Den Tree Availability and Denning Success of Black Bears on Industrial Forest Lands and National Forest Lands in Virginia and West Virginia.

by

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Abstract

During 1999-2001, potential den trees and denning success of black bears was investigated on industrial forest lands and national forest lands in Virginia and West Virginia. One hundred and fifty seven potential den trees were found on five study areas, 135 on national forest lands and 22 on the industrial forest lands. Twenty-seven hollow potential den trees were found, 22 on national forest lands and 5 on industrial forest lands. Densities of potential den trees ranged from 12.5/km^2 to 437.5/km^2 on the national forest lands and on the industrial forest lands the densities ranged from 0-187.5/km^2. There were significantly higher densities ($F_{1, 69}$=5.86, P=0.0181) of potential den trees on the national forest land than on the industrial forest land. There were also significantly ($F=_{2, 68=7.86}$ P=0.0008) higher densities of hollow potential den trees based on the stand age class. Denning success for females expected to have cubs was 98% (n=46) in tree dens on national forest lands and 100% (n=8) on industrial forest lands. Denning success for females expected to have cubs was 76% (n=55) in ground dens on national forest lands and 80% (n=5) in ground dens on industrial forest lands. Females expected to have cubs on the national forest lands had an overall denning success of 89% (n=80) and on industrial forest lands there was overall, 92% (n=13) denning success. Chi-square tests

showed that abandonment of dens by bears was significantly higher (x^2=19.02, 1df) in ground dens than in tree dens. Litter sizes were not different from national forest lands and industrial forest lands (t=-0.36, 44df, P=0.84). The mean litter sizes on the national forest lands was 2.55 (SE=0.16) cubs per litter and on the industrial forest land 2.4 (SE=0.22) cubs per litter.

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General Introduction

Black bears (*Ursus americanus*) in Virginia and West Virginia den on both national forest lands and industrial forest lands during the winter. Denning and hibernation enable black bears to survive the winter, which is a time of scarce food and, depending on location, of severe weather (Johnson and Pelton 1980). The ultimate reason for denning is to conserve energy (Schooley et al. 1994). Denning is crucial for pregnant females because during the denning period black bears produce their litters.

Black bears den in a variety of places, including brushpiles, excavated and natural depressions under tree roots, stumps, rock outcrops, fallen logs, and in hollow trees (Tietje and Ruff 1980, Johnson and Pelton 1981, Mack 1986). Dens are usually located in upland habitats (Schwartz et al. 1987) but can be found in well-drained lowland habitats (Hellgren and Vaughan 1989).

Industrial forest lands are defined here as "forest lands owned by a company or individuals operating a primary wood-using plant and managed primarily for wood products" (Helms 1998). Westvaco Corporation was a vertically integrated forestry industry corporation with large land holdings in the Appalachian region of both Virginia and West Virginia. In 2002 Westvaco Corporation was merged with Mead Corporation and is now known as MeadWestvaco. Because of the timing of the present study and for consistency, the corporation name "Westvaco" is used during the course of this report. Westvaco land was the industrial forest land in Virginia and West Virginia that was used for this study. Black bear populations appear to be on the increase on these lands, but there is no known documentation to support this contention. In general, industrial forest lands may offer different in habitats for black bears than do national forest lands.

Differences in land management including timber cutting practices may influence the availability of large den trees in contrast to national forest lands where the land is used for multiple uses and not exclusively for timber production.

This project involved two aspects of black bear ecology in two forest management systems. The first aspect was an examination of the number and density of potential den trees on each forest management system. Tree dens usually offer better protection to pregnant bears (and subsequently to their litters) than do ground dens (Wathen et al. 1986). The importance of tree dens for black bears is great and examination of availability of potential dens in relation to forest management systems (industrial forest lands compared to national forest lands) will allow decision makers to evaluate costs and benefits of alternative management practices.

The second aspect was to compare many components of denning success of black bears in the two forest management systems. The comparison involved questions of choice of den types and the bears' denning success in each, as measured by litter sizes and individual measurements of cubs and survival of litters to the point of emergence.

CHAPTER 1: Den Tree Availability

Introduction

Black bears (*Ursus americanus*) in Western Virginia depend heavily on den trees for hibernation (Godfrey 1996). Denning and hibernation enable black bears to survive the winter, a time of scarce food and, in some locations, severe weather (Johnson and Pelton 1980). The ultimate purpose of denning is to conserve energy (Schooley et al. 1994). Denning and location of secure den sites are crucial for pregnant females who must produce and nurture their young during this period of winter dormancy.

In the Appalachian region of Virginia and West Virginia, black bears inhabit both National Forest lands and industrial forest lands owned by private companies. Because of forest management practices on industrial forest lands, the availability of tree den sites may be altered. Large hollow trees (≥75cm Diameter Breast Height, DBH) and large snags may be more or less available to bears depending on forest management practices at and following tree harvesting. Brody (1987) stated that most timber harvesting in the Southern Appalachian forest in North Carolina was done by clear cutting. Potential ground dens may be abundant on industrial forest lands following logging, but flooding of dens, disturbance by dogs, other bears, or humans may negatively impact denning success (Johnson and Pelton 1980).

In this report "industrial forests" are defined as "forestland owned by a company or individuals operating a primary wood-using plant and managed primarily for wood products" (Helms 1998). A black bear den tree in Virginia is a large tree that in previous studies (e.g. Godfrey 1996) has ranged from 58.4cm DBH to 118.1cm DBH.

Westvaco Corporation was a vertically integrated forestry industry corporation with large land holdings in the Appalachian region of both Virginia and West Virginia. In 2002 Westvaco Corporation was merged with Mead Corporation and is now known as MeadWestvaco. Because of the timing of the present study, and for consistency, the corporation name "Westvaco" is used during the course of this report. Davis (1996) reported that commercial harvesting removes structures used by black bears for winter dens. Thus, black bears living on industrial forest lands may have to find alternative structures for denning. Black bears are very adaptable, but altered habitats may have effects on their reproduction and denning success.

By virtue of management strategies national forest lands can present differences in habitat from those of industrial forest lands. National forest lands are managed for multiple use, thus the intensity and/or frequency of tree harvest on national forest lands may be less than on industrial forest lands. Therefore, the availability of large trees (DBH >75cm) may be different on national forest lands than on industrial forest lands. Wathen et al. (1986) noted that projected increases of timber production, use of cable logging, and conversion of "poor" quality sites to white pine (*Pinus stobus*) reduced available den trees on national forest lands in the Southern Appalachian region. Wathen et al. (1986) also found that the then current U.S. Forest Service timber rotations of 80-100 years for hardwoods may reduce den tree resources and adversely impact Southern Appalachian bear populations. Loss of tree dens in timberlands is critical because denning success is directly correlated to reproductive success (Wathen et al. 1986). This relationship previously had led Pelton et al. (1980) to conclude that den trees were necessary to maintain viable black bear populations in the Southern Appalachians.

Kasbohm et al. (1996), determined that 71% of all dens (n=48) in the Shenandoah National Park Virginia were in trees. Godfrey (1996) reported that 82% of 56 black bears in the George Washington and Jefferson National Forests in Augusta and Rockingham counties, Virginia denned in hollow trees. Comparable information for bears living on industrial forest lands in the Appalachian region of Virginia and West Virginia is less available.

The objective of this study was to compare the availability of potential den trees on 2 forest management systems in Virginia and West Virginia. The null hypothesis was that there was no difference in the availability of potential den trees or hollow trees, suitable for black bear dens trees on industrial forest lands of Westvaco Corporation compared to National Forest Service lands.

Methods

Study Areas

The study was conducted on National Forest lands in Virginia and West Virginia, and on Westvaco lands in Virginia and West Virginia (Figure 1.1). The specific locations were as follows:

-National Forest lands of the George Washington and Jefferson National Forest lands (GWJNF) in the counties of Augusta and Rockingham, VA, represent the Northern study area of the Cooperative Alleghany Bear Study (CABS).

-National Forest lands of the George Washington and Jefferson National Forest lands (GWJNF) in the counties of Craig, Giles, and Montgomery, VA, represent the Southern study area of the Cooperative Alleghany Bear Study (CABS).

-National Forest lands of the Monongahela National Forest, in the counties of Pocohontas and Greenbrier, WV.

-Industrial forest lands of Westvaco Corporation in Botetourt County, VA.

-Industrial forest lands of Westvaco Corporation in Greenbrier County, WV.

All locations are in the Ridge and Valley Geographic Province and the trees of importance included chestnut oak (*Quercus prinus*), Northern red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), white oak (*Q. alba*), tulip poplar (*Liriodendron tulipifera*), cucumber tree (*Magnolia acuminata*), red maple (*Acer rubra*), pignut hickory (*Carya glabra*), eastern white pine (*Pinus strobus*), pitch pine (*P. rigida*) and yellow birch (*Betula allegheniensis*) were the common overstory species. Sassafras (*Sassafras albidum*), mountain laurel (*Kalmia latifolia*), downy serviceberry (*Amelanchier arborea*), flowering dogwood (*Cornus florida*), witch hazel (*Hamamelis virginia*), and rhododendron (*Rhododendron maximum*) (Ryan 1997).

Plots and Stand Age

Westvaco and the U.S. Forest Service provided maps with data including stand age indicated by color codes. Areas to be sampled for potential den trees on the 2 forest management systems were stratified by stand age. Stand ages were combined into 3 categories: young stands up to 50 years of age, mid-age stands 51-100 years old, and mature stands 100 years of age or older. The protocol was to have 5 plots, 40m x 400m, of each stand age group in all areas (Table 1.1).

Westvaco forest harvesting strategies call for leaving “leave strips” in important areas such as stream beds. Ten such leave strips, 5 each on the Botetourt, Virginia and

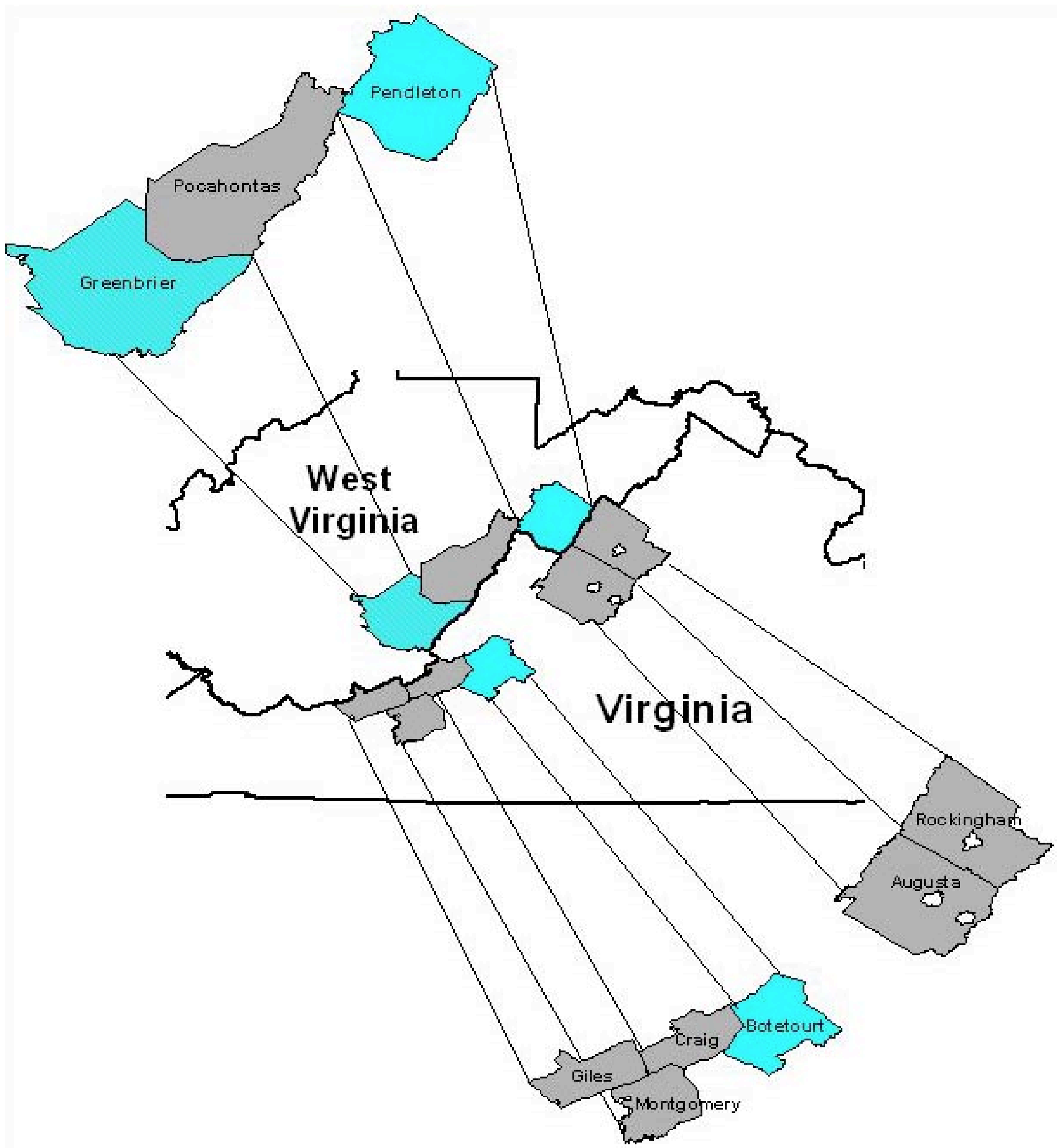

Figure 1.1. Study areas used in Virginia and West Virginia. Gray areas represents areas used on the National Forest Land areas; Blue represents counties used on Industrial Forest Lands; Greenbrier County (Blue with gray stripes) had both National Forest Lands and Industrial Forest Lands.

Greenbrier, West Virginia study areas were surveyed for potential den trees. Westvaco had 2 types of leave strips: Water Quality Zones, which are buffer strips along streams and Habitat Diversity Zones. In West Virginia Water Quality Zones are at least 33m wide on each side of the stream; in western Virginia, their width was 16m. Habitat Diversity Zones were 66m wide or wider strips that connect various watersheds. While both types typically are in mature timber, some silvicultral activities may be conducted within them. The main goal with both types of leave strips was to have older age classes retained on the landscape, and with them certain habitat features (Dr. Patrick Keyser, Westvaco Wildlife Biologist, personal communication).

Random Sampling of Plots

The design was a "stratified random sample", with the plots considered to be "strata". Within each stand age, plots (40m x 400m) were randomly chosen using the methodology that follows.

A numbered grid was overlaid for each National Forest Service map. Random numbers representative of both axes were drawn to determine plots. Numbers continued to be drawn until all 5 plots in each age group were drawn. If numbers drawn would not allow for 40m x 400m plots within the stand age class random drawing continued until five suitable areas were drawn.

For Westvaco industrial forest lands the proposed plots sizes were provided to Westvaco personnel who randomly selected plots to satisfy the design protocol. There were no 100+ year old plots available in the Botetourt, VA study area (Table 1.1).

Sampling Plots for Potential Den Trees

Trees were sampled with in the 40m x 400m quadrats by pacing through on a 400m transect and observing 20m to each side. The starting direction for the sampling was chosen *a priori*. If, on arrival, the starting direction was unsuitable for any reason an *a priori* decision was in place to start in a direction 180° from the initial choice. The center-line of each plot was marked. Tape measures for the 20m were used to confirm location within plots when potential den trees were encountered. Pacing was used to determine plot length. Length was confirmed by use of GPS from start to finish of pacing through plots.

Potential den trees were identified based on characteristics of trees known to be used by bears as den sites. Godfrey (1996), working on the GWJNF in Virginia found bears denning in chestnut oak, red oak, tulip poplar, and cucumber trees, and described key dimensions of trees and their dens (diameter at breast height, DBH of trees, entrance hole dimensions, and inside den dimensions). DBH for all den trees in his study ranged from 58.4 cm to 118.1 cm and den entrance hole measurements, height ranged from 37.0 cm to 152.4 cm, and width ranged from 20.3 cm to 53.3 cm. The lower 10% of Godfrey's (1996) measurements was eliminated to account for small den trees used by yearlings or small females in Godfrey's study. The resulting minimal measurements for potential den trees for this study were ≥75 cm DBH, ≥43.0 cm for den entrance height, and ≥24 cm for den entrance width.

Trees that fit the DBH criteria had species recorded and were considered potential den tree pending the outcome of inspection for the following characteristics: presence of an entrance hole of adequate dimensions. The aspect and elevation of the area around the tree was also taken. The soundness (hollowness) of the tree was determined by striking the tree with a steel hammer. If the tree was hollow it was marked as such. An ocular estimate of width and height of potential den entrance holes was recorded on the initial visit to each sample plot. Each tree that had the necessary DBH was marked with a numbered aluminum tag and was spray-painted in white with same number.

After the initial visit to a quadrat marked trees that met all the necessary criteria for a tree den were revisited. These trees were climbed and measurements were recorded on the entrance hole. An estimate of whether the tree floor was solid was made by evaluating the results of dropping a weighted object into the hollow tree.

Sampling of Leave Strips

Ten leave strips were identified (five each in Botetourt county, VA and Greenbrier county, WV). The protocol was to sample 40m x 400m strips in each. In eight instances the 400m dimensions were satisfied. In the remaining two strips the entire length dimensions were sampled to completion. In several instances the 40m width requirement was not met for the entire length of the surveyed plot.

Statistical Analyses

An analysis of variance (ANOVA) was used to test the null hypothesis that there were no differences in the densities and of potential den trees and hollow trees in relation to land status (industrial forest land or national forest land) and stand age class.

Results

Potential Den Trees

In the plots sampled 157 trees in the five study areas met the DBH requirement of 75cm DBH (Table 1.2) (Figure 1.2). All of the trees that were hollow (n=27), had entrance holes (n=18), and were safe to climb (n=8) were on national forest lands (Table 1.3). Only one tree met all of the criteria for a true den tree. Some of the other potential den trees that were not climbed may have been suitable and met the criteria, but were not safe to climb (Table 1.4).

Statistics Model

The ANOVA showed that there was a significantly ($F_{1, 69}$=5.86, P=0.0181) higher density of potential den trees on the national forest than there was on the industrial forest based on the forest management system and age ($F_{2, 68}$=10.06, P=0.0001). The ANOVA also showed that there were significantly ($F=_{2, 68=7.86}$ P=0.0008) more hollow potential den trees when comparing age classes.

National Forest Lands: Northern CABS, VA

Fifty-three trees on the Northern CABS study area met the DBH criteria for a potential den tree (Table 1.5). Twenty-one were chestnut oak, 21 northern red oak, and 11 tulip poplar. The mean DBH was 82.1cm (n=21), 80.8cm (n=21), 77.4cm (n=11), for chestnut oak, northern red oak, and tulip poplar, respectively. The stand age with the greatest number of potential den trees was the 100+ year old stand age, which had 35 potential den trees (66% of the total). The 51-100 year old stands had 32% (n=17) and the 0-50 year old stand age had only 2% (n=1) of the potential den trees. Only six of the 53 trees were hollow and only three of those were safe to climb to check entrance hole

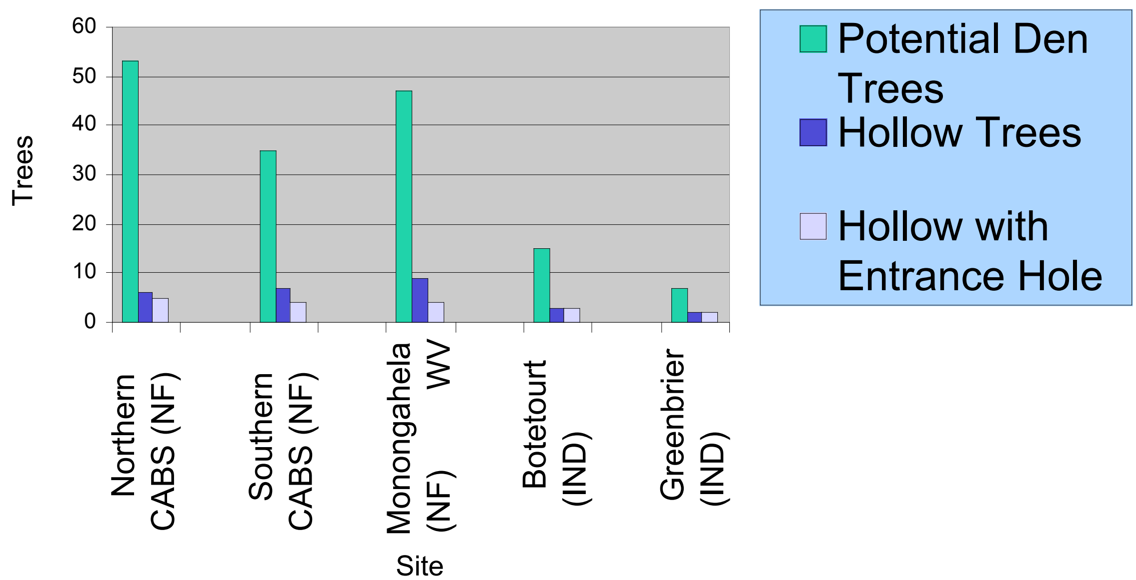

Figure 1.2. Location of hollow trees, hollow trees with entrance holes, and total potential den trees on industrial forest lands (IND) and national forest lands (NFL) in five study areas in Virginia and West Virginia.

dimensions and cavity characteristics. None of the three trees climbed met the minimal entrance hole dimensions criteria. The entrance hole dimensions for the trees climbed were 19.3cm height and 22.1cm width, 37.9cm height and 23.6cm width, and the third tree did not have an entrance hole, though at the initial sampling it appeared to have one.

National Forest Lands: Southern CABS, VA

Thirty-five trees on the Southern CABS study area met the DBH criterion for a potential den tree (Table 1.6). The 35 included six different species; chestnut oak, northern red oak, white oak, black oak, tulip poplar, and eastern white pine *(Pinus strobus)*. The mean DBH for chestnut oak was 86.2cm (n=6), northern red oak 87.1cm (n=14), eastern white pine 79.3cm (n=9), white oak 78cm (n=1), black oak 78.8cm (n=4), and tulip poplar 76cm (n=1). Most (n=31; 88%) potential den trees were in the 100+ year old stand age. The 0-50 year old stand ages (n=2) and the 51-100 year old stand ages (n=2) each represented 6% of the total potential den trees in the southern CABS area. Seven of the 35 trees sampled were hollow and four were safe to climb. Two of the three trees not climbed had no entrance hole and the third was not sturdy enough to be climbed. Only one of the four trees safe to climb met the criteria for a den tree. The den entrance hole dimensions for this tree were 46.4cm high and 35.8cm wide. This tree was a northern red oak in a 100+ year old stand age area. The entrance hole dimensions of the other three trees climbed on this site were 24.2cm high and 22.1cm wide, 18.1cm high and 14.7cm wide, and 29.7cm high and 23.1cm wide.

National Forest Lands: Monongahela, WV

Forty-seven trees of 5 species on the Monongahela National Forest lands met the criteria for potential den trees (Table 1.7). The five species were chestnut oak, northern red oak, black oak, white oak, and tulip poplar. The mean DBH of chestnut oak was 87.2cm (n=15), northern red oak 84.2cm (n=15), tulip poplar 85.7cm (n=9), black oak 82.0 cm (n=4), and white oak 80.6 cm (n=4). The stand age with the most trees meeting the criteria was the 100+ year old stand age (n=31, 66% of total). The 51-100 year old stand age had 30% (n=14) of the potential den trees in the area while the 0-50 stand age had 4% (n=2) of the trees. Nine trees were hollow, but only one of the nine was safe to climb. The tree climbed was a chestnut oak and had an entrance hole height of 27cm and an entrance hole width of 31cm. Three other trees in this area had entrance holes, but were not suitable for climbing.

Industrial forest lands: Botetourt County, VA

The Botetourt study area, which represented the industrial forest lands in Virginia, had 16 trees that met the DBH criteria of a potential den tree (Table 1.8). The 16 trees included, chestnut oak, northern red oak, and black oak. The average DBH of the chestnut oak was 82.9 cm (n=6), northern red oak was 82.6 cm (n=8), and black oak was 82.6 cm (n=2). All of the trees (n=16) were in the 51-100 year age class; there were no stands >100 years. Only three of 16 trees were hollow and none were climbed because the trees had considerable dead and rotting material.

Industrial forest lands: Greenbrier County, WV

Seven trees on the Greenbrier industrial forest lands in West Virginia met the DBH criteria of a potential den tree; two were chestnut oaks and five were northern red oaks (Table 1.9). The mean DBH of the chestnut oaks was 76.4 and 77.1 for the northern red oak. All seven trees were in the 51-100 year stand age category, and no trees sampled were hollow.

Leave strip areas on industrial forest lands

Leave strips in the Botetourt area had nine potential den trees, representing two species: chestnut oak (n=4) and northern red oak (n=5) (Table 1.10). The mean DBH of chestnut oak and red oak was 81.5cm and 79.6cm, respectively. None of these trees were hollow. The Greenbrier area had six potential den trees and also had only two species of trees represented: chestnut oak (n=4) and northern red oak (n=2) (Table 1.11). None of these six trees were hollow.

Potential Den Tree Densities

The national forest lands 51-100 year old stand ages had between 25 and 212.5 potential den trees/km^2 (Table 1.12), while the industrial forest lands 51-100 year old stand age averaged between 87.5 and 187.5 trees/km^2. The 100+ year age stands had the highest density of potential den trees on the national forest lands with densities between 387.5 and 437.5 trees/km^2. The density of potential den trees that were hollow was much lower on all study sites and age stands. Twenty-two hollow potential den trees on the national forest lands were counted, and the densities ranged from 12.5 to 87.5 trees/km^2 (Table 1.13). On the plots sampled on industrial forest lands the densities ranged from 25 to 37.5 trees/km^2.

Discussion

Potential Den Trees

At any time a large tree (≥75cm DBH) may develop a cavity that bears can use as a den. Cavities may be formed by breakage of large limbs, insect infestation, or from lightning damage. Wathen et al. (1986) found that most (92%) tree den cavities apparently resulted from wind breakage and ensuing natural decay. Kasbohm (1996) commented that cavities could form from gypsy moth infestation because of the moth's ability to eventually kill large oak trees. Trees can lose large limbs if struck by lightning and limb loss can possibly create entrance holes that a black bear will use for denning. Location of tree can predispose to wind-ice-or electrical storm damage. For example, trees at higher elevations or on slopes are more likely to be susceptible to wind damage (Johnson and Pelton, 1981) and availability of den trees was increased on upper slopes.

Overall, potential den trees in this study were not scarce, particularly is stands over 100 years in the national forest land. Potential den trees with cavities were also located in the 100+ stands of trees surveyed. Only one tree met *a priori* criteria for a den tree suitable of a hibernating pregnant female. Whether bears could have exploited the cavities noted, for example by further excavation is unknown. It should be noted that the cavity criteria set *a priori* for the study were those of known relevance to pregnant black bears and more cavity trees could have been found in trees smaller than the 75cm DBH criterion used.

Trees with DBH ≥75cm were not as abundant on industrial forest lands as they were on national forest lands because of harvesting practices. The national forest lands had a higher mean density of potential den trees on the 0-50 year old stand ages, they were 20.8/km^2 and 100+ year old stand ages 404.1/km^2 compared to the industrial forest lands (Table 1.14). The industrial forest lands sampled had no recorded potential den trees on the 100+ year old stand age areas (Table 1.15). However, the potential den tree densities on the 51-100 year stand ages were similar in the two forest management systems, which showed that potential den trees were as abundant in this age stand on these two forest management systems. Qualitative differences in forest management style may have potential for influencing whether potential den trees become den trees, but the present study showed differences between forest management systems studied in 100+ stand ages.

The possible disparity between the forest management systems in presence of potential den trees in stands older then 100 years old is worthy of discussion. The largest percentage of land on these two forest management systems are found in the 51-100 stand ages (Figure 1.2). However, the Westvaco lands studied had a higher percentage of land in the early stages of succession (<50 years) and much less stands older than 100 years old. As the proportion of den trees on national forest lands was higher in stands older than 100 years, younger ages of stands on the Westvaco forest land studied had diminished the potential for potential den trees to be present. If management strategies are such as to achieve the harvest at age younger than 100 years old the potential for formation of tree dens suitable for pregnant bears may be lower.

A proportion of the GWJNF and Monongahela National Forest Lands show that stand ages in this study trend towards older stands (Table 1.15). This may mean that Westvaco land has less potential to develop potential den trees when considering stand age as a factor. Any selection for or against tree species may also influence potential of den tree formation. Earlier harvest may also influence availability of material for ground dens. This speculation will be described later in the management implication section.

Hollow Potential Den Tree Densities

A similar proportion of hollow potential den trees was found in the 51-100 stand age on both forest management systems. Small numbers of hollow trees observed hampers discussion, but stand ages over 100 years consistently had more hollow trees. The lack of stand ages greater than 100 years on industrial forest lands probably limits the availability of hollow den trees as a higher density of potential den trees was found on national forest lands.

Methods chosen to identify hollow trees (striking the tree with a steel hammer) probably underestimated the number of hollow trees as the reach of the investigator was limited. Cavities present above this reach limit may not have resounded to striking. However, the trees struck were visually inspected for prescence of openings and trees with openings were recorded as "hollow".

Adult female bears are very mobile and have extensive home ranges (>50km^2, Amstrup 1976; <10km^2, Klenner, 1987). With the density of hollow potential den trees found on these two forest management systems being similar, it would appear that hollow den trees would be readily found and utilized by bears on both forest management systems.

Stand Ages

The three stand ages sampled were chosen because they represented young, mid-growth, and more mature forests. It was expected to find most of the potential den trees on both forest types in the more mature age class (100+). This was true for the national forest lands, but not the industrial forest lands though study areas on the latter were scarce. Indeed, Figure 1.3 show that the proportion of industrial forest lands in age stands older than 100 years old was less than in the national forest (2% vs. 28%). The Botetourt area did not have any stands in the 100+ year age class and the Greenbrier area had no trees ≥75cm DBH in the 100+ area. For these two industrial forest lands all potential den trees were in the 51-100 year old stand. Some of these trees may have been left behind when the area was originally harvested while others may have grown from saplings into mature trees within the last 51-100 years. Large trees in the 0-50 stand age were scarce on both forest types sampled.

Industrial Forest Lands

The industrial forest land in Botetourt county, Virginia was different from the other sites because of the absence of stands 100+ years of age in the stands sampled. All potential den trees that were found on this site (n=15) were in the 51-100 stand age plots.

No potential den trees on the industrial forest lands in the 0-50 age class were found and only five were found on the national forest lands. The 0-50 stand ages on the industrial forest lands were typically clear-cut areas <10 years old. Most were over grown with greenbrier and other early successional vegetation. In clear-cut areas, loggers often leave behind trees that may be useful to wildlife. However, on most clear cuts sampled or not sampled there were tall, small diameter trees that could be used as a raptor perch or for denning by small mammals, but nothing of use to a black bear.

The Greenbrier industrial forest land did not have any potential den trees in the 100 or older stand age area. There may be a few reasons for this. All of the five plots on the Greenbrier study site were in one stand. This area may not have had rich soil, where trees would grow faster and larger than on other areas. Some trees in this area were measured, but none met the DBH criteria of this study. This area was also very rocky and on a slope, which also may have militated against a large growth of trees in this area.

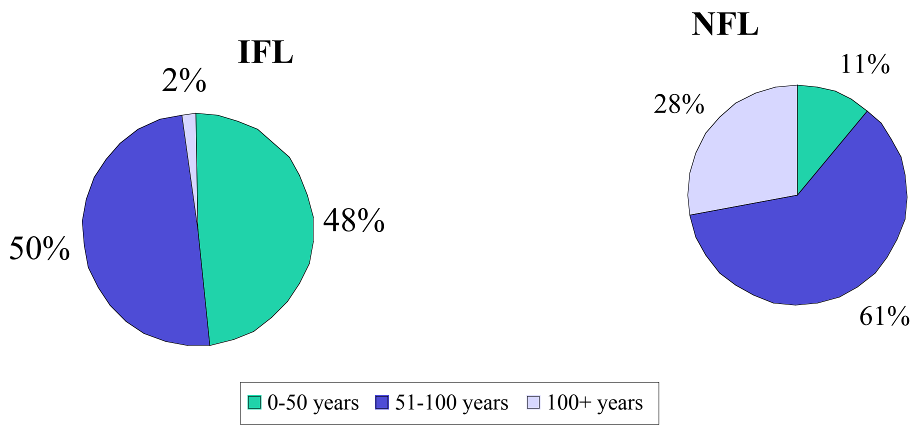

Figure 1.3. Stand age composition of the GWJNF and the Industrial forest land in Greenbrier County, West Virginia and Botetourt County, Virginia.

DBH Measurements

Black bears might have used smaller trees than our minimal den tree limits if the tree was hollow and had a large entrance hole. However, Wathen et al. (1986) found that the mean DBH of bear den tree in the Great Smoky Mountain National Park was 100.7cm: and Bull et al. (2000) found that the DBH of top entry den trees in northeastern Oregon (dens accessed through an opening in the trunk at least 5m off the ground) was 114cm. Lentz (1983) in Georgia found an average DBH of 98cm on all trees used as bear dens during their study.

Of relevance here is the concern for adequate dens for pregnant bears. Bears in Virginia occasionally den in trees less than 75cm DBH (Godfrey 1996). However, we took a conservative approach was taken and 10% of Godfrey's (1996) lowest values of DBH, den entrance height, and den entrance width were eliminated to obtain minimal measurements for a potential den tree. These measurements were from a study in western Virginia of known measurements of trees in which bears denned. Many trees were measured that were between 70-74.9cm DBH that looked very much like used tree dens, but were not considered because of the criteria we established. Some trees 65-70cm DBH also had entrance holes in them, but were not considered because of the pre-established DBH criteria.

Only one tree met all the criteria we established for an acceptable tree den, but all hollow potential den trees were not safe to climb. Some trees that met the DBH criteria and were hollow were unsafe to climb, but probably would have been considered a den tree based on ocular estimates of the entrance hole. Godfrey et al. (2000) observed that stricter safety protocol dismissed the idea of climbing some den trees that may have been climbed in the past. Some trees not climbed may have been climbed and used as den trees by black bears.

Dimensions for entry holes to tree dens used in this project were set conservatively based on Godfrey's observations. It should be noted that there is also the potential for black bears to widen tree entrance holes that are originally too small so they can be utilized as tree dens.

Recommendations

Management Implications

Black bears in the Appalachian Mountains of Virginia and West Virginia thrive on both national forest lands and on industrial forest lands. Chestnut oak and northern red oak are very important species for black bears and the retention of these trees in 100+ areas is very important. This study detected a difference in den tree availability between the two forest management systems, and the density of potential den trees on the national forestland was much greater than the density of on the industrial forest lands. Westvaco's policy (at the time of this study) of leaving behind trees on clear-cut land does not have an effect on black bears because the trees left behind cannot be utilized for tree denning purposes. Tree harvesting practices, especially harvesting trees under 100 years old, decrease the number of potential den trees on industrial forest lands. Tree dens are an important type of dens that can be managed for. Slash can be managed to improve the security of ground dens for bears. Slash can be and is used as ground den material. Ground dens are created or found by the bear, and dens found in clear-cut areas are used because of the branches and limbs that are left behind. Rock cavities and caves cannot be managed for because they are present depending on the landscape, not because of land use practices. Given known success of pregnant bears in tree dens an increase in tree dens should increase cub survival and will lower the chance of disturbance in comparison to bears denned on the ground.

Table 1.1. Number of study plots that were to be sampled for the potential den tree study in five study plots with tree stands stratified by age. (The number of study areas with sample plots[1] actually available is shown in parenthesis).

Site	State	Stand Age 0-50	Stand Age 51-100	Stand Age 100+
Northern CABS (NF)	VA	5 (5)	5 (5)	5 (5)
Southern CABS (NF)	VA	5 (5)	5 (5)	5 (5)
Monongahela (NF)	WV	5 (5)	5 (5)	5 (5)
Botetourt (IND)	VA	5 (5)	5 (5)	5 (0)
Greenbrier (IND)	WV	5 (5)	5 (5)	5 (5)

[1] Plots were 40m x 400m.

Table 1.2. Location and stand age of potential den trees on five study areas in Virginia and West Virginia.

Site		Stand Age			Total Trees
		0-50	51-100	100+	
Northern CABS[1] (NF)[2]	VA	1	17	35	53
Southern CABS (NF)	VA	2	2	31	35
Monongahela (NF)	WV	2	14	31	47
Botetourt (IND)[3]	VA	0	15	ND[4]	15
Greenbrier (IND)	WV	0	7	0	7
Totals		5	55	97	157

[1] CABS- Cooperative Allegheny Bear Study in the George Washington and Jefferson National Forests, Virginia. The Northern study area was in Rockingham and Augusta counties VA and the Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] NF- National forest lands
[3] IND- Industrial forest lands
[4] ND=No Data

Table 1.3. Location of hollow trees, hollow trees with entrance holes, and total potential den trees on five study areas in Virginia and West Virginia.

Site		**Potential den trees**[4]	**Hollow trees**	**Hollow w/entrance hole**
Northern CABS[1] (NF)[2]	VA	53	6	5
Southern CABS (NF)	VA	35	7	4
Monongahela (NF)	WV	47	9	4
Botetourt (IND)[3]	VA	15	3	3
Greenbrier (IND)	WV	7	2	2
Total		157	27	18

[1] CABS- Cooperative Allegheny Bear Study. The Northern study area was in Rockingham and Augusta counties VA and the Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] NF- National forest lands
[3] IND- Industrial forest lands
[4] Trees with DBH ≥75cm

Table 1.4. Measurements from eight potential black bear den trees on the National Forest lands in Virginia and West Virginia.

Tree Location	Tree species	Age stand	DBH	Entrance hole height (cm)	Entrance hole width (cm)	Depth (m)
Southern CABS[1]	QuPr[5]	100+	84.5	24.2	22.1	ND[3]
Southern CABS	QuPr	100+	98	29.7	23.1	2.8
Southern CABS[2]	QuRu[6]	100+	91.4	46.4	35.8	7.1
Southern CABS	QuRu	100+	89.5	18.1	14.7	1.4
Northern CABS	QuRu	0-50	75.2	ND[3]	ND	ND
Northern CABS	QuRu	100+	80	19.3	22.1	5.2
Northern CABS	QuRu	100+	77.6	37.9	23.6	3.3
Monongahela[4]	QuPr	100+	92.1	63	73	4

[1] CABS- Cooperative Allegheny Bear Study. The Northern study area was in Rockingham and Augusta counties VA and the Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] Met all the criteria for a potential den tree
[3] ND- No Data
[4] Monongahela National Forest, WV
[5] Chestnut oak
[6] Northern red oak

Table 1.5. Mean DBH (cm) of potential black bear den trees on the Northern CABS (NF) study area.

Tree species	Stand age	No. of trees	Mean DBH	SE
Chestnut oak	0-50	0	-	
	51-100	6	81.1	1.88
	100+	15	80.7	1.51
Northern red oak	0-50	1	75.2	
	51-100	5	80	2.19
	100+	15	83.2	1.57
Tulip poplar	0-50	0	-	
	51-100	6	78.2	0.66
	100+	5	76.5	0.21
All species	0-50	1		
	51-100	17		
	100+	35		

Table 1.6. Mean DBH (cm) of potential black bear den trees on the Southern CABS (NF) study area.

Tree species	Age stand	No. of trees	Mean DBH	SE
Northern red oak	0-50	2	76	1.00
	51-100	1	75	
	100+	11	90.2	3.95
Chestnut oak	0-50	0	-	
	51-100	0	-	
	100+	6	86.2	3.37
White oak	0-50	0	-	
	51-100	0	-	
	100+	1	78	
Black oak	0-50	0	-	
	51-100	0	-	
	100+	4	82	2.62
Tulip poplar	0-50	0	-	
	51-100	0	-	
	100+	1	76	
White pine	0-50	0	-	
	51-100	0	-	
	100+	9	79.3	1.97
All species	0-50	2		
	51-100	1		
	100+	31		

Table 1.7. Mean DBH (cm) of potential black bear den trees on the Monongahela (NF) study area.

Tree species	**Stand age**	**No. of trees**	**Mean DBH**	**SE**
Chestnut oak	0-50	0	-	
	51-100	1	84.4	
	100+	14	87.4	2.54
Northern red oak	0-50	2	83.8	4.45
	51-100	5	79.3	1.47
	100+	8	87.4	4.1
Tulip poplar	0-50	0	-	
	51-100	5	87.9	3.34
	100+	4	83.1	4.34
Black oak	0-50	0	-	
	51-100	3	78.8	1.47
	100+	1	100.4	
White oak	0-50	0	-	
	51-100	0	-	
	100+	4	80.6	1.63
All species	0-50	2		
	51-100	14		
	100+	31		

Table 1.8. Mean DBH (cm) of potential black bear den trees on the Botetourt county, Virginia study area.

Tree species	Stand age	No. of trees	Mean DBH	SE
Chestnut oak	0-50	0		
	51-100	6	82.9	2.98
	100+	ND[1]		
Northern red oak	0-50	0		
	51-100	8	82.6	1.44
	100+	ND		
Black oak	0-50	0		
	51-100	2	82.6	2.65
	100+	ND		
All species	0-50	0		
	51-100	16		
	100+	ND		

[1] ND=No Data

Table 1.9. Mean DBH (cm) of potential black bear den trees on the Greenbrier county, West Virginia study area.

Tree species	Stand age	No. of trees	Mean DBH	SE
Chestnut oak	0-50	0		
	51-100	5	76.4	0.46
	100+	0		
Northern red oak	0-50	0		
	51-100	2	77.1	0.7
	100+	0		
All Species	0-50	0		
	51-100	7		
	100+	0		

Table 1.10. Mean DBH (cm) of potential black bear den trees on five leave strip plots in Botetourt county, Virginia.

Tree species	Stand age	No. of trees	Mean DBH	SE
Northern red oak	Leave strip	5	79.6	1.72
Chestnut oak	Leave strip	4	81.5	3.02

Table 1.11. Mean DBH (cm) of potential black bear den trees on five leave strip plots in Greenbrier county, West Virginia.

Tree species	Age stand	No. of trees	Mean DBH	SE
Chestnut oak	Leave Strip	4	80.6	2.54
Northern red oak	Leave Strip	2	84.3	4.95

Table 1.12. Densities of potential den trees/km^2 on the five study areas on the two forest management systems in Virginia and West Virginia.

Study Areas		0-50	51-100	100+
North CABS[1] (NF)[2]	VA	12.5	212.5	437.5
South CABS (NF)	VA	25.0	25.0	387.5
Monongahela (NF)	WV	25.0	175.5	387.5
Botetourt (IND)[3]	VA	0	187.5	ND[4]
Greenbrier (IND)	WV	0	87.5	0

[1] CABS- Cooperative Allegheny Bear Study. The Northern study area was in Rockingham and Augusta counties VA and the Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] NF- National forest lands
[3] IND- Industrial forest lands
[4] ND=No Data

Table 1.13. Densities of hollow potential den trees/km^2 on the five study areas on the two forest management systems in Virginia and West Virginia.

Study Areas		0-50	51-100	100+
North CABS (NF)	VA	12.5	12.5	50.0
South CABS (NF)	VA	0	0	87.5
Monongahela (NF)	WV	0	87.5	25.0
Botetourt (IND)	VA	0	37.5	ND[4]
Greenbrier (IND)	WV	0	25.0	0

[1] CABS- Cooperative Allegheny Bear Study. The Northern study area was in Rockingham and Augusta counties VA and the Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] NF- National forest lands
[3] IND- Industrial forest lands
[4] ND=No Data

Table 1.14. Mean densities of potential den trees/km^2 on the two forest management systems in relation to age stand.

Stand age	NF PDT	SE	IF PDT	SE	NF HPDT	SE	IF HPDT	SE
0-50	20.8	11.6	0	0	0	0	0	0
51-100	137.5	35.1	137.5	99	8.3	5.6	31.2	14
100+	404.1	92.5	0	0	62.5	16.0	0	0

[1] National forest lands
[2] Industrial forest lands
[3] Potential den trees
[4] Hollow potential den trees

Table 1.15. Percents of land on the national forest lands and industrial forest land that are in the three stand age classes, along with mean density of potential den trees per stand age.

Study areas	Stand age	Percent of total forest land	Mean density of PDT's[1] /km^2	Weighted means
NF	**0-50**	11	20.8	2.2
	51-100	61	137.5	83.8
	100+	28	404.1	113.1
IND	0-50	48	0	0
	51-100	50	137.5	68.7
	100+	52	0	0

[1] Potential den trees

Chapter 2: Denning Success

Introduction

Denning for hibernation is a key part of a black bear's life cycle because during this time parturition occurs (Hellgren 1988). The ultimate reason for denning is to conserve energy so that the female and cubs can survive the winter months (Schooley et al. 1994). Denning also provides a secure setting for early maternal care (White et al. 2001).

Johnson and Pelton (1980) found that weather factors such as precipitation, number of days on which precipitation occurred, and minimum and maximum temperatures have an influence on when bears den. Food availability prior to denning plays an equal or greater role because black bears denned significantly earlier in years with poor hard mast production (Johnson and Pelton 1980, Tietje and Ruff 1980, Beecham et al. 1983) than in years when food was abundant (Johnson and Pelton 1980, Schooley et al. 1994). Schooley et al. (1994) found that when beechnuts *(Fagus grandifolia)* were scarce in Maine, most female bears were denned nearly one month before the first snowstorm. Elowe (1984) reported that bears in Massachusetts denned before snow cover when food was scarce, but suggested that bears continued to forage in moderate snow cover when mast was abundant until the energy costs of foraging exceeded energy gained.

Black bears attain puberty relatively late in life and have one of the lowest reproductive rates of any North American land mammal (Pelton 1982). At birth, cubs are about 0.3%-0.4% of the size of the mother (Oftedal et al. 1994). Black bears normally have between one and four cubs per litter with a mean of around 2.5 (Eiler et al. 1989, Kasbohm 1994, Godfrey 1996, Ryan 1997, Echols 2000). Black bears usually produce a litter every other year once they reach maturity. The peak breeding season for black bears runs from mid-June to mid-July, and this can vary within its range depending on the nutritional condition of the female and when they go into estrus (Eiler et al. 1989). Black bears exhibit delayed implantation, which allows females to eat and gain weight before the denning season without competition from developing fetuses. Timing of parturition allows the relatively underdeveloped cubs to be born when the female is in optimal condition to lactate (Barber and Lindzey 1986).

Studies indicate that black bears do not attain puberty until the age of four (Eiler et al. 1989 and Schooley et al. 1994), but exceptions do exist. Eiler et al. (1989) caught a two-three year old female while it was in estrus and Alt (1989) reported that a female gave birth at two years of age. Alt (1989) also found that 82% of females bred at 2.5 years old in Pennsylvania. In Virginia, Godfrey (1996) found that four 3-year old bears produced cubs, but the most recent data on a substantial sample of Virginia bears shows that about 70% of 3-year olds breed (Vaughan personal communication, 1999).

The minimal interval between successive births is two years, but the interval may be altered by a variety of circumstances. This interval appears strongly related to survival of cubs and nutritional condition of the female (Elowe and Dodge 1989). Observations on marked females that had lost litters before fall indicated that some had come back into estrus during the summer following parturition (Alt 1989, Eiler et al. 1989, and Kasbohm 1994). In years of poor nutritional condition the intervals been successive parturition of the black bear prior to hibernation exceed the two years considered normal (Eiler et al. 1989). When females do not reach an optimal weight they may resorb the fetus or abort the pregnancy. Resorption or abortion may happen during a female's first pregnancy.

After successful parturition females go through the most costly (in energy terms) stage of the mammalian productive process, which is lactation (Farley and Robbins 1995). Black bears begin lactating during hibernation and lactation depends on maternal storage tissue. Following den emergence, cub growth is much faster as cubs consume more of the sow's milk as they get larger (Farley and Robbins 1995). Farley and Robbins (1995) also found that only 9% of the sow's total lactation proportion is consumed prior to den emergence. Accordingly, its investment in lactation prior to emergence seems small in relation to post emergence investment. If cubs are abandoned prior to emergence, or soon thereafter, the energy cost is minimal and reserves may be adequate to breed again that same year.

This study focused on denning and reproductive success on national forest lands and industrial forest lands. The objectives of this portion of the study were to determine if there were differences in reproductive success and denning success on the two forest management systems under study. The null hypothesis was there were no differences in cub growth or litter sizes on the two forest management systems. A further objective was to determine differences between forest management systems in the extent of den abandonment by bears denning on one type of forest in comparison to the other.

Methods

Study Areas

The study was conducted on National Forest lands in Virginia and West Virginia, and on Westvaco lands in Virginia and West Virginia (Figure 2.1). The specific locations were as follows:

-National Forest lands of the George Washington and Jefferson National Forest lands (GWJNF) in the counties of Augusta and Rockingham, VA, represent the Northern study area of the Cooperative Alleghany Bear Study (CABS).

-National Forest lands of the George Washington and Jefferson National Forest lands (GWJNF) in the counties of Craig, Giles, and Montgomery, VA, represent the Southern study area of the Cooperative Alleghany Bear Study (CABS).

-Industrial forest lands of Westvaco Corporation in Botetourt County, VA.

-Industrial forest lands of Westvaco Corporation in Greenbrier County, WV.

-Industrial forest lands of Westvaco Corporation in Pendleton County, WV.

All locations are in the Ridge and Valley Geographic Province and the trees of importance included chestnut oak (*Quercus prinus*), Northern red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), white oak (*Q. alba*), tulip poplar (*Liriodendron tulipifera*), cucumber tree (*Magnolia acuminata*), red maple (*Acer rubra*), pignut hickory (*Carya glabra*), eastern white pine (*Pinus strobus*), pitch pine (*P. rigida*) and yellow birch (*Betula allegheniensis*) were the common overstory species. Sassafras (*Sassafras albidum*), mountain laurel (*Kalmia latifolia*), downy serviceberry (*Amelanchier arborea*), flowering dogwood (*Cornus florida*), witch hazel (*Hamamelis virginia*), and rhododendron (*Rhododendron maximum*) (Ryan 1997).

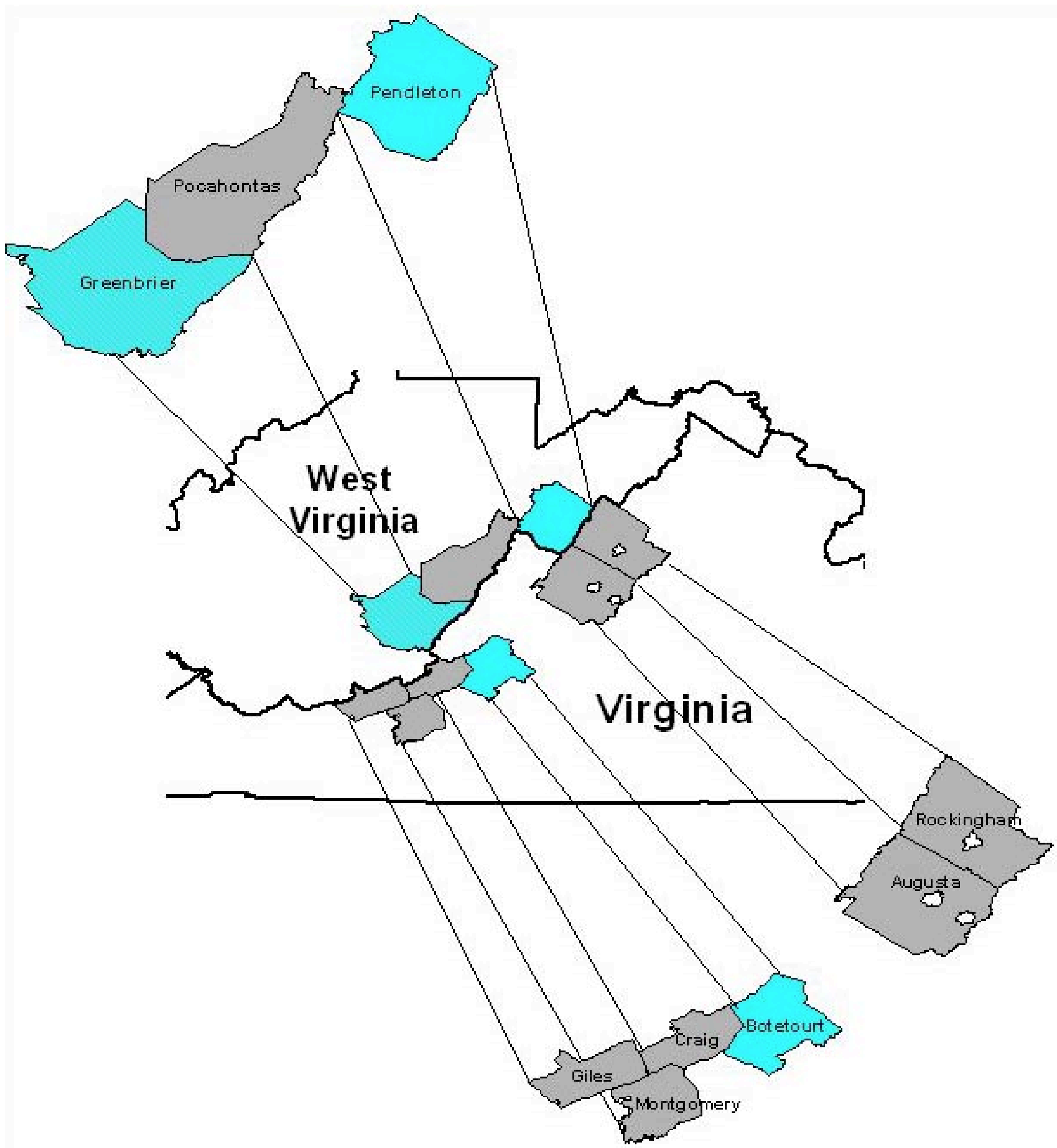

Figure 2.1. Study areas used in Virginia and West Virginia. Gray areas represents areas used on the National Forest Land areas; Blue represents counties used on Industrial Forest Lands; Greenbrier County (Blue with gray stripes) had both National Forest Lands and Industrial Forest Lands

Trapping

Bears were trapped between early June and late August of 1999 and 2000 on Westvaco land in Botetourt County, Virginia. The bears captured on these lands represented bears utilizing industrial forest lands. The personnel of the Cooperative Alleghany Bear Study (CABS) captured bears on the national forest lands, in Giles, Craig, Montgomery, Augusta, and Rockingham Counties, Virginia concurrently. All bears captured were captured by spring-activated Aldrich foot snares with "deer stops" to prevent the trapping of other animals and young bears. Trapped bears were immobilized with a 2:1 mixture of ketamine hydrochloride and xylazine hydrochloride (concentration of 300mg/ml) administered by a blow gun (Hellgren and Vaughan 1989) at dosages of 1cc per 45kg of body weight. Body weights were estimated based on experience. Every trapped bear had measurements taken including: weight, actual length, zoological length, front paw length and width, ear length, zygomatic arch width, hind paw length and width, canine width and canine breadth, shoulder height, tail length, and testicle width and length for males.

The sex of each bear was determined after it was captured. The bear was weighed to the nearest kg after immobilization. Each captured bear was ear-tagged and received a tattoo on the upper lip with a number corresponding to the ear-tag number. A first premolar was extracted for aging by cementum annuli analysis (Willey 1974). All (n=5) female bears that were over 45kg received collars and collars were put on 2 adult males. Each collar used was fitted with a breakaway spacer (Hellgren et al. 1988). The spacers were used to attach both ends of the collar to minimize collar-related neck injuries.

All female bears trapped were checked for estrus and lactation. Lactating females exhibiting an enlargement to the mammary glands and loss of hair around the nipples were considered to be nursing cubs (Godfrey 1996). The females caught without lactation-related characteristics and exhibiting signs of being in estrus were considered to be able to reproduce during the upcoming den season. Those non-lactating females greater than 45kg were considered potential breeders and were included in the "list" of bears to be located during hibernation and inspected in the dens.

From September to December all radio-collared bears were monitored once or twice a week to determine locations and to ensure the bears were still alive and on the study sites. All locations were recorded.

Bear Inspections at Dens

During the months of February and March dens of radio-collared bears were entered. Dens of female bears with yearlings were entered in late February and dens of females expected to be with newborn cubs were checked in March. Cubs are born in late January and early February, but by checking them in March the cubs have had an opportunity for substantial growth before being handled. Larger cubs at this stage were expected to be better able to withstand any separation from the mother due to den inspection work. Denned females were immobilized by the same methods used in the summer. Attempts were made to obtain all of the same information as listed above from females that were taken at capture in the summer. However, some measurements were more difficult to determine on denned bears. Females were weighed only if they had vacated dens following immobilization attempts and/or if weighing would not cause disturbance to the den area. Females in den trees could not be weighed without taking the female out of the den area. As a result several females in den trees were not weighed, although other indicators of growth e.g., neck and chest girth measurements, were made on most of the females.

Litter sizes and sexes of cubs were recorded. The cubs were weighed to the nearest 0.1kg and had the following body measurements taken: total length, front paw length and width, ear length, zygomatic arch, hind paw length and width and length of hair between the ears.

Habitat Measurements

Habitat measurements were taken on tree dens and ground dens on all study sites. For tree dens the following were recorded: tree alive or dead, tree species, total tree height, height of entrance, width of entrance, depth from cavity entrance to the bear, DBH (diameter at breast height) of tree, height to entrance, and depth of bedding material. For ground dens the type of den was noted as follows: slashpile, ground nest, rock cavity, excavation, or fallen log. Then the following measurements taken as appropriate to the den type: cavity height, cavity length, cavity width, bedding material depth, nest length, nest width, entrance height, and entrance width.

Denning Success

Following initial den inspection and measurements on females and cubs, dens were revisited after expected emergence (late April). Female bears with newborn cubs were designated as reproductively successful when they left the den with at least one offspring. Male bears and female bears with yearlings were deemed to have successfully survived when they emerged from the den in the spring. Dens were checked for signs of cub mortality and abandonment after the sow left the den. A direct indication of reproductive success was also obtained by listening for the cubs suckling, from outside the dens when dens could not be entered.

Statistical Analyses

Differences in cub growth measurements were compared using analysis of covariance (ANCOVA). This test determined if there were differences in cub growth measurements using several variables. The measurements used were weight, total length, chest girth, neck girth, ear length, front paw length, front paw width, hind paw length, hind paw width, and zygomatic arch width. The variables used for the ANCOVA test were; forest management systems (FMS) and sex. The covariates were litter size and date. Forest management systems were used to determine if there was a difference in cub growth measurements based on the forest management system the bear was denning on i.e. either national forest lands of industrial forest lands. The sex of the cubs was used to determine if the growth measurements differed between males and females. We also used a sex and forest management system interaction to see if trends in the sexes with the forest management systems were similar. Some data from the national forest lands were eliminated to conform with the range of dates when cubs were measured on the industrial forest lands. The dates were between March 10 and March 24. Therefore, eliminating these data and only comparing cubs on the national forest lands during the same period gave more appropriate comparisons. Two sample t-tests were used to compare litter sizes of bears from the national forest lands and industrial forest lands. Chi-square tests were done to see if there were differences in the number of tree den and ground den abandonment's.

Results

Litter Size

Litter sizes of bears on the national forest lands and industrial forest lands were similar (t=-0.36, 44df, P=0.84) (Tables 2.1, 2.2). The sample size in the national forest lands was much larger than that of the industrial forest lands (36 vs. 10). The mean litter size on the national forest lands was 2.55 cubs per litter (SE=0.16) and for the industrial forest lands the mean litter size was 2.4 cubs per litter (SE=0.22).

The litter sizes on the two forest management systems were compared by two groups of den types, which were tree dens or ground dens. Bears on the national forest lands that denned on the ground had comparable litter sizes to those denning in trees (t= -0.04, 34df, P=0.97) (Table 2.3). On the industrial forest lands bears in ground dens had 2.16 cubs per litter (n=6, SE=0.30) while tree dens had 2.75 cubs per litter (n=4, SE=0.25) (t=-1.35, 8df, P=0.18). When comparing all tree dens to all ground dens regardless of the forest management system the litter sizes did not differ (t=-0.44, 44df, P=0.62). Litter sizes of bears denned on the ground (t=-1.06, 24df, P=0.31) did not differ between forest management systems, nor did they for bears denned in trees (t=-1.25, 18df, P=0.62) (Table 2.2).

Habitat

Black bears on the national forest lands denned in six different types of dens during the winters of 1999-2000 and 2000-2001 and three different types of dens on the industrial forest lands during the same time periods (Table 2.4). On the national forest lands there were 110 dens used by black bears and 18 on the industrial forest lands. The type of den most frequently used on the national forest lands was a tree den (n=55, 50%), ground nests (n=18, 16.4%), and then rock cavities (n=16, 14.5%) were frequently used. The other types of dens used were: slashpiles (n=11, 10%), excavations (n=7, 6.4%), and hollow logs (n=3, 2.7. There was a total of 55 dens in trees and 55 dens were on the ground.

On the industrial forest lands more bears denned on the ground then in trees (Table 2.4). Tree dens (n=8, 45.4%), represented the most common type of den on industrial forest lands. Slashpiles (n=6, 33.3%) and excavations (n=2, 11.1%), were also used as dens. There was a total of eight tree dens and there were 10 ground dens.

Black bears on the national forest lands used five different species of trees for denning (Table 2.5). These were chestnut oak, northern red oak, white oak, tulip poplar, and red maple. Bear dens on the industrial forest lands were found in two species of trees (chestnut oak and northern red oak).

Tree Den Measurements

In all, five tree species (chestnut oak, northern red oak, white oak, tulip poplar, and red maple) were used for tree dens. Chestnut oak and northern red oak were both used on both forest management systems. The values for tree den parameters measured in both forest management systems were similar (Tables 2.5 and 2.6), but sample sizes were too small for comparison by statistical analysis. The mean tree height of den trees used on the national forest lands was 20.1m (n=40); and 19.5m (n=6) for the industrial forest lands (Table 2.7). Mean height at entrance was similar for trees in both forest management systems, 9.8m (n=39) for the national forest lands and 9.1m (n=5) on the industrial forest lands. The DBH of trees used was also very similar, on the national forest lands the mean DBH was 93.7cm (n=33) and on the industrial forest lands it was 92.3cm (n=3). Mean entrance height was 113.7cm (n=4) on the industrial forest lands and mean entrance width was 60.4cm (n=4). On the national forest lands mean entrance height was 68.7cm (n=18) and entrance width was 37.1cm (n=18).

Ground Den Measurements

Data on ground den measurements were pooled from the same forest management systems regardless of type of ground den measured. Ground dens were used as frequently as tree dens in both forest management systems. The national forest lands had 55 of each type and the industrial forest lands had 10 ground dens and eight tree dens. Ground dens on both areas had similar trends though the data on measurements were variable. Again, data were considered too few for meaningful statistical comparisons. Entrance height and entrance width means were 54.7cm (n=21) and 64.1 (n=21) on the national forest lands, respectively. Those on industrial forest lands were 73.9cm (n=6) entrance height and 78cm (n=6) entrance width (Table 2.8 and 2.9). The mean cavity length, width, and height of ground dens, were larger on the national forest lands than on industrial forest lands. The cavity length was 354.9cm (n=19), cavity width 191.2cm (n=20), and cavity height 147.9cm (n=21) and on the industrial forest lands it was 208.4cm (n=5), 85.4cm (n=5), and 69.6cm (n=5) respectively. Data were extremely variable and this variation combined with the small sample size precluded meaningful analysis.

Denning Success

A bear being able to den in one area, have a successful litter, and then leave the den with a cub during the spring constitutes denning success for females expecting to have cubs. Male bears and female bears with yearlings were deemed to have successfully survived when they emerged from the den in the spring. On the industrial forest lands 12 out of 13 females expected to have cubs denned successfully (Table 2.10). The remaining female did not have cubs. All eight female bears in tree dens denned successfully. Four female bears in ground dens denned successfully; thje female bear without cubs was in a ground den.

For all bears on the industrial forest lands 14 of 18 dens were (77%) successful, and all unsuccessful dens were on the ground (Table 2.10). Dens success in tree dens (n=8) was 100% and on ground dens (n=10) it was 60%.

There were 80 female bears expected to have cubs denned on the national forest land (Table 2.10). Seventy-one (88%) out of the 80 females expected to have cubs exhibited denning success and nine did not. Forty-five out of 46 (98%) females expected to have cubs exhibited denning success in tree dens and 26 out of 34 (76%) females expected to have cubs in ground dens were successful

For all bears on the national forest lands there was 114 possible dens. Ninety exhibited denning success and 34 did not (Table 2.10). Fifty-three of 55 tree dens (96.3%) were successful, but only 37 out of 59 (62.7%) ground dens were successful.

This is a total of 79% denning success on the national forest lands. The majority of den failure was because of den abandonment.

Abandonment of Dens

On the national forest lands 5 females with cubs abandoned their dens (Table 2.11). These abandonments were all because of researcher related incidences. There were no abandonemets from females with cubs on the industrial forest land.

On national forest lands 21 bears abandoned their dens and six different types of dens were abandoned (Table 2.11). The majority of abandonment was research related. There were significantly more abandonments in ground dens than in tree dens (x^2=19.02, 1df). Ground nests had the highest rate of abandonment (11 of 18, 61%). In contrast, bears that denned in trees abandoned only two of 52 (3.8%). In all dens other than tree dens bears seemed to have higher rates of den abandonment (Table 2.12). Three of six dens in slashpiles on industrial forest lands were abandoned. By contrast no tree dens, or any other den type of dens on industrial forest lands were abandoned.

Cub Physical Characteristics

Data on cub physical characteristics were separated by year (2000 and 2001) and compared by forest management systems (Table 2.13 and Appendix Tables 14-33). Only two physical characteristics of cubs were significantly ($P<0.1$) different between FMS's in 2000; no cub dimensions differed between FMS's in 2001. Cubs on industrial forest lands had larger neck girth and front paw lengths in 2000. (Table 2.13). Litter size significantly ($P<0.1$) affected several characteristics with larger litters having smaller measurements. Date measurements taken, also significantly ($P<0.1$) affected several characteristics, as time progressed cubs became larger primarily in the 2001 den season.

Discussion

A variety of factors contribute to success of winter denning and pregnancy. Presumably experience of the bear is one such factor. Food availability prior to hibernation is of crucial importance and general factors contributing to ovulation, implantation, and lactation also matter greatly. Hence, the discussion centers on whether the den types on the two forest management systems contributes to denning success and several parameters associated with pregnancy and cub growth. Food availability was not measured and the studies relied on there being comparable conditions within years as far as both forest managements systems were concerned.

Litter Size

Litter sizes of bears did not differ between forest management systems. Black bears in the Appalachian region commonly have between two and three cubs per litter (Godfrey 1996, Kasbohm 1994, Echols 2000, Ryan 1997). Data from the present study concurs with previous studies. In total, on the national forest lands, mean litter size was 2.6 (n=36) and on industrial forest lands mean litter size was 2.4 (n=10). There was no difference in litter sizes from tree and ground dens, though the sample size was too small to draw firm conclusions. In any event, the literature does not indicate differences in litter sizes associated with the type of den. Tree dens tend to offer more secure environments for litters than most ground dens. The present study cannot support or refute this argument due to limited data.

When a female becomes pregnant during the summer it is not pre-determined where she will den, but the number of ova released is determined at that time. Factors affecting implantation are not known, but apparently bears are in dens at implantation. It is difficult to imagine that the type of den would influence implantation rate. However, the quality of the den could impact cub survival as weather, wind, and flooding are factors (Oli et al. 1997), and potential for disturbances and abandonment can vary with den type. There were no litter size differences in the forest management systems or in the proportion of litter sizes on tree dens compared to ground dens.

Habitat

It was expected that black bears on the two forest management systems would use a variety of dens during the winter. It was surprising that black bears on the national forest lands used ground dens as often as they did tree dens (n=55 for each), as previous studies showed a preponderance of tree den use. Godfrey (1996) found 82% (n=56) of bears in tree dens and Kasbohm (1994) found 71% (n=48) of bears in trees. It was interesting to note that black bears on the industrial forest lands used tree dens and ground dens similarly (n=8 for tree dens, n=10 for ground dens) because the timbering practices used on the industrial forest lands may increase availability for ground dens such as slashpiles and hollow logs.

Tree Dens

Den tree measurements of tree dens used by bears on this study were similar on both forest management systems. This was expected because the bears were in different habitats, but not different regions so they likely would use similar trees when available. A wider range of species (five) was used on the national forest lands, Two species were used on the industrial forest lands. This observation may reflect that there are regional differences in the availability of some tree species or it may be that species are favored and/or harvested differentially on industrial forest lands. Chestnut oak and northern red oak were the common tree species important as den trees.

Finding den trees for a black bear is obviously important, but it is difficult to determine how they find these dens especially in areas where large trees may be scarce. One theory is that the den trees are in the bear's home range and may be found during any time of the year. Beecham et al. (1983) believed that bears may know of several den areas within their home range. They considered that a bear may travel far from this area, but will go back to this area to den in the winter, remembering where it is from its previous travels of the area. On the other hand, the den may be found by chance and is close to the last area where the bear had an abundance of food available at the end of its hyperphagia period. There are no definite answers as to why or when bears choose a den, but it probably involves checking tree conditions and checking if there is an available cavity.

Ground Dens

Tree dens for bears require large trees with cavities. Tree size requirements and cavity availability probably make tree dens less abundant than ground dens (bears can den in a variety of settings on the ground and can motify slashpiles and make excavations). It was not unusual to find many bears using ground dens. Ground dens were found in a lot of different habitats including mature forests, young forests, and, on the industrial forest lands, there were dens even located in recent clear-cut areas.

Denning Success of Females with Cubs

White et al. (2001) state that for parturient females, denning provides a secure setting for early maternal care. A black bear's ability to den in a secure area, have a litter, and leave the den with the litter is very important for the survival of the species. Overwintering in a single den may not be as important to a male or even a female with yearlings as it probably is to a female with cubs. Overwintering in a single den may even be essential for the survival of the cubs due to the altricial nature of cubs during the mother's hibernation. Cubs at birth are only 0.3 to 0.4% of the size of the mother (Oftedal et al. 1994). Johnson and Pelton (1981) reported that female black bears were more selective in choosing a den than were males. Even though the differences in heat retention in denning were not significant, their results suggested a tendency for females to select more protective dens, such as tree dens, than do males. A similar pattern emerged from data from more than 300 dens in Pennsylvania (Alt and Gruttaduria 1981). They found that females tended to use more protective dens, such as rock cavities, excavations, and hollow trees, whereas males denned more often in ground nests and brushpiles than did females.

Denning success on both forest management systems was similar in this study. Overall denning success of females with cubs on the industrial forest lands was 92% versus 89% denning success on the national forest lands. Within forest management systems the success of all bears in tree dens and of ground dens was comparable for a number of reasons. Black bears on the national forest lands denned on the ground more often than on previous studies on the GWJNF. Godfrey (1996) found only 18% (n=12) of bears denned on the ground compared to 50% (n=55) on this study. The ratio of tree den to ground den usage on the two forest management systems was similar (almost 1:1 on both). Therefore, similar denning success was not unexpected. It was hypothesized that the national forest lands would have higher denning success, but this was not the case because of the higher than usual proportion of ground dens on the national forest land and the higher than expected proportion of tree dens on industrial forest lands.

The data available do not indicate differences due to the different forest management systems despite the differences in availability of tree dens (See Chapter 1). Success probably reflects the security bears have in tree dens. The avoidance of disturbances and of aspects of winter weather within tree dens greatly increases survival of litters while decreasing chances of a female abandoning the den.

Den Abandonment

Bears may abandon dens during hibernation. Disturbance of dens by investigators, even merely approaching the dens, can disturb the female sufficiently to cause her to flee the den and possibly abandon it completely. Animals such as dogs may provoke abandoning of ground dens. Probably a wider range of species could provoke abandonment of ground dens than of tree dens. The majority of abandonment in the study was from research related incidences.

Abandoning the den may not necessarily result from an initial disturbance. However, a disturbance may heighten awareness and predispose bears to abandonment in response to any subsequent disturbance or disturbances.

There are no systematic data available on how denned bears react to disturbance, but, as reported by Linnell et al. (2000), the response generally reported is den abandonment, which is the most extreme reaction possible. Data on den abandonment can only be obtained through examination of the denned bears. This automatically adds investigator disturbance as a confounding factor in the den abandonment. Dens differ considerably in protection and isolation afforded to bears. Anecdotal information indicates that bears seldom defend the den from investigators and that they run off when disturbed; such running off usually leads to den abandonment.

In this project, investigation of denned bears involved radio-location of the collared bears. When arriving at a den a decision was made as to whether the bear could be immobilized based on location of the den, safety of the bear, and the safety of the investigators. If the bear could not be safely immobilized the bear would be left undisturbed. The bear still may run without investigators truly disturbing the area. The bear may run prior to discussion of whether or not to immobilize or it could run after the immobilizing drugs have been administered, in which case it would be recovered and returned to the den. Some immobilized bears abandoned dens whether they run off or not during examination. Data on den abandonment accordingly are difficult to advance beyond anecdotal data and suffer from being confounded by investigation. Because of these problems it is difficult to correlate den abandonment to forest management policies.

Black bears on these two forest management systems hibernated in many different den types; tree dens, slash piles, ground nests, rock cavities, and fallen logs. The tree dens were the easiest to approach without disturbing a bear. With the bear in a state of hibernation and because it is elevated above where a researcher, animal, or forest worker is moving about, the chance that the bear feels threatened or feels the need to abandon the den is probably much lower. A very low percentage of tree dens were abandoned on the national forest lands and no den trees were abandoned on the industrial forest lands. The disturbance factors, when doing research on a denned bear that is in a tree, involved the initial visit when all weights and measurements were made. Later visits merely involved checking presence of bears by radio locations within minimal distance.

Smith (1986) stated that bears denning on the ground appeared to be more susceptible to disturbance than those denning in elevated trees. The relatively limited data from this study support Smith's (1986) findings. Attempting to immobolize and measure a bear in a slashpile is much different than handling a bear in a tree. Sound and smell may be more prominent from a researcher because of the close distance obtained by approaching a den to immobilize the bear. A young female with cubs or a female with yearlings may be more likely to run when an investigator or animal ventures to close too her den.

The three bears that abandoned their ground dens on industrial forest lands all had yearlings with them. One of the dens had never been located before, and was in a clear-cut area. Locating this den necessitated use of approach through slash. This approach proved to be noisy. The female and her yearlings ran off because of the disturbance near their den. The other two bears that abandoned their dens on industrial forest lands were previously pre-located dens, which may have had the bears on alert for danger. When there was the opportunity to approach these dens the females and their yearlings were gone. Four dens on the national forest lands were abandoned before investigators could determine what kind of den the bear was in. These dens were most likely ground dens, but were abandoned before an identification could be made.

Ground nests for all bears on the national forest lands were frequently abandoned and this is probably because these dens are out in the open. There is no real shelter provided in a ground nest and therefore it is relatively easy to disturb by anything. In contrast, all bears denned in rock cavities, which are much more secure than other ground dens abandoned, only 18% of their dens were abandoned on national forest lands.

Cub Measurements

Measurements were expected to be similar on both forest management systems. Different forest management systems should not influence cub growth for black bears in the same geographic region. The data were more consistent in the 2001 measurements than in the 2000 data. It was intuitively expected that cubs would be larger as the date became later in the year. In 2000, chest girth increased to significantly as time progressed. In 2001, weight, total length, chest girth, ear length, front paw width, hind paw length, hind paw width, and zygomatic arch all increased significantly as time progressed. The reason for this difference in the two years in unknown, it could be as complicated as an environmental factor or it could be the nutrition of the females.

Male cub weights were expected to be larger than females, which was true in both forest management systems. Other measurements did not differ consistently. Front paw length and neck girth were different is 2000, but these differences were not seen in 2001.

Recommendations

Management Implications

Black bears that live on these two forest types used similar denning habitat. The black bears that live on industrial forest lands have viable and healthy litters similar to those of bears on the national forest lands. Black bears on the national forest lands may use more tree dens than the bears on the industrial forest lands because of availability, but until there are comparable sample sizes on both forests, this statement cannot be tested. Tree dens do make the best dens for black bears because of the better protection of adverse weather and animal disturbances. Managing for retention of tree dens and even snags, is recommended. Black bears on both forests have shown similar trends in denning success and abandonment, again showing that there may be few differences between these two forest management systems. This study did not show any major consistent differences in cub growth. Wildlife managers on these two forest management systems should realize that black bears still could have successful litters without den trees being available for denning. Recommendations for den management on one forest management system in this region may apply to other forest management systems because of similarities in the bears and the habitats.

Table 2.1. Litter sizes of black bears in Virginia and West Virginia on national forest lands and industrial forest lands during winters 2000 and 2001 (All den types are included).

Forest type and year	**Females**	**Cubs**	**Litter Size (Mean)**	**SE**
Industrial forest, 2000	4	10	2.5	0.29
Industrial, forest 2001	6	14	2.33	0.33
National Forest, 2000	11	29	2.63	0.31
National Forest, 2001	25	63	2.52	0.2
Industrial forest, both years	10	24	2.4	0.22
National Forest, both years	36	92	2.55	0.16

Table 2.2. P-values from t-tests comparing litter sizes of denning bears on national forest lands and industrial forest lands in Virginia and West Virginia during the denning seasons of 2000 and 2001 (pooled). Data in columns are compared to the data in the rows.

Location and Den Type[1]	**IF GD (n=6)**	**IF TD (n=4)**	**NF GD (n=20)**	**NF TD (n=16)**	**All IF (n=10)**	**All NF (n=36)**	**All GD (n=26)**	**All TD (n=20)**
IF[1] GD[2]		0.18	0.31					
IF TD[3]	0.18			0.62				
NF[4] GD	0.31			0.97				
NF TD		0.62	0.97					
All NF					0.84			
All IF						0.84		
All TD							0.62	
All GD								0.62

[1] IF=Industrial forest lands
[2] GD=Ground dens
[3] TD=Tree dens
[4] NF=National Forest Lands

Table 2.3. Litter Sizes for black bears in tree and ground dens in Virginia and West Virginia on national forest lands (NF) and industrial forest lands (IF) in 2000 and 2001.

Type of dens[1]/Location	Total # of dens	Mean litter size	SE
Ground dens, IF[1]	6	2.16	0.31
Ground dens, NF[2]	20	2.55	0.18
Tree dens, IF	4	2.75	0.25
Tree dens, NF	16	2.56	0.27

[1] "Ground dens included all types of ground dens observed. "Tree dens" included trees and snags.
[2] Industrial forest lands
[3] National forest lands

Table 2.4. Den type use by all black bears of all ages on national forest lands and industrial forest lands during the denning seasons of 1999-2000 and 2000-2001.

Den Type	Industrial Forest	%	National Forest	%
Tree[1]	8	44.5	55	50.0
Slashpile	6	33.3	11	10.0
Rock cavity	0	0	16	14.5
Excavation	4	22.2	7	6.4
Ground nests	0	0	18	16.4
Fallen logs	0	0	3	2.7
Total (Overall)	18	100	110	100
All trees[1]	8		55	
All ground dens	10		55	

[1] Includes snags

Table 2.5. Tree species used and dimensions [Mean, SE, (N)] of tree dens used by black bears in Virginia on national forest lands during the winters of 1999-2000 and 2000-2001. (Data pooled for both winters).

	Mean, SE, (N)				
Measurement	**QuRu[1]**	**QuPr[2]**	**QuAl[3]**	**LiTu[4]**	**AcRu[5]**
Tree height (m)	20.5, 0.9 (15)	18.3, 0.9 (17)	17.5, 1.6 (3)	24.7, 2.6 (3)	28.4, 5.1 (2)
Height to entrance (m)	10.5, 0.9 (14)	7.67, 0.8 (17)	6.73,1.8 (3)	18.5, 1.3 (3)	14.8, 0.7 (2)
Bear depth from entrance (m)	2.69, 0.8 (11)	3.71, 0.7 (13)	3.96, 2.1 (3)	2.7 (1)	0.9 (1)
DBH (cm)	96.1, 3.9 (14)	89.1, 5.3 (13)	72.4 (1)	108.2, 8.8 (3)	96.4, 4.6 (2)
Entrance height (cm)	99.3, 42.6 (4)	64.8, 10.1 (12)	31, 2.8 (2)	ND[6]	ND
Entrance width (cm)	34.8, 4.0 (5)	36.2, 3.3 (11)	47.5, 2.5 (2)	ND	ND

[1] Northern red oak (*Quercus rubra)*
[2] Chestnut oak *(Q. prinus)*
[3] White oak (*Q. alba)*
[4] Tulip poplar (*Liriodendron tulipifera*)
[5] Red maple *(Acer rubra)*
[6] ND=No Data

Table 2.6. Tree species used and dimensions [Mean, SE, (N)] of tree dens used by black bears in Virginia and West Virginia on industrial forest lands during the winters of 1999-2000 and 2000-2001 (Data pooled for both winters).

	Mean, SE (N)	
Measurement	**QuRu**[1]	**QuPr**[2]
Tree height (m)	18.1, 4.47 (3)	20.9, 0.57 (3)
Height to entrance (m)	9.13, 1.21 (3)	9.05, 3.57 (3)
Depth to bear from entrance (m)	2.21, 1.44 (2)	3.76, 2.52 (3)
DBH (cm)	76.2 (1)	100.4, 10.3 (2)
Entrance height (cm)	325 (1)	43.3, 7.7 (3)
Entrance width (cm)	190 (1)	74.3, 40.45 (3)

[1] Northern red oak (*Quercus rubra*)
[2] Chestnut oak (*Q. prinus*)

Table 2.7. Dimensions of tree dens [Means, SE, (N)] used by black bears on the national forest lands in Virginia and on the industrial forest lands in Virginia and West Virginia during the winters of 1999-2000 and 2000-2001.

	Mean, SE, (N)	
Measurement	**NF[1]**	**IF[2]**
Tree height (m)	20.1, 0.72 (40)	19.5, 2.10 (6)
Height to entrance (m)	9.83, 0.72 (39)	9.1, 1.36 (5)
Depth to bear from entrance (m)	3.22, 0.47 (29)	3.14, 1.50 (5)
DBH (cm)	93.7, 2.92 (33)	92.3, 10.02 (3)
Entrance height (cm)	68.77, 11.70 (18)	113.7, 70.63 (4)
Entrance width (cm)	37.1, 2.41 (18)	60.4, 31.77 (4)

[1]National forest lands
[2] Industrial forest lands

Table 2.8. Dimensions of ground dens used by black bears in Virginia on national forest lands during the winters of 1999-2000 and 2000-2001.

Measurement	**Mean**	**SE**	**N**	**Min**	**Max**
Entrance height (cm)	54.7	6.52	21	20	109.2
Entrance width (cm)	64.1	5.29	21	39	147.3
Bedding material depth (cm)	5.75	1.38	27	0	35
Nest length (cm)	122.8	22.84	34	37	830
Nest width (cm)	83.4	6.36	34	26	233.7
Cavity length (cm)	354.9	115.95	19	81.28	2260
Cavity width (cm)	191.2	62.17	20	55.9	1015
Cavity height (cm)	147.9	50.44	21	45.7	985

Table 2.9. Dimensions of ground dens used by black bears in Virginia and West Virginia on industrial forest lands during the winters of 1999-2000 and 2000-2001.

Measurement	Mean	SE	N	Min	Max
Entrance height (cm)	73.9	10.1	6	47.4	120
Entrance width (cm)	78	10.65	6	43	122
Bedding material depth (cm)	3.4	2.4	2	1	5.8
Nest length (cm)	106.1	18.9	8	64	227
Nest width (cm)	94.2	7.35	8	65	133
Cavity length (cm)	208.4	68.18	5	82	440
Cavity width (cm)	85.4	16.06	5	49	148
Cavity height (cm)	69.6	14.5	5	37	112

Table 2.10 Denning success of females with cubs on the national forest lands in Virginia and industrial forest lands in Virginia and West Virginia checked during 2000 and 2001. All bears are in parenthesis.

Location and den type	Total dens	Successful	Not Successful	% Successful
National forest Ground dens	36 (59[1])	26 (37)	8 (22)	76 (63)
National forest Tree dens	46 (55)	45 (53)	1 (2)	98 (96)
Industrial forest Ground dens	5 (10)	4 (6)	1 (4)	80 (60)
Industrial forest Tree dens	8 (8)	8 (8)	0 (0)	100 (100)
All national forest	80 (114[1])	71 (90)	9 (24)	89 (79)
All industrial forest	13 (18)	12 (14)	1 (4)	92 (77)
Total ground dens	39 (69[1])	30 (43)	9 (26)	78 (62)
Total tree dens	54 (63)	53 (61)	1 (2)	98 (97)

[1]Four dens were abandoned before researches arrived at the den area, the actual den was never found

Table 2.11. Den types of female bears with cubs and number of dens that were abandoned on the national forest lands checked during 2000 and 2001. All bear dens in parenthesis.

Den Type[1]	Total Dens	Abandoned	%
Trees	46 (55)	1 (2)	(4%)
Slashpiles	7 (11)	1 (2)	(18%)
Rock Cavities	9 (16)	0 (3)	(18%)
Ground nests	11 (18)	3 (11)	(61%)
Excavations	6 (8)	0 (1)	(12%)
Fallen logs	1 (2)	0 (1)	(50%)
All ground dens	34 (55)	5 (19)	(33%)
All tree dens	46 (55)	1 (2)	(4%)
Total	80 (110*)	5 (21)	(19%)

*Four dens were abandoned before researches arrived at the den area, the actual den was never found

[1] Combined data from national forest lands and indistrial forest lands, for all bears, indicate significantly (x2=19.02, 1df) higher abandonment of ground dens than of tree dens.

Table 2.12. Den types of female bears with cubs that were abandoned on the industrial forest lands in Virginia and West Virginia checked during 2000 and 2001. All bear dens in parenthesis.

Den Type[1]	**Total Dens**	**Abandoned**	**%**
Tree	8 (8)	0 (0)	0 (0)
Excavation	4 (4)	0 (0)	0 (0)
Slashpiles	3 (6)	0 (3)	0 (50)
All ground dens	7 (10)	0 (3)	0 (30)
All tree dens	8 (8)	0 (0)	0 (0)
Total	15 (18)	0 (3)	0 (17)

[1] Combined data from national forest lands and indistrial forest lands, for all bears, indicate significantly (x^2=19.02, 1df) higher abandonment of ground dens than of tree dens.

Table 2.13. Mean differences together with factors showing significance ($P < 0.1$) influencing differences in the variable, for measurements of black bear cubs in the national forest lands in Virginia and industrial forest lands in Virginia and West Virginia in 2000 and 2001.

2000

Measurement	Mean Differences	Statistical Difference
Weight (kg)	0.33	Sex (Males larger)
Total length (mm)	32.60	Sex (Males larger)
Chest girth (mm)		Litter size[1] and Date[2]
Neck girth (mm)	16.80	(FMS[3]) (IFL[4])
Ear length (mm)		None
Front paw length (mm)	4.50	FMS (IFL)
Front paw width (mm)		None
Hind paw length (mm)		Litter size
Hind paw width (mm)		None
Zygomatic arch (mm)		None

2001

Measurement	Mean Differences	Statistical Difference
Weight (kg)	0.27	Sex (Males), Date
Total length (mm)		Litter size, Date
Chest girth (mm)		Litter size, Date
Neck girth (mm)		None
Ear length (mm)		Date
Front paw length (mm)		Litter size
Front paw width (mm)		Date
Hind paw length (mm)		Date
Hind paw width (mm)		Date
Zygomatic arch (mm)		Date

[1] Litter size indicates that the larger the litter the smaller the measurement
[2] Date indicates measurements later in the year are larger
[3] FMS= Forest management system
4 IFL= Industrial forest land

General Summary

This work focused on the importance of denning to wintering pregnant female black bears and the impact of the two contrasting forest management systems on den availability. The forest lands studied were national forest lands and industrial forest lands. The most reliable structures for winter dens are hollow, standing den trees. Den trees are well recognized as the safest structures for preganant black bears in the Appalachian region.

Potential den trees suitable for pregnant black bears have large diameters (>75cm DBH). Such trees were found to be much more prevalent in tree stands greater than 100 years old. National forest lands had a much higher proportion of lands in stands older than 100 years in comparison to the industrial forest lands studied. Accordingly, the national forest lands had significantly more potential den trees. Tree harvesting on industrial forest lands studied seemed to limit the opportunity for trees to mature to sizes appropriate for potential den trees.

National forest lands are different from industrial forest lands in terms of landscape, habitat types, and availability of potential den trees. Only 1,162 acres of the 1.8 million (0.06%) acres of land on the GWJNF were harvested in 2001 (Jim Sitton, National Forest Service 2002, personal communication). In contrast, 3000 of the 178,000 acres (1.7%) on Westvaco land in Boteourt county, Virginia and Greenbrier county, West Virginia were harvested in 2001 (Pat Keyser, Westvaco Biologist 2002, personal communication). The average age of stands on the national forestland is between 70 and 90 years of age whereas the average stand age on Westvaco land is only about 50 years of age. Thus, potential for the occurrence of larger trees is greater on national forest lands because of this disparity in logging practices and average stand ages.

Slash for harvesting provided much bear denning substrate in industrial forest lands. However, ground dens were significantly more likely to abandoned than were tree dens. Management of slash can contribute to availability of safe denning opportunities for bears by ensuring that slashpiles are more compact and placed in locations not subject to flooding.

The density of hollow potential den trees was comparable in both forest management systems. The density was greatest in tree stands older than 100 years.

Certain tree species, specifically chestnut oak and northern red oak, consistently have dens and are used as den trees. Attention should be made to retention of these tree species when trees are left during harvest operations.

Litter sizes were not different on the forest management systems and there were no differences in different types of dens. Differences in measurements of bears were more reflective time of measurements were taken and variation in litter sizes. The differences noted were based on the modest sample sizes and are probably of limited value in making further recommendations.

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Appendix Tables

Appendix 1. Potential den tree measurements for the Northern CABS[1] study area on National Forest Lands in Virginia.

Age Class	Tree Species	DBH (cm)	Hollow	Entrance Hole	Claw Marks	Height of Tree (m)	Elevation (m)	Aspect
0-50	QuRu[2]	75.2	Y	Y	N	280.00		
51-100	LiTu[3]	78.3	N	N	N	26.82	692	220
51-100	LiTu	77.4	N	N	N	23.16	690	234
51-100	LiTu	80.1	Y	Y	N	22.55	652	196
51-100	LiTu	76.2	N	N	N	25.29	652	214
51-100	LiTu	80.2	N	N	N	25.6	886	8
51-100	LiTu	77.3	N	N	N	28.95	906	28
51-100	QuPr[4]	82.4	N	N	N	24.99	784	78
51-100	QuPr	75	N	N	N	14.63	683	180
51-100	QuPr	86.1	N	N	N	24.38	680	194
51-100	QuPr	83.4	N	N	N	25.29	583	340
51-100	QuPr	84.1	N	N	N	24.07	894	358
51-100	QuPr	75.8	N	N	N	30.48	900	24
51-100	QuRu	78.4	N	N	N	23.16	764	50
51-100	QuRu	87.5	N	N	N	21.64	612	28
51-100	QuRu	82.1	N	N	N	21.03	613	358
51-100	QuRu	75.2	N	N	N	22.55	628	12
51-100	QuRu	76.9	N	N	N	26.51	880	12
100+	LiTu	76.8	N	N	N	25.9	734	48
100+	LiTu	77.1	N	N	N	27.12	728	46
100+	LiTu	76.3	N	N	N	33.52	727	22
100+	LiTu	75.9	N	N	N	24.68	804	38
100+	LiTu	76.7	N	N	N	21.33	804	28
100+	QuPr	75.3	N	N	N	20.72	763	348
100+	QuPr	88.4	N	N	N	23.16	750	356
100+	QuPr	77.6	N	N	N	22.25	742	12
100+	QuPr	79.9	Y	N	N	21.33	741	2
100+	QuPr	92.3	N	N	N	24.68	740	18
100+	QuPr	78.1	N	N	N	22.86	739	12
100+	QuPr	80.2	N	N	N	24.07	739	342

100+	QuPr	75.8	N	N	N	22.86	736	9

Appendix 1. cont.

Age Class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
100+	QuPr	77.3	N	N	N	26.82	736	28
100+	QuPr	92.1	N	N	N	24.68	736	49
100+	QuPr	84.4	N	N	N	28.34	788	40
100+	QuPr	75.3	N	N	N	28.95	794	48
100+	QuPr	78.6	Y	Y	N	22.86	798	56
100+	QuPr	76.1	N	N	N	27.12	500	212
100+	QuPr	79.3	N	N	N	28.65	512	260
100+	QuRu	80	Y	Y	N	22.86	813	104
100+	QuRu	77.6	Y	Y	N	26.82	815	96
100+	QuRu	80.4	N	N	Y	25.6	751	8
100+	QuRu	84.3	N	N	N	28.04	740	338
100+	QuRu	93.4	N	N	N	20.42	739	17
100+	QuRu	81.3	N	N	N	30.78	792	36
100+	QuRu	94.1	N	N	N	23.16	806	24
100+	QuRu	91.3	N	N	N	29.87	824	320
100+	QuRu	78.1	N	N	N	23.77	840	346
100+	QuRu	86.8	N	N	N	28.04	846	2
100+	QuRu	84.4	N	N	N	19.5	524	242
100+	QuRu	86.3	N	N	N	23.77	526	240
100+	QuRu	75.4	N	N	N	20.72	530	290
100+	QuRu	76.1	N	N	N	30.48	530	320
100+	QuRu	79.3	N	N	N	33.52	530	300

[1] CABS- Cooperative Allegheny Bear Study. The Northern study area was in Rockingham and Augusta counties VA.
[2] Northern red oak
[3] Tulip poplar
[4] Chestnut oak

Appendix 2. Potential den tree measurements for the Southern CABS[1] study area on National Forest Lands in Virginia.

Age Class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
0-50	QuRu[1]	77	N	N	N	33.52	502.92	110
0-50	QuRu	75	N	N	N	21.33	822.96	88
51-100	QuRu	75	N	N	N	35.05	905.86	30
51-100	QuVe[2]	78.8	N	N	N	25.6	803	112
100+	LiTu[3]	76	N	N	N	28.04	988	0
100+	PiSt[4]	82.8	N	N	N	39.62		346
100+	PiSt	78.4	N	N	N	36.57		20
100+	PiSt	81.6	N	N	N	33.52		20
100+	PiSt	77.4	N	N	N	30.48		18
100+	PiSt	93	N	N	N	30.48		2
100+	PiSt	75	N	N	N	28.95		226
100+	PiSt	75.1	N	N	N	36.57		188
100+	PiSt	75.4	N	N	N	32		244
100+	PiSt	75	N	N	N	35.05		314
100+	QuAl[5]	78	N	N	N	30.48		138
100+	QuVe	82	N	N	N	23.77	1093	62
100+	QuVe	89.5	Y	Y	N	21.33	1087	66
100+	QuVe	78	Y	Y	N	36.88	1058	130
100+	QuPr[6]	75	N	N	N	19.2	1036	136
100+	QuPr	84.5	Y	Y	N	27.43	980	30
100+	QuPr	106	N	N	N	21.94	995	40
100+	QuPr	77.5	N	N	N	25.9	979	4
100+	QuPr	76.4	N	N	N	24.34	988	18
100+	QuPr	98	Y	Y	N	8.22	1048	158
100+	QuRu	79.9	N	N	N	33.52		276
100+	QuRu	116	Y	N	N	29.87	1007	342
100+	QuRu	80.5	Y	N	N	24.38	997	2
100+	QuRu	112	N	N	N	21.33	981	4
100+	QuRu	85.3	N	N	N	30.48	982	50

Appendix 2. cont.

Age Class	Tree Species	DBH (cm)	Hollow	Entrance Hole	Claw Marks	Height of Tree (m)	Elevation (m)	Aspect
100+	QuRu	91.4	Y	Y	N	32.91	975	28
100+	QuRu	76	N	N	N	25.9		30
100+	QuRu	79	N	N	N	28.95		28
100+	QuRu	88	N	N	N	26.82		8
100+	QuRu	90.1	N	N	N	28.04		8
100+	QuRu	94.2	N	N	N	19.81	805	150

[1] CABS- Cooperative Allegheny Bear Study. The Southern study area was in Craig, Giles, and Montgomery counties, VA.
[2] Northern red oak
[3] Black oak
[4] Tulip poplar
[5] White pine
[6] White oak
[7] Chestnut oak

Appendix 3. Potential den tree measurements for the Monongahela National Forest lands in West Virginia during 2000 and 2001.

Age class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
0-50	QuRu[1]	79.4	N	N	N		731	22
0-50	QuRu	88.3	N	N	N		748	48
51-100	LiTu[2]	76	N	N	N	94	632	280
51-100	LiTu	89	N	N	N	98	612	16
51-100	LiTu	92.8	N	N	N	78	638	300
51-100	LiTu	95.3	N	N	N	68	642	212
51-100	LiTu	86.5	N	N	N	20	840	34
51-100	QuPr[3]	84.4	N	N	N	22.4	707	164
51-100	QuRu	79.8	N	N	N	25.6	824	16
51-100	QuRu	81.4	N	N	N	24.9	822	18
51-100	QuRu	83.4	N	N	N	31.2	853	12
51-100	QuRu	75.4	Y	Y	N	14.2	840	68
51-100	QuRu	76.7	Y	Y	N	15.8	838	122
51-100	QuVe[4]	76.3	N	N	N	23.1	600	360
51-100	QuVe	78.9	N	N	N	27.8	604	12
51-100	QuVe	81.4	N	N	N	24	548	348
100+	LiTu	78.9	N	N	N	25.1	609	12
100+	LiTu	79.4	N	N	N	20.5	607	334
100+	LiTu	78	N	N	N	18.7	720	268
100+	LiTu	96.1	Y	N	N	26.3	601	336
100+	QuAl[5]	76.4	N	N	N	23.1	704	14
100+	QuAl	79.9	N	N	N	18.7	700	16
100+	QuAl	84	N	N	N	19.8	724	284
100+	QuAl	82.1	N	N	N	26.6	726	234
100+	QuPr	91.4	N	N	N	21.4	760	340
100+	QuPr	92.4	N	N	N	24.3	717	308
100+	QuPr	94.1	N	N	N	20.2	755	340
100+	QuPr	96.3	N	N	N	26.3	768	28
100+	QuPr	108	N	N	N	24.1	768	16
100+	QuPr	75.6	N	N	N	21.2	607	348
100+	QuPr	77.7	N	N	N	24.1	598	352
100+	QuPr	86.9	N	N	N	24.3	607	340
100+	QuPr	75.9	N	N	N	23.6	732	260
100+	QuPr	90.1	N	N	N	23.4	733	212

Appendix 3. cont.

Age Class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
100+	QuPr	88.6	Y	N	N	20.9	754	296
100+	QuPr	76	Y	Y	N	9.8	768	18
100+	QuPr	79.6	Y	N	N	24.7	760	222
100+	QuPr	92.1	Y	Y	N	19.7	644	38
100+	QuRu	75	N	N	N	22.8	757	288
100+	QuRu	86	N	N	N	219	708	358
100+	QuRu	86.7	N	N	N	22.1	755	290
100+	QuRu	92.9	N	N	N	19.7	712	294
100+	QuRu	112	N	N	N	28.7	710	306
100+	QuRu	75.6	N	N	N	20.1	748	286
100+	QuRu	84.3	Y	N	N	19.7	748	220
100+	QuRu	87.4	Y	N	N	21.9	730	224
100+	QuVe	100.4	N	N	N	196	708	2

[1] Northern red oak
[2] Tulip poplar
[3] Chestnut oak
[4] Black oak
[5] White oak

Appendix 4. Potential den tree measurements for the industrial forest lands in Botetourt county, Virginia.

Age Class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
51-100	QuVe[1]	80	N	N	N	25.9	650	358
51-100	QuVe	85.3	N	N	N	33.52	653	6
51-100	QuPr[2]	78.5	N	N	N	23.77	672	18
51-100	QuPr	75.4	N	N	N	25.9	641	292
51-100	QuPr	86.1	N	N	N	22.86	665	214
51-100	QuPr	86.7	N	N	N	22.86	761	345
51-100	QuPr	76.8	N	N	N	21.33	774	335
51-100	QuPr	94.3	N	N	N	23.77	747	10
51-100	QuRu[3]	75.3	N	N	N	20.72	749	94
51-100	QuRu	83.1	Y	Y	N	22.55	763	108
51-100	QuRu	78.5	N	N	N	24.38	768	136
51-100	QuRu	83	N	N	N	27.43	758	8
51-100	QuRu	88	N	N	N	21.33	748	146
51-100	QuRu	86.5	Y	Y	N	12.19	726	111
51-100	QuRu	83	Y	Y	N	24.38	701	110
51-100	QuRu	83.7	N	N	N	19.81	753	40

[1] Black oak
[2] Chestnut oak
[3] Northern red oak

Appendix 5. Potential den tree measurements for the industrial forest lands in Greenbrier county, West Virginia.

Age Class	Tree species	DBH (cm)	Hollow	Entrance hole	Claw marks	Height of tree (m)	Elevation (m)	Aspect
51-100	QuPr[1]	75.3	N	N	N		643	12
51-100	QuPr	77.8	Y	Y	N	24.38	645	18
51-100	QuPr	76	Y	Y	N	14.63	660	30
51-100	QuPr	77.1	N	N	N		641	312
51-100	QuPr	75.8	N	N	N		652	320
51-100	QuRu[2]	76.4	N	N	N		715	84
51-100	QuRu	77.8	N	N	N		730	80

[1] Chestnut oak
[2] Northern red oak

Appendix 6. Potential den tree measurements for the leave strip area on the industrial forest lands in Botetourt county, Virginia.

Age Class	Tree Species	DBH (cm)	Hollow	Entrance Hole	Claw Marks	Height of Tree (m)	Elevation (m)	Aspect
Leave Strip	QuPr[1]	77.2	N	N	N	25.6	670	168
Leave Strip	QuPr	75.6	N	N	N	26.82	648	146
Leave Strip	QuPr	87.4	N	N	N	28.04	632	200
Leave Strip	QuPr	86.1	N	N	N	28.04	612	230
Leave Strip	QuRu[2]	76.1	N	N	N	15.84	383	126
Leave Strip	QuRu	83.5	N	N	N	18.89	620	12
Leave Strip	QuRu	75	N	N	N	21.9	628	330
Leave Strip	QuRu	81.2	N	N	N	26.21	740	28
Leave Strip	QuRu	82.4	N	N	N	12.19	775	50

[1] Chestnut oak
[2] Northern red oak

Appendix 7. Potential den tree measurements for the leave strip area on the industrial forest lands in Greenbrier county, West Virginia.

Age Class	**Tree Species**	**DBH (cm)**	**Hollow**	**Entrance Hole**	**Claw Marks**	**Height of Tree (m)**	**Elevation (m)**	**Aspect**
Leave Strip	QuPr[1]	76.2	N	N	N	21.03	906	48
Leave Strip	QuPr	85.9	N	N	N	28.04	884	82
Leave Strip	QuPr	76.3	N	N	N	25.9	488	240
Leave Strip	QuPr	84	N	N	N	28.04	764	30
Leave Strip	QuRu[2]	89.3	N	N	N	22.55	910	318
Leave Strip	QuRu	79.4	N	N	N	27.12	512	262

[1] Chestnut oak
[2] Northern red oak

Appendix 8. Data on black bears captured during the summer on industrial forest land in Botetourt County, Virginia during 1999 and 2000.

Bear ID number	Date	Sex	Lactating	Estrus	Weight (kg)	Total length (mm)	Chest girth (mm)
B233	8/3/1999	Male			58.1	1486	770
B241	8/4/1999	Female	N	N	61.3	1641	772
B234	8/6/1999	Male			60.8 (est)	1441	816
B245	8/8/1999	Female	N	N	26.7	1188	591
B246	8/8/1999	Male			83.4	1720	905
B239	8/10/1999	Male			30.8	1325	665
B249	8/10/1999	Female	N	N	42.6	1325	710
B241	8/18/1999	Female	Y	N	53.1	1640	760
B248	8/18/1999	Male			90.8	1750	905
B236	8/20/1999	Female	N	N	40.4	1349	701
B235	8/22/1999	Male			37.4	1255	652
B237	8/25/1999	Male			54.4	1543	796
B252	6/7/2000	Male			102.1 (est)		
B251	6/7/2000	Female	N	N	61.3	1495	
B240	6/28/2000	Male			40.8	1350	663
B242	6/29/2000	Male			52.2	1375	715
B240	7/12/2000	Male			38.5	1352	648
B237	7/14/2000	Male			70.3	1720	817
B234	7/15/2000	Male			84	1541	845
B250	7/16/2000	Male			38.5	1288	668
B240	7/22/2000	Male			37.4	1382	590
B242	7/22/2000	Male			65.8	1383	718
B243	7/23/2000	Male			47.6	1424	691
B238	7/23/2000	Female	N	N	63.5	1461	834
B236	7/25/2000	Female	Y	N	42	1298	681
B273	8/5/2000	Male			63.5	1556	810
B279	8/5/2000	Male			136.2 (est)		
B278	8/7/2000	Female	N		51	1464	668

Appendix 9. Habitat measurements for tree dens on the National Forest Lands in Virginia during 2000 and 2001.

Tree Species	Tree height (m)	Height to entrance (m)	Depth to bear from entrance (m)	DBH (cm)	Entrance height (cm)	Entrance width (cm)
Chestnut oak	13.6	3.58	4			
White oak	14.6	3.3	3.4		29	50
Red maple	33.5	15.5		101		
Northern red oak	21.94					
Northern red oak	14.9	11.68	0.81	107		35
Northern red oak	14.02	10.97	0.86	105	18	22.5
Chestnut oak	15.54	9.26	6.8	104	108	37
ND					84	
White oak	20.11	7.92	7.92		33	45
Chestnut oak	19.46	13.47	3.5	80	39	36
Chestnut oak	21.94	9.6	0		23	22
Chestnut oak	26.51	5.48	5.48		88	46
Northern red oak	9.9	6.6	3	104		52.1
Chestnut oak	6.3	3.6	4.2	94.2		43.18
ND	6.9	6.9	3			
Tulip poplar	27.6	21	2.7	126		
Northern red oak	25.5	7.2	3.1	78.7	45.7	45.7
Northern red oak	23.7	15.3		110		
Northern red oak	23.4	8.1	6	92.7		
Northern red oak	23.7	13.5		106		
Northern red oak	20.1	18.3		96.5		
Northern red oak	24	4.2	2.1	96.3	180.3	40.6
Northern red oak	19.8	8.7	0.8	70.9	34	29
Chestnut oak	24	12.9	3.3	140	81.28	22.86
Chestnut oak	15.3	8.4		81.3		
Chestnut oak	17.7	7.8	4.7	76.2	83.8	53.3
Chestnut oak	21	5.1	1.6	93.5	137.2	27.9
Chestnut oak	21	12.3	9.3	101	53.3	38.1
Northern red oak			0	94.2		
Northern red oak	15	9	15	113		
Chestnut oak	26.7	15.6		105		
Chestnut oak	11.4	7.2	6.3	99.1		
White oak	18	9	0.58	72.4		

Appendix 9. cont.

Tree Species	Tree height (m)	Height to entrance (m)	Depth to bear from entrance (m)	DBH (cm)	Entrance height (cm)	Entrance width (cm)
Tulip poplar	19.5	16.5		99.1		
Tulip poplar	27	18		99.8		
Red maple	23.4	14.1	0.9	91.9		
Northern red oak	19.2	12.3		110		
Northern red oak	15.3	9.9	2.1	86.1		
Northern red oak	23.1	8.4	4.8	73.4		
Northern red oak	18.9	9	0.2	95.5	165.1	30.5
Chestnut oak	19.5	4.8	4.5	70.9		
Chestnut oak	18.3	9.6		92.7		
Chestnut oak			1.8			
Chestnut oak	18.6	8.7		76.5		
Chestnut oak	21	8.7	1.8	95.3		
Chestnut oak	12.12	4.8	3.56	79.8	36.8	34.3
Chestnut oak	13.5	3.2		67.3	53.3	53.3
Chestnut oak	13.5	2.8	2.5	71.4	29.2	27.9

Appendix 10. Habitat for tree dens on the industrial forest lands in Virginia and West Virginia during 2000 and 2001.

Tree Species	Tree height (m)	Height to entrance (m)	Depth to bear from entrance (m)	DBH (cm)	Entrance height (cm)	Entrance width (cm)
Northern red oak	9.4	9.2		76.2		
Northern red oak	21	11.2	3.65			
Northern red oak	24.07	7	0.77		325	19
Chestnut oak	19.8		1.41		27.9	154.9
Chestnut oak	21.6	5.3	1.09	90.1	51	40
Chestnut oak	21.4	12.8	8.8	110.7	51	28

Appendix 11. Habitat for ground dens on the national forests in Virginia during 2000 and 2001.

Den type	Entrance height (cm)	Entrance width (cm)	Bedding material depth (cm)	Nest length (cm)	Nest width (cm)	Cavity length (cm)	Cavity width (cm)	Cavity height (cm)
Day bed			1	53.34	43.18			
Day bed				93.98	81.28			
Excavation	32	80	0	70		112	92	70
Excavation	20	39						
Fallen log	47	61	0					
Fallen log	36	41	0	106	68	106.8	71	57
Ground nest			15.24	162.56	121.92			
Ground nest				96.5	139.7			
Ground nest			35	68	114			
Ground nest			8	204	133			
Rock cavity	60.96	82.55	6			205.74	119.38	50.8
Rock cavity	34.5	71	8	83	71	187	84	50.5
Rock cavity	33	53.3	0.25	37	26	373.4	88.9	144.8
Rootwad	76.2	73.7	10.16	106.7	55.9	106.7	55.9	76.2
Rootwad	85.3	76.2		91.4	76.2	115.8	207.3	70.1
Slashpile	30.48	63.5	3	81.28	66	81.28	66	63.5
Slashpile			8	279.4	233.7			
Slashpile	26	54	0	69	73	109	102	76
Day bed			8.9	81.3	61			
Day bed			5.1	81.3	66			
Day bed				106.7	96.5			
Day bed				94	91.4			
Day bed				152.4	104.1			
Day bed			3.8	88.9	81.28			
Ground nest				111.8	78.7			53.3
Rock cavity		50.8						
Rock cavity	109.2	147.3		830	77	373.4	213.4	135.9

Appendix 11. cont.

Den type	Entrance height (cm)	Entrance width (cm)	Bedding material depth (cm)	Nest length (cm)	Nest width (cm)	Cavity length (cm)	Cavity width (cm)	Cavity height (cm)
Rock cavity	96.5	45.7		99	63.5			
Rock cavity						213.36	61	45.7
Slashpile			0.3	104.1	71.1			
Slashpile			0	150	129.5			
Cave	58.2	45.5	5	67.1	43.7	901.5	62.5	95.4
Excavation	37.2	49		72	68	152	1015	650
Rock cavity	31	41.5				2260	970	985
Rock cavity	41	57.5	2	80	68.5	152	103	49.5
Rootwad	133		2	110	89	179	168	163
Slashpile	59.7	82.2	6.8	56.5	78.1	173.4	137	90
Rock cavity	47	83	4	78	54	312	61	50
Slashpile			2.54	72.5	64			
Slashpile	55	49	12.7	140	89		89	73

Appendix 12. Habitat measurements for ground dens on the industrial forests lands in Virginia and West Virginia during 2000 and 2001.

Den type	Entrance height (cm)	Entrance width (cm)	Bedding material depth (cm)	Nest length (cm)	Nest width (cm)	Cavity length (cm)	Cavity width (cm)	Cavity height (cm)
Rootball				227	89		89	42
Rootball	120	72	1					
Slashpile				65	89	283	49	37
Slashpile				121.9	88.9			
Slashpile	74	88		108	65	440	148	64
Slashpile	47.4	75.4	5.8	75.6	91.8	147		
Slashpile	72	122		109	82			
Slashpile	59	68		79	133	90	92	112
Slashpile	71	43		64	115	82	79	93

Appendix 13. Measurements of cubs taken at den sites on industrial forest lands in Botetourt County, Virginia, Greenbrier County, West Virginia, and Pendleton County, West Virginia.

Date	Sex	BLZ	Wgt (kg)	TL (mm)	CG (mm)	NG (mm)	EL (mm)	FPL (mm)	FPW (mm)	HPL (mm)	HPW (mm)	ZYGO (mm)
3/10/2000	F	yes	1.39	452	255	168	24.6	32.9	26.1	41.7	26.7	69.4
3/10/2000	F	no	1.39	424	253	153	35.6	44.7	27.7	32.3	24.8	67.8
3/10/2000	M	no	1.69	478	246	168	35.5	33.5	32.8	45.7	27.5	68.9
3/12/2000	F	yes	2.49	497	315	216	51	45	41	56	36	74.7
3/12/2000	F	yes	2.39	507	330	218	54	43	34	56	39	76.7
3/12/2000	M	yes	2.29	486	300	213	44	35	43	54	36	72.7
3/17/2000	M	no	2.81	540	298	197	32	56	34	69	28	74
3/17/2000	M	no	2.54	490	313	215	34	48	32	52	30	74.3
3/24/2000	F	no	0.816	370	202	140	27.3	30.1	27	46	24.2	59.4
3/24/2000	F	yes	2.35	500	265	210	49.8	46.1	39	58.1	34.3	74.5
2/24/2001	F	yes		413	308	195	19	29	36	40	30	67.6
2/24/2001	M	no		415	275	175	22	37	41	42	38	66.9
2/24/2001	M	no		447	298	211	27	33	38	36	32	66.9
3/13/2001	F	yes	2.05	468	276	185	40.4	40.2	38	55.8	32.8	70.6
3/13/2001	F											
3/13/2001	M	yes	2	468	271	188	38.2	43.3	36.3	26.9	32.2	72.5
3/13/2001	M	yes	2.35	508	262	175	31.6	35.2	35.4	54.4	30.3	68.1
3/13/2001	M											
3/15/2001	F	no	2.2	441	279	288	31.5	38.4	30.3	55.1	31.2	70.3
3/15/2001	F	no	2.2	483	320	198	20.5	20.3	26.8	37.4	27.8	59.5
3/15/2001	F	no	1.95	432	293	187	39.8	22.9	31.2	41.6	30.4	67.9
3/23/2001	F	yes	2.6	495	292.5	187	46	35.8	39.4	57	38.1	76.9
3/23/2001	F	no	2.4	490	282.5	184	39	35	39	58	35	73.7
3/23/2001	M	no	2.6	487	282	185	38	34	41	60	35	70.1

Appendix 14. Analysis of Covariance for cub weight for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	0.0227	0.0227	0.11	0.7428
Sex	1	0.6900	0.6900	3.35	0.0796
Interaction	1	0.1340	0.134	0.65	0.4278
Litter Size	1	0.4113	0.4113	2.00	0.1704
Date	1	0.0384	0.0384	0.19	0.6696
Error	24	4.9436	4.9436		
Corrected Totals	29	6.1347			

Appendix 15. Analysis of Covariance for cub weight for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	0.1586	0.1586	1.91	0.1806
Sex	1	0.3578	0.3578	4.30	0.0494
Interaction	1	0.0071	0.0071	0.09	0.7719
Litter Size	1	0.1796	0.1796	2.16	0.1553
Date	1	0.869	0.8690	10.45	0.0037
Error	23	1.9131	1.9131		
Corrected Totals	28	3.2505			

Appendix 16. Analysis of Covariance for total length for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	301.2496	301.2496	0.17	0.6839
Sex	1	6694.237	6694.237	3.77	0.0635
Interaction	1	226.8001	226.8001	0.13	0.7238
Litter Size	1	3548.7975	3548.7975	2	0.1698
Date	1	694.7469	694.7469	0.39	0.5373
Error	25	44388.6182	44388.6182		
Corrected Totals	30	55706.7096			

Appendix 17. Analysis of Covariance for total length for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	504.0007	504.0007	0.16	0.6549
Sex	1	0.2539	0.2539	2.12	0.1593
Interaction	1	1609.6015	1609.6015	2.33	0.1402
Litter Size	1	17315.3356	17315.3356	14.16	0.001
Date	1	30738.1016	30738.1016	9.97	0.0044
Error	23	70935.3961	70935.3961		
Corrected Totals	28	121102.6897			

Appendix 18. Analysis of Covariance for chest girth for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	797.0999	797.0999	1.22	0.2802
Sex	1	497.3593	497.3593	0.76	0.3916
Interaction	1	42.5078	42.5078	0.06	0.8009
Litter Size	1	4255.7393	4255.7393	6.5	0.0173
Date	1	4672.9863	4672.9863	7.14	0.0131
Error	25	4672.9863	4672.9863		
Corrected Totals	30	28303.4838			

Appendix 19. Analysis of Covariance for chest girth for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	791.9068	791.9068	2.3	0.1426
Sex	1	226.8085	226.8085	0.66	0.4248
Interaction	1	830.5834	830.5834	2.42	0.1336
Litter Size	1	2551.8886	2551.8886	7.43	0.0121
Date	1	1196.5031	1196.5031	3.48	0.0748
Error	23	7902.3946	7902.3946		
Corrected Totals	28	79423.24658			

Appendix 20. Analysis of Covariance for neck girth for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	1624.8098	1624.8098	4.29	0.0489
Sex	1	54.7874	54.7874	0.14	0.7071
Interaction	1	504.941	504.941	1.33	0.2594
Litter Size	1	496.9057	496.9057	1.31	0.2631
Date	1	136.1347	136.1347	0.36	0.5544
Error	25	9478.6469	9478.6469		
Corrected Totals	30	13437.0967			

Appendix 21. Analysis of Covariance for neck girth for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	1624.8098	1624.8098	2.91	0.1014
Sex	1	54.7874	54.7874	0.02	0.88
Interaction	1	504.941	504.941	2.4	0.1354
Litter Size	1	496.9057	496.9057	1.66	0.2105
Date	1	136.1347	136.1347	0.41	0.5275
Error	23	9478.6469	9478.6469		
Corrected Totals	28	14647.862			

Appendix 22. Analysis of Covariance for ear length for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	31.5662	31.5662	0.4	0.534
Sex	1	5.4309	5.4309	0.07	0.7958
Interaction	1	31.3444	31.3444	0.39	0.5354
Litter Size	1	54.5194	54.5194	0.69	0.415
Date	1	37.9335	37.9335	0.48	0.4957
Error	25	1983.8651	1983.8651		
Corrected Totals	30	2142.4309			

Appendix 23. Analysis of Covariance for ear length for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	5.8048	5.8048	0.13	0.7186
Sex	1	14.99	14.99	0.34	0.5635
Interaction	1	76.4402	76.4402	1.75	0.1986
Litter Size	1	49.2039	49.2039	1.13	0.2993
Date	1	203.2259	203.2259	4.66	0.0416
Error	23	1003.3865	1003.3865		
Corrected Totals	28	1397.1544			

Appendix 24. Analysis of Covariance for front paw length for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F Value	P-Value
Forest	1	112.4858	112.4858	4.2	0.0511
Sex	1	28.1925	28.1925	1.05	0.3148
Interaction	1	0.0429	0.0429	0	0.9684
Litter Size	1	244.8663	244.8663	9.14	0.0057
Date	1	1.1631	1.1631	0.04	0.8366
Error	25	669.8747	669.8747		
Corrected Totals	30	1108.687			

Appendix 25. Analysis of Covariance for front paw length for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F Value	P-Value
Forest	1	16.889	16.889	0.64	0.4319
Sex	1	7.1108	7.1108	0.27	0.6087
Interaction	1	77.3821	77.3821	2.93	0.1003
Litter Size	1	165.1059	165.1059	6.26	0.0199
Date	1	1.006	1.006	0.04	0.8469
Error	23	607.068	607.068		
Corrected Totals	28	1043.4744			

Appendix 26. Analysis of Covariance for front paw width 2000 for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	20.7871	20.7871	0.87	0.3612
Sex	1	0.7784	0.7784	0.03	0.8586
Interaction	1	36.1357	36.1357	1.5	0.2315
Litter Size	1	15.1353	15.1353	0.63	0.4349
Date	1	0.3211	0.3211	0.01	0.9089
Error	25	600.7531	600.7531		
Corrected Totals	30	680.7296			

Appendix 27. Analysis of Covariance for front paw width 2001 for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	0.6756	0.6756	0.05	0.827
Sex	1	32.6348	32.6348	2.36	0.1381
Interaction	1	20.5656	20.5656	1.49	0.235
Litter Size	1	4.8558	4.8558	0.35	0.5592
Date	1	100.1001	100.1001	7.24	0.0131
Error	25	318.0409	318.0409		
Corrected Totals	30	456.0317			

Appendix 28. Analysis of Covariance for hind paw length for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	0.0293	0.0293	0	0.9788
Sex	1	117.3244	117.3244	2.87	0.1027
Interaction	1	30.3938	30.3938	0.74	0.3967
Litter Size	1	182.0772	182.0772	4.45	0.045
Date	1	34.4247	34.4247	0.84	0.3676
Error	25	1022.0196	1022.0196		
Corrected Totals	30	1415.8038			

Appendix 29. Analysis of Covariance for hind paw length for cubs measured between March 10 and March 23rd 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	261.9516	261.9516	5.89	0.0234
Sex	1	7.2312	7.2312	0.16	0.6904
Interaction	1	41.9298	41.9298	0.94	0.3415
Litter Size	1	34.9357	34.9357	0.79	0.3844
Date	1	353.751	353.751	7.96	0.0097
Error	23	1022.0763	1022.0763		
Corrected Totals	28	2040.9124			

Appendix 30. Analysis of Covariance for hind paw width for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	41.8872	41.8872	2.22	0.1492
Sex	1	0.1475	0.1475	0.01	0.9303
Interaction	1	2.9149	2.9149	0.15	0.6979
Litter Size	1	20.0901	20.0901	1.06	0.3125
Date	1	8.2853	8.2853	0.44	0.5141
Error	25	472.7558	472.7558		
Corrected Totals	30	527.6877			

Appendix 31. Analysis of Covariance for hind paw width for cubs measured between March 10 and March 24th 2000.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	11.8661	11.8661	1.69	0.2064
Sex	1	12.0574	12.0574	1.72	0.2029
Interaction	1	3.8069	3.8069	0.54	0.4689
Litter Size	1	1.7404	1.7404	0.25	0.6232
Date	1	67.6522	67.6522	9.64	0.005
Error	25	161.405	161.405		
Corrected Totals	30	287.9944			

Appendix 32. Analysis of Covariance for zygomatic arch for cubs measured between March 10 and March 24 2000.

Source	DF	Sum of squares	Mean Square	F-Value	P-Value
Forest	1	1.4331	1.4331	0.05	0.836
Sex	1	3.0762	3.0762	0.1	0.762
Interaction	1	3.8574	3.8574	0.12	0.7346
Litter Size	1	0.4655	0.4655	0.01	0.906
Date	1	0.0444	0.0444	0	0.9709
Error	10	1847.607845	1847.607845		
Corrected Totals	15	337.2743			

Appendix 33. Analysis of Covariance for zygomatic arch for cubs measured between March 10 and March 23 2001.

Source	DF	Sum of squares	Mean square	F-Value	P-Value
Forest	1	7.6649	3990.03639	5.7	0.0198
Sex	1	3.0393	110.61076	0.16	0.6922
Interaction	1	3.2642	13.86383	0.02	0.8885
Litter Size	1	0.4243	15015.84735	21.46	<.0001
Date	1	325.2842	9022.22952	12.89	0.0006
Error	23	364.8594	699.73481		
Corrected Totals	28	772.7682			

Vita

Gyasi Adrian Quince was born August 28, 1975 to Kevin and Regina Quince. He graduated from Hightstown High School in June 1993. He attended Delaware State University where he received his Bachelor of Science Degree in Wildlife Management in May of 1998. He worked on a deer and soybean depredation project after graduation with Dr. Lisa Muller. He then went to Virginia Tech where he plans on receiving his Masters Degree in Fisheries and Wildlife Sciences in June of 2002.