December 19, 2014

Evaluation of the Feasibility of Establishing a Huntable Elk Population in North Carolina

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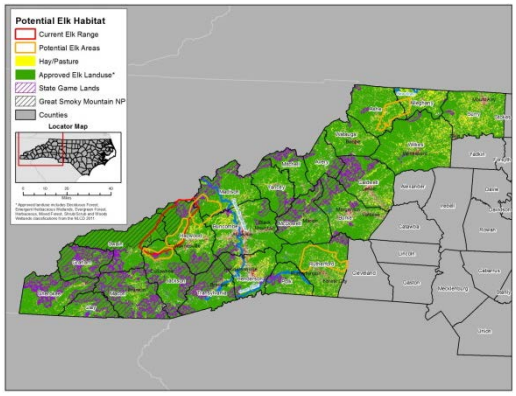
http://www.nps.gov/grsm/naturalscience/elk.htm



Final Report

Prepared for

North Carolina Wildlife Resources Commission
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RTI Project Number 0214320.000.004

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LIST OF ACRONYMS

BCA	benefit-cost analysis
GIS	geographic information system
GRSM	Great Smoky Mountains National Park
NCSU	North Carolina State University
NLCD	National Land Cover Database
NRSP	New River State Park
RFP	Request for Proposal
SD	standard deviation
SE	standard error
SMSP	South Mountains State Park
US	United States
USA	United States of America
USDA	U.S. Department of Agriculture
WRC	North Carolina Wildlife Resources Commission

EXECUTIVE SUMMARY

In 2008, the National Park Service transferred responsibility for elk management outside of the Great Smoky Mountains National Park (GRSM) to the North Carolina Wildlife Resources Commission (WRC). The expansion of elk outside of the GRSM boundaries presents additional recreational opportunities for residents and tourists but also increases human-elk conflicts and associated property damage, cost of preventive action, and administrative burden for WRC staff.

To address the challenges and responsibilities associated with elk management most effectively, the WRC surveyed landowners in 2014 to understand their attitudes toward and experiences with elk and asked North Carolina State University (NCSU) to examine and rank the suitability of habitats throughout North Carolina. The WRC determined that they should also assess the feasibility of establishing a sustainable elk population outside of GRSM and that the assessment should consider the biological needs of elk, as well as the potential positive and negative impacts to human stakeholders and other wildlife species. In March 2014, the WRC awarded a purchase order to RTI International to "evaluate biological, economic, and social variables and determine the feasibility of establishing a sustainable elk population in North Carolina." RTI's effort entailed the following:

- identifying locations within a 24-county western North Carolina region for the assessment,
- modeling multiple elk population scenarios with and without hunting, and
- determining the social and economic constraints and benefits of a sustainable and huntable elk population to both western North Carolina and the state.

Throughout the project, RTI communicated with the WRC, seeking and receiving input on the selection of study areas, assumptions made for the analyses, progress on the analyses, and preliminary findings.

ES.1 Site Selection

For this study, five study areas were selected within the 24-county region (***Figure ES-1***). Two basic considerations were applied when selecting the five areas: 1) habitat suitability and 2) the impact of human influences, such as road infrastructure and human population density. The WRC and RTI agreed that study areas would represent locations currently occupied and unoccupied by elk. RTI's study area selection process considered results of NCSU's 2014 Habitat Suitability Index data in tandem with RTI's geographic information system (GIS) mapping of land use, human population, and infrastructure (e.g., roadways). Following affirmation from WRC biologists, five areas were selected:

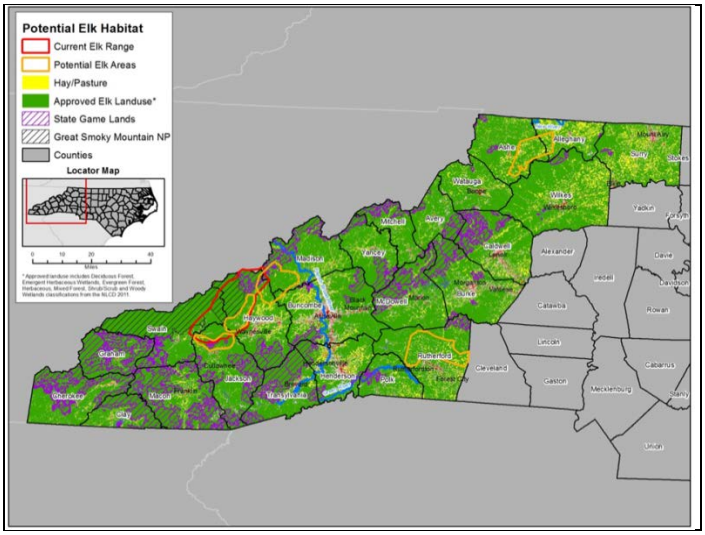

Figure ES-1. Five Elk Study Areas (Areas Bounded in Yellow) in Relation to Land Use, North Carolina Game Lands, and the Great Smoky Mountains National Park

- *Haywood study area*: the current range where elk exist (one contiguous area within portions of Swain, Haywood, Jackson, and Madison Counties);
- *Jackson and Madison study areas*: two contiguous areas within Haywood, Jackson, Madison, and Buncombe Counties adjacent to the current range (where elk exist) and where elk will likely expand soon; and
- *Rutherford and Alleghany-Ashe study areas*: two discrete elk-uninhabited areas that have adequate NCSU Habitat Suitability Index scores and have a considerable amount of potentially suitable land, as well as the best available socioeconomic circumstances to support elk.

ES.2 Integrated Biological and Socioeconomic Assessment

RTI integrated biological modeling and economic analysis of costs, benefits, and economic impacts associated with potential elk populations in each of the five study areas. The general objectives of the biological analysis were first to develop multiple elk population-level scenarios and potential harvest rate scenarios and then model over 25 and 50 years the population growth and, when applicable, harvesting for each study area. The modeling assumed the following observed elk populations: 5 elk in the Jackson study area, 55 elk in the Haywood study area, and 8 elk in the Madison study area. Both small (5 and 8 elk) and large (55 elk) stand-alone elk estimates were used to model the two unoccupied study areas of Alleghany-Ashe and Rutherford. RTI examined hunting scenarios allowing four or six elk hunting permits per year.

The economic analysis reflected the same biological scenarios and projected populations of elk in each location over 25 and 50 years and under each hunting scenario. The WRC's Human Dimension Survey findings provided valuable input for RTI's study, identifying types of elk impacts that stakeholders may view positively and negatively and quantifying how strongly the stakeholder opinions are held. A combination of survey information, WRC's complaint records, and RTI telephone interviews of a limited number of stakeholders was used in planning the economic analysis. RTI examined how those elk populations would interact with humans in each study area and evaluated the potential ways in which the elk could have a positive or negative effect on local stakeholders. The economic analysis included 1) a benefit-costs analysis and 2) a statewide economic impacts assessment.

ES.3 Findings

- *The presence of elk has a significant impact on the economy of North Carolina that is driven by additional tourism spending by visitors coming to see the animals.* An estimated 82 to 409 additional jobs could be created based on the range of visitation scenarios modeled. Statewide, net benefits ranged from $630,000 to $6.4 million in 2019, and from $125,000 to $4.98 million in 2064. Statewide economic output is estimated to increase by approximately $9.6 to $48.1 million per year, depending on the scenario considered. The expenditures associated with elk hunting make a relatively small contribution to the annual North Carolina economy.
- *In virtually all scenarios analyzed and all study areas, benefits of the elk herd are estimated to exceed the costs of the elk herd throughout the 25-year study period*. Estimated cumulative visitation benefits of hunting and elk-viewing tourism in the five western North Carolina study areas ranged from $0.8 million to $6.5 million in 2019 and from $0.6 million to $5.1 million in 2039. After 2039, total visitation

benefits to the five study areas level off (***Figure ES-2***). [In each year, hunting benefits were estimated to range from $1,320 to $3,000 for four elk harvested and from $1,980 to $4,500 for six elk harvested.]

- *Assuming no harvesting, elk population modeling showed that slow, steady growth can occur in the three study areas where elk currently reside*. The Haywood study area's elk population is predicted to reach its carrying capacity in approximately 30 years. The Jackson and Madison study areas' populations have much slower growth, but the probability of extinction remains small.
- *Modeling of the Haywood study area showed that the current population of 55 elk can sustain hunting four and six elk per year over 25 and 50 years*. Modeling results for the Jackson and Madison study areas showed that harvest scenarios were unsustainable. (Modeling shows the elk population in Jackson and Madison study areas would be extinct in less than 15 years with harvesting.)
- *Modeling found that the two unoccupied areas of Alleghany-Ashe and Rutherford will not sustain elk over 25 years, even without hunting*. This finding is attributed to the lower survival and recruitment rates because of factors such as road mortality and the likelihood of poaching. Even if the starting number of elk were greater than 55, modeling indicates that the two study areas could not sustain herds.
- *Changes in human behavior, such as installing elk-proof fencing to avoid negative impacts, have the potential to mitigate some of the projected losses*. (Behavior changes were not modeled.) Although it is capital intensive, fencing may reduce or eliminate future negative impacts.

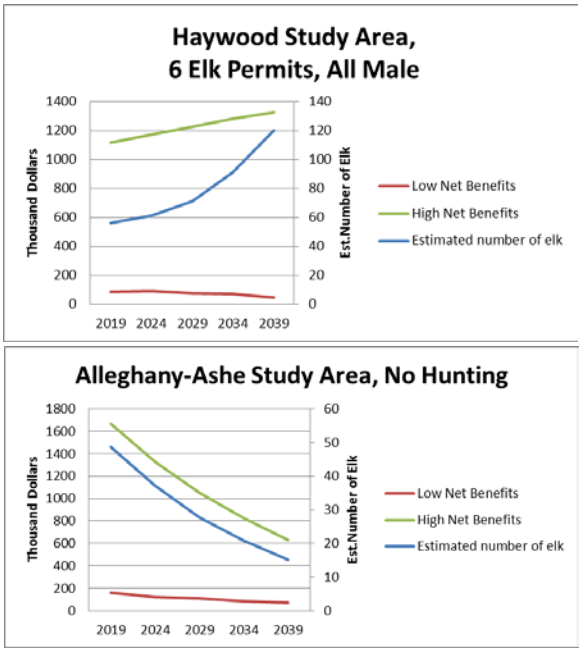

Figure ES-2. Projected Elk Populations and Net Benefits of Two Elk Study Areas

ES.4 Recommendations

Highlights of RTI's recommendations to the WRC include 1) monitoring and indexing the elk population annually to discern trends in demographics and influence of harvesting; 2) monitoring and recording human-elk incidents and the number of people who visit elk-occupied areas around the GRSM to view elk; and 3) in Haywood County, limiting any type of harvesting to males, if feasible; avoiding killing females; and, if possible, conducting aggressive, aversive conditioning of females (train the elk to avoid humans). If more than one or two depredation permits are issued per year in the Haywood area, it would probably be premature to consider harvesting elk. It is worth noting that most other eastern elk populations that are now legally hunted had reached population sizes exceeding 200 before hunting began.

SECTION 1
BACKGROUND

Elk were introduced in 2001 to the Cataloochee area of Great Smoky Mountains National Park (GRSM). In 2008, the National Park Service declared the experimental stage complete, transferring all responsibility for elk management outside of the GRSM to the North Carolina Wildlife Resources Commission (WRC). The expansion of elk outside of the GRSM boundaries presents additional recreational opportunities for residents and tourists but also increases human-elk conflicts and their associated property damage, cost of preventive action, and administrative burden for WRC staff. For example, depredation permits were issued in 2013 to two landowners in Haywood County for damage to a pumpkin crop and a dairy farm. As a result of elk's status as a Species of Special Concern in North Carolina, issuing depredation permits requires substantial administrative effort because only the Executive Director of the WRC may issue depredation permits.

To address the challenges and responsibilities associated with elk management most effectively, the WRC concluded that they should determine the feasibility of establishing a huntable elk population outside of GRSM in North Carolina. Further, they concluded that making a determination would require an integrated biological and socioeconomic analysis that considers the needs of elk and the potential positive and negative impacts to human stakeholders and other wildlife species, including economic impacts, costs, and benefits.

SECTION 2
PURPOSE

RTI International was awarded a purchase order on March 25, 2014, to "evaluate biological, economic, and social variables and determine the feasibility of establishing a sustainable elk (*Cervus elaphus* or *Cervus canadensis*[1]) population in North Carolina" (North Carolina WRC RFP #17-TK083013A, August 2013). This effort entailed

- identifying locations in western North Carolina where the biological needs of elk are satisfied and where elk herds and hunting are socially, economically, and politically sustainable;
- developing multiple elk population-level scenarios and projecting sustainable harvest rates under each scenario;
- determining the social and economic constraints and benefits both to select western North Carolina regions and to the state of North Carolina by the presence and persistence of a sustainable and huntable elk population;
- identifying management issues and social and economic carrying capacity of the established elk population in western North Carolina; and
- producing a synthesis of findings that quantifies scaled feasibility of maintaining or expanding elk in western North Carolina.

Section 3 of this report outlines RTI's general approach for the analysis, which is described in detail in subsequent sections. **Section 4** describes RTI's activities and findings on the public's perspective about elk, including a review of the WRC's Human Dimension Survey and RTI's interviews of a small number of WRC staff-suggested individuals representing various stakeholders in the western North Carolina study areas. **Section 5** explains our approach to identifying the five county-named study areas for analysis. **Section 6** contains biological modeling assumptions, methodology, and findings for predicting elk population growth. **Section 7** presents RTI's socioeconomic analysis, its integration with the biological modeling results, and the regional economic impact. **Section 8** contains further discussion, conclusions, and recommendations.

[1] *Cervus canadensis* is another name for elk (Ludt et al., 2004).

SECTION 3
APPROACH

3.1 Overview

RTI's methodological approach integrates the necessary biological and socioeconomic analyses to provide feedback and inform the required analytical steps outlined in ***Figure 3-1***. The method began with concurrent, yet coordinated, efforts in biological modeling and socioeconomic analysis. Then the results of these two analyses were integrated to produce estimates of net benefits and economic impacts for hunting and nonhunting scenarios. Detailed explanations of the methodologies for the biological and socioeconomic analyses are presented in **Sections 6** and **7**.

It is important to note that throughout the project, RTI has communicated with the WRC, seeking and receiving input on the selection of the five study areas, assumptions made for the analyses, progress on the concurrent analyses, and preliminary findings.

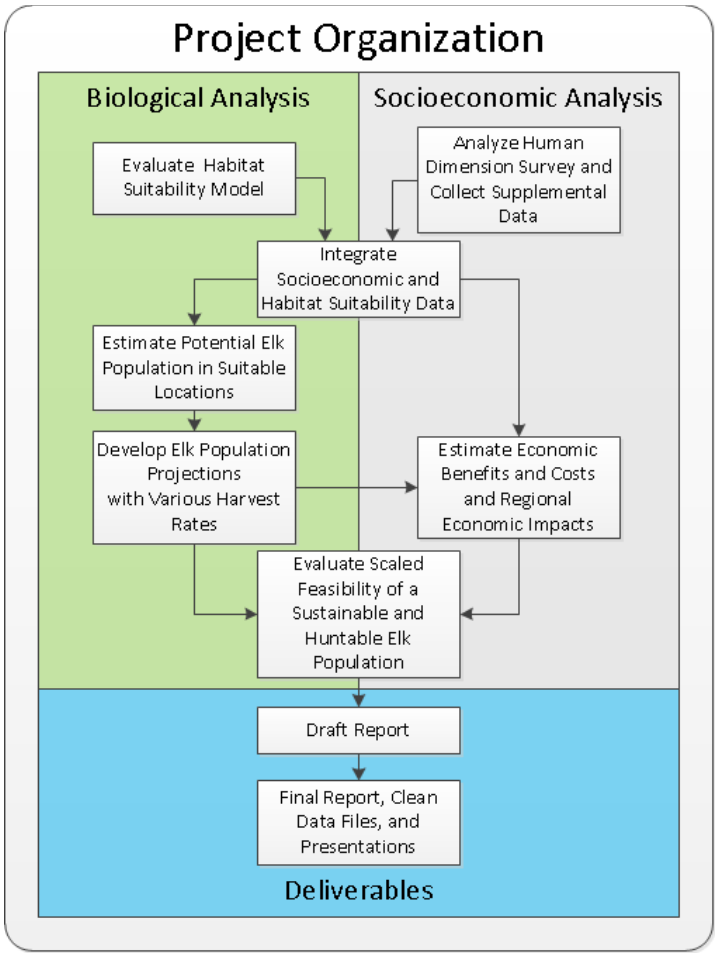

Figure 3-1. RTI's Overall Methodology Consisted of Concurrent, Coordinated Biological and Socioeconomic Analyses Followed by an Integrated Assessment

3.2 Study Area

Per WRC direction and consistent with the Commission's Human Dimension Survey (North Carolina Wildlife Resources Commission, 2014) (see **Section 4**), the regional study area focused on the following 24 western North Carolina counties (also shown in ***Figure 3-2***): Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Graham, Henderson, Jackson, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Surry, Swain, Transylvania, Yancey, Watauga, and Wilkes.

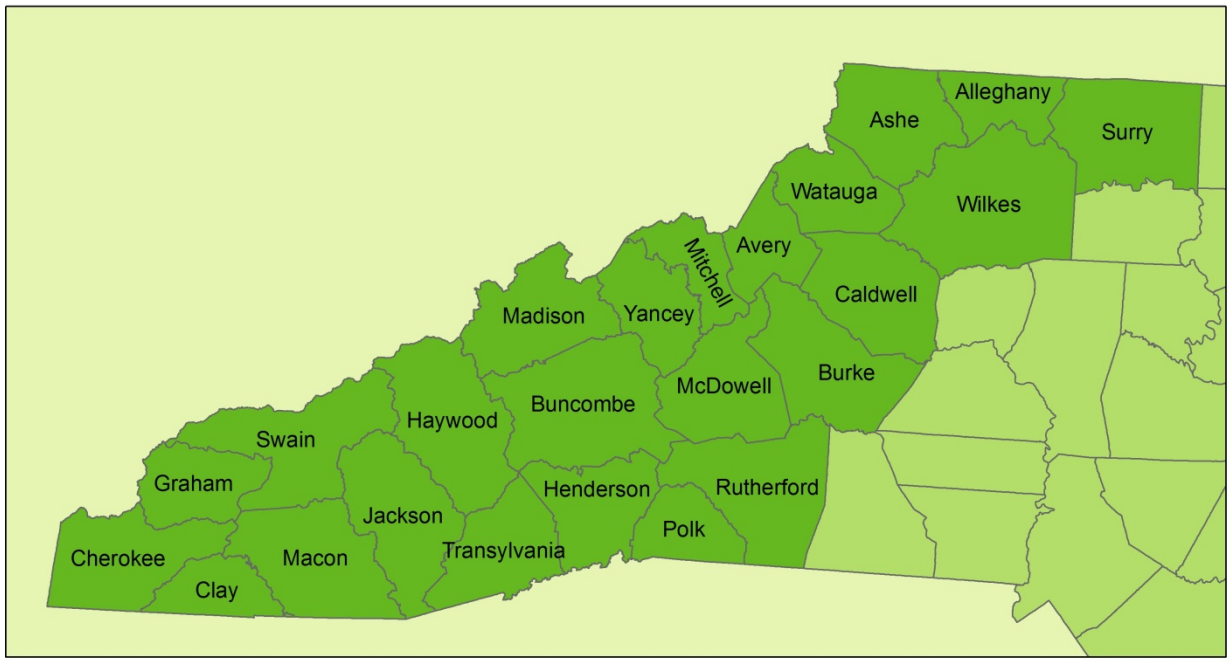

Figure 3-2. Western North Carolina Counties Designated by the North Carolina WRC for this Study

3.3 Study Caveats

Although RTI considers this analysis to be technically sound, circumstances such as data and model limitations make it important to identify certain caveats associated with this study (noted in italics).

The population projections for the currently occupied elk area assumed there was no major change in elk demographic parameters over the 25-year time span of the model projection.

It is not feasible to vary elk demographics over time beyond the ability of the biological model used (RISKMAN) to incorporate variation. Therefore, we are limited to the assumption that there is no major change in demographics either positively or negatively. This type of limitation is always an issue in wildlife population viability analyses. It is listed as a caveat because of the sensitivity of these projections to slight changes in adult female elk survival. If there were a slow consistent change over time of these demographics, the modeling results could be different.

Any shift in the number of animals depredated concurrent with the time span of the modeled projections would be considered harvesting.

Because extremely limited depredation (fewer than three per year) was included in the original elk demographics, any major shift in the number of animals routinely being removed via depredation permit would need to be accounted for in the population demographics. Accounting for this type of change is necessary because the survival rate used in this study is essentially survival without incorporating any major depredation. In terms of population modeling, depredation permits would function similarly to harvesting. Therefore, this caveat is noted to ensure that depredation is included in the accounting of any future harvesting. If depredation

permits were not included even though they were being issued, the effective harvesting impacts would be significantly magnified.

The elk population projection includes no immigration. We know that immigration or slow population spread is happening from GRSM.

Currently, RISKMAN does not incorporate any immigration or emigration. Therefore, the populations are modeled as stand-alone herds. In this study, it may be a conservative method of population viability analysis. Given that we know elk are moving in and around GRSM and biologists are documenting the slow increase in elk outside GRSM, this modeling limitation should be considered a caveat. From this perspective, model results into the future may be conservative estimates for areas near the existing elk herd.

Data on negative impacts of elk are too limited to provide reliable statistical patterns.

Projections of negative impacts of elk (e.g., vehicle accidents, fence damage) are based on only 3 years of data, with only a few incidents of each type reported per year. Patterns of negative impacts during those 3 years may not accurately reflect future frequencies of incidents relative to herd size. However, the data are the best information available on the number and type of negative impacts likely to occur.

Projections of future wildlife-viewing visitations reflect the impact of elk on visitation in the Cataloochee area of GRSM; this visitation pattern in the study areas may not be the same.

Wildlife-viewing tourism to GRSM may not be comparable to wildlife-viewing in state parks or national forests (the areas adjacent to the five study areas). The pattern shown in GRSM (i.e., a significant increase immediately after the introduction of the elk followed by no change from this higher level as the elk herd expanded) was used to simulate changes in wildlife tourism in the five study areas; it is unknown how similar wildlife tourism in state parks or national forests is to wildlife tourism in national parks.

Dollar values assigned to positive and negative impacts may not be representative.

Data used to assign dollar values to various types of positive and negative impacts are frequently based on a single source of information. Although the dollar values used are reasonable, they may not represent the experience of individuals having positive or negative elk impacts.

SECTION 4
ANALYSIS OF WRC'S HUMAN DIMENSION SURVEY AND SUPPLEMENTAL DATA COLLECTION

The presence of elk in western North Carolina has the potential to generate both positive and negative impacts for the human population. A first step in understanding the type and magnitude of these impacts is to review data that are available on human-elk interactions in that region of the state. Data sources include results of the Human Dimension Survey (a survey conducted by the WRC of landowners), documented complaint calls from residents near the elk herd, and semistructured interviews conducted by RTI with stakeholders in the area.

4.1 Review of WRC's Human Dimension Survey

The WRC surveyed landowners in 2014 to understand their attitudes toward and experiences with elk. The study's purposes were to describe

- western North Carolina landowners' experiences with elk,
- the general level of support for and opposition to elk in western North Carolina,
- opinions about possible outcomes of elk living in western North Carolina,
- opinions about possible elk management actions, and
- the likelihood of people participating in elk viewing and elk hunting.

Findings from the WRC's Human Dimension Survey provided valuable context for RTI's study, including the human dynamics of elk management. In this section, RTI summarizes the survey design and findings and highlights the most valuable contextual points gleaned from the survey.

An overall sample of 17,280 landowners was stratified by county and parcel size into nine total strata. The geographical strata included

- Haywood County;
- Jackson, Madison, and Swain Counties; and
- all remaining western North Carolina counties (Alleghany, Ashe, Avery, Buncombe, Caldwell, Cherokee, Clay, Graham, Henderson, Mitchell, McDowell, Polk, Rutherford, Surry, Transylvania, Watauga, Wilkes, and Yancey).

Parcel size strata included parcels that were 0 to 2 acres, 2 to 15 acres, and greater than 15 acres.

A sample of 1,920 landowners was selected from eight of the nine strata; in Haywood County, all 1,858 landowners with more than 15 acres were included. The sample thus totaled 17,218 landowners, who received a mail survey. Nonrespondents received follow-up mailings; ultimately, the survey response rate was 40.5% overall.

The landowners were asked about their knowledge of elk and whether they had seen or heard elk on their largest tract of land. In addition, they were asked whether they support or oppose wild, free-roaming elk within 5 miles of their largest tract and whether they had experienced any property damage due to elk.

Landowners were asked to rate on a 5-point scale how positive or negative they considered 10 possible outcomes of elk living in western North Carolina. Outcomes viewed positively included elk bringing economic benefits through tourism or hunting, people being able to view elk, and elk returning to part of their historical range. Outcomes viewed negatively included increased automobile-wildlife accidents and the risk of transmitting disease to other wildlife or livestock. RTI considered these impact categories when identifying the types of costs and benefits to be quantified in this study.

The Human Dimension Survey found that the majority of landowners support wild, free-ranging elk. In general, more landowners in Haywood County have experience with elk than landowners in other counties. Possibly as a result of having experienced negative impacts due to elk, more landowners in Haywood County expressed negative opinions of elk. For example, although the majority of landowners in Haywood County whose largest parcels exceed 15 acres "support" or "strongly support" elk within 5 miles of their property (58%), a larger share of this group of Haywood County landowners (25%) opposes or strongly opposes elk within 5 miles of their largest parcel compared with large landowners elsewhere in western North Carolina (14% or 15%). For Haywood County landowners whose largest parcels exceed 15 acres and who had experienced elk-related damage on their largest tract, more than 60% opposed or strongly opposed the presence of elk on private land in western North Carolina. The WRC concluded that these findings suggest that as the elk population expands and more landowners have experience with elk, support for wild, free-ranging elk may decline and opposition may increase.

The results of the Human Dimension Survey formed the foundation for developing the analysis of costs, benefits, and economic impacts associated with elk. RTI based its identification of key issues and types of interactions to be analyzed on the types of positive and negative interactions with elk identified by the survey and on respondents' evaluations of how strongly they support or oppose elk in certain contexts or how positively or negatively they rate certain impacts.

For example, landowners expressed support for returning elk to their historical range, having the opportunity to view elk, and having elk-related tourism. Conversely, landowners expressed concerns about automobile collisions, potential for disease transmission, and property damage. A substantial share of landowners whose largest property exceeds 15 acres views as acceptable or very acceptable allowing landowners to kill problem elk for problems ranging from bugling to leaving footprints to disturbing livestock to destroying crops and fencing. These findings pinpoint types of elk-human interactions that western North Carolina landowners viewed positively and negatively, which informed our selection of impacts to quantify and value. Further, the findings suggest that communicating to landowners that elk are being returned to their historical range has value and governmental and nongovernmental organizations may need to collaborate on such mitigating measures as improved fencing, aversive conditioning, and habitat management in addition to specifying when lethal control of problem elk would be permitted.

4.2 Complaints Documented by the WRC

In addition to examining the findings of the Human Dimension Survey, RTI obtained WRC complaint data that were compiled from November 2012 to August 2014. These complaints concerned incidents in which elk damaged residents' property. These incidents

occurred almost entirely in Haywood County near the Cataloochee area of GRSM. ***Table 4-1*** shows that the WRC received fewer than one dozen complaints per year.

This list of complaints provides insight into the types of adverse human impacts that may be associated with the presence of wild, free-ranging elk that spend at least part of their time outside of public lands such as GRSM. The WRC estimates that about 70 elk spend at least part of their time outside GRSM and are responsible for the damages listed in ***Table 4-1***.

Table 4-1. 2012–2014 Elk-Related Complaints Received by the North Carolina WRC

Year	Location	Damage Description
2012	Mt. Sterling	Hay loss and garden loss (1/4 ac)
2012	Suttontown	Tearing fence down, eating hay
2012	White Oak Rd	Killed dogs
2012	Mt. Sterling	Elk chasing wife
2012	Cove Creek	Stomped on potatoes, tearing up bank
2012	Cove Creek	Eating oak saplings
2012	White Oak	Hay loss and tearing fence
2012	Maggie Valley	Hoof prints in yard
2012	Mt. Sterling	Wanted to know rights about self-defense against elk
2012	Maggie Valley	Elk trampling yard (turned out to be feral hogs)
2013	Maggie Valley	Elk #67 stomped and killed dog
2013	Maggie Valley	Elk eating corn
2013	Maggie Valley	Elk killed poodle
2013	Waynesville	Elk scaring cattle
2013	Waynesville	Elk eating garden, tearing up bank
2013	Waynesville	Elk scaring cattle
2013	Waynesville	Elk eating crops
2013	Maggie Valley	Elk stomped dog
2013	Allens Creek	Elk in yard, concerned about livestock
2013	Mt. Sterling	Elk scaring horses
2013	Suttontown	Fence torn down on private property, which allowed cattle to escape
2014	Maggie Valley	Elk tearing up garden
2014	Maggie Valley	Elk eating corn
2014	Waynesville	Elk tearing up cemetery
2014	Maggie Valley	Elk eating corn
2014	Suttontown	Elk tearing up fence and cemetery
2014	Mt. Sterling	Elk charging mother and destroying orchard
2014	Mt. Sterling	Elk damaging garden

4.3 Stakeholder Interviews

To learn more about stakeholder experiences with and attitudes toward elk, RTI conducted a series of semistructured telephone interviews with nine stakeholders in western North Carolina. The WRC staff suggested individuals to contact. These interviews were not intended to generalize the opinions of an entire stakeholder group but rather to gain an introductory understanding of varied local residents' perspectives about elk. One person was contacted per stakeholder group. Each discussion was semistructured, based on a unique set of interview questions developed by RTI. These interviews were flexible to allow follow-up on subjects not covered by the interview guide if needed. (**Appendix A** contains the interview guides used.) In addition to the interviews completed, RTI reached out to several other stakeholders but received no response.

4.3.1 Farmer

RTI staff spoke with a farmer from Haywood County who farms full time; farming is a secondary source of income. This farmer has a small herd of about 16 to 17 elk that have been living on the property for several years. The elk have been a constant problem for him and have affected him economically. The elk eat the vegetables in his garden, as well as the hay grown for his livestock. The harvested hay's quality and quantity have decreased because the elk eat the best-quality hay before the farmer can harvest it. The farmer also reported that elk destroyed 90% of a newly planted apple orchard within two nights of planting by raking their antlers on the bark, which ultimately killed the trees.

The elk also have a significant effect on the farmer's livestock. Their presence on the farm upsets the animals. In one instance, a young cow became so startled that it ran through a barbed wire fence, was injured, and later had to be put down. The farmer said elk run through and destroy livestock fencing regularly. This makes it almost impossible to make improvements to the farm because the farmer constantly has to use his time and resources to repair elk damages.

Despite all the problems the elk cause, the farmer still seems to maintain a positive view about the animals. He realizes that the elk can provide benefits to the surrounding community, and he enjoys the animals when they are not damaging his property. The farmer would like the people who benefit from the elk, or the people responsible for their reintroduction, to provide some form of compensation to those who are bearing the negative outcomes.

4.3.2 Local Government Official

RTI spoke with the mayor of Maggie Valley, a small town in Haywood County with approximately 1,200 full-time residents and a sizeable number of people who own vacation homes in the area. The area is home to elk that wandered out of GRSM. Residents see the elk frequently.

The mayor acknowledged that many people enjoy having the elk in the valley, but they are also a nuisance to certain landowners. At this time, no specific town ordinances or policies are directed toward improving the interactions between the residents and the elk, but the mayor did mention several ideas that have been proposed. One possible measure is providing more educational opportunities to help the residents learn about elk. A primary concern that he voiced was that elk are perceived differently than other wildlife in the area (e.g., deer, bear). Because elk were reintroduced into North Carolina, people believe that the government is responsible for

the animals and reparations for any damage they cause. Educating the public about the history of elk in North Carolina may help change their opinions.

Overall, the mayor believes that having elk in the valley provides a positive impact to the community. Although some local farmers have complained, the number of complaints has been relatively low. He would like to see the benefits maximized by providing the citizens with as many opportunities as possible to view the animals safely.

4.3.3 Hunter

RTI spoke to a Haywood County resident who hunts large game, primarily black bear. He tends to hunt alone and on most days of the hunting season. When asked if he would be interested in hunting elk in North Carolina, he was tentative.

RTI also asked the hunter for his opinion about hunting elk and the positive and/or negative impacts of a regulated hunting season. He said he supports people's right to shoot the elk on their own land if they are causing a problem, but he thinks allowing hunting would cause more harm than good. He said the elk are a fixture of the community that people enjoy viewing, and a large group of people are against hunting. He believes they would be very unhappy if elk hunting were allowed. He said that if the population were large enough to successfully maintain a hunting season, a herd that large could present a number of other problems.

4.3.4 Local Tourism Business

RTI spoke to an employee of a Maggie Valley ranch that offers lodging, dining, and horseback riding to guests. He described the tourism industry in Maggie Valley as being a large part of the economy, and although most people do not visit the area specifically to view wildlife, it is an added bonus that people enjoy while in the area.

This ranch does not have any elk on their property, so they have not had a noticeable impact, in terms of number of guests, as a result of the elk herd. Some people have asked about the elk while staying there and seemed to hope to see them at this ranch. Even though people are not coming to the ranch to view elk specifically, it appears that they know elk inhabit the area, which could potentially increase tourism.

4.3.5 Agricultural Interest Group

RTI staff spoke to an employee of the North Carolina Farm Bureau who represents 12 western counties. The Bureau advocates to state and federal governments on behalf of all types of production agriculture and livestock producers. The group's official position on the elk is to not introduce any more into the area until a comprehensive study of the impacts on agriculture is performed. The Farm Bureau recommends that when elk become a threat to farm crops, livestock, equine, and fencing, farmers should be able to eliminate the offending elk as they so desire. Furthermore, Farm Bureau recommends farmers should receive compensation for damages from the National Park Service and Rocky Mountain Elk Foundation (since these entities) introduced elk into North Carolina.

The Farm Bureau representative said that the majority of its members favor having the elk in the area as long as the herd is managed and adequate food supplies are maintained on public lands. Members also would like to have the right to kill any animals that cause problems on their property. This interviewee's personal opinion was that the elk are good for the overall

regional economy but not for the farmers. People who are hurt economically by elk should be compensated in some way for the hardships they experience.

SECTION 5
STUDY AREAS SELECTION—ANALYSIS AND INTEGRATION OF HABITAT SUITABILITY, EXISTING POPULATION DATA, AND HUMAN LAND USE DATA

5.1 Five Study Areas Selected

Following affirmation from a WRC wildlife biologist,[2] RTI chose the following five areas in the 24-county western North Carolina region for this study:

- One area where elk currently exist (i.e., one contiguous area within portions of Swain, Haywood, Jackson, and Madison Counties). We refer to this area in the report as the Haywood study area.
- Two areas adjacent to the current range (where elk exist) and where elk will likely expand soon (two contiguous areas within Haywood, Jackson, Madison, and Buncombe Counties). We refer to these two areas as 1) the Jackson study area and 2) the Madison study area.
- Two elk-uninhabited areas that have adequate Habitat Suitability Index scores and a considerable amount of potentially suitable land use area, as well as the best available socioeconomic circumstances to support elk. These two areas are 1) one contiguous area in Rutherford County and 2) one contiguous area covering portions of Alleghany and Ashe Counties).

5.2 Approach to Selecting Five Study Areas

RTI approached its analysis of western North Carolina by selecting several smaller study areas within the 24-county region. Our objectives were to model elk population growth and predict socioeconomic impacts for 25-year and 50-year scenarios with and without hunting. Two fundamental considerations were applied for selecting the study areas: 1) habitat/land suitability and 2) the impact of human influences, such as road infrastructure and human population density. RTI discussed strategies with WRC biologists for selecting potential study areas, and it was agreed that one subset of the study areas would represent lands outside GRSM that elk currently occupy and another subset of study areas would represent areas currently unoccupied by elk.

First, RTI reviewed North Carolina State University's (NCSU's) 2014 Habitat Suitability Index data in tandem with our geographic information system (GIS) mapping of land use, human population, and infrastructure (e.g., roadways). The NCSU study examined the suitability of habitats throughout North Carolina and ranked areas of the state using an Index value (x) that ranged from 0 (very poor habitat) to 1 (highly suitable habitat). RTI's review of NCSU's Index results found that currently unoccupied western North Carolina counties were generally lower-Indexed elk habitat (NCSU Index value of 0.29, standard deviation = 0.21). (The Index values of currently occupied areas were Madison County, 0.38; Haywood County, 0.23; and Jackson County, 0.11.) RTI considered the methodology and assumptions used to create the original NCSU Index and discussed those assumptions and Index results with WRC biologists. For example, the Index relied noticeably on hay/pasture and scrub-shrub to predict quality habitat. It is known that elk depend on grasses and forbs and are typically considered mixed feeders and

[2] Teleconference with Brad Howard, WRC (8/26/14).

will vary from eating a grass-dominated diet to sometimes eating browse-dominated diets (Christianson and Creel, 2009). Grasslands in North Carolina are primarily in the form of private, small holdings of hay/pastureland. (Land use data obtained from the WRC for this study indicated that the western North Carolina region was 76% forestland, 18% hay/pasture, 1% scrub/shrub, and 5% developed land.) Although elk may use hay/pasture, hay/pasture can be subject to human management/change and potentially result in human conflict with elk. Thus, although hay/pastureland may have the potential to increase the biological carrying capacity of elk, hay/pasture may have the opposite effect on elk's social carrying capacity, through actions like forage consumption, fencing damage, and competition with cattle. Scrub/shrub comprises about 1% of land cover in the western North Carolina study area and is known to quickly succeed into forest. Although elk readily use this scrub/shrub land cover as refuge and for its food resources, RTI factored the small presence of shrub/scrub in western North Carolina and successional rate into the study area selection process. Given these conditions, we concluded that it was appropriate to select the top percentage values from the Index to identify potential unoccupied elk areas for analysis. From the top 40% of Index values (Index values where x was greater than 0.60), we identified several potential unoccupied areas.

Second, after considering the NCSU Habitat Suitability Index data, we evaluated RTI-compiled data on human influence in western North Carolina, including those areas currently unoccupied by elk. This section summarizes the socioeconomic data used in selecting study areas; however, Appendix B provides greater detail on RTI's socioeconomic evaluation of potential study areas. Based on the social and economic constraints and benefits identified in the WRC Human Dimension Survey, as well as supplemental data collection, RTI developed geospatial layers for the 24 western North Carolina counties that characterized where elk are most likely to be socially, economically, and politically sustainable. This exercise was independent of the NCSU Habitat Suitability Index study. However, because the Index considered human-defined or human-influenced land uses in ranking habitat, there was considerable overlap in the characteristics considered, and the findings are largely consistent. Informed by the WRC Human Dimension Survey results, the geospatial layers developed by RTI supported identifying where the presence of elk is likely to cause the least conflict. For example, based on the conflicts that have emerged with nuisance elk, we would expect that areas more reliant on agriculture and with greater household density are less likely to welcome the establishment of elk herds nearby, which is consistent with the NCSU Index study.

RTI examined the population density, the linear miles of roads in western North Carolina counties, and land uses and secondary roads ***(Figure 5-1)***. Commercial, industrial, and residential land uses were assumed to be unacceptable habitats for elk. Acceptable land uses included deciduous and evergreen forests, mixed forest, emergent herbaceous wetlands, herbaceous, shrub/scrub, and woody wetland classifications. RTI prepared a map showing agricultural land uses (hay/pasture and row crops) in yellow, land uses thought to be acceptable for elk in green, and unacceptable urban land uses in shades of pink and red.

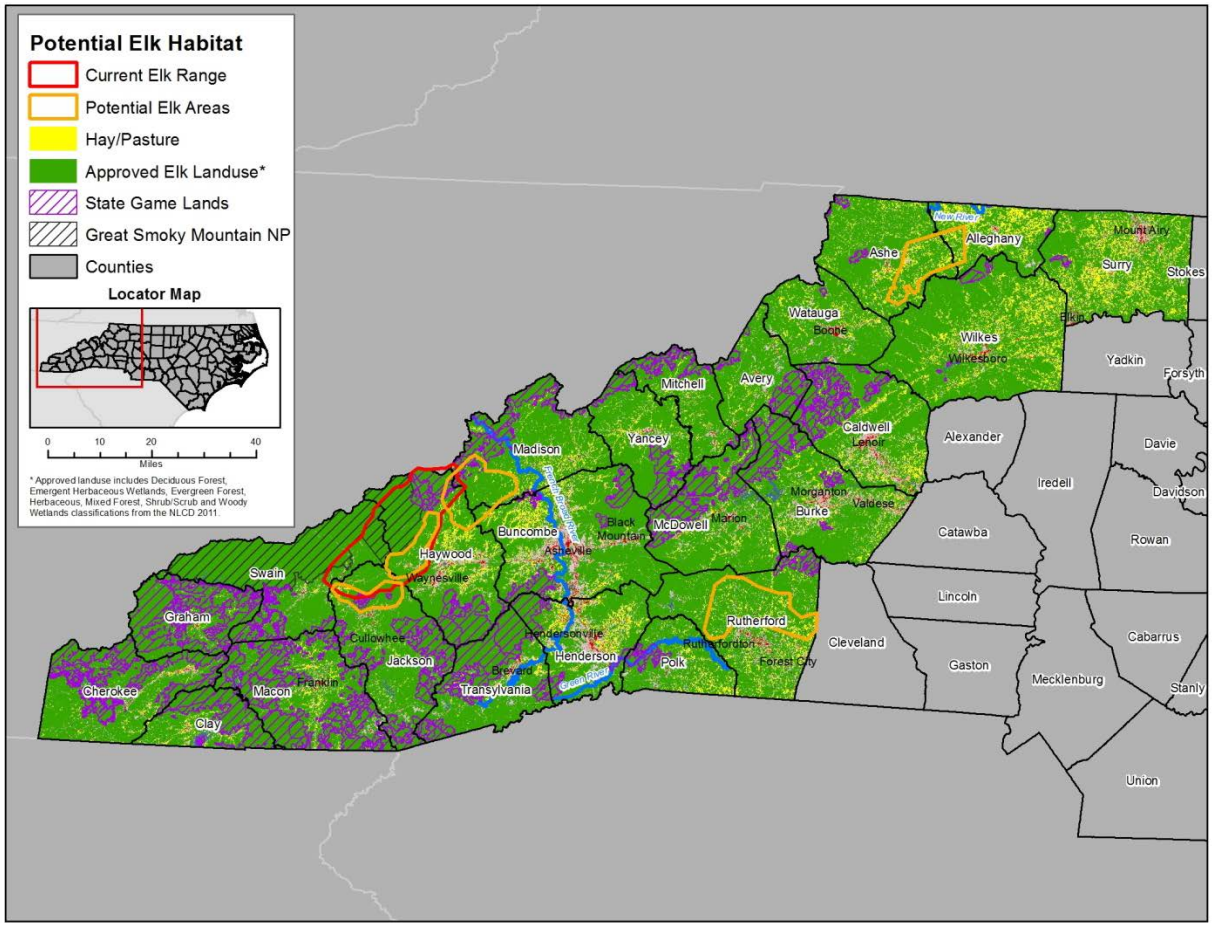

Figure 5-1. Five Elk Study Areas in Relation to Land Use, North Carolina Game Lands, and the Great Smoky Mountains National Park

Finally, following discussion with WRC' biologists about RTI's assessment of the NCSU Habitat Suitability Index results and our socioeconomic-based evaluation of the 24 western North Carolina counties, it was agreed the study would proceed with the selection of up to five areas. There was consensus that the areas consist of the following:

- one to three areas where elk are currently living in western North Carolina (e.g., Haywood County [WRC provided elk "collar" global positioning system data for locations]) and
- one to three areas identified from NCSU's Habitat Suitability Index data. RTI's analysis of the Habitat Suitability Index data identified the following candidates as workable: a cross section of Alleghany and Ashe Counties, Avery County, Rutherford County and a cross section of Wilkes and Surry Counties.

Of the unoccupied areas identified as having relatively high scores in the Habitat Suitability Index, RTI selected Rutherford County and the cross-section of Alleghany and Ashe Counties. RTI selected the Alleghany-Ashe area over the Wilkes-Surry area because the Alleghany-Ashe area has lower population density and a lower percentage of conflicting land use (e.g., both hay/pasture and residential land use). Both areas are within the historical range of elk.

Thus, following affirmation from a WRC representative,[3] the five areas chosen for further study were

- the current range where elk exist (one contiguous area within portions of Swain, Haywood, Jackson, and Madison Counties—referred to as the Haywood study area);
- two areas adjacent to the current range (where elk exist) and where elk will likely expand soon (two contiguous areas within Haywood, Jackson, Madison, and Buncombe Counties—referred to as the Jackson and Madison study areas); and
- two elk-uninhabited areas that have adequate Habitat Suitability Index scores and a considerable amount of potentially suitable land use area, as well as the best available socioeconomic circumstances to support elk. These two areas are 1) one contiguous area in Rutherford County—referred to as Rutherford study area—and 2) one contiguous area covering portions of Alleghany and Ashe Counties— referred to as Alleghany-Ashe study area.

Overlaying the Habitat Suitability Index's land uses, we note that all five of the areas selected include both agricultural and acceptable land uses, with little land area comprising unacceptable land uses or roads. The elk may find the agricultural land uses desirable forage, but their use of those areas will result in conflicts with landowners. The acceptable land uses may provide lower quality forage for the elk than agricultural land, but their use of those areas is less likely to result in conflicts.

[3] Teleconference with Brad Howard, WRC (8/26/14).

SECTION 6
ESTIMATION OF ELK POPULATION GROWTH AND SIMULATIONS OF HUNTING REGIME IMPACTS

6.1 General Objectives

The general objectives of this portion of the analysis were as follows:

1. Identify locations in western North Carolina to model elk population potential and growth.
2. Develop multiple elk population-level scenarios and potential harvest rate scenarios.
3. Model population growth and, when applicable, harvesting for each identified elk area.

6.2 Findings

- The Haywood study area's elk population is predicted to reach its carrying capacity in approximately 30 years.
- The two smaller populations in the Jackson and Madison study areas have much slower growth, but extinction probabilities remain small at less than 5% in 25 years.
- Modeling results for both the Alleghany-Ashe and Rutherford study areas indicated that harvest scenarios for a 2014 starting population of 55 elk/study area were unsustainable (i.e., populations were declining) for 25-year (Yr 2039) and 50-year (Yr 2064) elk population growth projections. (A larger population would result in the same pattern but at a slower pace.)

6.3 Overview of Analysis

As described in **Section 5**, we selected five study areas: three study areas occupied by elk (Haywood, Jackson, and Madison) and two study areas unoccupied by elk (Alleghany-Ashe and Rutherford). ***Figure 6-1*** presents these five study areas in the context of the Habitat Suitability Index findings.

To predict potential elk populations in the five study areas and determine the suitability of hunting, we estimated the carrying capacity of each area and determined existing elk population structures. We acquired the most recent demographic data for the western North Carolina elk herd, including recruitment rates (the probability of an elk calf surviving into a specific age class) and survival rates. (Recruitment data [unpublished] were from 2001 to 2006 for elk outside the GRSM where approximately eight females were tracked in White Oak, Maggie Valley, and Cherokee. Data were relatively in line with the GRSM data, although some elk were removed because of conflicts, which lowered female recruitment slightly.) Potential hunting or harvesting scenarios, including a no-hunt scenario, were then developed and modeled.

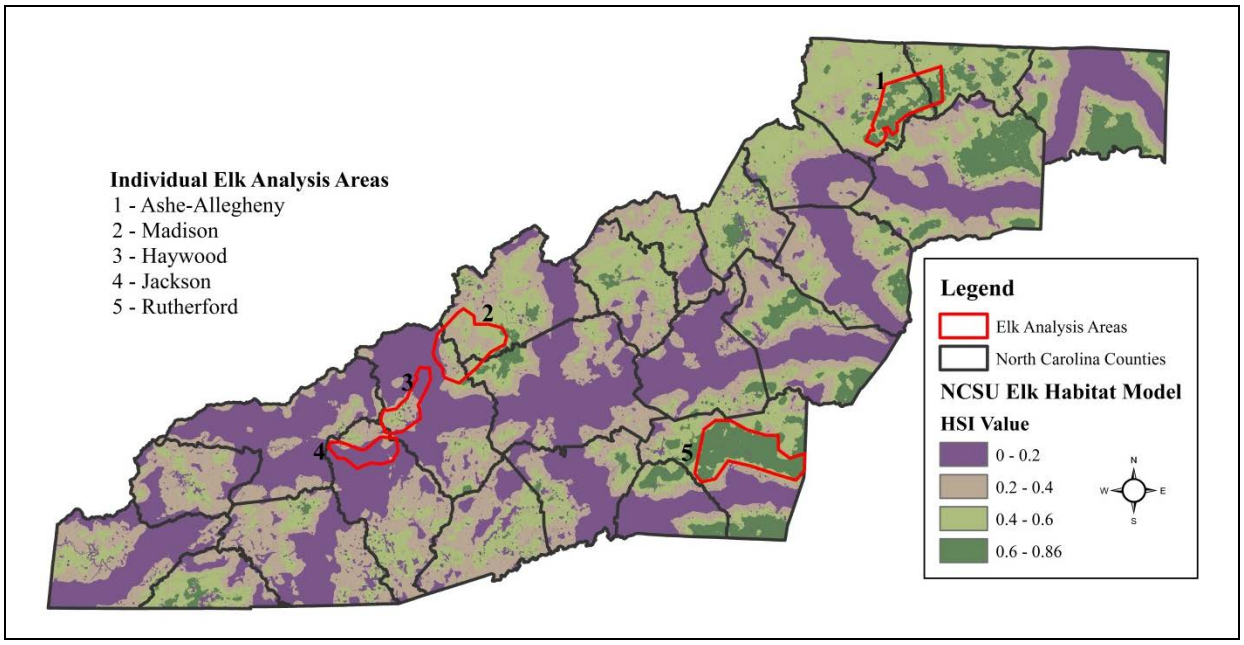

Figure 6-1. North Carolina State Habitat Suitability Index with Five Areas Identified (Red) for Elk Evaluation

6.4 Carrying Capacity

"Carrying capacity" is a biological term that refers to the number of animals a habitat can support without degradation to the species or the habitat. It is generally hard to establish for most wildlife species. The most accurate way to establish carrying capacity for elk is to conduct actual forage and habitat analyses and investigate individual health and elk demographic trends. For this analysis, we used the average documented elk density for Kentucky (2 elk/km^2 [~5 elk/mi^2]), in lieu of carrying capacity because of a lack of forage and health data (Dahl, 2008). The Kentucky density may be quite liberal given the differences in habitat and elk population size, but it provided a starting point for evaluation. We analyzed the number of km^2 of land cover types (all forests, shrub-scrub, grasses) in the five study areas and used that total area to calculate a maximum elk carrying capacity for each location (see ***Table 6-1***).

Table 6-1. Estimated Maximum Elk Carrying Capacities for Study Areas Based Only on the Area (km^2) of Land Cover Types within an Elk Area of Interest

Study Area (within named North Carolina County)	Maximum Carrying Capacity for Elk (at 2 elk/km^2)
Jackson	221
Haywood	226
Madison	531
Rutherford	556
Alleghany-Ashe	335

6.5 Demographic Parameters

Demographic parameters are quantifiable metrics, usually a statistical rate or percentage, that characterizes a certain population at a given time. For this analysis, we used parameter estimates calculated from a representative group of elk within the elk herd in western North Carolina. We obtained this information by contacting GRSM elk biologist Joe Yarkovich and research ecologist Dr. Joseph Clark with the U.S. Geological Survey's Southern Appalachian Research Branch, located at the University of Tennessee (Yarkovich, 2014; Clark, 2014). Based on their prior work, we used the demographic data from their 2013 report (Yarkovich and Clark, 2013) on the elk population in GRSM (see Table 3a in the report). The data were collected via weekly radio tracking of elk (greater than 67 adult elk and greater than 42 calves) throughout western North Carolina from 2006 to 2012. These estimates include calf sex ratio, elk survival, and calf recruitment.

"Recruitment" is the likelihood of an animal born at one point in time surviving into successive age classes, thereby potentially contributing to the population. If calf survival is low, recruitment into a subadult age class will be low. If calf survival is high but the subadult survival of those calves is low, recruitment into the subadult age class will be high, but recruitment into the adult age class would be low. In this way, recruitment by age class or cohort incorporates both calf survival and reproductive potential.

6.6 Elk Population Modeling Using RISKMAN

To simulate the potential growth and optional harvest scenarios in the elk populations, we used the computer simulation system RISKMAN (McLoughlin, 2004; Taylor et al., 2006). RISKMAN is a decision support tool for harvested and unharvested wild populations. It uses a Monte Carlo approach to estimate the uncertainty of population growth patterns based on estimates of the existing population and its demographic parameters.

RISKMAN: Risk Analysis for Harvested Populations of Age-Structured, Birth-Pulse Species

Management recommendations, particularly harvest policies, are often based on life table models of population dynamics. Estimates of population number, sex and age distribution, survival, recruitment, and harvest (if any) may be used in age-structured, birth-pulse simulation models to estimate population trend, status, or number at some future time and to explore the demographic consequences of a range of management options. Birth pulse models include both standard life table models that mimic the reproductive biology of species that reproduce annually (e.g. ungulates, wolves, and seals), and multi-annual models for species that reproduce in 2- or 3-year intervals (e.g. bears, elephants, and walrus).

Models may allow both exponential growth and density-dependent feedback mechanisms. Harvest can be modeled in a variety of ways ranging from detailed simulations that include the age-specific vulnerability and selectivity of the kill to simple apportionment of the kill according to the relative abundance of the population sex and age types. RISKMAN (RISK MANagement), a Windows© compatible program, was developed for the full range of options described above.

Deterministic simulations are difficult to interpret because all results are based on very uncertain estimates of input parameters, and cannot be objectively distinguished from results based on relatively precise estimates of input parameters. Similarly, simulation results from small populations are less certain than simulations for large populations. RISKMAN provides a stochastic option that uses the variance of input parameters and the structure identified by the simulation options that are selected. Monte Carlo techniques are applied to generate a distribution of results, and that distribution is used to estimate the variance of summary parameters (e.g. number at time, population growth rate, and proportion of runs that result in a decline to a user set value). RISKMAN uses the correct distributions of the population and rate variance estimates to provide accurate estimates of the uncertainty of simulation results. Input parameters may co-vary or be independent; RISKMAN allows the user to set the correlation to one or zero to bound the possibilities.

http://riskman.nrdpfc.ca/riskman2.htm

For this elk analysis, each RISKMAN model scenario was replicated 1,500 times to estimate metrics at 25 years (Yr 2039) and 50 years (Yr 2064). To incorporate uncertainty, each replicate applies variability to the input parameters.

6.7 Elk Population Modeling Scenarios

6.7.1 Elk Population Assumptions

Dr. Jennifer Murrow, consulting wildlife biologist to RTI, contacted area biologists with the WRC and GRSM to ascertain the total existing elk population size, the age, and the sex ratio of all elk and the same information for elk specifically in areas outside of GRSM. The estimates obtained (see ***Table 6-2***) are the best information available, which is based on radio-collared elk and elk observations. These estimates are for all of the elk in western North Carolina, including elk in GRSM, and stand-alone elk estimates of the three occupied elk study areas outside of GRSM (see ***Figure 6-1***). Because RISKMAN requires a starting population, we used both the smallest (n = 5 and n = 8) and largest (n = 55) stand-alone elk estimates to model the two unoccupied areas (i.e., Alleghany-Ashe and Rutherford study areas). We shared these values with WRC biologists and selected those starting population sizes, assuming the small population would represent a hypothetical “natural colonization” and the large population would represent a hypothetical “reintroduction.”

Table 6-2. Distribution of the Sex and Age of Elk Currently in Western North Carolina as of June 2014

Area	Male Elk Age Classes (yr)				Female Elk Age Classes (yr)				Total
	0	1	2–9	10+	0	1	2–9	10+	
All western North Carolina[a]	17	18	44	8	19	11	46	23	186
Jackson study area	0	0	1	0	0	0	4	0	5
Haywood study area	0	6	16	4	0	4	17	8	55
Madison study area	0	1	2	0	0	0	5	0	8

Sources: Yarkovich, 2014; Howard, 2014.
[a] Includes elk in GRSM.

6.7.2 Elk Demographic Assumptions

To run the population viability models in the RISKMAN model, we needed the most accurate elk demographic data along with each metric's standard error or deviation. We used the demographic data from the GRSM 2013 elk report (Yarkovich and Clark, 2013), which had parameter estimates calculated from a group of representative elk in the GRSM from 2006 to 2012 (***Table 6-3a***).

Table 6-3a. Modeling Parameters and Values Assigned for Occupied Elk Areas in Western North Carolina Based on Averages from 2006 to 2012

RISKMAN Inputs	2006–2012	Std. Error
Calf sex ratio	0.595	0.057
Calf recruitment 2 years of age (yoa)	0.031	0.042
Calf recruitment 3–9 yoa	0.226	0.103
Calf recruitment ≥ 10 yoa	0.668	0.083
Calf survival	1.000[a]	0.000
Male yearling survival	0.852	0.051
Female yearling survival	0.870	0.043
Male adult survival 2–9 yoa	0.935	0.018
Female adult survival 2–9 yoa	0.943	0.015
Male adult survival ≥ 10 yoa	0.888	0.036
Female adult survival ≥ 10 yoa	0.901	0.028

Source: Yarkovich and Clark, 2013.
[a] For purposes of modeling, calf survival is set to 100%, but recruitment values (i.e., survival to next age level) incorporate calf mortality and female reproduction.

Table 6-3a's demographic data were used to calculate population projections for the three areas where elk currently exist (i.e., Haywood, Madison, and Jackson Counties study areas) because those demographics were calculated with at least a few representative elk moving in and

out of the herd in those counties. Furthermore, the close proximity to extremely low human and road density, large blocks of contiguous forest (forested refugia), and the primary elk herd in GRSM made the assumption that the demographics would hold true more reasonable. However, while we recognize that the boundaries of the elk areas for analysis are arbitrary, a general evaluation of the unoccupied study areas reflected a potentially higher human population, higher concentration of agriculture, less contiguous forested refugia cover, and higher interspersion of roads. Therefore, we did not think it was appropriate to apply those same demographic rates to the study areas currently unoccupied by elk (Alleghany-Ashe and Rutherford). Based primarily on the road density, forested refugia, and amount and type of agriculture in the two study areas currently unoccupied by elk, we assigned changes in the demographic parameters for the currently unoccupied areas (see ***Table 6-3b***).

Table 6-3b. Modeling Parameters Used for Two Unoccupied Study Areas in Western North Carolina Based on Averages from 2006 to 2012

RISKMAN Inputs	2006–2012 Alleghany-Ashe Study Area	2006–2012 Rutherford Study Area	Std. Error
Calf sex ratio	0.595	0.595	0.057
Calf recruitment 2 years of age (yoa)	0.031	0.031	0.042
Calf recruitment 3–9 yoa	0.226	0.126	0.103
Calf recruitment ≥ 10 yoa	0.668	0.568	0.083
Calf survival	1.000	1.000	0.000
Male yearling survival	0.752	0.752	0.051
Female yearling survival	0.770	0.770	0.043
Male adult survival 2–9 yoa	0.835	0.835	0.018
Female adult survival 2–9 yoa	0.843	0.843	0.015
Male adult survival ≥ 10 yoa	0.788	0.788	0.036
Female adult survival ≥ 10 yoa	0.801	0.801	0.028

Source: Yarkovich and Clark, 2013.

Given the high likelihood of human-elk conflict because of the large amount of hay and pasture, a strong presence of Christmas tree farms, high road density, but the existence of forested refugia (protected lands to avoid stressors such as humans) such as the New River State Park and surrounding forest in the Alleghany-Ashe study area, we reduced all elk survival by 10% (see ***Table 6-3b*** and ***6-4***). This reduction is based on the assumption that there would likely be more depredation or poaching events in this area and, because of the much higher deer densities, potentially more elk might be infected by meningeal worm (*Parelaphostrongylus tenuis*). Rutherford County also had high road density, higher deer densities, and a large human influence, but development and urban sprawl may have led to its lack of refugia in the form of contiguous blocks of forest, so we reduced all survival and recruitment by 10%. We assumed the combination of lack of contiguous blocks forested refugia (more edge) and high deer densities with potential meningeal worm in Rutherford may reduce general survival and reproductive potential. These percentage decreases were based on Dr. Murrow's best professional judgment

along with an abundant literature base that documents road, human, and cover impacts on elk demographics (Webb et al., 2011; Larkin et al., 2003; Smallidge et al., 2003; Sawyer et al., 2007; Stankowich, 2008; Hebblewhite and Merrill, 2011).

6.7.3 Harvest Scenarios

"Harvesting" or hunting elk populations can be done in numerous and different ways. Historically, when populations are small or hunting is newly implemented, most agencies use a small, limited hunt, usually referred to as a "quota" hunt. They may restrict total numbers, age or sex taken, and area hunted, for example. We investigated the initial and current elk hunts in Tennessee and Kentucky and chose to model each of the five study areas, when appropriate, based on population growth and using three different hunts at three levels of take (i.e., number of elk):

- only males harvested with a quota of 4, 6, and 10 elk per year;
- 80% males and 20% females harvested with quota of 4, 6, and 10 elk per year; and
- 50% males and 50% females harvested with a quota of 4, 6, and 10 elk per year.

To keep modeling simple, we did not increase the percentage of elk harvested over time. Furthermore, if a harvesting scenario called for harvesting of males only, the model must be run in a deterministic mode (i.e., RISKMAN input values are constant). When RISKMAN is run deterministically, no standard deviation, standard error, or probabilities are calculated. All hunting and nonhunting scenarios considered for potential modeling are shown in ***Table 6-4***.

Table 6-4. All Potential Scenarios Considered for RISKMAN Modeling

Elk-Occupied Study Areas		Jackson	Haywood	Madison	Elk-Unoccupied Study Areas	Alleghany-Ashe	Rutherford
No harvesting		✓	✓	✓	No harvesting	✓	✓
Harvesting	Only male quota of 4, 6, and 10 elk	✓	✓	✓	Only male quota of 4, 6, and 10 elk	✓	✓
	80% male quota of 4, 6, and 10 elk	✓	✓	✓	80% male quota of 4, 6, and 10 elk	✓	✓
	50% male quota of 4, 6, and 10 elk	✓	✓	✓	50% male quota of 4, 6, and 10 elk	✓	✓

6.8 Results: Elk Population Modeling

This section summarizes measurable results of nonharvesting and harvesting scenarios for 25-year (Yr 2039) projections for elk populations in the five study areas. Each area was modeled as a stand-alone population, even though there were more elk in surrounding areas. When modeling produced immediate unsustainable results, more aggressive runs or runs that had higher harvesting rates were not analyzed. Detailed modeling output is available in **Appendix C**.

6.8.1 No Harvesting

6.8.1.1 Study Areas Currently Occupied by Elk

When there was no harvesting of the elk populations at the 2012 demographic levels, all existing elk populations had slow, steady growth (see ***Table 6-5***). The Haywood study area's elk population is predicted to reach its carrying capacity in approximately 30 years. The two smaller populations in the Jackson and Madison study areas have much slower growth, but extinction probabilities remain small at less than 5% in 25 years (see **Appendix C** for full details). This is not surprising, given the small starting numbers of elk. Furthermore, RISKMAN assumes no elk immigrate into the study areas.

Table 6-5. Modeling Results for 25-Year Population Projections Assuming No Harvesting, No Immigration, and No Major Changes in Demographic Values

Study Areas	Starting Population	Growth Rate at 25 Years	Population at 25 Years (Yr 2039)	Cumulative Probability of Extinction at Year 25
Jackson	5	0.977	30	0.048 (4.8%)
Haywood	55	1.033	192	0.000 (0.0%)
Madison	8	1.006	37	0.018 (1.8%)

6.8.1.2 Study Areas Currently Unoccupied by Elk

Using the lower estimated survival and recruitment rates described in ***Table 6-3b***, the population projections suggest that the Alleghany-Ashe and Rutherford study areas are not sustainable for elk for the 25-year (Yr 2039) and 50-year (Yr 2064) growth scenarios. Even when unoccupied areas hypothetically experienced an "elk reintroduction" but elk survival was decreased by only 10% due to factors including road mortality, depredation, or poaching, major decreases in growth were documented. We conducted a simple sensitivity analysis by increasing and decreasing each demographic sequentially; we determined that adult female survival is the main driver of the dramatic changes in population growth. When survival is decreased, adult survival of 2- to 9-year-old females is the driver of the population growth. If survival and recruitment are decreased, adult survival of 2- to 9- and 10+-year-old females are the drivers. Returning these sole demographics to the original value enabled the population to stabilize. As shown in ***Table 6-6***, only the 25-year growth scenario (2039) resulted in a measurable remaining population. Scenarios for 50 years into the future had experienced extinction probabilities all greater than 70% (see **Appendix C**). In summary, the long-term survivability of the elk population is primarily related to anthropomorphic-induced mortality. This has been an issue in other small populations too (e.g., Virginia). Further, elk are not typically hunted until the core population is greater than 200.

Table 6-6. Modeling Results for 25-Year Population Projections 25 Years into the Future Assuming No Harvesting and No Immigration, but Changes in Demographic Values

Study Area	Starting Population Assumed	Growth Rate at 25 Years	Population at 25 Years (2039)	Cumulative Probability of Extinction at Year 25
Alleghany-Ashe (decrease in survival)	55	0.900	15	0.160 (16.0%)
Rutherford (decrease in survival and recruitment)	55	0.875	9	0.362 (36.2%)

6.8.2 Harvesting

6.8.2.1 Study Areas Currently Occupied by Elk

RISKMAN modeling results showed that only the population of 55 elk in the Haywood study area could sustain any level of harvesting over 25 and 50 years. Harvests limited to only male or 80% male:20% female with a total annual hunting quota of 4 or 6 elk per study area were the only scenarios that were approximately stable or allowed for slight increases over time, although even these hunting scenarios resulted in dramatic increases in probability of extinction. (See **Appendix C** for full details of runs.) Initial modeling results for the Jackson and Madison study areas indicated that harvest scenarios were unsustainable (population would go extinct in all runs in less than 15 years, that is, before Yr 2029) at 25- and 50-year elk population growth projections, so those modeling runs were not continued. ***Table 6-7*** presents Year 25 modeling results.

Table 6-7. Haywood Study Area Elk Harvest Modeling Results for 25-Year (Yr 2039) Population Projections (Assumes No Elk Immigrated to the Study Area and No Change in Elk Demographics)

Hunting/Harvesting Scenario	Growth Rate at 25 Years (2039)	Population at 25 Years (2064)	Cumulative Probability of Extinction at Year 25
Quota of 4: Only male	1.045	142	NA[a]
Quota of 4: 80% male:20% female	1.006	90	0.176 (17.6%)
Quota of 6: Only male	1.049	120	NA[a]
Quota of 6: 80% male:20% female	1.011	95	0.774 (77.4%)

[a] Deterministic runs. Cannot calculate probabilities.

6.8.2.2 Study Areas Currently Unoccupied by Elk

Section 6.8.1.2 explained that RISKMAN modeling results for both the Alleghany-Ashe and Rutherford study areas indicated that nonharvest scenarios for a 2014 starting population of 55 elk/area were unsustainable (i.e., populations were declining) at 25-year (Yr 2039) and 50-

year (Yr 2064) elk population growth projections (see ***Table 6-6***). As described in **Section 6.7**, these declines may be attributed to factors such as higher likelihood of human-elk conflict, limited or lack of forested refugia, and potentially higher subadult/adult mortality (e.g., meningeal worm). Therefore, harvest scenarios were not modeled.

6.8.2.3 Summary

Table 6-8 contains a summary of all modeling scenarios.

Table 6-8. Study Areas Modeling Results for 25-Year (2039) Population Projections

Elk-Occupied Study Areas: Original Demographics		Jackson	Haywood	Madison	Elk-Unoccupied Study Areas: Reduced Demographics	Alleghany-Ashe	Rutherford
No harvesting		✓[a]	✓	✓	No harvesting	✓[b]	✓
Harvesting	Only male quota of 4 elk	NA[c]	✓	NA	Only male quota of 4, 6, and 10 elk	NA	NA
	Only male quota of 6 elk	NA	✓	NA	Only male quota of 4, 6, and 10 elk	NA	NA
	Only male quota of 10 elk	NA	✓	NA	Only male quota of 4, 6, and 10 elk	NA	NA
	80% male quota of 4 elk	NA	✓	NA	80% male quota of 4, 6, and 10 elk	NA	NA
	80% male quota of 6 elk	NA	✓	NA	80% male quota of 4, 6, and 10 elk	NA	NA
	80% male quota of 10 elk	NA	✓	NA	80% male quota of 4, 6, and 10 elk	NA	NA
	50% male quota of 4 elk	NA	✓	NA	50% male quota of 4, 6, and 10 elk	NA	NA
	50% male quota of 6 elk	NA	NA	NA	50% male quota of 4, 6, and 10 elk	NA	NA
	50% male quota of 10 elk	NA	NA	NA	50% male quota of 4, 6, and 10 elk	NA	NA

[a] A checkmark on green background indicates the scenario was run and had at least a stable growth rate.

[b] A checkmark on red background indicates the scenario was run and had unstable growth.

[c] NA indicates that the need to run the scenario was negated because of negative results of other runs.

6.9 Discussion

6.9.1 No Harvesting Scenarios

When there was no harvesting of the elk populations at the 2012 demographic levels, all currently occupied study areas experience slow growth. The Haywood study area is obviously the primary elk zone outside of GRSM because it has the largest population of the three currently occupied study areas and the closest proximity to the 2001 to 2002 release site for the experimental elk population. It will likely continue to have slow growth if there are no major changes in demographics. It may also serve as a source of elk in adjacent Madison and Jackson Counties because of elk movement. In terms of biological potential, the Madison study area seems to have the most opportunity for elk population expansion. Of the five study areas, it is large, has some positive landscape qualities (e.g., more contiguous forest, lower road density, and less human density with still a good interspersion of cover type that elk use), and is relatively close to existing populations. The Interstate 40 corridor in Haywood County, however, is a

significant barrier to elk travel and has high human safety issues when elk attempt to cross the interstate as opposed to using an underpass (e.g., White Oak Rd.).

In general, the study areas that are currently unoccupied (in Alleghany-Ashe and Rutherford study areas) do not appear to be feasible or sustainable for elk given the high human influence on the land. Even when elk were "hypothetically" reintroduced in higher numbers, the depressed demographics and estimated 10% decrease in survival (Alleghany-Ashe) or survival and recruitment (Rutherford) prevented those populations from being sustainable. Unless the demographics could be proven to be as high as areas around GRSM, it is unlikely that elk could maintain the viable population there. Given the much larger agricultural presence, the higher influence of development, and the lack of contiguous forested refugia (protected land), this finding was not surprising.

6.9.2 Harvesting Scenarios

Extremely small quota hunts of all males might be sustainable in the Haywood study area once elk populations have reached some minimum threshold. The higher the base population, the more these populations are able to handle small hunts. These populations are still vulnerable, especially to female mortality. For example, the 50-year projections experienced high cumulative probability of extinctions for the 80% male harvest rates of 4 and 6 elk per year (~40% and 80% cumulative extinction probability, respectively; see **Appendix C**). Therefore, if there are a few years of depredation kills of reproducing-aged female elk, the populations could experience severe setbacks in terms of stability or growth. In other studies, elk populations often reach several hundred before being harvested. However, depredation permits are usually in place before harvesting is implemented. If more than one or two depredation permits are being allocated per year, it would probably be premature to consider harvesting the Haywood population. Conversely, North Carolina could potentially consider offering some other class of permit for specific elk-problem areas that have characteristics of a hunting "tag" but would be best served if those tags are relegated to males.

SECTION 7
BENEFITS, COSTS, AND REGIONAL ECONOMIC IMPACTS OF ELK

This section describes RTI's integrated assessment of the biological sustainability analysis (**Section 6**) and our economic analysis of costs, benefits, and economic impacts associated with potential elk populations in the five study areas. The biological sustainability analysis addressed each of the five elk study areas under multiple hunting and nonhunting scenarios and estimated the future elk populations in each study area over 25 years and at 50 years in the future. The economic analysis reflected these same scenarios and projected populations of elk in each location over time and under each hunting scenario. We examined how those elk populations would interact with humans in each study area, and we evaluated the potential ways in which the elk would have a positive or negative effect on stakeholders within the study areas. The economic analysis combines an evaluation of the benefits and costs of the elk populations (to attempt to determine whether elk populations have a net positive or negative impact on the well-being of the people of western North Carolina) and an assessment of the economic impacts throughout the North Carolina economy that could result from expenditures for elk-viewing tourism and (where hunting is considered) elk hunting trips. This economic analysis, together with the biological assessment, provides information to help policy makers identify sustainable sizes of elk populations in each study area.

This section begins with a description of the benefit-cost analysis (BCA), describes the estimated economic impact and concludes with the results of integrating the biological sustainability and economic assessments to provide an overall assessment of sustainability of elk in each study area.

7.1 Benefit-Cost Analysis of Elk in Each of the Five Study Areas

A BCA allows citizens and policy makers to consider whether the elk herds are, on balance, good or bad for western North Carolina as a whole. Recognizing that different people experience positive and adverse impacts of elk, BCA aggregates impacts across all affected individuals to determine whether the benefits of elk exceed the costs or the costs exceed the benefits from the point of view of society as a whole. If the benefits exceed the costs, the elk herds increase society's well-being. If costs exceed the benefits, the elk herds reduce society's well-being.

7.1.1 Overall Technical Approach

All BCAs follow four basic steps, and we followed these steps in our assessment of the elk scenarios:

1. Identify and describe potential positive and negative impacts of elk in western North Carolina.
2. To the extent possible, quantify the positive and negative impacts of elk.
3. For as many as possible of the positive and negative impacts that have been quantified, estimate a per-impact dollar value.
4. Combine estimated quantitative impacts with value information to estimate total costs and benefits associated with elk in each location, and compute the net benefit of the elk in each location by subtracting total benefits minus total costs.

7.1.2 Implementation of Benefit-Cost Analysis

As described in **Section 4**, RTI gathered information from a variety of sources to understand the impacts of elk in western North Carolina. We reviewed the findings of the Human Dimension Survey conducted by the North Carolina WRC (Linehan and Palmer, 2014), obtained data on negative interactions with elk that resulted in complaints to the WRC (McVey, 2014), and interviewed stakeholders and various experts to gain a deeper understanding of the details of both positive and negative impacts of the elk that currently exist in the Cataloochee area of GRSM and nearby areas outside the Park (see **Section 4** for more information). We also reviewed published articles describing elk impacts in other parts of the United States to determine if other potential impacts have been associated with elk elsewhere but have not yet occurred in North Carolina. Because we are analyzing potential future positive and negative impacts of elk, based on very limited experience with elk in North Carolina, we do not have comprehensive data based on this elk population. We therefore combined data values we were able to identify with reasonable assumptions to provide quantitative and monetary estimates of costs and benefits associated with elk.

7.1.2.1 Impacts to Consider

The presence of elk in western North Carolina has the potential to cause both positive and negative impacts on people with whom they interact. Using information from the survey (Linehan and Palmer, 2014) and complaint data provided by the WRC (McVey, 2014), RTI compiled a list of potential impacts to consider, shown in the sidebar. Positive impacts may include increased tourism by visitors interested in viewing elk, elk hunting trips, and local residents' enjoyment from watching or hearing elk. Negative impacts include property damage; possible injury or death of livestock or pets; and risk of injury or property damage due to elk-vehicle collisions.

Elk Impacts Considered

Positive Impacts

- Increased wildlife-viewing tourism
- Hunting
- Enjoyment of elk viewing by area residents

Negative Impacts

- Property damage
- Livestock or pet injury or death
- Vehicle-elk collision

7.1.2.2 Estimated Future Impacts in Each Location

As described above in **Section 5**, the RTI team combined information contained in the Elk Habitat Suitability Analysis (NCSU, 2014) with an examination of present human populations and land use in western North Carolina to identify locations with the potential to support elk populations. These study areas, from north to south, are

- an area that includes parts of Alleghany and Ashe Counties (referred to as the Alleghany-Ashe study area);
- an area including parts of Madison, Haywood, and Buncombe Counties (referred to as the Madison County study area);
- an area in Haywood County;
- an area in Jackson County; and
- an area in Rutherford County.

See ***Figure 5-1*** for the location of these study areas.

No elk inhabit the Alleghany-Ashe and Rutherford study areas, the Madison and Jackson study areas have small populations (fewer than 10 elk in each area), and the Haywood study area has a substantial population (about 55 elk) living outside GRSM. Overall, we estimate that there are approximately 70 elk spending some time outside GRSM in Haywood, Jackson, and Madison Counties.

Taking into account conditions in each of these elk study areas and examining several elk hunting regimes for the Haywood study area, RTI estimated the potential growth of elk populations over the next 25 years (to year 2039) and 50 years (to year 2064) in each study area. The results of this analysis are described in **Section 6**. As the projected population of elk changes over time, so does the potential for positive and negative impacts. Methods for estimating future positive and negative impacts are described below.

Estimating the Benefits of Elk in Each Study Area

As described above, estimating the benefits associated with elk involves multiple steps, including estimating the number of positive impacts of each type and computing their value by multiplying the number of impacts times the value per impact.

Identifying Types of Positive Impacts and Projecting the Future Number of Positive Impacts

Three types of positive impacts were identified, two of which were quantified and valued: elk-watching tourism and hunting.

Elk-Watching Tourism. When elk were introduced into GRSM, there was an immediate increase in visitation to the Cataloochee area where the elk herd was located (from approximately 75,000 visitors per year to about 140,000). As the herd grew, however, visitation remained relatively steady at the new, higher level (see ***Figure 7-1***).

Using this pattern of visitation (visitors increase as a result of the presence of elk, but visitation does not increase proportional to the size of the elk herd), we assumed that the presence of the elk in each of the five study areas will result in an initial increase in visitation. At present, it is uncertain where the elk herds would be located within each area and whether their location would be readily accessible for wildlife-viewing tourism. If the elk are located in inaccessible areas or on private lands, visitors interested in viewing elk may be unsuccessful. In general, GRSM promotes visitation and wildlife viewing, while other public lands within western North Carolina (Pisgah and Nantahala National Forests, various state parks, and game lands) may be less accessible and less focused on wildlife viewing tourism. Although elk may find some suitable habitat on private lands, they may not be generally available for tourists to view in those locations. Thus, although the Cataloochee area of GRSM experienced more than a 50% increase in visitation when the elk arrived, we assumed a 1% to 5% initial increase in wildlife viewing visitation in the five elk study areas. After that initial increase, we assumed that the number of visitors will increase over time proportional to projected increases in the state human population. This assumption is based on the New River State Park (NRSP) camping visitors' home state.[4] The positive visitation impact was measured by the increase in wildlife-viewing visitation in each study area that is attributable to the presence of elk (***Table 7-1***).

[4] Joseph Shimel, Superintendent of NRSP, provided 2013 data on residence of campers, showing that approximately 80% of campers at NRSP were North Carolina residents.

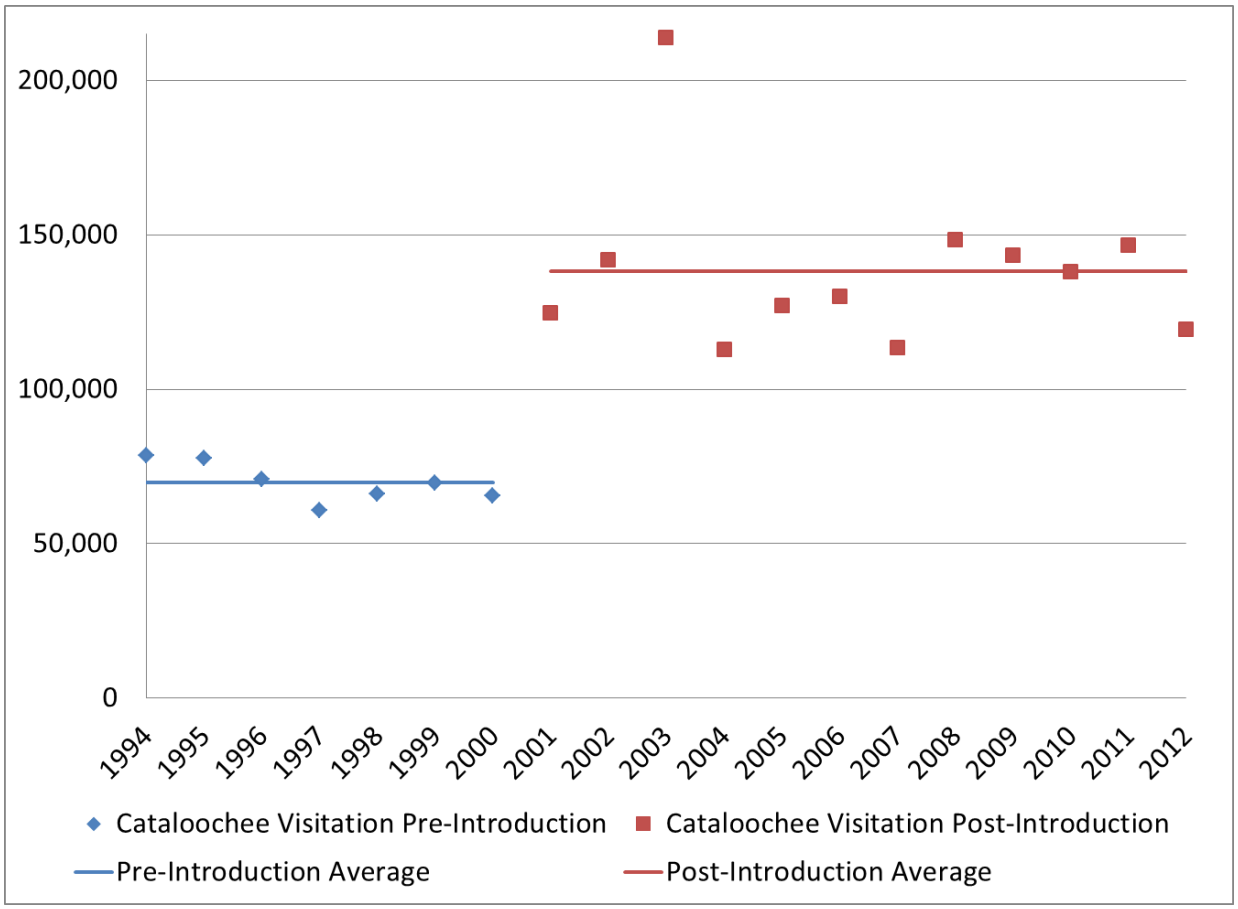

Figure 7-1. Visitation to Cataloochee Area of Great Smoky Mountains National Park, Before and After Elk Introduction

Baseline values for wildlife tourism for the Alleghany-Ashe and Rutherford study areas were estimated based on visitation to nearby state parks. We recognize that the state parks may not have much good elk habitat and that the elk may not be located in these state parks; however, visitors to state parks have demonstrated an interest in nature and outdoor experiences. Thus, we consider that they are also potentially interested in viewing wildlife. RTI used these data as estimates for baseline numbers of wildlife-viewing visitors in these counties. In fact, some state park visitors may not be interested in viewing wildlife, while visitors to other parts of the counties may hope to view wildlife.

In the Alleghany-Ashe study area, we assumed that visitation to NRSP and nearby state game lands represents tourism in the counties by visitors interested in nature and serves as a proxy for visitors who would be interested in wildlife viewing. Using NRSP visitation as the Alleghany-Ashe area baseline wildlife-viewing visitation, we assumed visitation would increase by 1% (low estimate) to 5% (high estimate) during the first year of the elk herd's presence. Similarly, in the Rutherford study area, we assumed that visitation in the South Mountains State Park (SMSP) is a proxy for baseline visitation by individuals interested in wildlife viewing. We assumed that visitation to SMSP would increase by 1% to 5% during the first year of the elk herd in that area. Our elk population models for these two areas project that the population of elk will slowly decline over time. Our visitation projection model assumes that, as the population of elk

Table 7-1. Visitation Impacts by Study Area: Increase in Visitation due to Elk (Additional Visitors)

	Low Estimated Visitation					
Year	Haywood Study Area	Jackson Study Area	Madison Study Area	Alleghany-Ashe Area	Rutherford Study Area	Total Visitation
2019	1,260	1,260	1,260	1,870	1,570	7,220
2024	1,320	1,320	1,320	1,500	1,140	6,600
2029	1,380	1,380	1,380	1,170	800	6,109
2034	1,450	1,450	1,450	920	560	5,800
2039	1,510	1,510	1,510	700	390	5,620
2064	1,900	1,900	1,900	—	—	5,700
	High Estimated Visitation					
Year	Haywood Study Area	Jackson Study Area	Madison Study Area	Alleghany-Ashe Area	Rutherford Study Area	Total Visitation
2019	6,290	6,290	6,290	9,360	7,870	36,100
2024	6,590	6,590	6,590	7,490	5,680	32,940
2029	6,900	6,900	6,900	5,830	5,680	32,210
2034	7,220	7,220	7,220	4,580	2,800	29,040
2039	7,560	7,560	7,560	3,510	1,950	28,140
2064	9,520	9,520	9,520	—	—	28,560

declines, visitation to view elk also declines. When the population of elk is projected to drop below 15 in each location (estimated to occur by Year 25), the probability of viewing elk will be so low that visitors will cease coming to the areas to view elk.

For the Jackson, Haywood, and Madison study areas, we assumed that visitation in the vicinity of each county would increase slightly during the first year of the study (see ***Table 7-1***). To quantify the increase in visitation, we estimated that visitation in these counties would increase by 60% of the average estimated increase for the Alleghany-Ashe and Rutherford study areas. This assumption reflects the fact that elk are already present in the area and thus would not present the novelty that they would in the more remote study areas. The elk population model projects slow positive growth in the Jackson, Haywood, and Madison study areas, even with some hunting allowed in the Haywood study area. Thus, we assumed that elk-viewing tourism would continue in those three areas throughout the 25-year duration of the analysis and would change over time proportional to the state's population.

Hunting. The elk population modeling assumed that only a few elk permits will be offered each year (either four or six). Thus, we assumed that there will be either four or six hunters, whom we assumed will require 3 days each to harvest an elk. (See **Section 6** for the reasons underlying the assumption of four or six permits per year.) Our analysis suggests that elk populations must reach 55 before any hunting is viable. Only in Haywood County (where an

estimated 55 elk live outside GRSM now) does the population of elk in the study area reach 55 within 25 years. Thus, hunting is modeled only within the Haywood study area.

Enjoyment by Local Residents. Although this is not quantified or valued, each stakeholder interviewed for this study and the majority of landowners surveyed by the WRC Human Dimension Survey reported that they considered the presence of elk in western North Carolina to be positive and that they enjoyed viewing them and hearing them. Although we are not able to quantify these impacts, qualitative impacts such as enjoyment by local residents should be retained and considered in the overall evaluation of benefits and costs of elk in each area.

Computing the Benefits

Benefits from wildlife-viewing visitation and hunting were estimated by multiplying the number of positive impacts of each type in each year and study area times a dollar value per day, assuming both viewing trips and hunting trips were 3 days each, as shown in ***Table 7-2***. In each study area, the low benefit was estimated by multiplying the low number of impacts times the low value, and the high benefit was estimated by multiplying the high number of impacts times the high value.

Table 7-2. Values for Positive Elk-Related Impacts

	Value per Day	
	Low	**High**
Wildlife viewing	$35	$60
Hunting	$110	$250

Source: Boyle et al, 1996, values for viewing big game and hunting elk. Updated to $2014 using the consumer price index.

As shown in ***Table 7-3***, visitation benefits range from $0.8 million to $6.5 million in 2019 and from $0.6 million to $5.1 million in 2039. After 2039, we estimate that so few elk will be surviving in the Alleghany-Ashe and Rutherford study areas that visitation benefits will drop to zero. In Jackson, Haywood, and Madison study areas, meanwhile, we estimate that visitation benefits will continue to increase slightly, totaling $0.6 million to $5.1 million in 2064.

Table 7-3. Estimated Benefits of Hunting and Elk-Viewing Tourism in Western North Carolina Study Areas (Thousand $2014)

Year	Low Wildlife-Viewing Benefit	High Wildlife-Viewing Benefit	Low Hunting Benefits	High Hunting Benefits	Low Total Benefits	High Total Benefits
2019	$758	$6,498	$1.3	$4.5	$759	$6,502
2024	$692	$5,928	$1.3	$4.5	$693	$5,933
2029	$641	$5,491	$1.3	$4.5	$642	$5,495
2034	$610	$5,229	$1.3	$4.5	$611	$5,233
2039	$591	$5,067	$1.3	$4.5	$592	$5,072
2064	$600	$5,140	$1.3	$4.5	$601	$5,145

Our analysis of hunting examines scenarios where four or six elk permits are made available each year. We do not include the value of the spending to obtain the permit, because the cost per permit has not yet been established.[5] Thus, the value of an elk hunting experience (assumed to be 3 days) is likely underestimated by the cost of the permit. In each year, hunting benefits are estimated to range from $1,320 to $3,000 for four elk harvested and from $1,980 to $4,500 for six elk harvested.

Estimating the Costs of Elk in Each Study Area

As with the benefits, estimating the costs of elk involves first identifying and describing the types of negative impact incidents that may result from human interactions with elk, then projecting how the expected number of impacts may change over time, and finally, assigning a dollar value to each incident to compute the cost of the incidents.

Identifying Types of Negative Impacts of Elk and Projecting the Number of Future Incidents Involving Negative Impacts

Damage to Property, Crops, Livestock, Fencing, or Pets. Over the past 3 years, the WRC has documented complaints received from residents who have incurred damage of some kind due to elk. Although the data are very limited, this is the best data available about negative impacts associated with the presence of elk in western North Carolina. These data may also underestimate the total number of negative impacts experienced, because minor or low-cost incidents may not be reported. RTI classified these reported damage incidents into several categories and tabulated the number of incidents per year of each category of damage. We then divided the number of damage incidents of each type by the estimated population of elk spending at least part of their time outside GRSM (70 elk) to compute the number of damage incidents per elk. Only about a dozen incidents were reported per year over the period 2012 to 2014; once these are subdivided into categories, there are at most four incidents per category. Dividing by

[5] However, the permit cost will likely be less than $100 and, thus, will be a small share of the expenditures associated with hunting elk.

the estimated 70 elk that spend at least some time outside GRSM, the number of impacts per elk range from 0.004 incidents per elk to 0.07 incidents per elk.

Unlike the visitation impacts, damage incidents are likely to increase proportional to the number of elk outside GRSM. Thus, we multiplied the high and low estimated number of damage incidents per elk times the projected number of elk in each location to compute high and low estimated damage incidents of each type in each location at 5-year intervals. In addition to incidents where actual damage occurred, the tabulated complaints listed several incidents where human beings had been chased by elk. No injuries were reported. These incidents are quantified, but no monetary cost was applied. Although there is a cost associated with being frightened, we were unable to estimate it. Thus, this negative impact, although not included in the monetary costs, should be considered in the overall comparison of benefits and costs of elk.

As described in **Section 6**, different hunting scenarios in the Haywood study area result in different elk population estimates over time. Thus, for the Haywood study area we computed six sets of tables, one for each hunting scenario. For simplicity, we present results associated with only one hunting scenario here (six permits, all male) in ***Table 7-4***, along with results for the other four study areas. Tables for all the hunting scenarios for the Haywood study area are found in **Appendix D**.

Damage due to Elk-Vehicle Collisions. Over the past several years, there have been, on average, one to three elk-vehicle collisions in the area of western North Carolina near the existing elk herd. Using collision data from 2011 (two accidents) and 2012 (three accidents) and the corresponding total elk population during those 2 years, we computed a range of estimated vehicle collisions per elk. These estimated impact incidents are also shown in ***Table 7-4***.

Computing the Costs Associated with Negative Impacts of Elk

The next step in estimating the costs involves assigning values to each type of possible negative impact projected. First, we made assumptions about the specific characteristics of the impact, such as:

- Residential ornamental or lawn damage: Low level of damage includes a small area of lawn disturbed and one or two shrubs damaged. High level of damage includes a larger area of lawn and/or a larger number of shrubs or landscape trees damaged.
- Garden damage: After examining values for garden produce from the literature (see Oregon State University, 2013), assumed low and high values within reported range.
- For hay crop damage, we obtained yield and price data for Haywood, Jackson, and Madison Counties for nonalfalfa hay (USDA, 2014). Assuming a 4-acre hay field, we estimated loss of 25% of the hay crop (low estimate) and 50% of the hay crop (high estimate).
- For row crop damage, we obtained yield and price information for corn grown in Haywood and Rutherford Counties and assumed a 17-acre field (USDA, 2014). The low estimate assumes a 5% reduction in yield; the high estimate assumes a 10% reduction in yield.

Table 7-4. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas

Year	Estimated Number of Elk	Low Estimated Impact Incidents	High Estimated Impact Incidents
Haywood study area, 6 permits, all male			
2019	56	5	21
2024	61	5	25
2029	71	6	28
2034	91	7	37
2039	120	14	46
2064	375	34	145
Jackson study area, no hunting			
2019	12	0	6
2024	18	0	8
2029	24	0	10
2034	29	0	10
2039	37	5	16
2064	109	13	43
Madison study area, no hunting			
2019	9	0	2
2024	14	0	6
2029	18	0	8
2034	23	0	9
2039	30	0	10
2064	92	7	36
Alleghany-Ashe study area, no hunting			
2019	49	5	17
2024	37	5	16
2029	28	0	10
2034	21	0	8
2039	15	0	6
2064	4	0	0
Rutherford study area, no hunting			
2019	42	5	17
2024	29	0	10
2029	19	0	8
2034	13	0	6
2039	9	0	2
2064	1	0	0

- In cases of livestock or pet injury or death, the low-cost estimate reflects estimated cost of treatment of injuries by a veterinarian (Dahms, 2014); the high-cost estimate includes the cost of euthanizing the animal, disposing of its body, and replacing it. For livestock, the low costs were estimated for veterinary treatment of an injured cow, and the high costs were estimated for the cost of euthanizing, disposing of, and replacing a horse (Dahms, 2014 (veterinary care), North Carolina Department of Agriculture, 2014 [cattle prices]; equine.com website [horse prices], 2014). All of these values represent estimates for typical impacts of each type. Clearly, there are cases where no supplies would be needed or no veterinarian would be called (on the low end) and cases where the value of the animal or property damaged would be unusually high (on the high end). RTI's analysis, however, reflects what we believe would be typical values.
- For fencing, we assumed a 4 acre square pasture with cross-fencing and applied unit costs for electric fencing (low cost) and barbed wire fencing (high cost) (Edwards and Chamra, 2012). High-tensile wire may be a good choice for replacement fencing because it uses springs and ratcheted rollers to maintain the fence's tension while allowing some give if animals hit it. The cost per linear foot of high-tensile fencing would be intermediate between our high- and low-cost values.
- For vehicle-elk collisions, the low and high values were calculated based on published costs of collisions with elk (U.S. Department of Transportation, 2008) minus and plus 15%.

RTI gathered information from a variety of sources to estimate the value of each impact type. These values are presented in ***Table 7-5***; for each impact type, we identified a range of possible dollar values.

Table 7-5. Cost Values per Negative Impact Incident ($2014)

Type of Incident	Low Value	High Value
Residential ornamental, or lawn damage	$100	$400
Garden damage	$250	$900
Hay crop damage	$297	$594
Row crop damage	$429	$858
Livestock injured or lost	$175	$1,400
Fence damage	$2,987	$4,967
Human chased	None	None
Pet injured or killed	$400	$800
Vehicle collisions	$15,777	$21,345

Sources: Residential ornamental/lawn damage: prices of supplies at several home stores and local nurseries. Garden damage: Oregon State University, 2013. Hay crop, row crop damage: USDA, 2014. Fence damage: Edwards and Chamra, 2012. Livestock or pet injured or killed: Veterinarian cost of care estimates (Dahms, 2014), North Carolina Department of Agriculture 2014 (cattle prices), equine.com website (horse prices), 2014. Vehicle collisions: U.S. Department of Transportation, 2008.

By multiplying the number of projected future incidents times the value of each type of incident, we computed the estimated costs of elk in each study area. These values are shown in ***Table 7-6***. Low costs were estimated by multiplying the low estimated number of impact incidents times the low value per impact incident; high costs were estimated by multiplying the high estimated number of impact incidents times the high value per impact incident.

In the Haywood, Jackson, and Madison study areas, the number of elk is projected to increase slowly. As a result, the costs associated with negative elk impacts are also projected to increase over the time frame of the analysis. In the Haywood study area, the elk population depends on the hunting permit regime being analyzed. For simplicity, we present the costs associated with only the "six permits, all male" hunting scenario; the other alternatives are presented in **Appendix D**. In the Jackson and Madison study areas, the number of elk is initially very low; as a result, the low estimate of costs remains at zero for 20 years in the Jackson study area and for 25 years in the Madison study area. Conversely, elk populations are projected to decline in the Alleghany-Ashe and Rutherford study areas. As a result, the low estimates of the costs of negative elk impacts in those locations drop to zero after 10 and 5 years, respectively.

Estimated Net Benefits of Elk in Each Location

The final step in conducting the BCA is to subtract estimated benefits minus estimated costs to compute estimated net benefits. To compute the low estimated net benefits, RTI subtracted the high estimated costs in each location and time period from the low estimated benefits. To compute the high estimated net benefits, we subtracted the low estimated costs in each study area and time period from the high estimated benefits. These values are shown in ***Table 7-7***.

Statewide, net benefits are projected to be positive throughout the analysis period under both the low net benefit calculation and the high net benefit calculation. The benefits are projected to be considerably larger than the costs, because a larger number of individuals are projected to experience benefits relative to costs. Although costs are projected to be relatively low in the aggregate, each individual experiencing adverse impacts due to elk has the potential to incur costs that range from a few hundred dollars to more than $10,000 for each incident. On balance, statewide net benefits due to elk are projected to decline slowly over time. Estimated benefits decline slowly over time and estimated costs increase, so the net benefits decline as time goes on. Throughout the period, however, estimated benefits exceed estimated costs of having elk in western North Carolina.

In the three study areas (in Jackson, Haywood, and Madison) where the population of elk is projected to increase over time, both benefits and costs are projected to increase as well. In the Jackson and Madison study areas and in the high net benefits estimate for the Haywood study area (assuming six elk permits), benefits exceed costs by enough that, even though the costs are growing at a faster rate, the net benefits increase over time. In the case of the low net benefit estimate for the Haywood study area, both costs and benefits increase over time, but the higher rate of growth for the estimated costs associated with the elk results in net benefits declining over time.

Table 7-6. Estimated Costs of Elk Impacts in Western North Carolina Study Areas (Thousand $2014)

Year	Estimated Number of Elk	Low Estimated Costs of Elk	High Estimated Costs of Elk
Haywood study area, 6 permits, all male			
2019	56	$19.5	$45.7
2024	61	$19.5	$48.4
2029	71	$19.8	$72.0
2034	91	$20.2	$83.3
2039	120	$40.0	$111.9
2064	375	$99.8	$326.9
Jackson study area, no hunting Low estimated impact incidents			
2019	12	$0.0	$5.0
2024	18	$0.0	$9.9
2029	24	$0.0	$12.2
2034	29	$0.0	$12.2
2039	37	$19.5	$37.6
2064	109	$39.7	$88.3
Madison study area, no hunting Low estimated impact incidents			
2019	9	$0.0	$2.3
2024	14	$0.0	$5.0
2029	18	$0.0	$9.9
2034	23	$0.0	$11.3
2039	30	$0.0	$12.2
2064	92	$20.2	$62.0
Alleghany-Ashe study area, no hunting Low estimated impact incidents			
2019	49	$19.5	$38.5
2024	37	$19.5	$37.6
2029	28	$0.0	$12.2
2034	21	$0.0	$9.9
2039	15	$0.0	$5.0
2064	4	$0.0	$0.0
Rutherford study area, no hunting Low estimated impact incidents			
2019	42	$19.5	$38.5
2024	29	$0.0	$12.2
2029	19	$0.0	$9.9
2034	13	$0.0	$5.0
2039	9	$0.0	$2.3
2064	1	$0.0	$0.0

Table 7-7. Estimated Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Haywood study area, 6 elk permits, all male				
		Low Estimate		
2019	56	$134.1	$45.7	$88.4
2024	61	$140.3	$48.4	$91.9
2029	71	$146.8	$72.0	$74.9
2034	91	$153.7	$83.3	$70.4
2039	120	$160.8	$111.9	$48.9
2064	375	$201.9	$326.9	($125.0)
		High Estimated Impact Incidents		
2019	56	$1,137.1	$19.5	$1,117.5
2024	61	$1,190.4	$19.5	$1,170.9
2029	71	$1,246.2	$19.8	$1,226.5
2034	91	$1,304.7	$20.2	$1,284.5
2039	120	$1,365.9	$40.0	$1,325.9
2064	375	$1,717.9	$99.8	$1,618.1
Jackson study area, no hunting				
		Low Estimated Impact Incidents		
2019	12	$132.1	$5.0	$127.2
2024	18	$138.4	$9.9	$128.4
2029	24	$144.9	$12.2	$132.7
2034	29	$151.7	$12.2	$139.5
2039	37	$158.8	$37.6	$121.2
2064	109	$199.9	$88.3	$111.6
		High Estimated Impact Incidents		
2019	12	$1,132.6	$0.0	$1,132.6
2024	18	$1,185.9	$0.0	$1,185.9
2029	24	$1,241.7	$0.0	$1,241.7
2034	29	$1,300.2	$0.0	$1,300.2
2039	37	$1,361.4	$19.5	$1,341.9
2064	109	$1,713.4	$39.7	$1,673.7

(continued)

Table 7-7. Estimated Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Madison study area, no hunting				
		Low Estimated Impact Incidents		
2019	9	$132.1	$2.3	$129.9
2024	14	$138.4	$5.0	$133.4
2029	18	$144.9	$9.9	$135.0
2034	23	$151.7	$11.3	$140.4
2039	30	$158.8	$12.2	$146.7
2064	92	$199.9	$62.0	$137.9
		High Estimated Impact Incidents		
2019	9	$1,132.6	$0.0	$1,132.6
2024	14	$1,185.9	$0.0	$1,185.9
2029	18	$1,241.7	$0.0	$1,241.7
2034	23	$1,300.2	$0.0	$1,300.2
2039	30	$1,361.4	$0.0	$1,361.4
2064	92	$1,713.4	$20.2	$1,693.3
Alleghany-Ashe study area, no hunting				
		Low Estimated Impact Incidents		
2019	49	$196.5	$38.5	$158.0
2024	37	$157.3	$37.6	$119.6
2029	28	$122.5	$12.2	$110.3
2034	21	$96.2	$9.9	$86.2
2039	15	$73.7	$5.0	$68.7
2064	4	$0.0	$0.0	$0.0
		High Estimated Impact Incidents		
2019	49	$1,684.4	$19.5	$1,664.8
2024	37	$1,347.9	$19.5	$1,328.4
2029	28	$1,049.7	$0.0	$1,049.7
2034	21	$824.3	$0.0	$824.3
2039	15	$631.5	$0.0	$631.5
2064	4	$0.0	$0.0	$0.0

(continued)

Table 7-7. Estimated Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Rutherford study area, no hunting				
		Low Estimated Impact Incidents		
2019	42	$165.2	$38.5	$126.7
2024	29	$119.3	$12.2	$107.1
2029	19	$83.5	$9.9	$73.6
2034	13	$58.8	$5.0	$53.8
2039	9	$41.0	$2.3	$38.7
2064	1	$0.0	$0.0	$0.0
		High Estimated Impact Incidents		
2019	42	$1,415.8	$19.5	$1,396.3
2024	29	$1,022.4	$0.0	$1,022.4
2029	19	$716.0	$0.0	$716.0
2034	13	$503.6	$0.0	$503.6
2039	9	$351.4	$0.0	$351.4
2064	1	$0.0	$0.0	$0.0
Statewide total net benefits, including Haywood study area 6 permits, all male				
		Low Estimated Impact Incidents		
2019	168	$760.1	$129.9	$630.2
2024	159	$693.6	$113.1	$580.5
2029	159	$642.6	$116.2	$526.4
2034	178	$612.0	$121.7	$490.3
2039	211	$593.1	$168.9	$424.3
2064	581	$601.7	$477.1	$124.6
		High Estimated Impact Incidents		
2019	168	$6,502.5	$58.6	$6,443.9
2024	159	$5,932.6	$39.1	$5,893.5
2029	159	$5,495.4	$19.8	$5,475.6
2034	178	$5,233.0	$20.2	$5,212.8
2039	211	$5,071.6	$59.6	$5,012.0
2064	581	$5,144.8	$159.7	$4,985.1

In the two areas for which the number of elk is projected to decline over time (the Alleghany-Ashe and Rutherford study areas), the benefits decline and drop to zero when the elk herd is projected to become small enough that the chances of viewing an elk are very low. Costs also decline over time. Because benefits exceed costs in magnitude, the decline in benefits causes net benefits to decline over time.

7.2 Economic Impact of Elk in Each Location: Overall Technical Approach

To estimate the statewide economic impacts associated with the presence of elk in five study areas in western North Carolina, RTI used a state-level input/output (I/O) model that quantifies all the supply-chain linkages throughout the economy. ***Figure 7-2*** illustrates the basic structure of an I/O model. When a spending change occurs in, for example, wildlife tourism in North Carolina, the overall impact of the spending change includes not only that direct change but also the increased output of all the sectors of the economy that provide supplies and inputs to serve the wildlife tourism. That additional output and spending is referred to as the "indirect impact" of the initial increase in tourism. As part of the increase in output in all those sectors, additional labor hours will be worked, resulting in increased household incomes and increased consumer spending. This is referred to as the "induced" impact of the direct increase in tourism spending. The overall economic impact is the sum of the direct, indirect, and induced effects.

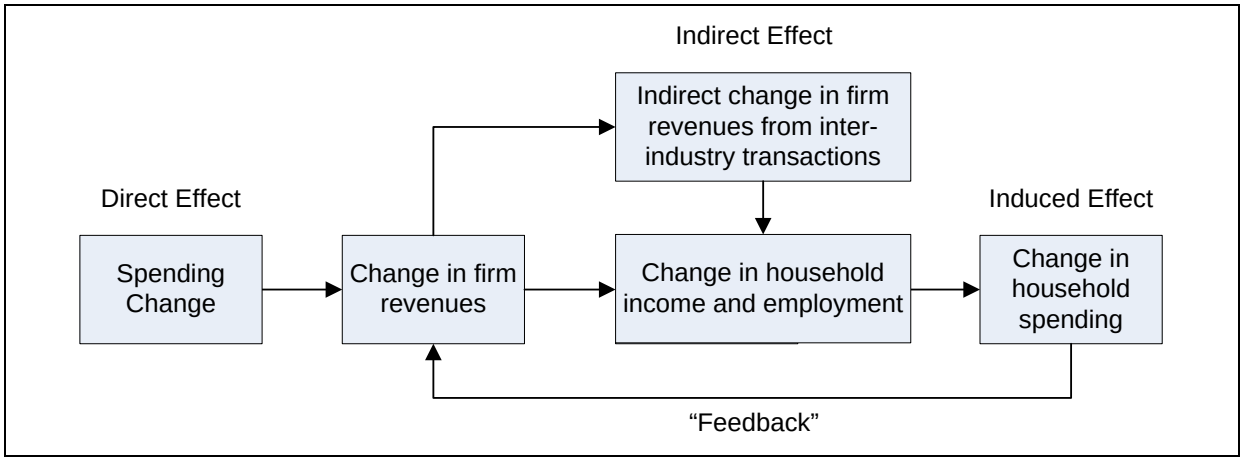

Figure 7-2. An Illustration of the Input-Output Economic Impact Model

To analyze the total direct economic impact and total statewide impact that elk are having in North Carolina, RTI used an I/O model approach. The first step was to find total new expenditures from the presence of elk. This calculation was done by taking our estimate of increased visitation to the selected areas for elk and multiplying by the average expenditures per person per day. This provided an estimate of the total increase in spending due to the presence of elk in western North Carolina. The average expenditures were taken from the U.S. Fish and Wildlife's *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (U.S. Fish and Wildlife Service, 2011).

The I/O model (IMPLAN, 2013) that was used takes expenditures and multipliers to distribute the spending throughout the economy in direct, indirect, and induced effects. The direct effects are the increase in spending that otherwise would not have taken place resulting from the presence of the elk. The IMPLAN model uses the multipliers to display how a specific region, in our case North Carolina, will respond to these direct effects. The indirect effects are the impacts of local industries buying goods and services from other local industries with their increased revenue. Finally, the induced effects are the responses by consumers to an increase in income that results from the direct effect, or the presence of elk. These are rolled up to create a total economic impact for a specified area.

For IMPLAN to assign spending to the correct multipliers it first has to be assigned to the correct industry or commodity grouping. RTI used the *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* to find what percentage of total expenditures were spent on various commodities used in wildlife viewing or hunting **(*Table 7-8*)**. These percentages were applied to the total expenditures to create a value of expenditures for the various IMPLAN industries.

Using estimated high and low increases in visitation for the first year of the study period, RTI ran six different scenarios through the model to estimate the total economic impact of elk. The first year of the study period is estimated to have the largest increase in wildlife-viewing tourism motivated by the presence of elk. As elk herds are projected to decline in the Alleghany-Ashe and Rutherford study areas, visitation in those areas is projected to decline as well. Elk-related tourism in Haywood, Jackson, and Madison study areas is projected to grow slowly throughout the study period. Total statewide tourism is projected to decline slowly until 2044; after that time, it is projected to grow slowly. The scenarios consisted of both high and low visitation estimates for no hunting, a four-permit hunt, and a six-permit hunt. The additional visitation from elk includes all five areas that are mentioned in this analysis, and the economic benefits are calculated on a statewide basis. When displaying economic impacts, IMPLAN provides four different measures: employment, labor income, value added, and output. Labor income is the increase in all forms of employment income (this includes both wages and benefits). The value-added column represents the net additions to the state's gross domestic product, and the output column is the value of the total additional production.

One finding to take away from the results in ***Table 7-9*** is that hunting has very little effect on overall economic impact because the two hunting scenarios that were introduced have to be a very low number of elk based on the population projections done. The additional jobs created ranged from 82 to 409 based on the high and low scenarios for visitation. The other key indicator of economic impact is the total output, which ranges from approximately $9.6 to $48.1 million. The presence of elk has a significant impact on the economy of North Carolina that is driven by additional tourism revenue from people coming to see the animals.

7.3 Integration of Economic and Biological Analysis

Figure 7-3 shows how we project net benefits (benefits minus costs) of the elk herd to change over time as the size of the elk herd in each study area changes. For the three areas near GRSM where we project the elk population to increase, elk appear to be sustainable, with a modest harvest rate once the population in a given study area reaches 55 animals. If more than 1 or 2 elk are taken under depredation permits annually, hunting limits may need to be adjusted or hunting postponed. We project that both benefits and costs of elk will increase over time in these areas, but the costs increase more rapidly than the benefits, so net benefits decline as the size of the elk population increases. For the other two areas, the elk population is projected to decline over time, and both benefits and costs are projected to decline also, falling to zero when the size of the elk herd drops below 15 in the study area.

Table 7-8. Allocation of Wildlife Viewing Expenditures into Spending Categories

Trip Related	Percentage of Total Wildlife Viewing Expenditures
Food	9.40%
Lodging	7.10%
Public transportation	3.40%
Private transportation	6.30%
Guide fees	0.50%
Public land use fees	0.30%
Private land use fees	0.10%
Equipment	0.30%
Boating	0.50%
Heating and cooking fuel	0.20%
Trip-related total	28.20%
Wildlife Watching Equipment	
Binoculars	1.40%
Cameras	8.40%
Commercially prepared bird food	5.90%
Other foods for birds	1.40%
Feed for other wildlife	1.50%
Bird nest	1.70%
Day packs and special clothing	1.00%
Other	0.20%
Wildlife-watching total	21.60%
Auxiliary	
Tents	0.50%
Frames	0.30%
Other camping equipment	0.80%
Other (blinds)	0.60%
Auxiliary total	2.30%
Special	
Off-the-road vehicles	8.40%
Travel tents and campers	11.70%
Boats	4.00%
Cabins	2.80%
Special total	26.90%
Other	
Travel books	0.80%
Land	14.40%
Membership	2.30%
Plantings	3.60%
Other, Total	21.00%

Table 7-9. Estimated Annual (2014) Statewide Economic Impacts of Wildlife Tourism and Hunting Associated with Elk in Western North Carolina (Thousand $2014)

	Impact Type	Employment	Labor Income	Value Added	Output
Low—No Hunt	Direct effect	53	$2,061	$3,451	$5,699
	Indirect effect	13	$610	$1,099	$1,839
	Induced effect	17	$693	$1,320	$2,087
	Total effect	82	$3,364	$5,869	$9,624
High—No Hunt	Direct effect	263	$10,305	$17,253	$28,494
	Indirect effect	63	$3,051	$5,494	$9,193
	Induced effect	83	$3,466	$6,600	$10,436
	Total effect	409	$16,822	$29,347	$48,122
Low—4 Hunt	Direct effect	53	$2,064	$3,455	$5,705
	Indirect effect	13	$611	$1,100	$1,840
	Induced effect	17	$694	$1,322	$2,090
	Total effect	82	$3,369	$5,877	$9,636
High—4 Hunt	Direct effect	263	$10,308	$17,257	$28,500
	Indirect effect	63	$3,052	$5,495	$9,195
	Induced effect	83	$3,467	$6,602	$10,439
	Total effect	409	$16,827	$29,354	$48,134
Low—6 Hunt	Direct effect	53	$2,066	$3,457	$5,708
	Indirect effect	13	$611	$1,101	$1,841
	Induced effect	17	$695	$1,323	$2,091
	Total effect	82	$3,371	$5,880	$9,641
High—6 Hunt	Direct effect	263	$10,310	$17,259	$28,503
	Indirect effect	63	$3,052	$5,496	$9,196
	Induced effect	83	$3,467	$6,603	$10,440
	Total effect	409	$16,829	$29,358	$48,139

The presence of elk herds in western North Carolina study areas has the potential to convey both positive economic impacts statewide and positive net benefits (increases to social well-being) in the study areas. These net benefits will decline as the herd population increases, so the WRC will need to monitor and manage the size of the elk herds in these locations to ensure that the economic and social welfare benefits are realized. Small estimated per-person benefits are projected to accrue to a large number of wildlife-viewing visitors, while more substantial per-person costs are borne by a few individuals (those who have a collision with an elk or whose property or livestock are damaged by elk). The WRC may wish to facilitate mitigation activities such as installing elk-resistant fencing and undertaking aversive training of elk to reduce the number of adverse impacts and thus the costs incurred. If such mitigation measures succeed, the costs of elk may not increase as rapidly over time as the elk population grows.

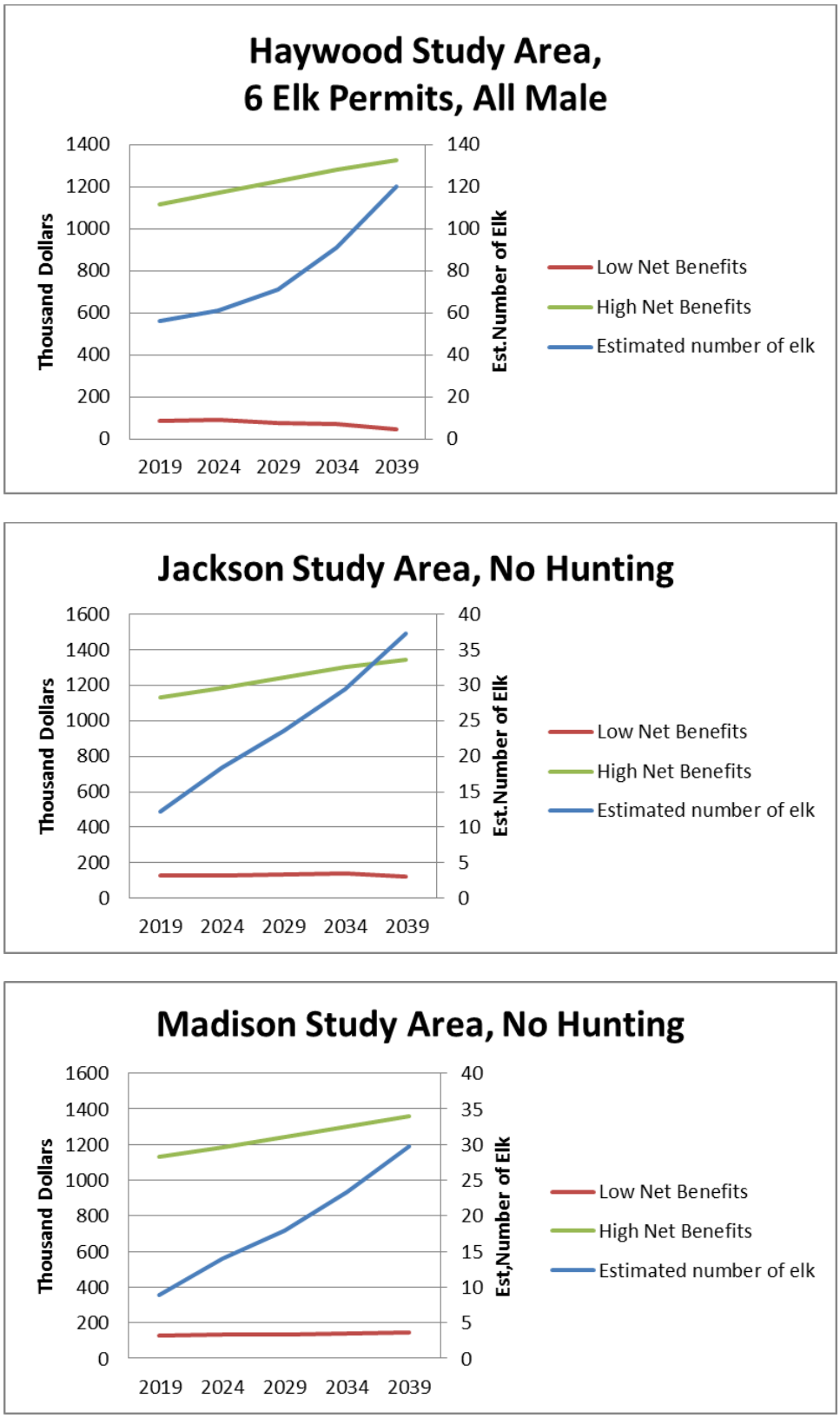

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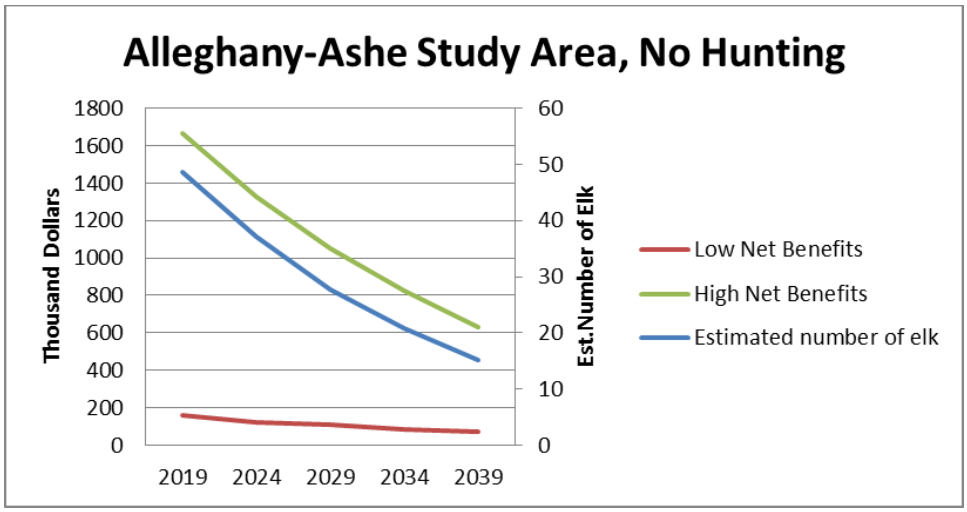
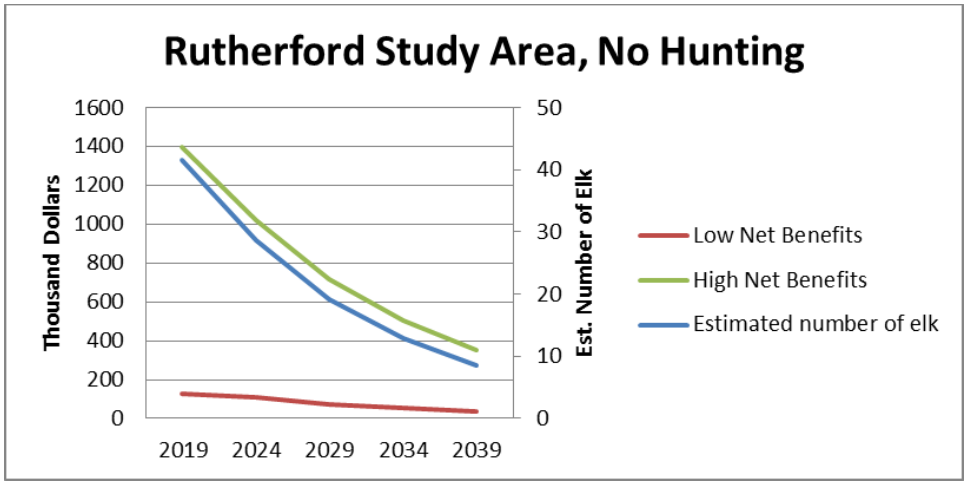
Figure 7-3. Projected Elk Populations and Net Benefits by Elk Study Area





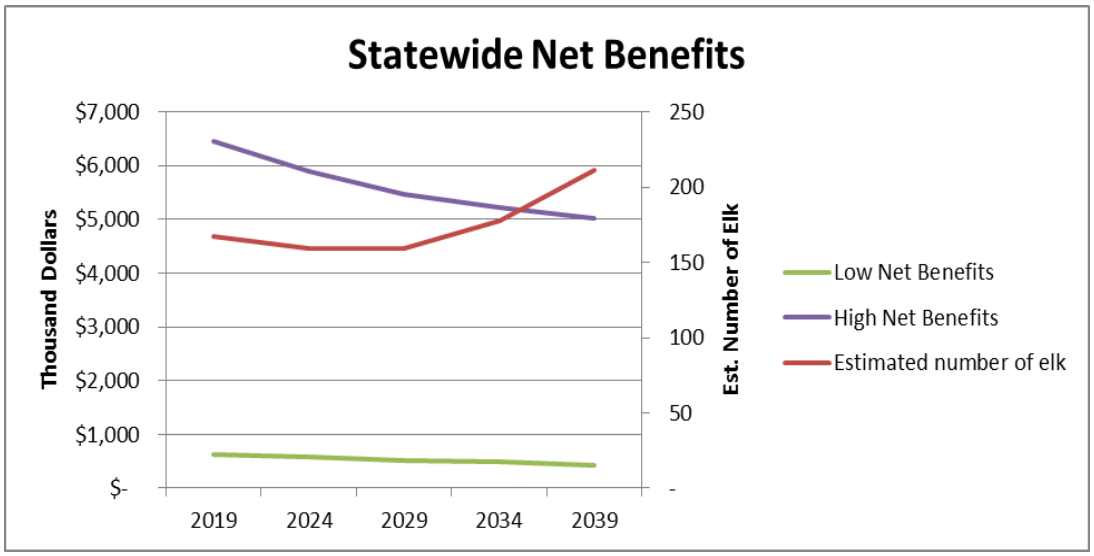


Figure 7-3. Projected Elk Populations and Net Benefits by Elk Study Area (cont.)

SECTION 8
DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The 2008 National Park Service's completion of its GRSM elk reintroduction experiment resulted in the WRC being responsible for managing elk that are moving beyond Park boundaries. The WRC has monitored elk activity in adjoining lands in Haywood, Jackson, and Madison Counties and estimates that approximately 70 elk now spend at least part of their time on these nonfederal lands. Elk have generated both positive and negative impacts thus far in North Carolina. Although elk appear to be drawing additional visitors (and their tourism dollars) to the area in hopes of viewing elk, incidents of property damage and potential risk to humans have been reported and have also resulted in the issuance of a small number of depredation permits.

In 2014, the WRC issued a purchase order to RTI International to assess the feasibility of establishing not only a sustainable elk population outside GRSM in North Carolina but also a huntable population. RTI's analysis entailed selecting five study areas within a 24-county region of western North Carolina. This section discusses RTI's findings described in earlier report **Sections 5** through **7**, as well as our conclusions and recommendations.

8.1 Discussion

8.1.1 Study Area Selection

RTI's approach to selecting study areas was a collaborative effort with the WRC. For example, WRC staff provided its Human Dimension Survey report, contacts with NCSU's Habitat Suitability Index study team, feedback on study area selection criteria, collar data to support our estimation of the number and distribution of elk on non-Park lands, and names of stakeholders from varied backgrounds (e.g., farming, business). RTI used all of this information, in addition to our own GIS analysis of land use, human population density and demographics, residents' interview findings, and our consulting wildlife biologist's expertise in elk habitat to recommend and receive WRC staff consent to analyze five study areas.

RTI selected three study areas where elk currently exist (Haywood, Madison, Jackson) and two study areas that were potentially suitable for introducing elk (Rutherford and Alleghany-Ashe). RTI chose areas that had the greatest potential to support elk in western North Carolina with the understanding that conditions may not be ideal and may not sustain elk. For example, we understood that unlike the western U.S. lands that successfully support elk populations, western North Carolina's land cover described as hay/pasture is typically in small land holdings with many owners and may lead to significant elk-human conflicts. Furthermore, unlike the elk-favored scrub/shrub in much of the West and Northeast, North Carolina's scrub-shrub is a very small portion of the landscape, is often succeeding into forest, and may not adequately support elk. North Carolina's considerable road infrastructure and farming also constrained the identification of optimum lands for the study.

8.1.2 Biological Analysis

To predict potential elk populations in the five study areas and determine the suitability of hunting, RTI estimated the carrying capacity of the approved areas and determined existing elk population structures. We acquired the most recent demographic data for the western North

Carolina elk herd, including recruitment rates (the probability of an elk calf making it into a specific age class) and survival rates. Potential hunting or harvesting scenarios, including a nonhunting scenario, were then developed and modeled. The RISKMAN-modeled population projections for the currently occupied elk area assumed there was no major change in elk demographic parameters over the 25-year time span of the model projection. In addition, there is no immigration included in the elk population projection because the RISKMAN model does not incorporate elk immigration or emigration. We do know that immigration or slow population spread is happening from GRSM.

8.1.3 Socioeconomic Analysis and the Integrated Analysis of Biological and Socioeconomic Analyses Results

RTI's approach to analyzing the socioeconomic impacts of elk and hunting over a 25-year period focused on quantifying and valuing the positive (e.g., tourism) and negative impacts (e.g., crop damage and automobile accidents) of elk to estimate the total costs, benefits, net benefits (benefits minus costs), and overall economic impacts. Because of the limited socioeconomic experience with elk in North Carolina (e.g., limited number of human-elk conflict incidents; limited data on visitors seeking to view elk outside of GRSM), our analysis of the positive and negative impacts did not have a comprehensive elk dataset to use as input. RTI, therefore, combined data values we were able to identify with reasonable assumptions to produce results as ranges of quantitative and monetary estimates of elk-related costs and benefits.

To estimate the statewide economic impacts associated with the presence of elk in five study areas in western North Carolina, RTI used a state-level I/O model that quantifies all the supply-chain linkages throughout the economy. Using total estimated expenditures for wildlife-viewing tourism and hunting trips under six different scenarios, RTI entered direct spending impacts into the model to estimate the total economic impact of elk under each scenario, including high and low visitation expenditure estimates for no hunting, a four-permit hunt, and a six-permit hunt. The additional visitation from elk includes all five areas that are mentioned in this analysis, and the economic benefits were calculated on a statewide basis.

8.2 Conclusions

- Assuming no harvesting, RISKMAN modeling results showed that in the three study areas where elk currently reside, slow steady growth can occur. The Haywood study area's elk population is predicted to reach its carrying capacity in approximately 30 years, and the two smaller populations in the Jackson and Madison study areas have much slower growth, but extinction probabilities remain small at less than 5% in 25 years.
- Modeling found that the two new unoccupied areas (Alleghany-Ashe and Rutherford) will not sustain elk over 25 years, even without hunting. This is attributed to the lower survival and recruitment rates because of factors such as road mortality, higher deer densities, and the likelihood of poaching. Even if the state increased the starting number of elk to more than 55, modeling indicates that the two study areas could not sustain herds. Declines may be attributed to factors such as higher likelihood of human-elk conflict, limited or lack of forested refugia, and potentially higher subadult/adult mortality (e.g., meningeal worm). Such issues have impeded several past reintroductions.

- Modeling of population growth assuming hunting scenarios of four and six elk hunted per year indicated that the current population of 55 elk in the Haywood study area could sustain harvesting over 25 and 50 years. Initial modeling results for the Jackson and Madison study areas indicated that harvest scenarios were unsustainable (population would go extinct in less than 15 years).
- In virtually all scenarios and all study areas, benefits of the elk herd are estimated to exceed the costs of the elk herd throughout the 25-year study period. In general, net benefits (benefits minus costs) decline over time as the herd size increases. Costs of elk increase proportional to the size of the elk herd, while benefits of elk are projected to increase more slowly, proportional to the human population (and thus projected tourism). Benefits are projected to be experienced by a relatively large number of individuals; costs, however, are higher on a per-incident basis and are incurred by a relatively small number of individuals (those who have farms located near areas that elk favor or drivers who have a collision with an elk).
- RTI did not model any changes in human behavior designed to avoid negative impacts, but such changes may have the potential to mitigate some of the losses projected by the analysis. For example, if farmers experience annual crop damage or need to make frequent fence repairs, installation of a stronger "elk-proof" fence, while a costly upfront investment, may reduce or eliminate future negative impacts.
- Our economic impact analysis found that because the two hunting scenarios that were introduced have to limit the number of elk hunted to a very low number based on the population projections done, the expenditures associated with elk hunting make a relatively small contribution to the annual North Carolina economy. Estimated increases in wildlife-viewing tourism, however, have the potential to add substantially to economic activity in North Carolina, including statewide increases in output, employment, and labor incomes. The additional jobs created ranged from 82 to 409 based on the low and high scenarios for visitation. Statewide economic output is estimated to increase by approximately $9.6 to $48.1 million per year, depending on the scenario considered. The presence of elk has a significant impact on the economy of North Carolina that is driven by additional tourism spending by visitors coming to see the animals.

8.3 Recommendations

- The WRC should monitor and index the elk population annually to discern any trends in elk demographics and influence of harvesting on demographics.
- The WRC should monitor and record human-elk incidents and the number of visitors to the elk-occupied areas surrounding the GRSM for the purpose of viewing elk. Better data will strengthen the certainty of any future estimates of costs, benefits, and economic impacts.
- Based on RISKMAN modeling assumptions and caveats previously described, hunting four or six male elk per year over 25 and 50 years in the Haywood study area will not impair the sustainability of elk. Recommended management efforts in Haywood study area may include 1) continuing to concentrate on mitigating elk-human issues in Haywood County; 2) continuing to collar and monitor elk survival

and reproduction; and 3) limiting any type of harvesting to males, if feasible. Additional management efforts could include avoiding killing females (i.e., depredation), if possible, and for the time being, if feasible, conducting aggressive aversive conditioning of females (train the elk to avoid human interactions).

- If more than one or two depredation permits are allocated per year in the Haywood study area, it would probably be premature to consider harvesting the Haywood population. Conversely, North Carolina could potentially consider offering some other class of permit for specific elk-problem areas that have characteristics of a hunting "tag" but would be best served if those tags are relegated to males. It is worth noting that most other eastern elk populations that are now being legally hunted had reached population numbers exceeding 200 before hunting began.
- Madison and Jackson elk population growth should be monitored to reassess at a later date if hunting would impair herd sustainability.
- RISKMAN modeling indicated that an introduced 55-head elk population in either the Alleghany-Ashe or Rutherford study area could not be sustained even with no hunting. Land cover characteristics and anthropogenic risk factors in these counties indicate larger herds are also not sustainable.

SECTION 9
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APPENDIX A:
STAKEHOLDER INTERVIEW QUESTIONS

Evaluation of the Feasibility of Establishing a Huntable Elk Population in North Carolina

Draft Stakeholder Interview Guide

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July 2014

DRAFT STAKEHOLDER INTERVIEW PACKAGE—7/29/14

Goal of Interview

To obtain information about stakeholder views of elk in western North Carolina, which can be used to 1) provide context to the information gathered from the North Carolina Wildlife Resources Commission's (WRC's) Human Dimension Survey and 2) inform the assumptions RTI will use about concerns, attitudes, and behaviors in the integrated biological and socioeconomic assessment. (Note: RTI may provide interview quotes or summaries in the final report but may not provide information about who was interviewed, except general descriptions such as stakeholder group.)

Approach to Designing Interview Guides

- *Identify how data will be used:* Information about stakeholder attitudes may be combined with information from relevant peer-reviewed literature to inform the cost-benefit analysis.
- *Identify groups to be interviewed:* Stakeholders potentially affected by or interested in elk who represent varied interests.
- *Determine the scope of questions:* Opinions and behaviors of stakeholders with respect to elk that are believed to be most appropriate for the stakeholder.
- *Draft interview questions:* Tailor each set of questions to the stakeholder group. Interviews will focus on year 2013 activities.
- *Estimate the number of interviews:* RTI expects to conduct 8 to 10 semistructured interviews, with no more than two per stakeholder category.
- *Determine how interviews will be conducted:* Scheduled telephone calls, probably 15 to 30 minutes each in length.
- *Identify individuals to interview:* RTI is asking WRC to recommend names to be contacted for each stakeholder group.
- *Establish and implement quality assurance practices:* To improve the quality and consistency of the information gathered through the interviews, RTI will develop interview guides, including a scripted opening statement, with predetermined questions for each type of stakeholder group. In the opening statement, RTI will describe the project, counties covered, who recommended them, RTI's role, estimated length (time) of interview, general range of questionnaire topics, and how the results will be used. To the extent that the results are entered into a spreadsheet, RTI project management will review interview notes and data entry to ensure accurate spreadsheet entries.
- *Initiate contact:* RTI will plan to contact individuals first in writing via email, if feasible. If WRC prefers or thinks it would be more productive, WRC could make the initial contact and provide an introduction for RTI.
- *Determine need for confidentiality:* If requested, and unless compelled by law to release information, RTI can offer to keep the identity of interview respondents and their specific responses confidential.

Schedule

RTI's goal is to conduct the interviews over a 2-week period, beginning upon WRC's review and approval of the draft interview guides, provision of names of individuals to interview, and RTI's

final comparison of the approved interview guides to the cost-benefit analysis methodology for adequacy.

Proposed Stakeholder Groups for Interviews

- Agriculture (farmers) and/or
- Agricultural interest groups
- Local business owners/chambers of commerce—nontourism/recreation, nonagriculture
- Local business owners—recreation/tourism
- Hunters (clubs/organizations)
- Animal welfare groups
- Natural resource conservation groups
- Local government officials

In addition to these external stakeholder groups, RTI believes it would be beneficial to interview a representative of the Great Smoky Mountains National Park staff and/or WRC staff to gather information about their experience with the Cataloochee elk herd.

Information RTI is requesting from WRC before beginning interviews

1. Identify any alternate or additional stakeholder groups deemed necessary. (For example, would it be beneficial to interview nonagriculture residents?)
2. Provide comments on the interview questions—scope, appropriateness, sensitive wording (providing Word track comments would be most helpful).
3. Provide up to 4 names, email addresses, and telephone numbers of candidate interviewees for each group to help ensure at least 1 to 2 individuals per agreed upon stakeholder group can be interviewed.
4. Express whether it would be more favorable for the study if WRC or RTI made the initial contact with each candidate interviewee.

STAKEHOLDER GROUP—AGRICULTURE (farmer)

1) In what county do you farm?
2) Do you own or lease the land you farm (if combination, ask for % distribution in 2013)?
3) Acres farmed in 2013:
    a. Acres actively farmed
    b. Farm acres idle
4) What percentage of the land you farm is fenced?
5) What type of fencing? (barbed wire, electric, wooden, other)
6) Is farming your primary source of income? Yes, No.
7) What types of farming do you do?
    a. Row crops
    b. Hay
    c. Pasture
    d. Orchards
    e. Livestock (including equine) and/or poultry: confined? pasture-fed?
    f. Any combination of the above (specify and ask if any one predominates)
    g. Other
8) Is there water on your farmland?
    a. If yes, is it a pond, stream/river, or spring?
9) Are you aware that there are elk in western North Carolina?
10) Have elk ever entered your farm to feed, water, or shelter? If no, skip to question (16).
    a. If yes, how many times in year 2013—
    1–5, 5–10, 10 or more?
    b. Please describe the incident.
    c. Have you experienced any property or crop damage?
    d. What is the estimated value of the damage?
11) If elk were to use your farm to feed, water, or shelter, would that concern you?
    a. If yes, what are your specific concerns?
    b. If no, why not a concern?
12) For each area of concern listed in (11) above, rate the seriousness of your concern on a scale of 1 to 5, where 1 is not very concerned and 5 is extremely concerned.
13) Would you take active measures to discourage elk from feeding or sheltering on your land?
    a. If no, how would you respond?
    b. If yes, what actions would you likely undertake to discourage elk from using your farmland to feed or shelter?
        - Make loud noises
        - Seek help from WRC elk experts to discourage the elk
        - Seek permission or assistance to move or kill the elk
        - Other (please describe)
14) Do you have any additional comments?

STAKEHOLDER GROUP—AGRICULTURE INTEREST GROUP

1) What counties does your group represent?
2) Describe the stakeholders your group represents:
    a. Row crop farming
    b. Fruit growers
    c. Soil and water conservation
    d. Livestock and poultry producers
    e. Agri-suppliers
    f. Other (please specify)
3) What types of farming do you consider most important in western North Carolina?
    a. Row crops
    b. Hay
    c. Pasture
    d. Orchards
    e. Livestock (including equine) and/or poultry
    f. Any combination of the above (specify and ask if any one predominates)
    g. Other
4) Does your group have an official position with regard to elk?
   If yes, do you support or oppose wild, free-ranging elk in western North Carolina?
5) Have any of your members experienced property or crop damage due to elk?
   If yes, please describe one or more examples. Cost estimate for losses or repairs?
6) Have your members expressed opinions with regard to the presence of elk in the area?
   If yes, what best characterizes their opinions:
    a. majority opposed
    b. majority favors
    c. equal distribution of opposition vs. favor
7) Would your group be in favor of allowing elk to be moved onto other public lands (such as state or national forests, state parks, etc.) within western North Carolina?
8) Would your group be in favor of allowing elk to be moved onto private lands within western North Carolina?
9) Do you have any other observations we have not touched on?

STAKEHOLDER GROUP—LOCAL BUSINESS OWNERS, e.g., local chambers of commerce (excludes recreation/tourism and agricultural interest groups)

1) What is the mission of the stakeholder group you represent?
2) What geographic region do you represent (or where is your business located)?
3) What are the most important business sectors in your region?
    a. Can you rank the types of business in terms of revenues generated or number of people employed?
4) How much of the economic activity (revenues or employment) of your region is associated with tourism?
    ___%
5) Is wildlife viewing an important part of tourism in your region?
6) What share of visitors to your region is interested in wildlife viewing?
7) Is wildlife viewing a primary reason for visits or a secondary bonus for people interested in hiking or camping or some other activity?
8) Do visitors interested in wildlife viewing tend to come from—
    a. Within the county?
    b. Outside the county but within the state of North Carolina?
    c. Out of state?
9) Do visitors interested in wildlife viewing tend to stay—
    a. Overnight?
    b. For the weekend?
    c. For 3 or more days?
10) Is hunting an important part of tourism in your region?
11) What share of visitors to your region are there to hunt?
12) Do visitors interested in hunting tend to come from—
    a. Within the county?
    b. Outside the county but within the state of North Carolina?
    c. Out of state?
13) Do visitors interested in hunting tend to stay
    a. Overnight?
    b. For the weekend?
    c. For 3 or more days?
14) What are the potential positive aspects of increasing numbers of elk in western North Carolina to businesses in your region?
15) What are the potential negative aspects of increasing numbers of elk in western North Carolina to businesses in your region?
16) Do you have any other observations we have not touched on?

STAKEHOLDER GROUP—LOCAL RECREATION/TOURISM BUSINESS OWNERS

1) What is the mission of the stakeholder group you represent?
2) What geographic region do you represent (or where is your business located)?
3) What are the most important business sectors in your region?
    a. Can you rank the types of business in terms of revenues generated or number of people employed?
4) How much of the economic activity (revenues or employment) of your region is associated with tourism?
    ___%
5) Is wildlife viewing an important part of tourism in your region?
6) What share of visitors to your region is interested in wildlife viewing?
7) Is wildlife viewing a primary reason for visits or a secondary bonus for people interested in hiking or camping or some other activity?
8) Do visitors interested in wildlife viewing tend to come from—
    a. Within the county?
    b. Outside the county but within the state of North Carolina?
    c. Out of state?
9) Do visitors interested in wildlife viewing tend to stay—
    a. Overnight?
    b. For the weekend?
    c. For 3 or more days?
10) Is hunting an important part of tourism in your region?
11) What share of visitors to your region are there to hunt? Do visitors interested in hunting tend to come from—
    a. Within the county?
    b. Outside the county but within the state of North Carolina?
    c. Out of state?
12) Do visitors interested in hunting tend to stay—
    a. Overnight?
    b. For the weekend?
    c. For 3 or more days?
13) What are the potential positive aspects of increasing numbers of elk in western North Carolina to businesses in your region?
14) What are the potential negative aspects of increasing numbers of elk in western North Carolina to businesses in your region?
15) Do you have any other observations we have not touched on?

STAKEHOLDER GROUP—HUNTERS (e.g., hunting clubs)

1) In what western North Carolina counties do your club members hunt?
2) What wildlife and birds does your club hunt (e.g., turkey, deer, dove)
3) How large is your membership?
4) What services do you offer your members?
5) How much annually (cite year) do your members in western North Carolina spend on supplies for hunting?
6) How much annually (cite year) do your members spend in western North Carolina on travel and lodging for hunting?
7) What percentage of your members would be interested in hunting elk, if that were available?
8) Do any of your members travel out of state to hunt elk?
    a. If yes, how many?
9) What are the potential positive aspects of increasing numbers of elk hunters in your region?
10) Are there potential negative aspects of increasing numbers of elk to hunters in your region?
    a. If yes, please describe.
11) Do you have any other observations we have not touched on?
12) How many acres are hunted in your club's western North Carolina region annually (cite year)—
    a. % leased?
    b. % privately owned by clubs
13) In your opinion, what is the average $/acre (going rate) for hunting in western North Carolina in year 2013?
14) What % of the land hunted is forested? scrub? cropland? open pasture?

STAKEHOLDER GROUP—ANIMAL WELFARE GROUPS

1) Describe the stakeholders your group represents; how large is your membership?
2) What is your organization's mission?
3) What services do you offer your members?
4) What western North Carolina counties does your group represent?
5) Does your organization have an official position on the elk herd in western North Carolina?
    a. If so, please state your position. (if written, get verbatim)
6) If not, have any of your members brought up the topic of the elk located in the Cataloochee area?
7) Do your members participate in wildlife-watching tourism?
    a. If yes, which wildlife?
    b. If yes, how much do you estimate your members spend annually on travel and lodging for wildlife watching annually per person?
8) How many of your members have viewed the elk in Cataloochee?
9) Do any of your members travel out of state to view elk?
    a. If yes, How many trips/year? Average number of people per trip?
10) What are the potential positive aspects of increasing numbers of elk in your region?
11) Are there potential negative aspects of increasing numbers of elk in your region?
    a. If yes, please describe.
12) Do you have any other observations we have not touched on?

STAKEHOLDER GROUP—NATURAL RESOURCE CONSERVATION GROUPS

1) Describe the stakeholders your group represents; how large is your membership?
2) What is your organization's mission?
3) What services do you offer your members?
4) What western North Carolina counties does your group represent?
5) Does your organization have an official position on the elk herd in western North Carolina? If so, please state your position. (if written, get verbatim)
6) If not, have any of your members brought up the topic of the elk in located in the Cataloochee area?
7) Do your members participate in wildlife watching tourism?
    a. If yes, which wildlife?
    b. If yes, how much do you estimate your members spend annually on travel and lodging for wildlife watching annually per person?
8) How many of your members have viewed the elk in Cataloochee?
9) Do any of your members travel out of state to view elk?
    a. If yes, How many trips/year?
    b. Average number of people per trip?
10) What are the potential positive aspects of increasing numbers of elk in your region?
11) Are there potential negative aspects of increasing numbers of elk in your region?
    a. If yes, please describe.
12) Do you have any other observations we have not touched on?

STAKEHOLDER GROUP—LOCAL GOVERNMENT OFFICIALS

1) What jurisdiction do you serve?
2) How large is the population of that jurisdiction?
3) Are there any elk currently living within your community/county/jurisdiction?
4) Does your local government have any ordinances or resolutions pertaining to wildlife management, hunting, and/or tourism in your jurisdiction?
    a. If yes, please share.
    b. If no, do you think such actions as ordinances or resolutions would be needed if there was the potential for elk to enter your jurisdiction and, if yes, would the governing body support such actions (e.g., ban hunting?)
    c. If no, have any of your citizens brought up the topic of the elk located in the Cataloochee area?
5) Do your citizens participate in wildlife-watching tourism?
6) Are there businesses in town that cater to wildlife-watching tourism?
    a. If yes, please identify one or more.
7) Are any of your citizens hunters?
8) Are there businesses in your town/county that cater to hunters?
    a. If yes, please describe one or more.
9) What are the potential positive aspects of increasing numbers of elk in your region?
10) Are there potential negative aspects of increasing numbers of elk in your region?
    a. If yes, please describe.
11) Do you have any other observations we have not touched on?

APPENDIX B:
SOCIOECONOMIC ASSESSMENT OF PROPOSED STUDY AREAS

To evaluate the suitability of proposed elk study areas, RTI gathered information about population, land use, and economic activity in each study area proposed. First, we gathered land use/land cover data for all the western North Carolina counties (***Figure B-1***). These data were also central to the biological assessment of suitability for the proposed study areas. Areas with relatively low population density, no urban land uses, and a relatively high score (above 0.5) in the NCSU Habitat Suitability Index are shown in yellow in the figure. Three of the areas are adjacent to the existing elk range (shown in red) and have some elk living or spending some time within these areas; others are remote and have no elk currently.

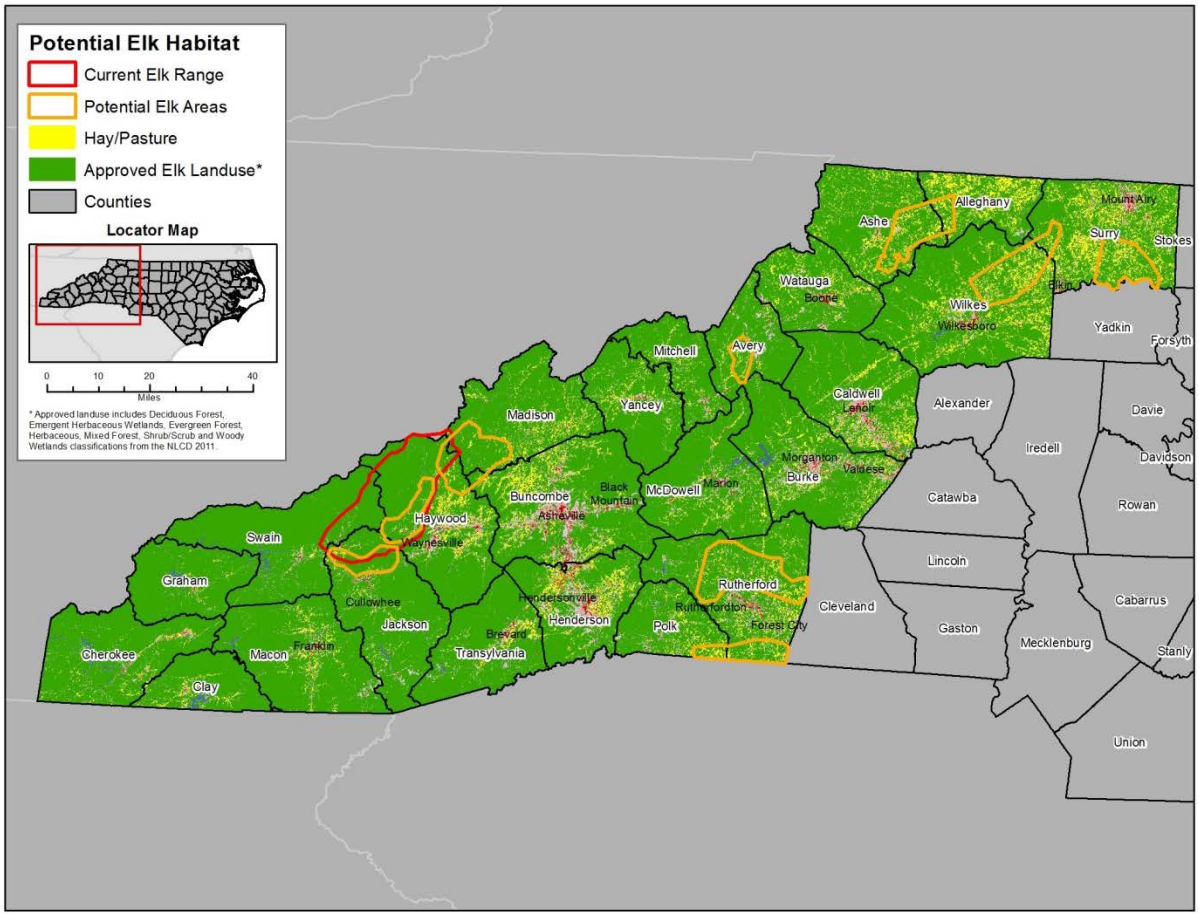


Figure B-1. Land Use/Land Cover in Potential Elk Study Areas, 2011
Source: Multi-Resolution Land Characteristics Consortium, 2011.

After discussion among the team, three areas were discarded because they are too small to support isolated elk populations: the area in Avery County, the area on the South Carolina border in Pitt and Rutherford Counties, and the area in Surry County bordering Yadkin County.

The predominance of hay/pasture land use (private, fairly intensively used farming areas) led us to discard the area spanning Wilkes and Surry Counties. This left five study areas: the three that are adjacent to the current elk range and have some elk already, one crossing a section of Ashe and Alleghany Counties, and one in Rutherford County. (See ***Figure 5-1*** in **Section 5** of

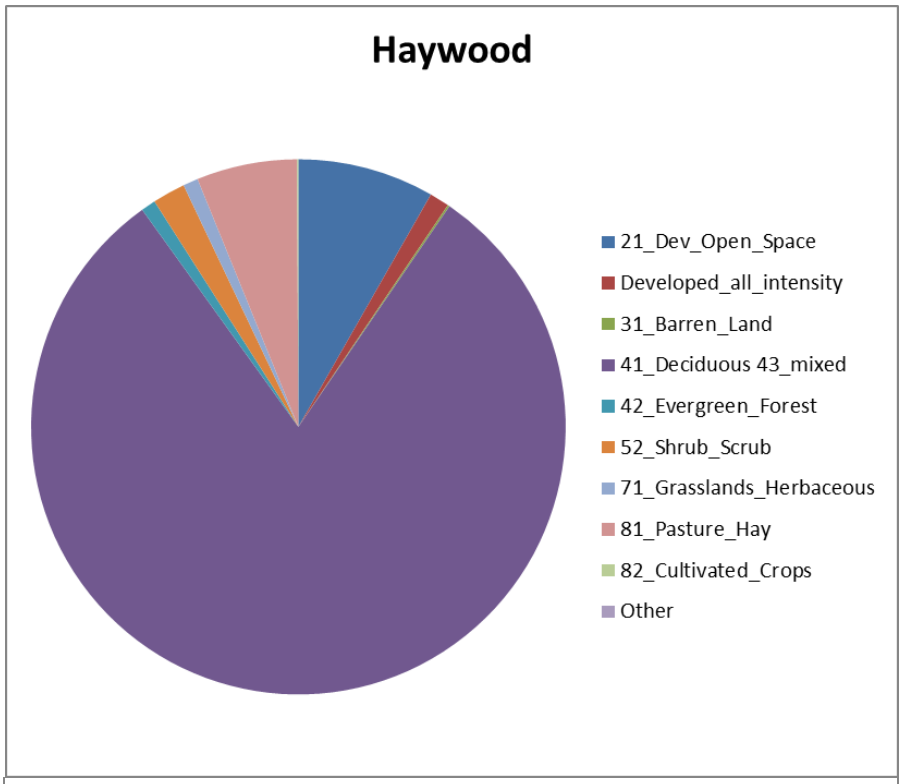
the main report for the location of these study areas.) We examined the land use/land cover pattern in more detail for these study areas, as shown in ***Figure B-2***. Land use and land cover in the study areas adjacent to the existing elk range, where some elk currently spend at least part of their time, is quite similar, with 80% to 85% of land cover being deciduous, evergreen, or mixed forest. In these three study areas, agricultural and developed land uses represent a small share of the land cover. In the other two study areas, however, forest land covers are a much smaller share (between 55% and 60%) of the total, and pasture/hay land uses are a larger share (19% and 28%). This suggests that there is a greater potential for conflict between elk and agricultural uses in the study areas in Alleghany-Ashe and Rutherford Counties.

After conferring with project biologist Dr. Jennifer Murrow and WRC project staff, RTI gathered additional publicly available information to further profile the five selected study areas (***Table B-1***). From the U.S. Census Bureau, we gathered information on population and household income in the counties within which the study areas are located. Rutherford and Haywood Counties had the largest populations in 2010, and Haywood and Madison Counties had higher median household incomes than the other three counties in 2012, and Rutherford and Alleghany Counties had the highest unemployment rates in 2012.

Table B-1. Population and Income, Study Area Counties

County	Population 2010[a]	Population Estimate for 2012[b]	Median Household Income[b] (2012 dollars)	Percentage of the Labor Force Unemployed, 2012
Alleghany	11,155	10,939	32,449	12.4
Ashe	27,281	27,151	35,670	9.9
Haywood	59,036	59,183	42,089	8.6
Jackson	40,271	40,919	36,403	7.4
Madison	20,764	21,022	38,658	7.3
Rutherford	67,810	66,956	35,941	14.8

Source: U.S. Census Bureau. (a) 2010 Census of Population and Housing. (b) 2012 Annual Community Survey.



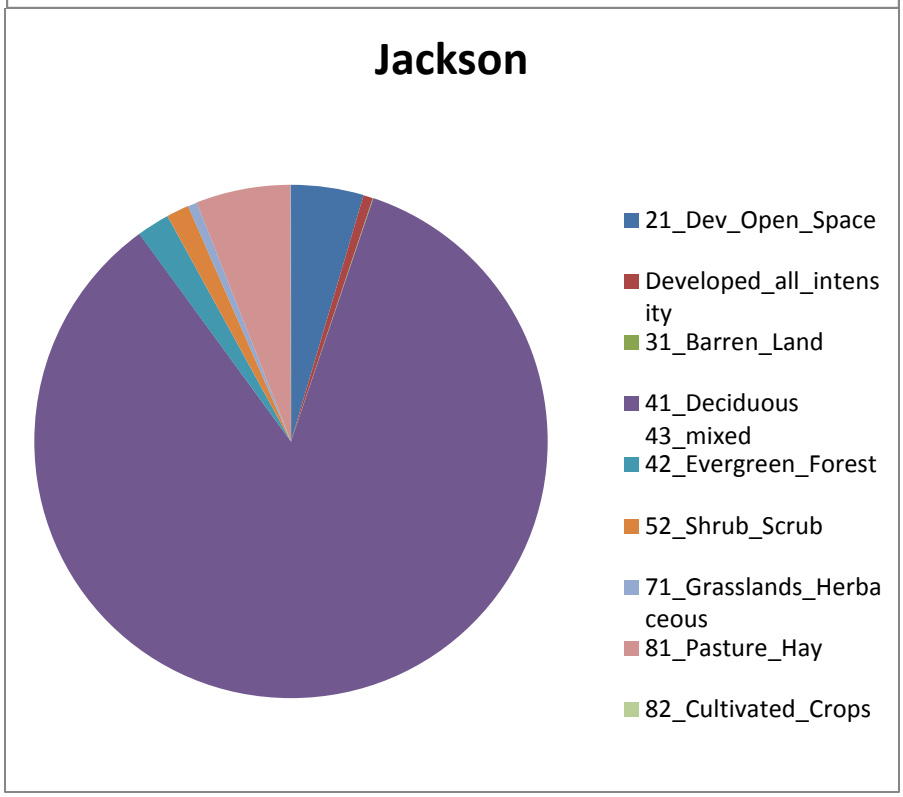


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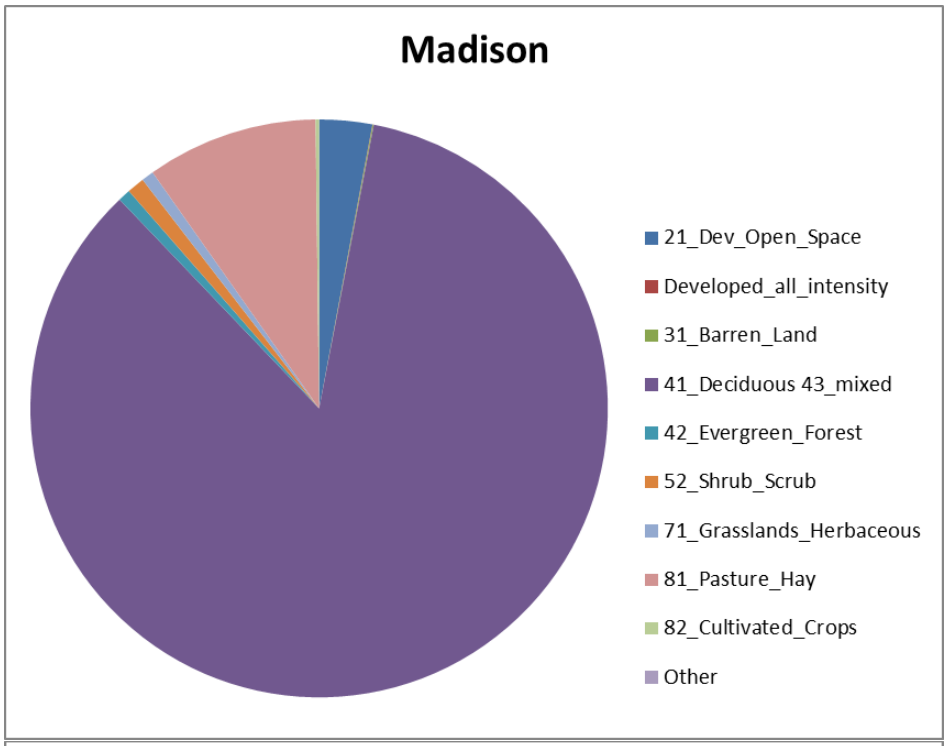
Figure B-2. Land Use/Land Cover in Study Areas, 2011



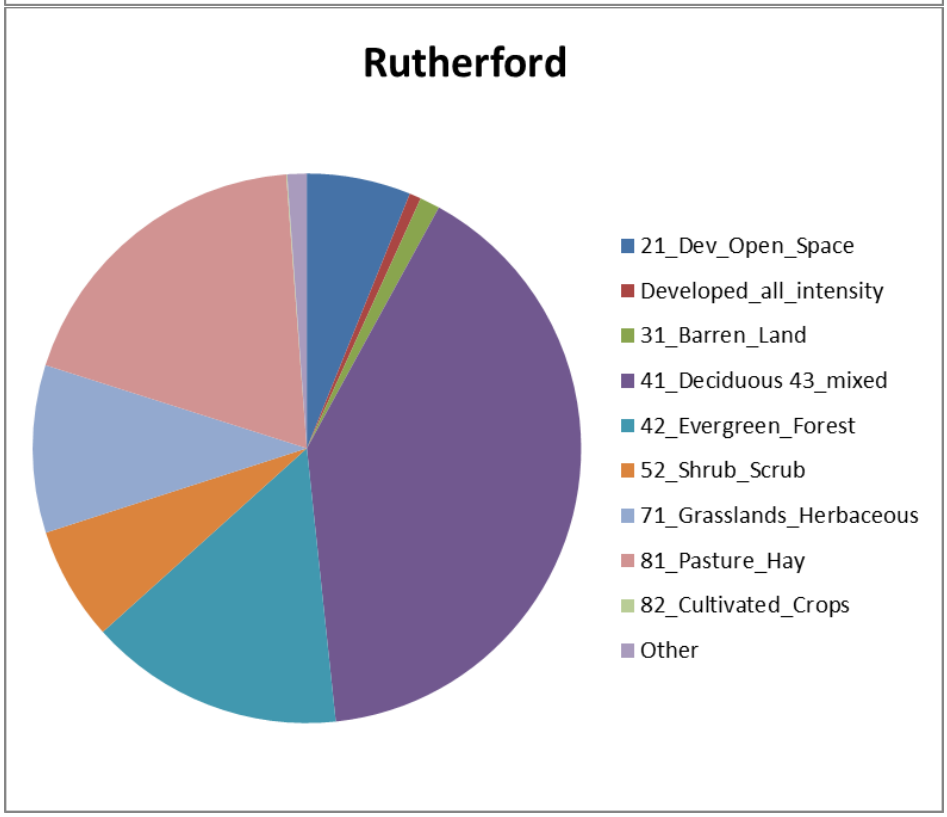


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Figure B-2. Land Use/Land Cover in Study Areas, 2011

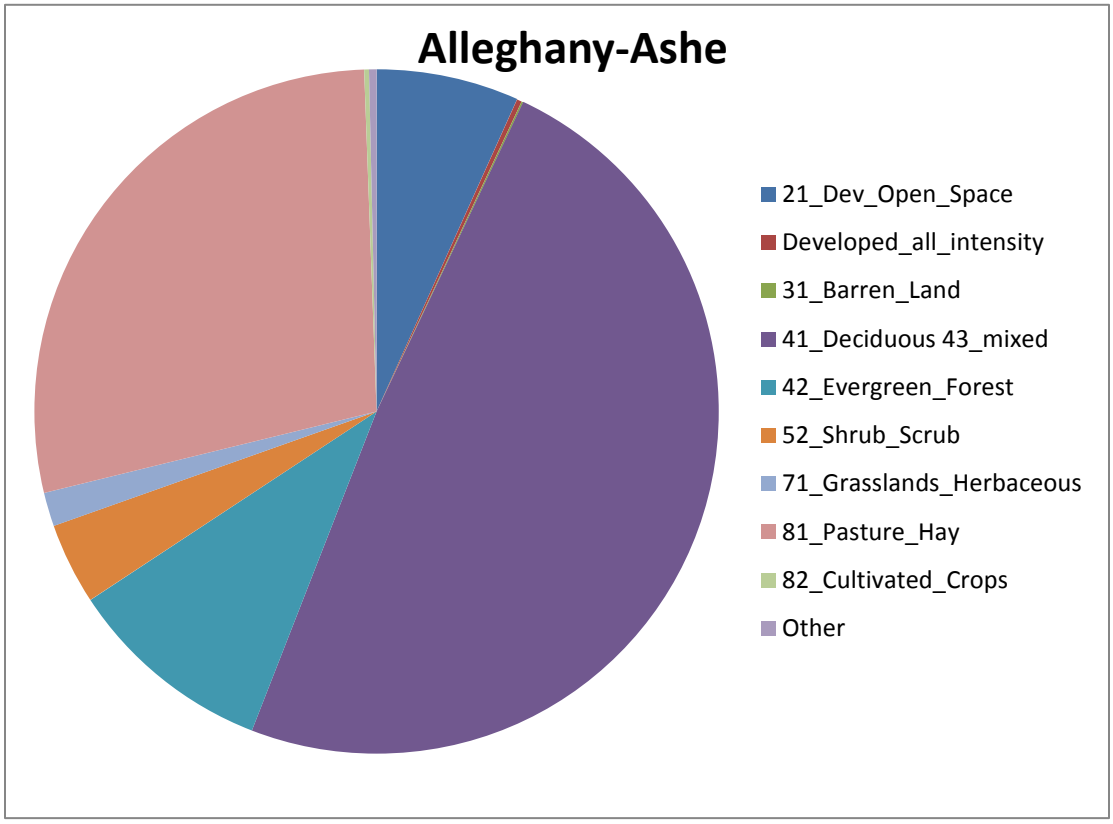

Figure B-2. Land Use/Land Cover in Study Areas, 2011
Source: Multi-Resolution Land Characteristics Consortium, 2011.

Next, we gathered information on projected population growth over the next 25 years to see how populations and population density may change over the length of the study period. ***Table B-2*** shows that the populations of study area counties are projected to grow much slower than the population of the state as a whole. The populations of Alleghany and Rutherford Counties are even projected to decline during at least part of the 2010 to 2030 period. Because population is projected to grow slowly or to decline, we concluded that population density and human land uses are not likely to become significantly less suitable for elk over the 25 years of the project analysis period. Thus, we modeled potential conflicts between elk and the areas' human populations as depending on the size of the elk herd, rather than the size of the human population.

Table B-2. Projected Rates of Population Growth, 2010 to 2029

	Projected Annual Rate of Growth	
County	**2010–2020**	**2020–2029**
Alleghany	−0.07%	0.06%
Ashe	0.09%	0.05%
Haywood	0.43%	0.44%
Jackson	0.37%	0.33%
Madison	0.52%	0.32%
Rutherford	−0.19%	−0.10%
STATE	1.02%	0.92%

Source: North Carolina State Office of Budget and Management, no date.

Data on the study area counties' economies were gathered from the American Community Survey for 2012 (Census, 2013) and show that the industry sector with the highest share of employment in all counties is Education, Health Care, and Social Assistance. Much of this sector represents public-sector (county-level) employment (***Table B-3***). Other sectors with relatively large employment shares include construction and manufacturing.

Table B-3. Industry Share of Employment by County, 2012

	Study Area Counties					
Industry	**Alleghany**	**Ashe**	**Hay-wood**	**Jackson**	**Madison**	**Ruther-ford**
Agriculture, forestry, fishing and hunting, and mining	7.1	5.6	1.2	1.6	1.8	1.1
Construction	15.7	11.9	9.3	10.7	9.3	6.6
Manufacturing	12.3	14.2	11.4	2.2	12.3	18.3
Wholesale trade	2.2	1.3	2.6	0.8	3.0	2.6
Retail trade	9.1	13.9	13.3	10.1	12	14.1
Transportation and warehousing, and utilities	4.6	3.9	4.2	1.9	5.1	4.7
Information	1.8	3.1	0.9	0.4	1.0	1.2
Finance and insurance, and real estate and rental and leasing	2.6	5.3	5.7	3.6	3.9	4.1
Professional, scientific, and management, and administrative and waste management services	6.8	6.0	7.0	6.9	7.6	5.9
Educational services, and health care and social assistance	21.8	20.2	25.2	29.6	28.4	26.2

(continued)

Table B-3. Industry Share of Employment by County, 2012 (continued)

Industry	Study Area Counties					
	Alleghany	Ashe	Hay-wood	Jackson	Madison	Ruther-ford
Arts, entertainment, and recreation, and accommodation and food services	7.7	5.6	10.1	23.2	6.6	6.8
Other services, except public administration	4.5	6.5	4.7	5.0	4.5	5.2
Public administration	3.8	2.5	4.5	4.0	4.5	3.2

Source: U.S. Census Bureau, 2013.

As shown in ***Table B-4***, the Haywood study area is more densely populated than the other four study areas. The Alleghany-Ashe and Madison study areas are very sparsely populated, while the Jackson and Rutherford study areas have intermediate population density.

Table B-4. Study Area Population Density, 2010

Study Area	Study Area Population	Study Area Square Miles	Study Area Population Density (population/square mile)
Haywood	5,312	51.9	102.4
Jackson	4,208	47.9	87.8
Madison	2,741	117.7	23.3
Rutherford	11,447	150.4	76.1
Alleghany-Ashe	4,871	102.6	47.5

Source: Multi-Resolution Land Characteristics Consortium, 2011.

Although education, health care, county government, and manufacturing generally employ more residents in the study area counties, agriculture is still a leading industry. Further, agricultural land uses tend to be among the land uses that are associated with elk-human conflict. We, therefore, gathered information from the Agricultural Census to characterize agriculture in each of the study area counties (***Table B-5***). These data show that Jackson County has both the smallest number of farms and the smallest average farm size. Madison County, however, has the smallest value of agricultural products sold. Only Haywood County gets the majority of its agricultural sales from livestock; the other four counties rely mainly on crops, with Jackson County realizing 94% of its agricultural sales from crops. For two of the counties, Jackson and Ashe, the largest crop in terms of acreage is cut Christmas trees. For the other three, the largest farm acreage is in forage land used for hay. Both hay crops and Christmas trees have the potential to be damaged by elk; hay crops can be trampled and eaten, and round bales left in the field may be damaged or destroyed. Christmas trees may have tender vegetation eaten and may be damaged by male elk rubbing their antlers.

Table B-5. Agricultural Data for Study Area Counties, 2012

County	Number of Farms	Land in Farms (acres)	Average Size (acres)	Market Value of Products Sold	Percentage Crop Sales	Percentage Livestock Sales	Top Crop (acres)
Alleghany	567	90,926	160	$36,340,000	57%	43%	Forage land used for hay
Ashe	1140	112,462	99	$54,480,000	74%	26%	Cut Christmas trees
Haywood	597	48,975	82	$14,125,000	46%	54%	Forage land used for hay
Jackson	245	16,201	66	$8,208,000	94%	6%	Cut Christmas trees
Madison	719	56,282	78	$5,652,000	67%	33%	Forage land used for hay
Rutherford	638	59,540	93	$22,809,000	14%	86%	Forage land used for hay

Source: U.S. Department of Agriculture.

B.2 References

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APPENDIX C:
ELK POPULATION MODEL OUTPUT FOR ALL VIABLE SCENARIOS

C.1 Assuming No Hunting

Table C-1. Elk Population Growth Projection Modeling Results for 25 Years (2039) into the Future

Elk Study Area in Named County	Starting Population Size (Yr 2014)	Growth Rate at Year 25 (Yr 2039)	Std. Deviation	Std. Error	Year Population Reaches K	Extinction Probability in 25th Year (Yr 2039)	Cumulative Extinction Probability Over 25 Years
Haywood	55 (se 5)	**1.033**	0.036	0.001	**29**	**NA**	**NA**
Jackson	8 (se 0)	**1.006**	0.165	0.003	**NA**	**0.001**	**0.018**
Madison	5 (se 0)	**0.977**	0.242	0.008	**NA**	**0.009**	**0.048**
Alleghany-Ashe	5 (se 0)	**0.447**	0.504	0.010	**NA**	**0.0352**	**0.532**
Alleghany-Ashe	8 (se 0)	**0.510**	0.500	0.010	**NA**	**0.023**	**0.488**
Alleghany-Ashe	55 (se 5)	**0.900**	0.203	0.004	**NA**	**0.032**	**0.160**
Rutherford	55 (se 5) [a]	**0.875**	0.269	0.005	**NA**	**0.034**	**0.362**

[a] Simulations with the smaller starting populations were not viable for Rutherford County.

K = carrying capacity

se = standard error

NA = not applicable

Table C-2. Elk Population Growth Projection Modeling Results for 50 Years (2064) into the Future

Elk Study Area in Named County	Starting Population Size (Yr 2014)	Growth Rate at Year 50 (Yr 2064)	Std. Deviation	Std. Error	Extinction Probability in 50th Year (Yr 2064)	Cumulative Probability of Extinction Over 50 Years
Haywood	55 (se 5)	**1.035**	0.025	0.001	**0.000**	**0.000**
Jackson	8 (se 0)	**0.975**	0.243	0.005	**0.001**	**0.054**
Madison	5 (se 0)	**0.947**	0.291	0.009	**0.002**	**0.082**
Alleghany-Ashe	5 (se 0)	**0.099**	0.297	0.006	**0.005**	**0.896**
Alleghany-Ashe	8 (se 0)	**0.132**	0.339	0.007	**0.007**	**0.861**
Alleghany-Ashe	55 (se 5)	**0.535**	0.491	0.010	**0.014**	**0.722**
Rutherford	55 (se 5)	**0.285**	0.453	0.009	**0.004**	**0.922**

se = standard error

Table C-3. Elk Population Size and Sex Ratio for Year 25 (2039) Assuming No Hunting

Elk Study Analysis Area in Named County	Starting Population Size (Yr 2014)	Total Population in 25 Years (Yr 2039)	Std. Deviation	Std. Error	Total Males	Std. Deviation	Std. Error	Total Females	Std. Deviation	Std. Error
Haywood	55 (se 5)	**192.277**	66.967	1.339	**110.247**	34.900	0.698	**82.030**	34.809	0.696
Jackson	8 (se 0)	**37.240**	23.475	0.470	**21.168**	12.789	0.256	**16.072**	11.732	0.235
Madison	5 (se 0)	**29.696**	19.994	0.632	**16.793**	10.973	0.347	**12.903**	10.000	0.316
Alleghany-Ashe	5 (se 0)	**2.248**	3.699	0.074	**1.271**	2.039	0.041	**0.977**	1.963	0.039
Alleghany-Ashe	8 (se 0)	**2.815**	4.227	0.085	**1.574**	2.311	0.046	**1.241**	2.227	0.045
Alleghany-Ashe	55 (se 5)	**15.177**	10.170	0.203	**8.730**	5.811	0.116	**6.447**	5.159	0.103
Rutherford	55 (se 5)	**8.591**	6.341	0.127	**4.844**	3.636	0.073	**3.747**	3.423	0.068

se = standard error

C.2 Assuming Specific Hunting Scenarios

Table C-4. Elk Population Growth Projection Modeling Results for 25 Years (2039) into the Future Assuming There Is Hunting

Elk Study Analysis Area in Named County	Starting Population Size (Yr 2014)	Hunting Regime	Growth Rate at Year 25 (Yr 2039)	Std. Deviation	Std. Error	Year Population Reaches K	Extinction Probability in 25th Year (Yr 2039)	Cumulative Extinction Probability over 25 Years
Haywood	55 (se 5)	4 quota: 100% Male*	**1.045**	NA	NA	36	NA	NA
Haywood	55 (se 5)	4 quota: 80% Male:20% Female	**1.006**	0.072	0.002	NA	0.014	0.176
Haywood	55 (se 5)	4 quota: 50% Male:50% Female	**0.481**	0.43051	0.009	NA	0.05	0.402
Haywood	55 (se 5)	6 quota: 100% Male*	**1.049**	NA	NA	38	NA	NA
Haywood	55 (se 5)	6 quota: 80% Male:20% Female	**1.011**	0.062	0.002	44	0.001	0.774
Haywood	55 (se 5)	10 quota: 100% Male*	**NA**[a]	NA	NA	NA	NA	NA
Haywood	55 (se 5)	10 quota: 80% Male:20% Female	**NA**[b]	NA	NA	NA	NA	NA

* Ran (all M) deterministically: no standard deviation (SD)/standard error (SE)

[a] All males dead by Year 3

[b] Extinction by 13th year (Yr 2027)

NA = not applicable

SE = standard error

Table C-5. Elk Population Growth Projection Modeling Results for 50 Years (2064) into the Future Assuming There Is Hunting

Elk Study Analysis Area in Named County	Starting Population Size (Yr 2014)	Hunting Regime	Growth Rate at Year 50 (Yr 2064)	Std. Deviation	Std. Error	Extinction Probability in 50th Year (Yr 2064)	Cumulative Extinction Probability at 50 Years
Haywood	55 (se 5)	4 quota: 100% male	**1.039**	NA	NA	NA	NA
Haywood	55 (se 5)	4 quota: 80% male:20% female	**1.022**	0.067	0.002	0.005	0.379
Haywood	55 (se 5)	4 quota: 50:50	**0.074**	0.255	0.005	0.005	0.919
Haywood	55 (se 5)	6 quota: 100% male	**1.042**	NA	NA	NA	NA
Haywood	55 (se 5)	6 quota: 80% male:20% female	**1.030**	0.042	0.002	0.001	0.773
Haywood	55 (se 5)	10 quota: 100% male	**NA**	NA	NA	NA	NA
Haywood	55 (se 5)	10 quota: 80% male:20%	**NA**	NA	NA	NA	NA

NA = not applicable

se = standard error

Table C-6. Elk Population Size and Sex Ratio for Year 25 (2039) Assuming There Is Hunting

Elk Study Analysis Area in Named County	Starting Population Size (Yr 2014)	Hunting Regime	Total Population at 25 Years (Yr 2039)	Std. Deviation	Std. Error	Total Males	Std. Deviation	Std. Error	Total Females	Std. Deviation	Std. Error
Haywood	55 (se 5)	4 quota: 100% male	**142.000**	NA	NA	**67.517**	NA	NA	**74.765**	NA	NA
Haywood	55 (se 5)	4 quota: 80% male:20%	**90.285**	53.897	1.188	**44.233**	28.372	0.625	**46.053**	27.255	0.601
Haywood	55 (se 5)	4 quota: 50% male:50% female	**30.476**	28.039	0.561	**18.601**	15.772	0.315	**11.875**	12.702	0.254
Haywood	55 (se 5)	6 quota: 100% male	**120.211**	NA	NA	**45.447**	NA	NA	**74.765**	NA	NA
Haywood	55 (se 5)	6 quota: 80% male:20%	**94.576**	47.058	10.217	**41.000**	22.879	5.160	**53.576**	26.170	5.138
Haywood	55 (se 5)	10 quota: 100% male	**NA**	NA	NA	**NA**	NA	NA	**NA**	NA	NA
Haywood	55 (se 5)	10 quota: 80% male:20%	**NA**	NA	NA	**NA**	NA	NA	**NA**	NA	NA

NA = not applicable

se = standard error

Table C-7. Elk Population Size for Year 50 (2064) Assuming There Is Hunting

Elk Study Analysis Area in Named County	Starting Population Size (Yr 2014)	Hunting Regime	Total Population at 50 Years (Yr 2064)	Std. Deviation	Std. Error
Haywood	55 (se 5)	4 quota: 100% Male	**393.949**	NA	NA
Haywood	55 (se 5)	4 quota: 80% Male:20% Female	**242.254**	197.039	5.047
Haywood	55 (se 5)	4 quota: 50% Male:50% Female	**105.188**	46.447	0.929
Haywood	55 (se 5)	6 quota: 100% Male	**374.911**	NA	NA
Haywood	55 (se 5)	6 quota: 80% Male:20% Female	**281.639**	243.506	10.217
Haywood	55 (se 5)	10 quota: 100% Male	**NA**	NA	NA
Haywood	55 (se 5)	10 quota: 80% Male:20% Female	**NA**	NA	NA

NA = not applicable

se = standard error

APPENDIX D:
ECONOMIC ANALYSIS MODEL OUTPUT FOR ALL VIABLE SCENARIOS

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
					Low Impacts						
Haywood, no hunting											
2019	82	1	1	0	1	1	1	0	0	1	6
2024	105	1	1	0	1	1	1	1	1	1	8
2029	128	2	2	1	2	1	2	1	1	2	14
2034	158	2	2	1	2	1	2	1	1	2	14
2039	192	3	3	1	3	1	3	1	1	3	19
2064	525	8	8	2	8	4	8	3	3	8	52
Haywood, 4 permits, all male											
2019	65	1	1	0	1	0	1	0	0	1	5
2024	76	1	1	0	1	1	1	0	0	1	6
2029	90	1	1	0	1	1	1	0	1	1	7
2034	114	2	2	0	2	1	2	1	1	2	13
2039	142	2	2	1	2	1	2	1	1	2	14
2064	394	6	6	2	6	3	6	2	2	6	39
Haywood, 4 permits, 80/20											
2019	61	1	1	0	1	0	1	0	0	1	5
2024	63	1	1	0	1	0	1	0	0	1	5
2029	67	1	1	0	1	0	1	0	0	1	5
2034	76	1	1	0	1	1	1	0	0	1	6
2039	90	1	1	0	1	1	1	0	1	1	7
2064	242	3	3	1	3	2	3	1	1	3	20
Haywood, 4 permits, 50/50											
2019	57	1	1	0	1	0	1	0	0	1	5
2024	49	1	1	0	1	0	1	0	0	1	5
2029	37	1	1	0	1	0	1	0	0	1	5
2034	26	0	0	0	0	0	0	0	0	0	0
2039	30	0	0	0	0	0	0	0	0	0	0
2064	105	2	2	0	2	1	2	1	1	2	13

(continued)

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas (continued)

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
					Low Impacts						
Haywood, 6 permits, all male											
2019	56	1	1	0	1	0	1	0	0	1	5
2024	61	1	1	0	1	0	1	0	0	1	5
2029	71	1	1	0	1	1	1	0	0	1	6
2034	91	1	1	0	1	1	1	0	1	1	7
2039	120	2	2	1	2	1	2	1	1	2	14
2064	375	5	5	2	5	3	5	2	2	5	34
Haywood, 6 permits, 80/20											
2019	53	1	1	0	1	0	1	0	0	1	5
2024	53	1	1	0	1	0	1	0	0	1	5
2029	61	1	1	0	1	0	1	0	0	1	5
2034	76	1	1	0	1	1	1	0	0	1	6
2039	95	1	1	0	1	1	1	0	1	1	7
2064	282	4	4	1	4	2	4	1	2	4	26
Jackson, no hunting											
Low Estimated Impact Incidents											
2019	12	0	0	0	0	0	0	0	0	0	0
2024	18	0	0	0	0	0	0	0	0	0	0
2029	24	0	0	0	0	0	0	0	0	0	0
2034	29	0	0	0	0	0	0	0	0	0	0
2039	37	1	1	0	1	0	1	0	0	1	5
2064	109	2	2	0	2	1	2	1	1	2	13
High Estimated Impact Incidents											
2019	12	1	1	1	1	1	0	0	1	0	6
2024	18	1	1	1	1	1	1	1	1	0	8
2029	24	1	1	1	2	2	1	1	1	0	10
2034	29	1	1	1	2	2	1	1	1	0	10
2039	37	2	2	2	2	3	1	1	2	1	16
2064	109	5	5	5	7	8	3	3	5	2	43

(continued)

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas (continued)

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
					Low Impacts						
Madison, no hunting											
Low Estimated Impact Incidents											
2019	9	0	0	0	0	0	0	0	0	0	0
2024	14	0	0	0	0	0	0	0	0	0	0
2029	18	0	0	0	0	0	0	0	0	0	0
2034	23	0	0	0	0	0	0	0	0	0	0
2039	30	0	0	0	0	0	0	0	0	0	0
2064	92	1	1	0	1	1	1	0	1	1	7
High Estimated Impact Incidents											
2019	9	0	0	0	1	1	0	0	0	0	2
2024	14	1	1	1	1	1	0	0	1	0	6
2029	18	1	1	1	1	1	1	1	1	0	8
2034	23	1	1	1	1	2	1	1	1	0	9
2039	30	1	1	1	2	2	1	1	1	0	10
2064	92	4	4	4	6	7	3	3	4	1	36
Alleghany-Ashe, no hunting											
Low Estimated Impact Incidents											
2019	49	1	1	0	1	0	1	0	0	1	5
2024	37	1	1	0	1	0	1	0	0	1	5
2029	28	0	0	0	0	0	0	0	0	0	0
2034	21	0	0	0	0	0	0	0	0	0	0
2039	15	0	0	0	0	0	0	0	0	0	0
2064	4	0	0	0	0	0	0	0	0	0	0
High Estimated Impact Incidents											
2019	49	2	2	2	3	3	1	1	2	1	17
2024	37	2	2	2	2	3	1	1	2	1	16
2029	28	1	1	1	2	2	1	1	1	0	10
2034	21	1	1	1	1	1	1	1	1	0	8
2039	15	1	1	1	1	1	0	0	1	0	6
2064	4	0	0	0	0	0	0	0	0	0	0

(continued)

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas (continued)

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
Low Impacts											
Low Estimated Impact Incidents											
2019	42	1	1	0	1	0	1	0	0	1	5
2024	29	0	0	0	0	0	0	0	0	0	0
2029	19	0	0	0	0	0	0	0	0	0	0
2034	13	0	0	0	0	0	0	0	0	0	0
2039	9	0	0	0	0	0	0	0	0	0	0
2064	1	0	0	0	0	0	0	0	0	0	0
High Estimated Impact Incidents											
2019	42	2	2	2	3	3	1	1	2	1	17
2024	29	1	1	1	2	2	1	1	1	0	10
2029	19	1	1	1	1	1	1	1	1	0	8
2034	13	1	1	1	1	1	0	0	1	0	6
2039	9	0	0	0	1	1	0	0	0	0	2
2064	1	0	0	0	0	0	0	0	0	0	0

(continued)

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas (continued)

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
					High Impacts						
Haywood, no hunting											
2019	82	3	3	3	5	6	2	2	3	2	29
2024	105	4	4	4	7	7	3	3	4	2	38
2029	128	5	5	5	8	9	4	4	5	3	48
2034	158	7	7	7	10	11	5	5	7	3	62
2039	192	8	8	8	12	14	5	5	8	4	72
2064	525	23	23	23	34	38	15	15	23	11	205
Haywood, 4 permits, all male											
2019	65	3	3	3	4	5	2	2	3	1	26
2024	76	3	3	3	5	5	2	2	3	2	28
2029	90	4	4	4	6	6	3	3	4	2	36
2034	114	5	5	5	7	8	3	3	5	2	43
2039	142	6	6	6	9	10	4	4	6	3	54
2064	394	17	17	17	25	28	11	11	17	8	151
Haywood, 4 permits, 80/20											
2019	61	3	3	3	4	4	2	2	3	1	25
2024	63	3	3	3	4	5	2	2	3	1	26
2029	67	3	3	3	4	5	2	2	3	1	26
2034	76	3	3	3	5	5	2	2	3	2	28
2039	90	4	4	4	6	6	3	3	4	2	36
2064	242	10	10	10	16	17	7	7	10	5	92
Haywood, 4 permits, 50/50											
2019	57	2	2	2	4	4	2	2	2	1	21
2024	49	2	2	2	3	3	1	1	2	1	17
2029	37	2	2	2	2	3	1	1	2	1	16
2034	26	1	1	1	2	2	1	1	1	1	11
2039	30	1	1	1	2	2	1	1	1	1	11
2064	105	5	5	5	7	8	3	3	5	2	43

(continued)

Table D-1. Estimated Number of Negative Impact Incidents per Year in Western North Carolina Study Areas (continued)

Year	Estimated Number of Elk	Property or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Risk	Fence Damage	Human Risk	Pet Risk	Vehicle Collisions	Total
High Impacts											
Haywood, 6 permits, all male											
2019	56	2	2	2	4	4	2	2	2	1	21
2024	61	3	3	3	4	4	2	2	3	1	25
2029	71	3	3	3	5	5	2	2	3	2	28
2034	91	4	4	4	6	7	3	3	4	2	37
2039	120	5	5	5	8	9	3	3	5	3	46
2064	375	16	16	16	24	27	11	11	16	8	145
Haywood, 6 permits, 80/20											
2019	53	2	2	2	3	4	2	2	2	1	20
2024	53	2	2	2	3	4	2	2	2	1	20
2029	61	3	3	3	4	4	2	2	3	1	25
2034	76	3	3	3	5	5	2	2	3	2	28
2039	95	4	4	4	6	7	3	3	4	2	37
2064	282	12	12	12	18	20	8	8	12	6	108

Table D-2. Cost Values per Negative Impact Incident ($2014)

Type of Incident	Low Value	High Value
Residential ornamental, or lawn damage	$100.00	$400.00
Garden damage	$250.00	$900.00
Hay crop damage	$297.00	$594.00
Row crop damage	$428.75	$857.50
Livestock injured or lost	$175.00	$1,400.00
Fence damage	$2,986.84	$4,966.88
Human chased	None	None
Pet injured or killed	$400.00	$800.00
Vehicle collisions	$15,776.85	$21,345.15

Sources: Residential ornamental/lawn damage: prices of supplies at several home stores and local nurseries. Garden damage: Oregon State University, 2013. Hay crop, row crop damage: USDA, 2014. Fence damage: Edwards and Chamra, 2012. Livestock or pet injured or killed. Veterinarian cost of care estimates: North Carolina Department of Agriculture, 2014 (cattle prices), equine.com website (horse prices), 2014. Vehicle collisions: U.S. Department of Transportation, 2008.

Table D-3. Estimated Annual Costs of Elk Impacts in Western North Carolina Study Areas (Thousand $2014)

Year	Estimated Number of Elk	Residential Ornamental, or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Injured or Lost	Fence Damage	Human Chased	Pet Injured or Killed	Vehicle Collisions	Total
Haywood, 6 permits, all male											
Low Estimate											
2019	56	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2024	61	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2029	71	$0.1	$0.3	$0.0	$0.4	$0.2	$3.0	$0.0	$0.0	$15.8	$19.8
2034	91	$0.1	$0.3	$0.0	$0.4	$0.2	$3.0	$0.0	$0.4	$15.8	$20.2
2039	120	$0.2	$0.5	$0.3	$0.9	$0.2	$6.0	$0.0	$0.4	$31.6	$40.0
2064	375	$0.5	$1.3	$0.6	$2.1	$0.7	$14.9	$0.0	$0.8	$78.9	$99.8
High Estimated Impact Incidents											
2019	56	$0.8	$1.8	$1.2	$3.4	$5.6	$9.9	$0.0	$1.6	$21.3	$45.7
2024	61	$1.2	$2.7	$1.8	$3.4	$5.6	$9.9	$0.0	$2.4	$21.3	$48.4
2029	71	$1.2	$2.7	$1.8	$4.3	$7.0	$9.9	$0.0	$2.4	$42.7	$72.0
2034	91	$1.6	$3.6	$2.4	$5.1	$9.8	$14.9	$0.0	$3.2	$42.7	$83.3
2039	120	$2.0	$4.5	$3.0	$6.9	$12.6	$14.9	$0.0	$4.0	$64.0	$111.9
2064	375	$6.4	$14.4	$9.5	$20.6	$37.8	$54.6	$0.0	$12.8	$170.8	$326.9
Jackson, no hunting											
Low Estimated Impact Incidents											
2019	12	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2024	18	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2029	24	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2034	29	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2039	37	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2064	109	$0.2	$0.5	$0.0	$0.9	$0.2	$6.0	$0.0	$0.4	$31.6	$39.7

(continued)

Table D-3. Estimated Annual Costs of Elk Impacts in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Residential Ornamental, or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Injured or Lost	Fence Damage	Human Chased	Pet Injured or Killed	Vehicle Collisions	Total
Jackson, no hunting (continued)											
High Estimated Impact Incidents											
2019	12	$0.4	$0.9	$0.6	$0.9	$1.4	$0.0	$0.0	$0.8	$0.0	$5.0
2024	18	$0.4	$0.9	$0.6	$0.9	$1.4	$5.0	$0.0	$0.8	$0.0	$9.9
2029	24	$0.4	$0.9	$0.6	$1.7	$2.8	$5.0	$0.0	$0.8	$0.0	$12.2
2034	29	$0.4	$0.9	$0.6	$1.7	$2.8	$5.0	$0.0	$0.8	$0.0	$12.2
2039	37	$0.8	$1.8	$1.2	$1.7	$4.2	$5.0	$0.0	$1.6	$21.3	$37.6
2064	109	$2.0	$4.5	$3.0	$6.0	$11.2	$14.9	$0.0	$4.0	$42.7	$88.3
Madison, no hunting											
Low estimated Impact Incidents											
2019	9	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2024	14	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2029	18	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2034	23	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2039	30	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2064	92	$0.1	$0.3	$0.0	$0.4	$0.2	$3.0	$0.0	$0.4	$15.8	$20.2
High Estimated Impact Incidents											
2019	9	$0.0	$0.0	$0.0	$0.9	$1.4	$0.0	$0.0	$0.0	$0.0	$2.3
2024	14	$0.4	$0.9	$0.6	$0.9	$1.4	$0.0	$0.0	$0.8	$0.0	$5.0
2029	18	$0.4	$0.9	$0.6	$0.9	$1.4	$5.0	$0.0	$0.8	$0.0	$9.9
2034	23	$0.4	$0.9	$0.6	$0.9	$2.8	$5.0	$0.0	$0.8	$0.0	$11.3
2039	30	$0.4	$0.9	$0.6	$1.7	$2.8	$5.0	$0.0	$0.8	$0.0	$12.2
2064	92	$1.6	$3.6	$2.4	$5.1	$9.8	$14.9	$0.0	$3.2	$21.3	$62.0

(continued)

Table D-3. Estimated Annual Costs of Elk Impacts in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Residential Ornamental, or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Injured or Lost	Fence Damage	Human Chased	Pet Injured or Killed	Vehicle Collisions	Total
Alleghany-Ashe, no hunting											
Low Estimated Impact Incidents											
2019	49	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2024	37	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2029	28	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2034	21	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2039	15	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2064	4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
High Estimated Impact Incidents											
2019	49	$0.8	$1.8	$1.2	$2.6	$4.2	$5.0	$0.0	$1.6	$21.3	$38.5
2024	37	$0.8	$1.8	$1.2	$1.7	$4.2	$5.0	$0.0	$1.6	$21.3	$37.6
2029	28	$0.4	$0.9	$0.6	$1.7	$2.8	$5.0	$0.0	$0.8	$0.0	$12.2
2034	21	$0.4	$0.9	$0.6	$0.9	$1.4	$5.0	$0.0	$0.8	$0.0	$9.9
2039	15	$0.4	$0.9	$0.6	$0.9	$1.4	$0.0	$0.0	$0.8	$0.0	$5.0
2064	4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Rutherford, no hunting											
Low Estimated Impact Incidents											
2019	42	$0.1	$0.3	$0.0	$0.4	$0.0	$3.0	$0.0	$0.0	$15.8	$19.5
2024	29	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2029	19	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2034	13	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2039	9	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2064	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

(continued)

Table D-3. Estimated Annual Costs of Elk Impacts in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Residential Ornamental, or Lawn Damage	Garden Damage	Hay Crop Damage	Row Crop Damage	Livestock Injured or Lost	Fence Damage	Human Chased	Pet Injured or Killed	Vehicle Collisions	Total
Rutherford, no hunting (continued)											
High Estimated Impact Incidents											
2019	42	$0.8	$1.8	$1.2	$2.6	$4.2	$5.0	$0.0	$1.6	$21.3	$38.5
2024	29	$0.4	$0.9	$0.6	$1.7	$2.8	$5.0	$0.0	$0.8	$0.0	$12.2
2029	19	$0.4	$0.9	$0.6	$0.9	$1.4	$5.0	$0.0	$0.8	$0.0	$9.9
2034	13	$0.4	$0.9	$0.6	$0.9	$1.4	$0.0	$0.0	$0.8	$0.0	$5.0
2039	9	$0.0	$0.0	$0.0	$0.9	$1.4	$0.0	$0.0	$0.0	$0.0	$2.3
2064	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0

Table D-4. Estimated Annual Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Haywood, 6 permits, all male				
Low Estimate				
2019	56	$134.1	$45.7	$88.4
2024	61	$140.3	$48.4	$91.9
2029	71	$146.8	$72.0	$74.9
2034	91	$153.7	$83.3	$70.4
2039	120	$160.8	$111.9	$48.9
2064	375	$201.9	$326.9	−$125.0
High Estimated Impact Incidents				
2019	56	$1,137.1	$19.5	$1,117.5
2024	61	$1,190.4	$19.5	$1,170.9
2029	71	$1,246.2	$19.8	$1,226.5
2034	91	$1,304.7	$20.2	$1,284.5
2039	120	$1,365.9	$40.0	$1,325.9
2064	375	$1,717.9	$99.8	$1,618.1
Jackson, no hunting				
Low Estimated Impact Incidents				
2019	12	$132.1	$5.0	$127.2
2024	18	$138.4	$9.9	$128.4
2029	24	$144.9	$12.2	$132.7
2034	29	$151.7	$12.2	$139.5
2039	37	$158.8	$37.6	$121.2
2064	109	$199.9	$88.3	$111.6
High Estimated Impact Incidents				
2019	12	$1,132.6	$0.0	$1,132.6
2024	18	$1,185.9	$0.0	$1,185.9
2029	24	$1,241.7	$0.0	$1,241.7
2034	29	$1,300.2	$0.0	$1,300.2
2039	37	$1,361.4	$19.5	$1,341.9
2064	109	$1,713.4	$39.7	$1,673.7
Madison, no hunting				
Low Estimated Impact Incidents				
2019	9	$132.1	$2.3	$129.9
2024	14	$138.4	$5.0	$133.4
2029	18	$144.9	$9.9	$135.0
2034	23	$151.7	$11.3	$140.4
2039	30	$158.8	$12.2	$146.7
2064	92	$199.9	$62.0	$137.9

(continued)

Table D-4. Estimated Annual Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Madison, no hunting (continued)				
High Estimated Impact Incidents				
2019	9	$1,132.6	$0.0	$1,132.6
2024	14	$1,185.9	$0.0	$1,185.9
2029	18	$1,241.7	$0.0	$1,241.7
2034	23	$1,300.2	$0.0	$1,300.2
2039	30	$1,361.4	$0.0	$1,361.4
2064	92	$1,713.4	$20.2	$1,693.3
Alleghany-Ashe, no hunting				
Low Estimated Impact Incidents				
2019	49	$196.5	$38.5	$158.0
2024	37	$157.3	$37.6	$119.6
2029	28	$122.5	$12.2	$110.3
2034	21	$96.2	$9.9	$86.2
2039	15	$73.7	$5.0	$68.7
2064	4	$0.0	$0.0	$0.0
High Estimated Impact Incidents				
2019	49	$1,684.4	$19.5	$1,664.8
2024	37	$1,347.9	$19.5	$1,328.4
2029	28	$1,049.7	$0.0	$1,049.7
2034	21	$824.3	$0.0	$824.3
2039	15	$631.5	$0.0	$631.5
2064	4	$0.0	$0.0	$0.0
Rutherford, no hunting				
Low Estimated Impact Incidents				
2019	42	$165.2	$38.5	$126.7
2024	29	$119.3	$12.2	$107.1
2029	19	$83.5	$9.9	$73.6
2034	13	$58.8	$5.0	$53.8
2039	9	$41.0	$2.3	$38.7
2064	1	$0.0	$0.0	$0.0
High Estimated Impact Incidents				
2019	42	$1,415.8	$19.5	$1,396.3
2024	29	$1,022.4	$0.0	$1,022.4
2029	19	$716.0	$0.0	$716.0
2034	13	$503.6	$0.0	$503.6
2039	9	$351.4	$0.0	$351.4
2064	1	$0.0	$0.0	$0.0

(continued)

Table D-4. Estimated Annual Net Benefits of Elk in Western North Carolina Study Areas (Thousand $2014) (continued)

Year	Estimated Number of Elk	Benefits	Costs	Net Benefits
Statewide total net benefits, including Haywood 6 permits, all male				
Low Estimated Impact Incidents				
2019	168	$760.1	$129.9	$630.2
2024	159	$693.6	$113.1	$580.5
2029	159	$642.6	$116.2	$526.4
2034	178	$612.0	$121.7	$490.3
2039	211	$593.1	$168.9	$424.3
2064	581	$601.7	$477.1	$124.6
High Estimated Impact Incidents				
2019	168	$6,502.5	$58.6	$6,443.9
2024	159	$5,932.6	$39.1	$5,893.5
2029	159	$5,495.4	$19.8	$5,475.6
2034	178	$5,233.0	$20.2	$5,212.8
2039	211	$5,071.6	$59.6	$5,012.0
2064	581	$5,144.8	$159.7	$4,985.1

Table D-5. Examination of Estimated Annual Net Benefits for Alternative Hunting Scenarios for Haywood Study Area, (Thousand $2014)

Year	Estimated Number of Elk	Negative Incidents	Estimated Costs
	Low Estimate		
No hunting			
2019	82	6	$19.8
2024	105	8	$20.2
2029	128	14	$40.0
2034	158	14	$40.0
2039	192	19	$59.6
2064	525	52	$159.1
4 permits, all male			
2019	65	5	$19.5
2024	76	6	$19.8
2029	90	7	$20.2
2034	114	13	$39.7
2039	142	14	$40.0
2064	394	39	$119.3
4 permits, 80% male, 20% female			
2019	61	5	$19.5
2024	63	5	$19.5
2029	67	5	$19.5
2034	76	6	$19.8
2039	90	7	$20.2
2064	242	20	$59.8
4 permits, 50% male, 50% female			
2019	57	5	$19.5
2024	49	5	$19.5
2029	37	5	$19.5
2034	26	0	$0.0
2039	30	0	$0.0
2064	105	13	$39.7
6 permits, all male			
2019	56	5	$19.5
2024	61	5	$19.5
2029	71	6	$19.8
2034	91	7	$20.2
2039	120	14	$40.0
2064	375	34	$99.8
6 permits, 80% male, 20% female			
2019	53	5	$19.5
2024	53	5	$19.5
2029	61	5	$19.5
2034	76	6	$19.8
2039	95	7	$20.2
2064	282	26	$79.7

(continued)

Table D-5. Examination of Estimated Annual Net Benefits for Alternative Hunting Scenarios for Haywood Study Area (Thousand $2014) (continued)

Year	Estimated Number of Elk	Negative Incidents	Estimated Costs
	High Estimate		
No hunting			
2019	82	29	$73.4
2024	105	38	$84.2
2029	128	48	$116.8
2034	158	62	$131.7
2039	192	72	$161.7
2064	525	205	$453.6
4 permits, all male			
2019	65	26	$49.8
2024	76	28	$72.0
2029	90	36	$81.9
2034	114	43	$88.3
2039	142	54	$121.8
2064	394	151	$331.8
4 permits, 80% male, 20% female			
2019	61	25	$48.4
2024	63	26	$49.8
2029	67	26	$49.8
2034	76	28	$72.0
2039	90	36	$81.9
2064	242	92	$206.0
4 permits, 50% male, 50% female			
2019	57	21	$45.7
2024	49	17	$38.5
2029	37	16	$37.6
2034	26	11	$33.5
2039	30	11	$33.5
2064	105	43	$88.3
6 permits, all male			
2019	56	21	$45.7
2024	61	25	$48.4
2029	71	28	$72.0
2034	91	37	$83.3
2039	120	46	$111.9
2064	375	145	$326.9
6 permits, 80% male, 20% female			
2019	53	20	$44.8
2024	53	20	$44.8
2029	61	25	$48.4
2034	76	28	$72.0
2039	95	37	$83.3
2064	282	108	$243.6

(continued)

Table D-5. Examination of Estimated Annual Net Benefits for Alternative Hunting Scenarios for Haywood Study Area (Thousand $2014) (continued)

Year	Low	High
Estimated Net Benefits		
2019	$58.7	$1,112.8
2024	$54.2	$1,165.7
2029	$28.0	$1,201.7
2034	$20.0	$1,260.2
2039	−$2.8	$1,301.8
2064	−$253.7	$1,554.4
4 permits, all male		
2019	$83.7	$1,116.0
2024	$67.7	$1,169.1
2029	$64.3	$1,224.6
2034	$64.7	$1,263.5
2039	$38.4	$1,324.4
2064	−$130.6	$1,597.1
4 permits, 80% male, 20% female		
2019	$85.1	$1,116.0
2024	$89.9	$1,169.4
2029	$96.4	$1,225.2
2034	$81.0	$1,283.4
2039	$78.2	$1,344.2
2064	−$4.7	$1,656.7
4 permits, 50% male, 50% female		
2019	$87.8	$1,116.0
2024	$101.2	$1,169.4
2029	$108.6	$1,225.2
2034	$119.5	$1,303.2
2039	$126.6	$1,364.4
2064	$113.0	$1,676.7

(continued)

Table D-5. Examination of Estimated Annual Net Benefits of Alternative Hunting Scenarios for Haywood Study Area (Thousand $2014) (continued)

Year	Low	High
6 permits, all male		
2019	$88.4	$1,117.5
2024	$91.9	$1,170.9
2029	$74.9	$1,226.5
2034	$70.4	$1,284.5
2039	$48.9	$1,325.9
2064	−$125.0	$1,618.1
6 permits, 80% male, 20% female		
2019	$89.3	$1,117.5
2024	$95.5	$1,170.9
2029	$98.5	$1,226.7
2034	$81.7	$1,284.9
2039	$77.5	$1,345.7
2064	−$41.7	$1,638.2

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