SUITABILITY OF STREAM BUFFERS AND RIPARIAN HABITATS FOR BROWN BEARS

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Abstract: We studied riparian habitat use by a high density brown bear (*Ursus arctos*) population on the Tongass National Forest (Tongass) where spawning salmon (*Oncorhyncus* spp.) provide an important seasonal food resource. The Tongass contains large tracts of pristine old-growth coniferous forest and some of these tracts are within riparian zones that are subject to timber harvest and various timber management guidelines. Determining the size of protective riparian no-cut buffers to conserve fish and wildlife habitat and water quality was a major component of a revision of the U.S. Department of Agriculture (USDA) Forest Service's Tongass Land Management Plan (TLMP; U.S. Forest Service 1997). We radiocollared 111 brown bears on a 1,119 km² portion of Chichagof Island to evaluate bear use of riparian habitats and to determine how proposed buffers might be used by brown bears. Our study area was managed for timber harvest and had >25 salmon spawning streams and associated riparian habitats with various riparian-zone management opportunities. Sixty-three percent of 2,069 aerial radiotelemetry locations were in riparian habitats during August and 61% of all August locations were <1,000 m from a salmon-spawning stream. The new Tongass forest plan has 2 types of administrative buffers on salmon streams: (1) a riparian standard and guideline, which is a variable-width buffer and usually incorporates <150 m of protection, and was established primarily to protect salmon habitat and water quality, and (2) a 153-m no-cut buffer established to protect foraging areas for brown bears. Twenty-four percent of the August locations were within the riparian standard and guideline buffer, and 39% fell within the brown bear buffer, assuming it was applied across all salmon spawning streams used by bears. These results were useful in revising the Tongass forest plan and in assisting decision-makers with the necessary information to change historic land allocations and provide more habitat conservation for brown bears. A panel of brown bear scientists recommended that a 153-m no-cut forest buffer be placed on all salmon spawning streams that are used by brown bears. The final forest plan weakened this recommendation, and its implementation will be subject to future interpretation. However, compared with previous forest planning efforts that had little protection of riparian habitats and none specifically for brown bears, this conclusion was an important measure for brown bear conservation.

Wildlife biologists interested in providing useful information for resource management decision-makers often find the link between science-based information and land allocation decisions to be a complex combination of political, regulatory, and conservation issues. Resource agencies often strive to integrate research and management to assist with problems of uncertainty in ecosystem management and to minimize future controversy with objective information (e.g., Christensen et al. 1996,Thomas 1996). The Tongass National Forest covers most of southeast Alaska and its management has been the source of controversy. Much of the debate has focused on determining how much old-growth coniferous forest should be set aside to maintain habitat for viable fish and wildlife populations versus how much should be allocated for timber harvest. Completion of TLMP (USDA Forest Service 1997) for the Tongass National Forest in 1997 was the culmination of >10 years of planning. During part of this planning, scientists analyzed and synthesized new information in a value-neutral manner; this information was provided to TLMP decision-makers (Everest et al. 1997). Most of the wildlife information was subject to peer-review. For selected wildlife species including the brown bear, assessment panels were convened with experts, and they evaluated the risk to that species of draft forest plan alternatives (Swanston et al. 1996).

Conservation of brown bears on the Tongass has received considerable attention over the past decade. This is because brown bears (1) occur in very high densities in some portions of the Tongass (Schoen and Beier 1990, Titus and Beier 1993), (2) have high public interest for viewing and hunting (Titus et al. 1994), (3) have economic value (McCollum et al. 1996), and (4) are subject to conservation concerns associated with development activities (McLellan 1990). Pacific salmon are an important component of the annual cycle of coastal Alaskan and British Columbia brown bears (Hamilton and Bunnell 1987, Barnes 1990, Schoen and Beier 1990), and some think that maintaining high brown bear densities may be linked to the conservation of forested riparian habitats (Schoen et al. 1994). Maintaining forested buffers along anadromous fish streams also is recognized as important for the long-term health of salmon stocks (Anadramous Fish Habitat Assessment 1995). As the Tongass forest plan was being developed, we provided information to the science team and decision-makers about our findings regarding brown bear use of salmon-spawning habitats and associated riparian areas. We report on brown bear use of riparian habitats and on how the scientific findings and subsequent land allocation decisions fit these data relative to the conservation of riparian habitats. Our objectives were to (1) demonstrate
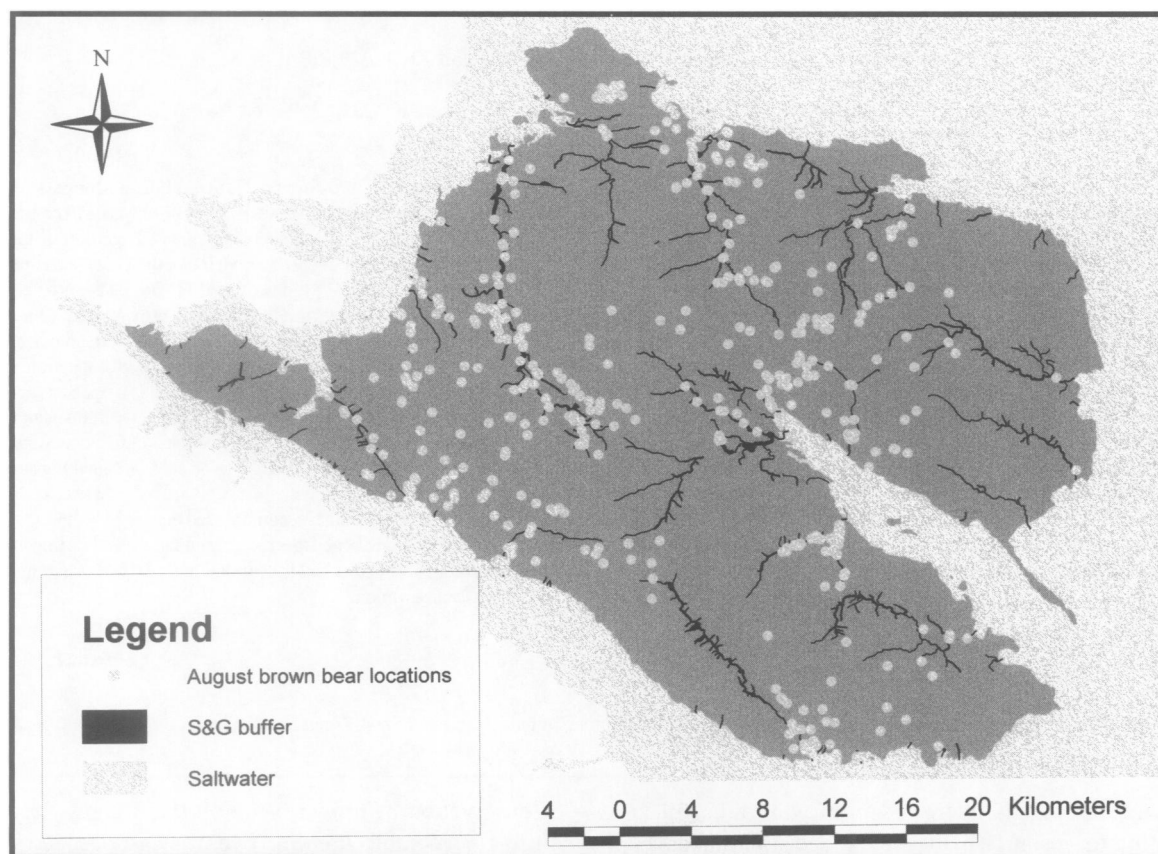
Fig. 1. Northeast portion of Chichagof Island, Alaska, depicting USDA Forest Service riparian standard and guideline (S&G) buffers along salmon spawning streams and August brown bear radiotelemetry locations, 1990–97.

seasonal use of riparian forest areas by brown bears, (2) review the science component of the Tongass planning process, (3) describe riparian protection measures in the final plan, and (4) describe the amount of protection provided to brown bears as determined by our data.

STUDY AREA

The Tongass National Forest covers approximately 68,000 km² within the Alexander Archipelago of southeast Alaska. Brown bears are found on Admiralty, Baranof, Chichagof, and 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. Snow accumulates at sea level in some areas during winter, and elevations >600 m are covered by snow 6–9 months of the year.

Our 1,119 km² study area (Fig. 1.) contained about 370 bears (Titus and Beier 1993, Miller et al. 1997) and was on the northeast portion of the 5,340-km² Chichagof Island. The connection of this area with the rest of Chichagof Island is by a narrow neck of land, making

the study area island-like. Topography is rugged with mountains rising from sea level to 1,100 m. Forests are primarily western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) mosaics. Poorly drained areas include non-forested muskegs and support tree species such as Alaska cedar (*Chamaecyparis nootkatensis*) and lodgepole pine (*Pinus contorta*). Mountain hemlock (*T. mertensiana*) is common in the transition zone to alpine habitats. Nonforested steep slopes are common >300 m and are composed of rock, vegetated avalanche slopes, and alpine habitat. Streams that contain spawning salmon are abundant on the study area. Over 25 streams (Fig. 1) 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 a maximum of 90,000 pink and 45,000 chum salmon for larger streams in some years. Salmon escapements vary widely among years.

The study area has 2 communities with about 250 and 750 inhabitants. The area has at least 420 km of roads, including those under Forest Service, Alaska native corporation, and state or local management. Clearcut log-

ging of lowland old-growth forests has occurred along all roads. Most of this timber harvest occurred during the 1980s and early 1990s. The amount of historic no-cut stream-side buffers varies across the study area.

METHODS

We captured, immobilized using Telazol® (Fort Dodge Animal Health, Fort Dodge, Iowa, USA) at 7–10 mg/kg of estimated body weight (Taylor et al. 1989), and radiocollared 111 brown bears (37 males, 74 females) 141 times from October 1989 through October 1997 using methods standard for bear biologists. Subadult bears received surgical-tubing break-away radiocollars (Telonics, Mesa, Arizona, USA). We captured 73% of the bears by darting from helicopters 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. A few bears (9%) were captured by shooting them with a dart gun, mostly at a local landfill. Capture and handling methods followed the Alaska Department of Fish and Game's animal welfare policy to ensure that bears received humane care and treatment.

Over the 8-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 riparian habitat use patterns. We eliminated 9 bears captured at the Hoonah landfill from analysis because their foraging and home range patterns differed from those of >200 brown bears we monitored on Admiralty and Chichagof islands.

Following methods of Schoen and Beier (1990), we conducted aerial radiotelemetry flights at 5–14 day intervals from late April through early October. We defined riparian habitats to be those areas, typically forested with Sitka spruce, along salmon-spawning streams and associated tributaries. These areas often contain alluvial and floodplain soils and are more productive than poorly drained upland habitats. We plotted radiotelemetry location points on 1:63,360 topographic maps and on orthophoto quads using an ArcView (Environmental Systems Research Institute, Inc. 1996) data entry system. Based on retrieval of 12 marten (*Martes americana*) radiocollars as a test of aerial radiotelemetry error from the same study area and using the same airplane and pilots as our study, R. Flynn (Alaska Department of Fish and Game, Juneau, Alaska, personal communication, 1999) estimated locations to be within 100 m of the actual location. Less rigorous evaluation of the error associated with the retrieval of >20 brown bear collars (dropped collars or bear

mortalities) indicates error up to 150 m. We acknowledge these errors in our data but we did not incorporate error into our analyses. We believe that the general patterns of riparian use by brown bears would not be changed by incorporation of an error analysis into this paper.

We acquired Tongass National Forest Geographic Information System (GIS) data layers for our spatial analysis. Important attributes included bear radiotelemetry location data and spatially referenced information about streams and riparian buffers as programmed for the final TLMP (USDA Forest Service 1997). We acquired GIS maps of all of the anadromous fish streams from the study area and manually corrected the maps to reflect our best knowledge of the extent of spawning pink or chum salmon. Data on bear locations were applied to 2 different administrative buffers for the new TLMP. The riparian standards and guideline buffers (riparian buffers) for TLMP vary in width and are based on a complicated combination of stream channel types, stream class type, and soil characteristics. The riparian standards and guidelines were applied during the planning of an on-the-ground management activity (e.g., timber harvest), and our GIS data represent the best approximation of that riparian, no-cut buffer. These riparian buffers vary from 31 m to >153 m around a stream (Fig. 1). The Tongass plan also has a standard and guideline requiring the establishment of 153-m no-cut buffers along streams where there are important brown bear foraging sites (brown bear buffers).

We established 6 distance buffers at 50-m intervals from salmon spawning streams to evaluate the proportion of bear locations in each successive buffer. We also evaluated the proportion of locations in the variable-width riparian buffers. Although we evaluated these other distance buffers, only the 153-m brown bear and the riparian buffers were directly relevant to the Tongass forest plan. For July, August, and September we cumulatively assessed the proportion of bear locations <1,000 m of salmon spawning streams. All buffers and management prescriptions are measured in feet by the Forest Service, but are reported here to the nearest meter.

RESULTS

We acquired 2,069 locations from 111 brown bears over 8 years, and our locations were distributed across most watersheds in the study area. Results were skewed toward females (79% of locations) because our ability to recapture and maintain collars on females was greater and because our study population was skewed toward females. We had 21 females and 1 male with >30 locations. Most of our aerial telemetry data were acquired

from April through October (April, 6%; May, 10%; June, 14%; July, 13%; August, 30%; September, 16%; October, 10%).

Riparian Habitat Use

We conducted 2 analyses to demonstrate brown bear use of riparian habitats. We visually categorized 23 habitats while obtaining a location and we also acquired riparian habitat information using a Forest Service GIS layer. Based on the visual assessment of habitat categories, 16% (321 of 2,043) of the locations were in riparian habitats across all seasons, and 63% (202 of 321) of these locations occurred during August. Our results follow the seasonal patterns of habitat use by southeast Alaska brown bears described by Schoen and Beier (1990). The combination of riparian and old-growth forest habitat types accounted for 59% (373 of 629) of all August locations. Visually discerning where a riparian forest ended and where our upland old-growth forest habitat category began was not always easy, so there was error in separating these 2 habitats. In May, only 2% (4 of 199) of the locations were in riparian habitats. Additionally, our radiocollared brown bears used avalanche chutes extensively. Bear use of avalanche chutes was most frequent during September when 44% (145 of 331) of all locations were in this habitat type. Our experience indicates that by mid-September, most brown bears are no longer associated with salmon streams and have moved up in elevation to feed on ripening currants (*Ribes bracteosum*), blueberries (*Vaccinium ovalifolium* and *V. alaskaense*), salmonberries (*Rubus spectabilis*), and other vegetation.

Use of Riparian and Salmon Stream Buffers

The greatest number of radiolocations in the riparian buffer occurred in August, when most bears were near salmon streams (Fig. 2). The riparian standard and guideline buffer was usually narrower than the prescription of a 153-m brown bear buffer along all streams that have spawning salmon; hence, they had fewer bear locations in them. Twenty-four percent of all August brown bear locations were in the riparian standard and guideline buffer, and 36% were in the 153-m brown bear buffer. The riparian standard and guideline buffer composed 3.7% of the study area, and the fixed 153-m buffer composed 9.3% of the study area, suggesting selection by brown bears for these areas compared to their availability. During July, August, and September, 3 of 42 bears (with >10 locations) were never found in this 153-m buffer, suggesting some coastal brown bears do not eat salmon (Schoen and Beier 1990, Hilderbrand et al. 1996, K. Titus and L. Beier unpubl. data). Ten of 42 (24%)

bears had >50% of their locations within this buffer, and 3 bears were in the buffer >75% of the time.

We found that 23% of the August locations were in the narrow 50-m buffer. Examining successive 50-m incremental buffers, we found a high concentration of locations near the stream and a more linear decrease in buffer use beyond 200 m (Fig. 2). We found that 28%, 44%, and 27% of the locations were within 300 m of a salmon spawning stream during July, August, and September, respectively.

We examined the proportion of bear locations continuously in an area up to 1,000 m from a salmon spawning stream and found that 61% of the August locations were within this area (Fig. 3). During July and September, bear use of the area within 1,000 m of a salmon spawning stream dropped to 44% and 41% of the locations in this area, respectively.

DISCUSSION

Southeast Alaska brown bears were highly selective for the narrow, forested riparian zone during mid- to late-summer. Bears concentrated on specific segments of streams where they catch spawning salmon. They move from other habitats to these riparian areas in mid-July when spawning salmon first arrive in streams. Although peak spawning varies by a few weeks among neighboring streams, most pink and chum salmon spawn in mid- to late August. By early September, bears begin to move away from these riparian areas and by mid-September, most bears have moved to other habitats. The forested riparian habitat associated with these salmon spawning streams provide security and resting habitat for brown bears. During the peak of the salmon run and foraging period in August, most bears travel small distances (<1,000 m) between foraging sites on the stream and resting sites in the adjacent riparian forest. Our radiotelemetry results indicated that these brown bears do not usually travel to >1 salmon spawning stream and that they visit the same stream section year after year. These factors lead us to conclude that riparian habitat and the maintenance of no-cut buffers are important for the long-term conservation of high-density brown bear populations.

The analysis of the proportion of brown bear locations <1,000 m from salmon-spawning streams indicated that bear use was concentrated near the stream (Fig. 3). Riparian and floodplain forests dominated by Sitka spruce seldom extend beyond a few hundred meters from the stream. On our study area these riparian forests often transition to open muskegs or upland hemlock–spruce forest. These habitats were used by brown bears, but less so than the riparian forest. At distances approaching
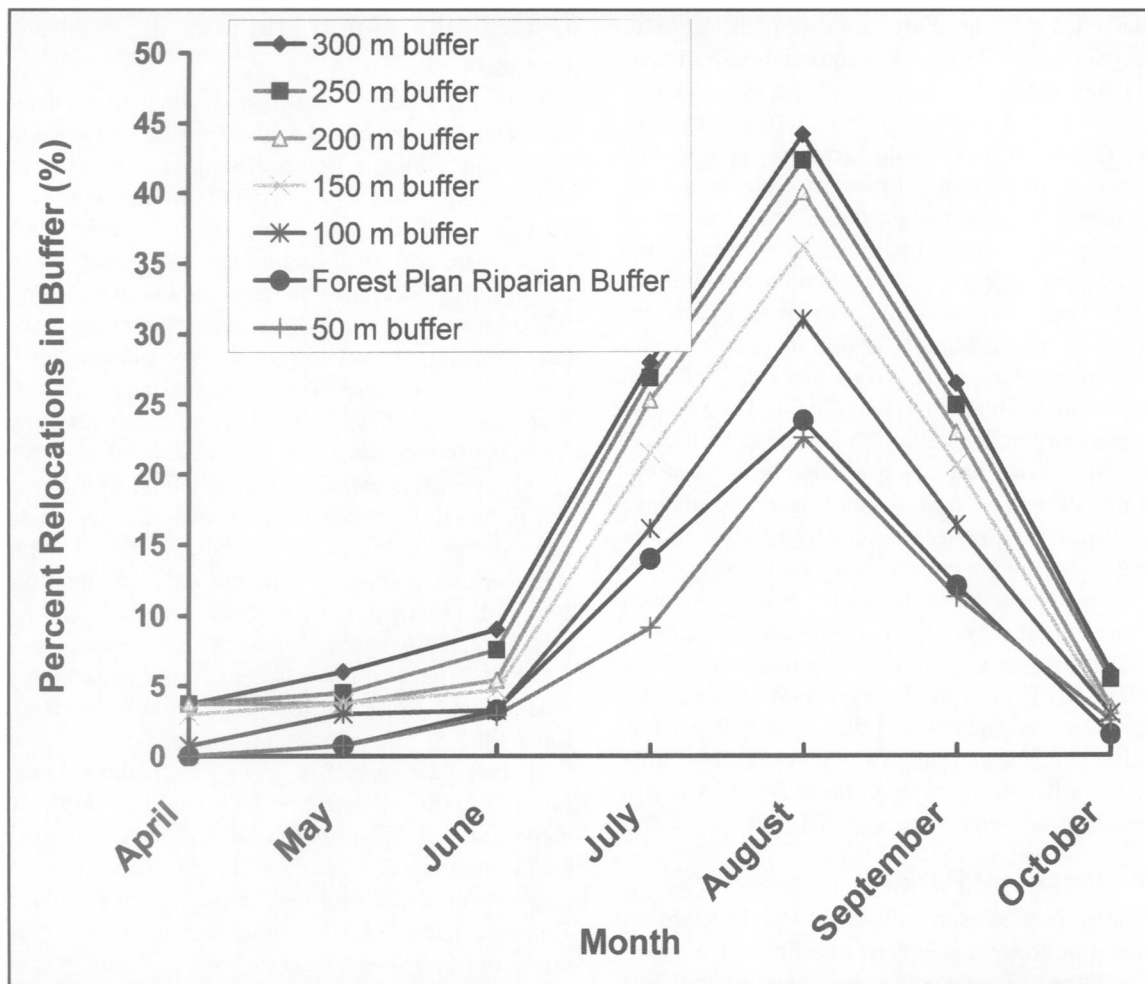
Fig. 2. Percent of brown bear radiotelemetry locations (*n* = 102 bears; 1,935 locations) within 6 distance buffers and 1 administrative stream buffer on the Tongass National Forest, Alaska, based on a geographic information system analysis. The riparian standard and guideline (riparian buffer) and the 150 m brown bear buffers are part of the Tongass Land and Resource Management Plan (USDA Forest Service 1997). All other distance buffers are hypothetical.
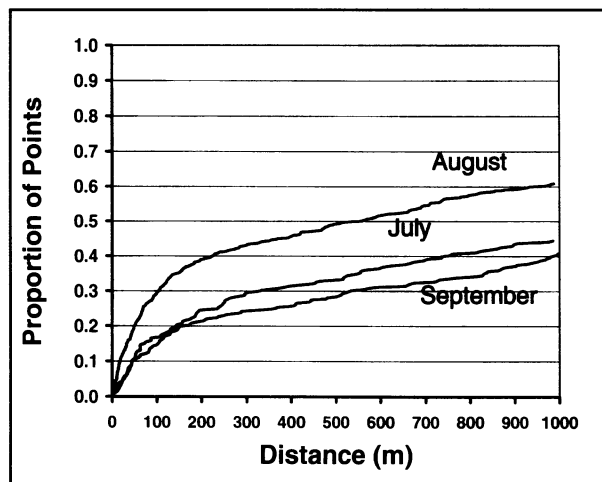

Fig. 3. Monthly cumulative proportion of brown bear radiotelemetry locations up to 1,000 m from salmon spawning streams (*n* = 116, July; *n* = 383, August; *n* = 135, September).

1,000 m from a salmon-spawning stream, brown bears probably are not influenced by the salmon food resource and the nearby riparian forest in terms of short-term habitat use.

Bear Use of Administrative Buffers

The riparian standard and guideline buffer and a blanket buffer of 153-m on all salmon spawning streams provided different levels of protection for brown bears during late summer when most bears were in lowland old-growth and riparian habitats (Fig. 2). Our analysis indicated that the 153 m buffer had 13% more locations than the riparian standard and guideline buffer during the peak period of the salmon run in August.

The levels of riparian habitat protection were based on 2 assumptions. First, we assumed that there was no error in our radiotelemetry data and that the buffers were correctly mapped. The 153-m buffers were mapped based

on our knowledge of the study area and modification of the Forest Service's GIS class I anadromous fish streams to include only those portions of the stream where salmon actually spawned. These errors were probably small for this application but they would increase when applied on the Tongass away from our research study area. The riparian standard and guideline buffer was more problematic to apply regarding its correctness because the boundaries were subject to field evaluation and interpretation. The Forest Service, along with other agency experts, crafted a complicated riparian standard and guideline that will have some error when translated from the GIS map to its application in the field. Because this riparian standard and guideline is new and complicated, the exact size of the buffer may change because of on-the-ground information when implemented. Second, we assumed that the buffers could actually be allocated on the ground. In reality, some streams on the study area either have no streamside buffers or the buffers are much smaller than the analyses we performed here. Consequently, the level of streamside protection afforded by the new TLMP can only provide these buffers from 1998 forward. Riparian areas with little or no existing forested buffer (i.e., clearcut up to stream bank) have little use by brown bears even though these stream sections have spawning salmon (Schoen et al. 1994).

Risk Assessment Panels

The Forest Service used a modified Delphi approach with species or ecosystem experts to estimate the risk to specific wildlife resources and socioeconomic conditions when implementing the various management alternatives in the draft TLMP (Swanston et al. 1996). In addition to expert panels for the brown bear, there were panels for other wildlife species and a fish and riparian panel to integrate protection recommendations for riparian habitats. A key finding of the brown bear risk assessment panel was that "an undisturbed buffer (no harvest, no roads) along salmon-bearing streams where bears concentrate and feed helps to maintain brown bear habitat. Such buffers provide some isolation of bear feeding sites from humans and other bears. The panel identified 500 feet (153 m) along each side of salmon bearing-streams as an appropriate buffer width (Swanston et al. 1996:9). The brown bear risk assessment panel was concerned about the long-term health of salmon habitat, because they felt that salmon habitat was important for brown bear populations.

Use of Information and Forest Service Decisions

The use of scientific information about brown bear use of riparian areas evolved as the Tongass forest plan was developed. First, a Revised Supplement to the Draft Environmental Impact Statement (USDA Forest Service 1996) for the Tongass in 1996 and before the brown bear panels were convened had no specific buffer distances and it stated "Maintain a buffer of productive old growth forest on both sides of important and traditional brown bear foraging habitats to provide cover during feeding, among bears, and between bears and humans" (USDA Forest Service 1996:4–126). Second, when convened in 1996, the brown bear panel reviewed this draft and provided a specific distance recommendation. Third, Iverson and Rene (1997) reviewed the conceptual approach for maintaining viable and well-distributed wildlife populations across the Tongass as part of the planning process. They indicated that a key parameter for brown bears based on their viability synthesis was the maintenance of ". . . 300-foot buffers on low-gradient class I streams to provide visual barrier and foraging habitat" (Iverson and Rene 1997:5). Fourth, the brown bear risk assessment panel met again in 1997 to assess the likelihood that the Final EIS (USDA Forest Service 1997) preferred alternative (with a 153-m buffer) would provide sufficient habitat to support a viable and well distributed brown bear population across their historic range within the Tongass. The 1997 panel "reiterated their concern for a minimum 500 feet no harvest/no road buffer around brown bear feeding areas. This concern was based largely on available telemetry data" (C. Meade, 1997, Brown bear risk assessment panel summary; Tongass Land Management Plan Revision Planning File, USDA Forest Service, Juneau, Alaska, USA). Concern was expressed by some brown bear experts that the Forest Service was changing the burden of proof and weakening the suggestions of the panel. The final Tongass plan Record of Decision was published in July of 1997 (USDA Forest Service 1997:4–114) and it stated —

> During project planning, evaluate the need for additional protection of important brown bear foraging sites (e.g., waterfalls used as fishing sites) in addition to the buffers already provided by the Riparian and Beach & Estuary Fringe Forest-wide standards & Guidelines, and the Old-growth Habitat and other natural setting Land Use Designations. Es-

tablish forested buffers, where available, of approximately 500 feet from the stream sites where, based upon the evaluation, additional protective measures are needed to provide cover among bears while feeding, or between brown bears and humans. This may be especially important on Class I anadromous fish streams . . . where a large amount of bear feeding activity on salmon occurs. Consider the combination of bear foraging behavior, stream channel types, and adjacent landform to help identify probable important feeding sites.

As indicated from our results (Fig. 2), the risk to brown bears will increase should this buffer only be applied in a few areas. Because of the high brown bear density on our study area and across all of Baranof and Chichagof islands that are available for timber harvest, we believe that nearly all of the salmon spawning streams are important for brown bears. During the August peak period of salmon spawning and bear foraging for salmon, the 153-m brown bear buffer contained 36% of the radiotelemetry locations, whereas the 1,000-m hypothetical buffer contained over 60% of the locations. Whether there will be long-term decline in brown bear numbers as a result of this management prescription will be difficult to determine. Other factors such as hunting pressure, roads and access management, and the long-term health of salmon stocks likely will mask the effectiveness of these buffers assuming that the buffers receive some use by brown bears. Our results demonstrate the importance of these forested riparian habitats for brown bears and that it is a prudent conservation measure to establish these stream buffers. We believe that both the variable-width riparian buffer and the 153-m brown bear buffer should be instituted as stated in the new Tongass forest plan. The brown bear buffer can be applied with discretion in the forest plan. We agree with the suggestion of the brown bear panel that this buffer should be applied across all salmon-spawning streams used by brown bears rather than a discretionary approach. Subsequent field evaluation should take place to determine if the buffer can be reduced.

ACKNOWLEDGMENTS

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