Final Report for Black-tailed Deer Research
Administration for Native Americans
90NR0180

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INTRODUCTION

Past management of black-tailed deer resources has assumed that habitat does not limit the population and that annual harvest rates of adult deer were inconsequential to population growth. These assumptions were questioned as deer harvest was declining and annual spotlight surveys indicated fewer deer than were historically reported. Additionally, a disease called hair slip syndrome was known to be affecting black-tailed deer populations throughout western Washington. The specific objectives of this study were to fill the void in baseline data to improve Tribal management of the black-tailed deer resource.

We captured and radiocollared black-tailed deer over three years both on the Reservation and on industrial timberland adjacent to the Reservation to determine the current status of the deer population and the rate of population growth. The radiocollars were used to provide valuable insight into annual survival rates of adult male and female deer. This information was proposed to be used in conjunction with aerial composition flights and harvest statistics to estimate the deer population and estimate the rate of population growth. A positive rate of population growth would indicate current habitat conditions and harvest management regulations were not limiting the population. A negative rate of population growth would indicate the population was declining and would signal the need for potential changes in hunting regulations and habitat management. Due to a small sample of male deer during the study and the fact that none survived for more than a year, it was impossible to estimate the population through reconstruction. However, we used the female deer and their observed reproductive output to develop a predicted rate of increase (population trend) for female deer within the study area. This was assumed to provide an index of the overall population trend as females are the most important parameter to population growth through reproduction (fawn production).

We also used the radiocollared deer to determine the average home range size and habitat used by black-tailed deer. Black-tailed deer are considered to be a species that thrives in early to midseral vegetation following natural and anthropogenic disturbances. Deer forage is most abundant for the first 10-15 years following disturbance such as logging, then as forest stands mature desirable forage species are shaded out and the value of the stands to deer decline. Deer are also reported to require cover for security and thermal benefits, allowing deer to expend less energy to regulate body temperature, and making more energy available for growth and reproduction (B.C. Ministry of Forests 1990). Maintaining appropriate cover to forage ratios at the landscape level may be an important consideration to maximize habitat suitability. Additionally, the size and shapes of clearcut harvest units can affect deer use by influencing the distance between forage and cover habitats. As distance from cover increases, deer use of suitable foraging habitat decreases (Reynolds 1966, Thomas et al. 1979). High road density and frequent traffic can also negatively affect deer habitat, causing deer to avoid suitable foraging habitat in areas of high open road density and heavy traffic (B.C. Ministry of Forests 1990).

The aforementioned factors affecting black-tailed deer are general in nature. Very little research has been conducted on habitat use by black-tailed deer. The published accounts generally address preference or avoidance of habitat type designations but do not investigate multiscale habitat selection. Because habitat selection is predicted to occur at a hierarchy of scales (Johnson 1980) we addressed habitat relationships at 2 levels of selection: (1) selection of home ranges from a background habitat mosaic landscape scale and; (2) selection of habitat patches within the home ranges. This analysis would provide local manager with specific information regarding habitats that are important to black-tailed deer populations both at the landscape and home range scales. Additionally, we investigated whether roads had an affect on deer use of available habitat.

The data provided by this study will be used in conjunction with a completed 4 year Roosevelt Elk Project by the Makah Tribe to develop a Deer and Elk Management Plan (DEMP). The DEMP will assess current population and habitat conditions, and establish population and habitat objectives for deer and elk within biologically important landscape planning units on the Makah Reservation. This information will be incorporated into forest management decisions, land use planning and annual hunting regulations. In regards to hunting regulations, the data provided by this study will be used to set both on and off Reservation hunting regulations.

STUDY AREA

The Makah Reservation and a portion of the Hoko Game Management Unit comprise the study area (Fig. 1). The Hoko GMU is located in the extreme northwest section of the Olympic Peninsula. It is bounded to the north by the Makah Reservation, on the south by the Hoko-Ozette Road, on the west by ONP between Ozette and the Makah Reservation, and on the east by the Straight of Juan de Fuca between the Mouth of the Hoko River and the northeast corner of the Makah Reservation. However, the study area within the Hoko GMU is limited to areas within 4 miles south and 8 miles east of the Reservation.

The majority of lands within the Hoko GMU are privately owned industrial timberlands owned by Cascade Timberlands, Inc. The Washington Department of Natural Resources also owns land in the Hoko GMU, of which the largest block is located in the Carpenter Creek area. A minor amount of land within the Hoko is developed either as small residential areas, isolated homes, or small ranching operations (primarily fenced pastureland for livestock grazing). These developments are primarily located along Highway 112 between the mouth of the Hoko River and the Makah Reservation and along the Hoko-Ozette Road.

The majority of lands on the Makah Reservation are also managed for commercial timber production. However, the pace of timber harvest is significantly slower than off Reservation as the average harvest age of stands is 60 to 70 years while off-Reservation timber harvest occurs at around 50 years. Development for residential and commercial

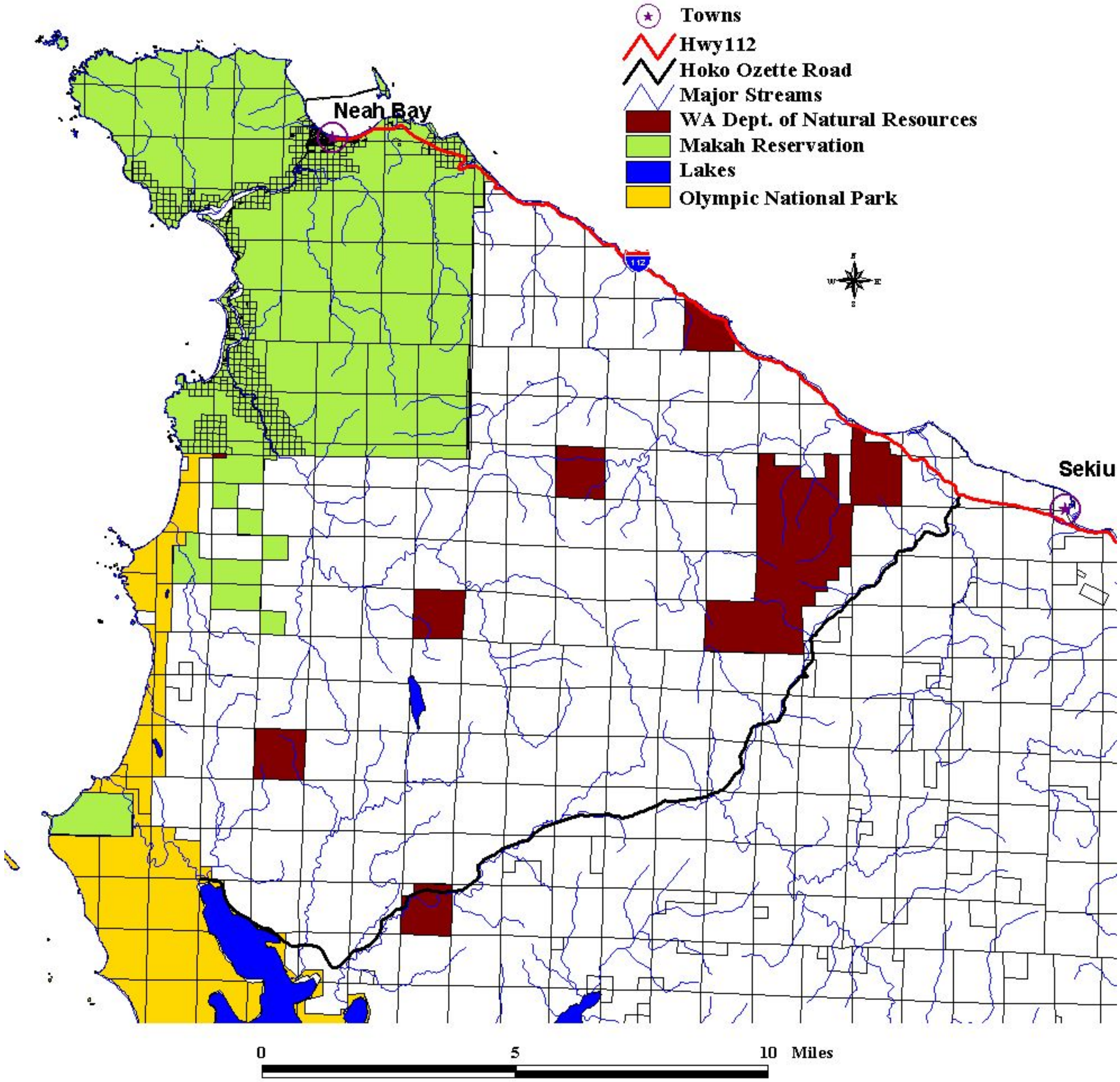


Figure 1. Black-tailed deer study area in Clallam County, WA.

usage on the Reservation is limited to Neah Bay primarily, with scattered homesites located along the west coast between the Waatch and Sooes Rivers.

Intensive timber harvest has converted what was historically extensive old growth to second growth forests with stand conditions ranging from grass-forb following clearcutting to closed-sapling-pole sawtimber (Hall et al. 1985). Timber harvest occurs in second growth stands at 50-70 years, thus, these stands never attain old growth characteristics. The only old growth habitat available to deer is found outside of the Hoko GMU in Olympic National Park (west side) and on the southwest corner of the Makah Reservation.

Within the Hoko GMU, intensive timber harvest has resulted in high road densities. Prior to 1987, the majority of roads on industrial timber lands were open to public access, resulting in reduced deer use of available habitat near heavily traveled roads, increased disturbance of wintering and fawning deer, and increased vulnerability of deer to tribal and state hunting. Since 1987, roads on industrial timberlands have been closed to the public. Tribal and state hunting is allowed, however access is limited to non-motorized transportation from locked gates along Hwy. 112 and the Hoko-Ozette Road. On the Makah Reservation timber harvest has also resulted in high open road densities, however, these roads are not typically gated and deer are potentially exposed to higher levels of disturbance and vulnerability to tribal hunting (state hunting is not allowed).

METHODS

Deer Capture and Collaring

We captured 33 deer (7 males and 26 females) between 3 April 2003 and 22 June 2005. The majority of deer (26) were captured at night utilizing spotlights to locate deer then approaching on foot with portable spotlights in 2 person teams. The remainder (7) was captured during daylight hours. Deer were chemically immobilized with Carfentanil (0.75 mg.) and Xylazine (60 mg.) delivered in 1 c.c. transmitter darts (Pnuedart, Inc., Williamsport, PA). Deer were located after darting by following the radiotransmitter in the dart with directional antennae (Telonics, Tucson, AZ) and telemetry receiver (Communication Specialists, Inc., Orange, CA). Immobilized deer were monitored for respiration and temperature immediately upon locating. Then were fitted with a radiocollar, aged based on tooth replacement (Severinghaus 1949), and injected with antibiotic and penicillin. Finally, the deer were injected with Naltrexone and Tolazine to reverse the immobilizing effects of Carfentanil and Xylazine.

Data Collection

Deer were monitored weekly with a portable receiver, a hand-held 2-element yagi antenna, and omni directional vehicle-mounted antennae to establish home range points. Observers used the “loudest signal method” to determine the direction of radio signals (Springer 1979), and 3-5 compass bearings to locate deer by triangulation (when direct observations were not obtained). Universal Transverse Mercator (UTM) coordinates were assigned to all locations on USGS 1:24000 quadrangle maps in the field, and later entered into a database compatible with Geographic Information System (GIS) software ArcView 3.2 (ESRI, Redlands, CA). To increase location accuracy, the distance between and observers and study animals and the time lapsed between bearing locations were minimized. Additional information recorded was time, weather conditions, group size and composition (visuals), and general habitat type of location. Additional, habitat measurements for each location were determined by projecting the location in the GIS environment to determine distance to roads, cover, and habitat edge and the actual habitat type of location. Azimuth error, which has been reviewed extensively (Garrott et al. 1986, White and Garrot 1986, Zimmerman and Powell 1995), was estimated during field trials. Ground telemetry error was derived by Euclidean distances between estimated and known test transmitters (Zimmerman and Powell 1995). The field trial results were used to determine an acceptable level of error associated with test transmitter locations.

Population Trend

We used a number of different methodologies to determine the trend of the black-tailed deer population within the study area. The radiocollared deer provided the basis for determining the annual survival rate of males and females for 2 annual cycles. The survival rate was estimated for 2003-2004 and 2004-2005 using the staggered entry, Kaplan-Meier estimator, which allows newly radiocollared animals to be added as the study progressed (Pollock et al. 1989). Additionally, the radiocollars provided the basis for determining the cause of death via field necropsy upon recovery of deer. The survival data was used to determine if survival rates within the study area were similar to what was reported for other populations of black-tailed deer in western Washington and to identify potential mortality sources that may be negatively affecting population size.

Helicopter surveys were conducted during each successive year of the study (2003-2005) during the summer to determine the composition of the population. At each observation the number of adult males and females, fawns, and a GPS location was recorded. The helicopter surveys were used to determine the buck:doe and fawn:doe ratios (number of bucks and fawns produced per 100 does). This information was used to determine if deer composition within the study area was similar to that reported for other populations of black-tailed deer in western Washington. Additionally, the composition data provided valuable insight into levels of recruitment into the population from reproduction.

Initially we planned to use the survival rates for both sexes, composition data from helicopter surveys, and harvest statistics to reconstruct the population size during each successive study year and determine the trend of the population. However, the small sample of male deer limited our ability to reconstruct population size. Therefore, we estimated the trend of the population utilizing annual female survival rates and radiocollared female productivity during 2004-2005 (June 2004-May 2005). Female productivity was defined as the number of female fawns that survived to the yearling age class. The female segment of the population was assumed to be the most important factor affecting population growth because females produce young annually, which contributes to population growth or maintenance, while the role of the male is primarily for breeding. The analysis was limited to 2004-2005 since the sample of female deer during the 2003-2004 was only 5. By 2004 we had a sample of 14 female deer. Additionally, the annual survival and productivity rates for 2005-2006 will not be available until May of 2006.

The number of radiocollared female deer surviving the analysis timeframe and the number of female fawns they produced (that survived to the yearling age class) were used to set a initial sample population size (N_0) (subset of the overall population). A model was established where the annual survival rate for adult female deer was applied to the adult females and fawns entering the yearling age class to predict the number of females surviving to the next year (N_1) (2005-2006). The model assumed that annual survival rates remained equivalent to what was observed for 2003-2004 and 2004-2005. Additionally, the model assumed that survival rates for adult and yearling females were the same. Black-tailed deer are reported to have nearly 50-50 sex ratios (Kie et al. 2000) therefore; the number of female fawns entering the yearling age class was determined by dividing the total number of fawns born to radiocollared females that survived to May of 2005 by 2 and a recruitment rate per adult fawn was calculated. The expected number of female fawns to be produced during the subsequent year was determined for the predicted number of surviving adult females from $N_{0.}$ The yearlings that entered the population at N_0 were not predicted to produce young as black-tailed deer do not typically reproduce until 2 year of age (Anderson and Wallmo 1984). However, the model did add the surviving yearlings as adult does available for reproduction at N_2 (2006-2007). The model was used to predict changes in the sample population size from N_0 to N_5 (five years into the future). The model was based on the following variables:

> N_0 = Female population subset at initial year (N_1 would be population subset at year 1)
> N_{at} = Number of adult females in each model year
> N_f = Female fawn recruitment rate
> S_x = Annual survival rate

The model for future years 1 to 5 used the following iterative process:

$$N_1 = N_0S_x + N_fN_{a1}$$
$$N_2 = N_1S_x + N_fN_{a2}$$
$$N_3 = N_2S_x + N_fN_{a3}$$
$$N_4 = N_3S_x + N_fN_{a4}$$
$$N_5 = N_4S_x + N_fN_{a5}$$

The resulting model data was used to estimate the population growth rate by using linear regression (Johnson 1996). The predicted female population size from $N_1 – N_5$ was log transformed and linear regression of the transformed data on the series of years provided the regression coefficient and intercept. The slope was transformed by exponentiating to provide estimates of the rate of population increase. Linear regression as well as all subsequent statistical analysis was performed with Statistix 7 (Analytical Software, Tallahassee, FL)

Home Range Analysis

The home range of deer is defined as the area traversed in its normal activities of food gathering, mating, and caring for young (Burt 1943). The core area within the home range reflects those areas that are more intensively utilized (Hodder et al. 1998). We used the weekly location data gathered to date in the study to characterize the home range and core use areas for black-tailed deer. An important consideration in analysis of this data was sample size. The accuracy of home range estimation is dependent on the number of observations and the sampling interval. A number of locations with small sample intervals will do little to improve accuracy of the estimates. Therefore, for sample size estimates to be reflective of the actual home range size we used a computer simulation which plots the area estimate against sample size to develop an area-observation curve (Gese et al. 1990). We used bootstrapping to generate expected area of home ranges based on increasing sample size. We then plotted the data to determine a minimum sample size required for all subsequent home range and habitat use analysis.

Home range analysis was performed on deer which met the criteria for minimum sample size. All home range and subsequent habitat analysis utilized the Animal Movement (2.5) extension (Hooge et al. 2002) for ArcView for GIS based data processing. Overall home range size was determined using the kernel estimator using the ninety percent utilization contours to remove outlier points or points that represent occasional movements at the periphery of the home range. Kernel estimators are free of distributional assumption, are superior to other nonparametric techniques for determining the utilization distribution, and are a widely used statistical technique (Worton 1995, Seaman and Powell 1996). Core use areas were determined using the kernel estimator using a 50% utilization contours. Core use areas represent more intensively used portions of the overall home range.

Habitat Use

Habitat use analysis was performed on deer which met the criteria for minimum sample size as detailed previously. Analysis was performed to 2 levels of selection: (1) selection of home ranges from a background habitat mosaic landscape scale and; (2) selection of habitat within the home ranges. Additionally, road use has been reported to negatively affect deer use of available habitats (B.C. Ministry of Forests 1990). Therefore, we analyzed the effect of roads on deer habitat use within the home ranges.

Landscape Scale: Landscape level analysis was performed by first determining the proportional availability of habitats within each home range and within a 1.5 Kilometer (Km) area surrounding each home range. The habitat types utilized were clearcuts (0-5 years of age), young regenerating clearcuts (6-15 years of age), older regenerating clearcuts (16-25 years of age), forest (26+ years of age), riparian forest, wetlands, and non-forest. Forested habitat designations were based on typical regenerating forest processes following timber harvest (Hall et al. 1985). The first 5 years are typically dominated by grass and forbs, from 6-15 years of age regenerating stands begin to be dominated by shrubs and small trees with some grass and forb component, from 16-25 years regenerating stands begin to be dominated by trees which begin to shade out understory shrubs, grass, and forbs (limits their growth), and from 26 years until harvest occurs very little understory vegetation remains as the trees have restricted sunlight from hitting the forest floor. Age of regenerating forests was determined in the GIS environment utilizing accurate stand age data for the study area. Riparian habitat was delineated by applying buffers to type 1, 2, and 3 streams (perennial streams). Type 1 streams were provided with a 100 foot buffer and type 2 and 3 streams were provided a 50 foot buffer. It was assumed based on knowledge of the study area these buffers were appropriate to identify areas with high water tables, unique soil characteristics, unique vegetation, and unique microclimates associated with higher humidity and greater air movement (Oakley et al. 1985). Wetlands or areas that are permanently or intermittently flooded were delineated in the GIS environment from the national wetland inventory GIS coverage for the study area. Non-forested habitats included sandy beaches, developed areas, lakes, large rivers, rock quarries, etc. To determine if resource selection occurred at the landscape level, Chi-square analysis ($\alpha = 0.05$, used for all statistical tests) (Zar 1984) was used to test the null hypothesis that the proportions of habitats within the home ranges of deer were equivalent to the proportion of habitats in the surrounding landscape (1.5 Km buffers). Next, to determine where resource selection occurred *t*-tests were used to test for differences between home range habitats and landscape habitats.

Home Range Scale: Selection of habitats within the home range was analyzed in 2 manners, by comparing habitat use to habitat availability within the home range and habitat availability within the home range to that within the core area. To determine if deer were using habitats within the home ranges proportionally to their availability we compared the proportional availability of habitats within the home range (described previously) to the proportional use of those habitats by radiocollared deer. Habitat use for visual observations was classified according to the habitat type in which they were collected. Home range points classified by triangulation were buffered with a polygon representing the average telemetry error (discussed previously). Habitat proportions were determined for each polygon surrounding a triangulation location. The habitat use for these locations was determined by the habitat that represented the greatest proportion within the polygon. To test the null hypothesis that habitat use within home ranges was equivalent to the proportional availability of habitats we used a Chi-square and *t*-tests as described previously.

To determine if habitat availability within the home ranges was equivalent to habitat availability within the core use areas we determined the proportional distribution of habitats within each as described previously under landscape level selection. We used a Chi-square and *t*-tests as described previously to test the null hypothesis that no significant difference existed between the home ranges and core use areas.

Roads: Within each deer home range we classified all roads to either primary or secondary roads. Primary roads would represent haul routes on the managed landscape that would be frequently used for hauling timber for forest management activities or were paved public roads with frequent use. Secondary roads were infrequently used timber haul routes or private access roads to individual home sites in developed areas. The animal movement extension for ArcView was used to generate minimum distances between each home range location and both primary and secondary roads within each home range. Next, random points were generated utilizing the animal movement extension within each home range and minimum distances between random points and primary and secondary roads were determined. The number of random points within each home range was equivalent to the number of home range locations. To determine if primary and secondary roads affected deer habitat selection we expected that actual deer distances from both classes of roads would be significantly different from random points within the home range. Because primary and secondary roads receive different levels of traffic we tested each class of road separately as deer may be avoiding primary roads but not secondary roads. We used *t*-tests to test the null hypothesis that distances between primary roads and actual deer locations were equivalent to distances between primary roads and randomly generated locations and the null hypothesis that distance was equivalent between secondary roads and actual deer locations and secondary roads and randomly generated locations.

RESULTS

Population Trend

Deer survival was calculated for 2 successive study years for each sex. During 2003-2004 a total of 6 does were radiocollared. One doe slipped her radiocollar and was excluded from the analysis and one doe died from predation (unknown source). The female that was predated had been heavily scavenged by bears and we were unable to determine if a bear was the mortality source or simply scavenged an existing carcass. Female survival for 2003-2004 was 80%. During 2004-2005, a total of 4 bucks and 14 does were radiocollared. None of the bucks survived. Mortality was attributed to capture myopathy (1), hunting (2), and cougar predation (1). Thus, buck survival was for 2004-2005 was 0%. Of the 14 does, only 1 was killed and was attributed to cougar predation. Female survival for 2004-2005 was 93%. The cumulative survival rate for female deer was 74%. Cumulative survival reflects the expected survival rate for a female for 2 years. The average annual survival rate for female deer is 86% (average of year 1 and 2).

We are currently in the middle of the 2005-2006 study year. A total of 25 deer were radiocollared and at risk during the current study year including 3 bucks and 21 does. To date 1 doe has been lost to cougar predation and 1 buck has been lost to unknown predation. Formal survival analysis for the current study year will not be available until May of 2006.

Helicopter surveys to determine the annual composition of the black-tailed deer population within the study area were accomplished in 2003-2005. The results of the surveys are in Table 1.

Table 1. Deer composition data for 2003-2005.

Year	Does	Fawns	Bucks	Total	Fawn:Doe Ratio	Buck:Doe Ratio
2003[a]	11	3	5	19	27:100	45:100
2004	46	30	3	79	65:100	7:100
2005	33	21	6	60	64:100	18:100

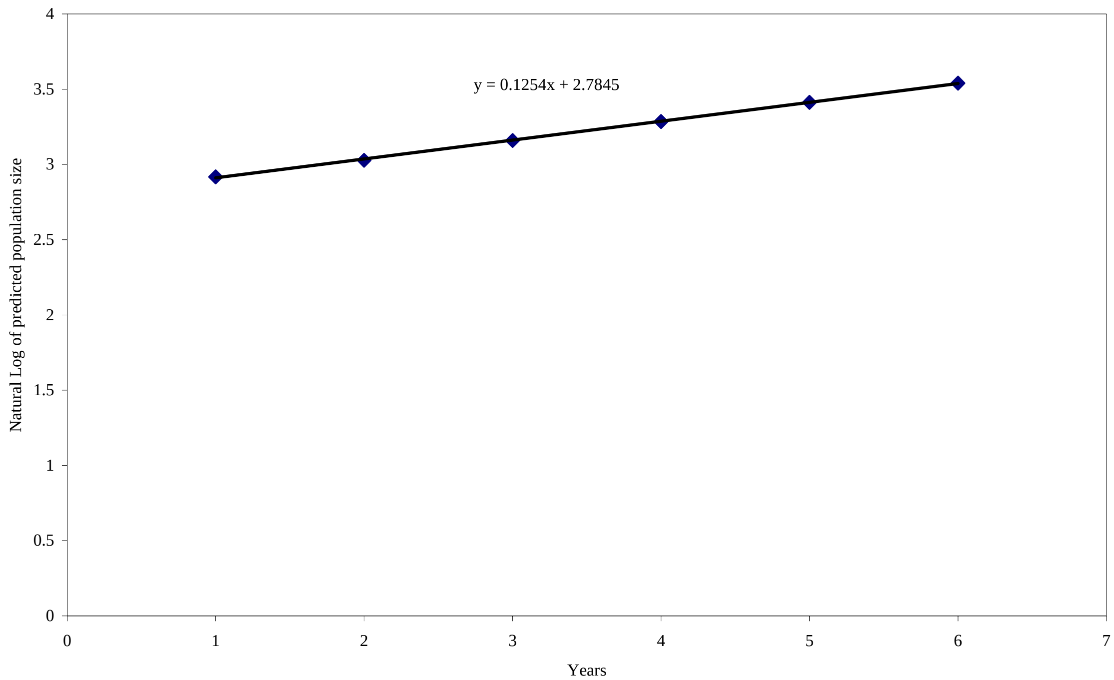
[a]Collected on Makah Reservation only, remainder included Makah Reservation and adjacent timberlands comprising entire study area.

To determine the population trend for the female subset of the population used the following variable for model calculations. The overall annual survival rate of 86% was applied to the model for adult and yearling female survival. The total number of fawns born to radiocollared deer that survived to the yearling age class based on field observation was 13, using the 50:50 assumed sex ratio approximately 5.5 females fawns were recruited as yearlings for a female fawn recruitment rate of 0.42. The resulting regression equation had a slope of 0.1254, thus the female segment of the population would be predicted to be growing by 12.5% annually. Predicted model outputs for the female subset population for the initial year and 5 years into the future are provided in Table 2. The predicted population growth is graphically displayed in Figure 2.

Table 2. Predicted model outputs for the female subset of the population.

Model Year	Adult Females	Yearling Females	Female Fawns	Total Female Population
N_0	13	5.5	0	18.5
N_1	11.18	4.73	4.73	20.64
N_2	13.68	4.07	5.79	23.54
N_3	15.27	4.98	6.46	26.71
N_4	17.41	5.55	7.37	30.33
N_5	19.75	6.33	8.36	34.44

Figure 2. Predicted population growth for the subset of the female population.



Home Range Analysis

A total of 32 deer were had been radiocollared during first 3 years of the study. The bootstrapped sample size analysis was plotted to determine the minimum sample size needed for home range and habitat analysis (Figure 3). The graph indicated that the most robust sample size would be approximately 70; however, very few of our deer met this sample size. We reasoned that a minimum of 30 locations would provide for sufficient analysis power as the total area began to flatten out at this point. Fifteen of the 32 deer had a minimum of 30 home range locations established (range 30-106) (Table 3). These 15 deer were used in all subsequent reported habitat analyses. Only 1 male met the minimum sample size. We assumed that male and female home ranges were not significantly different and lumped both sexes into the subsequent analyses. The poor survival rate for males rendered it impossible to statistically test for differences in home range size between the sexes as all but the 1 male died with fewer than 30 home range locations.

The mean home range size (n=15) was 150.8 hectares (range 68.1-640.5) (Table 4). The mean core area size (n=15) was 31.2 hectares (range 3.4-88.8) (Table 4).

Figure 3. Sample size plotted against area to determine the minimum number of home range locations required for home range and habitat use analysis.

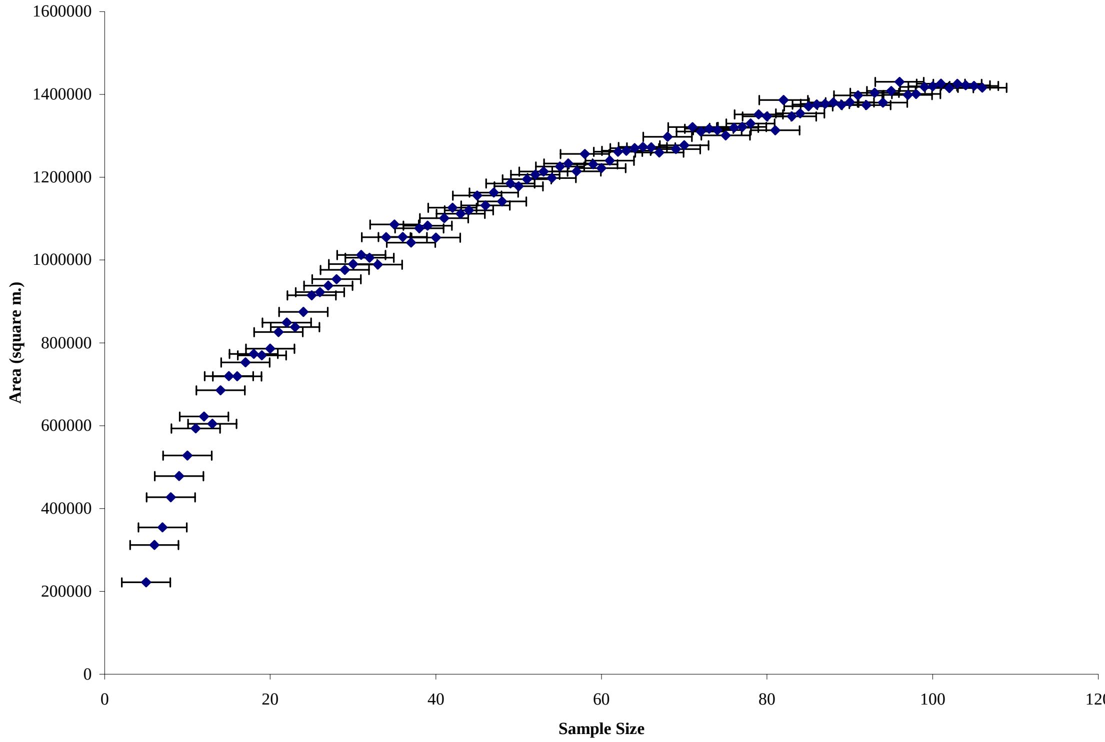


Table 3. Sample size for radiocollared deer used in home range and habitat use analysis.

Deer	Sample Size
170	52
210	70
230	68
290	50
310	88
330	67
370	91
410	69
490	30
510	71
550	104
590	35
610	64
630	51
800	106

Table 4. Home range and core use area sizes (hectares) for deer used in the home range and habitat use analyses.

Deer	Home Range	Core Use
170	51.8	15.3
210	27.6	3.4
230	259.2	75.4
290	44.1	12.1
310	250.4	71.0
330	43.9	4.2
370	159.7	37.0
410	50.8	10.4
490	373.9	88.8
510	162.9	42.8
550	559.7	71.7
590	73.8	7.1
610	43.3	10.3
630	53.8	7.4
800	107.4	11.1

The habitat use analysis indicated that the amount of riparian forest and wetland habitats were too low for statistical analysis. Therefore, we combined riparian forest into the forest habitat category (26+ years of age) and wetland habitat was combined with non-forest to facilitate analysis.

Landscape Scale: The proportional distribution of habitats between the landscape and home range were found to be significantly different (χ^2 = 12.3, d.f. = 4, $P < 0.025$). The *t*-tests indicated that there were significantly more clearcut habitat (0-5 years of age) available in the home ranges (t = 2.24, d.f. = 14, P = 0.042) and significantly less forest habitat (t = -4.0, P = 0.001). There was no significant difference between the landscape and home range for young (t = 0.71, P = 0.49) and old regenerating habitats (t = -0.10, P = 0.925), and wetland habitat and non-forest habitat (t = -1.0, P = 0.333) (Figure 4).

Home Range Scale: There was no significant difference between the proportion of habitats available and the proportional use of the habitats within the home ranges (χ^2 = 2.61, d.f. = 4, P = 0.90) (Figure 5). However, there was a significant difference in the proportional distribution of habitats between the home ranges and core use areas (χ^2 = 10.83, d.f. = 4, $P < 0.05$). The *t*-tests indicated that were significantly more clearcut habitat available within the core use areas than the home range (t = 2.16, d.f. = 14, P = 0.048) and significantly less forest habitat (t = -3.2, P = 0.006). There was no significant difference between the home range and core use area for younger (t = 1.04, P = 0.315) and older regenerating habitats (t = 0.72, P = 0.486), and wetland habitat and non-forest habitat (t = 1.17, P = 0.26) (Figure 6).

Figure 4. Distribution of habitats within the home ranges of 15 black-tailed deer and the surrounding landscape.

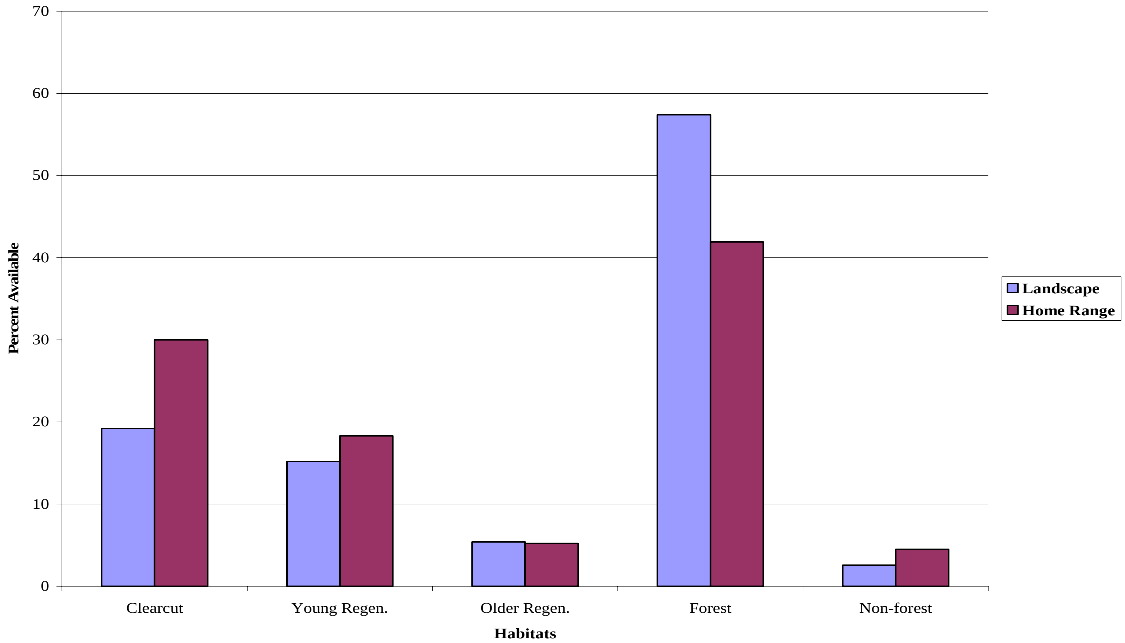


Figure 5. Distribution of habitats and habitat use within the home ranges of 15 black-tailed deer.

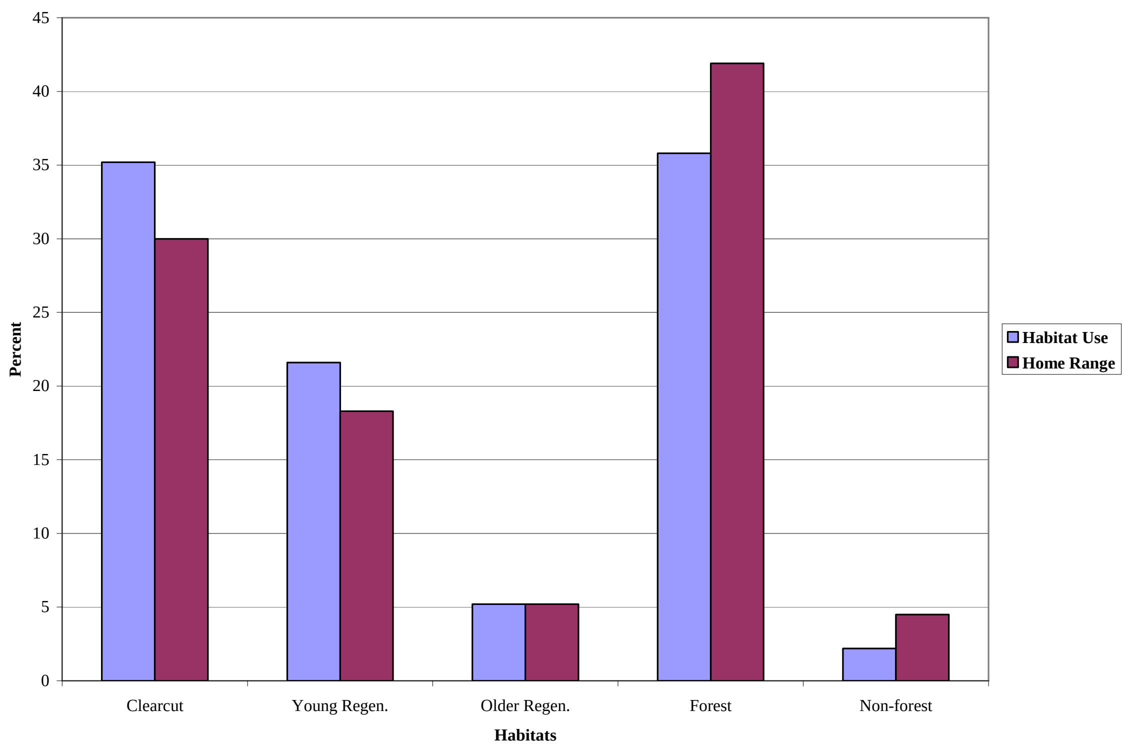
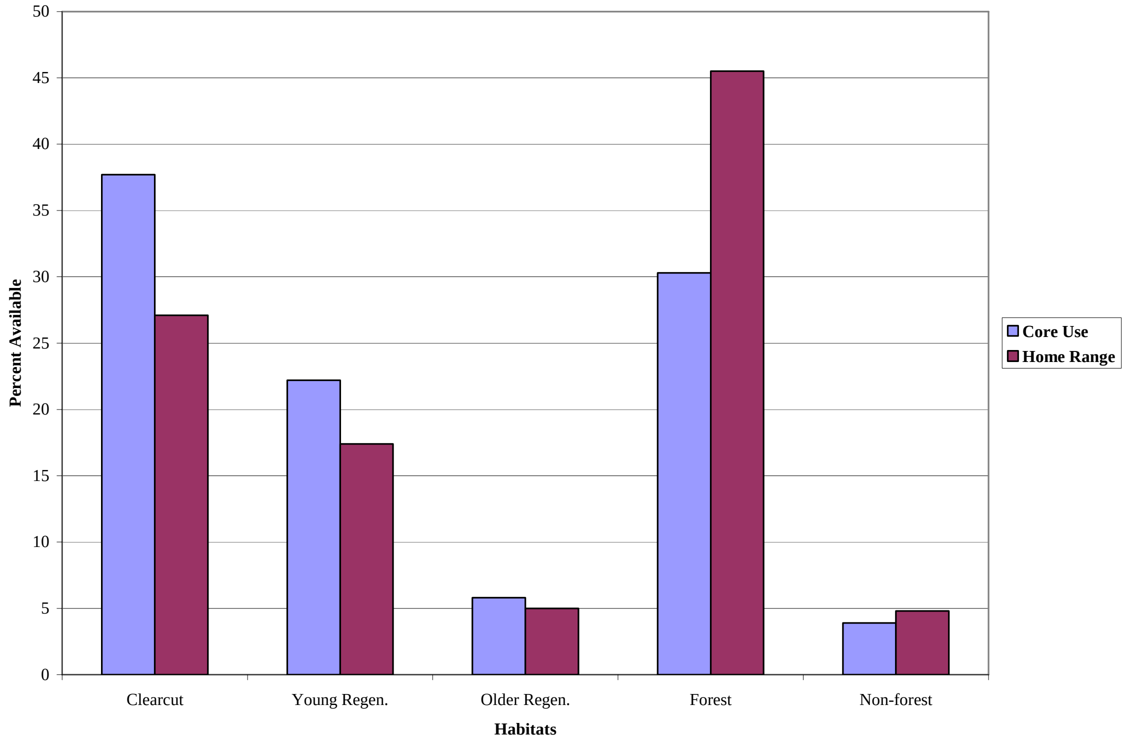


Figure 6. Distribution of habitats between the home ranges and core use areas of 15 black-tailed deer.



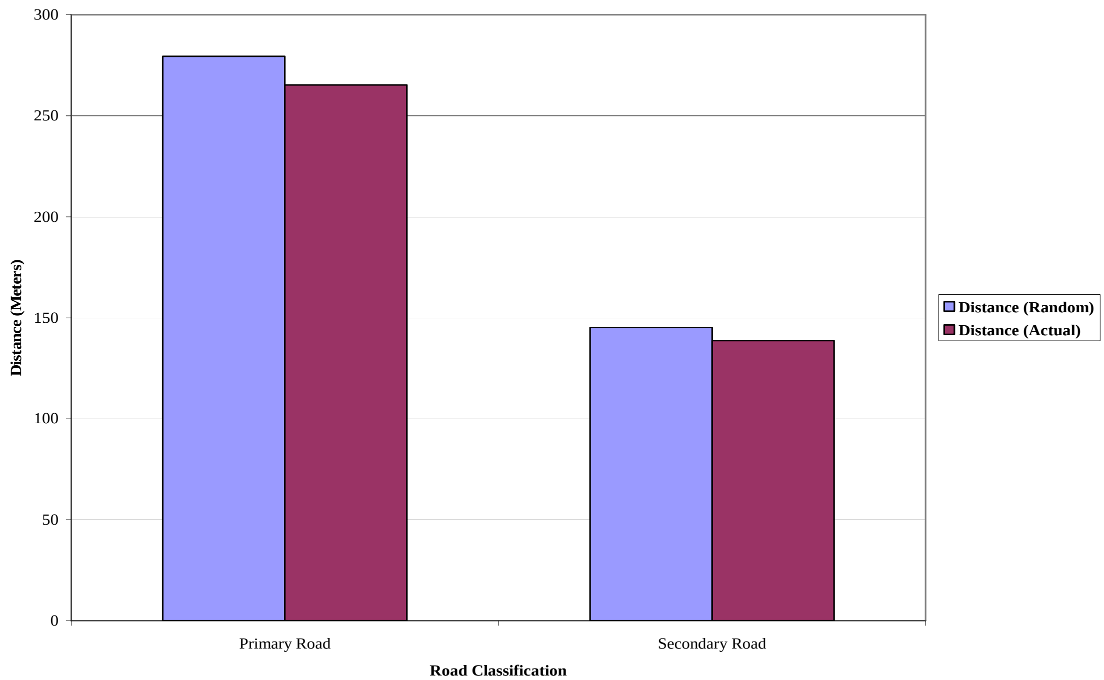
Roads: The average distance between actual deer home range locations and primary and secondary roads was 265.3 and 138.7 meters, respectively. The average distance between randomly generated locations and primary and secondary roads was 279.4 and 145.2 meters, respectively (Figure 7). There was no significant difference between actual home range locations and randomly generated locations and primary roads (t = 1.71, d.f. = 14, P = 0.11). There was no significant difference between actual home range locations and randomly generated locations and primary roads (t = 1.22, d.f. = 14, P = 0.24).

DISCUSSION

Population Trend

Estimation of survival rates has become an important component in the assessment of natural and management factors regulating animal populations. Because male and female black-tailed deer are managed differently in regards to hunting we had hoped to generate reliable survival estimates for both sexes. Males are the primary target for hunting by Tribal and non-tribal hunters within the study area. We did not have any males survive that were radiocollared during the first 2 years of the study. Undoubtedly some males must survive to provide for breeding of females as our fawn production statistics were fairly robust during 2004 and 2005. We were simply unable to capture enough males to adequately determine their annual survival. Based on anecdotal sightings during our capture attempts and the aerial compositions surveys, it is apparent that the male segment

Figure 7. Average distance from primary and secondary roads to actual black-tailed deer locations and randomly generated locations.



of the population is much lower than the female segment. Low male:female ratios are reportedly common in areas where hunting pressure seeks to maintain hunter satisfaction. The entire study area is managed for maximum hunter opportunity and any buck is a legal buck for harvest. Additionally, male deer are probably vulnerable to hunting as the study area has been subject to high rates of timber harvest which provides large expanses of open habitats and increasing road densities where deer are more easily encountered. Bender (2002) reported annual survival rates of males in heavily hunted populations in western Washington were 38.5%. We believe our actual buck mortality rate is probably similar, however, our sample size is simply too low to effectively calculate a reliable estimate.

Our female annual survival rate was higher than reported in the literature for northwestern black-tailed deer populations. McNay and Voller (1995) reported that average annual female survival on Vancouver Island, B.C. was 74%. McCorquodale (1999) reported average annual female survival in the Klickitat River Basin in Washington was 82%. McNay and Voller (1995) reported that wolves and cougars were significant predators of female deer. McCorquodale (1999) reported that illegal hunting was a significant mortality source. Female deer in our study area are not subject to wolf predation as wolves were believed exterminated on the Olympic Peninsula by 1920. Additionally, none of our study animals have been lost to hunting. The majority of the study area off Reservation is gated and access is limited to walking or biking for hunting. The portion on-Reservation is open for Tribal member access only with lower hunting pressure than off-Reservation. Additionally, both the Makah Tribe and Washington

Department of Fish and Wildlife limit antlerless harvest to very low levels. All of these factors probably contribute to low levels of illegal hunting.

Cougar predation is the leading cause of known black-tailed deer mortality to date within the study area. Mountain lions prey heavily on deer and are more efficient at taking adults (Hornocker 1970, Shaw 1977). Mountain lions are the primary large predator inhabiting the study area. Other predators present are black bear, coyote, and bobcat. However, these species primarily prey on fawns (Richens 1967, Robinette et al. 1977). The data collected to date suggests that predators are not having a significant affect on the female segment of the black-tailed deer population within the study area, particularly when considering the average annual survival rate for females is higher than other regional studies. Hunting mortality for males is probably a significant contributor to male survival as discussed previously.

The aerial composition surveys indicate that females significantly outnumber males. This is typical for most heavily hunted populations. Mackie et al. (1982) reported that heavily hunted populations may average only 5-25 males:100 females while lightly hunted populations may average 20-40 males:100 females. Thus, the results from our composition survey are consistent with reported number of males in heavily hunted populations.

The model developed to assess population growth for the female subset of the population within the study area indicated a ~12% growth rate. The validity of the model is realistically limited by the model assumptions. We applied an average female survival rate based on only 2 years of survival data. This rate was higher than reported for other areas in Washington (see previous discussion) and over the long term of this study the average annual survival rate may be lower. Additionally, we applied the adult survival rate to the yearling age class. If yearling survival is lower than adult survival, the actual rate of population growth would be smaller. Finally, the average female fawn productivity rate per adult was based on analysis of one cohort. Data collected on additional cohorts may indicate the actual productivity rate is lower. Despite the assumptions in the model we believe that the overall trend in the female segment of the population is indeed positive, however, the actual rate of population growth is probably less than the modeled ~12% rate. The study area is has been rapidly converted from primarily forested stands to a mosaic of forest and clearcuts or regenerating stands of various ages. Black-tailed deer have long been considered a species that thrives in early to midseral vegetation following natural or human-induced disturbance (B.C. Ministry of Forests 1990). Logging and other disturbances have resulted in increased numbers of black-tailed deer in many areas (Kie and Czech 2000). Thus, the high rate of logging probably contributes to a positive population growth rate in the study area.

Home Range Analysis

Home range sizes for non-migratory black-tailed deer in coastal habitats of Washington are largely unknown. Home ranges for migratory black-tailed deer are reported, however, are not suitable for comparison (McNay and Voller 1995, McCorquodale

1999). The black-tailed deer home ranges were extremely variable in our study; however, the average home range size was approximately 1.5 km^2. Core use area for our study animals was variable as well. The average core use area was approximately 0.3 km^2.

Landscape and Homerange Scales: Black-tailed deer in our study area consistently selected young clearcut habitats at both the landscape and home range scale. Black-tailed deer home ranges had a higher proportion of clearcut habitats than in the landscape surrounding the home ranges. Similarly, core use areas were comprised of a higher proportion of clearcut habitats than the remainder of the home range. As stated previously black-tailed deer are reported to thrive in early seral habitats following natural and anthropogenic disturbances. Yeo and Peek (1992) found that black-tailed deer selected shrub communities (<10 years of age). However, recommended that older forests were important to deer. Similar recommendations have been made in areas where heavy snowfall affects black-tailed foraging success. Older forests typically intercept snow and provide for access to understory vegetation (Hanley and Rose 1987). Interestingly, our deer displayed a negative association with older forested stands. This may be explained by the lack of persistent snow in the study area. The moderating effects of our coastal climate result in very little snow accumulation. Therefore, deer are not restricted from forage resources in clearcuts during the winter timeframe. Furthermore, the rapid rate of re-growth in clearcuts provides sufficient hiding cover in many instances for security purposes. However, it is important to note that our deer did use forested habitats within each home range so while they statistically appeared to avoid forested habitats, measured use indicates these areas do provide some benefits. Benefits may be for thermal purposes during extreme cold or warm conditions or foraging where canopy gaps promote understory vegetation.

While black-tailed deer select for clearcut habitats in this study, the current patterns of landscape management are not conducive to long term productivity within the study area. Deer do not heavily utilize older age classes of regenerating forests and forests that have reached the stem exclusion stage (26+ years of age) are typically devoid of understory vegetation for foraging. When large scale logging is applied there will be abundant forage for approximately for 10-16 years, however, when the regenerating forests shade out the understory forage availability will be limited. Therefore, deer density should be expected to decline for a period of 30-50 years until a new cycle of timber harvest occurs. Management of habitat to benefit black-tailed deer should focus on creating a mosaic of forest stand conditions at a scale approximately the size of deer home ranges to provide for stability in black-tailed deer populations.

Roads: We did not find a significant difference in the distance between primary and secondary roads and both actual deer locations and randomly generated points. The effect of roads on ungulates has been well studied. A number of studies have demonstrated an increasing frequency of habitat use at greater distances from open roads, however, the response varies in relation to traffic rates (Wisdom 1998), the extent of forest canopy adjacent to roads (Wisdom et al. 2004), and type of road (Rowland et al. 2000). Roads can also increase the vulnerability of ungulates to mortality from hunter harvest (McCorquodale et al. 2003). Interestingly, deer within our study area did not seem to avoid roads based on our analysis. This is probably due to the fact that the majority of the study area is gated and road access is limited to forest management activities. Thus, the majority of roads receive very little traffic except for relatively brief periods of time when timber harvest is occurring in a particular area. Road closures that restrict large scale traffic have been reported to successfully eliminate many of the problems associated with roads and to the benefit of ungulates (Forman et al. 2003). Black-tailed deer on Vancouver Island displayed a similar relationship with roads. Black-tailed deer were reported to be fairly tolerant of humans and light vehicle traffic, especially during the closed hunting season (B.C. Ministry of Forests 1990). Roads also provide feeding opportunities for deer on roadside vegetation and provide travel pathways for easy movement within their home ranges.

Conversely, the lack of significant response by black-tailed deer in our study to roads could be explained by the high road density within the study area. Road density across the study area averaged 3.8 km of road per km^2 of habitat. The high road density probably renders it impossible for deer to use habitats within their home range without being in relatively close proximity to primary and secondary roads. Regardless, the restriction on motorized access over most of the study area is probably a benefit for black-tailed deer. Managers should continue to utilize this valuable tool to minimize disturbance and vulnerability of black-tailed deer in the heavily managed forest landscape.

CONCLUSION

The funding provided by the Administration for Native Americans was extremely valuable in assisting the Makah Tribe with gathering baseline data on black-tailed deer populations on the Olympic Peninsula of Washington. This information will be invaluable in the development of a DEMP, forest management decisions, land use planning, and annual hunting regulation development by the Makah Tribe. We have secured additional funding to continue the black-tailed deer project well into the future to continue to collect home range, habitat use, and mortality data. Additionally, the black-tailed deer population within the study area is afflicted by a condition called hair slip syndrome (HSS). The clinical signs of HSS are apparent during the winter and early spring with deer displaying significant hair loss over portions of their body. The loss of hair impairs their ability to adequately thermoregulate and they die from secondary infections such as pneumonia. Recently, HSS has been shown to be caused by an exotic species of biting lice that was probably introduced to black-tailed deer from imported exotic species of ungulates from Europe. The Makah Tribe has secured funding and developed a partnership with the Washington Department of Fish and Wildlife to investigate the effects of HSS on fawn survival and subsequent reproductive success. Thus, the assistance from ANA has been successful in establishing the technical capacity for the Makah Tribe to improve the regulatory management of black-tailed deer.

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