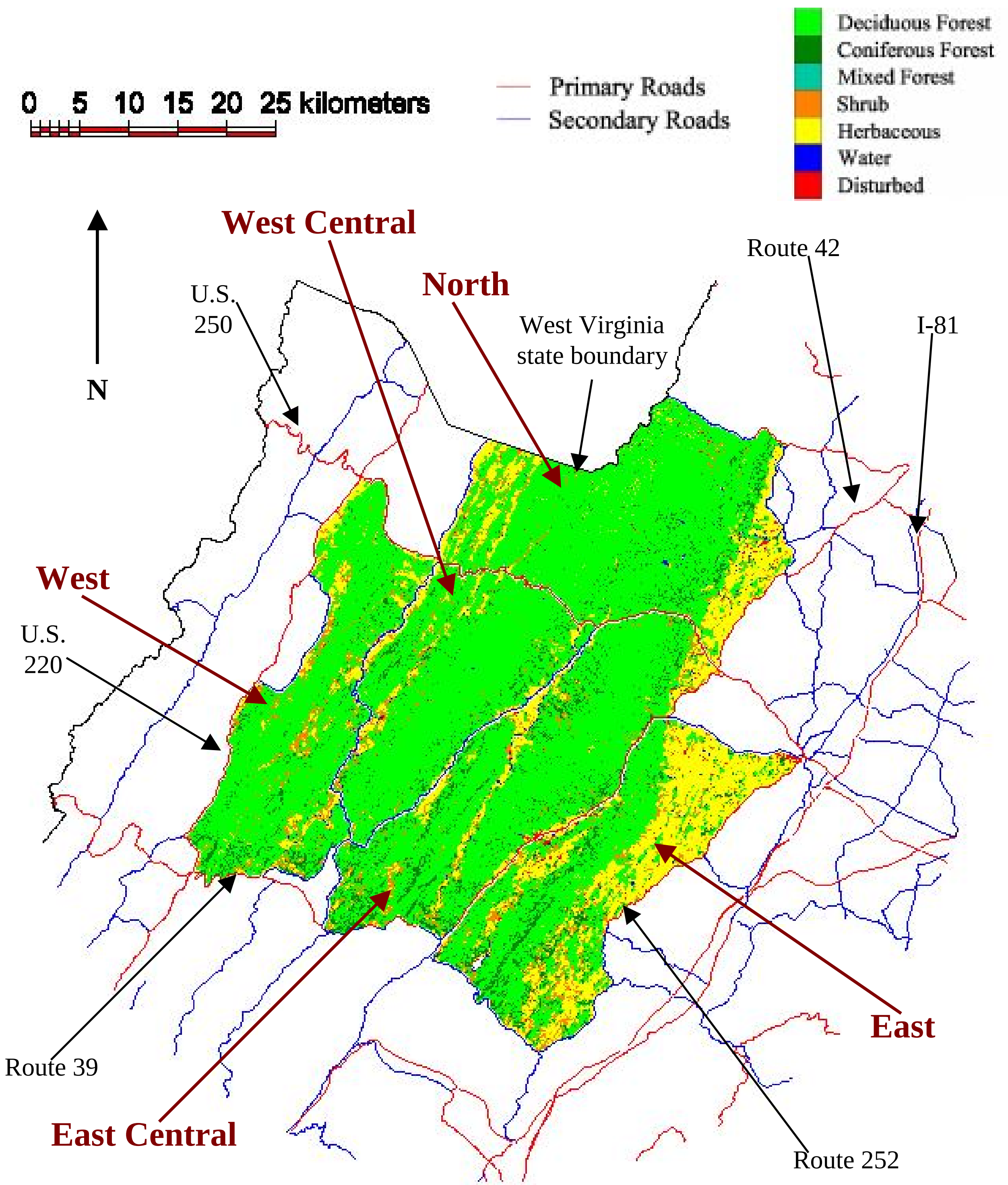


Figure 2.13. Location, boundaries, and existing land uses of the 5 polygons composing the Highland study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

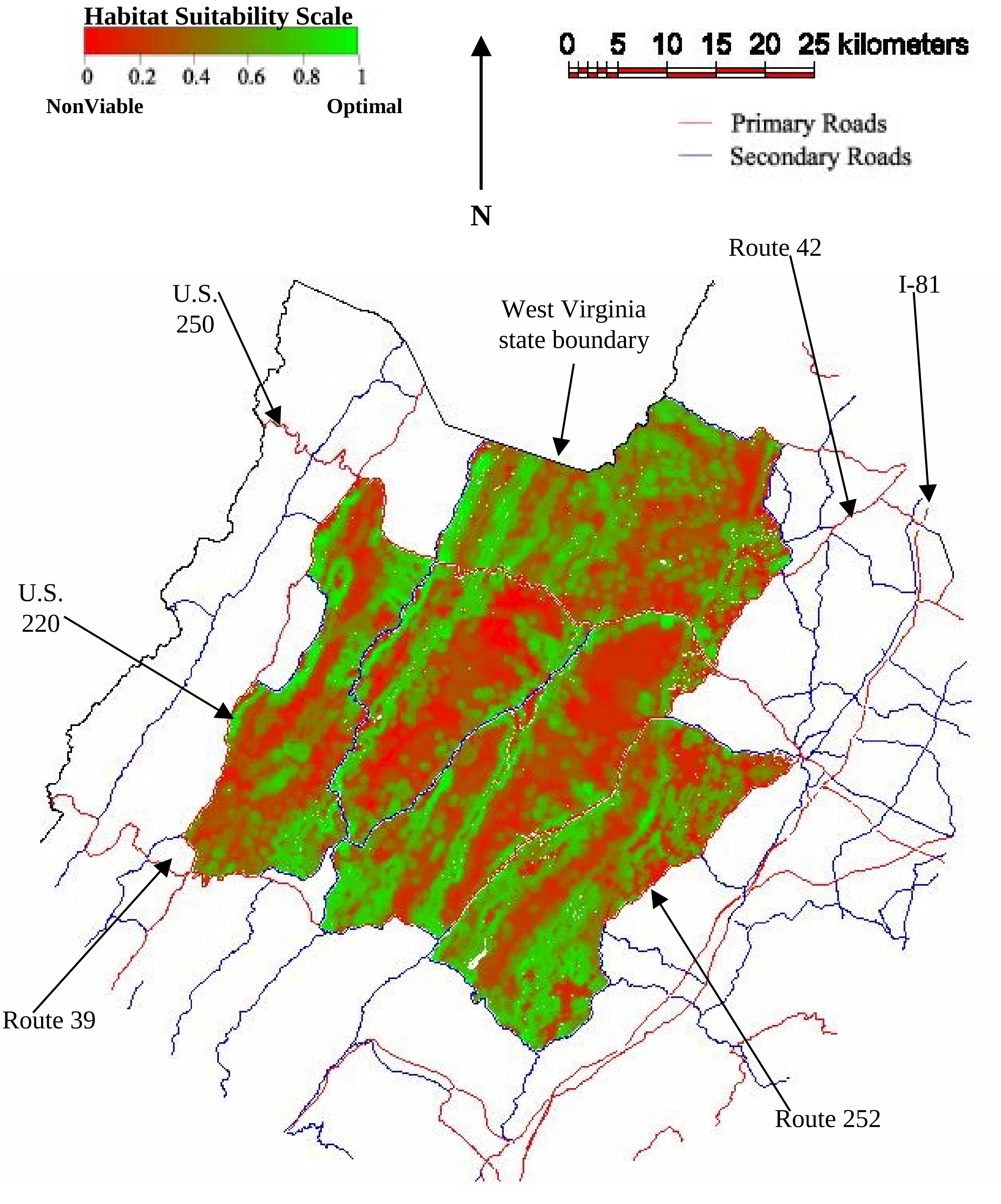


Figure 2.14. Pictographic display of habitat suitability for elk for the 5 polygons comprising the Highland study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

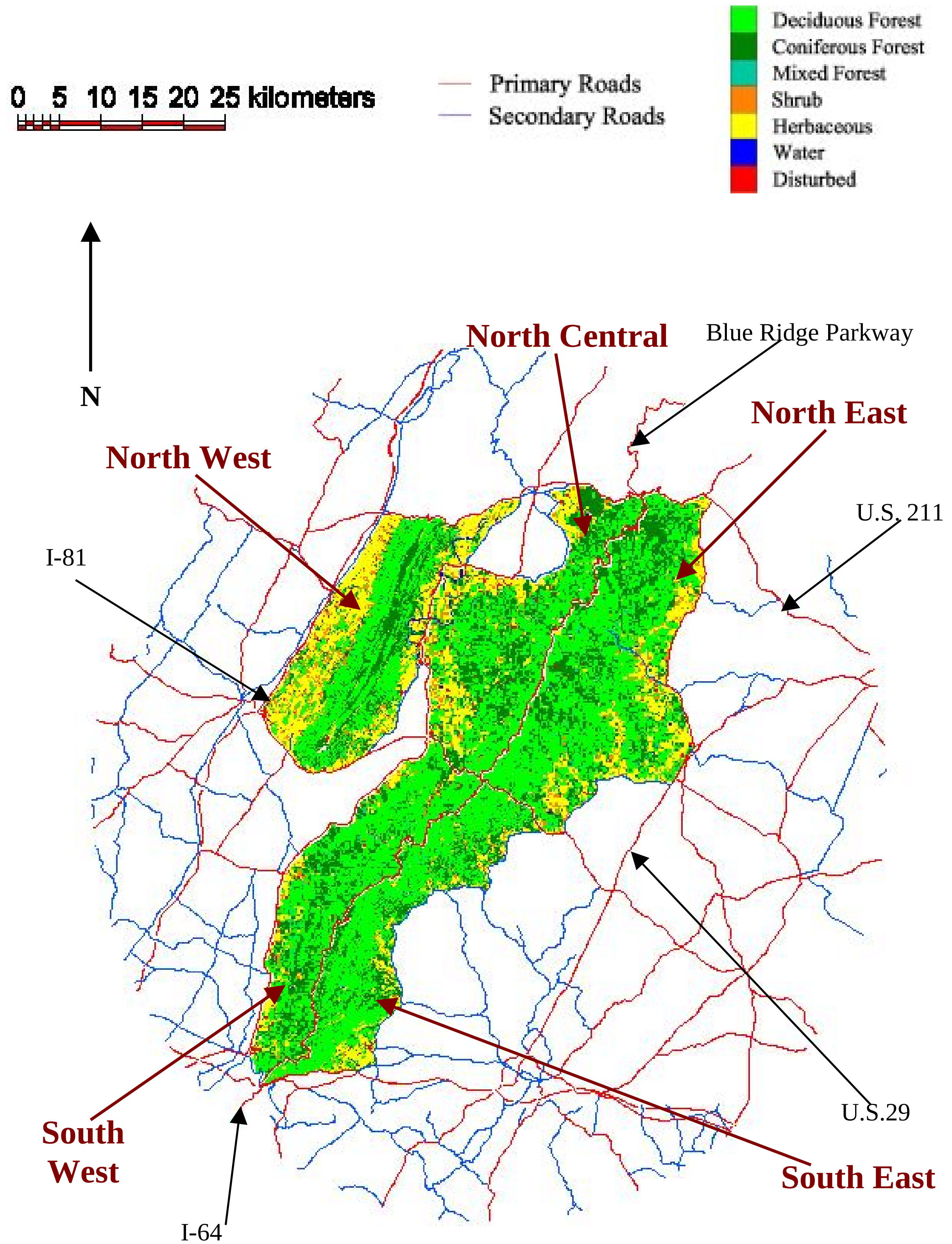


Figure 2.15. Location, boundaries, and existing land uses of the 5 polygons composing the Big Meadows study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

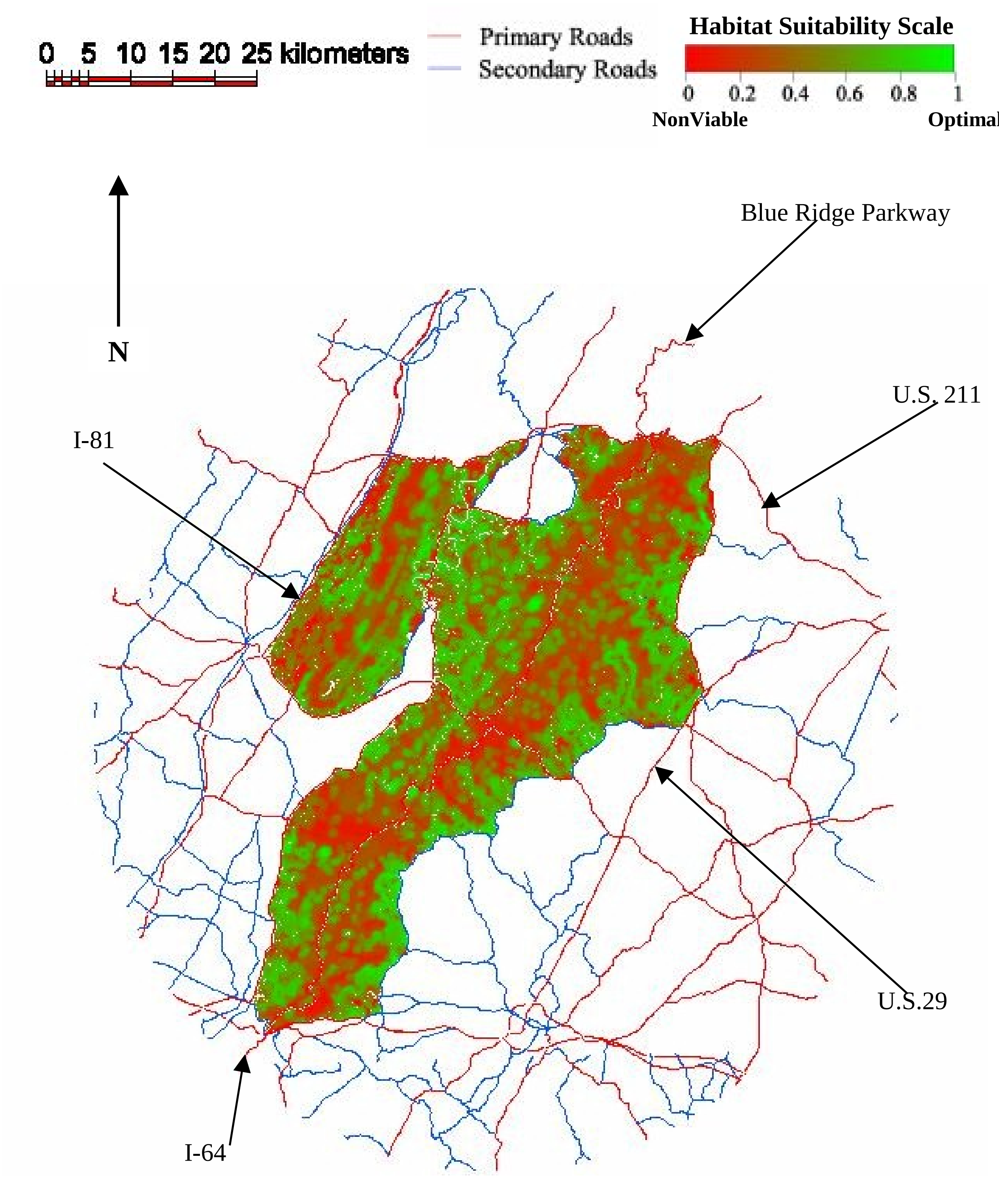


Figure 2.16. Pictographic display of habitat suitability for elk for the 5 polygons comprising the Big Meadows study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

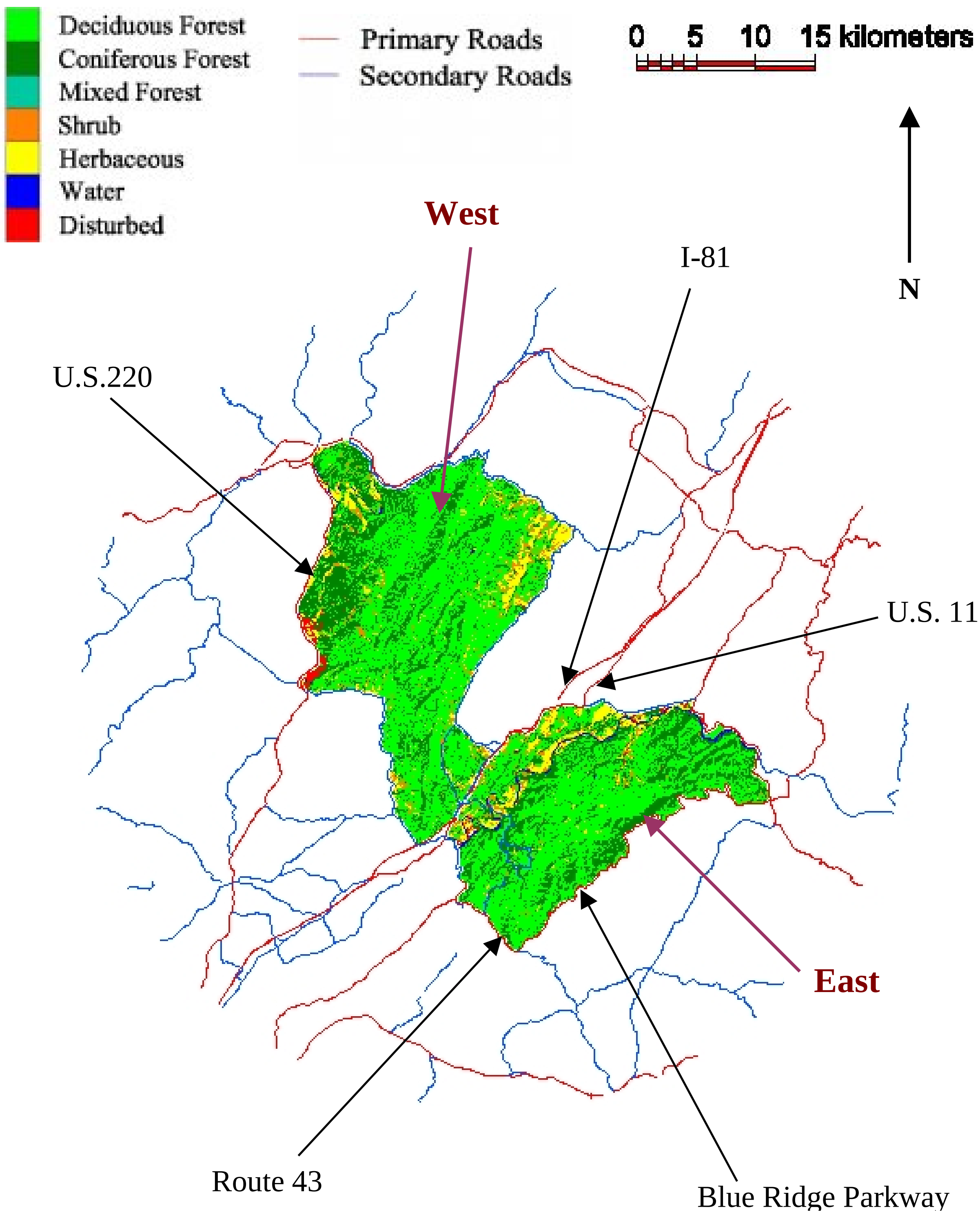


Figure 2.17. Location, boundaries, and existing land uses of the 2 polygons composing the Peaks of Otter study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

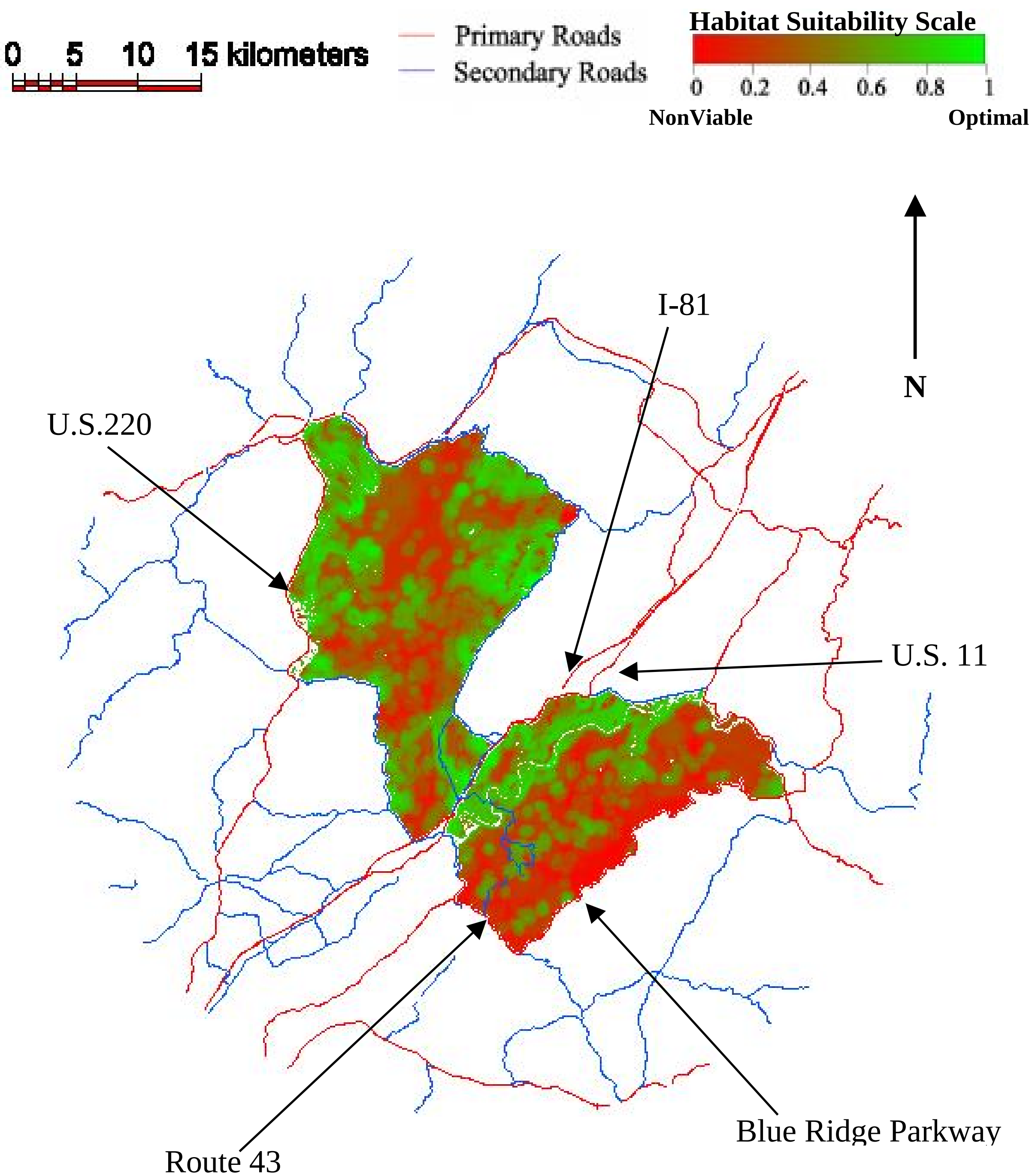


Figure 2.18. Pictographic display of habitat suitability for elk for the 2 polygons comprising the Peaks of Otter study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

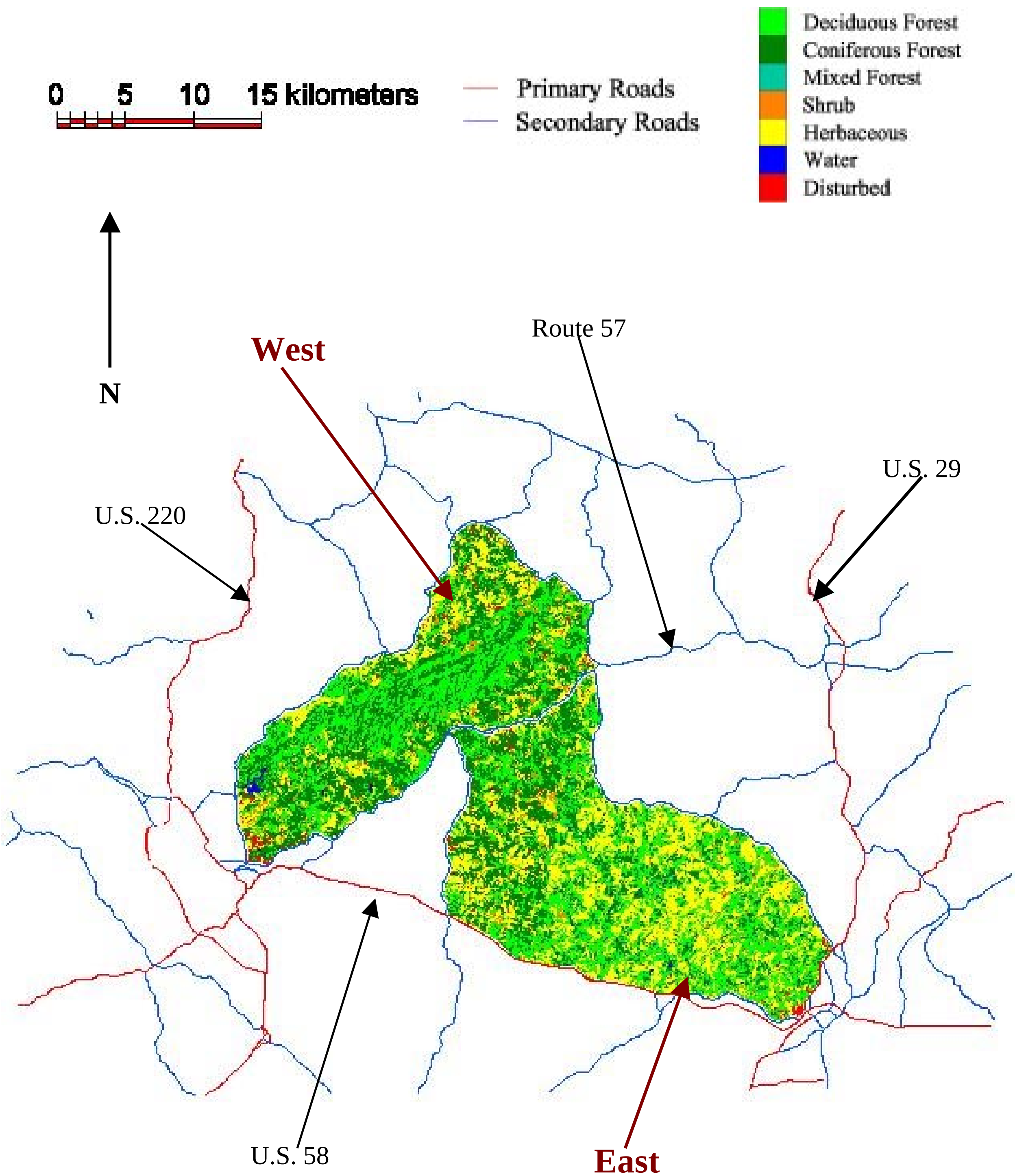


Figure 2.19. Location, boundaries, and existing land uses of the 2 polygons composing the Danville study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

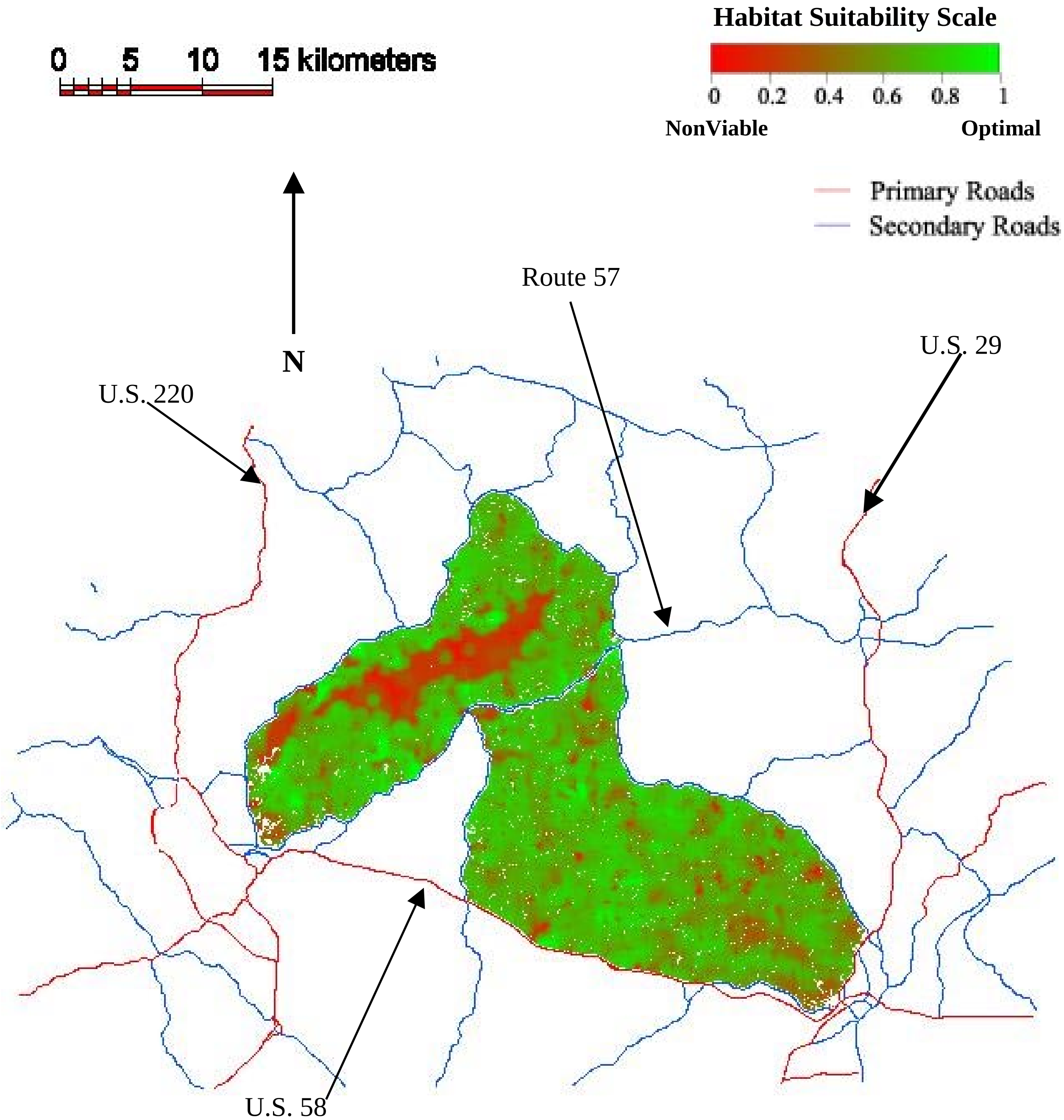


Figure 2.20. Pictographic display of habitat suitability for elk for the 2 polygons comprising the Danville study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

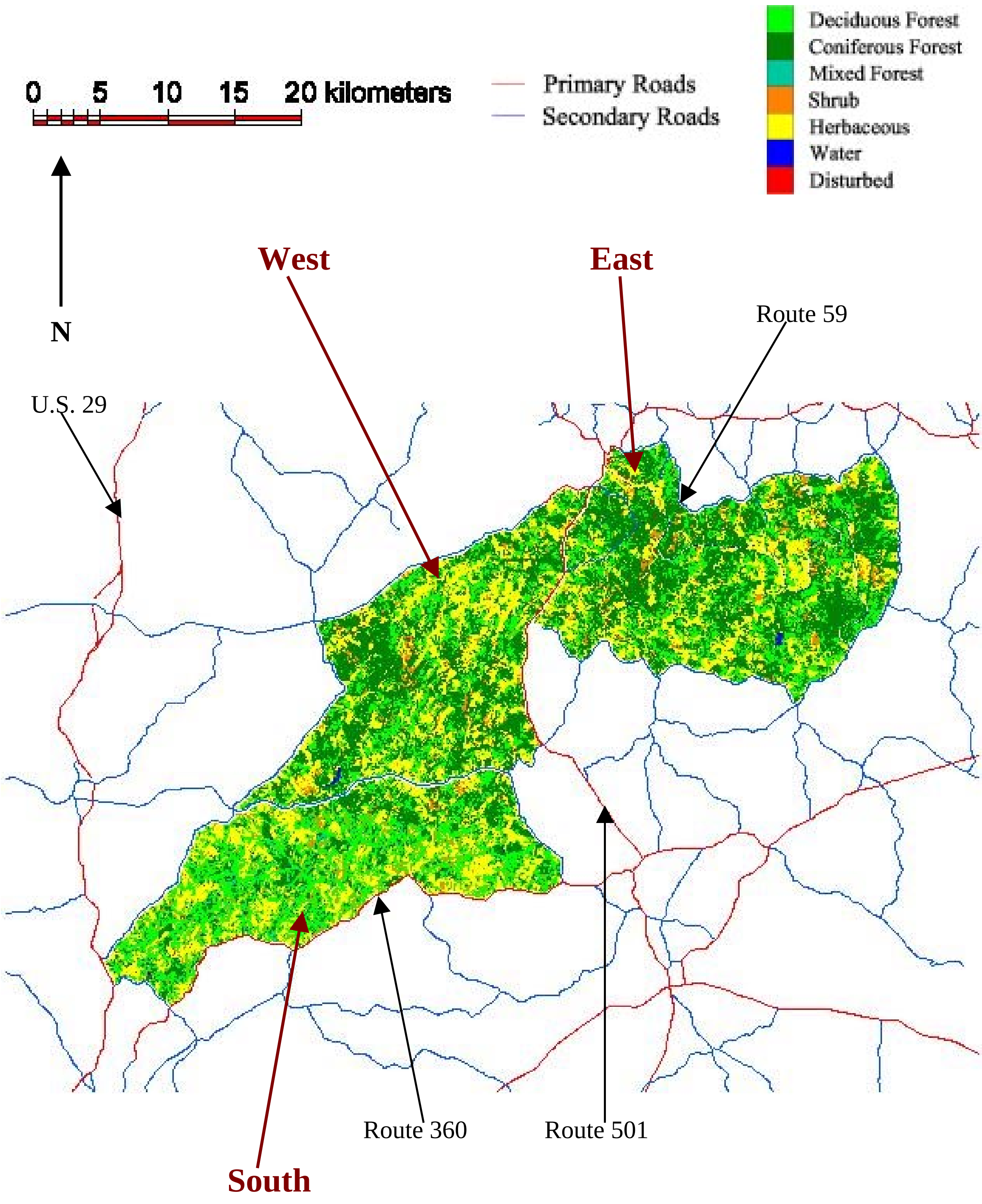


Figure 2.21. Location, boundaries, and existing land uses of the 3 polygons composing the Brookneal study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

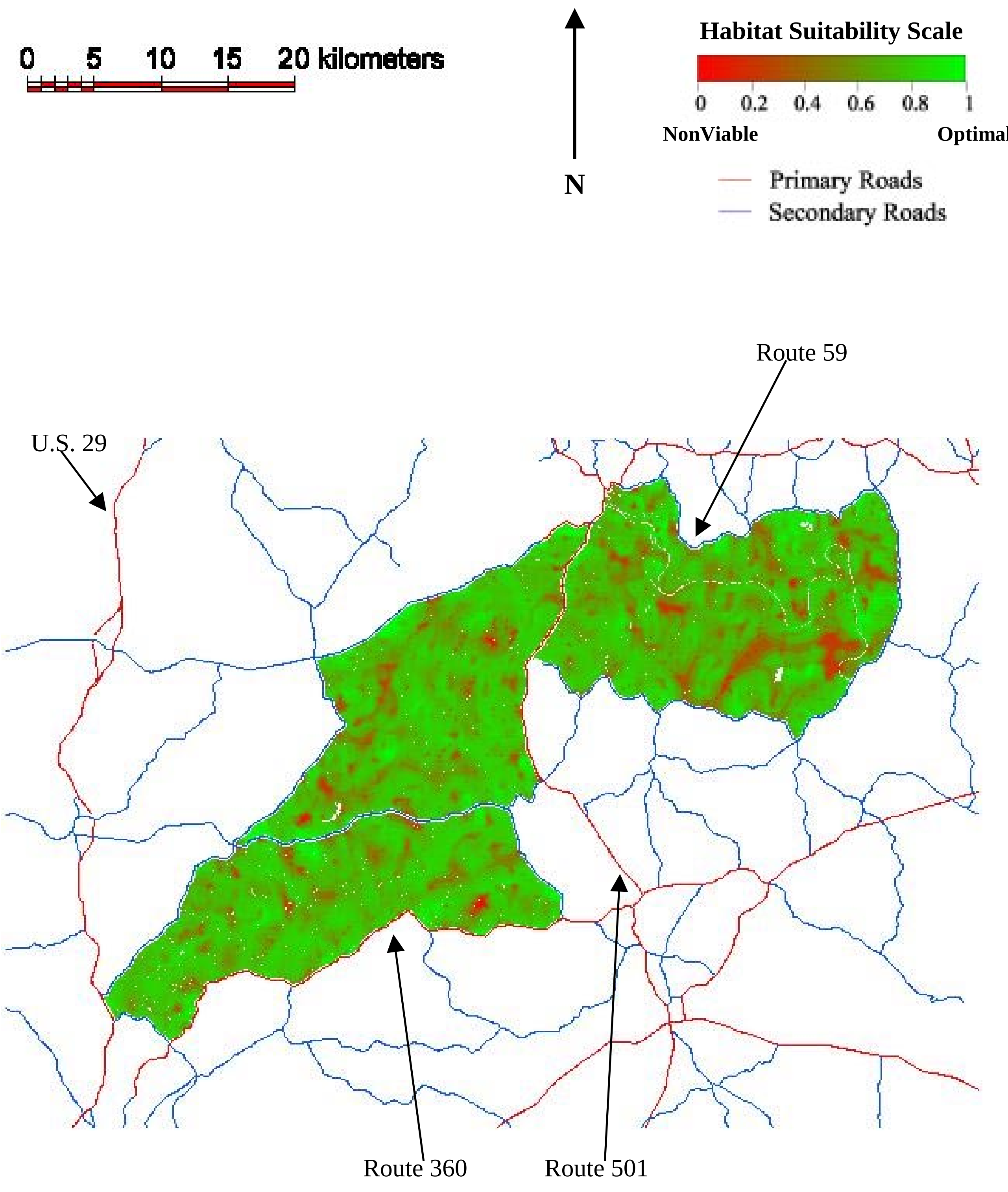


Figure 2.22. Pictographic display of habitat suitability for elk for the 3 polygons comprising the Brookneal study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

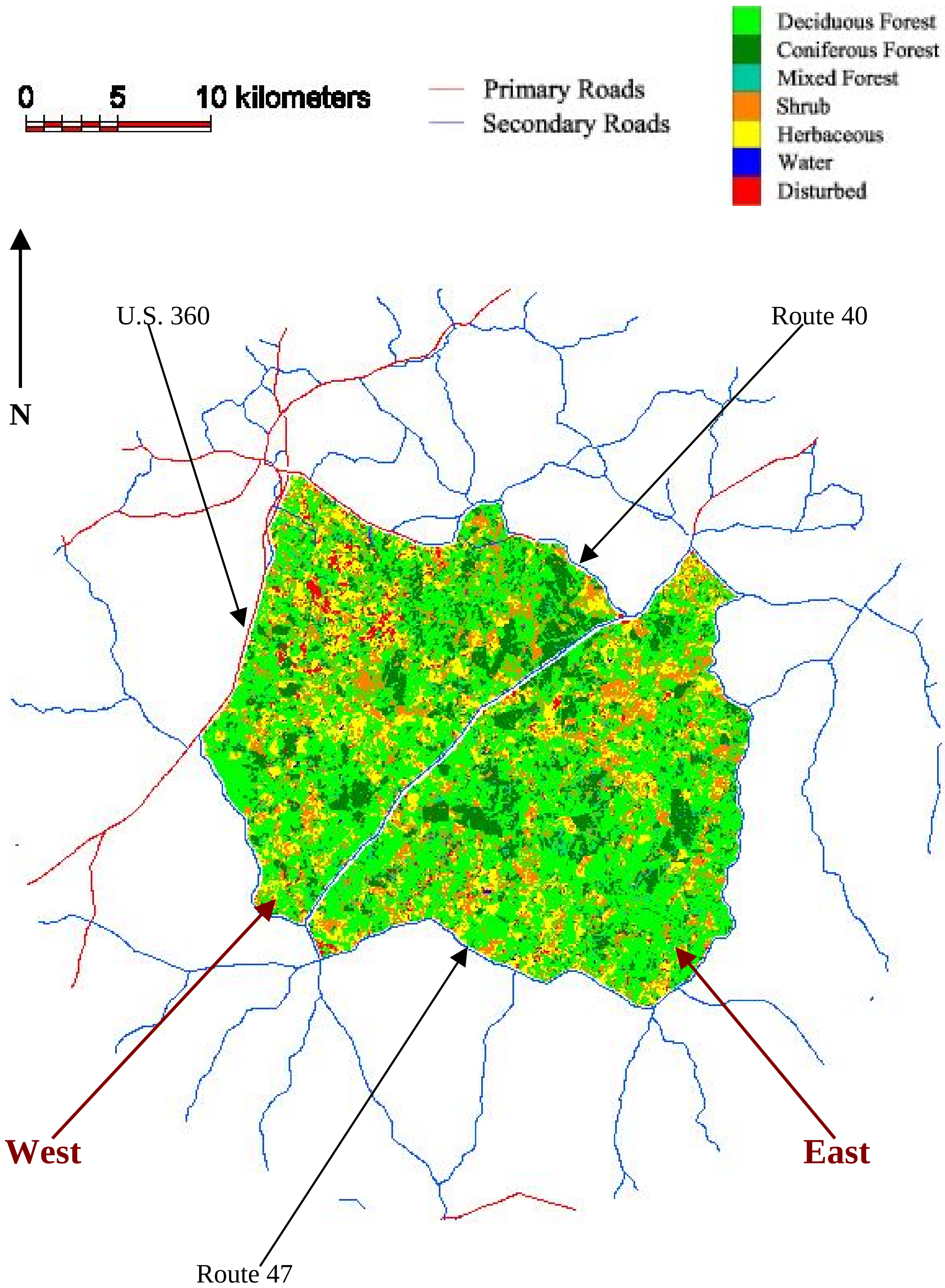


Figure 2.23. Location, boundaries, and existing land uses of the 2 polygons composing the Rehobeth study site that was examined as part of an assessment of biologic feasibility for reintroducing elk to Virginia. Major roads are identified to facilitate orientation.

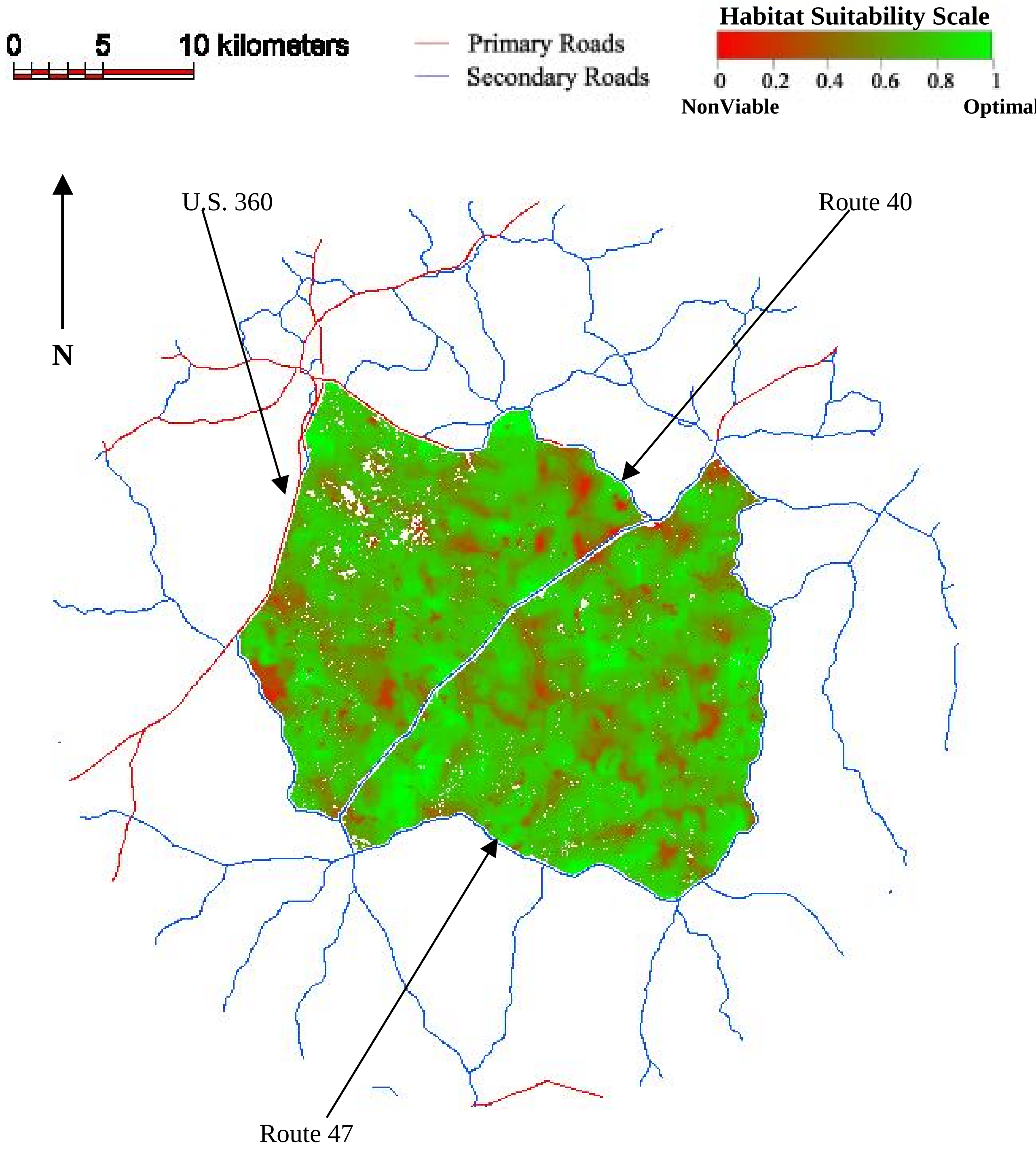


Figure 2.24. Pictographic display of habitat suitability for elk for the 2 polygons comprising the Rehobeth study site. Habitat suitability was determined by calculation of habitat suitability index (HSI) as part of an assessment of the biological feasibility of reintroducing elk to Virginia.

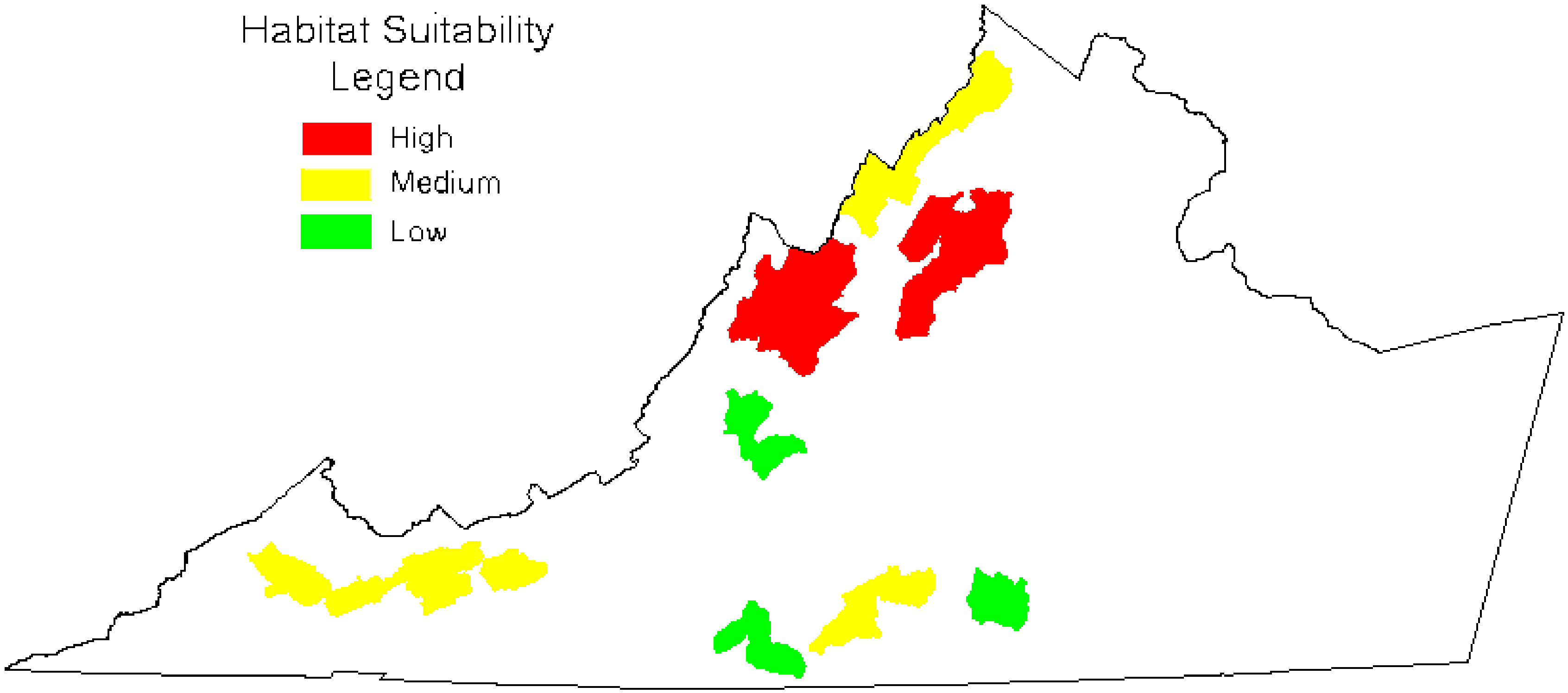


Figure 2.25. Biological feasibility (high, medium, low feasibility) for each of 8 study areas considered in a feasibility assessment for elk restoration in Virginia.

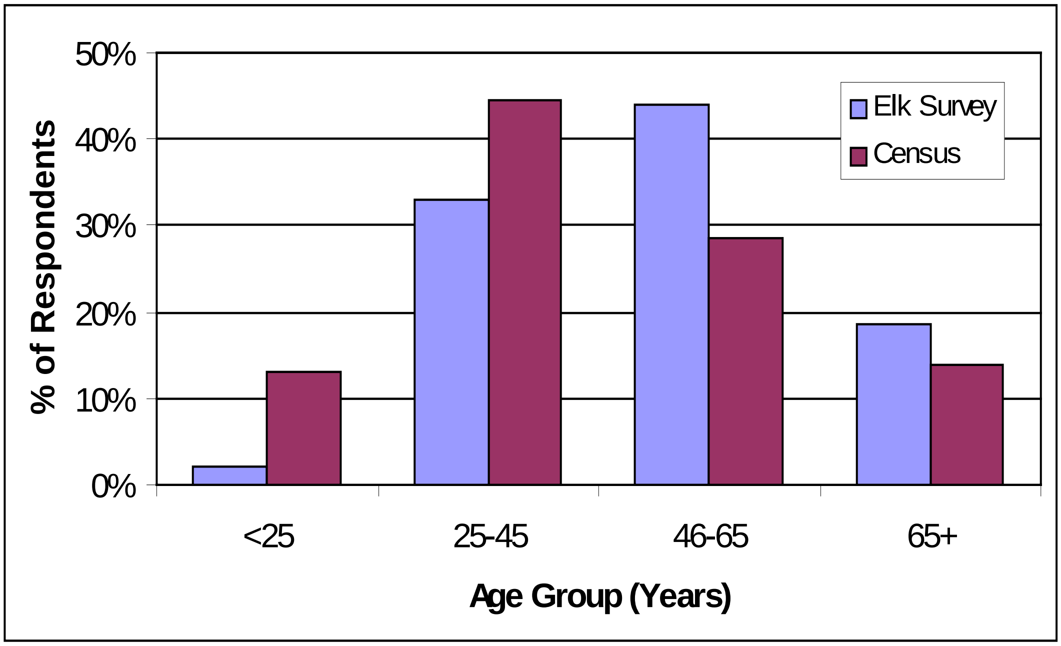
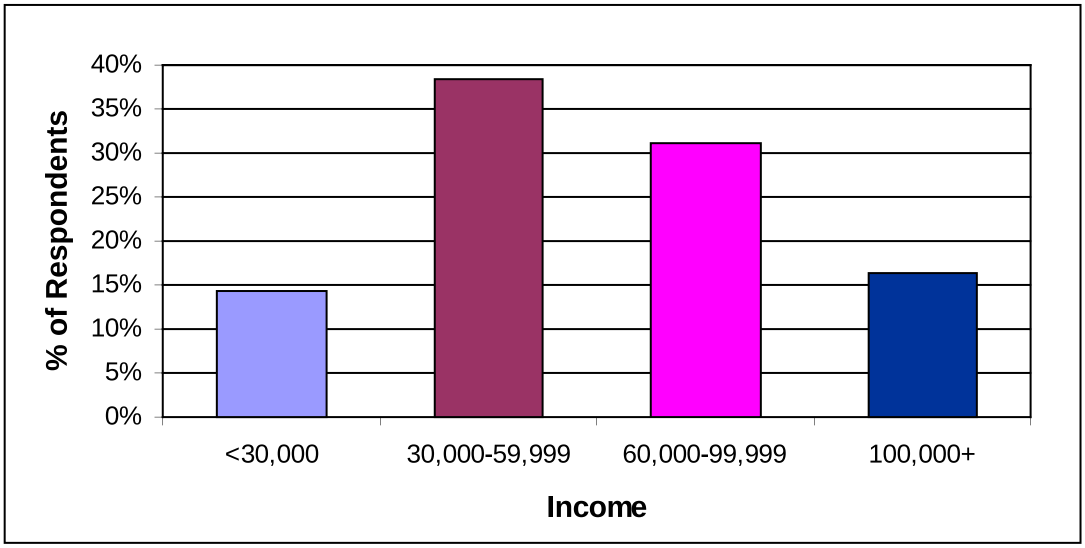
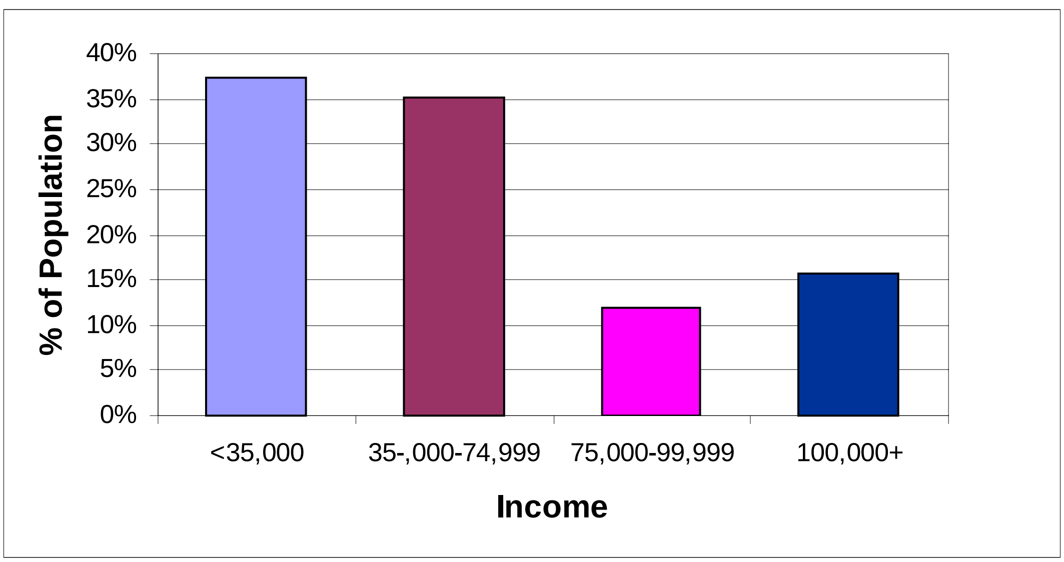


Figure 3.1. Age of respondents to a mail survey on elk restoration in Virginia, conducted during spring 1999, versus age among all Virginia residents, based on respondents to 1990 U.S. Census (χ^2 = 142.10,* df *= 3,* P *< 0.001).



a)



b)

Figure 3.2. Income of respondents to a mail survey conducted in spring 1999 about elk restoration in Virginia (a) vs. income among general population in Virginia (b), based on respondents to 1990 U.S. Census.

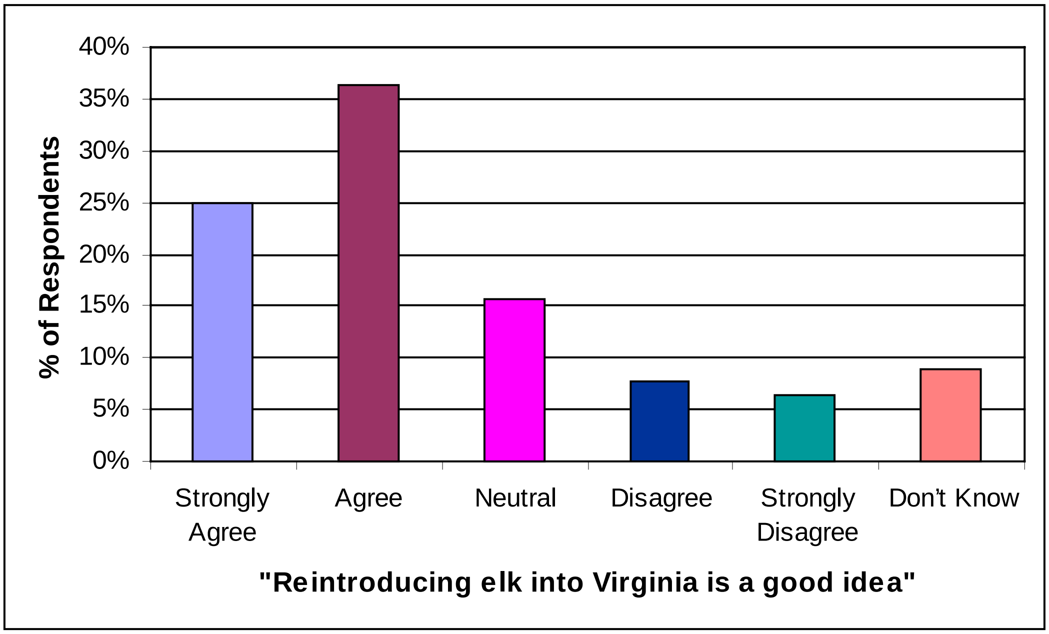


Figure 3.3. Attitudes of Virginia residents toward elk restoration in Virginia, as determined through a mail survey conducted during spring 1999 **(n = 610).**

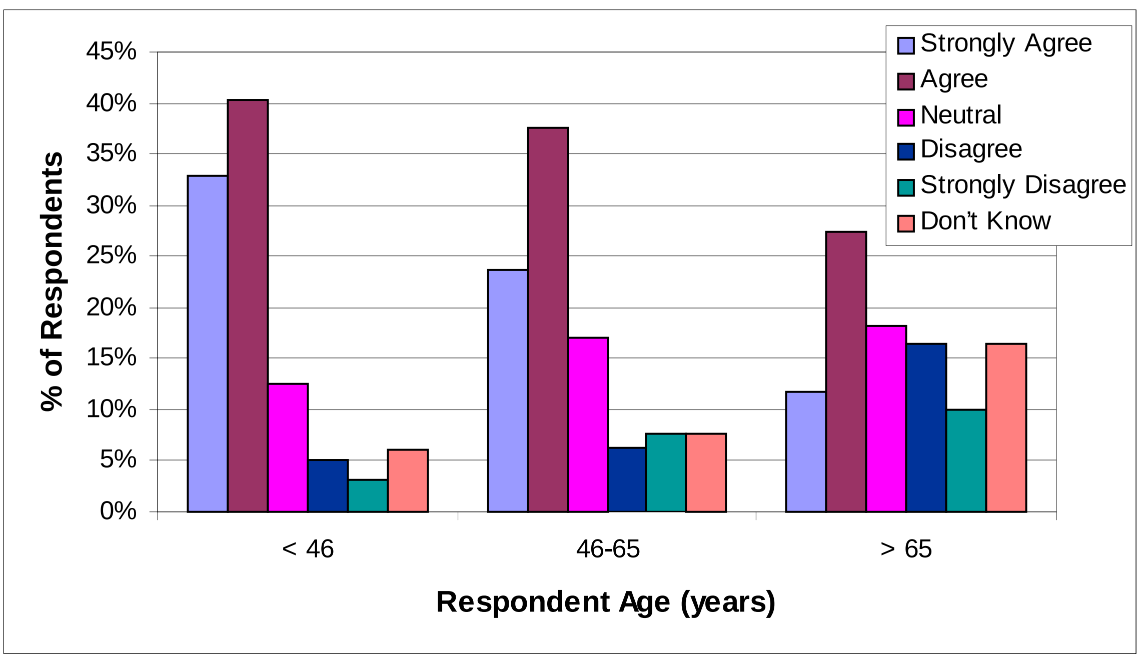


Figure 3.4. Effect of respondent age on attitude toward elk restoration in Virginia (agree versus disagree that elk restoration is a good idea), based on responses from Virginia residents to a mail survey conducted during spring 1999 **(G** ***= 37.31,*** **df** ***= 8,*** **P** ***< 0.001, γ= 0.303).***

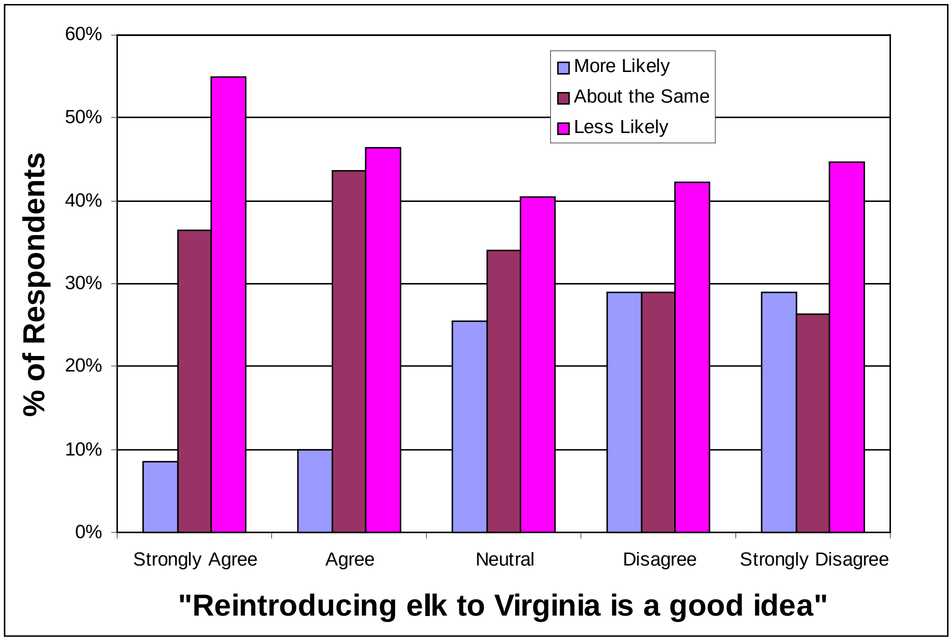


Figure 3.5. Effect of the suggestion that elk be kept in an enclosure on respondents' attitude toward elk restoration (i.e., more or less likely to support if kept in an enclosure) based on responses to a mail survey of Virginia residents conducted during spring 1999 (G = 31.11, df = 8, P < 0.001, γ= -0.199).

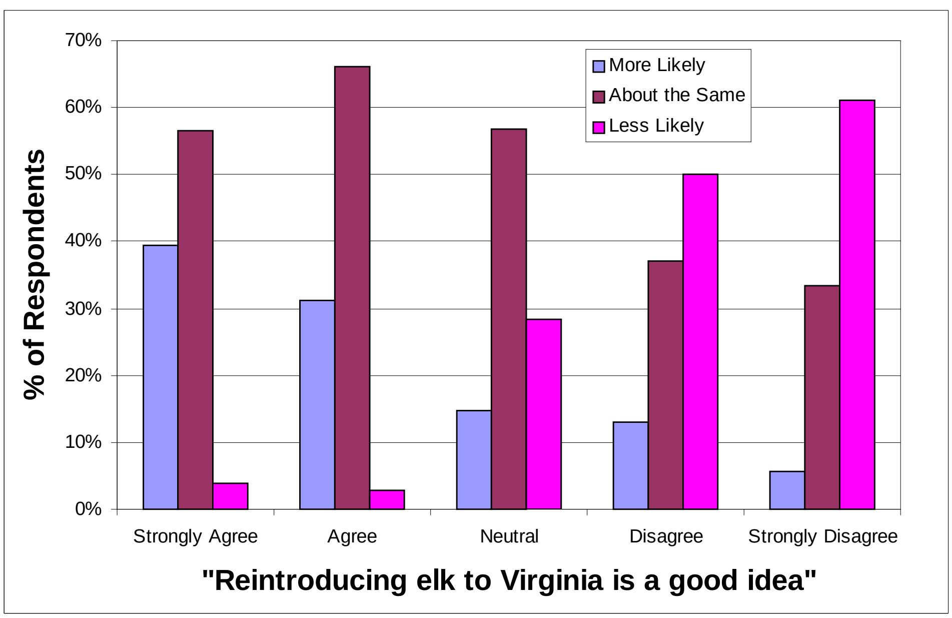


Figure 3.6. Change in level of support for elk restoration in Virginia (i.e., more or less likely to support elk restoration) if newly released elk were released within 30 km of the respondent's home, as determined by responses to a mail survey of Virginia residents conducted during spring 1999 (G = 151.61, df = 8, P < 0.001, γ= 0.532).

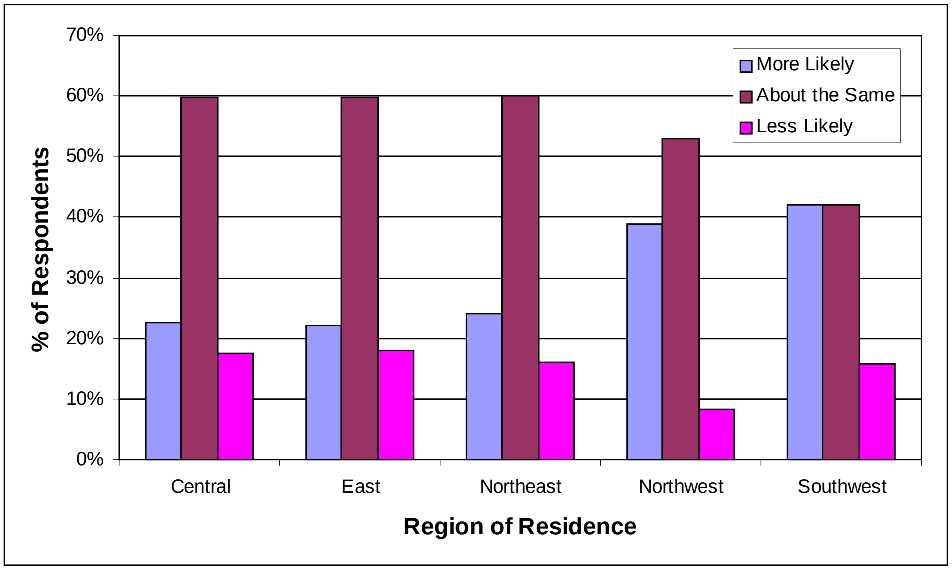


Figure 3.7. Change in attitudes toward elk restoration in Virginia (i.e., more or less likely to support elk restoration) if elk were to be released within 30 km of respondents home for the 5 regions of Virginia (**G** ***= 20.58,*** **df** ***= 10,*** **P** ***= 0.024).***

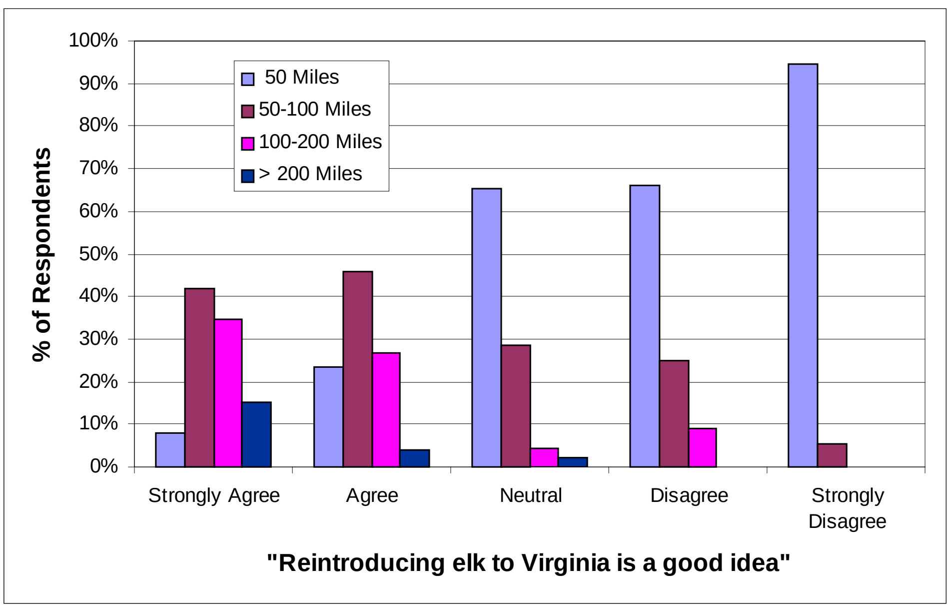


Figure 3.8. Maximum distance respondents to a mail survey of Virginia residents conducted during spring 1999 would be willing to travel solely to view elk, given their stated support for elk restoration in Virginia (G = 215.06, df = 12, P < 0.001, γ = -0.658).

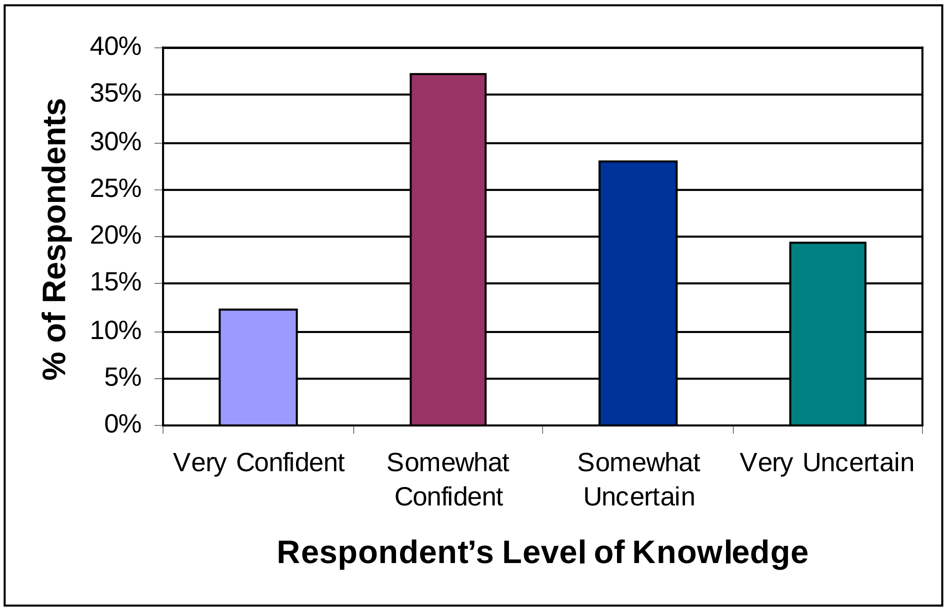


Figure 3.9. Respondents' self-perceived confidence in their knowledge about elk, as determined by a mail survey of Virginia residents about elk restoration during spring 1999.

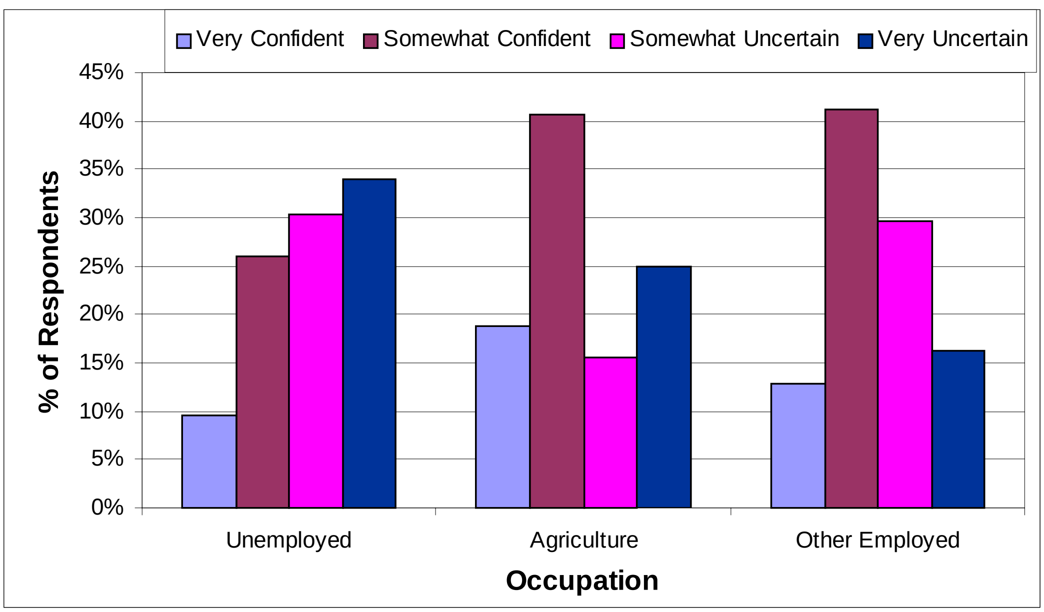


Figure 3.10. Relationship between perceived knowledge of elk and present occupation of respondents to a mail survey about elk restoration in Virginia conducted during spring 1999 ($G = 18.90$, df = 3, $P < 0.001$).

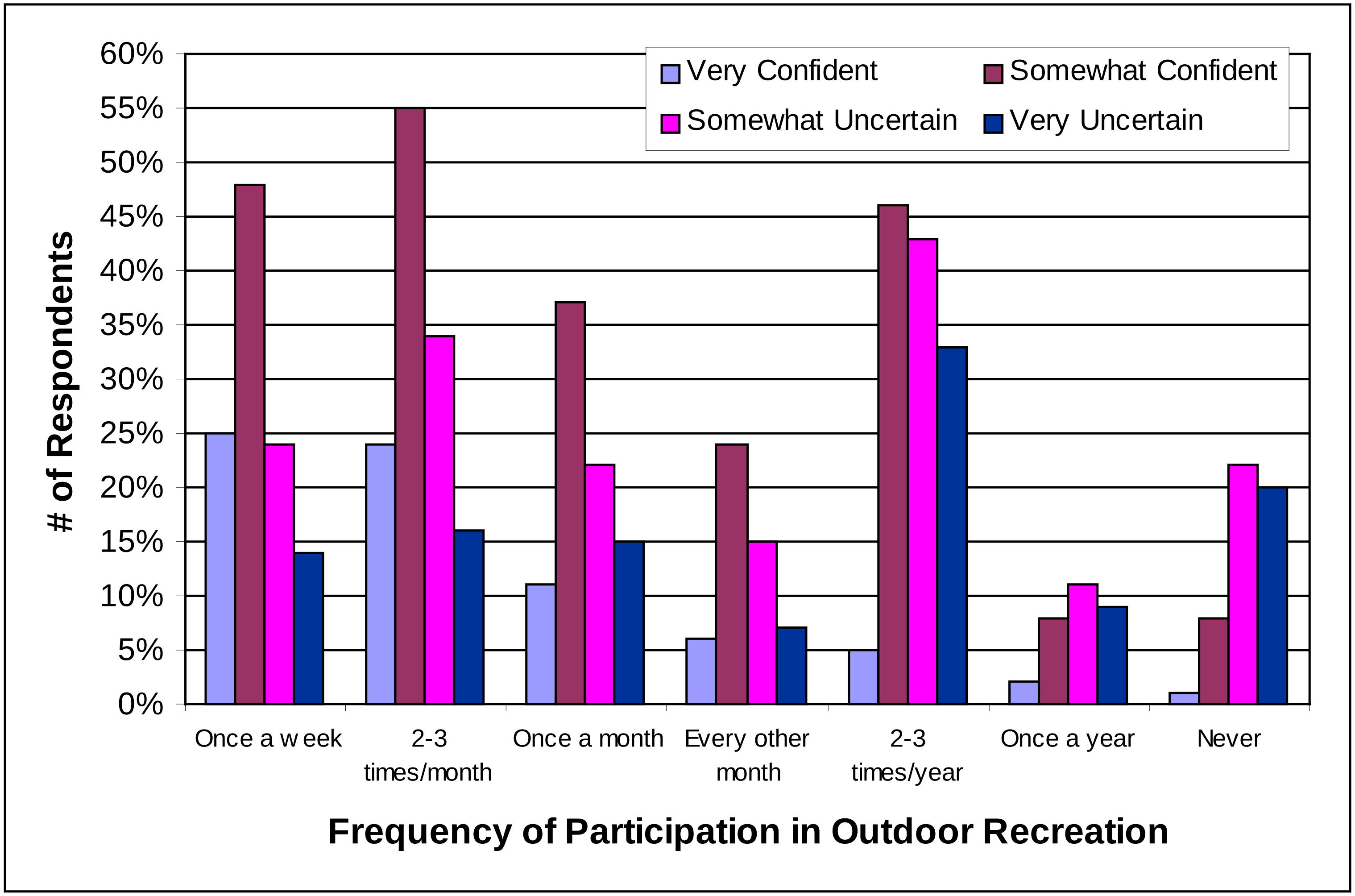


Figure 3.11. Relationship between level of knowledge (i.e., confident vs. uncertain with level of knowledge) about elk and the frequency of participation in outdoor recreational activities during 1998 among respondents to a mail survey of Virginia residents about elk restoration conducted during spring 1999 (G = 68.98,* df *= 18,* P *< 0.001, γ= 0.320.

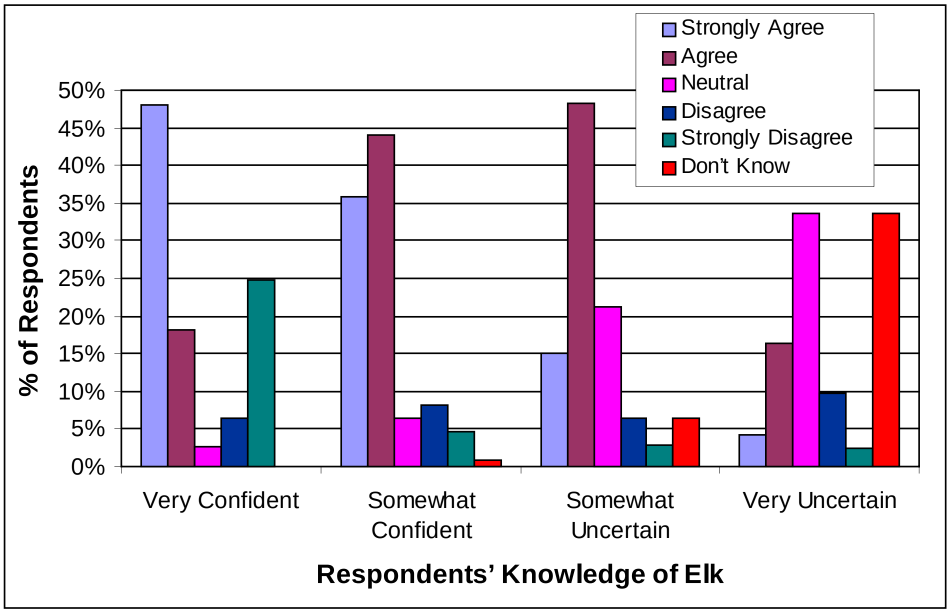


Figure 3.12. Relationship between knowledge of elk (i.e., confident vs. uncertain) and agreement with the statement that "Reintroducing elk into Virginia is a good idea" among respondents to a mail survey of Virginia residents conducted during spring 1999. Confident respondents were more likely to agree with elk restoration (G = 172.63, df = 12, P <0.001, γ= 0.317), whereas less confident respondents were more likely to be neutral or respond "Don't Know" (G = 103.52, df = 3, P <0.001, γ= 0.886).

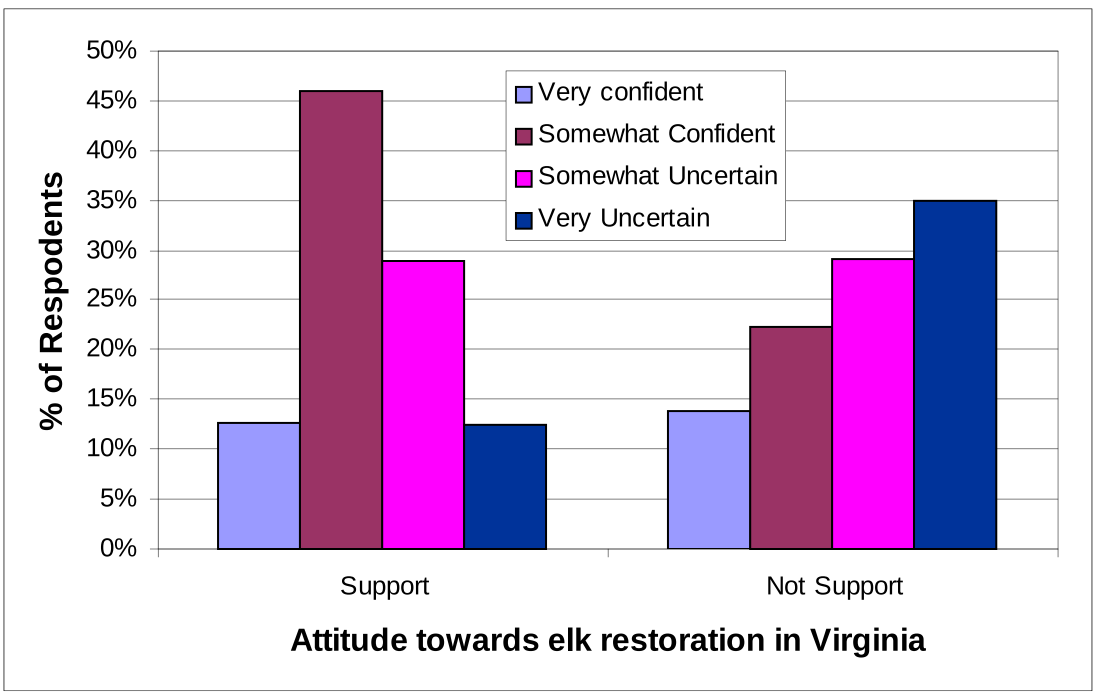


Figure 3.13. Relationship between attitude toward elk restoration when forced to take a side and perceived level of knowledge about elk (i.e., confident vs. uncertain) among respondents to a mail survey of Virginia residents conducted during spring 1999 (G = 51.82, df = 3, P < 0.001, γ= 0.341).

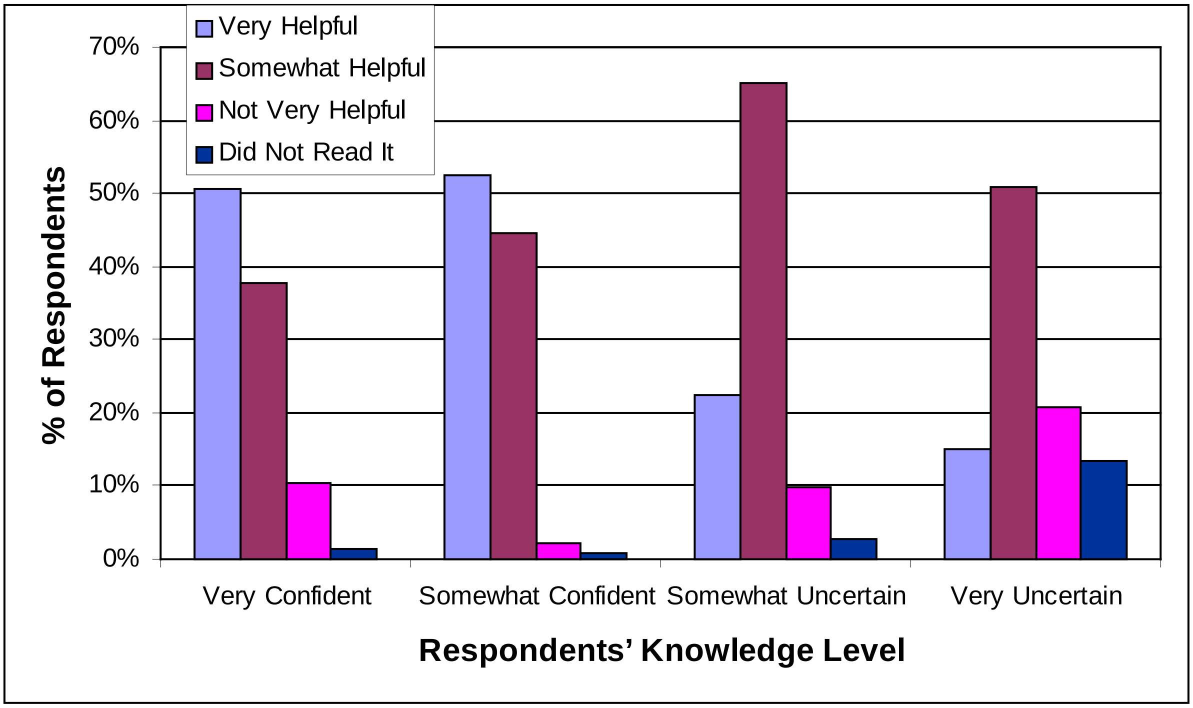


Figure 3.14. Relationship between perceived knowledge about elk (i.e., confident vs. uncertain) and the perceived helpfulness of the informational brochure among respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999. Less confident respondents either did not read the brochure (G = 28.47, df = 3, P < 0.001, γ= 0.710) or found it less helpful than did more confident respondents (G = 88.53, df = 6, P < 0.001, γ= 0.451).

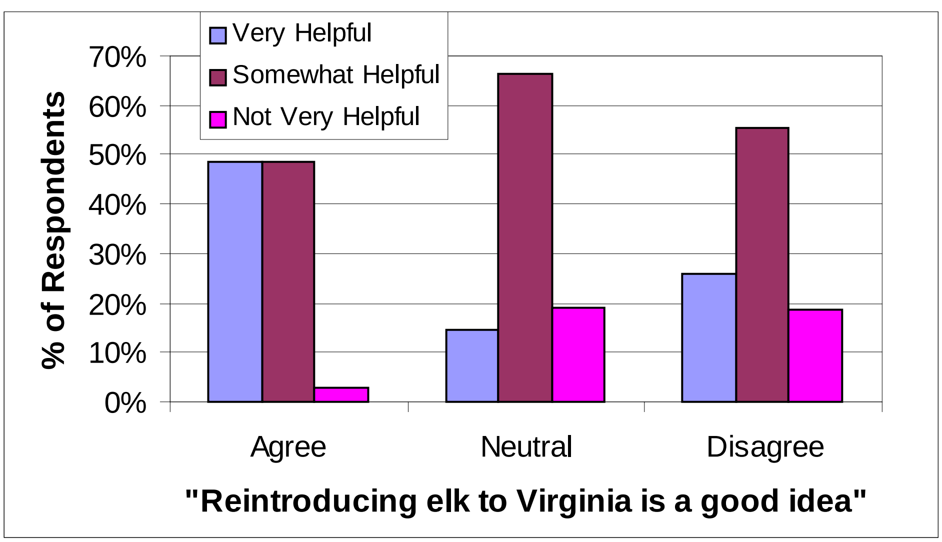


Figure 3.15. Relationship between attitude toward elk restoration and the perceived helpfulness of the informational brochure among respondents to a mail survey of Virginia residents on restoration in Virginia conducted during spring 1999 (G = 68.64, df = 4, P < 0.001, γ= 0.525).

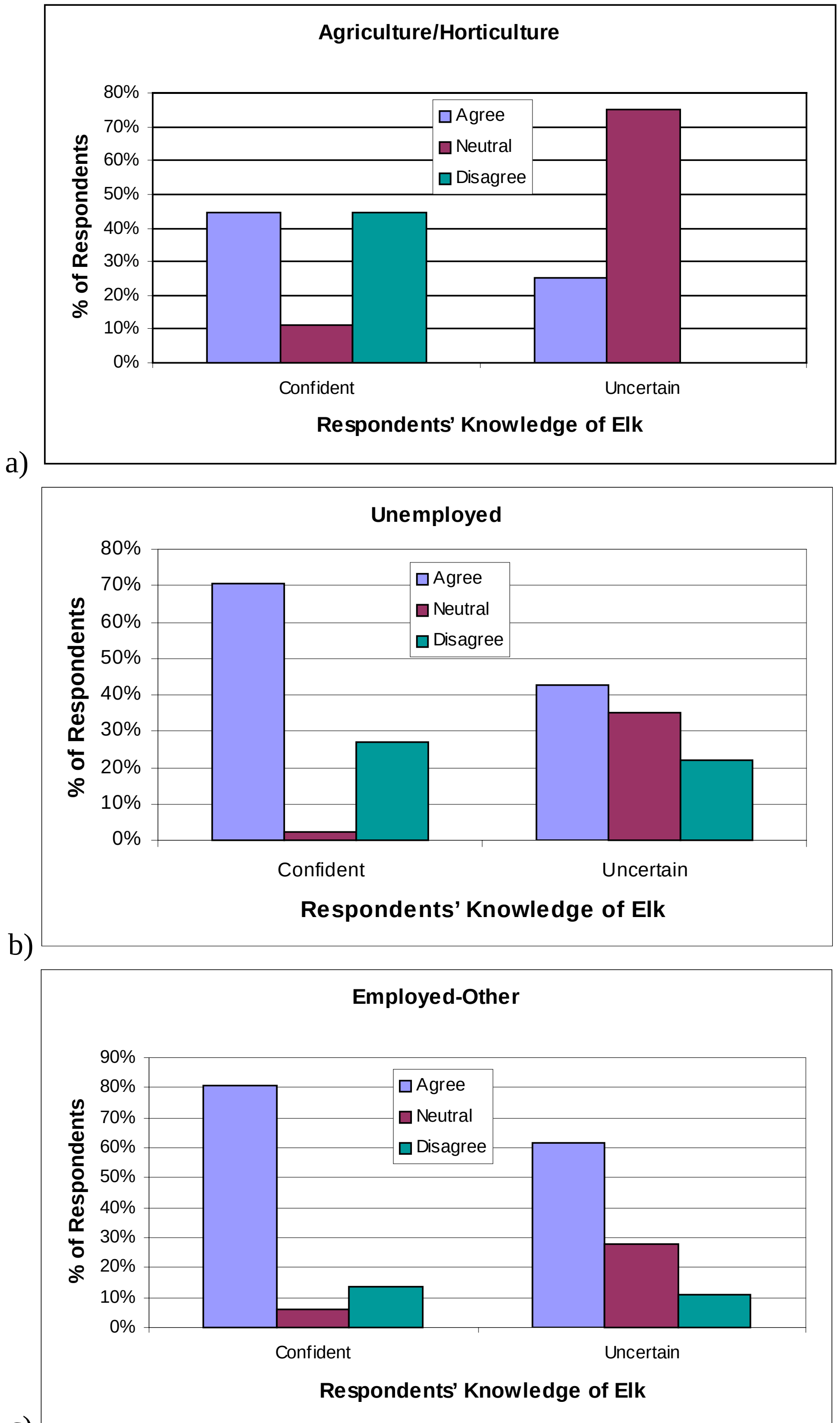


Figure 3.16 Relationship between perceived knowledge about elk (i.e., confident vs. uncertain) and attitude toward elk restoration (i.e., agree or disagree that elk restoration is a good idea) for respondents employed in agriculture/horticulture (a), respondents who are unemployed (b), and respondents employed in a field other than agriculture/horticulture (c), as determined by a mail survey of Virginia residents conducted during spring 1999. Confident agriculturalists were more likely than less confident agriculturalists to disagree that elk restoration is a good idea (G = 17.069, df = 2, P < 0.001), whereas other confident respondents were more likely to agree (employed: G = 39.49, df = 2, P <0.001; unemployed G = 18.74, df = 2, P < 0.001).

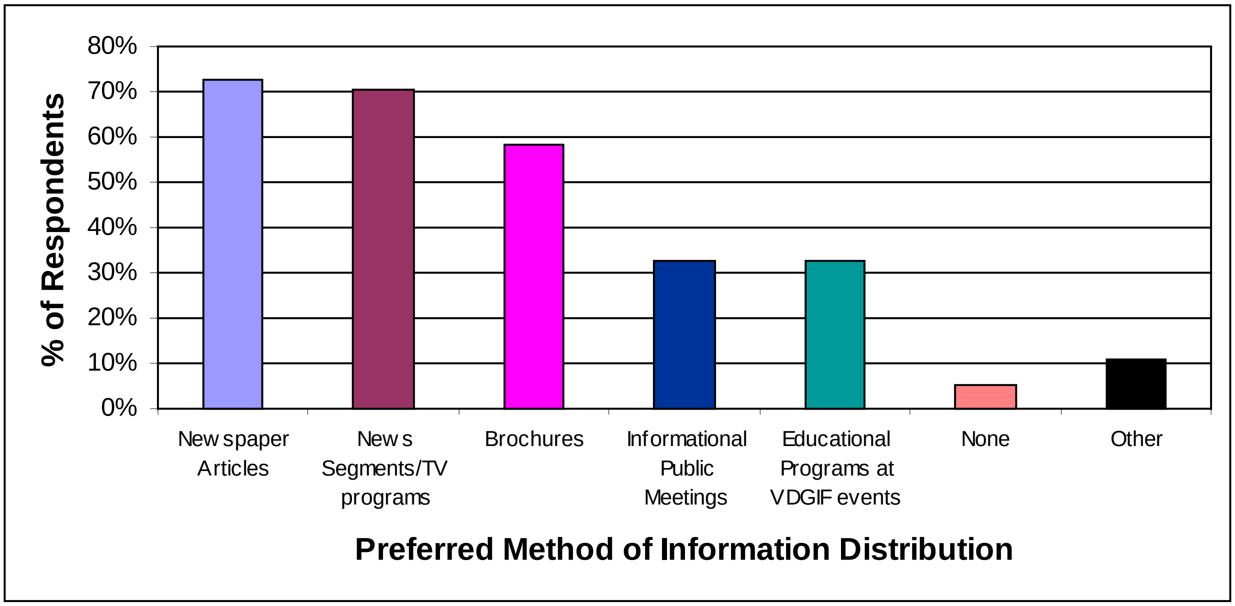


Figure 3.17. Preferred methods for disseminating information about elk restoration (n = **603***), as reported by respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.*

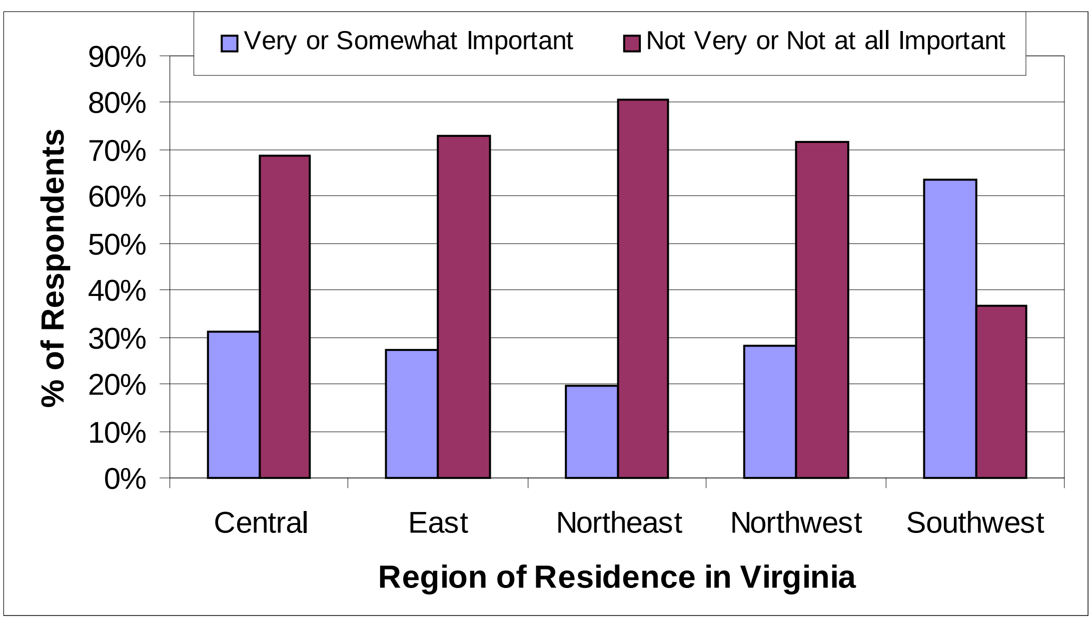
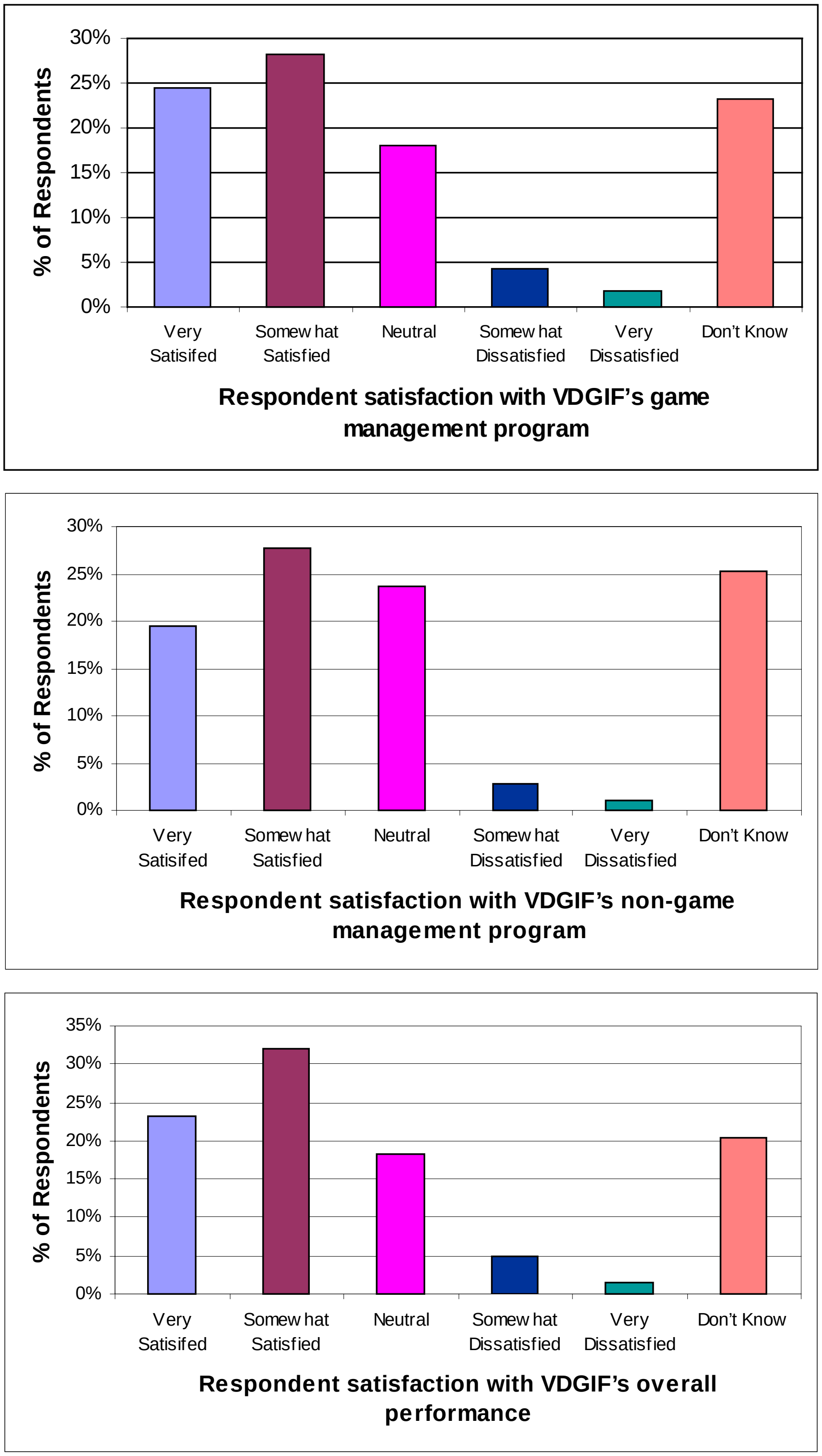


Figure 3.18. Importance of the possibility to hunt elk as motivation to support elk restoration in Virginia depicted by region of residence, as reported by respondents to a mail survey of Virginia residents conducted during spring 1999.



a)

b)

c)

Figure 3.19. Satisfaction with Virginia Department of Game and Inland Fisheries' (VDGIF) game management program (a), nongame management program (b), and overall agency performance (c), as reported by respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.

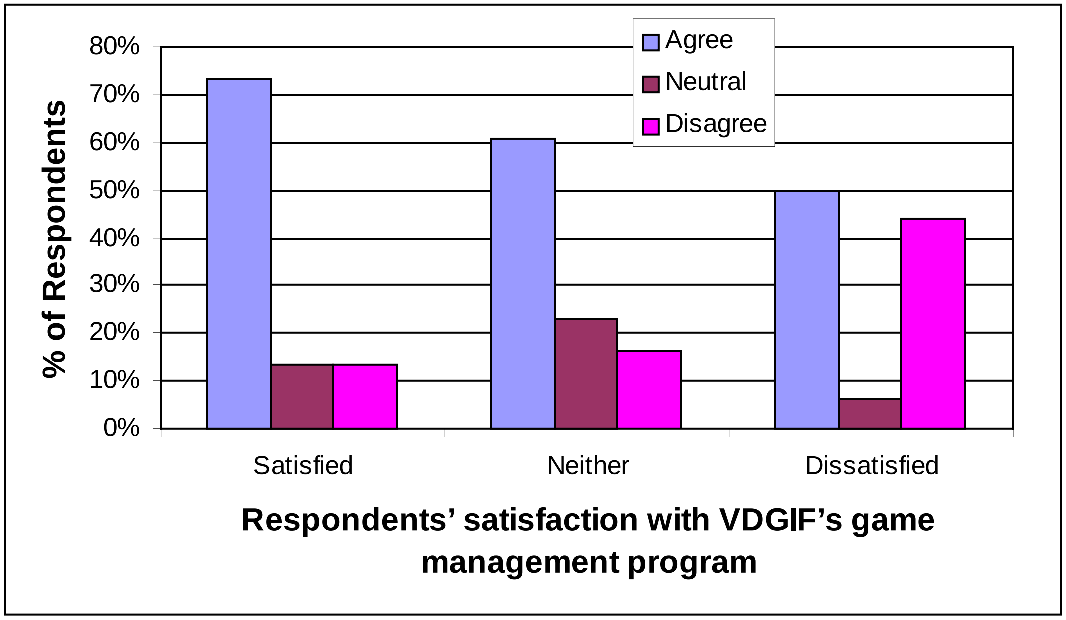


Figure 3.20. Relationship between satisfaction with Virginia Department of Game and Inland Fisheries' (VDGIF) game management program and agreement or disagreement that elk restoration is a good idea, as expressed by respondents to a mail survey of Virginia residents conducted during spring 1999 (G = 22.12, df = 4, P < 0.001, γ = 0.304).

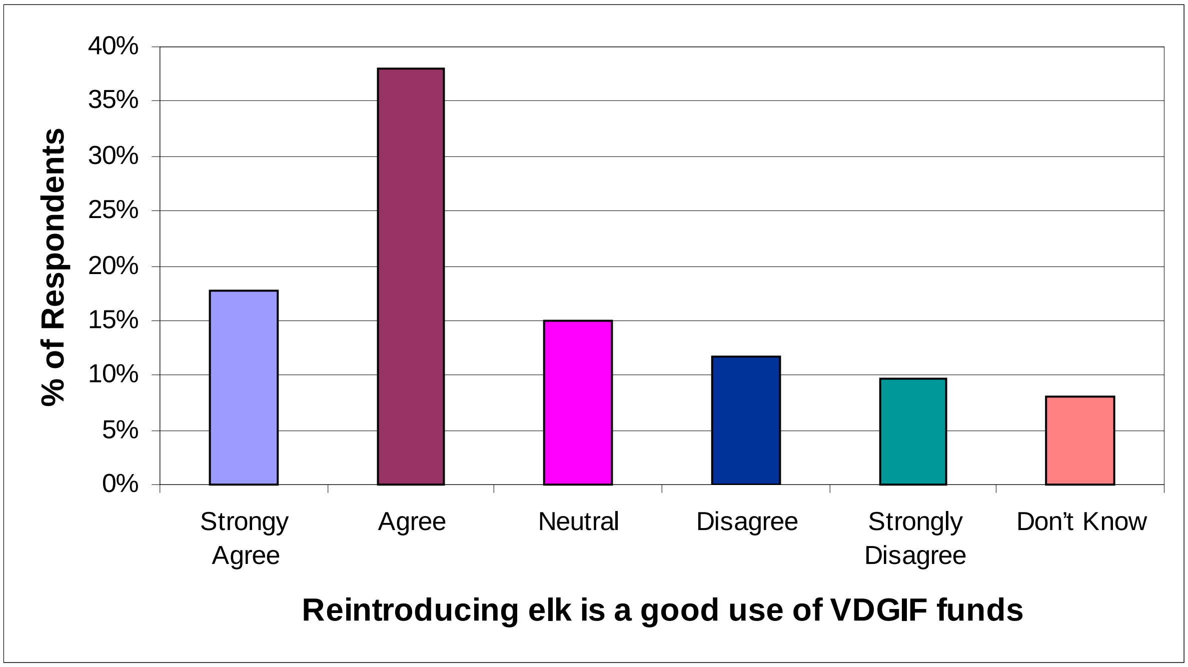


Figure 3.21. Attitudes about the appropriateness of using Virginia Department of Game and Inland Fisheries' (VDGIF) funds to manage a restored elk herd in Virginia as expressed by respondents to a mail survey of Virginia residents conducted during spring 1999.

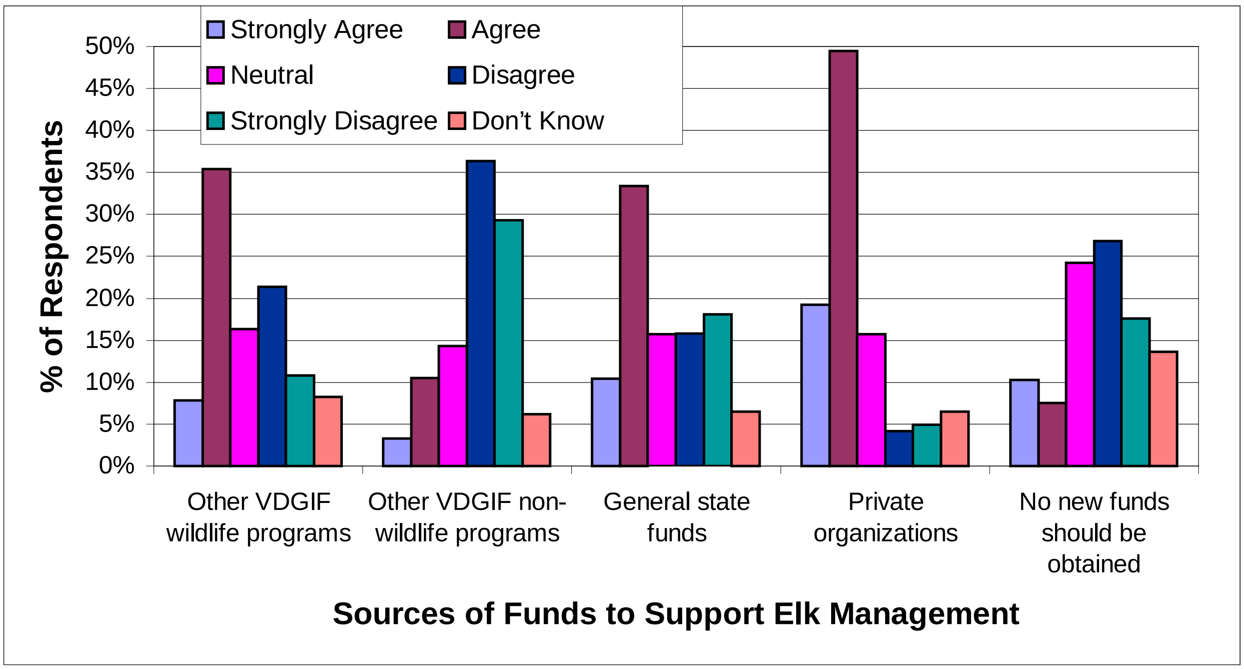


Figure 3.22. Respondent attitudes about how Virginia Department of Game and Inland Fisheries' (VDGIF) management of a restored elk herd should be funded in Virginia, as expressed by respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.

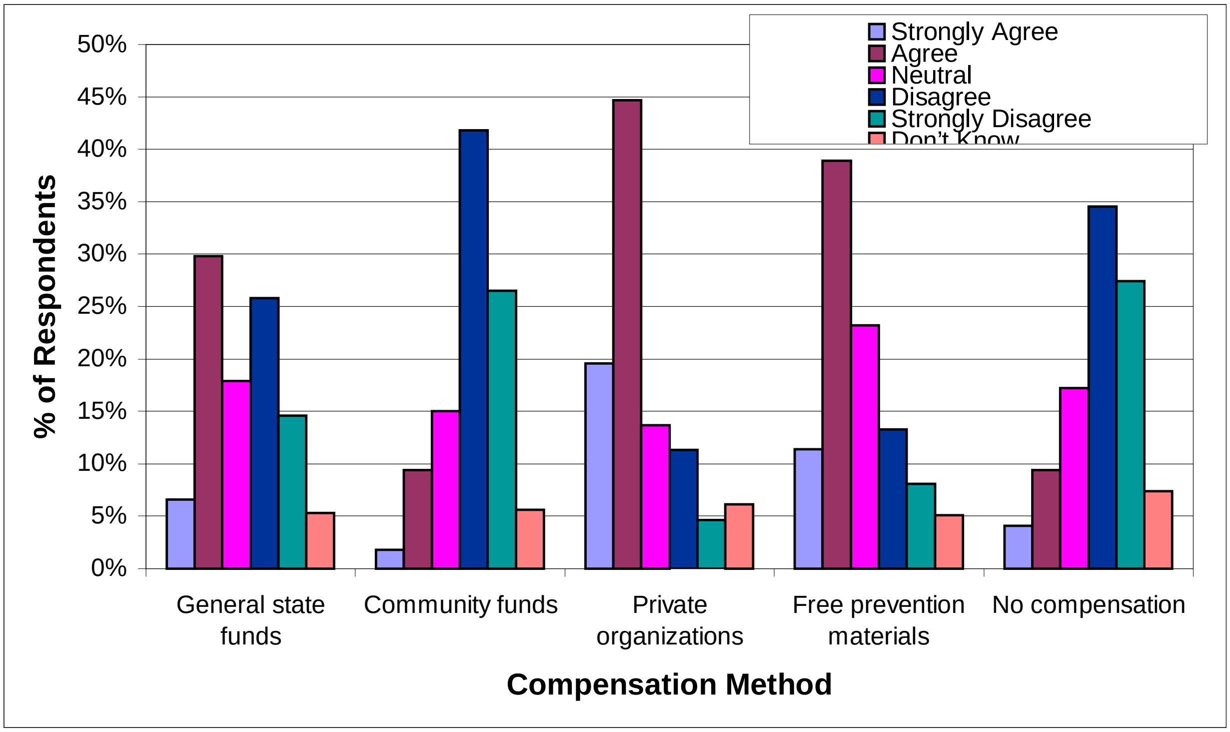


Figure 3.23. Attitudes toward compensation options for private property damage caused by elk, as expressed by respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.

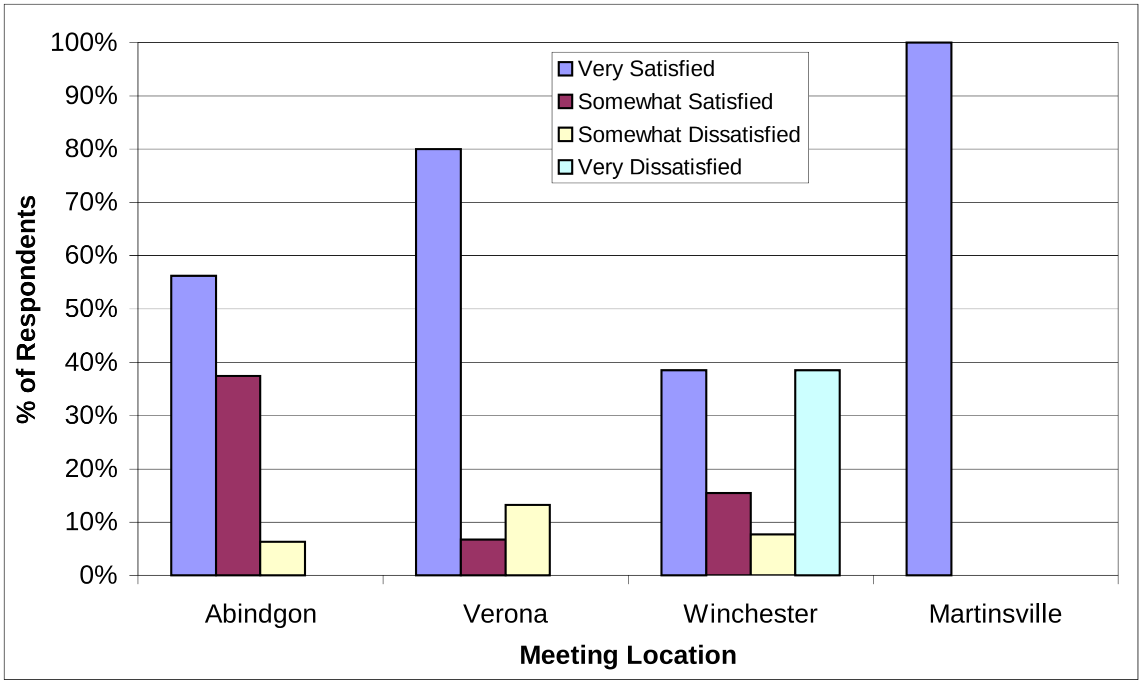


Figure 3.24. Participants' satisfaction with the presence of a noncompetitive, unthreatening atmosphere during 4 regional stakeholder workshops held during summer and fall 1999 to discuss elk restoration in Virginia.

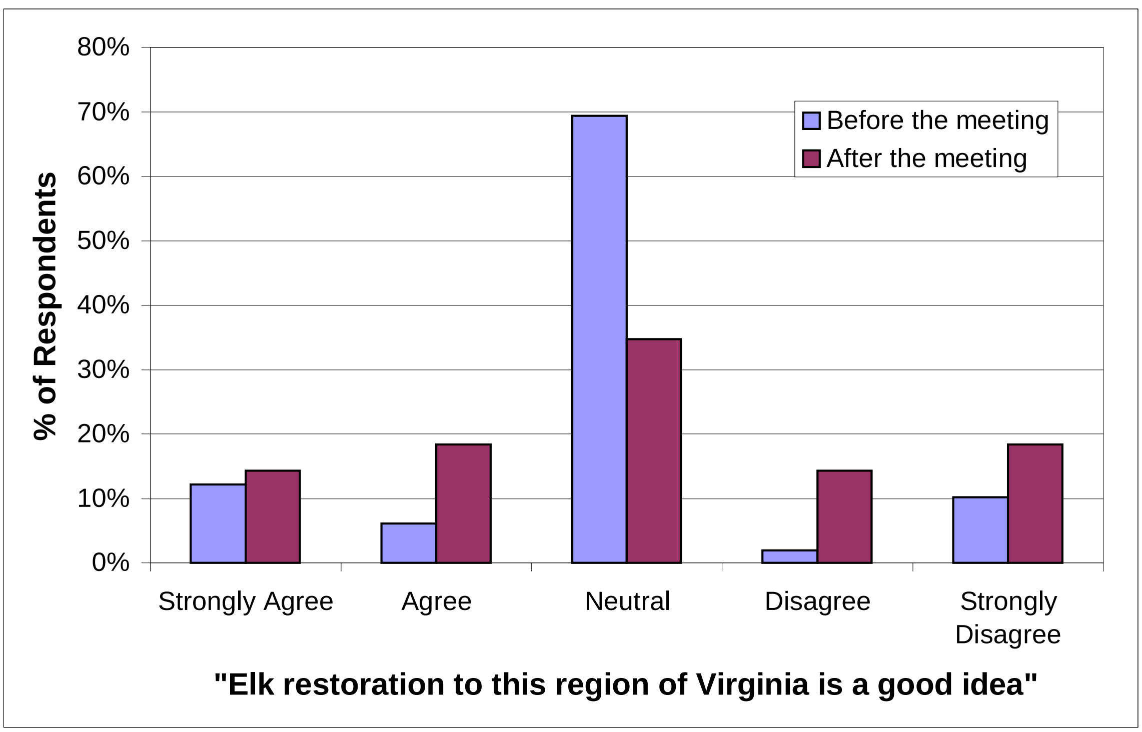


Figure 3.25. Attitudes toward elk restoration among workshop participants before and after participating in 1 of 4 regional workshops held during summer and fall 1999 to discuss the elk restoration in Virginia.

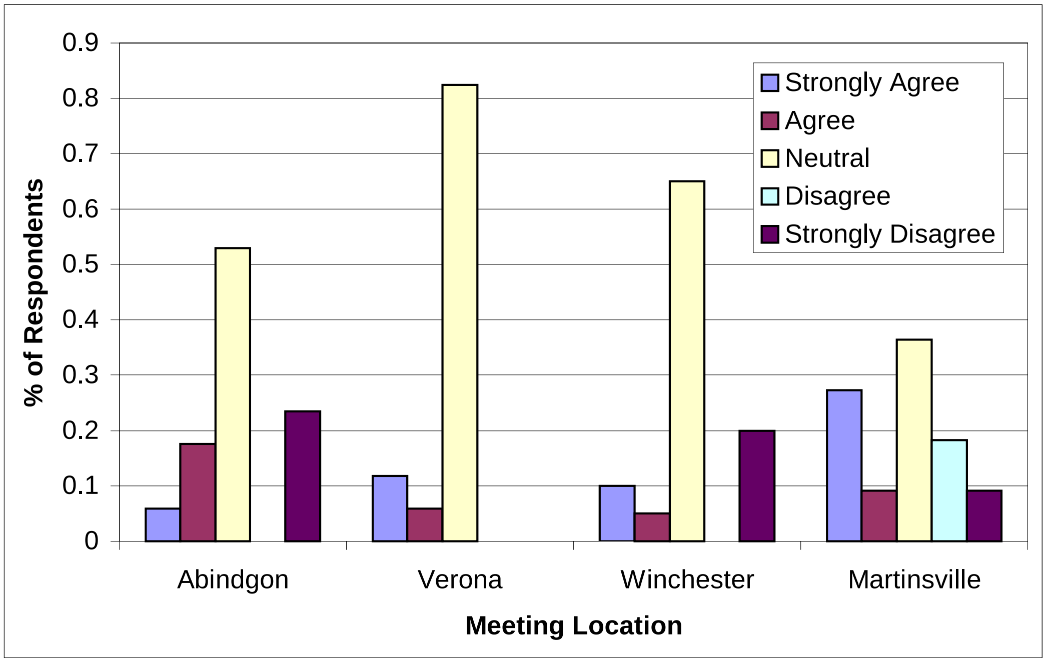


Figure 3.26. Participants' attitudes toward elk restoration prior to participation in 1 of 4 regional workshops held during summer and fall 1999 to discuss elk restoration in Virginia.

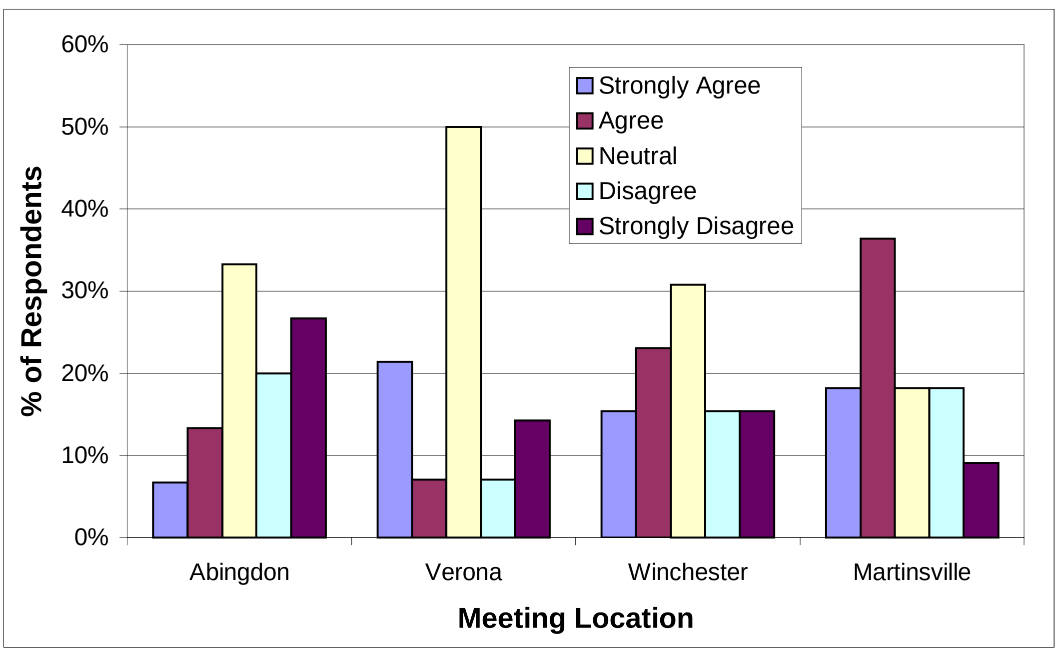


Figure 3.27. Participants' attitudes toward elk restoration after participation in 1 of 4 regional workshops held during summer and fall 1999 to discuss elk restoration in Virginia.

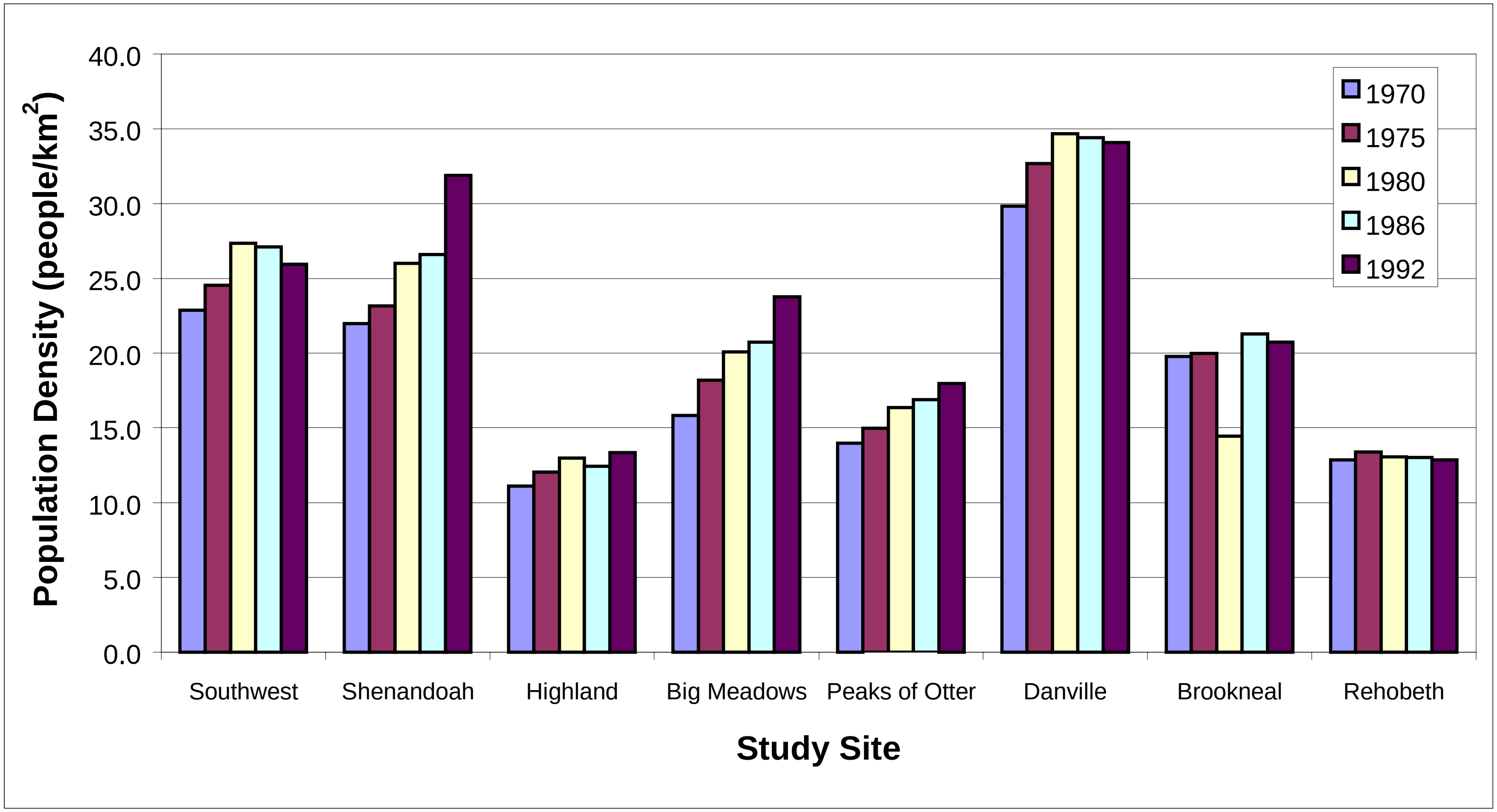


Figure 3.28. Trends in human population density (1970-1992) for 8 study areas under consideration for elk restoration in Virginia, based on consolidation of U.S. Census Bureau data (1973, 1978, 1983, 1988, 1994).

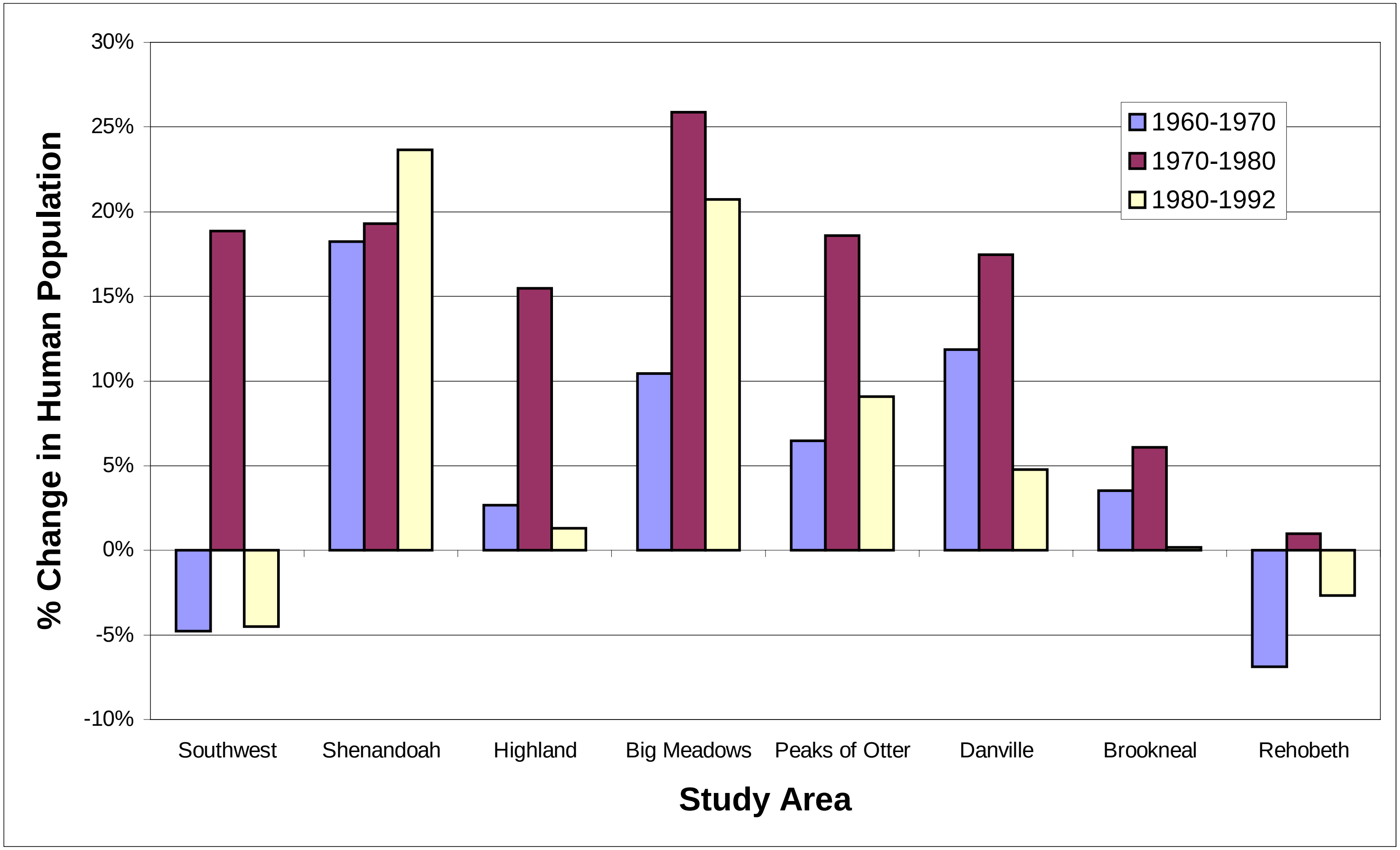


Figure 3.29. Trends in human population growth rate (1960-1992) for 8 study areas under consideration for elk restoration in Virginia, based on consolidation of U.S. Census Bureau data (1973, 1983, 1994).

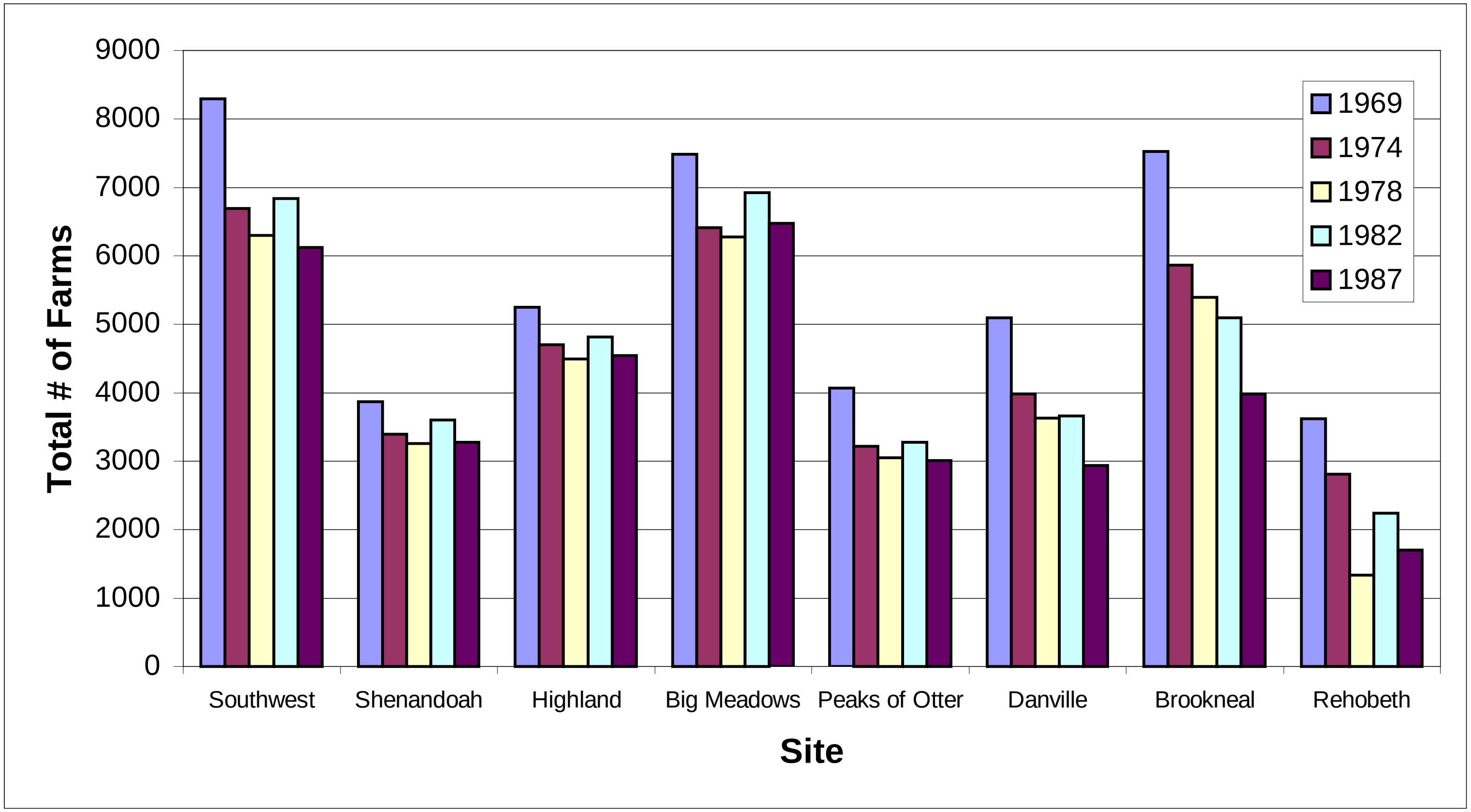


Figure 3.30. Change in the total number of farms in operation within each of the 8 study areas under consideration for elk restoration in Virginia, based on consolidation of U.S. Census Bureau data (1973, 1978, 1983, 1988, 1994).

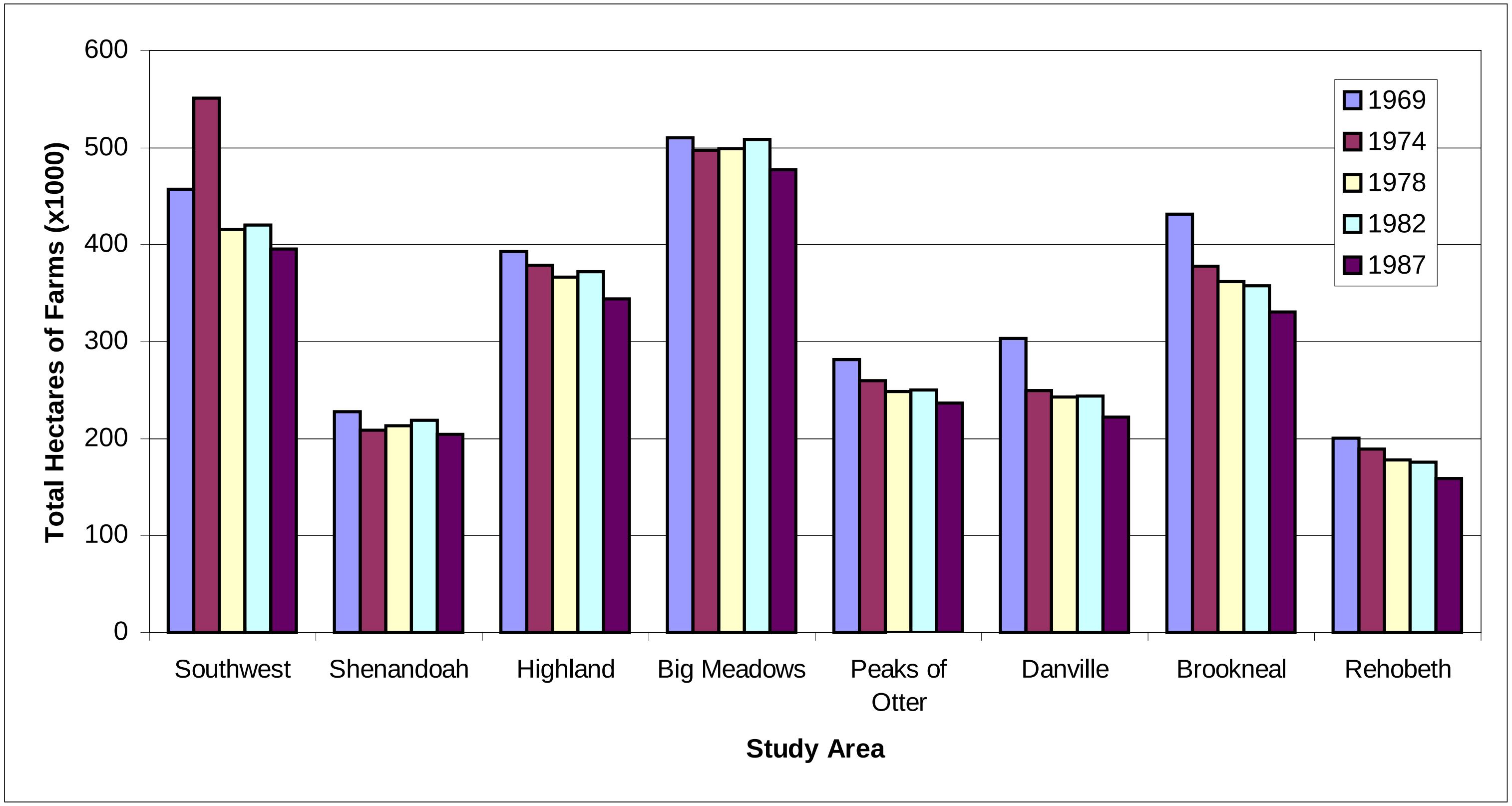


Figure 3.31. Change in total farm acreage within each of 8 study areas under consideration for elk restoration in Virginia, based on consolidation of U.S Census Bureau data (1973, 1978, 1983, 1988, 1994).

Tables

Table 2.1. A guide to interpreting habitat effectiveness (HE) scores and habitat suitability indexes (HSI) for rating elk habitat in Virginia (adapted from Wisdom et al. 1986).

HE Scores for Individual Components or Overall HSI	Habitat Condition
1.0	Optimal
0.9 0.8 0.7 0.6	Highly Viable
0.5 0.4	Viable
0.3 0.2	Marginal
0.1 0	Possibly Non-viable

Table 2.2. Study areas examined during a feasibility study for elk restoration in Virginia, ranked according to biological feasibility. Final ranks are based on estimated cultural carrying capacity (CK) (as determined by habitat suitability index, HSI, and habitat units, HU) and area:perimeter ratio (A/P).

Study Area	Overall HSI	HUs	Estimated CK[a]	Rank 1	Area[b] (km^2)	Perimeter[c] (km)	A/P	Rank 2	*Overall Rank* [d]
Southwest Region									
Southwest	0.608	126,975	1016	High	2,108.10	474.9	4.44	Medium	***Medium***
Shenandoah Region									
Shenandoah	0.609	94,721	758	High	1,593.20	327.4	4.87	Medium	***Medium***
Highland	0.562	124,038	992	High	2,264.20	281.4	8.05	High	***High***
Big Meadows	0.567	109,195	874	High	1,991.70	318.3	6.26	High	***High***
Peaks of Otter	0.564	37,685	301	Low	679.6	184.9	3.68	Low	***Low***
Southern Piedmont Region									
Danville	0.743	47,848	383	Low	654.8	155	4.22	Medium	***Low***
Brookneal	0.779	68,653	549	Medium	895.8	206.2	4.35	Medium	***Medium***
Rehobeth	0.77	42,851	343	Low	573.9	111.39	5.15	High	***Low***

[a] Estimated cultural carrying capacity (CK) = # HUs * (1 elk/125 HUs)
[b] Area is based on outside boundary (including area of roads and road buffers separating adjacent polygons).
[c] Perimeter is based on outside perimeter (not including boundaries separating adjacent polygons).
[d] Overall rank taken as the lowest of the 2 partial ranks

Table 2.3. Summary of physiographic characteristics for the 6 polygons that compose the Southwest study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	Bounding Roads	Land Use			Water Density[b] (km/km^2)	Road Density[c] (km/km^2)
		% Open	% Forest	% Other[a]		
West 27,620	North = S.R. 661 & 80[d] East = S.R. 601 & 621 South = S.R. 82 West = S. R. 63	2	97	<1	0.287	0.962
West-central 29,962	North = S.R. 80 East = U.S. 19 South = S.R. 82 West = S.R. 601 & 621	21	77	2	0.671	1.054
Central 36,795	North = U.S. 19 & S.R. 609 East = S.R. 16 South = S.R. 601, 42, & 613 West = S.R. 80	18	82	<1	0.328	0.620
East-central (north) 49,224	North = S.R. 61 & 614 East = I-77 South = S.R. 42 West = S.R. 16	25	74	<1	0.528	0.554
East-central (south) 27,181	North = S.R. 42 East = U.S. 52 South = S.R. 680 West = S.R. 622	25	74	<1	0.530	0.770
East 39,012	North = S.R. 42 East = S.R. 738 South = S.R. 610 West = I-77	22	78	<1	0.440	0.740

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.4. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 6 polygons comprising the Southwest study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
West	27,620	.376	.601	.665	.578	.500	13,750
West-Central	29,962	.690	.840	.843	.561	.686	20,213
Central	36,795	.577	.711	.747	.704	.633	23,256
East Central (N)	49,224	.524	.575	.854	.732	.606	29,788
East Central (S)	27,181	.588	.604	.852	.649	.610	16,553
East	39,012	.568	.622	.777	.662	.602	23,415
Overall[d]	***209,794***	***.550***	***.652***	***.794***	***.658***	***.608***	***126,975***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density

[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores

[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)

[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.5. Summary of physiographic characteristics for the 4 polygons that compose the Shenandoah study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	Bounding Roads	Land Use			Water Density[b] (km/km^2)	Road Density[c] (km/km^2)
		% Open	% Forest	% Other[a]		
North 39,868	North = S.R. 50 & 37[d] East = U.S. 11 South = S.R.55 West = West Virginia border	38	58	3	0.600	1.326
North-central 30,845	North = S.R. 55 East = I-81 & S.R. 623 South = S.R. 675 West = West Virginia border	22	77	<1	0.300	0.916
South-central 39,058	North = S.R. 675 East = S.R. 42 South = S.R. 259 West = West Virginia border	23	76	1	0.380	1.51
South 48,307	North = West Virginia border East = S.R. 259 & 612 South = U.S. 33 West = West Virginia border	11	89	<1	0.435	0.860

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.6. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 4 polygons comprising the Shenandoah study site in an assessment of elk restoration feasibility for Virginia.

Polygon	Area (ha)	HE_C[a]	HE_I	HE_W	HE_R	HSI[b]	HUs[c]
North	39,868	.639	.765	.865	.513	.639	24,635
North-central	30,845	.568	.754	.710	.612	.607	18,592
South-central	39,058	.565	.723	.777	.486	.575	22,194
South	48,307	.511	.722	.805	.626	.612	29,300
Overall[d]	***158,078***	***.567***	***.739***	***.794***	***.561***	***.609***	***94,721***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.7. Summary of physiographic characteristics for the 6 polygons that compose the Highland study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	**Bounding Roads**	**Land Use**			**Water Density[b] (km/km^2)**	**Road Density[c] (km/km^2)**
		% Open	**% Forest**	**% Other[a]**		
North 53,797	North = S.R. 257[d] & WV border East = S.R. 42 & 730 South = U.S. 250 West = S.R. 654	16	83	<1	0.317	0.830
West 39,322	North = U.S. 250 East = S.R. 678 South = S.R. 39 West = U.S. 220	16	84	<1	0.255	0.741
West-central 35,482	North = U.S. 250 East = S.R. 629 West = S.R. 678	10	89	<1	0.343	0.627
East-central 48,982	North = U.S. 250 East = S.R. 42 South = S.R. 42/39 West = S.R. 629	12	87	<1	0.330	0.780
East 45,292	North = S.R. 254 East = S.R. 252 South = S.R. 39 West = S.R. 42	44	54	2	0.360	1.145

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.8. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 5 polygons comprising the Highland study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
North	53,797	.493	.692	.700	.645	.572	30,535
West	39,322	.576	.682	.575	.665	.566	22,169
West-Central	35,482	.490	.587	.735	.697	.569	20,033
East-Central	48,982	.502	.565	.665	.666	.539	26,167
East	45,292	.611	.666	.688	.548	.565	25,134
Overall*	***222,875***	***.533***	***.640***	***.673***	***.642***	***.562***	***124,038***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.9. Summary of physiographic characteristics for the 5 polygons that compose the Big Meadows study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	**Bounding Roads**	**Land Use**			**Water Density[b] (km/km^2)**	**Road Density[c] (km/km^2)**
		% Open	**% Forest**	**% Other[a]**		
Northwest 40,436	North = U.S. 211 East = U.S. 340 South = U.S. 33 West = I-81 & U.S. 11	39	59	2	0.397	1.153
North-central 37,957	North = U.S. 211 East = Blue Ridge Parkway South = U.S. 33 West = S.R. 689 &U.S. 340[d]	22	76	2	0.392	1.237
Northeast 54,448	North = U.S. 211 East = S.R. 231, 230 & U.S. 29 South = U.S. 33 West = Blue Ridge Parkway	18	81	<1	0.357	1.216
Southwest 31,866	North = U.S. 33 East = Blue Ridge Parkway South = I-64 West = U.S. 340	10	89	1	0.315	0.755
Southeast 30,760	North = U.S. 33 East = S.R. 810 South = I-64 West = Blue Ridge Parkway	13	86	<1	0.359	0.870

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.10. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 5 polygons comprising the Big Meadows study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
North-west	40,436	.567	.648	.689	.550	.545	21,481
North-central	37,957	.574	.701	.768	.531	.588	21,733
North-east	54,448	.524	.630	.773	.514	.554	29,999
South-west	31,866	.498	.610	.734	.687	.567	17,844
South-east	30,760	.536	.633	.763	.645	.593	18,138
Overall[d]	***195,467***	***.540***	***.645***	***.747***	***.574***	***.567***	***109,195***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.11. Summary of physiographic characteristics for the 2 polygons that compose the Peaks of Otter study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	**Bounding Roads**	**Land Use**			**Water Density[b] (km/km^2)**	**Road Density[c] (km/km^2)**
		% Open	**% Forest**	**% Other[a]**		
West 39,860	North = S.R. 251 & 269[d] East = S.R. 11 & I-81 South & West = S.R. 43 & U.S. 220	11	88	1	0.303	.829
East 28,134	North = S.R. 130 East = Blue Ridge Parkway South = S.R. 43 West = I-81/U.S. 11	10	88	2	0.578	1.156

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.12. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each polygons comprising the Peaks of Otter study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
West	39,860	.520	.705	.673	.662	.584	23,002
East	28,134	.488	.568	.788	.537	.535	14,683
Overall[d]	***67,994***	***.507***	***.649***	***.720***	***.611***	***.564***	***37,685***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.13. Summary of physiographic characteristics for the 2 polygons that compose the Danville study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	**Bounding Roads**	**Land Use**			**Water Density[b] (km/km^2)**	**Road Density[c] (km/km^2)**
		% Open	**% Forest**	**% Other[a]**		
West 27,632	North = S.R. 969[d] East = S.R. 57 South = U.S. 58 West = S.R. 108 & 890	22	75	3	0.856	1.174
East 37,768	North = S.R. 57 East = S.R. 41 South = U.S. 58 West = S.R. 647	37	61	2	0.864	1.681

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.14. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 2 polygons comprising the Danville study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
West	27,632	.757	.821	.951	.542	.719	19,359
East	37,768	.919	.948	.977	.420	.760	28,125
Overall[d]	***65,400***	***.851***	***.895***	***.966***	***.471***	***.743***	***47,484***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.15. Summary of physiographic characteristics for the 3 polygons that compose the Brookneal study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	**Bounding Roads**	**Land Use**			**Water Density[b] (km/km^2)**	**Road Density[c] (km/km^2)**
		% Open	**% Forest**	**% Other[a]**		
South 26,965	North & East = S.R. 832[d] South = S.R. 360 West = S.R. 640	36	63	<1	0.668	1.231
West 27,431	North = S.R. 40 East = U.S. 501 South = S.R. 832 West = S.R. 640	34	65	<1	0.702	1.248
East 34,361	North = S.R. 59 East = S.R. 746 South = S.R. 630 West = U.S. 501	29	70	<1	0.713	1.058

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.16. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 3 polygons comprising the Brookneal study site in an assessment of elk restoration feasibility for Virginia.

Polygon	**Area (ha)**	**HE_C[a]**	**HE_I**	**HE_W**	**HE_R**	**HSI[b]**	**HUs[c]**
South	26,965	.911	.952	.941	.502	.789	21,095
West	27,431	.900	.938	.961	.501	.786	21,470
East	34,361	.854	.923	.918	.522	.765	26,088
Overall[d]	***88,757***	***.886***	***.936***	***.938***	***.509***	***.779***	***68,653***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.17. Summary of physiographic characteristics for the 2 polygons that compose the Rehobeth study site examined during an elk restoration feasibility assessment for Virginia.

Polygon Area (ha)	Bounding Roads	Land Use			Water Density[b] (km/km^2)	Road Density[c] (km/km^2)
		% Open	% Forest	% Other[a]		
West 25,913	North = S.R. 40[d] East = S.R. 49 South & West = U.S. 15/360	31	66	3	0.737	1.285
East 30,996	North & East = S.R. 635 South = S.R. 47 West = S.R. 49	28	70	2	0.633	1.188

[a] % Other = Open water area + Disturbed area
[b] Based on total linear shoreline distance for permanent water features
[c] Based on total length of minor roads and streets
[d] S.R. = State Route

Table 2.18. Summary of individual habitat effectiveness (HE) scores for variables used in an elk habitat model for Virginia, habitat suitability index (HSI) values, and number of habitat units (HU) in each of 2 polygons comprising the Rehobeth study site in an assessment of elk restoration feasibility for Virginia.

Polygon	Area (ha)	HE_C[a]	HE_I	HE_W	HE_R	HSI[b]	HUs[c]
West	25,913	.840	.942	.940	.496	.773	19,425
East	30,996	.849	.943	.913	.525	.768	23,426
Overall[d]	***56,909***	***.845***	***.943***	***.925***	***.512***	***.770***	***42,851***

[a] Key to variables: HE_C = Landscape composition, HE_I = Landscape interspersion, HE_W = Distance to water, HE_R = Road density
[b] HSI scores are averages of scores obtained from pixel-by-pixel calculations, rather than the mean of the averages. These 2 methods result in slightly different scores
[c] HUs are calculated using habitat area. Habitat area = total area – (open water + disturbed)
[d] Overall values were calculated as weighted (by area) averages of polygon values.

Table 2.19. Summary of high and unknown risk diseases to be considered during elk translocations to Virginia.

Disease or Parasite	Risk-Level	Infectious Agent	Reason for Concern	Species of Concern	References
Chronic Wasting Disease (CWD)	High	Prion	damages brain tissue leading to death; little known about transmission, pathology; no diagnostic test for live animals	elk, deer, livestock, humans	Lantos 1992; Nettles and Corn 1998; Spraker et al. 1997; Lacey 1998;
Brucellosis	High	Bacterium- *Brucella abortus*	Causes spontaneous abortion in cervids and livestock; causes undulant fever in humans; economic concerns for cattle farmers	elk, deer, livestock, humans	Kistner 1982; Nettles and Corn 1998; Berger and Cain 1999
Bovine Tuberculosis (TB)	High	Bacterium- *Mycobacterium bovis*	Infect livestock and wildlife, economic concerns for livestock producers	elk, deer, other wildlife, livestock	Schmitt et al. 1997; Nettles and Corn 1998
Dermacentor andersoni	High	Tick vector of anaplasmosis, tuleremia, Colorado tick fever, Rocky Mountain spotted fever	*D. andersoni* is a more efficient vector of these diseases than is currently present in the Southeast	livestock, humans	Nettles and Corn 1998
Ixodes pacificus	High	Tick vector of Lyme disease and tick paralysis	May be a more effective vector of already problematic pathogens	humans	Nettles and Corn 1998
Psoroptic Mange	High	Mite- *Psoroptes spp.*	Causes mange and death in elk	elk	Nettles and Corn 1998
Paratuberculosis	Unknown	Bacterium- *Mycobacterium paratuberculosis*	Can infect ruminant livestock	livestock	Cook et al. 1997; Nettles and Corn 1998
Septicemic pasteurellosis	Unknown	Bacterium- *Pasteurella multocida*	pneumonia-like symptoms in elk	elk, possibly other cervids	Nettles and Corn 1998

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Table 2.19. (Continued)

Disease or Parasite	Risk-Level	Infectious Agent	Reason for Concern	Species of Concern	References
Elaphostrongylus cervi	Unknown	Nematode parasite	imported into Canada with infected elk from Europe	elk	Nettles and Corn 1998
Fascioloides magna	Unknown	Large liver fluke	can infect cheep and cattle	livestock	Nettles and Corn 1998
Echinococcus granulosis	Unknown	Tapeworm	maintained via predator-prey relationship between cervids and canids; humans can become infected	humans	Nettles and Corn 1998
Dermacentor albipictus	Unknown	Winter tick	infestation can cause severe alopecia	elk, deer	Nettles and Corn 1998
Otobius megnini	Unknown	Spinous ear tick	Causes inflammation leading to secondary bacterial infections	elk, deer, livestock, horses, canids	Nettles and Corn 1998

Table 3.1. Nonresponse analysis comparing mail and telephone respondents to a survey of Virginia residents about elk restoration in Virginia conducted during spring (mail) and summer (telephone) of 1999.

Question	Phone Survey			Mail Survey			Test on % "Don't Know"			Test on Mean		
	N	% Don't Know	Mean	*N*	% Don't Know	Mean	Chi-Square Value[a]	*df*	P-Value	Chi-Square Value[b]	*df*	P-Value
Do you agree or disagree that reintroducing elk into Virginia is a good idea?[c]	50	46%	1.7	610	9%	1.5	86.40	3.00	<0.001	2.22	4	0.329
How helpful was the informational brochure?[c, d]	50	68%	1.7	603	4%	1.7	562.00	3.00	<0.001	0.65	4	0.724
If elk restoration caused an increase in agricultural damages, how would you be affected?[e]	50	18%	2.3	621	7%	2.2	10.33	3.00	0.016	1.53	4	0.466
If elk restoration increased Virginia's biodiversity, how would you be affected?[e]	50	38%	1.5	605	13%	1.4	30.33	3.00	<0.001	1.45	4	0.484
If elk restoration increased recreational opportunities, how would you be affected?[e]	50	26%	1.6	614	7%	1.4	32.32	3.00	<0.001	4.68	4	0.964
If elk restoration resulted in disease transmission from elk to Virginia's livestock, how would you be affected?[e]	50[f]	38%	2.3	619	14%	2.4	23.84	3.00	<0.001	2.96	4	0.228
If elk restoration resulted in disease transmission from elk to Virginia's wildlife, how would you be affected?[e]				618	14%	2.4	25.82	3.00	<0.001	3.92	4	0.141
Do you agree or disagree that reintroducing elk into Virginia is an appropriate use of funding by VDGIF?[c]	50	24%	1.7	616	8%	1.6	18.14	3.00	<0.001	1.32	4	0.517

[a] Goodness-of-fit test statistics comparing % of "Don't Know" responses between mail and telephone surveys.
[b] Goodness-of-fit test statistics based on means with "Don't Know" responses removed from analysis.
[c] Means based on scaled responses: 1 = Agree, 2 = Neutral, 3 = Disagree
[d] %"Don't Know" column reflects % "Didn't Read It" responses
[e] Means based on scaled responses: 1 = Positive, 2 = No Affect, 3 = Negative
[f] Questions about disease transmission to livestock and wildlife were combined into 1 question for telephone survey.

Table 3.2. Comparison of respondents indicating "Don't Know" responses between mailing events in a survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.

Question	Mail 1[a]		Mail 2		Mail 3		Mail 4		G^{b}	*df*	P-Value	Gamma
	N	% Don't Know	*N*	% Don't Know	*N*	% Don't Know	*N*	% Don't Know				
Do you agree or disagree that reintroducing elk into Virginia is a good idea?	181	5.5%	140	5.0%	228	13.6%	61	9.8%	11.47	3	0.009	0.301
How helpful was the informational brochure?[c]	180	0.0%	139	3.6%	224	7.1%	60	5.0%	19.61	3	<0.001	0.540
How likely would you be to make a special trip to view a restored elk herd?	183	0.5%	144	1.4%	236	4.7%	65	4.6%	1.71	3	0.635	0.071
If elk restoration increased agricultural damages, how would you be affected?	181	3.9%	145	7.6%	231	8.7%	64	9.4%	4.71	3	0.195	0.234
If elk restoration increased Virginia's biodiversity, how would you be affected?	179	9.5%	141	7.1%	225	18.2%	60	13.3%	12.02	3	0.007	0.238
If elk restoration increased recreational opportunities, how would you be affected?	180	4.4%	143	4.9%	228	7.9%	63	14.3%	7.41	3	0.060	0.309
If elk restoration resulted in disease transmission from elk to Virginia's livestock, how would you be affected?	180	13.9%	145	15.8%	230	15.2%	64	12.5%	0.56	3	0.907	-0.001
If elk restoration resulted in disease transmission from elk to Virginia's wildlife, how would you be affected?	180	12.8%	143	15.4%	231	14.7%	64	14.0%	0.52	3	0.915	0.036
Do you agree or disagree that elk restoration is an appropriate use of funding by VDGIF?	181	6.6%	142	4.9%	228	9.6%	65	13.8%	5.87	3	0.118	0.228

[a] Mail 1-4 represent each of 4 mailing events during the mail survey
[b] Log-likelihood ratio test statistic on % "Don't Know" responses
[c] % "Don't Know" column represents % "Didn't Read It" responses

Table 3.3. Comparison of respondents' attitudes between mailing events in a survey of Virginia residents about elk restoration conducted in spring 1999.

Question	Mail 1[a]		Mail 2		Mail 3		Mail 4		G^b	*df*	P-Value	Gamma
	N	Mean	*N*	Mean	*N*	Mean	*N*	Mean				
Do you agree or disagree that reintroducing elk into Virginia is a good idea?[c]	181	2.1	140	2.3	228	2.4	61	2.5	18.98	12	0.089	0.134
If given the opportunity, would you support or oppose elk restoration?[d]	178	1.2	141	1.3	229	1.4	61	1.5	22.23	3	<0.001	0.311
How confident are you of your knowledge level regarding elk?[d]	181	2.4	141	2.4	227	2.7	61	2.7	24.06	9	0.004	0.169
How helpful was the informational brochure?[e]	180	1.7	139	1.7	224	1.8	60	1.8	6.25	6	0.396	0.088
How likely would you be to make a special trip to view a restored elk herd?[f]	183	1.8	144	2.0	236	2.1	65	2.3	24.06	6	0.001	0.236
If elk restoration increased agricultural damages, how would you be affected?[g]	181	3.2	145	3.3	231	3.2	64	3.2	10.94	12	0.534	-0.020
If elk restoration increased Virginia's biodiversity, how would you be affected?[g]	179	2.3	141	2.2	225	2.3	60	2.3	24.48	12	0.017	0.070
If elk restoration increased recreational opportunities, how would you be affected?[g]	180	2.3	143	2.2	228	2.5	63	2.3	17.59	12	0.129	0.172
If elk restoration resulted in disease transmission from elk to Virginia's livestock, how would you be affected?[g]	180	3.6	145	3.6	230	3.6	64	3.4	4.59	12	0.97	0.001
If elk restoration resulted in disease transmission from elk to Virginia's wildlife, how would you be affected?[g]	180	3.6	143	3.7	231	3.6	64	3.5	8.91	12	0.711	-0.032
Do you agree or disagree that elk restoration is an appropriate use of funding by VDGIF?[c]	181	2.4	142	2.4	228	2.7	65	2.8	14.43	12	0.274	0.127

[a] Mail 1-4 represent each of 4 mailing events during the mail survey
[b] Log-likelihood ratio test statistic with % "Don't Know" responses removed from analysis
[c] Mean based on scaled responses: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree
[d] Mean based on scaled responses: 1 = Very Confident, 2 = Somewhat Confident, 3 = Somewhat Uncertain, 4 = Very Uncertain
[e] Mean based on scaled responses: 1 = Very Helpful, 2 = Somewhat Helpful, 3 = Not Very Helpful
[f] Mean based on scaled responses: 1 = Very Likely, 2 = Somewhat Likely, 3 = Not Very Likely
[g] Mean based on scaled responses: 1 = Very Positive, 2 = Positive, 3 = No Affect, 4 = Negative, 5 = Very Negative

Table 3.4. Relationships between demographic characteristics and respondent attitude toward the statement "Reintroducing elk to Virginia is a good idea," based on a mail survey of Virginia residents conducted in spring 1999.

Demographic Characteristic		Mean[a]	*N*	*G*[b]	*df*	P-Value	Gamma
Age			597	37.31	8	<0.001	0.303
	<46	2.0					
	46-65	2.3					
	>65	2.8					
Gender			598	1.42	4	0.841	NA
	Male	2.3					
	Female	2.3					
Education			596	16.39	16	0.426	0.003
	< High School	2.6					
	High School	2.4					
	Some College	2.1					
	Bachelor's	2.4					
	Graduate	2.2					
Income			552	17.07	15	0.315	0.009
	<$30,000	2.5					
	$30,000-$59,000	2.2					
	$60,000-$99,000	2.3					
	>$100000	2.2					
Employment Status			600	10.45	4	0.033	NA
	Unemployed	2.6					
	Employed	2.2					
Employment Type			485	19.28	4	0.001	NA
	Employed in Agriculture	2.8					
	Employed in Other Field	2.2					
Size of city where grew up			600	20.77	12	0.054	-0.055
	Rural area	2.4					
	City <50,000 people	2.3					
	City 50,000-249,000 people	2.1					
	City >250,000 people	2.2					
Size of city where currently live			597	36.57	12	<0.001	-0.009
	Rural area	2.4					
	City <50,000 people	2.3					
	City 50,000-249,000 people	2.2					
	City >250,000 people	2.2					

[a] Means based on scaled responses: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree
[b] Log-likelihood ratio test statistic

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Table 3.4 (Continued)

Question	Mean[a]	*N*	*G*[b]	*df*	P-Value	Gamma
Frequency of outdoor recreation		585	47.23	24	0.003	0.162
Once/week	2.1					
2-3 times/month	2.2					
Once/month	2.3					
Every other month	2.1					
2-3 times/year	2.3					
Once/year	2.5					
Never	2.7					
Region of residence		610	19.77	10	0.031	NA
Central	2.7					
East	2.0					
Northeast	2.3					
Northwest	2.2					
West	2.2					

[a] Means based on scaled responses: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree
[b] Log-likelihood ratio test statistic

Table 3.5. Matrix of respondents' initial attitudes toward elk restoration (rows) and respondent attitudes partway through a survey (no neutral option given; columns) of Virginia residents conducted during spring 1999.

		Attitude partway through the survey, no neutral response option provided		
Initial response to the statement "Reintroducing elk into Virginia is a good idea"		Support	Not Support	Total
Strongly Agree	*N*	145	5	150
	% of Strongly Agree	97%	3%	100%
	% of Support/Not Support	36%	3%	39%
Agree	*N*	209	9	218
	% of Agree	96%	4%	100%
	% of Support/Not Support	52%	5%	57%
Neutral	*N*	31	57	88
	% of Neutral	35%	65%	100%
	% of Support/Not Support	8%	30%	38%
Disagree	*N*	2	44	46
	% of Disagree	4%	96%	100%
	% of Support/Not Support	1%	23%	24%
Strongly Disagree	*N*	0	38	38
	% of Strongly Disagree	0%	100%	100%
	% of Support/Not Support	0%	20%	20%
Don't Know	*N*	16	35	51
	% of Don't Know	31%	69%	100%
	% of Support/Not Support	4%	19%	23%
Total	*N*	403	150	553
	% of Total	68%	32%	100%
	% of Support/Not Support	100%	100%	100%

Table 3.6. Perceived effects (positive vs. negative) of potential outcomes of elk restoration compared with respondents attitude toward elk restoration (support vs. not support) as determined by a mail survey of Virginia residents during spring 1999. Respondents answering "Don't Know" were compared against respondents offering an opinion (Column A), and respondents offering positive and negative opinions were compared (Column B).

			(A) Positive vs. Negative Impact					(B) Don't Know vs. Other				
Potential Outcome	*N*	Attitude Toward Elk	Mean[a]	*G*[b]	*df*	P-Value	Gamma	% Don't Know	*G*	*df*	P-Value	Gamma
An increase in Virginia's biodiversity	590			42.53	4	<0.001	0.484		26.75	1	<0.001	0.582
		Support	2.1					7.4%				
		Not Support	2.6					30.0%				
An increase in recreational opportunities	599			113.01	4	<0.001	0.666		26.79	1	<0.001	0.716
		Support	2.1					2.7%				
		Not Support	2.9					16.7%				
Economic benefits to communities near release stes	602			114.45	4	<0.001	0.634		15.84	1	<0.001	0.551
		Support	2.3					4.6%				
		Not Support	3.1					14.3%				
A reduction in the size of Virginia's deer herd due to competition with	602			13.09	4	0.011	-0.052		9.08	1	0.003	0.446
		Support	2.8					5.1%				
		Not Support	2.8					12.2%				
Movement of elk from release sites	596			55.01	4	<0.001	0.234		0.37	1	0.054	0.258
		Support	2.9					9.9%				
		Not Support	3.2					16.9%				
An increase in agricultural damages	605			109.51	4	<0.001	-0.028		5.17	1	0.023	0.355
		Support	3.2					5.3%				
		Not Support	3.2					11.8%				
Negative effects on other wildlife due to habitat alteration by elk	602			90.87	4	<0.001	-0.111		5.57	1	0.018	0.319
		Support	3.3					8.7%				
		Not Support	3.1					14.4%				

[a] Mean scores based on scaled responses: 1 = Very Positive, 2 = Positive, 3 = No Effect, 4 = Negative, 5 = Very Negative
[b] Log-likelihood ratio test statistic

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Table 3.6 (Continued)

Potential Outcome	N	Attitude	(A) Positive vs. Negative Impact: Mean[a]	G[b]	df	P-Value	Gamma	(B) Don't Know vs. Other: % Don't	G	df	P-Value	Gamma
Economic hardship placed on farmers	601			117.20	4	<0.001	-0.110		0.01	1	0.923	0.014
		Support	3.4					9.9%				
		Not Support	3.1					11.3%				
Elk poaching	601			23.62	4	<0.001	-0.237		0.38	1	0.539	0.093
		Support	3.5					9.3%				
		Not Support	3.1					11.2%				
Disease transmission from elk to Virginia's livestock	603			88.12	4	<0.001	-0.003		1.01	1	0.315	0.125
		Support	3.6					14.7%				
		Not Support	3.5					18.9%				
Disease transmission from elk to Virginia's wildlife	603			78.72	4	<0.001	-0.067		2.28	1	0.131	0.187
		Support	3.7					11.8%				
		Not Support	3.4					19.6%				
Inhumane treatment of elk during trapping, transport, and release	604			14.32	4	0.006	-0.172		2.22	1	0.136	0.204
		Support	3.6					10.1%				
		Not Support	3.4					15.2%				

[a] Mean scores based on scaled responses: 1 = Very Positive, 2 = Positive, 3 = No Effect, 4 = Negative, 5 = Very Negative
[b] Log-likelihood ratio test statistic

Table 3.7. Relationship between demographic characteristics and self-perceived level of knowledge about elk as indicated by respondents to a mail survey of Virginia residents about elk restoration in Virginia conducted during spring 1999.

Demographic Characteristic	Mean[a]	*N*	G[b]	*df*	*P*-Value	Gamma
Age		596	25.22	6	<0.001	0.198
<46	2.5					
46-65	2.5					
>65	3.0					
Gender		597	7.70	3	0.053	NA
Male	2.5					
Female	2.7					
Education		595	10.87	12	0.540	-0.033
< High School	2.5					
High School	2.7					
Some College	2.6					
Bachelor's	2.5					
Graduate	2.6					
Income		553	5.09	9	0.826	-0.029
<$30,000	2.7					
$30,000-$59,999	2.5					
$60,000-$99,999	2.6					
>$100,000	2.5					
Employment status		600	18.90	3	<0.001	NA
Unemployed	2.9					
Employed	2.5					
Employment type		485	4.29	3	0.231	NA
Agriculture	2.5					
Other	2.5					
Size of city where grew up		600	24.78	9	0.003	0.191
Rural	2.4					
City <50,000 people	2.6					
City 50,000-250,999 people	2.7					
City >250,999 people	2.9					
Size of city where currently live		597	20.91	9	0.013	0.152
Rural	2.4					
City <50,000 people	2.4					
City 50,000-249,999 people	2.7					
City >249,999 people	2.7					

[a] Mean scores based on scaled responses: 1 = Very Confident, 2 = Somewhat Confident, 3 = Somewhat Uncertain, 4 = Very Uncertain

[b] Log-likelihood ratio test statistic

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Table 3.7 (Continued)

Demographic Characteristic	Mean[a]	*N*	*G* [b]	*df*	*P*-Value	Gamma
Frequency of outdoor recreation		585	68.98	18	<0.001	0.320
Once/week	2.3					
2-3 times/month	2.3					
Once/month	2.5					
Every other month	2.4					
2-3 times/year	2.8					
Once/year	2.9					
Never	3.2					
Region of residence		610	25.91	15	0.039	NA
Central	2.6					
East	2.5					
Northeast	2.6					
Northwest	2.4					
Southwest	2.2					

[a] Mean scores based on scaled responses: 1 = Very Confident, 2 = Somewhat Confident, 3 = Somewhat Uncertain, 4 = Very Uncertain

[b] Log-likelihood ratio test statistic

Table 3.8. Factors motivating respondents' decisions to support elk restoration, in order of stated importance, and the difference between these motivating factors for men and women according to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Overall Mean[a]	Men		Women		G^b	*df*	*P*
			N	Mean	*N*	Mean			
To restore natural heritage	415	1.7	311	1.7	96	1.5	14.63	3	0.002
Elk were present historically	416	1.7	311	1.7	97	1.6	3.52	3	0.318
To be able to see elk	415	1.7	311	1.7	96	1.7	1.11	3	0.774
To increase biodiversity	409	1.7	306	1.8	95	1.6	10.48	3	0.015
Elk have a right to live in native range	415	1.8	311	1.9	96	1.5	20.43	3	<0.001
To increase recreational opportunities	414	2.0	310	1.9	96	2.2	9.43	3	0.024
Economic benefits to communities	415	2.1	311	2.0	96	2.2	6.59	3	0.086
Is a good use of funds	413	2.3	310	2.2	95	2.4	7.87	3	0.049
To reduce the size of the deer herd	413	2.5	310	2.5	95	2.5	7.92	3	0.048
Would like to hunt elk in Virginia	412	3.1	309	2.9	95	3.6	30.54	3	<0.001

a Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
b Log-likelihood ratio test statistic

Table 3.9. Factors motivating the decision to support elk restoration in Virginia, as determined by the education level of respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Mean Scores by Education Level[a]					G^b	*df*	*P*	Gamma
		< High School	High School	Some College	Bachelor's Degree	Graduate Degree				
To restore natural heritage	406	1.6	1.6	1.6	1.7	1.8	20.99	12	0.051	0.173
Elk were present historically	407	1.5	1.7	1.7	1.7	1.8	8.22	12	0.768	0.070
To be able to see elk	406	1.4	1.6	1.6	1.8	1.8	13.97	12	0.303	0.197
To increase biodiversity	400	2.0	1.8	1.7	1.8	1.6	10.79	12	0.547	-0.111
Elk have a right to live in native range	406	1.6	1.8	1.7	1.9	2.0	15.47	12	0.217	0.157
To increase recreational opportunities	405	1.6	1.7	1.9	2.2	2.1	30.25	12	0.003	0.267
Economic benefits to communities	406	1.5	1.9	1.9	2.2	2.2	28.19	12	0.005	0.242
Is a good use of funds	404	2.0	2.1	2.2	2.5	2.3	29.95	12	0.003	0.160
To reduce the size of the deer herd	404	2.6	2.4	2.5	2.5	2.4	12.24	12	0.426	-0.001
Woud like to hunt elk in Virginia	403	2.4	2.6	3.0	3.4	3.2	36.27	12	<0.001	0.229

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.10. Factors motivating the decision to support elk restoration in Virginia, as determined by the frequency of participation in outdoor recreation in 1998 for respondents to a mail survey of Virginia residents conducted during spring 1999.

		Mean Scores by Frequency of Outdoor Recreation Participation[a]							
Motivating Factors	*N*	At least 1/month	At least every other month	At least once/ year	Never	G^b	*df*	*P*	Gamma
To restore natural heritage	408	1.6	1.7	1.7	2.1	11.33	9	0.254	0.146
Elk were present historically	409	1.6	1.8	1.8	2.0	12.64	9	0.180	0.199
To be able to see elk	408	1.6	1.8	1.7	2.3	42.01	9	<0.001	0.280
To increase biodiversity	402	1.7	1.8	1.7	1.8	10.23	9	0.332	0.074
Elk have a right to live in native range	408	1.8	1.9	1.8	1.8	7.71	9	0.629	0.068
To increase recreational opportunities	407	1.7	2.2	2.0	2.5	40.22	9	0.000	0.333
Economic benefits to communities	408	1.9	2.2	2.1	2.5	30.32	9	<0.001	0.196
Is a good use of funds	406	2.1	2.4	2.4	2.6	32.65	9	0.018	0.211
To reduce the size of the deer herd	406	2.5	2.5	2.4	2.3	15.40	9	0.080	-0.052
Woud like to hunt elk in Virginia	405	2.6	3.4	3.4	3.8	68.23	9	<0.001	0.430

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.11. Effects of background (i.e., rural vs. urban) on the motivation to support elk restoration in Virginia among respondents to a mail survey of Virginia residents conducted during spring 1999.

		Size of city where grew up[a]							
Motivating Factors	*N*	Rural	<50,000 people	50,000-249,999 people	>250,000 people	G^b	*df*	*P*	Gamma
To restore natural heritage	410	1.6	1.7	1.7	2.0	16.08	9	0.065	0.136
Elk were present historically	411	1.7	1.7	1.7	1.8	3.66	9	0.932	0.042
To be able to see elk	410	1.6	1.7	1.8	2.0	17.56	9	0.041	0.218
To increase biodiversity	404	1.8	1.8	1.6	1.7	13.02	9	0.162	-0.086
Elk have a right to live in native range	410	1.8	1.9	1.7	2.2	15.59	9	0.076	0.131
To increase recreational opportunities	409	1.9	2.0	2.0	2.1	6.68	9	0.671	0.144
Economic benefits to communities	410	2.0	2.2	2.1	2.1	19.07	9	0.025	0.111
Is a good use of funds	408	2.1	2.4	2.2	2.7	21.11	9	0.012	0.157
To reduce the size of the deer herd	408	2.5	2.4	2.5	2.5	5.03	9	0.832	-0.014
Would like to hunt elk in Virginia	407	2.8	3.2	3.3	3.5	37.44	9	<0.001	0.305

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.12. Effects of current living conditions (i.e., rural vs. urban) on the motivation to support elk restoration in Virginia among respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Size of city where currently live[a]				G^b	*df*	*P*	Gamma
		Rural	<50,000 people	50,000-249,999 people	>250,000 people				
To restore natural heritage	407	1.6	1.7	1.6	2.0	18.53	9	0.03	0.165
Elk were present historically	408	1.6	1.7	1.7	1.8	6.83	9	0.655	0.076
To be able to see elk	407	1.5	1.6	1.8	2.1	27.45	9	0.001	0.295
To increase biodiversity	402	1.8	1.7	1.7	1.8	8.92	9	0.445	0.035
Elk have a right to live in native range	407	1.8	1.8	1.8	1.9	4036	9	0.886	0.051
To increase recreational opportunities	406	2.0	1.9	2.0	2.0	6.41	9	0.698	0.073
Economic benefits to communities	407	2.1	2.0	2.1	2.0	16.00	9	0.067	0.019
Is a good use of funds	405	2.2	2.1	2.3	2.5	17.94	9	0.036	0.15
To reduce the size of the deer herd	405	2.4	2.4	2.5	2.4	7.65	9	0.569	0.032
Would like to hunt elk in Virginia	404	2.7	3.0	3.4	3.3	35.31	9	<0.001	0.269

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.13. Motivations to oppose elk restoration in Virginia, in order of stated importance, and the difference between these motivating factors for men and women among respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Overall Mean[a]	Male		Female		*G*[b]	*df*	P
			N	Mean	*N*	Mean			
Will cause automobile-elk collisions	185	1.7	148	1.8	67	1.6	1.66	3	0.646
Will increase agricultural damage	185	1.7	148	1.7	66	1.8	3.31	3	0.346
Not a good use of funds	184	1.8	148	2.0	65	2.1	1.88	3	0.599
Disease transmission to other wildlife	184	1.9	148	2.0	64	1.9	11.78	3	0.008
Disease transmission to livestock	183	1.9	147	2.0	65	1.9	7.01	3	0.072
Land uses have changed too much	185	2.0	148	2.0	66	1.9	2.60	3	0.457
Will negatively impact other wildlife	184	2.0	148	2.1	64	2.0	4.73	3	0.193
Will compete with deer	183	2.3	147	2.3	65	2.4	1.94	3	0.586
Will be unsuccessful again	184	2.5	148	2.4	65	2.7	4.78	3	0.189
Translocation is inhumane to elk	183	2.5	147	2.6	64	2.3	5.89	3	0.117
Not interested in seeing elk	184	2.7	149	2.8	66	2.8	1.47	3	0.699

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.14. Factors motivating the decision to oppose elk restoration in Virginia, as determined by the education level of respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Means Scores by Education Level[a]					G^b	*df*	P	Gamma
		< High School	High School	Some College	Bachelor's Degree	Graduate Degree				
Will cause automobile-elk collisions	214	1.7	1.9	1.6	1.6	1.6	11.92	12	0.452	-0.063
Will increase agricultural damage	212	1.8	1.8	1.6	1.8	1.5	10.54	12	0.568	-0.034
Not a good use of funds	211	1.7	1.9	1.8	2.1	1.7	20.07	12	0.066	0.048
Disease transmission to other wildlife	211	1.8	2.1	1.9	1.8	1.9	7.63	12	0.813	-0.021
Disease transmission to livestock	210	2.2	2.1	1.8	1.7	1.9	10.68	12	0.557	-0.022
Land uses have changed too much	213	1.8	2.0	2.1	2.1	1.7	25.69	12	0.012	-0.011
Will negatively impact other wildlife	210	2.3	2.3	1.9	2.1	1.7	10.98	12	0.531	-0.142
Will compete with deer	210	2.3	2.2	2.1	2.6	2.3	8.53	12	0.742	0.085
Will be unsuccessful again	211	2.5	2.8	2.4	2.6	2.3	12.70	12	0.391	-0.074
Translocation is inhumane to elk	209	2.7	2.6	2.5	2.5	2.5	23.64	12	0.023	0.000
Not interested in seeing elk	212	2.2	2.8	2.8	2.6	2.7	23.86	12	0.021	0.015

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.15. Factors motivating the decision to oppose elk restoration in Virginia, as determined by the frequency of participation in outdoor recreation in 1998 for respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Mean Scores by Frequency of Outdoor Recreation Participation[a]				G^b	*df*	*P*	Gamma
		At least 1/month	At least every other month	At least once/ year	Never				
Will cause automobile-elk collisions	202	1.7	1.4	1.6	2.0	4.44	9	0.880	0.085
Will increase agricultural damage	200	1.5	1.4	1.8	2.0	11.35	9	0.253	0.159
Not a good use of funds	200	1.7	1.7	1.9	2.4	15.59	9	0.076	0.166
Disease transmission to other wildlife	200	1.7	1.7	2.0	2.3	9.03	9	0.435	0.180
Disease transmission to livestock	199	1.7	1.6	2.0	2.3	13.46	9	0.143	0.104
Land uses have changed too much	201	1.7	1.7	2.2	2.2	12.40	9	0.192	0.249
Will negatively impact other wildlife	200	1.8	2.0	2.1	2.2	6.05	9	0.735	0.157
Will compete with deer	199	2.2	2.6	2.4	2.3	4.98	9	0.836	0.052
Will be unsuccessful again	199	2.4	2.4	2.6	2.9	2.84	9	0.013	0.169
Translocation is inhumane to elk	198	2.6	2.5	2.6	2.4	1.61	9	0.996	-0.021
Not interested in seeing elk	200	2.6	2.6	2.7	2.8	2.96	9	0.996	0.037

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.16. Effects of background (i.e., rural vs. urban) on the motivation to oppose elk restoration in Virginia among respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Size of city where grew up[a]				G^b	*df*	*P*	Gamma
		Rural	<50,000 people	50,000-249,000 people	>249,000 people				
Will cause automobile-elk collisions	216	1.6	1.7	1.8	1.7	8.09	9	0.525	0.097
Will increase agricultural damage	215	1.6	1.9	1.8	1.5	17.78	9	0.038	0.086
Not a good use of funds	215	1.8	1.6	2	1.9	4.16	9	0.901	0.065
Disease transmission to other wildlife	215	1.8	2.3	1.9	1.7	22.53	9	0.007	0.019
Disease transmission to livestock	214	1.8	2.3	1.9	1.6	15.30	9	0.083	0.071
Land uses have changed too much	216	1.9	1.9	2.1	2.2	9.27	9	0.413	0.155
Will negatively impact other wildlife	214	1.9	2.2	2.1	1.9	8.66	9	0.469	0.031
Will compete with deer	214	2.2	2.4	2.3	2.7	9.76	9	0.371	0.128
Will be unsuccessful again	214	2.4	2.5	2.7	2.9	9.90	9	0.359	0.216
Translocation is inhumane to elk	213	2.6	2.4	2.2	2.7	13.99	9	0.123	-0.016
Not interested in seeing elk	215	2.7	2.6	2.8	2.7	4.77	9	0.854	-0.028

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.17. Effects of current living conditions (i.e., rural vs. urban) on the motivation to oppose elk restoration in Virginia among respondents to a mail survey of Virginia residents conducted during spring 1999.

Motivating Factors	*N*	Size of city where currently live[a]				G^b	*df*	*P*	Gamma
		Rural	<50,000 people	50,000-249,000 people	>249,000 people				
Will cause automobile-elk collisions	216	1.5	1.7	1.8	1.7	10.63	9	0.302	0.156
Will increase agricultural damage	215	1.5	1.8	1.8	1.8	16.88	9	0.051	0.205
Not a good use of funds	215	1.69	1.7	2	2	9.46	9	0.396	0.162
Disease transmission to other wildlife	215	1.7	2	2	1.8	10.33	9	0.325	0.142
Disease transmission to livestock	214	1.7	2	1.9	1.9	11.58	9	0.238	0.159
Land uses have changed too much	216	1.8	2.1	2	2.1	13.85	9	0.128	0.168
Will negatively impact other wildlife	214	1.9	1.9	2.1	1.9	11.22	9	0.261	0.064
Will compete with deer	214	2.3	2.3	2.3	2.5	6.88	9	0.650	0.088
Will be unsuccessful again	214	2.6	2.4	2.5	2.4	5.94	9	0.746	0.008
Translocation is inhumane to elk	213	2.6	2.6	2.2	2.7	14.78	9	0.097	-0.006
Not interested in seeing elk	215	2.5	2.8	2.8	2.7	11.93	9	0.217	0.064

[a] Mean scores based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Not Very Important, 4 = Not at all Important
[b] Log-likelihood ratio test statistic

Table 3.18. Relationships between satisfaction with the Virginia Department of Game and Inland Fisheries (VDGIF) and agreement with the statement "Reintroducing elk to Virginia is a good idea," as indicated by respondents to a mail survey of Virginia residents conducted during spring 1999.

Satisfaction with VDGIF Programs	*N*	Mean satisfaction scores by attitude towards elk restoration[a]			G^c	*df*	*P*	Gamma
		A[b]	N	D				
Game management	545	1.3	1.4	1.6	22.12	4	<0.001	0.304
Non-Game management	543	1.4	1.5	1.5	7.94	4	0.094	0.188
Overall performance	542	1.3	1.4	1.6	11.08	2	0.004	0.131

[a] Mean scores based on scaled responses: 1 = Agree ("Strongly Agree" + "Agree"), 2 = Neutral, 3 = Disagree ("Disagree" + "Strongly Disagree")

[b] Responses to statement "Reintroducing elk to Virginia is a good idea": A = Agree, N = Neutral, D = Disagree

[c] Log-likelihood ratio test statistic

Table 3.19. Preferences for funding an elk management program among supporters and opponents of elk restoration in Virginia, as expressed by respondents to a mail survey of Virginia residents conducted during spring 1999.

	Support Elk Restoration		Oppose Elk Restoration					
Potential Funding Sources	*N*	Mean[a]	*N*	Mean	*G*[b]	*df*	*P*	Gamma
Outside private sources	396	2.1	167	2.5	50.95	4	<0.001	0.214
New money from general state funds	391	2.5	169	4.0	153.37	4	<0.001	0.711
Reallocate from other wildlife programs	389	2.7	166	3.5	69.46	4	<0.001	0.493
Reallocate from non-wildlife programs	393	3.7	168	4.2	42.54	4	<0.001	0.419
No new funds should be obtained	361	3.8	157	2.4	158.40	4	<0.001	-0.703

[a] Mean scores based on scaled responses:1= Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree.
[b] Goodness of fit test

Table 3.20. Preferences for implementing an elk damage compensation program among supporters and opponents of elk restoration in Virginia, as expressed by respondents to a mail survey of Virginia residents conducted in spring 1999.

	Support Elk Restoration		Oppose Elk Restoration					
Compensation Method	*N*	Mean[a]	*N*	Mean	*G* [b]	*df*	*P*	Gamma
Private organization funds	389	2.5	170	1.8	88.62	4	<0.001	-0.566
Free damage prevention materials	393	2.6	171	2.8	64.90	4	<0.001	0.065
General state funds	385	2.9	174	3.6	70.83	4	<0.001	0.419
Community funds	390	3.8	171	4.1	43.55	4	<0.001	0.343
No compensation	386	3.7	161	4.0	28.33	4	<0.001	0.303

[a] Mean scores based on scaled responses:1= Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree.
[b] Goodness of fit test

Table 3.21. Top-ranked potential benefits associated with elk restoration in Virginia identified by participants during 4 regional workshops held in summer and fall 1999, compiled across meetings and classified into broad topics.

		# Dots/Workshop			
Total # of Dots	**Potential Benefits**	**Abingdon**	**Verona**	**Winchester**	**Martinsville**
165	Elk as a draw for tourism: includes economic benefits from influx of tourists and associated user fees, service fees, sales taxes, etc.; economic benefits from sale of hunting license and hunting leases; social and cultural benefits to tourists and local community; recreational benefits to tourists	86	50	16	13
91	Provision of new/enhanced recreational opportunities: Consumptive (hunting), non-consumptive (viewing, photography, art, listening)	16	26	30	19
86	Impact on wildlife habitat management: spill-over effects of elk habitat management onto other species, creation of elk habitat is good for other species, impetus to improve large-scale habitat and wildlife management, elk as a natural manager of forest openings, impetus for managers to create additional forest openings, associated sale of timber from creation of forest openings, control of undesirable plant species through elk herbivory	21	24	28	13
74	Educational opportunity presented by elk: chance to educate children and general public and increase their understanding of wildlife and wildlife management, research opportunity for universities and wildlife scientists, chance to increase environmental awareness among general public	36	11	15	12
58	Fostering local biodiversity; restoring a missing part of the ecosystem, restoring a native/extirpated species, associated attraction to tourists as a unique draw to a portion of the state	4	23	8	23

Table 3.22. Top-ranked potential concerns associated with elk restoration in Virginia identified by participants during 4 regional workshops held during summer and fall 1999, compiled across meetings and classified into broad topics.

Total # of Dots	Potential Concerns	# Dots/Workshop: Abingdon	Verona	Winchester	Martinsville
204	Private property damage due to elk depredation: crop destruction (economic and physical impacts) to row crops, grains, forage crops, fruit trees, etc.; family garden/landscaping depredation; resulting property rights infringement when private farms become elk grazing lands; damage to fences and resulting loss of livestock, hay bales; reduced profitability for farmers; need for farmers to compensate for crop damage by increasing production	74	34	78	18
83	Ecosystem impacts: competition with native fauna, microhabitat damage due to social tendencies of elk to herd; potential for over-grazing/over-browsing by elk; an additional stress on already stressed systems (e.g., National Park land); potential impacts on endangered/threatened/protected species of flora and fauna	0	53	21	9
82	Economic costs associated with restoration and maintenance of an elk population: administrative costs, compensation of private property damage, program monitoring, land acquisition, increased demands for personnel, increased workload on existing personnel, habitat management	51	12	13	6
54	Public safety on roads: potential for elk-vehicle collisions; risk for physical damage, economic impact (insurance premiums), personal injury/fatality, emotional trauma, loss of elk; creation of additional hazards through increased traffic volume from tourist and elk watchers	10	15	12	17
50	Disease transmission: human health concerns , disease transmission from elk to livestock, elk to indigenous wildlife, indigenous species back to elk	24	18	3	5

Table 3.23. Top-ranked potential resolutions to reconcile differences among benefits and concerns associated with elk restoration in Virginia identified by participants during 4 regional workshops held during summer and fall 1999..

Total # of Dots	Potential Resolutions	# Dots/Workshop Abingdon	Verona	Winchester	Martinsville
108	Start out small: permanently enclose elk on public property, temporarily enclose elk as an experiemental herd, perform a small-scale pilot project to determine indentify true impacts and expected returns; limit elk to public lands	18	28	38	24
97	"Just say no." Forget the proposal. Do not restore elk to Virginia	50	N/A	47	N/A
93	Address economic concerns: secure necessary funding beforehand; use private funds, corporate sponsors, tourism revenues, general assembly, grants, partnerships, hunting license fees, damage stamps, user fees, timber sale revenues, etc. to pay for program implementation and property damages; create expedient and clear-cut compensation program before restoration; provide incentives such as tax adjustments, easements, or leases to encourage private landowners to manage and accept elk	10	47	14	22
56	Perform more research to better define the biological/ecological parameters: select habitat that is largely public where conflicts will be minimized and elk restoration agrees with existing management goals	22	4	20	10
51	Learn as much as possible from other eastern states: what will the program cost; what are the expected returns	31	2	N/A	18
32	Launch public education program: inform public about potential disease transmission; increase awareness about elk history, habitat requirements, potential conflicts and ways to prevent damages; inform public about objectives of restoration and methods to be used in the program; target the "uninformed" public that are not generally involved in wildlife issues (e.g.., church groups, youth, ruritan groups, civic group)	4	11	9	8

Table 3.24. Importance of different motivations and meeting characteristics to participants in each of 4 regional workshops about elk restoration in Virginia held during summer and fall 1999.

	Overall		Abingdon		Verona		Winchester		Martinsville	
	N	Mean[a]	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean
Motivations										
Interacting with other interest groups	67	1.5	18	1.2	18	1.5	19	1.7	12	1.7
Having my idea and concerns heard	67	1.7	18	1.6	18	1.5	19	1.8	12	1.9
Learning about other viewpoints	67	1.4	18	1.3	18	1.3	19	1.6	12	1.5
Learning about elk	67	1.7	18	1.5	18	1.6	19	2.1	12	1.6
Influencing the results of the feasibility study	67	1.9	18	1.7	18	1.8	19	1.9	12	2.1
Formulating solutions to complex problems	66	1.6	18	1.4	18	1.5	18	1.9	12	1.7
Meeting Characteristics										
Presence of a noncompetitive atmosphere	63	1.4	18	1.6	17	1.3	16	1.6	12	1.2
Interaction among opposing groups	65	1.3	18	1.1	18	1.2	17	1.5	12	1.5
Open-mindedness of participants	66	1.1	18	1.2	18	1.0	18	1.3	12	1.0
Generation of large number of ideas	65	1.6	18	1.6	18	1.4	17	1.6	12	1.6
Group discussion of generated ideas	65	1.5	18	1.5	18	1.2	17	1.6	12	1.6
Objectivity of facilitators	63	1.4	18	1.3	18	1.2	17	1.6	12	1.3
Fairness of facilitators	63	1.3	17	1.3	17	1.1	17	1.5	12	1.3

a Mean scores are based on scaled responses: 1 = Very Important, 2 = Somewhat Important, 3 = Little Importance, 4 = Not Needed.

Table 3.25. Participant knowledge levels at the start of each of 4 regional workshops held during summer and fall 1999 to discuss elk restoration in Virginia and their perception of the quality of information provided during the workshops.

	Overall		Abingdon		Verona		Winchester		Martinsville	
	N	Mean	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean
Pre-Meeting Knowledge Level[a]										
Elk biology	65	3	17	3	17	2.5	20	3.2	11	3.6
Elk management	65	3.1	17	3	17	2.7	20	3.3	11	3.6
Post-Meeting Information Provided[b]										
Elk history	56	1.8	16	1.6	15	1.9	14	2.1	11	1.5
Elk biology	56	1.8	16	1.7	15	1.9	14	2.1	11	1.5
Elk management	56	2	16	2.1	15	2.1	14	2.1	11	1.9
Project description	56	1.9	16	1.9	15	1.7	14	2.1	11	1.6

[a] Pre-meeting means represent participant agreement that they are knowledgeable: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree

[b] Post-meeting means represent participant judgement of information provided: 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor.

Table 3.26. Participant satisfaction with various meeting aspects in each of 4 regional workshops about elk restoration in Virginia held during summer and fall 1999.

	Overall		Abingdon		Verona		Winchester		Martinsville	
	N	Mean[a]	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean
Meeting Experience										
Level of interaction with other interest groups	56	1.5	16	1.2	15	1.7	14	1.9	11	1.5
Level of attention you received	56	1.3	16	1.2	15	1.5	14	1.4	11	1.3
Degree to which you were able to contribute	56	1.4	16	1.2	15	1.5	14	1.6	11	1.5
Number of ideas generated	56	1.5	16	1.4	15	1.5	14	1.4	11	1.5
Quality of ideas generated	55	1.7	15	1.4	15	1.9	14	1.7	11	1.6
Quality of group discussions	55	1.7	15	1.5	15	1.9	14	2.1	11	1.4
Feasibility of proposed solutions	55	2.2	15	1.9	15	2.5	14	2.3	11	2.1
Potential effectiveness of proposed solutions	54	2.3	14	2.1	15	2.4	14	2.4	11	2.4
Meeting Characteristics										
Appropriateness of the meeting style	56	1.4	16	1.1	15	1.5	14	1.9	11	1.1
Presence of a noncompetitive atmosphere	56	1.6	16	1.5	15	1.3	14	2.6	11	1
Organization of the agenda	56	1.3	16	1.1	15	1.5	14	1.6	11	1.1
Convenience of the meeting time	56	1.4	16	1.3	15	1.3	14	1.9	11	1.4
Convenience of the meeting location	56	1.3	16	1.2	15	1.1	14	1.4	11	1.4
Competency of the facilitators	56	1.3	16	1.1	15	1.2	14	1.9	11	1.1
Objectivity of the facilitators	56	1.8	16	1.3	15	1.3	14	1.5	11	1.2

[a] Mean scores based on scaled responses: 1 = Very Satisfied, 2 = Somewhat Satisfied, 3 = Somewhat Dissatisfied, 4 = Very Dissatisfied.

Table 3.27. Attitudes toward elk restoration before and after participation in 1 of 4 regional workshops held during summer and fall 1999.

Attitude toward elk restoration	Before or After Meeting	Overall		Abingdon		Verona		Winchester		Martinsville	
		N	Mean[a]	*N*	Mean	*N*	Mean	*N*	Mean	*N*	Mean
There are many possible advantages to elk restoration	Before	65	2.8	17	2.7	17	2.2	20	3.4	11	2.5
The advantages outweigh the disadvantages	After	56	3.2	16	3.2	15	3.3	14	3.8	11	2.5
There are many possible disadvantages to elk restoration	Before	64	2.4	17	2.2	17	2.5	19	2.3	11	2.6
The disadvantages are great to consider elk restoration	After	56	1.2	16	2.9	15	3	14	2.6	11	3.4
Managers would not be able to handle problems generated by elk	Before	65	3	17	2.9	17	3.3	20	2.8	11	3
The disadvantages can be minimized by managers	After	55	2.7	16	2.8	14	2.9	14	3	11	2
Elk should be restored to this part of Virginia	Before	65	3	17	3.2	17	2.7	20	3.2	11	2.7
Elk restoration in this area is a good idea	After	54	3	15	3.5	14	2.9	14	2.9	11	2.6

[a] Mean scores based on scaled responses: 1 = Strongly Agree. 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly Disagree

Table 3.28. Potential benefits and costs associated with elk restoration, based on figures reported from eastern states currently supporting elk herds.

	Value/ Animal	Value/ Hectare[f]	Total Value[g]
Economic Benefits/year			
Hunting[a]	$299.79	$1.50	$149,895
Tourism[b]	$284.40	$1.42	$142,200
Total Benefits	**$584.19**	**$2.92**	**$292,095**
Economic Costs/year			
Crop Damage[c]	$45.33	$0.23	$22,665
Elk-vehicle Collisions[d]	$26.54	$0.13	$13,274
Management Costs[e]	$266.67	$1.33	$133,333
Total Costs	**$345.33**	**$2.21**	**$169,272**
Overall Value of Elk/year	**$238.86**	**$0.71**	**$122,823**

[a] Hunting income (per animal in the population) includes primary expenditures for license and application fees, guide services, and service fees for lodging and food, based on experiences in Michigan (SEAFWA 1997).
[b] Tourism includes all primary expenditures paid by visitors traveling to view elk in Pennsylvania (SEAFWA 1997).
[c] Crop damage is based on PA's worst reported year (1982) (SEAFWA 1997).
[d] Elk/vehicle collision costs are based on Michigan's estimated $3,000 of property damage/ collision and 3 collisions/81,000 ha/year (SEAFWA 1997)
[e] Management costs are estimated from Michigan's annual budget, and include habitat improvement, hunt season administration, and personnel needs (Parker 1990)
[f] Value/ha is based on 1 elk/200 ha of habitat.
[g] Total value is based on 100,000 ha of elk range and a density of 1 elk/200 ha.

Table 3.29. Annual expenses for elk restoration in Kentucky and proportion of expenses paid for by University of Kentucky (UK), Kentucky Department of Fish and Wildlife Resources (KDFWR), and Rocky Mountain Elk Foundation (RMEF) (Roy Grimes, Kentucky Department of Fish and Wildlife Resources, personal communication).

Management Expenses	FY98			FY99			FY2000 (projected)			3-Year Total
	UK Paid	KDFWR Paid	RMEF Paid	UK Paid	KDFWR Paid	RMEF Paid	UK Paid	KDFWR Paid	RMEF Paid	
Elk Capture			$4,070							$4,070
Elk Food			$411			$1,776			$4,000	$6,187
Disease Screening			$9,819			$6,074			$15,000	$30,892
Holding Facility						$13,857				$13,857
Elk Transport			$15,138			$23,890			$35,000	$74,028
Diagnostic Services - UK						$4,500				$4,500
Graduate Students[a]									$109,000	$109,000
Administrative Costs	$22,015		$30,693				$59,100			$111,808
Travel - Personnel		$9,650	$349		$49,530	$13,313		$7,650	$35,500	$115,992
Time - Personnel		$89,975			$79,153			$120,000		$289,128
Conferences			$1,511			$594			$5,550	$7,655
Herd Monitoring[b]				$40,392		$69,813			$40,000	$150,205
Telemetry Supplies			$118,379			$93,126			$72,500	$284,005
Other Supplies			$7,531			$7,000			$14,000	$28,531
Publicity			$836			$1,799				$2,635
Damage Prevention						$4,836				$4,836
GIS Habitat Mapping									$20,000	$20,000
Habitat Improvements								$3,000	$40,000	$43,000
Miscellaneous			$6,397			$2,388			$9,650	$18,435
Annual Totals	$22,015	$99,625	$195,133	$40,392	$128,684	$242,966	$59,100	$130,650	$400,200	$1,318,765
	$316,773			$412,042			$589,950			

[a] Graduate students include research and herd monitoring expenses and technicians wages.
[b] Herd monitoring includes air time and staff (e.g., graduate student where no estimate given) support.

Table 3.30. Annual (1988-1989) budget for elk management in Michigan (Parker 1990).

Activity	1988-1989 Cost
Habitat Improvement	$57,000.00
Elk Hunt (Preparation, Administration)	$52,000.00
Law Enforcement	$42,000.00
Elk Licence Processing	$24,000.00
License Dealer Revenue (8% of profit)	$24,000.00
Winter Census	$20,000.00
Regulation Meeting and Planning	$10,000.00
Crop Damage Investigation[a]	$8,000.00
Research (projected to increase)	$4,000.00
Total	**$241,000.00**

[a] Michigan does not have a damage compensation program.

Table 3.31. Annual expenses for elk management in Arkansas and the proportion of expenses paid by Arkansas Department Game and Fish (AGFC), Rocky Mountain Elk Foundation (RMEF), and donations (Mike Cartwright, AGFC, personal communication).

Management Expenses	FY98		FY99		FY00 (projected)		3-year Total
	AGFC	RMEF	AGFC	Donations[a]	AGFC	Donations[a]	
Project Administration	$1,775.00		$2,450.00		$3,200.00		$7,425.00
Heicopter Survey	$3,500.00		$4,000.00		$4,500.00		$12,000.00
Nuisance Elk Survey	$16,250.00	$3,000.00	$4,050.00				$23,300.00
***Wild About Elk* Trunk**	$375.00	$325.00					$700.00
Elk Habitat Improvement	$19,962.00	$20,000.00		$2,500.00		$25,000.00	$67,462.00
Elk Hunt			$41,275.00		$19,500.00	$4,700.00	$65,475.00
Habitat Inventory				$25,100.00			$25,100.00
Habitat Inventory Support				$5,500.00			$5,500.00
Lab/Forensics Test				$500.00			$500.00
Assistantship Planning				$2,750.00			$2,750.00
Gate Construction						$1,500.00	$1,500.00
Grant to RMEF					$25,000.00		$25,000.00
Totals	$41,862.00	$23,325.00	$51,775.00	$36,350.00	$52,200.00	$31,200.00	$236,712.00
Annual Totals	$65,187.00		$88,125.00		$83,400.00		

[a] Donations received from annual elk hunting license lottery and auction.

Table 3.32. Human population densities and growth rates for Virginia counties that compose the 8 study areas identified as potential elk habitat. County totals do not include incorporated cities; incorporated cities were not included in potential elk habitat and so were not included here.

Counties	Human Population Density (#/km^2)[a]					% Change in Population[a]		
	1970	1975	1980	1986	1992	1960-1970	1970-1980	1980-1992
Southwest Region								
Southwest Study Site								
Bland	5.8	5.8	6.8	6.9	6.9	-9.3%	17.1%	4.3%
Buchanan	24.3	26.2	29.1	27.4	24.3	-12.7%	18.5%	-16.7%
Dickenson	18.5	21.2	23.1	23.1	20.4	-20.5%	23.2%	-10.3%
Pulaski	34.7	38.2	42.7	41.5	41.7	8.5%	19.2%	-2.0%
Russel	19.7	20.8	25.6	25.9	23.5	-6.7%	29.5%	-9.1%
Smyth	27.8	28.5	28.5	28.2	28.2	0.9%	6.4%	-1.5%
Tazewell	29.3	33.6	37.5	37.4	34.7	-11.1%	26.9%	-7.2%
Washington	27.4	26.6	31.9	32.5	32.0	7.2%	13.8%	1.0%
Wythe	18.5	19.7	21.2	21.3	21.6	0.7%	15.3%	0.8%
Overall	22.9	24.5	27.4	27.1	25.9	-4.8%	18.9%	-4.5%
Shenandoah Mountain Region								
Shenandoah Study Site								
Frederick	27.4	26.2	31.8	34.3	44.8	31.7%	18.2%	40.5%
Rockingham	21.2	23.5	25.5	24.3	26.6	18.3%	19.1%	13.3%
Shenandoah	17.4	19.7	20.8	21.3	24.3	4.7%	20.6%	17.1%
Overall	22.0	23.1	26.0	26.6	31.9	18.2%	19.3%	23.6%
Highland Study Site								
Augusta	17.4	19.7	20.9	20.3	22.4	18.4%	21.5%	18.3%
Bath	3.9	3.9	4.2	3.7	3.5	-2.7%	12.9%	-18.9%
Highland	2.3	2.3	2.7	2.6	2.3	-21.5%	16.1%	-11.7%
Rockbridge	10.8	10.8	11.5	11.3	12.0	0.8%	7.7%	5.4%
Rockingham	21.2	23.5	25.5	24.3	26.6	18.3%	19.1%	13.3%
Overall	11.1	12.0	13.0	12.4	13.3	2.7%	15.5%	1.3%
Big Meadows Study Site								
Albemarle	19.7	23.9	29.7	32.4	36.6	22.0%	47.7%	22.6%
Augusta	17.4	19.7	20.9	20.3	22.4	18.4%	21.5%	18.3%
Greene	13.5	16.2	18.7	21.4	28.5	11.3%	45.3%	51.1%
Madison	10.0	11.6	12.3	12.8	14.3	5.5%	18.5%	17.5%
Page	20.1	22.4	23.9	24.7	27.8	6.5%	17.0%	14.8%
Rappahannock	7.3	8.5	8.8	9.0	9.6	-3.1%	17.2%	11.1%
Rockingham	21.2	23.5	25.5	24.3	26.6	18.3%	19.1%	13.3%
Shenandoah	17.4	19.7	20.8	21.3	24.3	4.7%	20.6%	17.1%

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

(Continued on next page)

Table 3.32. (Continued)

Counties	Human Population Density (#/km²)[a]					% Change in Population[a]		
	1970	1975	1980	1986	1992	1960-1970	1970-1980	1980-1992
Peaks of Otter Study Site								
Allegheny	10.8	11.2	12.4	12.0	11.2	2.7%	15.0%	-8.9%
Amherst	21.2	22.8	23.5	23.3	23.5	13.6%	11.7%	-0.3%
Bedford	14.3	15.4	18.0	20.3	24.7	6.5%	30.7%	38.4%
Botetourt	12.7	14.7	16.5	17.5	18.5	8.8%	27.9%	10.9%
Rockbridge	10.8	10.8	11.5	11.3	12.0	0.8%	7.7%	5.4%
Overall	14.0	15.0	16.4	16.9	18.0	6.5%	18.6%	9.1%
Southern Piedmont Region								
Danville Study Site								
Franklin	15.0	17.0	20.2	21.0	22.8	8.6%	26.6%	14.5%
Henry	51.7	56.3	58.2	56.7	57.5	26.2%	13.3%	-1.3%
Pittsylvania	22.8	24.7	25.7	25.4	22.0	0.8%	12.5%	1.1%
Overall	29.8	32.7	34.7	34.4	34.1	11.9%	17.5%	4.8%
Brookneal Study Site								
Campbell	31.6	30.1	7.8	36.1	37.4	31.4%	10.9%	7.2%
Charlotte	10.0	10.4	9.9	9.5	9.6	-7.5%	-0.8%	-3.4%
Halifax	14.7	14.7	14.5	14.1	13.9	-10.6%	1.7%	-4.2%
Pittsylvania	22.8	24.7	25.7	25.4	22.0	0.8%	12.5%	1.1%
Overall	19.8	20.0	14.4	21.3	20.7	3.5%	6.1%	20.0%
Rehobeth Study Site								
Charlotte	10.0	10.4	9.9	9.5	9.6	-7.5%	-0.8%	-3.4%
Lunenburg	10.0	10.8	10.8	10.9	10.4	-6.7%	3.7%	-5.4%
Mecklenburg	18.5	18.9	18.4	18.7	18.5	-6.4%	0.1%	0.8%
Overall	12.9	13.4	13.1	13.0	12.9	-6.9%	1.0%	-2.7%

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

Table 3.33. Changes in the number of farms and total farm area during 1969-1987 for counties that compose the 8 study areas identified as potential elk habitat in Virginia.

Counties	# of Farms[a, b]					Total Acreage (x1000)[a]				
	1969	1974	1978	1982	1987	1969	1974	1978	1982	1987
Southwest Region										
Southwest Study Site										
Pulaski	382	360	333	367	360	34	32	35	31	32
Bland	465	361	363	354	327	39	39	37	35	32
Wythe	871	847	738	805	746	68	185	60	66	58
Tazewell	632	537	471	494	488	65	60	61	57	55
Smyth	1,257	940	887	959	873	58	54	49	50	50
Russel	1,427	1,228	1,177	1,283	1,134	78	72	72	74	68
Washington	2,608	2,167	2,134	2,289	1,972	97	86	82	87	82
Buchanan	281	113	82	120	105	11	4	5	4	4
Dickenson	367	144	115	170	120	9	4	4	5	4
Shenandoah Mountain Region										
Shenandoah Study Site										
Frederick	660	564	565	632	555	53	46	50	51	45
Shenandoah	1,022	863	819	922	830	60	54	56	57	56
Rockingham	2,187	1,967	1,872	2,046	1,895	109	103	102	106	98
Highland Study Site										
Highland	461	335	329	320	303	54	45	44	42	38
Augusta	1,636	1,540	1,483	1,606	1,536	118	126	123	127	118
Bath	189	153	145	138	135	30	26	24	24	22
Rockbridge	780	712	667	711	682	72	68	64	64	59
Rockingham	2,187	1,967	1,872	2,046	1,895	109	103	102	106	98
Big Meadows Study Site										
Page	529	421	448	506	489	30	25	27	28	27
Rappahannock	276	257	266	313	288	36	31	32	35	31
Madison	842	402	418	462	441	45	44	45	45	43
Greene	227	213	222	243	225	14	15	17	17	16
Albemarle	766	750	750	830	772	85	86	84	81	75
Augusta	1,636	1,540	1,483	1,606	1,536	118	126	123	127	118
Rockingham	2,187	1,967	1,872	2,046	1,895	109	103	102	106	98
Shenandoah	1,022	863	819	922	830	60	54	56	57	56

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

[b] In 1969, a farm is any land <10 acres with ≥$250 in sales or any land ≥10 acres with ≥$50 in sales. Other years, a farm is any land producing ≥$1000 in sales

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Table 3.33. (Continued)

Counties	# of Farms[a, b]					Total Acreage (x1000)[a]				
	1969	1974	1978	1982	1987	1969	1974	1978	1982	1987
Peaks of Otter Study Site										
Allegheny	626	195	155	182	150	18	14	13	14	11
Botetourt	631	572	549	586	532	46	45	41	40	40
Bedford	1,537	1,306	1,246	1,353	1,240	97	87	86	89	83
Amherst	493	438	432	446	408	41	39	38	38	38
Rockbridge	780	712	667	711	682	72	68	64	64	59
Southern Piedmont Region										
Danville Study Site										
Franklin	1,443	1,254	1,138	1,212	1,016	92	82	81	78	73
Henry	497	404	368	424	342	32	21	23	26	22
Pittsylvania	3,156	2,333	2,126	2,024	1,583	172	140	134	134	122
Brookneal Study Site										
Halifax	2,362	1,873	1,750	1,652	1,252	133	107	106	104	98
Campbell	956	850	784	740	628	68	61	57	58	54
Charlotte	1,048	814	740	686	518	48	60	55	53	48
Pittsylvania	3,156	2,333	2,126	2,024	1,583	172	140	134	134	122
Rehobeth Study Site										
Lunenburg	842	710	N/A	566	404	51	43	40	42	34
Mecklenburg	1,738	1,291	603	990	780	97	81	79	76	73
Charlotte	1,048	814	740	686	518	48	60	55	53	48

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

[b] In 1969, a farm is any land <10 acres with ≥$250 in sales or any land ≥10 acres with ≥$50 in sales. Other years, a farm is any land producing ≥$1000 in sales

Table 3.34. Change in the proportion of agricultural sales coming from nonforage crop production (1969-1982) in the counties that compose the 8 study areas identified as potential elk habitat in Virginia.

Study Area Counties	Value of Crops (% of total production)[a]			
	1969	1974	1978	1982
Southwest Region				
Southwest Study Site				
Pulaski	5.0%	NA	NA	4.7%
Bland	7.7%	8.2%	5.6%	7.0%
Wythe	5.4%	NA	NA	NA
Tazewell	7.6%	13.5%	3.8%	6.0%
Smyth	40.1%	34.5%	24.9%	31.1%
Russel	26.0%	30.3%	30.1%	45.5%
Washington	23.3%	26.3%	NA	33.5%
Buchanan	14.8%	80.2%	61.2%	74.5%
Dickenson	48.6%	80.3%	NA	42.6%
Shenandoah Mountain Region				
Shenandoah Study Site				
Frederick	61.0%	69.9%	66.0%	63.6%
Shenandoah	12.5%	10.8%	10.5%	9.7%
Rockingham	5.5%	4.9%	3.8%	3.7%
Highland Study Site				
Highland	4.1%	3.2%	1.4%	NA
Augusta	9.2%	12.8%	8.0%	8.7%
Bath	9.7%	13.3%	NA	NA
Rockbridge	8.8%	14.3%	10.2%	9.9%
Rockingham	5.5%	4.9%	3.8%	3.7%
Big Meadows Study Site				
Page	8.0%	10.5%	NA	4.6%
Rappahannock	41.5%	52.5%	48.5%	44.1%
Madison	15.0%	NA	12.1%	15.6%
Greene	3.2%	8.9%	9.4%	13.7%
Augusta	9.2%	12.8%	8.0%	8.7%
Rockingham	5.5%	4.9%	3.8%	3.7%
Shenandoah	12.5%	10.8%	10.5%	9.7%
Peaks of Otter Study Site				
Allegheny	19.0%	12.1%	NA	8.6%
Botetourt	19.5%	26.8%	20.6%	19.1%
Bedford	17.8%	20.2%	NA	11.7%
Amherst	31.6%	35.3%	NA	16.3%
Rockbridge	8.8%	14.3%	10.2%	9.9%

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

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Table 3.34 (Continued)

Study Area Counties	Value of Crops (% of total production)[a]			
	1969	1974	1978	1982
Danville Study Site				
Franklin	35.3%	32.4%	29.4%	22.9%
Henry	47.0%	60.2%	60.4%	56.4%
Pittsylvania	80.7%	85.7%	83.6%	81.1%
Brookneal Study Site				
Pittsylvania	80.7%	85.7%	83.6%	81.1%
Halifax	82.7%	85.5%	86.7%	85.0%
Campbell	43.6%	49.4%	8.9%	13.2%
Charlotte	56.3%	65.3%	58.6%	55.9%
Rehobeth Study Site				
Charlotte	56.3%	65.3%	58.6%	55.9%
Lunenburg	76.8%	82.0%	84.4%	74.9%
Mecklenburg	77.2%	79.5%	80.7%	78.3%

[a] U.S. Census Bureau (1973, 1978, 1983, 1988, 1994)

Table 4.1. Feasibility matrix for elk restoration in Virginia. Overall feasibility for the 8 study areas examined in this study area is determined by habitat suitability, regional attitudes toward elk restoration, and an assessment of the potential risk for human-elk conflicts.

Study Area	Habitat Suitability	Regional Attitudes	Risk Assessment[a]	*Overall Feasibility*[b]
Southwest Region				
Southwest	Medium	Low	Medium	***Medium***
Shenandoah Mountain Region				
Shenandoah	Medium	Low	Low	***Low***
Highland	High	High	High	***High***
Big Meadows	High	Medium	Medium	***Medium***
Peaks of Otter	Low	High	Medium	***Low***
Southern Piedmont Region				
Danville	Low	High	Low	***Low***
Brookneal	Medium	High	Low	***Medium***
Rehobeth	Low	High	Low	***Low***

[a] A rank of “High” on the risk assessment scale corresponds to a low risk and high feasibility.
[b] Overall feasibility is determined as follows: habitat suitability determines the highest final rank possible for each study area, then regional attitudes and risk assessment have equal weight. If 2 out of the 3 scores are the same, the final rank is equal to that common score so long as it is not higher than that received for habitat suitability

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Appendix 1
Minimum Viable Population Size

The fundamental goal of restoring any wildlife species is to produce a viable population. Before proceeding with a reintroduction, it is important, to define a viable population and know not only if suitable habitat exists at the release site, but also if sufficient habitat exists. This is of special concern for elk restoration because elk are large animals and require a lot of space to meet their life requisites. Small populations risk inbreeding (which decreases heterozygosity and increases the expression of deleterious alleles) and genetic drift (which decreases adaptive capacity through random loss of alleles). Unfortunately, the definition of "small" is not defined clearly, and varies based on the species and geographic location in question. To address this issue, I attempted define the minimum viable population size (MVP), for elk.

Minimum Effective Population Size

The minimum effective population size (N_e) assumes an idealized population with random mating, nonoverlapping generations, 100% reproductive success, equal sex ratios, equal contributions to the next generation). Many MVP estimates for wild populations are based a maximum acceptable rate of heterozygosity loss (f) of 1% per generation. This corresponds to an N_e = 50 individuals (Equation A1.1).

Equation A1.1

$f = 1/(2N_e)$, (Soule 1980, Franklin, 1980)

This calculation has led to the 50-500 rule where N_e = 50 for short term population viability (50-90 generations) and N_e = 500 for long term viability (500-900 generations, f = 0.1%) when the threshold inbreeding level is set at f = 40-60% (Equation A1.2).

Equation A1.2

$f = 1-[1-1/(2N_e)]^t$, (Soule 1980)

These 2 estimates require different management approaches; managing for the N_e = 50 may require long-term genetic monitoring and additional translocations, whereas a population meeting N_e= 500 requirement would be more self-sufficient.

Although many conservation biologist today argue about the soundness of these N_e estimates, particularly when environmental stochasticity and catastrophic events are considered, I believe that the 50-500 rule is appropriate here. I recognize that it represents an absolute minimum below which genetic viability is at risk, and that a higher N_e would increase the chances of survival. However, I also recognize that the space available for elk restoration is limited and that and an N_e= 50 may be the best that can be done in Virginia. If this is the case, it will be imperative to monitor genetic variability, and take steps to maintain heterozygosity.

Actual Population Size

Given N_e = 50 (or 500), species specific information can be applied to convert N_e to an actual population size (N). Several characteristics of elk populations impact this conversion. First, elk populations reproduce through a hierarchical harem social system and typically have biased sex ratios; hence, males do not contribute as much genetic variability to the next generation as do females. Second, a proportion of adults fail to reproduce in any given year. Third, elk generations are overlapping rather than discrete, which raises the chance for related individuals to mate (i.e., inbreeding) and allows one individual to contribute to more than one generation. Overlapping generation also means that there are always pre-reproductive (juvenile) and post-reproductive (senescent) members of the population that do not breed. Finally, elk populations, like almost any wildlife population, tend to fluctuate over time. Population fluctuations (particularly the downward phase) impact genetic variability by removing gene combinations from the gene pool and risking the loss of rare alleles. Each of these features has a large impact on the N required to achieve an N_e= 50 because offspring are more similar genetically than they would have been in an ideal population.

Many population geneticists have attempted to address these common concerns by using mathematical models to estimate MVP. Here, I compare the results of 4 such models that address some or all of the above concerns. For a side-by side comparison, see Table A1. For each model, I calculated a short-term MVP for elk using population parameters estimated by the modelers. To be consistent, however, I used a sex ratio of 1 bull:5 cows in all calculations. This ratio represents a commonly reported average harem size (i.e., sex ratio among breeders) in eastern elk populations (resulting from a population sex ratio of ~6 bulls:10 cows, Schonewald-Cox 1986, Bender 1996).

Lehmkuhl's (1984) model yielded an MVP = 504 elk. It addresses each of the concerns listed above: biased sex ratios, presence of nonbreeding adults, overlapping generations, and population fluctuations. However, this model also considered a fifth parameter: variance in the number of progeny produced per individual (V_k). While it is true that, in any given year, individuals produce different numbers of progeny (especially among males), LaCava and Hughes (1984) suggest that, for elk, this difference is accounted for largely by the biased sex ratio and, therefore, is overcompensated in Lehmkuhl's model. While I agree that the sex ratio accounts most of this variance, it does not adequately address the presence of nonbreeding

Table A1. Comparison of models used in estimating minimum viable population (MVP) size for elk from an effective population size (N_e) of 50.

Model	**Lehmkuhl (1984)**	**LaCava & Hughes (1984)**	**Schonewald-Cox (1986)**	**Reed et al. (1986)**
MVP (based on N_e = 50)	504	90	150-200	224
N_e/MVP	0.099	0.556	0.250-0.333	0.223
Parameters Considered	(1) individual fecundity (mean and variance) (2) biased sex ratio among breeders; (3) overlapping generations; (4) population fluctuations	biased sex ratio among breeders	(1) biased sex ratio among breeders; (2) overlapping individuals; (3) presence of non-breeding adults	(1) biased sex ratio among breeders; (2) overlapping generations; (3) presence of non-breeding adults
Comments	may overcompensate for variance in progeny number by factoring it twice	assumes non-overlapping generations, 100% reproductive success, and stable population size	rough modification of Lacava and Hughes' (1984) estimate with no mathematical backup but good logic; assumes stable population size	based on complex mathematical models and tentative population parameter estimates; assumes stable population size

adults. However, since V_k attempts to represent this entire variance, it may artificially inflate the resultant N. I concluded, then, that the estimated MVP = 504 may be slightly high.

A second, simpler model is presented by LaCava and Hughes (1984). They considered only the biased sex ratio (and its effects V_k); their model yielded an MVP = 90. They did not account for several critical criteria including the presence of nonbreeding adults, overlapping generations, and population fluctuations. For this reason, I believe that this estimate is too low.

Similar to LaCava and Hughes (1984), Schonewald-Cox (1986) estimated the MVP for elk based only on a biased sex ratio to be 90. However, she went on to qualify her estimate, by stating that the estimate represents 90 **breeding** individuals, and that after accounting for juveniles, nonbreeding adults, and senescent individuals, this estimate would have to increase to a total population size of 150-200. Unfortunately, she did not attempt to mathematically account for these other individuals; she simply made the logical statement. Also, Shonewald-Cox did not address population fluctuations, which may have led to a low MVP estimate.

Reed et al. (1986) modified LaCava and Hughes' (1984) model to account for overlapping generations and nonbreeding adults by estimating sex-specific rates of survival to reproduction (*l*), generation intervals (mean age of breeders, *L*), and number of progeny (*k*). Reed et al. estimated these parameters for elk with complex mathematical models, and for lack of better data, I used these estimates in my calculation. The final result, however, assumes the accuracy of these estimates and their reproducibility in a restored population. This model yielded an MVP = 224, which is appropriately larger than LaCava and Hughes' (1984), but roughly only ½ of Lehmkuhl's (1984). Because Reed et al.'s model does not include population fluctuations and because of the uncertainty involved in estimating *l*, *L*, and *k*, I believe that Reed et al.'s model underestimates MVP.

To assist me in comparing these models, I refer to a similar assessment made by Harris and Allendorf (1989). Harris and Allendorf estimated the N_e of a theoretical grizzly bear population using a stochastic computer model and compared the results to those obtained using the mathematical models presented here (except for Shonewald-Cox, 1986). My evaluations of these models coincides well with the observations of Harris and Allendorf. Lehmkuhl's (1984) model seems to consistently overestimating MVP, LaCava and Hughes' (1984) seems to underestimate MVP, and Reed et al. (1986) tends to fall somewhere in the middle. Harris and Allendorf further agree that Lehmkuhl (1984) may overcompensate for the variance in progeny number, and that this variance can be attributed to 1) biased sex ratios, and 2) overlapping generations. Incidentally, if the first step is omitted from Lehmkuhl's model (the step that adjusts for V_k), MVP is estimated at 360 (rather than 504).

Based on this evaluation, I believe that the true value of MVP lies somewhere between the estimates obtained from Reed et al.'s model (MVP = 224) and Lehmkuhl's model (including all steps, MVP = 504). For the purposes of this feasibility assessment, I use a short-term MVP = 400. Interestingly, this is in agreement with the estimate obtained after deleting the questionable V_k parameter from Lehmkuhl's (1984) model (MVP = 360) and qualitatively re-adjusting for the presence of nonbreeding adults (the effects of which are partially removed by ignoring V_k).

MVP is influenced by many aspects of the genetic and demographic characteristics of a species. It is impossible to come up with a number that will tell a manager exactly what to do. Even with the best model, decisions must be made under uncertainty. An MVP = 400 certainly is not without risks, but I believe that these risks can be minimized through careful management.

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Appendix 2
Land Use Defragmentation

Appendix 2A – The Defragmentation Process

Before beginning the landscape analysis, I found it necessary to perform some preliminary work on the land use maps. To correct for possible classification errors and create a land use map likely to be more sensitive to the large-scale needs of an elk (and less sensitive at a smaller scale), I wrote an SML program (See Appendix 2-B) that removes all forested and open areas of ≤3 pixels. This program goes through the raster based land use map, pixel by pixel, and examines the 8 cells surrounding each pixel in a moving window operation. If ≥2 of those 8 pixels are classified the same as the center pixel (creating ≥3 adjacent pixels), then the center pixel keeps its original classification. Otherwise, the center pixel is reclassified as whatever the majority of those 8 pixels are classified as. This system removes all "fragments" that are ≤0.27 ha. Any fragment >0.27 ha is more likely to be a significant feature of the landscape relative to elk habitat selection and also is less likely to be the result of a classification error.

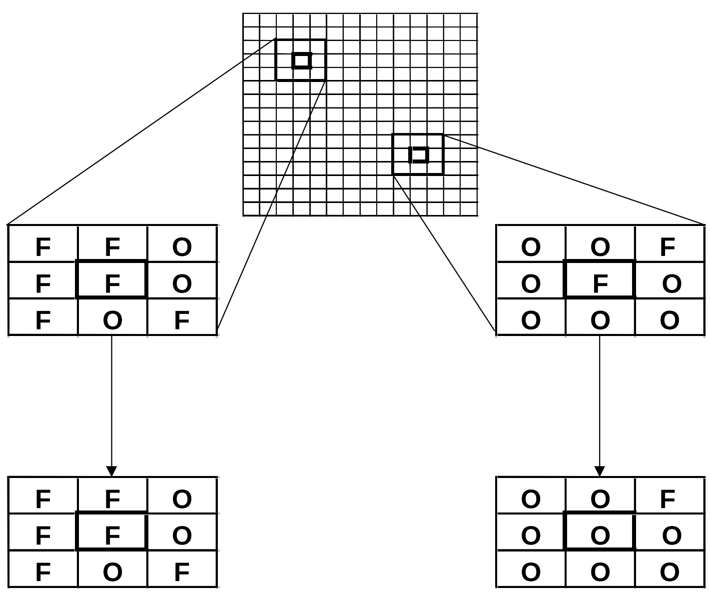

Figure A1. Defragmentation Process. The example on the left has 4 neighboring forested pixels surrounding a forested center pixel; center pixels retain forest classification. The example on the right has only 1 neighboring forested pixel; center pixel is reclassified as dominant surrounding land use type (open).

Appendix 2B – Defragmentation SML

```
#=====================================================================
#       Landscape Defragmenter, MicroImages TNT MIPS, Version 5.9
#       DeFrag.sml
#
#       This program modifies a land use map and reclassifies any forest (deciduous + coniferous
#       +  mixed) or open (herbaceous + shrub) patches ≤3 pixels (0.27 ha) in area as the
#       locally dominant cover type using a  9-pixel moving window.  This operation partially
#       corrects for any possible classification errors in heterogeneous landscapes and
#       compensates for the fine scale of the 30m resolution which may otherwise over-
#       emphasize small patches with little biological or ecological meaning with respect to elk
#       habitat selection.
#
#       INPUT = Classified satellite image (30m pixels) with following classes:
#               10 – Deciduous Forest          20 – Herbaceous
#               11 – Coniferous Forest         30 – Shrub
#               12 – Mixed Forest
#
#       OUTPUT = Classified Satellite TM Image with same classes, all patches (combined
#       forest codes or combined herbaceous/shrub codes) ≤0.27 ha removed
#
#       Last modified 7/6/98 by Julie McClafferty
#=====================================================================
clear()

####Set variables to be used in file identification

path$ = "e:/elkhsimodel/"
divider$ = "/"
suffix$ = ".rvc"

#Set date variable to be placed in output file
date = Date()
print(date)
type$ = "32-bit float"

#Ask user to type in polygon identification information
print("What region are you currently working on?")
region$ = input$()

print("What polygon are you currently working on?")
polygon$ = input$()

#Create file string for reading and writing spatial information generated in the program
file$ = path$ + region$ + divider$ + polygon$ + suffix$
```

```
#Asks user to verify correct filename
print("  The file you are working on is", file$)
print("             Is this correct?")
confirm$ = input$("yes")

if (confirm$ == "yes") then begin


####Open the input file to be defragmented
OpenRaster(LandUse, file$, "LandUse")
SetNull(LandUse, 255)


####Create output rasters

#Create blank raster for defragmented landuse
description$ = "Corrected LandUse"
CreateRaster(DeFrag, file$, "DeFrag_LandUse", description$, NumLins(LandUse),
NumCols(LandUse), RastType(LandUse))

CopySubobjects(LandUse, DeFrag)
        SetNull(DeFrag, 255)

#Create blank raster for binary landuse map; Open = 1, Forest = 0; to be used in later programs
description$ = "Open = 1"
CreateRaster(OpenBin, file$, "OpenBin", description$, NumLins(DeFrag), NumCols(DeFrag),
"binary")

CopySubobjects(DeFrag, OpenBin, "GeoRef")
        IgnoreNull(OpenBin)

#Create blank raster for binary landuse map; Open = 0, Forest = 1; to be used in later programs
description$ = "Forest = 1"
CreateRaster(ForBin, file$, "ForBin", description$, NumLins(DeFrag), NumCols(DeFrag),
"binary")

CopySubobjects(DeFrag, ForBin, "GeoRef")
        IgnoreNull(ForBin)


####Begin defragmentation

#Set variables used in counter for progress reporting
count = 0
ncells = NumCols(LandUse) * NumLins(LandUse)
```

```
interval = round(ncells/20)

#Starting the moving window
print("Defragmenting lone open and forest pixels")

for each LandUse[i,j] begin
                if (IsNull(LandUse)) then DeFrag = NullValue(LandUse)
        else begin

#Determine the dominant land use type surrounding each pixel
        mode = FocalMajority(LandUse, 3, 3)

#If current pixel is 'open' (herbaceous or shrub) and most surrounding pixels are also open, then
#move on, otherwise count surrounding open pixels
if ((LandUse == 20) or (LandUse == 30)) then begin
                if ((mode == 20) or (mode == 30)) then DeFrag = LandUse
        else begin

#Name the surrounding 8 pixels
                        north = LandUse[i-1,j]
                        northe = LandUse[i-1,j+1]
                        east = LandUse[i,j+1]
                        southe = LandUse[i+1,j+1]
                        south = LandUse[i+1,j]
                        southw = LandUse[i+1,j-1]
                        west = LandUse[i,j-1]
                        northw = LandUse[i-1,j-1]

#Count the open pixels in the surrounding 8  pixels
                        v = 0
                        if (north == 20) then v = v + 1
                        if (north == 30) then v = v + 1
                        if (northe == 20) then v = v + 1
                        if (northe == 30) then v = v + 1
                        if (east == 20) then v = v + 1
                        if (east == 30) then v = v + 1
                        if (southe == 20) then v = v + 1
                        if (southe == 30) then v = v + 1
                        if (south == 20) then v = v + 1
                        if (south == 30) then v = v + 1
                        if (southw == 20) then v = v + 1
                        if (southw == 30) then v = v + 1
                        if (west == 20) then v = v + 1
                        if (west == 30) then v = v + 1
                        if (northw == 20) then v = v + 1
                        if (northw == 30) then v = v + 1
```

```
#If open patch size ≥3 pixels (including center pixel), then v ≥ 2; Keep current classification

        if (v >= 2) then DeFrag = LandUse

#If open patch size <3 pixels (including center pixel), then v < 2; Reclassify current pixel

                        else DeFrag = mode
                end
                        end

#If current pixel is 'forest' (any type) and most surrounding pixels are also forested, then move
#on, otherwise count surrounding forested pixels

        else if ((LandUse == 11) or (LandUse == 12) or (LandUse == 13)) then begin
                if ((mode == 11) or (mode == 12) or (mode == 13)) then DeFrag = LandUse
                else begin

#Name the surrounding 8 pixels
                        north = LandUse[i-1,j]
                        northe = LandUse[i-1,j+1]
                        east = LandUse[i,j+1]
                        southe = LandUse[i+1,j+1]
                        south = LandUse[i+1,j]
                        southw = LandUse[i+1,j-1]
                        west = LandUse[i,j-1]
                        northw = LandUse[i-1,j-1]

#Count the forest pixels in the surrounding 8 pixels
                        v = 0
                        if (north == 11) then v = v + 1
                        if (north == 12) then v = v + 1
                        if (north == 13) then v = v + 1
                        if (northe == 11) then v = v + 1
                        if (northe == 12) then v = v + 1
                        if (northe == 13) then v = v + 1
                        if (east == 11) then v = v + 1
                        if (east == 12) then v = v + 1
                        if (east == 13) then v = v + 1
                        if (southe == 11) then v = v + 1
                        if (southe == 12) then v = v + 1
                        if (southe == 13) then v = v + 1
                        if (south == 11) then v = v + 1
                        if (south == 12) then v = v + 1
                        if (south == 13) then v = v + 1
                        if (southw == 11) then v = v + 1
```

```
                        if (southw == 12) then v = v + 1
                        if (southw == 13) then v = v + 1
                        if (west == 11) then v = v + 1
                        if (west == 12) then v = v + 1
                        if (west == 13) then v = v + 1
                        if (northw == 11) then v = v + 1
                        if (northw == 12) then v = v + 1
                        if (northw == 13) then v = v + 1

#If forest patch size ≥ 3 pixels (including center pixel), then v ≥ 2; Keep current classification

                        if (v >= 2) then DeFrag = LandUse

#If forest patch size <3 pixels (including center pixel), then v < 2; Reclassify current pixel

                        else DeFrag = mode
                        end
                        end

#All other classified pixels stay the same (e.g., water, disturbed)

        else DeFrag = LandUse
        end

#Report progress
count = count + 1
if (round(count%interval) == 0) then
print(round((count/ncells) * 100), "percent complete with Defragmentation")
end

#Defragmentation complete
        print("Finished with Defragmentation")

CreateHistogram(DeFrag)
CreatePyramid(DeFrag)
CloseRaster(LandUse)


####Create binary maps for use in later programs
        print("Creating binary maps")

        for each DeFrag[i,j] begin

#Forest binary: If input = forest, output = 1; else output = 0

        if ((DeFrag == 11) or (DeFrag == 12) or (DeFrag == 13)) then ForBin = 1
```

```
        else ForBin = 0

#Open binary: If input = open, output = 1; else output = 0
        if ((DeFrag == 20) or (DeFrag == 30)) then OpenBin = 1
        else OpenBin = 0
        end

#Binary maps complete
CloseRaster(OpenBin)
CloseRaster(ForBin)


####Calculate areas of each land use type in defragmented maps for descriptive purposes

print("Calculating Land Cover Areas")

#Set all land cover type variables to zero
                dec = 0         #Deciduous forest
                con = 0         #Coniferous forest
                mix = 0         #Mixed forest
                herb = 0        #Herbaceous
                shrub = 0       #Shrub
                wat = 0         #Open water
                dist = 0        #Disturbed
                null = 0        #Null

#Count pixels of each cover type
        for each DeFrag[i,j] begin
                if (IsNull(DeFrag)) then null = null +1
                else if (DeFrag == 11) then dec = dec + 1
                else if (DeFrag == 12) then con = con + 1
                else if (DeFrag == 13) then mix = mix + 1
                else if (DeFrag == 20) then shrub = shrub + 1
                else if (DeFrag == 30) then herb = herb + 1
                else if (DeFrag == 40) then wat = wat + 1
                else if (DeFrag == 50) then dist = dist + 1
        end

#Open output text file
output$ = "e:/habitatdata/" + region$ + ".txt"
print("Output is listed in ", output$)
out = fopen(output$, "a+")

#Print date and region identification info to text file
fprintf(out, "%d%s%s%s%s\n\n", date, "      DATA FOR... ", region$ , "-" ,  polygon$)
```

```
#Print areas of polygon and each landuse type within polygon to output file

fprintf(out, "%s%.2f%s\n\n", "Total area of polygon = ", dec+con+herb+shrub+ wat+dist+
mix)*0.09, " hectares")

fprintf(out, "%s%d%s%.2f%s\n", dec, "Area of deciduous Forest = ", dec*0.09," hectares")

fprintf(out, "%s%d%s%.2f%s\n", con, "Area of coniferous forest = ", con*0.09," hectares")

fprintf(out, "%s%d%s%.2f%s\n", mix, "Area of mixed forest = ", mix*0.09," hectares")

fprintf(out, "%s%d%s%.2f%s\n\n", dec+con+mix, "Total area of forest = ",
(dec+con+mix)*0.09, " hectares")

fprintf(out, "%s%d%s%.2f%s\n", herb, "Area of herbaceous = ", herb*0.09, " hectares")

fprintf(out, "%s%d%s%.2f%s\n", shrub, "Area of shrub = ", shrub*0.09, " hectares")

fprintf(out, "%s%d%s%.2f%s\n\n", shrub+herb, "Total area of open = ", (shrub+open)*0.09, "
hectares")

fprintf(out, "%s%d%s%.2f%s\n", dist, "Area of disturbed = ", dist*0.09, " hectares")

fprintf(out, "%s%d%s%.2f%s\n\n", wat, "Area of water = ", wat*0.09, " hectares")

fprintf(out, "%s%s%s%s\n", "End of ", region$,":", polygon$)

fprintf(out, "%s\n", "----------------------------------------")


####Program complete; close all files
print("Finished with batch job for", file$)
fclose(out)

print("Done")
CloseRaster(DeFrag)

end
```

Appendix 3
HSI Model Programs

Appendix 3A – HSI Construction SML

```
#==============================================================
#       HSI Layer Analysis; MicroImages TNT MIPS SML; V. 5.9
#       BatchJob.sml
#
#       This program creates the input layers for a habitat suitability model used for predicting
#       elk habitat in Virginia. It asks which polygon to analyze, creates the habitat effectiveness
#       (HE) maps for the 5 variables, and print summary statistics (average component scores
#       for the  polygon. See individual sections of this program for more information.
#
#       INPUT:          Distance-to-forest-from-open map
#                       Distance-to-open-from-forest map
#                       Forest binary map (forest = 1, else = 0)
#                       Open binary map (open = 1, else = 0)
#                       Rasterized water feature map with distance-to data
#                       Rasterized road map with "minor" roads
#                       Raster slope data
#
#       OUTPUT: interspersion, composision, road, water, and slope HE Maps, Final HSI map
#                       Habitat condition  map corresponding to Final HSI score
#
#       Created by Julie McClafferty            Last Revised: 12/20/99
#==============================================================
clear()

####Set variables to be used in file identification
path$ = "e:/elkhsimodel/"
divider$ = "/"
suffix$ = ".rvc"

#Set date variable to be placed in output file
date = Date()
print(date)
type$ = "32-bit float"

#Ask user for polygon identification information
print("What region are you currently working on?")
region$ = input$()

print("What polygon are you currently working on?")
polygon$ = input$()

#Create file string for reading/writing spatial data
global file$ = path$ + region$ + divider$ + polygon$ + suffix$
```

```
#Ask user to verify file information
print("The file you are working on is", file$)
print("Is this correct?")
        confirm$ = input$("yes")

if (confirm$ == "yes") then begin

#Open output text file
output$ = "e:/habitatdata/" + region$ + ".txt”
print("Output is listed in ", output$)
out = fopen(output$, "a+")

#Print descriptive information to text file
fprintf(out, "%d%s%s%s%s\n", date, "        DATA FOR... ", region$ , "-" ,  polygon$)
fprintf(out, "\n")

####Get input raster, landuse data
OpenRaster(LandUse, file$, "DeFrag_LandUse")
        SetNull(LandUse, 255)

####SLOPE HSI
#===============================================================
#       This section will evaluate a raster map containing degrees slope data and convert each
#       cell into a habitat suitability index score
#
#       INPUT: A grayscale raster contained degrees slope (0-90) data for the polygon
#
#       OUTPUT: A grayscale raster containing HSI scores that correspond to the slope at each
#       point in the polygon.
#===============================================================

#Get input raster
        OpenRaster(Slope, file$, "Slope")
        SetNull(Slope, 255)

#Create output raster
description$ = "Slope Scores"
CreateRaster(SlopeHSI, file$, "SlopeHSI", description$, NumLins(Slope), NumCols(Slope),
type$)

CopySubobjects(Slope, SlopeHSI, "GeoRef")
        SetNull(SlopeHSI, 2)
        NullValue(SlopeHSI)

###Begin reclassification
```

```
print("Reclassifying slope data into HE classes")

for each Slope[i,j] begin
        if (IsNull(LandUse)) then SlopeHSI = NullValue(SlopeHSI)
        else begin
                if (IsNull(Slope)) then SlopeHSI = NullValue(SlopeHSI)
                else begin
                        if (Slope <= 40) then begin
                                if (Slope <= 20) then SlopeHSI = 1
                                else SlopeHSI = ((-0.04 * Slope) + 1.8)
                                end
                        else begin
if (Slope <= 60) then SlopeHSI = ((-0.01 * Slope) + 0.6)
else begin
        if (Slope <= 90) then SlopeHSI = 0
        else SlopeHSI = NullValue(SlopeHSI)
end
end
end
end
end

#Reclassification complete
CreateHistogram(SlopeHSI)

#Calculate summary stats and print to text file
        meanslope = GlobalMean(Slope)
        meanslopehsi = GlobalMean(SlopeHSI)

fprintf(out, "%s%.3f%s\n", "  Average Slope = ", meanslope, " degrees")
fprintf(out, "%s%.3f\n", "      Average Slope HSI = ", meanslopehsi)

CloseRaster(Slope)
CloseRaster(SlopeHSI)


####INTERSPERSION HSI
#=================================================================
#       This section will take raster files with distance-to-open-area data and distance-to-forest-
#       area data and reclassify each pixel into the appropriate HSI score according to which 90-
#       meter distance band it falls into. The input files can be created from classified TM scenes
#       containing land use data
#
#       INPUT = 2 raster files:
#                       1) Distance from forested pixels to nearest open pixel (Dist2opn)
```

```
#                    2) Distance from open pixels to nearest forested pixel (Dist2for)
#
#      OUTPUT = 1 combined raster with HSI scores representing proximity to edge.
#
#            FORESTED AREA SCORES
#            1 = 0-270 meters from open area = 1.0
#            2 = 271-360 meters from open area = 0.8
#            3 = 361-450 meters from open area = 0.6
#            4 = 451-540 meters from open area = 0.4
#            5 = 541 + meters from open area = 0.2
#
#            OPEN AREA SCORES
#            1 = 0-90 meters from forest area = 1.0
#            2 = 91-180 meters from forest area = 0.7
#            3 = 181-270 meters from forest area = 0.25
#            4 = 271-360 meters from forest area = 0.1
#            5 = 361 + meters from forest area = 0.05
#==========================================================
print("Examining Interspersion")

#Get input rasters
OpenRaster(Dist2opn, file$, "Dist2opn")
SetNull(Dist2opn, 0)

OpenRaster(Dist2for, file$, "Dist2for")
      SetNull(Dist2for, 0)

#Create temporary output rasters
CreateTempRaster(D2opnHSI, NumLins(Dist2opn), NumCols(Dist2opn), "32-bit float")
CopySubobjects(Dist2opn, D2opnHSI, "GeoRef")
      SetNull(D2opnHSI, 0)

CreateTempRaster(D2forHSI, NumLins(Dist2for), NumCols(Dist2for), "32-bit float")
CopySubobjects(Dist2for, D2forHSI, "GeoRef")
      SetNull(D2forHSI, 0)

#Create output raster
description$ = "Interspersion Scores"
CreateRaster(IntersppHSI, file$, "InterspHSI", description$, NumLins(Dist2for),
NumCols(Dist2for), type$)
CopySubobjects(Dist2for, InterspHSI, "GeoRef")
      SetNull(InterspHSI, 2)

###Reclassify distance-to-open map
print("Assigning forested pixels an interspersion score")
```

```
for each Dist2opn[i,j] begin
	if (IsNull(Dist2opn)) then D2opnHSI = NullValue(D2opnHSI)
	else begin
		if (Dist2opn <= 270) then D2opnHSI = 1
		else begin
			if (Dist2opn <= 360) then D2opnHSI = 0.8
			else begin
				if (Dist2opn <= 450) then D2opnHSI = 0.6
				else begin
					if (Dist2opn <= 540) then D2opnHSI = 0.4
					else D2opnHSI = 0.2
				end
			end
		end
	end
end

#Reclassify distance-to-forest map
print("Assigning open pixels an interspersion score")
for each Dist2for[i,j] begin
if (IsNull(Dist2for)) then D2forHSI = NullValue(D2forHSI)
else begin
	if (Dist2for <= 90) then D2forHSI = 1
		else begin
			if (Dist2for <= 180) then D2forHSI = 0.7
			else begin
				if (Dist2for <= 270) then D2forHSI = 0.25
				else begin
					if (Dist2for <= 360) then D2forHSI = 0.1
					else D2forHSI = 0.05
				end
			end
		end
	end
end

###Combining open and forest interspersion layers
print("Combining forest and open interspersion scores")

IgnoreNull(D2opnHSI)
IgnoreNull(D2forHSI)

for each D2forHSI[i,j] begin
if (IsNull(LandUse)) then IntersphSI = (NullValue(IntersphSI))
	else begin
		if ((D2forHSI + D2opnHSI) > 1) then IntersphSI = NullValue(IntersphSI)
```

```
                else InterspHSI = (D2forHSI + D2opnHSI)
        end
end

#Finishing with Interspersion
CreateHistogram(InterspHSI)
DeleteTempRaster(D2forHSI)
DeleteTempRaster(D2opnHSI)
CloseRaster(Dist2for)
CloseRaster(Dist2opn)

#Calculating summary statistics and printing to text file
meaninthsi = GlobalMean(InterspHSI)
fprintf(out, "%s%.3f\n", "       Average Interspersion HSI = ", meaninthsi)

CloseRaster(InterspHSI)


####DISTANCE TO WATER
#===================================================================
#       This section will calculate the HSI score for each pixel based on its distance from the
#       nearest water feature pixel.  The input layer can be created from a rasterized water
#       feature map with distance-to-nearest-water feature calculated for each nonwater pixel
#
#       INPUT: Rasterized water map with distances to nearest water feature
#
#       OUTPUT:  Distance to water HSI map
#===================================================================
#Get input raster
OpenRaster(D2Water, file$, "Dist2Water")
        IgnoreNull(D2Water)
        description$ = "Distance to Water Scores"

#Create output raster
CreateRaster(WaterHSI, file$, "WaterHSI", description$, NumLins(D2Water),
NumCols(D2Water), type$)
CopySubobjects(D2Water, WaterHSI, "GeoRef")
SetNull(WaterHSI, 2)

#Reclassify distance data
print("Assigning Water HE Scores")

for each D2Water[i,j] begin
        if (IsNull(LandUse)) then WaterHSI = NullValue(WaterHSI)
        else begin
                if (D2Water <= 800) then WaterHSI = 1
```

```
        else begin
            if (D2Water <= 1200) then WaterHSI = .8
            else begin
                if (D2Water <= 1600) then WaterHSI = .4
                else WaterHSI = .2
            end
        end
    end
end

#Reclassification complete
CloseRaster(D2Water)

#Calculate summary statistics and print to text file
meanwaterhsi = GlobalMean(WaterHSI)
fprintf(out, "%s%.3f\n", "    Average Distance to Water HSI = ", meanwaterhsi)

CloseRaster(WaterHSI)

####Landscape Composition
#=================================================================
#    This section will compute an HE score for each pixel in a raster land user map based on
#    he ratio of open to forested area within a 1-km radius centered on that pixel.  Input maps
#    are either created in a previous program (DeFrag.sml) or can be created from a raster
#    landuse map
#
#    INPUT = 2 raster maps:
#            1)Binary forest map (forest = 1, else = 0)
#            2)Binary open map (open = 1, else = 0)
#
#    OUTPUT = 2 raster maps:
#            1)Land use composition map (% forested ratio)
#            2)Composition HSI Map
#=================================================================
print("Working on Ratio")

#Get input rasters
OpenRaster(OpenBin, file$, "OpenBin")
IgnoreNull(OpenBin)

OpenRaster(ForBin, file$, "ForBin")
    IgnoreNull(ForBin)

#Create temporary output rasters
CreateTempRaster(OpnSum, NumLins(LandUse), NumCols(LandUse), "16-bit unsigned")
CopySubobjects(LandUse, OpnSum, "GeoRef")
```

```
IgnoreNull(OpnSum)

CreateTempRaster(ForSum, NumLins(LandUse), NumCols(LandUse), "16-bit unsigned")
CopySubobjects(LandUse, ForSum, "GeoRef")
	IgnoreNull(ForSum)

#Create output rasters
description$ = "% Forested Area"
CreateRaster(Ratio, file$, "Ratio", description$,  NumLins(LandUse), NumCols(LandUse),
type$)
CopySubobjects(LandUse, Ratio, "GeoRef")
SetNull(Ratio, 2)

description$ = "% Forest HE"
CreateRaster(RatioHSI, file$, "RatioHSI", descrption$, NumLins(LandUse),
NumCols(LandUse), type$)
CopySubobjects(LandUse, RatioHSI, "GeoRef")
	SetNull(RatioHSI, 2)

###Compute variables to prepare for ratio calculation
	count = 0
	npixels = (NumLins(LandUse) * NumCols(LandUse))
	interval = int(npixels/50)

#Compute FocalSum for OpenBin map (33x33 pixels = 1 sq. km)
print("Calculating FocalSum for open binary layer")

for each OpenBin[i,j]
	begin
		if (IsNull(LandUse)) then OpnSum = 0
		else begin
			OpnSum = FocalSum(OpenBin, 33, 33)
		end

#Report Progress
	count = count + 1
	if (count%interval == 0) then
	print(round((count/npixels) * 100), "percent complete with 1st FocalSum")
	end

#Finished with OpenBin
print("Done calculating FocalSum for open binary layer")
CloseRaster(OpenBin)

#Compute FocalSum for ForBin map (33x33 pixels = 1 sq. km)
	count = 0
```

```
print("Calculating FocalSum for forested binary layer")

for each ForBin[i,j] begin
	if (IsNull(LandUse)) then ForSum = 0
	else begin
		ForSum = FocalSum(ForBin, 33, 33)
	end

#Report progress
	count = count + 1
	if (count%interval == 0) then
	print(round((count/npixels) * 100), "percent complete with second FocalSum")
end

#Finished with ForBin
print("Done calculating FocalSum for forested binary layer")

CloseRaster(ForBin)

###Create ratio layer
print("Creating Ratio layer")
count = 0

for each ForSum[i,j] begin
	if (IsNull(LandUse)) then Ratio = NullValue(Ratio)
	else begin
		if ((ForSum + OpnSum) > 0) then Ratio = (ForSum/(ForSum + OpnSum))
		else Ratio = NullValue(Ratio)
	end

#Report progress
	count = count + 1
	interval = (int(npixels/10))
	if (count%interval == 0) then
	print(round((count/npixels) * 100), "percent complete with Ratio calculation")
end

#Ratio layer complete
print("Done creating ratio layer")

DeleteTempRaster(ForSum)
DeleteTempRaster(OpnSum)

###Assign ratios to HE classes
print("Assigning ’open’ FocalSum pixels to HE classes")
```

```
for each Ratio[i,j] begin
if (IsNull(Ratio) or IsNull(LandUse)) then RatioHSI = NullValue(RatioHSI)
        else begin
                if (Ratio < 0.4) then RatioHSI = ((2 * Ratio) + 0.2)
                else begin
                        if (Ratio <= 0.8) then RatioHSI = 1
                        else RatioHSI = (((0 - 3.5) * Ratio) + 3.8)
                end
        end
end

#Composition analysis complete
        print("Done with Composition")

CreateHistogram(RatioHSI)
        CreateHistogram(Ratio)

#Calulate summary statistics and print to text file
meanratiohsi = GlobalMean(RatioHSI)
fprintf(out, "%s%.3f\n", "       Average Ratio HSI=", meanratiohsi)

CloseRaster(Ratio)
CloseRaster(RatioHSI)

#=================================================================
#       This section will calculate the density of roads within 800m of each pixel in a rasterized
#       road map.  These densities will then be reclassifed into HE scores
#
#       INPUT = Rasterized map of roads (binary) boundary
#
#       OUTPUT = 2 raster file:
#                       1)Raster road density map (cell value = count of road pixels)
#                       2)Road density HE map
#=================================================================
print("Working on Road Density")

#Get input raster
OpenRaster(RoadRast, file$, "Minor_Roads")
        IgnoreNull(RoadRast)

#Create temporary output rasters
CreateTempRaster(RoadSum, NumLins(LandUse), NumCols(LandUse), "16-bit unsigned")
CopySubobjects(LandUse, RoadSum, "GeoRef")
```

```
        IgnoreNull(RoadSum)

#Create output raster
        description$ = "Road Density HE Scores"
CreateRaster(RdDenHSI, file$, "RdDenHSI", description$, NumLins(LandUse),
NumCols(LandUse), type$)
CopySubobjects(LandUse, RdDenHSI, "GeoRef")
        SetNull(RdDenHSI, 2)

#Set variables for progress reporting
count = 0
        npixels = (NumLins(RoadRast) * NumCols(RoadRast))
interval = int(npixels/100)

#Calulcate road density (55x55 pixels = 800 m in all directions)
print("Creating FocalSum for RoadRast")

for each RoadRast[i,j] begin
        if (IsNull(LandUse)) then RoadSum = 0
        else begin
                RoadSum = FocalSum(RoadRast, 55, 55)
end

#Report progress
count = count + 1
if (count%interval == 0) then
print(round((count/npixels) * 100), "percent complete with Road Sum")
end

#Reclassifying road densities into HE classes
print("Assigning RoadSum pixels to HSI classes")

for each RoadSum[i,j] begin
        if (IsNull(LandUse)) then RdDenHSI = NullValue(RdDenHSI)
        else begin
                if (RoadSum == 0) then RdDenHSI = 1
                else begin
                        if (RoadSum < 46) then RdDenHSI = (((0-0.0089)*RoadSum) + 1)
                        else begin
                                if (RoadSum < 272) then RdDenHSI = ((0-0.0022)*RoadSum + .7)
                                else begin
                                        if (RoadSum < 3500) then RdDenHSI = .1
                                        else RdDenHSI = NullValue(RdDenHSI)
                                end
                        end
                end
```

```
	end
end

#Finished with road density
print("Finished reclassifying")

print("Done with Road Density")

CreateHistogram(RdDenHSI)

CloseRaster(RoadRast)
DeleteTempRaster(RoadSum)

#Calculate summary statistics and print to text file
meanroadhsi = GlobalMean(RdDenHSI)
fprintf(out, "%s%.3f\n\n", "    Average Road Density HSI=", meanroadhsi)

CloseRaster(RdDenHSI)

####FINAL HSI
#=================================================================
#	This section will combine all HE maps into a single Final HSI map using a geometric
#	mean function.
#
#	INPUT: Interspersion HSI, SlopeHSI, RatioHSI, Rd Density HSI, Water HSI
#
#	OUTPUT:3 rasters
#			1) A final HSI map
#=================================================================
#Get input rasters
OpenRaster(RatioHSI, file$, "RatioHSI")
	SetNull(RatioHSI, 2)

OpenRaster(RdDenHSI, file$, "RdDenHSI")
	SetNull(RdDenHSI, 2)

OpenRaster(SlopeHSI, file$, "SlopeHSI")
	SetNull(SlopeHSI, 2)

OpenRaster(WaterHSI, file$, "WaterHSI")
	SetNull(WaterHSI, 2)

OpenRaster(InterspHSI, file$, "InterspHSI")
	SetNull(InterspHSI, 2)

#Create output raster
```

```
description$ = "HSI Scores"
CreateRaster(FinalHSI, file$, "FinalHSI", description$, NumLins(LandUse),
NumCols(LandUse), type$)
CopySubobjects(LandUse, FinalHSI, "GeoRef")
SetNull(FinalHSI, 2)


#Calculate HSI map
print("Combining HE layers with GEOMETRIC MEAN")

for each LandUse[i,j] begin
if (IsNull(LandUse)) then begin
		FinalHSI = NullValue(FinalHSI)
	end

	else begin
FinalHSI = ((Intersp HSI * WaterHSI * RdDenHSI * RatioHSI * SlopeHSI)^(1/5))
	end

#HSI maps complete
CloseRaster(SlopeHSI)
CloseRaster(RdDenHSI)
CloseRaster(WaterHSI)
CloseRaster(RatioHSI)
CloseRaster(InterspHSI)

CreateHistogram(FinalHSI)

#Calculate summary statistics and print to text file
meanfinalhsi = GlobalMean(FinalHSI)
fprintf(out, "%s%.3f\n\n", "    Average Overall HSI (with all variables) = ", meanfinalhsi)


####HABITAT SUITABILITY
#===================================================================
#	This section will reclassify the Final HSI map into suitability classes based on the
#	scheme depicted in the model by Wisdom et al. (1986)
#
#	INPUT: Final HSI map
#	OUTPUT: Habitat suitability classes
#===================================================================

#Get input raster
OpenRaster(FinalHSI, file$, "FinalHSI")
	SetNull(FinalHSI, 2)
```

```
#Create output raster
	description$ = "Overall Suitbility Classes"
CreateRaster(HabCond, file$, "HabCond", description$, NumLins(FinalHSI),
NumCols(FinalHSI), "8-bit unsigned")
CopySubobjects(FinalHSI, HabCond, "GeoRef")
	SetNull(HabCond, 0)

#Begin reclassification
print("Assigning HSI to Condition classes")

for each FinalHSI begin
	if (IsNull(FinalHSI) or IsNull(LandUse)) then HabCond = NullValue(HabCond)
	else begin
		if (FinalHSI == 1) then HabCond = 5
		else begin
			if (FinalHSI >= 0.6) then HabCond = 4
			else begin
				if (FinalHSI >= 0.4) then HabCond = 3
				else begin
					if (FinalHSI >= 0.2) then HabCond = 2
					else HabCond = 1
				end
			end
		end
	end
end

#Finished reclassifying
CreateHistogram(HabCond)

#Calculate areas of each suitability class
print("Calculating Class Areas")

		nonv = 0	#Nonviable
		mar = 0		#Marginal
		via = 0		#Viable
		hv = 0		#Highly Viable
		opt = 0		#Optimal
		no = 0		#Null

for each HabCond[i,j] begin
	if (IsNull(HabCond)) then no = (NullValue(HabCond))
else begin
		if (HabCond == 1) then nonv = nonv + 1
		else begin
			if (HabCond == 2) then mar = mar + 1
```

```
                else begin
                        if (HabCond == 3) then via = via + 1
                        else begin
                                if (HabCond == 4) then hv = hv + 1
                                else begin
                                        if (HabCond == 5) then opt = opt + 1
                                        else no = no + 1
                                end
                        end
                end
        end
    end
end


#Calculate summary statistics and print to text file
totalarea = (nonv+mar+via+hv+opt)*0.09

fprintf(out, "%s%.2f%s\n", "Total area of polygon = ", totalarea, " hectares")
fprintf(out, "%s%d%s%.2f%s\n", opt, "Area of ’optimal’ habitat = ", opt*0.09, " hectares")
fprintf(out, "%s%d%s%.2f%s\n", hv, "Area of ’highly viable’ habitat = ", hv*0.09, " hectares")
fprintf(out, "%s%d%s%.2f%s\n", via, "Area of ’viable’ habitat = ", via*0.09, " hectares")
fprintf(out, "%s%d%s%.2f%s\n", mar, "Area of ’marginal’ habitat = ", mar*0.09, " hectares")
fprintf(out, "%s%d%s%.2f%s\n\n", nonv, "Area of ’nonviable’ habitat = ", nonv*0.09, "
hectares")
fprintf(out, "%s%.2f%s\n\n", "Total Habitat Units = ", totalarea*meanfinalhsi, " units, from
average HSI")

###Calculate habitat units (area * HSI)
#Create temporary output raster
CreateTempRaster(HU, NumLins(FinalHSI), NumCols(FinalHSI), "32-bit float")

for each FinalHSI[i,j] begin
    if (IsNull(FinalHSI)) then HU = NullValue(HU)
    else HU = FinalHSI * 0.09
end

#Calculate summary statistics and print to text file
hu = GlobalSum(HU)

fprintf(out, "%s%.2f%s\n\n", "Total Habitat Units = ", hu, " units, from pixels hsi values")

###Program complete, close all files and exit
DeleteTempRaster(HU)
CloseRaster(FinalHSI)
CloseRaster(HabCond)
```

```
fprintf(out, "%s%s%s%s\n", "           End of ", region$,":", polygon$)
fprintf(out, "%s", "----------------------------------------------")
fprintf(out, "\n")
print("Finished with batch job for", file$)
fclose(out)
end
```

Appendix 3-B – HSI Model Sensitivity SML

```
#==================================================================
#	Marginal HSI Scores; MicroImages TNT MIPS; V. 5.9
#	Marginal.sml
#
#	This program combines all habitat effectiveness (HE) maps except for the one you are
#	testing for sensitivity into a single Final HSI map using a geometric mean function.  The
#	program will ask you which region and polygon you are working on, and which variable
#	you want to leave out. If you do not want to leave any out, then just hit enter when
#	it asks.
#
#	INPUT: InterspersionHSI, SlopeHSI, RatioHSI, Rd Density HSI, Water HSI
#
#	OUTPUT: Final HSI map, and habitat suitability class map, with statistics printed to an
#		output text file.
#
#	Julie McClafferty				Last Revised 10/30/98
#==================================================================
clear()

####Set variables to be used in file identification
path$ = "e:/elkhsimodel/"
divider$ = "/"
suffix$ = ".rvc"

#Set date variable to be placed in output file
date = Date()
print(date)
type$ = "32-bit float"

#Ask user for polygon identification information
print("What region are you currently working on?")
region$ = input$()

print("What polygon are you currently working on?")
polygon$ = input$()

#Create file string for reading and writing spatial data
file$ = path$ + region$ + divider$ + polygon$ + suffix$

#Ask user to verify correct path
print("  The file you are working on is", file$)
print("  Is this correct?")
confirm$ = input$("yes")
```

```
if (confirm$ == "yes") then begin

#Open output text file
output$ = "e:/habitatdata/" + region$ + ".txt"
print("  Output is listed in ", output$)
out = fopen(output$, "a+")

####Prepare for calculation
#Ask user which of 5 variables he/she is testing (to leave out). Letters in parentheses are
#abbreviations to be used as input
print("Which variable do you want to leave out?")
print("(s)lope, (w)ater, (i)nterspersion, (c)omposition(Ratio), or (r)oads")

#Set variable to desired layer; if user wants overall HSI (no variables left out), hit enter and
#default value of ‘none’ will be assigned
        mvar$ = input$("none")

#Print descriptive info to text file
fprintf(out, "%s%s%s%s%s%s\n\n", "Marginal Output for Final HSI & Habitat Units, no HE",
mvar$, ", ",  region$, ":", polygon$)

#Open input rasters
OpenRaster(LandUse, file$, "DeFrag_LandUse")
        SetNull(LandUse, 255)

OpenRaster(RatioHSI, file$, "RatioHSI")
        SetNull(RatioHSI, 2)

OpenRaster(RdDenHSI, file$, "RdDenHSI")
        SetNull(RdDenHSI, 2)

OpenRaster(SlopeHSI, file$, "SlopeHSI")
        SetNull(SlopeHSI, 2)

OpenRaster(WaterHSI, file$, "WaterHSI")
        SetNull(WaterHSI, 2)

OpenRaster(InterspHSI, file$, "InterspHSI")
        SetNull(InterspHSI, 2)

#Name output file according to left-out variable
if (mvar$ == "none") then name$ = "FinalHSI"
else name$ = "FinalHSI_" + mvar$

        description$ = "HSI Scores"
```

```
#Create output raster
CreateRaster(Final, file$, name$, description$, NumLins(LandUse), NumCols(LandUse), type$)
CopySubobjects(LandUse, Final, "GeoRef")
        SetNull(Final, 2)

####Begin HSI calculations
print("Combining HE layers with GEOMETRIC MEAN")

for each LandUse[i,j]begin
if (IsNull(LandUse)) then Final = NullValue(Final)
else begin
if (mvar$ == "none") then Final = ((IntersрHSI * WaterHSI * RdDenHSI * RatioHSI *
SlopeHSI)^(1/5))
else if (mvar$ == "s") then Final = ((IntersрHSI * WaterHSI * RdDenHSI * RatioHSI)^(1/4))
else if (mvar$ == "i") then Final = ((SlopeHSI *WaterHSI * RdDenHSI * RatioHSI)^(1/4))
else if (mvar$ == "c") then Final = ((IntersрHSI * WaterHSI *  RoadDenHSI * SlopeHSI)^(1/4))
else if (mvar$ == "r") then Final = ((IntersрHSI * WaterHSI * SlopeHSI * RatioHSI)^(1/4))
else if (mvar$ == "w") then Final = ((IntersрHSI * RdDenHSI* SlopeHSI * RatioHSI)^(1/4))

end
end

#Finished calculating HSI
CloseRaster(SlopeHSI)
CloseRaster(RdDenHSI)
CloseRaster(WaterHSI)
CloseRaster(RatioHSI)
CloseRaster(IntersрHSI)

CreateHistogram(Final)

#Calculate overall mean HSI for raster just created
meanfinalhsi = GlobalMean(Final)

#Print mean HSI to output text file
fprintf(out, "%s%.3f\n\n", "    Average Overall HSI = ", meanfinalhsi)


#Program complete; close all files and quit
CloseRaster(Final)

fprintf(out, "%s%s%s%s\n", "            End of ", region$,":", polygon$)
fprintf(out, "%s\n", "----------------------------------------")
print("Finished with batch job for", file$)
fclose(out)
```

end

Appendix 4
Forest Understory

In small scale analyses (<25,000 ha), the availability of "optimal" cover may become an important measure of elk habitat suitability. Optimal cover is defined by 3 criteria. First, sufficient canopy closure (>60%) must exist to function as thermal cover. Canopy closure can be evaluated using GIS or simple field measurements. Second, the understory must be able to provide hiding cover. Hiding cover is present when ≥90% of a standing elk is hidden when viewed at a distance of ≤60 m (Lee 1984; Wisdom et al. 1986; Thomas et al. 1979, 1988). Third, the understory must provide adequate forage, especially where open foraging areas are less abundant (Lee 1984, Wisdom et al. 1986). Forage is sufficient when understory vegetation ≤2 m tall covers ≥25% of the forest floor (Long 1996). Based on these requirements, I established a tentative set of rules (Table 2.1) for assigning HE scores to forests based on their understory. Areas with <60% canopy closure are open forage areas and cannot be analyzed in this way.

This variable must be field measured because satellite imagery does not provide detailed understory data. Note that areas providing both thermal cover and forage, but no hiding cover, are assigned a higher score than areas providing both thermal and hiding cover, but no forage. This reflects the important role that forested areas must play in providing adequate forage on eastern ranges. The understory score for an area can be obtained by estimating the proportion of forested area that is classified at each level of the matrix (Table A2) and obtaining a weighted average of the scores.

Figure A2. Elk habitat effectiveness based on understory structure in forested stands.

Forested Site Description	**Habitat Effectiveness Score**	**Forested Site Description**	**Habitat Effectiveness Score**
>60% Canopy Closure <60m Sight Distance >25% Cover in Herbaceous or Shrub Layer < 2m tall	1.0 *Optimal*	>60% Canopy Closure <60m Sight Distance <25% Cover in Herbaceous or Shrub Layer < 2m tall	0.3 *Thermal + Hiding*
>60% Canopy Closure >60m Sight Distance >25% Cover in Herbaceous or Shrub Layer < 2m tall	0.7 *Thermal + Forage*	>60% Canopy Closure >60m Sight Distance <25% Cover in Herbaceous or Shrub Layer < 2m tall	0.1 *Thermal Only*

Appendix 5
General Public Mail Survey

Elk Restoration in Virginia

A survey of public opinions and concerns

Survey prepared and administered by:
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0321

This questionnaire is designed to assess the attitudes, beliefs, opinions, and concerns of residents of the Commonwealth about elk and elk restoration in Virginia. Information you provide will help formulate recommendations on whether or not elk should be reintroduced and, if so, to identify special considerations that need to be addressed. Therefore, your response is important to this study, and we would greatly appreciate your input. There is space at the end of the survey for you to make comments and address issues that are not covered by the questionnaire. All responses will be kept confidential. Your identity will never be connected to the responses you give.

For the purposes of this survey, please note that a biological assessment has been conducted, potentially suitable habitat has been identified, and that reintroduction of elk was determined to be biologically feasible. As you read and answer the questions that follow, please limit your consideration only to issues relating to the social and economic desirability of elk restoration in Virginia. Thank you!

(1) Do you agree or disagree with the following statement? (Please check the appropriate box)

Reintroducing elk into Virginia is a good idea.

- ❑ Strongly Agree
- ❑ Agree
- ❑ Neither Agree nor Disagree
- ❑ Disagree
- ❑ Strongly Disagree
- ❑ Don't Know

(2) Based on past research, it has been shown that the amount of knowledge and experience a person has regarding a particular topic greatly affects his/her attitudes and opinions about that issue (such as elk and elk restoration). Measuring this effect is important to making good management decisions. How confident do you feel about your knowledge of elk and your ability to make judgment on the costs and benefits of reintroducing elk in Virginia?

- ❑ Very Confident
- ❑ Somewhat Confident
- ❑ Somewhat Uncertain
- ❑ Very Uncertain

(3) How helpful was the enclosed brochure in giving you the information you need to make the types of decisions referred to in Question 2?

- ❑ Very Helpful
- ❑ Somewhat Helpful
- ❑ Not Very Helpful
- ❑ Did Not Read It

Questions 4-8 are designed to assess your interests in the potential of viewing elk and your opinions about the placement of released elk. Your responses will help determine the potential for increased tourism in and around potential release sites.

(4) If elk were reintroduced in Virginia, how likely would you be to make a special trip to view them?

- ❑ Very Likely
- ❑ Somewhat Likely
- ❑ Not Very Likely
- ❑ Don't Know

(5) What is the farthest distance you would be willing to travel if the primary purpose of your trip was to view the elk?

- ❑ Less than 50 miles
- ❑ Between 50 and 100 miles
- ❑ Between 100 and 200 miles
- ❑ More than 200 miles

(6) Would you be more or less likely to make a trip to view elk if a special viewing facility (such as an overlook) were built in an area where elk are likely to be?

- ❑ More Likely
- ❑ About the Same
- ❑ Less Likely

(7) Would you be more or less likely to support elk reintroduction in Virginia if elk were kept in a permanent enclosure (i.e., surrounded by an elk-proof fence)?

- ❑ More Likely
- ❑ About the Same
- ❑ Less Likely

(8) Would you be more or less likely to support elk reintroduction in Virginia if the release site was near (less than 50 miles from) your home?

- ❑ More Likely
- ❑ About the Same
- ❑ Less Likely

Below is a list of possible outcomes or concerns about elk reintroduction in Virginia. Please indicate how positive or negative you believe the impacts on YOU would be if each scenario were to occur. (Check ONE box for each statement.)

If this scenario were to occur, I believe the impacts ON ME would be…

As a direct result of reintroducing elk to Virginia, there could be…	Very Positive	Positive	Neither Positive nor Negative	Negative	Very Negative	Don't Know
(9) ...an increase in agricultural damages (i.e., damage to crops, fences, and gardens)	❑	❑	❑	❑	❑	❑
(10) ...an economic hardship placed on farmers	❑	❑	❑	❑	❑	❑
(11)...an increase in Virginia's biodiversity.	❑	❑	❑	❑	❑	❑
(12) ...a reduction in the size of Virginia's deer herd due to competition for forage	❑	❑	❑	❑	❑	❑
(13) ...negative impacts on other wildlife through habitat alteration caused by elk	❑	❑	❑	❑	❑	❑
(14) ...movement of elk from release sites and their intended range	❑	❑	❑	❑	❑	❑
(15)...an increase in recreational opportunities associated with elk	❑	❑	❑	❑	❑	❑
(16) ...disease transmission from elk to Virginia's livestock	❑	❑	❑	❑	❑	❑
(17) ...disease transmission from elk to Virginia's wildlife	❑	❑	❑	❑	❑	❑
(18)...economic benefits to communities near release sites	❑	❑	❑	❑	❑	❑
(19) ...a problem of illegal taking of elk (i.e., poaching) .	❑	❑	❑	❑	❑	❑
(20) ...inhumane treatment of elk during trapping, transport, and release	❑	❑	❑	❑	❑	❑

The next section of the survey is designed to assess the reasons why people may choose to support or not support elk reintroduction in Virginia. Please respond according to your personal beliefs about how elk reintroduction would affect YOU personally.

(21) Based on what I know today, if given the opportunity, I would...
(Check the most appropriate box)

❑ **SUPPORT** elk reintroduction in Virginia **(proceed to #22 below)**

❑ **NOT SUPPORT** elk reintroduction in Virginia **(skip to #33 on page 5)**

If you indicated in Question 21 that you would SUPPORT reintroduction of elk in Virginia, please indicate below how important each factor listed was in your decision.

	Very Important	Somewhat Important	Not Very Important	Not a Factor in My Decision
(22) Elk were present in Virginia historically	❑	❑	❑	❑
(23) Elk have a right to live in their historic native range	❑	❑	❑	❑
(24) Reintroducing elk may restore a part of Virginia's natural heritage	❑	❑	❑	❑
(25) Reintroducing elk may increase biodiversity in Virginia	❑	❑	❑	❑
(26) I would like to be able to see elk in Virginia . . .	❑	❑	❑	❑
(27) I would like to hunt elk in Virginia some day . .	❑	❑	❑	❑
(28) Managing reintroduced elk in Virginia would be a good use of existing funds by the Department of Game and Inland Fisheries.	❑	❑	❑	❑
(29) Reintroducing elk may reduce the size of Virginia's deer herds.	❑	❑	❑	❑
(30) Elk may increase opportunities for outdoor recreation in Virginia	❑	❑	❑	❑
(31) Elk may bring economic benefits to communities near the release sites	❑	❑	❑	❑

(32) Please list any other reasons you may have for **SUPPORTING** elk reintroduction in Virginia. (Then skip to Question 45 on Page 6)

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Please skip to Question 45 on Page 6

If you indicated in Question 21 that you would NOT SUPPORT elk reintroduction in Virginia, please indicate below how important each factor listed was in your decision.

	Very Important	Somewhat Important	Not Very Important	Not a Factor in My Decision
(33) Land uses in Virginia may have changed too much to support an elk herd	❑	❑	❑	❑
(34) I am not interested is seeing elk in Virginia . . .	❑	❑	❑	❑
(35) Reintroducing elk in Virginia may be unsuccessful again	❑	❑	❑	❑
(36) Trapping, transporting, and releasing elk for reintroduction into Virginia may be inhumane to the elk	❑	❑	❑	❑
(37) Elk may compete with deer for forage and harm the deer population	❑	❑	❑	❑
(38) Elk may have a negative impact on other wildlife by altering existing ecosystems and habitats	❑	❑	❑	❑
(39) Managing reintroduced elk in Virginia would not be a good use of existing funds by the Department of Game and Inland Fisheries.	❑	❑	❑	❑
(40) Elk may cause an increase in automobile-wildlife collisions	❑	❑	❑	❑
(41) Elk may transmit diseases to Virginia's livestock	❑	❑	❑	❑
(42) Elk may transmit diseases to other wildlife in Virginia	❑	❑	❑	❑
(43) Elk may cause agricultural damage on farms (such as crop, fence, and garden damage)	❑	❑	❑	❑

(44) Please list any other reasons you may have for **NOT SUPPORTING** an elk reintroduction in Virginia. (Then proceed to Question 45 on Page 6)

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Please proceed to Question 45 on Page 6

Questions 45-48 deal with your perceptions of the Virginia Department of Game and Inland Fisheries (VDGIF) and its ability to effectively and efficiently carry out an elk reintroduction program.

(45) Do you agree or disagree with the following statement? (Please check the appropriate box)

Management of a reintroduced elk herd is an appropriate use of funding by Virginia's Department of Game and Inland Fisheries.

- ❑ Strongly Agree
- ❑ Agree
- ❑ Neither Agree nor Disagree
- ❑ Disagree
- ❑ Strongly Disagree
- ❑ Don't Know

(46) If elk were restored to Virginia and VDGIF needed to obtain additional funding in order to manage the elk herd, where do you think that money should come from? Please indicate your agreement or disagreement with the following statements.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Don't Know
a) Funds should be reallocated from other wildlife programs within VDGIF	❑	❑	❑	❑	❑	❑
b) Funds should be reallocated from other non-wildlife programs within VDGIF (such as law enforcement or information and education)	❑	❑	❑	❑	❑	❑
c) New money should be obtained from general state funds	❑	❑	❑	❑	❑	❑
d) New funds should be obtained from outside private sources (such as non-governmental organizations)	❑	❑	❑	❑	❑	❑
e) Additional funds should not be obtained	❑	❑	❑	❑	❑	❑

(47) How satisfied are you with the performance of the Department of Game and Inland Fisheries in the following areas? (Please check one box for each statement)

	Very Satisfied	Somewhat Satisfied	Neither Satisfied nor Dissatisfied	Somewhat Dissatisfied	Very Dissatisfied	Don't Know
a) Wildlife Management (Game Species)	❑	❑	❑	❑	❑	❑
b) Wildlife Management (Non-Game Species)	❑	❑	❑	❑	❑	❑
c) Overall Performance	❑	❑	❑	❑	❑	❑

(including fisheries management, law enforcement, information/education)

(48) If people affected by elk damage were to be compensated for their losses, money for that compensation must come from some source. Please indicate your agreement or disagreement with the following statements.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Don't Know
a) Money from general state funds should be paid to victims of elk damage	❑	❑	❑	❑	❑	❑
b) Communities in the vicinity of the release site should pay a fee to compensate victims of elk damage	❑	❑	❑	❑	❑	❑
c) Organizations that support elk reintroduction should contribute money to compensate victims of elk damage	❑	❑	❑	❑	❑	❑
d) Free damage prevention tools (such as fencing materials) should be given to victims of elk damage	❑	❑	❑	❑	❑	❑
e) Victims of elk damage should not be compensated at all	❑	❑	❑	❑	❑	❑
f) Other (please specify)	❑	❑	❑	❑	❑	❑

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Questions 49 and 50 ask you to think about what types of information (other than that provided in the brochure) you believe were necessary to answer the questions presented in this survey. This information will be used in future information and education programs as the study progresses.

(49) What method(s) do you feel would be most effective for distributing additional information to the general public about an elk restoration program in Virginia? (Please check all that apply.)

- ❑ Brochures (such as the one included with this survey)
- ❑ Newspaper articles
- ❑ Informational public meetings
- ❑ Educational programs at VDGIF events
- ❑ News segments or programs on TV
- ❑ It is not necessary to provide information
- ❑ Other: ______________________________

(50) What types of information, in addition to that provided in the enclosed brochure, would have helped you most in responding to this survey?

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The last group of questions will provide useful information about your background and activity in wildlife-related activities. This information will help us to combine your responses to this survey with the responses of other participants having similar backgrounds. Remember, all responses are confidential.

(51) What is your age?

- ❑ Less than 25 years
- ❑ 25-45 years
- ❑ 46-65 years
- ❑ More than 65 years

(52) What is your gender?

❑ Female ❑ Male

(53) What county or city do you currently live in?

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(54) Please check the highest level of education you have completed

- ❑ Less than High School
- ❑ High School Diploma
- ❑ Some college
- ❑ Bachelor's Degree
- ❑ Graduate or other advanced degree

(55) What is the approximate income (before taxes) of your household? (Check the appropriate range)

- ❑ Less than $30,000
- ❑ $30,000 - $59,999
- ❑ $60,000 - $99,999
- ❑ Greater than $100,000

(56) Other experiences have suggested that people who work in agriculture or horticulture may have very different opinions of wildlife issues than those who work in other fields. Which category best describes your current employment?

- ❑ I am not employed
- ❑ Agriculture or Horticulture
- ❑ Other

(57) Which of the following environments best describes your upbringing or background?

- ❑ A rural area
- ❑ A city of less than 50,000 people
- ❑ A city of 50,000 to 249,999 people
- ❑ A city of more than 250,000 people

(58) Which of the following environments best describes your current living conditions?

- ❑ A rural area
- ❑ A city of less than 50,000 people
- ❑ A city of 50,000 to 249,999 people
- ❑ A city of more than 250,000 people

(59) What types of outdoor recreational activities have you participated in during the last year? (Check all that apply)

- ❑ Camping
- ❑ Hiking
- ❑ Boating
- ❑ Hunting
- ❑ Trapping
- ❑ Other: ________________________________
- ❑ Fishing
- ❑ Wildlife watching
- ❑ Rock Climbing
- ❑ Outdoor Photography

(60) Please estimate how often you participated in any form of outdoor recreation such as those listed above during 1998.

- ❑ Once a week
- ❑ 2-3 times a month
- ❑ Once a month
- ❑ Once every other month
- ❑ 2-3 times a year
- ❑ Once a year
- ❑ Never

After all questionnaires have been returned, the information provided by respondents will be summarized. Would you like us to mail you a copy of these results?

- ❑ Yes, I would like a copy of the results
- ❑ No, I do not wish to receive a copy of the results

We would like to thank you for taking the time and having the patience to complete this survey. The information that you have provided is valuable and important to the quality of the decision that will be made about the reintroduction of elk into Virginia. Please use the space below and on the back of this survey to provide any additional comments or opinions that you have concerning the reintroduction of elk into Virginia.

If you have any questions or comments, feel free to write or call. Thank you again for your cooperation and participation.

James A. Parkhurst and Julie A. McClafferty
Department of Fisheries and Wildlife Sciences
100 Cheatham Hall
Virginia Tech
Blacksburg, VA 24061
(540) 231-9283

Appendix 6
Informational Brochure

What Is Elk Habitat?

The best elk habitat occurs at the edges between between two habitat types (such as forest and field). Here, elk find the basics that they need: food, water, cover, and space.

In addition to a plentiful supply of food, elk need plenty of water to drink all year. In summer, they'll also splash in it to cool off and avoid biting insects. In fact, elk often spend the summer within 1/2 mile of water.

Elk seek cover for 2 reasons. First, thermal cover protects elk from weather extremes. It keeps them warm during the winter and cool during the summer. Second, elk seek shelter in hiding cover to rest and escape from predators or disturbances. They find both thermal and hiding cover in the dense vegetation that occurs along ecotones and stream valleys.

Elk need plenty of space, too, in which to find enough food throughout the year and to find the variety of shelter they need. They need to be able to travel to food, water, and shelter easily and without human disturbance, such as highways and houses. Elk may wander many miles from their home range in search of these things, but prefer to stay on familiar ground.

The Current Project...

Because many restoration attempts have failed in the past, a feasibility study is a critical first step to making an informed decision. Much has been learned about elk, their habitat requirements, their management, and their interactions with people. This knowledge allows us to predict the likely outcomes of an elk restoration in various parts of Virginia. The current study is organized to answer 3 major questions:

1) Does Virginia have the habitat?
This step will identify potential habitat using a computerized analysis of Virginia's landscape based on the habitat requirements of elk.

2) Do elk fit in with the social, economic, and political goals of Virginia residents?
This stage examines the costs and benefits associated with reintroducing elk. Surveys are a major way this type of information will be obtained. Also, public meetings will be held near potential release sites to gain a local perspective of the attitudes and opinions of residents who will be affected directly.

3) How would we manage a new elk herd?
A new herd would need to adjust to their new habitat, and conflicts within local communities are possible. This step will look at potential problems, and suggest ways that the Department of Game and Inland Fisheries could deal with them.

The outcome of these 3 questions will lead to a recommendation on the feasibility of restoring elk to Virginia. This recommendation will be passed to Virginia's Department of Game and Inland Fisheries, where the final decision will be made.

North American Elk

History, Biology, and Current Projects

Department of Fisheries and Wildlife
Virginia Polytechnic and State University
Blacksburg, VA 24061-0321

Elk Restoration: Why Consider It?

The North American elk once was common throughout most of the United States, including Virginia and the surrounding states. However, by the mid-1800s, elk had disappeared from much of their native range and become limited to small herds in western and northwestern states of the U.S. Reasons for the disappearance of elk are unclear, but may include excessive hunting, growth of human populations, loss of habitat, disease, natural changes in vegetation, or a number of other changes that occurred during the 1800s.

Since that time, many efforts have been made to restore elk to portions of their former range and to increase the size of the remaining populations. Programs to protect the remaining populations in western states have been very successful, and surplus elk from many of these herds are being moved to other regions as part of reintroduction projects.

Between 1915 and 1981, many eastern and central states attempted to reestablish elk herds. Efforts in 6 states (Oklahoma, South Dakota, Texas, Arkansas, Pennsylvania, and Michigan) are considered successful, and they now have elk herds that range in size from 300 to over 1200 animals. Other reintroduction attempts failed for various reasons. The most common explanations for failure have been insufficient habitat and over-hunting of elk to minimize crop damage.

Elk were introduced in Virginia, but ultimately did not survive. In 1917, about 150 elk were released as small groups in various portions of the Commonwealth. Most groups quickly died out, but 2 small groups persisted until about 1970. One was in Giles and Bland Counties of southwest Virginia, and the other was near Peaks of Otter along the Blue Ridge. Neither group reached more than 100 elk. As before, reasons for the failure are unclear. However, at the time, very little was known about the habitat requirements of elk, and the selection of release sites may not have included suitable habitat.

Recently, Wisconsin released an experimental herd, and Kentucky has established both captive and free-ranging herds. Other states also are considering elk restorations.

The successes of other eastern herds as well as recent gains in knowledge about the habitat requirements of elk and management of elk herds have created renewed interest in restoring elk to the eastern U.S. As a result, a study has been initiated to assess the biological, social, and economic feasibility of beginning a program to establish a free-ranging elk herd in Virginia.

What Is An Elk?

Elk are part of the deer family that includes deer, moose, and caribou. Elk are herbivores and eat only plants. Their diet is mostly grasses and other herbaceous plants, but also includes shrubs and trees (leaves, stems, and bark). When native foods are hard to find, elk may look to agricultural fields for forage.

A mature cow elk (female) can weigh more than 500 pounds, and the average mature bull (male) weighs about 700 pounds. Bulls begin to grow antlers when they are 1🗎 years old. Antlers are shed every spring and grow back each summer. By the 7th year, antlers may may have 6 tines each, weigh 40 pounds, and measure more than 4 feet across. Elk can live 18 years or more.

In order to eat and watch for danger at the same time, elk gather into herds. There is always at least one animal looking up. Even animals that are feeding are constantly alert and listening for unusual sounds. This is especially important in the summer when cows must protect their calves. Elk predators include humans, black bears, and coyotes. In the west, grizzly bears, mountain lions, and wolves also are important predators.

Herding is common during the fall mating season, called the *rut*. Bulls gather cows in a harem which they defend from other bulls. The rut lasts from September into early November.

Appendix 7
Regional Elk Workshops: Participants and Results

Appendix 7 – Results of Regional Meetings

Southwest Virginia (Abingdon, VA)

Participants (21 total) – Appalachian Trail Council (1), Rocky Mountain Elk Foundation (3), Virginia Tourism Corporation (1), Mt. Rogers Planning District (1), Natural Resources Conservation Service (1), Break Interstate Park (1), Dickenson County Board of Supervisors (1), VA State Police (1), U.S. Forest Service (2), Virginia Department of Transportation (1), Agricultural Experiment Station (1), Farmer's Market Board (1), Mt. Rogers Christmas Tree Growers Association (1), Copper Creek Cattle Company (1), Southwest Virginia Agricultural Association (1), general interest farmers (3).

Invited but not present – Local outdoorsman store (1), The Nature Conservancy (1), U.S. Forest Service (1), Buchanan County Sheriff's Department (1), Coalfield Beef Cattle & Land Use Assoc. (1), Southwest VA Agricultural Association (1),

Benefits

# Dots	Potential Benefits Listed
39	Money generated from tourism spurred by elk under enclosure
29	Enhancement of tourism in general: economic, social, cultural, recreational benefits
19	The availability of a new research opportunity to learn from elk
17	Educational opportunity for children and the general public
16	Opportunity for enhancement of habitat for multiple species
15	Opportunity to foster public/private relationships
14	Creation of a philosophical existence value; (e.g., "just because they are there")
11	Creation of new recreational opportunities (consumptive)
5	Opportunity for better "large-scale" habitat/wildlife management
5	Creation of new recreational opportunities (nonconsumptive)
4	Opportunity to foster native biodiversity
4	Source of food for hunters/farmers/poachers
2	Creation of new job opportunities for natural resource professionals
1	A chance to further understand human interest groups
0	Opportunity to foster naturalized biodiversity

Costs

# Dots	Potential Concerns Listed
48	Crop destruction (e.g., hay, corn, tobacco, fruit trees, Christmas trees, alfalfa)
30	Economic costs associated with elk re-introduction (e.g., crop damage, compensation of property damage,

	administrative/management cost, land acquisition)
22	Human health impacts (e.g., CWD/scrapie/BSE, TB)
18	Creation of a property rights infringement when private lands become elk grazing lands
13	Increased manpower needs/demands resulting from calls for assistance (e.g., management agencies, police/sheriff)
10	Vehicle/elk collisions and the associated physical damage, economic impact (insurance), personal health and safety and emotional trauma
8	Increased demand upon management agencies to create “better” lands to attract/hold elk
7	Damage to family garden damage
2	Transmission of disease/parasites from native wildlife to elk and from elk to livestock and/or deer
2	“Inhumaneness” toward elk – physical effects from trapping, transporting, and releasing in poor habitat
1	Personal health and safety risks resulting from contact or confrontation with habituated elk
1	Hunting safety issue due to the need for higher power weapons and the associated risk of stray shots into personal property
1	Competition for forage with livestock and native species
1	Decreased quality of life and/or changed character of region due to tourism
0	Inability to control influences of elk movement/wandering
0	Spotlighting/poaching and the effects on elk restoration program and risks of target misidentification (e.g., livestock hits)
0	Creations of sociopolitical strain among constituent groups
0	Impacts on and competition with native flora/fauna
0	Microhabitat damage due to social tendencies of elk (e.g., herding)
0	Increased potential for trespass
0	Creation of a fear factor; elk present an unknown (possibly misleading) danger to many people

Resolutions

# Dots	Potential Resolutions Listed
50	“Just say no” to elk restoration in Virginia
31	Clearly establish true costs and expected returns beforehand (by example). This can be done by VA Tech Extension and/or VA Tourism Authority.
22	Perform more research to better define the biological/ecological parameters and issues
18	Use a temporary “experimental” herd under enclosure before releasing them
15	Clearly state the objectives of elk restoration and go from there

7	Use public/private partnerships to deal with elk/habitat management
4	Launch education program to inform the general public about the disease issue
3	Execute a herd health monitoring and quarantine program before release
2	Create an insurance pool to cover costs of property damage using tourism revenue, general assembly taxpayers, partnerships (nongame constituents, hunters), grants, etc.
1	Secure funding beforehand
0	Find ways to let elk pay their way
0	Permanent enclosure release only
0	Obtain money for management from fees charged to view elk

Shenandoah Valley (Verona, VA)

Participants (20 total) – Rocky Mountain Elk Foundation (3), Rockingham County Economic Development (1), Bath County Administrator (1), Augusta County Board of Supervisors (1),Virginia Department of Transportation (2), Virginia State Police (1), U.S. Forest Service (3), National Park Service (1), Wildlife Veterinarian (1), Augusta County Farm Bureau (1), Westvaco Corporation (1), Virginia Cattleman's Association (1), vegetable/livestock general interest (3).

Invited but not present – The Nature Conservancy (1), Augusta County Sheriff's Office (1)

Benefits

# Dots	Potential Benefits Listed
32	Impacts of tourism – economic value to local community through businesses, taxes, and revenue producing sources
24	Impetus to create and/or maintain "open habitat" and the associated economic benefits from timber harvest followed by the natural maintenance of openings by elk
23	Biodiversity – opportunity to restore a missing part of the ecosystem
20	Increased nonconsumptive recreational opportunities (e.g., art, photography, wildlife watching)
18	Increased revenue to federal land management agencies through recreational user fees associated with increased tourism and recreational participation
18	Aesthetics – Creation of a better quality of life and more beautiful landscape
11	Increased education/research opportunity's with associated increase in environmental awareness among general public
8	Fulfillment of an ethical/moral obligation to restore native species

6	Opportunity for future hunting
5	Availability of RMEF financial assistance to state and federal management agencies
3	Enhancement of property values and associated benefits to private landowners
3	Better/enhanced use of public lands
1	Possibility for competition with deer leading to a reduced deer herd
0	Alternative food source for hunters, farmers, poachers

Costs

# Dots	Potential Concerns Listed
23	Increased private property damage (e.g., crops, fences)
21	Ecosystem impacts due to over-grazing/browsing
18	Disease transmission to livestock, to wildlife, to people, and back to elk
16	Competition with indigenous wildlife
16	Increased foraging pressure on already over-grazed, over-browsed habitat esp. on localized, limited habitat such as on Park Service lands with associated hands-off regulatory mandates; creation of a new impediment to achieving management goals
15	Elk/vehicle accidents and associated personal injury and property damage
11	Competition with livestock
5	Difference of opinion on how land should be managed and used (e.g., preservation vs. conservation)
5	Cost of regulating/managing an elk herd (e.g., personnel, methods)
4	Impacts on water quality
4	Costs of managing for habitat needs of elk on public property
3	Costs of re-introduction (e.g., acquisition, transportation, planning)
2	Cost of accident prevention and lack of effective measures
2	Use of exotic subspecies of elk
2	Habitualization/domestication of elk due to illegal feeding
2	Need for a lot of space and associated loss of the use of that land for other community needs
1	Undesired change in lifestyle (e.g., traffic, development, demand on infrastructure and services)
1	Public education needs
1	Potential for land condemnation for elk conservation and associated loss of revenue and impacts on private property use
1	Question of liability for personal injury/property damage
0	Public safety concerns with potential for physical attacks by elk
0	Difficulty of enforcing poaching laws

0	Increased use of public lands leading to traffic problems and over-use of facilities
0	Inconsistency of the current regulatory classification of elk with the goals of restoration

Resolutions

# Dots	Potential Resolutions Listed
27	Apply management techniques to keep elk herd at “desired” level to limit damages
19	Establish a park and enclose the elk permanently using public land and surrounding willing landowners
18	Need elk to generate tourism money to pay for the program
17	Take measures to prevent diseases from being introduced
15	Compensate farmers for damage (e.g., damage stamps, user fees, general state funds)
11	Launch public education campaign to increase awareness
10	Create a sound “acceptable” Environmental Impact Statement
9	Perform a small-scale pilot project (possibly under enclosure) to identify the true impacts first
4	Hunt elk and sell/auction permits
4	Delineate/select large areas suitable for elk that consider compatibility with existing management goals, limitations of conflicts, and legislative/regulatory limitations
4	Development of a “viewable” herd and associated infrastructure to promote tourism
3	Allow landowner to shoot depredating elk (e.g., damage permits)
3	Provide assurances that viewing will remain available to public
2	Establish public/private partnerships to address costs and find ways to enhance economic value
2	Set up a fee-based viewing area to allow elk to be self-supporting
2	Create a market for elk products (e.g., meat, antlers)
2	Learn more about herds in other states
2	Enforce speed limit and other traffic control measures
1	Execute an effective damage control program (e.g., manipulate food sources, develop habitat on public lands, provide fencing)
0	Give citizens the right to hold state liable for all damages
0	Know which private landowners are willing to be a part of reintroduction site
0	Limit liability to the state; (e.g., make the state liable for damages but limit with liability caps)
0	Resolve regulatory/legislative issues hampering management
0	Recognize that problems may/may not arise over time and that there will be time to work them out
0	Seek input of private funds (e.g., NGO’s) to avoid or mitigate problems and improve management options

0	Mitigate the larger economic costs by using tourism revenue

Shenandoah Valley (Winchester, VA)

Participants – Rocky Mountain Elk Foundation (2), Smithsonian Institute Conservation and Research Center (1), National Park Service (1), U.S. Forest Service (4), Frederick County Sheriff's Office (1), Virginia Department of Transportation (2), Virginia Department of Forestry (1), Tree Fruit Research and Extension Center (1), Virginia Farm Bureau Federation (2), apple growers (3), dairy producers (1), fruit/vegetable/ornamental general interest (1) .

Invited but not present – Conservation and Research Center (1), VA State Police (1), alfalfa grower (1)

Benefits

# Dots	Potential Benefits Listed
17	Money generated from timber harvest to create habitat openings
16	Economic return to communities from visitation and tourism
16	Potential for new hunting opportunity
14	Enhancement/creation of a new wildlife viewing opportunity
10	Educational opportunity and chance to heighten public environmental awareness
10	Provide incentive for a shift in habitat/wildlife management (e.g., create new openings)
7	Restoration of extirpated/native species
5	Opportunity to generate money for research
5	Economic return and community infrastructure support from hunting/lease hunts
1	Potential for elk herbivory to act as a management tool to control less desirable forest species
1	"Feel good" opportunity for individuals viewing elk restoration as good
1	Opportunity to increase biodiversity from ethical perspective
0	Associated increase in community pride/recognition
0	Creation of new government employment positions
0	Opportunity to follow legal mandates of federal agencies (e.g., NMFA)

Costs

# Dots	Potential Concerns Listed
44	Crop depredation (e.g., tree fruits, vegetables, alfalfa, soybeans, clover, ornamentals, Christmas trees)
13	Ecological competition between elk and native fauna/flora
12	Elk/vehicle collisions and associated death/injury/loss of animals and risks for personal injury
12	Reduced profitability for farmers

11	Destruction of fences by elk and implications on operations (e.g., hay bale protection, breeding in livestock)
9	Negative impacts of additional tourists on community (e.g., traffic)
9	Lack of stated objectives. Why do this?
8	Additional burden/workload placed upon management agencies (e.g., personnel needs, equipment)
8	Over-browsing of native flora and regeneration and associated impacts on threatened and endangered plants
7	Lack of information about study
6	Transfer of burden (monetary costs of providing habitat) onto private lands
5	Law enforcement problems related to poaching and trespass
5	Specific impacts on Fort & Page Valleys due to their geographic/topographic locations
3	Disease transmission from elk (vector for existing diseases)
3	Currently sufficient habitat needs (e.g., open space, water) are not met on federal lands
3	Interaction with deer will force greater deer problems on residents
3	Species to be introduced is not native
3	Self-interest would be dominating over public good
2	Competition for water resources
2	Potential for equipment damage on farms
1	Potential erosion caused from use of trails by elk
1	Waste of research money and time
1	Public domination over private residents
0	Importation of nonindigenous diseases
0	Need to construct fences for control/restricting elk movement
0	Politics involved with proposal
0	Securing public "buy-in"
0	Erosion of public support for management agencies following re-introduction
0	Costs for coordination with adjoining states
0	Liability issues related to hunting (to landowner)
0	Forces people to do unlawful actions (anything to get the crop)
0	Forces/creates change in land use

Resolutions

# Dots	Potential Resolutions Listed
47	Forget the proposal to restore elk to Virginia
25	First, try an experimental population under controlled conditions to monitor the impacts/benefits
22	Control deer herd first before elk come in
20	To realize benefits that exist, look elsewhere in Virginia where habitat is better and conflicts are less

9	Launch public education program about restoration objectives and methods
7	Initiate effort to enhance habitat on federal forests/state lands to keep elk off private lands
6	Elk brought to VA should only be in enclosure
5	Agricultural landowners must have controlling/weighted say
4	Acquire adjoining private lands through conservation easements, outright purchase, etc.
4	Allow landowners to kill/remove any animal from private property regardless of damage or need for permit
4	Enforce strict anti-poaching regulations
3	Create expedient compensation program for agricultural sector and private property owners prior to introduction
2	Dedicate economic returns (from tourism, timber sales, etc.) towards compensation for damages
2	Install and maintain protective fencing on private or public lands using outside private funding
0	Be better prepared. More research is needed on history, political issues, life history, etc. Be forthright and inform public about all issues first.
0	Maintain elk population below damage threshold

Southern Piedmont (Martinsville, VA)

Participants – Rocky Mountain Elk Foundation (2), Fairy Stone State Park (1), Virginia Department of Transportation (2), Virginia State Police (2), Soil and Water Conservation District (1), Cooperative Extension (2), Master Gardener (1), Agricultural Producer (1)

Invited but not present – Chambers of Commerce (1-Franklin Co., 1-Patrick County, 1-Danville), Tobacco Producer (1), Livestock Producer (1), General Agricultural Producers (2)

Benefits

# Dots	Potential Benefits Listed
19	Recreational draw through provision of viewing and hunting opportunities, increased diversity of large game, and aesthetic experience (bugling)
13	Potential tourism opportunity and economic benefits derived from increased recreational and tourist interest
12	Educational opportunity to increase awareness and understanding of wildlife and wildlife management to youth and the general public
10	“Righting a wrong” and bringing back a native species
9	Provision of aesthetic and quality of life values (e.g. bugling) now missing for local residents
8	“Spill-over” benefits derived from elk management programs (e.g., habitat enhancement elk also good for other species)

8	Increase biological diversity in the area and associated biological and economic benefits
5	Potential for increased diversity as a tourism draw specific to this area of the state
5	Vegetation control/management through elk browsing (e.g., noxious weeds)
5	Opportunity to broaden cooperative efforts between adjacent state management agencies
3	Potential effect on slowing down community growth an development (opportunity to save undeveloped land)
2	Marketing and land use enhancement for private property by providing incentives to keep real estate in large acreages, attracting additional buyers, and providing lease opportunities
2	Potential to increase the ethical responsibility of general public towards wildlife
2	Potential for competition for forage/space with deer as a population control measure
1	Ability to experience the diverse ecosystem created
1	Availability of a charismatic species to attract interest among corporations and enhance the flow of money into elk and elk habitat management
0	Potential to retain "young" contributors in the community infrastructure (e.g., prevent youth from leaving the area) and associated economic returns
0	Provision of the "elk experience" close to home
0	Opportunity for local people to share a new/different hunting experience with those who live in western ranges
0	Potential economic gain to VDGIF ultimately from license sale, firearms/ammunition, etc.

Detriments

# Dots	Potential Concerns Listed
17	Public safety associated with elk as a road hazard and the increased volume of traffic due to tourism; chances for elk/vehicle collisions and resulting human injuries/fatalities
15	Crop damage (elk depredation in addition to all other types of damage). Concerned with both physical and economic impacts to alfalfa, melons, soybeans, corn, tree fruits, home horticulture & landscaping, forage/pasture, tobacco
10	Need for increased personnel to meet demands of law enforcement and management (e.g., VDGIF, local government)
9	Who derives the benefits? Where are elk placed? Public or private land? Would access to elk be "locked up" on private land?
8	"Who's going to pay" – issue of equitable distribution of costs

	and benefits
7	Impact on sensitive (e.g., threatened, endangered) species
6	Landscape is changing ecologically. Will habitat available today still be available tomorrow?
6	Can we/will we control number of elk if necessary? Do we have the manpower to do so? What about political/social obstacles to hunting?
5	Questions of species status (e.g., protected/threatened/ endangered) and associated takings regulations (e.g., implications on ability to conduct infrastructure improvements)
5	Illegal hunting/poaching
5	Potential disease issues (elk to livestock, elk to humans, elk to other wildlife)
3	Dealing with people who choose not to have elk (can they be moved?, who moves them?)
2	Potential for increased damage to personal property
2	Can humans and elk coexists? Are we too urban? Does habitat truly exist?
2	Escalating cost to public (e.g., insurance premiums)‘
2	Impacts on other small game, birds, indigenous wildlife through habitat alteration
1	Effect of increased tourism on community integrity
1	Cost to monitor the program
1	Need for agricultural producers to increase production to compensate for elk depredation
1	Land use prioritization to keep lands open will be needed. Can we do it? Who is responsible?
1	Effects of current hunting legislation on elk (e.g., incidental elk chases through use of deer dogs, need rifles to shoot elk, but rifles illegal in several counties)
0	Perceived problem/misconception about elk:deer competition
0	Need for elk population control: predators? Other means?
0	Potential for fence damage and associated escape of cattle
0	Impact on water supply/quality
0	Impacts derived from increased use of off-road (e.g., ATV) vehicles to get to elk
0	Preventing realization of experiences the “mystique” of personal fantasy (e.g., the dream of traveling to West to hunt elk will no longer be necessary)

Resolutions

# Dots	Potential Resolutions Listed
18	Learn from experience of other states and apply that knowledge appropriately
15	Start with a large tract of public land as the core of an elk range

	and add willing surrounding private landowners with a low potential for conflicts (e.g., Fairy Stone State Park/VDGIF/COE lands; Kerr Lake/COE/Staunton River State Park)
10	Need more detailed habitat analysis that looks at land ownership and concentrates on public land as the core range
9	Provide financial incentives to landowners through tax incentives or easements paid for by state and federal government with private assistance
9	Limit elk to large public lands
8	Education targeted at uninformed public (i.e., not at wildlife groups) such as church groups, ruritan groups, Lions, Elks, or Moose Lodges, civic groups, public figures, youth, and genera public
5	Generate funds for increased personnel needs by lobbying the general assembly or instituting user fees to make elk "pay their way"
4	Use private funds for compensation to large landowners
3	Recognize potential battles – prepare to take regional interests into account
3	Control/slow-down development through use of easements, cost-share programs, purchase of development rights, tax adjustments
2	"Market" elk to general public for volunteerism, donations, support, etc.
2	Fund the restoration with corporate sponsors
1	Research ways to control an elk population and associated damages
0	Use of license plates, tax check-offs to generate funds
0	Develop partnerships with established entities to perform marketing, education, promotions, etc.
1	Use common sense. "Take the good with the bad"

Appendix 8
Regional Elk Workshops: Pre- and Post- Meeting Surveys

Thank you for attending today's workshop. Before we start, please complete this short survey. Your responses will tell us what you hope to accomplish today. Your responses also will help us determine the range of attitudes that people from different interest groups hold regarding elk restoration in Virginia.

The major goal for today's meeting is to foster communication between different interest groups on issues concerning elk restoration in Virginia. As you begin your participation, what do you hope to get out of your experience?

	Very Important	Somewhat Important	Little Importance	Not Needed
Interacting with other interest groups	❑	❑	❑	❑
Having my ideas and concerns about elk restoration heard	❑	❑	❑	❑
Learning about the attitudes and concerns of other groups concerning elk restoration	❑	❑	❑	❑
Learning about elk biology & management	❑	❑	❑	❑
Influencing the results of the elk restoration feasibility study	❑	❑	❑	❑
Formulating solutions to complex management problems involving elk	❑	❑	❑	❑

Other (please specify) ____

____

Considering the purpose of today's activities and what you hope to accomplish, what do you foresee as being the most important aspect(s) of a meeting such as this?

	Very Important	Somewhat Important	Little Importance	Not Needed
Presence of a noncompetitive, unthreatening atmosphere	❑	❑	❑	❑
Interaction among opposing interest groups	❑	❑	❑	❑
Open-mindedness of all participants	❑	❑	❑	❑
The generation of a large number of ideas .	❑	❑	❑	❑
Group discussion of generated ideas	❑	❑	❑	❑
Objectivity of facilitators	❑	❑	❑	❑
Fairness of facilitators	❑	❑	❑	❑

Other (please specify) ____

____

In order for us to assess the impact of this meeting, we need to know your opinions and knowledge levels on several issues. Please indicate your level of agreement or disagreement with the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I am knowledgeable about elk biology	❑	❑	❑	❑	❑
I am knowledgeable about elk management	❑	❑	❑	❑	❑
There are many possible advantages to restoring elk to Virginia	❑	❑	❑	❑	❑
There are many possible disadvantages to restoring elk to Virginia	❑	❑	❑	❑	❑
Managers would not be able to handle problems generated by elk restoration	❑	❑	❑	❑	❑
Elk should be restored to southwestern Virginia	❑	❑	❑	❑	❑

Thank you for your input. If you would like to make any other preliminary comments, please use the space below or attach additional sheet(s) as necessary. Enjoy the workshop!

Now that you have had a couple days to reflect on your experiences at our workshop on September 24, please take a few minutes and complete this short survey. Your answers will help us determine how successful we were in achieving our goals for this meeting, how the meeting impacted you and your attitudes, and how we can improve the format for future meetings.

Our objectives for this meeting were to 1) solicit information from the major interest groups, 2) create a list of potential advantages and disadvantages of elk restoration, and 3) generate ideas about how these advantages and disadvantages can be reconciled. Regarding these stated goals, how satisfied were you with:

	Very Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Very Dissatisfied
the level of interaction you had with other interest groups	❑	❑	❑	❑
the level of attention you received .	❑	❑	❑	❑
the degree to which you were able to contribute	❑	❑	❑	❑
the number of ideas generated	❑	❑	❑	❑
the quality of the ideas generated . .	❑	❑	❑	❑
the quality of the group discussions	❑	❑	❑	❑
the feasibility of proposed solutions (can they be done?)	❑	❑	❑	❑
the potential effectiveness of the proposed solutions (will they work?)	❑	❑	❑	❑

Compared with your hopes and expectations coming into this meeting, how satisfied were you with the following aspects of the workshop?

	Very Satisfied	Somewhat Satisfied	Somewhat Dissatisfied	Very Dissatisfied
Appropriateness of the meeting style	❑	❑	❑	❑
Presence of a noncompetitive, unthreatening atmosphere	❑	❑	❑	❑
Organization of the agenda	❑	❑	❑	❑
Convenience of the meeting time .	❑	❑	❑	❑
Convenience of the meeting location	❑	❑	❑	❑
Competency of the facilitators	❑	❑	❑	❑
Objectivity of the facilitators	❑	❑	❑	❑

A secondary goal of this meeting was to present you with basic information about elk and to communicate to you the importance and general methods of our current study. In your opinion, how well did we accomplish these objectives? Please mark the appropriate rating.

	Excellent	Good	Fair	Poor
Elk history	❑	❑	❑	❑
Elk biology	❑	❑	❑	❑
Elk management	❑	❑	❑	❑
Description of our study	❑	❑	❑	❑

After participating in this meeting and learning about the possible advantages and disadvantages associated with elk restoration in Virginia, what is your current opinion regarding the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The advantages of elk restoration outweigh the disadvantages.	❑	❑	❑	❑	❑
The potential disadvantages of elk restoration are too great to consider such a program	❑	❑	❑	❑	❑
The disadvantages of elk restoration can be minimized by managers	❑	❑	❑	❑	❑
Elk restoration in southwest Virginia is a good idea and should be explored further	❑	❑	❑	❑	❑

Thank you for participating in our workshop! If there is anything else you would like to add that was not specifically addressed in this survey, please use the space below, or attach additional sheets as needed.

Vita

Julie Anne McClafferty was born to Bruce G. and Sandra L. Fine on September 3, 1975 in Canandaigua, New York. After living in New York and Illinois, her family settled in Newark, Delaware. She graduated as class valedictorian from Glasgow High School in June, 1993. She was a member of the National Honor Society, the school orchestra, and served as editor-in-chief of the school yearbook for 2 years.

Julie enrolled in the College of Agriculture at the University of Delaware in September, 1993. She received her Bachelor of Science Degree in May, 1997 with a double major in Plant Science and Entomology, a concentration in Wildlife Conservation, and a minor in Biology. While attending the University of Delaware, Julie was a member of the Wildlife Conservation Club, Alpha Zeta Agricultural Honors Fraternity, Golden Key Honor Society, and the University Orchestra. During this time, she also gained valuable experience as an Environmental Technician with James C. McCulley, Environmental Consultants, Inc. in Newark, Delaware. Shortly after receiving her Bachelor of Science Degree, Julie was married to Mark A. McClafferty on July 5, 1997.

Julie became a Master's Degree candidate in August, 1997 when she enrolled in the Department of Fisheries and Wildlife Sciences at Virginia Polytechnic Institute and State University. While at Virginia Tech, she served as an officer for the Fisheries and Wildlife Graduate Student Association. She is a member of The National Wildlife Society and the GIS/Remote Sensing/Telemetry Working Group of the Wildlife Society. She completed her degree requirements in February, 2000.