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STUDY TITLE: Population and Habitat Ecology of Brown Bears on Admiralty and Chichagof Islands

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SUMMARY

We analyzed radiotelemetry location data from 112 brown bears (*Ursus arctos*) from the northeast portion of Chichagof Island to evaluate home range size and patterns of seasonal habitat selection. Our 1112 km^2-study area was mostly within the Tongass National Forest and the entire study area was subject to intensive roading and timber harvest of old-growth coniferous forest since the early 1980s. We developed 9 habitat categories using a geographic information system (GIS) and created habitat availability polygons across the study area. Four seasons were created including spring (den emergence–15 May), early summer (16 May–15 July), late summer (16 July–15 September), and fall (16 September–denning). We then determined the habitat types associated with 2242 aerial telemetry locations acquired from 1989–1999. Each location was buffered by 150 m to account for error. Habitat selection data were analyzed by developing confidence intervals from mean-weighted ratios of use to availability based on season and sex. Mean minimum convex polygon home range estimates for 21 males was 82 km^2 (median 77 km^2) and for females was 35 km^2 (median 21 km^2). We found differences in seasonal habitat selection by males and females and wide variation among individual bears across our radiotagged sample. During spring, males selected for nonvegetated and shrub/avalanche chute habitat types. In early summer, males selected the alpine/herbaceous habitat type relatively more than forests, clearcuts, and other lowland habitat types. Male brown bear selection of riparian areas with spawning salmon was very high during the late summer. By fall males were found across the landscape and exhibited little selection across habitat types. During spring females selected for shrub/avalanche chute and nonvegetated habitat types. In early summer, females selected alpine/herbaceous and shrub/avalanche chute habitat types relatively more than all other habitat types. In the late summer females highly selected riparian forest areas with spawning salmon, compared to all 8 other habitat types. By the fall season, females were once again associated with shrub/avalanche chutes and their selection ratio for this habitat type did not overlap with any other habitat type. Both species made use of upland old-growth forest habitat in relative proportion to their availability. The very high seasonal selection of riparian forests that contain spawning salmon indicates that this habitat type is probably one key to the maintenance of high-density brown bear populations. Forest management efforts need to ensure that these forested riparian habitats are protected to maintain healthy salmon stocks and provide cover for brown bears.

Key Words: Admiralty Island, brown bear, Chichagof Island, dispersal, grizzly bear, population ecology, Southeast Alaska, Tongass National Forest, *Ursus arctos*.

CONTENTS

INTRODUCTION

Long-term conservation of brown bear (*Ursus arctos*) populations is of high public interest for a variety of reasons including viewing, hunting, ecosystem and biodiversity values, and intrinsic human values. Worldwide, brown bear numbers have been greatly reduced over the past century (Servheen 1990) and in North America they occupy a much smaller range compared with their historic distribution (Rausch 1963). In Alaska, brown bear populations are considered healthy across nearly all of the state except the Kenai Peninsula (Schwartz and Arthur 1997). In Southeast Alaska, brown bear populations are in high densities on Admiralty, Baranof and Chichagof Islands (ABC islands; Schoen 1990, Titus and Beier 1993, Miller et al. 1997). While portions of the ABC islands are designated as wilderness and are not subject to multiple use forest management, some portions of these islands have been or still are subject to land management activities affecting brown bear populations.

Most of the ABC islands and other portions of the Southeast Alaska mainland that are inhabited by brown bears are managed by the U.S. Forest Service as the Tongass National Forest (Tongass). The Tongass recently underwent a forest plan revision, and some of the forest management prescriptions, standards, and guidelines will have short- and long-term effects on brown bears and their habitats (U.S. Forest Service 1997). The most important land management activities that can affect brown bear populations are habitat changes from logging of old-growth forest and the subsequent increase of human access by road construction. There is evidence that logging or other types of resource-extraction industries have impacts on brown bear populations (McLellan 1989, 1990, McLellan and Schackleton 1988), and, specifically for the Tongass, Schoen et al. (1994) thought that habitat change associated with forest management lowered the capability to support future brown bear populations.

Successful long-term management of brown bears requires solutions to a number of complicated social and biological issues (Mattson et al. 1996). Short and long-term degradation of brown bear habitat can be difficult to detect and once detected difficult to reverse in terms of rebuilding bear populations to a previously high level (Doak 1995). One key aspect of understanding and managing habitats for the long-term conservation of very dense brown bear populations is an evaluation of the habitats they use and select. Quantitative descriptions of seasonal habitat use by low-density brown bear populations have been conducted in the Rocky Mountains (e.g., Craighead et al. 1995, Wielgus and Bunnell 1994, Waller and Mace 1997), but few studies have been conducted on a high-density brown bear population in coastal habitats (Hamilton and Bunnell 1987). Our report describes the seasonal patterns of habitat use and selection by coastal brown bears on a portion of Chichagof Island, Alaska. We chose to study brown bears on the northeast portion of Chichagof Island because the land cover has changed with extensive road-building and logging in the past 20 years. Human access to this area increased dramatically over this period; in 1994 logging roads provided entrance to all major watersheds on the study area. Our approach was to use extensive data from >100 radiotagged brown bears to describe their seasonal movements in a landscape that has been subject to intensive forest management.

STUDY AREA

The Tongass National Forest covers approximately 68,000 km^2 within the Alexander Archipelago of Southeast Alaska. Brown bears are on Admiralty, Baranof, Chichagof, associated islands, and the mainland; they are absent from islands south of Frederick Sound. The area is a coastal, temperate rainforest with a cool maritime climate. Our long-term brown bear studies focused on the northern portion of Admiralty Island on Hawk Inlet (Schoen and Beier 1990) and the northeast portion of Chichagof Island. The Alaska Department of Fish and Game manages Admiralty, Baranof, Chichagof, and nearby islands as Game Management Unit 4.

CHICHAGOF ISLAND

The northeast Chichagof Island study area is a 1112 km^2 island-like area north of Tenakee Inlet and east of Port Frederick (Fig. 1). This area is connected to another 5451 km^2 of Chichagof Island by a 100–200-m-wide strip of land at the Portage. The communities of Hoonah and Tenakee Springs are at opposite corners of the study area. Whitestone logging camp is ~8 km by road from Hoonah. The topography of northeast Chichagof Island is rugged with mountains rising from sea level to 1100 m. The ridges are steeper with less alpine habitat than on our northern Admiralty Island study area (Schoen and Beier 1990). Lowland habitats are dominated by a dense old-growth rain forest in riparian and well-drained sites. These forests are primarily western hemlock (*Tsuga heterophylla*) – Sitka spruce (*Picea sitchensis*) mosaics. Sitka spruce dominates lowland riparian areas, the saltwater-forested beach fringe, and some steep forested areas between avalanche slopes. Western hemlock dominates the remainder of upland old-growth sites. Common understory plant species in old-growth forest stands include several species of blueberry and huckleberry (*Vaccinium* sp.), rusty menzieia (*Menziesia ferruginea*), devil's club (*Oplopanax horridus*), salmonberry (*Rubus spectabilis*), elderberry (*Sambucus racemosa*), skunk cabbage (*Sichiton americanum*), bunchberry (*Cornus canadensis*), and trailing raspberry (*Rubus pedatus*). Poorly drained areas include nonforested muskegs and tree species such as lodgepole pine (*Pinus contorta*) and Alaska cedar (*Chameacyparis nootkatensis*). Mountain hemlock (*Tsuga mertinsiana*) is common in the transition zone to subalpine and alpine habitats, and this species can assume both tree and bush life forms. Nonforested steep slopes are common above 300 m and comprise rock, avalanche slopes and alpine habitat. Avalanche slopes are dominated by red alder (*Alnus rubra*), salmonberry, stink current (*Ribes bracteosum*), and devil's club. Poorly drained sites contain open muskeg and muskegs interspersed with lodgepole pine (*Pinus contorta*). Overall, the vegetated areas of the study area form a complex and heterogeneous mosaic of forested riparian stringers, forested upland hillsides, large poorly drained open muskegs, and avalanche chutes along steep hillsides with forested stringers between these chutes. Detailed descriptions of plant associations are in Martin et al. (1985).

Precipitation occurs throughout the year and snow accumulates from higher elevations to sea level during winter, and elevations >600 m are covered by snow 6–9 months of the year, especially on north-facing slopes. At higher elevations snow is often >2 m deep for much of the winter, contributing to the numerous avalanche slopes and annual scouring of the shrub vegetation.

Streams that contain spawning salmon are abundant on the study area. Over 25 streams (Fig. 2) in the study area support spawning chum (*O. keta*) and pink (*O. gorbuscha*) salmon with escapement varying from a few hundred pink salmon on small streams 1–2 m wide to >90,000 pink and 45,000 chum salmon for larger streams in some years. Salmon escapements vary widely among years with pink salmon escapements being larger on the odd-numbered years. Most of the larger streams also support autumn runs of coho salmon (*O. kisutch*).

Land Management

Nearly all of our study area was subject to timber production on both private and Forest Service lands. The Forest Service's land-use designation for the study area was timber production during our study period (US Forest Service 1997). Forest Service land management goals for this land-use designation include "to maintain and promote industrial wood production from suitable timber lands…" and "to manage these lands for sustained long-term timber yields" (US Forest Service 1997). The 1997 Tongass Land and Resource Management Plan (TLMP) changed some of the land management prescriptions from the previous plan, increasing protection to some areas for the long-term conservation of wildlife habitat and to ensure that wildlife remain viable and well-distributed across the Tongass. To conserve brown bear habitat, the 1997 TLMP increased protection of lowland riparian habitats (riparian buffers) for protection of salmon habitat, requested a 500-ft no-cut buffer at important feeding sites for brown bears along salmon streams (see Titus and Beier, in press), a 1000-ft no-cut beach buffer, and an old-growth reserve system (US Forest Service 1997). However, harvest took place on most of the study area before these new TLMP conservation measures, complicating future application of these measures.

During the 1980s >250 km of roads were built on the study area, all associated with timber production. Using GIS data provided by the Forest Service, we estimate that about 500 km of private and public logging roads exist on the study area as of 1999. Most of these roads are accessible for driving from the community of Hoonah.

METHODS

BROWN BEAR CAPTURE

We used radiotelemetry to gather data in this study and that necessitated capturing bears. We immobilized bears using Telazol® (Fort Dodge Animal Health, Fort Dodge, Iowa, USA) at 7–10 mg/kg of estimated body weight (Taylor et al. 1989), from October 1989 through August 1998 using methods standard for bear biologists. Subadult bears received surgical tubing breakaway radio collars (Telonics, Mesa, Arizona, USA), and adult bears received standard radio collars. Some bears received collars that were red, green, light blue, and orange to facilitate resighting for our population density estimation study (Titus and Beier 1993, Miller et al. 1997).

Using darts from helicopters, we captured 73% of the bears in rugged alpine habitats, mostly in June and early July when a large portion of the bear population is in this habitat. We also captured 18% of the bears with footsnares near a local landfill or on well-used trails along salmon-spawning streams. When deploying footsnares along salmon-spawning streams, we used trapsite transmitters to indicate if a snare had been sprung. We captured a few bears (9%) by shooting them with a dart gun, mostly at a local landfill. We tried to recapture bears 3–4 years after their radio collars were first deployed to fit them with new collars. Recapturing bears was difficult because most of our bears were seldom in open habitats. Capture and handling methods followed the Alaska Department of Fish and Game's animal welfare policy to assure that bears received humane care and treatment. Over the 10-year study we believe we captured bears in representative habitats across the study area and that there was no bias regarding capturing most bears in alpine habitats and subsequently assessing their seasonal patterns of habitat selection.

Following methods of Schoen and Beier (1990), from late April through mid October we conducted aerial radiotelemetry flights in a Piper Super Cub and a Helio Courier at 5–14-day intervals. Aerial telemetry flights were limited to daylight hours when the weather was adequate for flying in mountainous terrain. We did not target denning habitat as part of this study (see Schoen et al. 1987) and only conducted sporadic radiotelemetry flights during winter.

GIS METHODS

We plotted radiotelemetry location points on 1:63,360 topographic maps and transferred the points to ortho-photo quads, using an ArcView (Environmental Systems Research Institute, Inc. 1996) data entry system. The initial capture point was considered a location. We estimated a 150-m (radius) error for each radiotelemetry location point for subsequent habitat analyses.

GIS Habitat Type Coverages

A habitat map was created using various GIS coverages obtained from the Forest Service and subject to our editing. We began with the Timber Type (TIM-94) coverage that contained a variety of cover type polygons. Because timber harvest occurred after 1994 on the study area, recent clearcuts were edited and added to the coverage, resulting in a modified Timber Type coverage. Riparian and stream coverages were also edited from the Class 1 and Class 2 stream (US Forest Service 1997) coverage for the study area.

We added an attribute to the stream coverage that included an edited coverage of the lengths of stream that actually contain spawning pink and chum salmon based on the field experience of L. Beier and K. Titus. This *salmon spawning streams* coverage was a smaller subset of Class 1 streams because it did not contain all anadromous fish habitat, high quality resident fish waters, or habitat above fish migration fish barriers that could be enhanced to provide additional spawning areas for anadromous fish. This coverage of salmon stream lengths was then buffered by 160 m on each side of the stream. The remaining segments of Class 1 streams and all Class 2 streams were buffered by 100 m. Next we performed a union coverage of the Timber Type map and the 2 riparian coverages.

We then created polygons of the area above 458 m (1500 feet) from a contour coverage with the Timber Type coverage. This allowed for analysis of location data with respect to alpine and nonvegetated cover types that occur at high elevations.

The Hoonah dump was buffered with a 1000-m radius circle and added as a habitat type for analyses. The size of this circle was added retrospectively after examining radiotelemetry location data for bears associated with the dump. We felt that it was important to be able to identify locations that were strongly influenced by the concentrated food resource independent from the cover type of bear locations near the dump.

The result from this GIS work was a habitat map for the study area that was a composite of various coverages for a total of 10 habitat cover types (Table 1).

Brown Bear Locations

The brown bear location file included all radiotelemetry locations from 1989–1999. In addition to the standard attributes of this file (e.g., date, time, sex, age), were added attributes from other GIS coverages, including elevation, slope and aspect as calculated from a digital elevation model (DEM), distance from the saltwater shoreline, and whether or not the location was within the dump buffer. Each point was then buffered by a 150-m radius circle to incorporate radiotelemetry and mapping errors into the habitat analysis (Waller and Mace 1997). The buffered area of 7.06 ha for each point was then intersected with the final habitat type coverage map to determine the area of each habitat type in the buffered location circle. Thus, each buffered bear location could contain $\geq$1 habitat type.

Brown Bear Home Ranges

We selected bears with >7 locations for estimation of home ranges for our habitat selection analyses. We conducted the minimum convex polygon (MCP) routine to provide estimates of home range. During data screening, some outlier locations were eliminated by visual examination to reduce the size of the area and exclude large areas where the bear probably spent little time. Not all bears had locations eliminated from their respective data sets. Each bear home range was intersected with the habitat type coverage to provide an estimate of the number of habitat types within each bear's home range.

DATA ANALYSIS

For all habitat analyses, we separated data by the following seasons: spring (den emergence–15 May), early summer (16 May–15 July), late summer (16 July–15 September), and fall (16 September–denning). Our GIS data screening resulted in 3 different types of data for habitat-selection analyses. The first data set was a 10-variable habitat availability map of the northeast Chichagof study area. The second data set were the MCP home range estimates for bears with >7 locations. The third data set were individual location areas for all 112 bears. Using these data, we examined habitat use across 9 habitat cover types and habitat selection at 2 scales. Hoonah dump data were excluded from subsequent analysis.

Habitat Use

Habitat use was described by examining individual telemetry locations for the 112 bears, by sex and season, where each location contained the area of all habitat cover types in the 150-m radius plot centered on the point estimate. Proportional habitat use was then calculated across the sum of all location polygons for each bear. We determined mean habitat use by a bootstrap method that was weighted by the number of locations for that bear (Manley 1991).

Habitat Selection

Habitat selection was evaluated at 2 scales by comparing habitat use with habitat availability using ratios (Manley et al. 1993). At the landscape scale, we compared the study area with the location data. We computed a selection ratio for each bear. The geometric mean was calculated for all of the bears with mean and 95% confidence intervals for the ratios being bootstrapped to account for differing sample sizes per animal (Pendleton et al. 1998). Because the ratio being compared was between the locations for each bear and the entire study area, some zeros occurred in the bear-use data. That is, a bear might not have location data for some habitat cover types that occur on the study area. When we found zeros in the use data, we replaced them with 0.0025 for the analysis.

At the home range scale, we compared the estimated home ranges for all bears with >7 locations with the individual location data. For each bear a selection ratio was computed and the geometric mean was calculated as above. For this analysis zeros could occur in both the location data (use) and the home range (availability) data. We replaced these zeros with 0.0025 for the analysis.

Advantages of using these habitat selection ratios are that each animal was considered a sampling unit, yet the mean ratios were weighted more by animals with more locations. The ratios were also independent from one another so an increase in one proportion (habitat type) does not impose a decrease in another. Other advantages and disadvantages of the method are in Aebischer et al. (1993) and Pendleton et al. (1998).

RESULTS

BROWN BEAR CAPTURES

We captured and radiocollared 112 brown bears on the northeast portion of Chichagof Island from October 1989 through June 1998. Two bears were captured 4 times, 2 were captured 3 times, and 17 were captured twice for a total of 139 captures. Two bears died during our capture operations, both presumably from suffocation. A total of 55% of all captures took place in June (Table 2) when many bears were in alpine and other high elevation habitat types, making them visible and vulnerable for capture using helicopter. The large number of captures in 1990 was associated with premarking for a mark-resight density estimation procedure conducted in 1992.

AERIAL TELEMETRY LOCATIONS

A total of 2103 aerial radiotelemetry locations were acquired. Combining this with 139 capture and recapture locations, the total number of locations for all 112 bears was 2242. We eliminated bears with <8 locations from some of our analyses, resulting in 80 bears for subsequent analysis. We had locations in at least 2 different years for these 80 bears, and for 65 bears we had locations spanning at least 3 years (Table 3). We had 5 or more years of location data on 29 bears. The seasonal distribution of locations was weighted to the month of August, when we attained 29% of the locations (Table 4). Yet we had location data for 53 of 80 (66%) bears across the 7 months from April through October when most brown bears were out of their dens. A total of 84% of the 80 brown bears with >7 locations had at least 1 location in each of 6 months. This indicates that our data were adequate as descriptions of seasonal habitat use, selection, and multiyear home range.

HOME RANGE

Screening the location data further reduced the number of bears for which multiyear home range estimates were made by 1 for a total of 79, including 21 for males and 58 for females. Home range size was not related to the number of telemetry locations (Fig. 3). Mean multiyear home range size for male brown bears was 82.8 km^2 (median = 77.1 km^2; SD = 81.6) and mean multi-year home range size for female brown bears was 35.1 km^2 (median = 20.8 km^2; SD = 57.5).

Seasonal Habitat Use and Selection

Across both sexes and all 4 seasons, we found wide variation in patterns of individual habitat use by brown bears (Figs. 4 and 5). For example, in the spring for both sexes, a few bears used avalanche chute habitat almost exclusively, while others had few locations in this habitat cover type. Two males used large old-growth forest stands in the spring, while all other male bears seemed to use this cover type less than or equal to its availability. In early summer, both sexes made high use of the alpine/herbaceous habitat cover type. By late summer both sexes had high use of riparian areas with spawning salmon, the highest single habitat type use of the year for any habitat type. During fall males made little use of small old-growth forest, and their overall pattern of habitat use seemed similar to the availability of habitat types on the study area.

Males

Through the early and late summer seasons, many of our 21 radiotagged brown bears spent considerable time at the Hoonah landfill. We eliminated these availability and use data from the analyses presented here. Selection ratios for male brown bears at the study area level in the spring indicated selection for nonvegetated and shrub/avalanche chute habitat types compared to clearcut and riparian forests that have no spawning salmon (Fig. 6). During the spring, shrub/avalanche chutes, and clearcuts were often snow covered as were all higher elevation areas. Selection for nonvegetated and shrub/avalanche chute habitat types reflected bears emerging from dens at higher elevations where these habitat types were more likely. In early summer male brown bears select the alpine/herbaceous habitat cover type more than forests, clearcuts, and other lowland habitats. This pattern was very noticeable when comparing bear locations to the study area (Fig. 6) but less so when comparing bear locations to their home range (Fig. 7).

Relative to all other habitat cover types, male brown bear selection of riparian areas with spawning salmon was very high during late summer (Figs. 6 and 7). On our study area, this habitat cover type is characterized mostly as riparian old-growth forest, often with floodplain and alluvial channels. The pattern of high selection for riparian habitats associated with spawning fish was the same at the study area and home range scales. During late summer nearly all males were associated with salmon streams and only 1 male bear used this habitat type less than its occurrence on the study area (Fig. 4). By fall males were found across the landscape, in no particular selection pattern and with high variability among individuals. This was especially noticeable when comparing selection ratios at the scale of the study area where selection across habitat types differed (Fig 6).

Females

Selection ratios for 58 female brown bears at the study area level in the spring indicated selection for shrub/avalanche chute habitat and nonvegetated habitats, primarily rock and ice at higher elevations (Fig 8). Most females den at high elevations (Schoen et al. 1987), they remain in their dens longer than males, and they tend to linger near their dens once they emerge. Our data may be confounded by some spring female locations associated with their dens, but this represents a small number of locations. Our field experience indicates that females do linger or move to shrub/avalanche chute habitat where snow is melting, bare ground is present, and vegetation is beginning to leaf out. At the home range selection scale, females made higher use of the nonvegetated habitat cover type than they did at the study area scale (Fig 9). Nearly all nonvegetated habitat is above 500 m in elevation, and our results indicate that the proportion of this habitat cover type differs between the study area and female home ranges.

In early summer, females selected alpine/herbaceous and shrub/avalanche chute habitat types more than all other types, at both the study area and home range scales. Both of these habitat types are usually associated with higher elevations, although shrub/avalanche chutes often extend below 500 m in elevation.

Relative to all other habitat types, female brown bear selection of riparian areas with spawning salmon was very high during late summer (Figs. 8 and 9). The 95% confidence interval had no overlap with any other habitat type. Based on our definition of this habitat type, we found it to occur on 9.1% of the study area, and the geometric mean of female bear use of this habitat was about 25%. Many of our radiocollared females had >40% of their relocations in this habitat type during late summer.

By fall females once again were associated with shrub/avalance chutes, and their selection ratio for this habitat type did not overlap with any other habitat type at the scale of the study area (Fig 8). Of secondary selection were alpine/herbaceous and nonvegetated habitat types. Examination of the use data indicates that many females have more than half of their seasonal locations in avalanche chutes; our field experience indicates strong selection for this habitat type.

DISCUSSION

HOME RANGES

Our multiyear home range size estimates for male and female brown bears were consistent with Schoen and Beier (1990) for Admiralty and Chichagof Islands and other coastal brown bear studies. Brown bear size varies widely across North America according to region, sex, age, and reproductive status. Even though sample sizes, number of locations, and home range estimates differ among studies, some general comparisons can be made. Hamilton and Bunnell (1987) had home range estimates of 60 km^2 and 85 km^2 for 2 female brown bears in coastal British Columbia. Barnes (1990) and Smith and Van Daele (1990) found that annual female brown bear home ranges vary from means of 28 km^2 and 92 km^2 on 2 study areas on Kodiak Island, and they found mean male home ranges of 133 km^2 and 219 km^2 on 2 different study areas. Our mean female and male multiyear home range estimates of 83 km^2 for males and 35 km^2 for females were slightly smaller than those reported for coastal brown bears and indicate that Chichagof Island brown bears can usually obtain their habitat and food resources in a small area. The number and distribution of salmon streams in a landscape may have a strong influence on home range size. Travel distance to obtain food is usually short for bears that feed on salmon on our study area. Our slightly smaller home ranges on Chichagof Island, compared to those on Kodiak Island, were probably not related to the density of brown bears, which were similar in both areas (Miller et al. 1997).

Noncoastal brown bears have home ranges larger than those that we found. Mace and Waller (1997) showed mean annual home ranges of 125 km^2 for adult females and 768 km^2 for adult males in northern Montana, and Blanchard and Knight (1991) had multiyear home range estimates of 884 km^2 for females and 3757 km^2 for males in Yellowstone. There are many examples of large home ranges for brown bears that do not have access to salmon. We assume that our small home ranges reflect the widely available seasonal food resource of spawning salmon combined with prolific berry crops across the study area. Bears that do not have access to these food resources near their core use area in season will travel long distances for seasonally abundant food, thereby increasing their annual home range.

SEASONAL HABITAT USE AND SELECTION

Our patterns of brown bear seasonal habitat use and selection followed those described by Schoen and Beier (1990), although some of our patterns were weaker. There are a few possible reasons for the differences. Schoen and Beier (1990) did not have access to GIS technology and relied on aerial telemetry descriptions of bear habitat use when they estimated the location of a bear. We acquired the same information using their habitat type descriptions, but these data were not used in this analysis. As a result, the habitat type descriptions from our GIS analysis are not necessarily the same as theirs. Finally, although only 10 km from their Admiralty Island study area, we found differences in the numbers but not types of habitats available to bears on each of the study areas.

We chose to use Forest Service GIS coverages, largely based on “timtype,” the only currently available polygon coverage for the Tongass National Forest. The advantage of using a modified GIS coverage was that we were able to conveniently describe the study area and have completely mapped polygons. We were also able to accurately map all roads, streams, and clearcuts. These advantages allowed us to compare habitat use and availability with the same coverage for attributes that Schoen and Beier (1990) could not estimate. The GIS system also allowed us to incorporate radiotelemtry and mapping errors into our analysis. Disadvantages of the coverage we used include 1) small patches of some habitat types are poorly mapped, causing fine scale loss of information, and 2) errors in the mapping of polygons, especially with regard to the size classes of old-growth forest.

Schoen and Beier (1990) found high use of old-growth forest during their spring season (~71%), on their Admiralty Island study area. When pooling habitat use across GIS habitat types that were forest (scrub forest, small old-growth, medium and large old-growth, riparian with fish, riparian with no fish), we found that males and females used some forest type in 57% and 43% of the locations, respectively. Although we do not have quantitative GIS coverage for the Admiralty Island study area, our experience on both study areas indicates that there is less forest, less alpine, and more shrub/avalanche chute habitat on the Chichagof Island study area. We conclude this accounts for some of the minor differences in habitat use and selection patterns between study areas.

We found high selection for the shrub/avalanche chute habitat type by females during spring and fall and less such selection for males. The shrub/avalance chute habitat type probably varies greatly in food quality by season, so females may be selecting this habitat type for different reasons in different seasons. Wielgus and Bunnel (1994) suggested that females may use food-poor habitats to avoid males. They found that females had lower use of forest habitats in the spring and fall to avoid encountering males. One interpretation of our results is in agreement with this hypothesis, at least during the spring. Further analysis of our data with respect to elevation differences between the sexes may provide more information about this hypothesis.

The high selection we found for females of the shrub/avalanche chute habitat in the fall (Fig. 8) suggests the importance of this habitat in providing food resources for bears immediately before denning. Avalanche chutes have long been identified as an important seasonal habitat type for brown bears in the Northern Continental Divide Ecosystem (Waller and Mace 1997) for the herbaceous forage and cover security provided. Similarly, female brown bears in other coastal areas make high seasonal use of avalanche chutes related to berry production (Hamilton and Bunnell 1987). It was unclear why males select this habitat type less than females on our study area.

The highest seasonal selection of a habitat type was for riparian areas with spawning salmon during the late summer (Figs. 6–9). Weighted mean use was 28% by males and 48% by females during this season. The riparian area with spawning salmon accounted for just 9% of the study area, yet some bears used this area almost exclusively during the late summer. Schoen and Beier (1990) also found very high use of this habitat type during late summer, although they defined the habitat type more broadly than we did. This salmon resource concentrates a major portion of the brown bear population along stream corridors and the associated forest during late summer. As a result, the salmon resource is considered a keystone species group because so many other ecosystem interactions depend on that seasonal resource (Willson and Halupka 1995). Our results indicate that the conservation and maintenance of both riparian forest habitats and salmon stocks across Southeast Alaska are two key components for ensuring naturally high densities of brown bears in the future.

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PREPARED BY:

Kimberly Titus
Regional Supervisor

Rodney W Flynn
Wildlife Biologist II

Grey W Pendleton
Biometrician II

LaVern R Beier
Fish and Wildlife Tech V

SUBMITTED BY:

Kimberly Titus
Regional Supervisor

APPROVED BY:

____
Wayne L Regelin, Director
Division of Wildlife Conservation

____
Steven R Peterson, Senior Staff Biologist
Division of Wildlife Conservation