Final Wildlife Research Report, ADF&G/DWC/WRR-2012-04

Spatial Use, Habitat Selection, and Population Ecology of Brown Bears along the Proposed Juneau Access Improvements Road Corridor, Southeast Alaska

Rodney W. Flynn, Stephen B. Lewis, LaVern R. Beier, Grey W. Pendleton, Anthony P. Crupi, and David P. Gregovich

2012

Alaska Department of Fish and Game   Division of Wildlife Conservation

Final Wildlife Research Report, ADF&G/DWC/WRR-2012-04

Spatial Use, Habitat Selection, and Population Ecology of Brown Bears along the Proposed Juneau Access Improvements Road Corridor, Southeast Alaska

Rodney W. Flynn, Stephen B. Lewis, LaVern R. Beier, Grey W. Pendleton, Anthony P. Crupi, and David P. Gregovich

Division of Wildlife Conservation, Alaska Department of Fish & Game,
P. O. Box 110024, Juneau, AK 99811, USA
rod.flynn@alaska.gov
907-465-4353

Region 1, Division of Wildlife Conservation, Alaska Department of Fish and Game, P. O. Box 110024, Juneau, Alaska 99811

Final Wildlife Research Reports are final reports detailing the objectives, methods, data collected and findings of a particular research project undertaken by ADF&G Division of Wildlife Conservation staff and partners. They are written to provide broad access to information obtained through the project. While these are final reports, further data analysis may result in future adjustments to the conclusions. Please contact the author(s) prior to citing material in these reports. These reports are professionally reviewed by research staff in the Division of Wildlife Conservation. They are provided a number for internal tracking purposes.

This Wildlife Research Report was reviewed and approved for publication by Douglas Larsen, Regional Supervisor for Region 1 for the Division of Wildlife Conservation.

Wildlife Research Reports are available from the Alaska Department of Fish and Game's Division of Wildlife Conservation, PO Box 115526, Juneau, Alaska 99811-5526; phone (907) 465-4190; email: dfg.dwc.publications@alaska.gov; website: www.adfg.alaska.gov. The report may also be accessed through most libraries, via interlibrary loan from the Alaska State Library or the Alaska Resources Library and Information Service (www.arlis.org).

This document should be cited as:

Flynn, R. W., S. B. Lewis, L. R. Beier, G. W. Pendleton, A. P. Crupi, and D. P. Gregovich. 2012. Spatial use, habitat selection, and population ecology of brown bears along the proposed Juneau Access Improvements road corridor, Southeast Alaska. Final Wildlife Research Report. ADF&G/DWC/WRR-2012-04. Alaska Department of Fish and Game, Juneau, AK. USA

Cover Photo: Looking for brown bears on the estuary at Berners Bay.

Table of Contents

List of Figures

List of Tables

List of Appendices

Abstract

We studied spatial use, habitat selection, and population ecology of brown bears (*Ursus arctos*) in the proposed corridor of the Juneau Access Improvements Project (JAIP) road during 2006 to 2010. The primary purpose of this research was to provide population and habitat information useful for managing a sustainable population of brown bears in Berners Bay after the proposed road is constructed. Originally, we planned to include all drainages intercepted by the planned JAIP road corridor in our study. Because of increased costs for helicopters and fuel, we focused our research activities in the drainages of Berners Bay and adjacent Lynn Canal to Independence Lake Creek, including the Antler, Berners, Lace, and Gilkey rivers, and Cowee, Sawmill Johnson, Slate, Sherman, and Sweeny creeks. We captured 48 (21 males, 26 females, 1 unknown) brown bears in Berners Bay, Southeast Alaska during 2006 to 2010. We recorded movements and habitat selection for 30 brown bears (17 males, 13 females) using global positioning system (GPS) radiocollars. Male bears had a mean home range of 555 km^2 (range = 24 to 2,027 km^2), nearly 4 times larger than that of females (147 km^2; range = 39 to 357 km^2). Brown bear use patterns were distributed mostly throughout the 4 primary river systems within the Berners Bay watershed. Radiocollared brown bears went south to Herbert River and north to the Katzehin River. Throughout the year, the confluence of the major river systems at the Berners Bay estuary served as a central location for bear activity, especially in the early and late summer seasons. As the proposed road bisects the lower bay, most brown bear home ranges intersected the vicinity of the road corridor. We found that 27 of 30 collared bears shared a portion of their home range within the lower bay and the road corridor. We documented breeding activity by brown bears on or near the estuary during 21 June through 15 July. We found brown bear use within 1.0 km of the JAIP road alignment was extensive, as 32% (60,124) of all successful locations were within this distance, particularly during the early (45%) and late summer (31%) seasons. Brown bear paths consistently followed the river bottoms in all seasons, except for denning. We estimated 3,074 locations from the movement paths of 28 brown bears that crossed the proposed road corridor. Locations of bear crossings were not evenly distributed along the JAIP. Most brown bear crossings occurred where the road corridor crosses Sawmill Creek, the entire Berners Bay estuary, Slate Creek, Sweeny Creek, and Independence Lake Creek. We estimated that 1,595 (51.8%) of the bear crossings occurred along 7 km of the proposed road, near the Berners Bay estuary, between the Antler Slough and the Lace River. We found 528 (17.3%) of the bear crossings were in locations associated with planned road structures, primarily bridges over the Antler and Lace rivers. In the two locations where there are planned wildlife underpasses, we documented 20 (0.07%) bear crossings.

We modeled resource selection functions (RSF) by brown bears during early summer and late summer seasons in our Berners Bay intensive study area. In early summer, brown bears selected estuarine emergent, herbaceous, closed forest, open forest, shrub, beach, and unvegetated landcover habitats and the riparian index physical variable. For late summer, habitat selection by brown bears was best described by the distance to salmon-spawning reaches and riparian index for physical variables, and estuarine emergent, open forest, shrub, and unvegetated landcover for habitat variables. We extended our habitat analysis to the greater study area by applying the RSF habitat scores from our intensive study area. Mean elevation at den locations was 231 m (SD = 119).

The estimated total brown bear population for Berners Bay ranged from 29.9 to 37.5 for females and 14.4 to 29.2 for males. Combining the estimates for males and females, the total population was estimated at 44.3 bears in 2006, 66.7 bears in 2007, and 60.4 bears in 2008. In terms of density, we estimated 33.5/1,000 km^2 (95% CI = 29.1–38.5) in 2006, 50.3/1,000 km^2 (95% CI = 45.7–55.4) in 2007, and 45.5/1,000 km^2 (95% CI = 41.3–50.3) in 2008 in our intensive study area. We obtained precise population estimates (within about 10%) by combined live captures, radiotelemetry, and hair snagging. The estimate for survival for the total brown bear population based on the mark-recapture analysis was 0.839 (95% CI = 0.732–0.908). Beginning in 1960, we have observed an average of 1.8 brown bears killed by all human causes per year. For the same period, the annual hunter harvest averaged 1.4 brown bears. Over the last 2 years, human-caused mortality has averaged 2.5. The brown bear population seems to be less productive than those on Admiralty, Chichagof, and Kodiak islands, but it is difficult to measure precisely because of the small population size. Brown bears in the Berners Bay area formed a unique genetic cluster with limited gene flow among neighboring populations of brown bears. Thus, the Berners Bay bears are nearly demographically isolated. We provided recommendations for population management, highway design, and mitigation for the proposed road and corridor.

***Key words*:** Brown bears, habitat selection, genetic structuring, home range, mark-recapture, movements, population estimation, resource selection function modeling, roads, survival, Southeast Alaska, *Ursus arctos*.

Introduction

The Alaska Department of Transportation and Public Facilities (DOT&PF) is proposing to construct an all-season highway between Echo Cove and the Katzehin Flats, the Juneau Access Improvements Project (JAIP) (DOT&PF 2006). The road would be about 78 km in length, crossing Berners Bay and following the east coast of Lynn Canal to the Katzehin River, a currently unroaded area (Fig. 1). Brown bears (*Ursus arctos*) were identified as a wildlife species likely to be affected by the road (DOT&PF 2006). In Berners Bay, the planned road corridor crosses habitats used by brown bears along the lower Berners, Lace, and Antler rivers (Christensen and Van Dyke 2004). In addition, the proposed road will cross habitats with seasonal spawning salmon (Johnson and Blanche 2012). An all-season highway will increase access into a previously remote area (DOT&PF 2006).

The primary purpose of this research is to provide population and habitat information necessary to manage the brown bear population after the proposed road is constructed (Statement of Services, DOT&PF). In response to identified concerns, DOT&PF provided funding to ADF&G to implement a cooperative monitoring and assessment program focused on collecting baseline data on brown bears in Berners Bay and surrounding areas. The analyses presented within this report were outlined in an agreement between ADF&G and DOT&PF (Statement of Services, DOT&PF). We prepared this report to meet final reporting requirements for the DOT&PF.

This information will be important for future management of brown bears in the area. The Alaska Department of Fish and Game (ADF&G) and Alaska Board of Game (BOG) may use the information to set seasons and bag limits for brown bears; the DOT&PF may use it for road management; the U.S. Forest Service (USFS) may use it for recreational management; and the City and Borough of Juneau (CBJ) may use it for public safety management.

Although the ecology of brown bears has been extensively studied on Admiralty and Chichagof islands (Schoen and Beier 1990, Titus et al. 1999, Ben-David et al. 2004, Flynn et al. 2007), little research has been conducted on brown bears along Southeast Alaska's mainland coast beyond Flynn et al. (2010). Managers need a better understanding of brown bear population numbers, survival, movements, and spatial use patterns for the mainland coast (Porter 2001). Limited information and evidence suggest that brown bear densities may be notably lower on the mainland coast compared to Admiralty, Baranof, and Chichagof (ABC) islands (Miller et al. 1997, Porter 2001, Flynn et al. 2010). If lower brown bear densities prove to be the case, wildlife managers, the BOG, and the Federal Subsistence Board (FSB) will have to consider this as they regulate harvest allowances. Knowledge of seasonal spatial use and movement patterns of mainland brown bears can help guide the timing and location of regulated activities.

Our research was designed to investigate the spatial relationships, movements, habitat selection, and population ecology of brown bears along the proposed Juneau Access Improvements Project road corridor. We began our study in 2006 and completed it in 2011. Our spatial use and movement data from global positioning systems (GPS) radiocollared brown bears will set a baseline for current brown bear use of the proposed road corridor. Furthermore, we evaluated important habitats for brown bears during early summer and late summer on a portion of Southeast Alaska's mainland coast. We estimated the number of brown bears in

Berners Bay during 2006–2008 and measured the bears' survival over the same 3-year period using a DNA, mark-recapture approach. In addition, we determined the extent to which the population is demographically closed by assessing gene frequencies among surrounding populations of brown bears. This data will be useful in planning subsequent studies.

Brown bears are an important resource in Southeast Alaska for hunting, viewing (Titus et al. 1994), and ecosystem functioning (Helfield and Naiman 2006). Brown bears are managed as big game in Alaska and regulated by the BOG. Brown bears may be hunted in both spring and autumn. The proposed road corridor is located in Game Management Unit (GMU) 1C (which includes Berners Bay) and GMU 1D (which includes the Katzehin River drainage). The current season dates for GMU 1C and 1D are: 1) 15 March to 31 May and 2) 15 September to 31 December. The bag limit is 1 brown bear every 4 years. Hunting regulations prohibit hunting big game within one-quarter mile of Glacier Highway between Mile 0 and the northern bank of Peterson Creek. In addition, the CBJ prohibits any person from discharging a firearm within one-quarter mile of any public or private street, road, or right-of-way or highway within the City and Borough of Juneau for public safety purposes. In addition, state regulations prohibit shooting from on, or across a road. Federal subsistence regulations set by the FSB usually parallel state regulations on federal lands for federally-qualified subsistence users.

In the design of the proposed road, the Final Environmental Impact Statement (EIS) and Record of Decision (DOT&PF 2006 and Federal Highway Administration 2006) committed to mitigation measures that will be incorporated into the selected alternative. For brown bears, proposed mitigation includes modifying the bridges to function as wildlife underpasses as well as constructing stand-alone wildlife underpasses. Two identified wildlife underpasses would be constructed on the peninsula between the 2 rivers based on observations by Christensen and Van Dyke (2004). All anadromous fish streams on the project, including Sawmill Creek, Antler Slough, Antler River, Lace River, Slate Creek, Sherman Creek, Sweeny Creek, Independence Creek, and Katzehin River will be bridged, providing for wildlife undercrossing at those locations. Wildlife underpasses are proposed at the ends of the bridges over the Antler and Lace rivers and sloughs. Another mitigation element is a commitment to not construct pullouts on the estuary.

We evaluated where brown bears crossed the proposed road corridor using GPS radiocollar data.

Study Area

The study area for this research was on the mainland coast of Southeast Alaska, an area located from 55 to 120 km north of Juneau, Alaska (lat 58°48'36"N, long 134°58'49"W) (Fig. 1). Originally, we planned to include all drainages intercepted by the planned Juneau Access Improvements Project (DOT&PF 2006) in our study (Fig. 1). However, rather than focusing on the entire 3,000 km^2 that extends up to the international border from the road corridor, we focused our research activities in the drainages of Berners Bay, including the Antler, Berners, Lace, and Gilkey rivers, and Cowee, Johnson, Slate, and Sawmill creeks (Fig. 1). Because much of the study area was covered by rock and ice, we used the home ranges of radiocollared bears to define an intensive study area (Fig. 1). We constrained the study area on Lynn Canal to a point 10 km north of Independence Lake Creek and then south to Eagle River (Fig. 1).

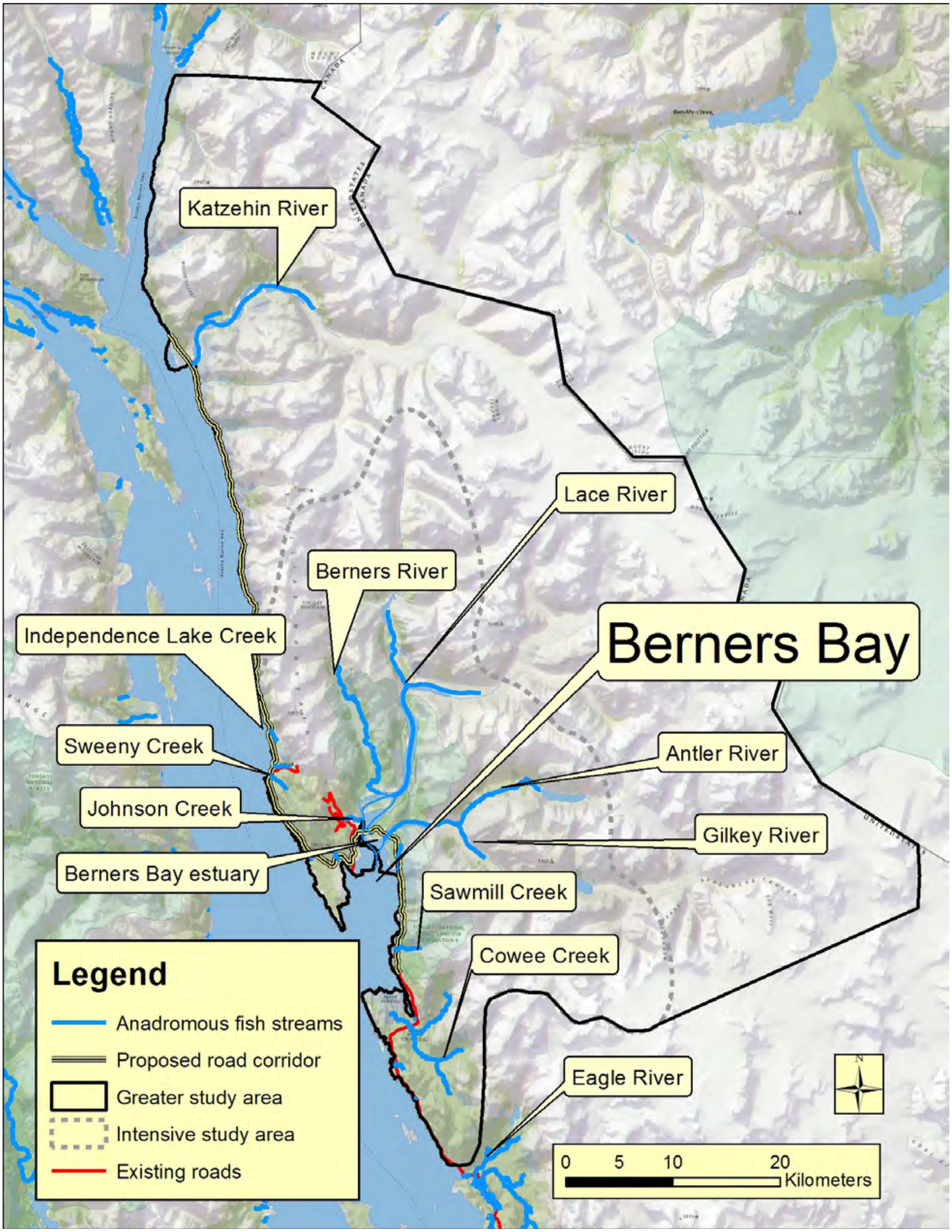


Figure 1. Study areas in the eastern Lynn Canal, Southeast Alaska, showing the greater study area and the Berners Bay intensive study area including places referred to in this report. The proposed Juneau Access Improvements Project road corridor is also shown.

Initially, we intended to include the Katzehin River drainage in our core study area. Because of increased costs for helicopters and fuel, we decided to exclude the area north of Independence Lake Creek from our intensive study area. However, we modeled habitat selection for the entire road corridor area based on our results from our intensive study area (Fig. 1).

Southeast Alaska consists of rugged mountains, numerous islands, and conifer-dominated rain forest. Mountains rise from the sea to over 1,400 m. The climate is cool and moist. Precipitation is distributed evenly throughout the year but varies throughout the region, ranging from 130–600 cm. Heavy snow accumulations often occur during winter; higher elevations are snow-covered for 7 to 9 months of the year. The natural vegetation is dominated by temperate rain forest, (Alaback 1988), interspersed with muskegs and alpine tundra. Because of the lack of frequent, large-scale, catastrophic natural disturbance, the rain forests of Southeast Alaska are predominantly in an old-growth condition (Alaback and Juday 1989). Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) dominate the overstory of most plant associations on productive sites (Martin 1989, Alaback and Juday 1989, Samson et al. 1989). Poorly drained sites often contain mountain hemlock (*Tsuga mertensiana*), Alaska-yellow cedar (*Chamaecyparis nootkatensis*), or western red cedar (*Thuja plicata*). The understory, depending on site conditions, may be dominated by shrubs such as blueberry (*Vaccinium* sp.), rusty menziesia (*Menziesia ferruginea*), or devil's club (*Oplopanax horridum*); bunchberry (*Cornus canadensis*), trailing raspberry (*Rubus pedatus*), and skunk cabbage (*Lysichitum americanum*) are common forbs.

Estuarine and riverine systems are important habitats in Southeast Alaska. Estuarine systems consist of tidal habitat adjacent to tidal wetlands (Cowardin et al. 1979). Estuarine emergent wetlands are within the intertidal zone but vary in species composition based on exposure to salt water. In the Berners Bay area, vegetation of these habitats consist of beach rye (*Leymus arenarius*), silverweed (*Argentina anserine*), beach pea (*Lathyrus japonicas*), northern rice root (*Fritillaria camschatcensis*), and Lyngbye’s sedge (*Carex lyngbyei*) (DOT&PF 2006). Areas more frequently inundated with salt water support salt-tolerant sedges (*Carex* spp.) and other forbs. Marine areas (or beach zones) include intertidal beach bar, flats, and rocky shore. Riverine systems include all wetlands and deepwater habitat contained in channels, with two exceptions: wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and habitat with water containing ocean-derived salts in excess of 5% (Cowardin et al. 1979). A channel is an open conduit, which periodically or continuously contains moving water.

Other mammals that occur in the Berners Bay area include American black bear (*Ursus americanus*), wolves (*Canis lupus*), coyotes (*Canis latrans*), wolverines (*Gulo gulo*), American martens (*Martes americana*), moose (*Alces alces*), mountain goats (*Oreamnos americanus*), hoary marmots (*Marmota caligata*), porcupines (*Erethizon dorsatum*), long-tailed voles (*Microtus longicaudus*), and red squirrels (*Tamiasciurus hudsonicus*).

Many streams in the study area support spawning Pacific salmon (*Oncorhynchus* spp.) during the late summer and autumn. From our field surveys, we detected spawning pink salmon (*O. gorbuscha*) and chum salmon (*O.keta*) in sections of Cowee, Sawmill, Johnson, Slate, Sweeny, and Independence Lake creeks and in the Gilkey, Lace, and Berners rivers in the late summer (Fig. 2). We found sockeye salmon

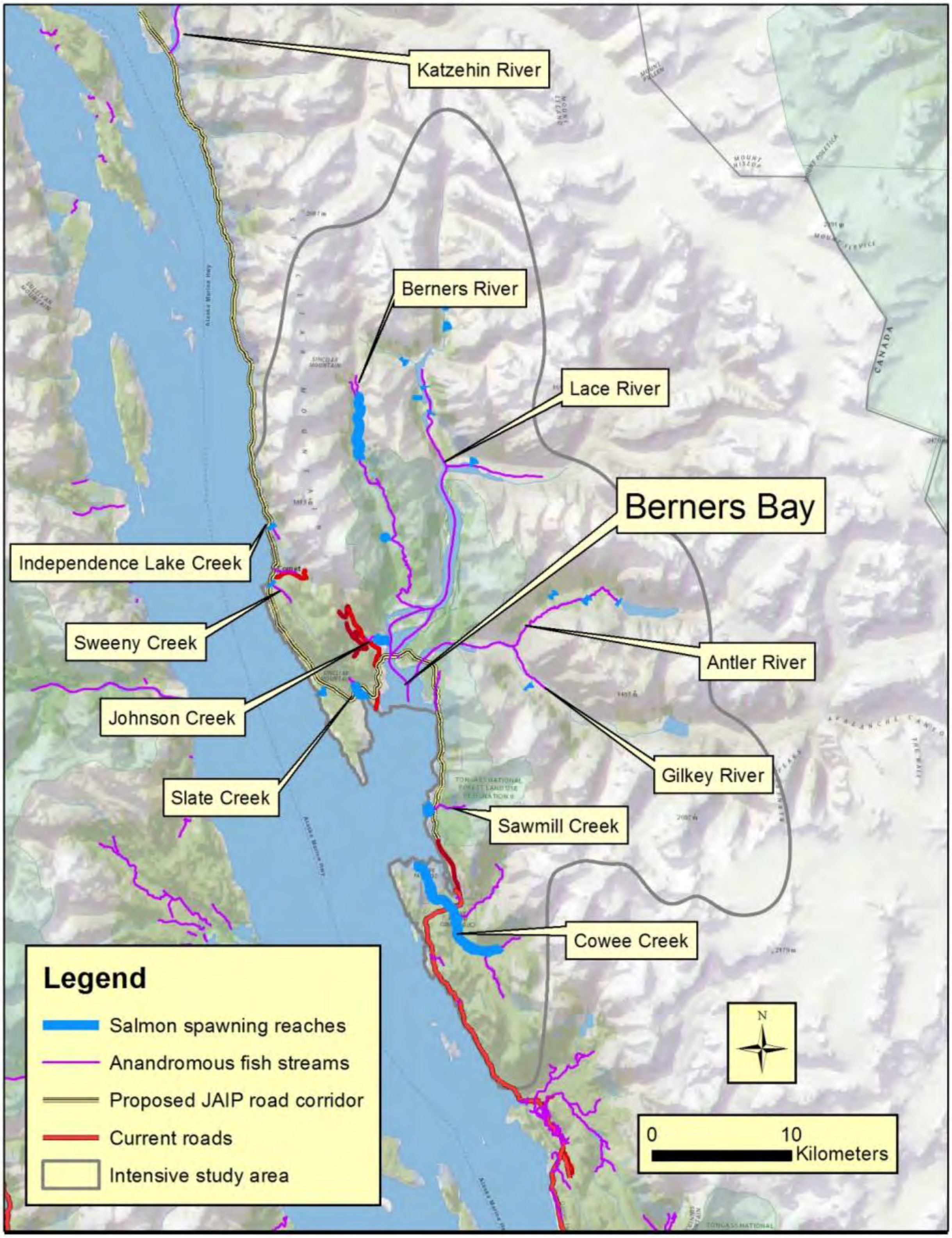


Figure 2. The Berners Bay intensive study area showing anadromous fish streams and salmon spawning reaches. The proposed Juneau Access Improvements Project road corridor is also shown along with current roads.

(*O. nerka)* spawning in portions of the Gilkey, Antler, Lace, and Berners rivers in late summer. Coho salmon (*O. kisutch*) spawn in the Berners, Lace, Antler, and Gilkey rivers and Cowee Creek in the autumn.

Methods

BROWN BEAR CAPTURES

In Southeast Alaska, forested habitats restrict visibility of animals, prohibiting aerial counting. Inclement weather conditions and rough terrain can also limit conventional radiotracking. The emergence of GPS radiocollars has allowed the collection of precise and frequent location information (Arthur and Schwartz 1999, Schwartz and Arthur 1999). The development of a self-release mechanism for the radiocollars reduces the difficulty of retrieving the collars from live animals, especially in remote areas. The collars were programmed to release when the bears were likely to be near streams during early autumn.

We captured brown bears beginning in late spring 2006 through summer 2010, and attached GPS radiocollars (Table 1). From our experience on the Unuk River (Flynn et al. 2010), we learned that mainland brown bears seldom used alpine habitat. Furthermore, ADF&G staff (Kevin White, personal communication) saw only 1 brown bear in the alpine during 60 mountain goat surveys in the study area from 2005 to 2011 (White et al. 2012). We therefore decided to focus our capture efforts near the Berners Bay estuary in the early summer and along the major salmon spawning stream (Berners River) in the autumn.

During spring, early summer, and autumn, we captured bears using foot snares set along trails near beaches and within riparian zones of study area streams. These bears were processed according to Titus et al. (1999). We checked snares daily from the ground or helicopter. Once snared, bears were darted from the ground for immobilization using Telazol® (Fort Dodge Animal Health, Fort Dodge, Iowa, USA) at a dosage of 7–10 mg/kg estimated body weight (Taylor et al. 1989). We deployed GPS collars (Telonics Inc., Mesa, AZ) on all cub, subadult and adult bears large enough to carry a collar (the lightest collar weighs about 2 kg). Other captured bears, including black bears, were processed, marked with ear tags, and then released. For all captures, samples of ear tissue resulting from the insertion of the ear tag were collected for DNA analysis. In addition, we collected hair samples with intact roots. The tissue samples were placed in 95% ethanol for storage. The hair specimens were air dried, placed in paper envelopes, and then stored in a dry environment. We collected a premolar tooth for aging by cementum analysis. Matson's Laboratory (Milltown, Montana, USA) provided cementum-aging analysis of the teeth (Matson et al. 1993). We grouped the age class of bears as young of the year [(age class 0 or cubs of year (COY)], cubs/subadult (age class 1–4) and adults (≥ age class 5) (Barnes and Van Daele 2008).

We also captured brown bears in tidal areas during the early summer using a Hughes 500D helicopter (Titus et al. 1999). We waited with the helicopter in the evening on a high bluff overlooking the main Berners Bay estuary. When we observed brown bears out on the estuary, we launched the helicopter and approached bears within darting distance. Brown bears were darted and processed using the same protocol as the ground captures. During the study, we replaced collars on any brown bears that were recaptured after 6 months. We followed capture protocols approved by the Department's Animal Care and Use Committee (ACUC Protocol #07-14).

Table 1. Captures, age class at capture, gender, capture method, and reproductive condition of brown bears in Berners Bay during 2006 to 2010, Southeast Alaska. The WGI ID is the number assigned by Wildlife Genetics International from the DNA analysis.

Bear number	WGI ID	Gender	Age class	Capture date	Capture method	General location	Female reproductive status
401	6001	F	5	06/10/2006	FS	Lower Berners Bay	No cubs; in estrus
402[a]	6002	M	12	06/11/2006	FS	Lower Berners Bay	
402[b]	6002	M	12	11/02/2006	FS	Upper Berners River	
402[c]	6002	M	13	11/03/2007	FS	Upper Berners River	
402[d]	6002	M	14	06/19/2008	FS	Lower Berners Bay	
403	6003	F	3	06/11/2006	FS	Lower Berners Bay	No cubs; no estrus
403	6003	F	5	07/01/2008	H	Lower Berners Bay	No cubs; in estrus
404	6004	M	1	06/11/2006	FS	Lower Berners Bay	
405	6005	M	13	06/11/2006	FS	Lower Berners Bay	
406[a]	6006	M	12	06/12/2006	FS	Lower Berners Bay	
406[b]	6006	M	14	07/02/2008	H	Lower Berners Bay	
406[c]	6006	M	15	07/06/2009	H	Lower Berners Bay	
407	6007	F	7	06/12/2006	S	Lower Berners Bay	1 1-yr cub; lactating
408	6008	M	3	06/13/2006	S	Lower Berners Bay	
409	6009	F	12	06/27/2006	H	Lower Berners Bay	No cubs; not lactating; no estrus
410[a]	6010	M	12	06/29/2006	H	Lower Berners Bay	
410[b]	6010	M	13	07/06/2007	H	Lower Berners Bay	
410[c]	6010	M	13	11/06/2007	S	Upper Berners River	
411[a]	6011	F	15	06/29/2006	H	Lower Berners Bay	No cubs; not lactating; no estrus
411[b]	6011	F	16	06/19/2007	S	Lower Berners Bay	No cubs; not lactating; no estrus
412	6012	F	18	06/30/2006	H	Lower Berners Bay	2 2-yr cub; lactating
413	6013	F	11	07/06/2006	H	Lower Berners Bay	2 0-yr cub; lactating
414	6189	F	20	10/29/2006	S	Upper Berners River	1 unk cub; not lactating
415[a]	6190	F	17	10/31/2006	S	Upper Berners River	No cubs; not lactating; no estrus
415[b]	6190	F	18	07/07/2007	H	Lower Berners Bay	3 0-yr cub; lactating
415[c]	6190	F	18	10/31/2007	S	Upper Berners River	3 0-yr cub; not lactating
415[d]	6190	F	19	06/30/2008	H	Lower Berners Bay	3 1-yr cub; not lactating
416	6191	F	6	10/31/2006	S	Lower Berners Bay	No cubs; not lactating; no estrus
417[a]	6192	M	16	11/01/2006	S	Upper Berners River	

Bear number	WGI ID	Gender	Age class	Capture date	Capture method	General location	Female reproductive status
417[b]	6192	M	17	06/15/2007	S	Lower Berners Bay	
417[c]	6192	M	18	07/13/2008	H	Lower Berners Bay	
418[a]	6193	F	7	11/02/2006	S	Upper Berners River	No cubs; not lactating; no estrus
418[b]	6193	F	9	07/02/2008	H	Lower Berners Bay	2 0-yr cub; lactating
418[c]	6193	F	9	10/31/2008	S	Upper Berners River	No cubs; not lactating; no estrus
419[a]	6194	M	4	11/02/2006	S	Upper Berners River	
419[b]	6194	M	6	06/19/2008	H	Lower Berners Bay	
420[a]	6089	F	4	06/17/2007	S	Lower Berners Bay	No cubs; not lactating; in estrus
420[b]	6089	F	4	06/18/2007	S	Lower Berners Bay	No cubs; not lactating; in estrus
421	6196	M	7	06/17/2007	S	Lower Berners Bay	
422	6063	F	9	06/17/2007	H	Lower Berners Bay	No cubs; not lactating; in estrus
423	6198	M	3	06/18/2007	S	Lower Berners Bay	
424[a]	6199	M	15	06/19/2007	S	Lower Berners Bay	
424[b]	6199	M	16	07/01/2008	H	Lower Berners Bay	
425	6200	M	9	06/19/2007	S	Lower Berners Bay	
426	6030	F	17	06/20/2007	S	Lower Berners Bay	No cubs; lactating; no estrus
427	6018	M	4	07/06/2007	H	Lower Berners Bay	
428[a]	6203	M	6	07/07/2007	H	Lower Berners Bay	
428[b]	6203	M	7	07/13/2008	H	Lower Berners Bay	
429	6204	M	3	07/07/2007	H	Lower Berners Bay	
430[a]	6323	M	2	09/13/2007	H	Lower Berners Bay	
430[b]	6323	M	3	07/15/2008	H	Lower Berners Bay	
430[c]	6323	M	3	10/20/2008	H	Upper Berners River	
430[d]	6323	M	4	06/25/2009	H	Lower Berners Bay	
431[a]	6232	F	3	10/31/2007	S	Upper Berners River	No cubs; no lactating; no estrus
431[b]	6232	F	6	07/07/2010	H	Lower Berners Bay	No cubs; no lactating; no estrus
432	6045	F	4	11/02/2007	S	Upper Berners River	No cubs; no lactating; no estrus
433[a]	6086	M	4	11/02/2007	S	Upper Berners River	
433[b]	6086	M	5	11/06/2008	S	Upper Berners River	
434[a]	6305	F	20	11/03/2007	S	Upper Berners River	No cubs; no lactating; no estrus
434[b]	6305	F	20	11/05/2007	S	Upper Berners River	No cubs; no lactating; no estrus
436[a]	6375	F	7	11/06/2007	S	Upper Berners River	No cubs; no lactating; no estrus
436[b]	6375	F	8	07/03/2008	FR	Lower Berners Bay	No cubs; no lactating; no estrus

Bear number	WGI ID	Gender	Age class	Capture date	Capture method	General location	Female reproductive status
437[a]	6443	F	18	06/13/2008	S	Lower Berners Bay	2 1-yr cub; lactating
437[b]	6443	F	18	10/18/2008	S	Upper Berners River	2 1-yr cub; lactating
437[c]	6443	F	19	06/25/2009	H	Lower Berners Bay	No cubs; no lactating; no estrus
438	6280	M	5	06/15/2008	S	Lower Berners Bay	
439[a]	6141	F	6	06/30/2008	H	Lower Berners Bay	No cubs; no lactating; estrus
439[b]	6141	F	7	06/25/2009	H	Lower Berners Bay	No cubs; no lactating; no estrus
440	6095	M	3	07/01/2008	H	Lower Berners Bay	
441[a]	6558	M	6	07/13/2008	H	Lower Berners Bay	
441[b]	6558	M	6	10/31/2008	S	Upper Berners River	
441[c]	6558	M	7	06/24/2009	H	Lower Berners Bay	
442	6667	F	2	10/18/2008	S	Upper Berners River	No cubs; no lactating; no estrus
443	6534	M	3	10/18/2008	FR	Upper Berners River	
444	6172	F	9	10/31/2008	S	Upper Berners River	1 1-yr cub; lactating; no estrus
445	6269	F	1	10/31/2008	FR	Upper Berners River	No cubs; no lactating; no estrus
446[a]	6231	F	10	11/01/2008	S	Upper Berners River	2 2-yr cub; lactating; no estrus
446[b]	6231	F	10	11/06/2008	S	Upper Berners River	2 2-yr cub; lactating; no estrus
447[a]	6238	F	2	11/01/2008	FR	Upper Berners River	No cubs; no lactating; no estrus
447[b]	6238	F	2	11/07/2008	S	Upper Berners River	
448	6265	M	2	11/01/2008	S	Upper Berners River	
449[e]			0	11/04/2007	S	Upper Berners River	

[a] The first capture of an individual bear; [b] The second capture of an individual bear; [c] The third capture of an individual bear; [d] The fourth capture of an individual bear, [e] A COY cub that we didn’t process because the sow (#415) was nearby.
Capture method is H = helicopter capture, FR = free range, and S = foot snare.

We assumed that we captured and radiocollared a representative sample of subadult and adult brown bears, both males and females, in our study area. We used 3 methods of capture: foot snares, helicopter darting, and free range. We captured bears in 2 areas within our intensive study area. While foot snaring, we collared every brown bear, except 5 cubs (1 COY, 1 yearling, and 3 2-year bears). These bears were considered too small to collar (<60 kg). Furthermore, we examined the data from 2006 and discovered that all the brown bears either visited the Berners estuary or the upper Berners River in the autumn.

GPS LOCATION DATA

In order to collect frequent, precise bear locations, we deployed GPS-equipped radiocollars (Telonics Models TGW-3600, 3700, or 3790, Telonics, Mesa, AZ) on all captured subadult or adult brown bears. The GPS receivers were set to collect a location fix every 20 or 30 minutes from the date of deployment until 15 November, and then switched to an acquisition rate of 1 fix per day until 1 April. At that point, the collars switched back to the original rate of a location every 20 or 30 minutes until the next 15 November. Collars stored location information in their on-board memories. Each collar was also equipped with a standard Very High Frequency (VHF) transmitter. Collars were set to self-release 10–16 months after their deployment. We selected release dates that we believed would best facilitate collar retrieval.

Periodically, we located radiocollared bears with fixed-wing aircraft. These locations were entered into a geographical information system (GIS) database. Often, aerial locations were obtained shortly after the collars were set to release to determine whether the collars had released as scheduled, and, if so, their locations. If we were unable to retrieve a bear's collar, these aerial observations became our only locations. After we determined that a collar was no longer on a bear, we tracked the collar from the ground until located. If the collar was in a difficult location, such as high elevation or rough terrain, we used a helicopter to get close and then tracked it from the ground.

We downloaded the stored GPS fix locations on a personal computer using Telonics software. The output files were then converted to GIS databases (ArcGIS 10, ESRI, Redlands, CA) and prepared for data analysis. We plotted the spatial distribution of all GPS locations to determine the spatial extent of brown bear activity. We used the activity and temperature sensors in the collars to determine actual drop dates and times. When activity sensor readings became and remained 0 and the temperature recorded by collars dropped to ambient air temperature, we assumed collars had dropped after the previous location fix. We determined the time of death of any mortalities using the same approach.

We divided the year into 5 seasons: 1) spring, 1 April to 31 May; 2) early summer, 1 June to 15 July; 3) late summer, 16 July to 15 September; 4) autumn, 16 September to 30 November; and 5) winter, 1 December to 31 March. These seasons correspond to expected seasonal changes in brown bear behavior due to changing food resources and denning behavior.

HOME RANGE AND MOVEMENT PATTERNS

Home Range

The spatial distributions of locations were displayed using ArcGIS (Version 10, ESRI 2011). We mapped the locations of collared brown bears within the study area and identified seasonal use patterns according to season dates.

We calculated male and female home ranges (100% convex polygon) using the Geospatial Modeling Environment (GME; Beyer 2011), minimum convex polygons (genmcp command). We calculated whether an individual brown bear home range was within 1.0 km of the JAIP road corridor as a measure of vulnerability of brown bears to human activities.

Movement Patterns

We created daily movement paths between each point location for individual bears using GME (convert.pointstolines) (see Graves et al. 2007 and Clevenger and Waltho 2000 for applications to wildlife movement studies). We then generated a point at each location (isectfeatures) where the bear's path intersected the proposed alignment of the JAIP road corridor. Given the short interval between acquired locations (20–30 minutes), we found the level of uncertainty acceptable for where the bear crossing occurred. This method provided an estimate of where the bear crossed the proposed highway alignment.

Using ArcGIS, we partitioned the road into 30 m (about 100 ft), 200 m, and 1 km segments, and totaled the number of bear crossings for each segment. We chose the 30-m division to more closely align with the JAIP Alternative 2B (revised alignment dated 6 February 2012) stations, and bridge and wildlife underpass locations on the Berners Bay valley floor. However, the error associated with GPS technology and movement path analysis may be unreliable at such a fine scale resolution. We showed these data graphically as color-coded segments of the proposed road corridor according to frequency of bear crossing locations with a label for the number of crossings within each given segment. We evaluated the entire road corridor and focused our fine scale analyses on a portion of the Berners Bay estuary. We displayed the proposed wildlife underpasses and bridge structures for reference to the bear crossing analysis. We totaled the number of crossings by the structure type and expressed the number as a percentage of the total number of crossings.

We calculated the number and percentage of locations within 1.0 km of the road corridor. We assumed bears would be vulnerable to human activities while in this zone.

HABITAT SELECTION

Resource Selection Function Model Development

We developed resource selection function (RSF) models (Boyce et al. 2002) using GPS locations from brown bears captured in Berners Bay and mapped habitat variables in a GIS framework. We looked at 1^{st}-order selection (Johnson 1980) at the population level using a Design II approach (Manly et al. 2002). Thus, we measured the used resources for each bear and compared them to available resources at the population level for each of 2 seasons. We considered the early summer (1 June–15 July) and late summer (16 July–15 September) for this analysis because more bears were in the lower bay during these seasons than during other seasons. Some bears started seeking out dens in mid-October; some bears did not emerge from dens until late May. Because we wanted to make a model for all brown bears, we did not separate the bears by gender at first. Once we had an overall model of habitat selection, we examined any gender differences by constructing RSF models for males and females.

We delineated a study area for habitat selection using the 99% isopleths of a kernel density estimation (KDE) function in the Geospatial Modeling Environment (GME; Beyer 2011). We constrained the study area to extend from a point 10 km north of

Independence Lake Creek south to Eagle River. We used a 1% subsample of all the bear locations to generate the KDE because the program would not run when including all of the location data. This 99% isopleths polygon was then clipped to the shoreline to obtain the final intensive study area (total area = 1,323 km^2, Fig. 1).

Table 2. Physical and landcover factors used in resource selection functions (RSF) for brown bears in Berners Bay, Southeast Alaska, including the source GIS data.

Variable	Definition	Source data
Terrain		
Distance from estuary	Euclidean distance to nearest patch of estuarine emergent vegetation	Digitized from DOT&PF imagery; ArcGIS Spatial Analyst
Distance from spawning	Euclidean distance to nearest spawning stream reach	Digitized from ADF&G aerial survey results; ArcGIS Spatial Analyst
Riparian index	Cost-distance to nearest Anadromous Waters Catalog (AWC) stream reach	SRTM-DEM; ArcGIS Spatial Analyst
Landcover		
Estuarine emergent	Intertidal areas with emergent vegetation	Digitized from DOT&PF imagery
Beach	Intertidal areas without vegetation	Digitized from DOT&PF imagery
Shrub	Landcover types dominated by deciduous shrubs	Terrestrial Systems Database
Scrub forest	Forest characterized by small trees (canopy closure 10-25%)	Terrestrial Systems Database
Open forest	Forest characterized by smaller trees (canopy closure = 25-60%)	Terrestrial Systems Database
Closed forest	Forest characterized by large trees (canopy closure = 60-100%)	Terrestrial Systems Database
Herbaceous	Landcover types dominated by sedges, grass, and other herbaceous plants	Terrestrial Systems Database
Unvegetated	Landcover type of snow, rock, or sparse alpine vegetation	Terrestrial Systems Database

Habitat selection, as described in the variables that are listed in Table 2, was analyzed within this area using a logistic regression approach in which locations used by bears are contrasted with available (random) points (Boyce et al. 2002, Manly et al. 2002). The used locations comprised all GPS locations collected from brown bears in the Berners Bay intensive study area. The available points, either physical features or habitats, were chosen randomly within the study area at a density of 30 points per 1 km. We used a two-stage modeling approach in which the GPS points for each bear were analyzed against the pool of available points (Fieberg et al. 2010). This approach resulted in a separate logistic regression equation for each bear. The coefficients were weighted by the variance (Lele and Keim 2006) and then averaged to obtain an overall model. We used a backward model selection and incorporated whether the confidence intervals of model coefficients excluded zero. Models were built using the GLM function in the R statistical environment (R Development Core Team 2011). Such models result in resource selection functions (RSFs) describing the relationship between animal use and model factors (Table 2) via the equation:

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n),$$

where () represents a RSF that is proportional to the probability of use of variables $x_1 + x_2 + \ldots + x_n$.

All used and available locations were given a suite of terrain and landcover variables (Table 2). The terrain variables were either derived from the Shuttle Radar Tomography Mission Digital Elevation Model (SRTM-DEM) or measured as straight-line (Euclidean) distance from landscape features. The landcover variables were largely derived from a database of terrestrial ecological systems (Albert and Schoen 2006). Additional landcover variables representing the estuarine emergent and beach habitats were digitized in ArcGIS according to definitions outlined in Cowardin et al. (1979) because the delineation of these potentially important bear habitats in the original terrestrial systems GIS layer was inaccurate. We computed a riparian index (Albert and Schoen 2006) as a function of slope and distance from any ADF&G anadromous waters cataloged (AWC) stream (Johnson and Blanche 2012). In addition, we mapped the length of spawning streams' segments in the study area by ground surveys (Fig. 2). We flew over the study area streams in a helicopter 4 times each year during 2006–2008 to look for spawning salmon. We also examined bear concentrations around stream reaches in the late summer for evidence of spawning salmon.

In initial data investigations, a number of the potential terrain factors were discarded from further analysis because they were 1) highly correlated with other variables or 2) did not appear to have strong correlations with bear-use locations. The final set of variables was then pared down to those physical variables that had both strong correlations to bear use in single-factor (univariate) models as well as a reasonable biological basis for their effect. For instance, the unused terrain factor 'distance to shoreline' and the factor 'distance to estuary' that was eventually used in analyses were highly correlated (r_s = 0.98). In single-factor models using each of these two variables, 'distance to estuary' had the higher performance based on Akaike's Information Criterion (AIC; Burnham and Anderson 2002). Bears were also observed using estuarine habitats extensively, though were not found using more general shoreline areas. Hence, the distance to estuary factor was included in subsequent models and not distance to shoreline.

Two models were developed to describe brown bear habitat selection in Berners Bay corresponding to early summer (1 June–15 July) and late summer (16 July–15 September) periods. These periods correspond to a general switch in bear forage from herbaceous to salmon-based diets. Habitat models developed for Berners Bay were predicted to the entire, larger eastern Lynn Canal greater study area. Landscape factors used in the Berners Bay models were available for the entire study area, making such predictions possible. However, the novel ranges and combinations of these factors in the greater study area may have limited model accuracy when such extrapolation was performed.

Model Validation

Early- and late-summer habitat selection models were validated using the *k*-fold cross-validation method (Boyce et al. 2002; Johnson et al. 2006). In the *k*-fold cross-validation method, a set of validation data is removed from the total pool of data, leaving the training data. A new model is built using only the training data and the original model factors. This new model is then tested to see how accurately it predicts the removed validation data. The variable *k* represents the number of times this process is iterated. Typically (and here), $k = 5$ is chosen, the training data being built on $1 - (k/n)$ of the data and validated using k/n of the data, where n is the total number of bears ($n = 30$).

Each of the 5 resulting models was then used to generate RSF scores for all the available (random) points and for all of the point locations from the bears in the removed, validation set. The RSF scores for the available points were then split into 10 equal-sized bins ranked in increasing order. The mean RSF score of each bin is divided by the sum of these means to yield the *expected* proportion of locations in each bin. The RSF scores of the validation-set bears were similarly split using the same breakpoint values as used to split the available points. This yields the *observed* proportion of values in each bin.

These sets of expected and observed proportions were then analyzed against each other using Spearman's rank correlation and linear regression. Larger Spearman's rho values approaching 1 (with low p-values) indicate concordance between the rankings of observed versus expected values (Boyce et al 2002). Regression analysis results in optimum performance when the slope approaches 1, the *y*-intercept approaches 0, and the adjusted *r*-squared approaches 1. Such optimal results indicate proportionality between observed and expected results (Johnson et al. 2006; Wiens et al. 2006). An additional comparison of the bin-wise mean expected and observed proportions across all cross-validations provided an integrated summary of performance.

Den sites

We visited winter brown bear den sites in the following early summer. For some of the collared bears, the collars came off the bears near their dens. For each den location, we described the site.

POPULATION DYNAMICS

Abundance and Survival

Great strides have been made in the use of non-invasive genetic methods to identify individual bears and inventory populations (Woods et al. 1999). DNA markers can be used to accurately identify individual bears (Paetkau 2003). Also, the species of bear can be easily determined in areas where the ranges of black and brown bears overlap. Small amounts of DNA can be collected from hair snagged at desired locations (Beier et al. 2005). Individual bear capture histories can be used to estimate numbers of bears (Mowat and Strobeck 2000). In addition, radiotracking data and live-captured bears can supplement the capture histories of individual bears.

We estimated the number of brown bears in our intensive study area by using a DNA-based, capture-mark-recapture (CMR) procedure (Woods et al. 1999, Mowat and Strobeck 2000). Brown bear DNA was collected from snagged hair using a method described by Flynn et al. (2007). First, we located salmon-spawning reaches of streams in our intensive study area. During summer 2006, 2007, and 2008, we placed hair traps along these salmon-spawning reaches. Each hair trap consisted of a modified neck snare with 3 lengths of barbed wire attached to the snare cable (Beier et al. 2005). We set hair traps at roughly 50 m intervals along stream segments, but the number of snares set per stream varied depending on the length of salmon spawning habitat. After setting, the hair snares were checked 4 times at about weekly intervals during the peak of the salmon run, roughly 25 July–30 August. Tripped snares with visible hair were collected, placed in individual 2-gallon plastic bags, labeled with the trap site number and date, and then returned to the office. All tripped snares were replaced with new snares. At the office, hair from each snare was removed and then placed in individually labeled paper envelopes for storage. We removed any residual hair by burning. Each paper envelope was air dried, and then kept in a dry place until ready for shipping. We also collected a sample of DNA (either hair or tissue) from each bear capture event.

At the end of the season, the hair and tissue samples were sent to a commercial genetics laboratory (Wildlife Genetics International Lab (WGI), Nelson, BC) for individual bear identification using DNA microsatellite markers (Paetkau 2003). The DNA extracted using the DNeasy tissue kits (Qiagen Inc., Mississauga, Ontario, Canada). We determined that 7 polymorphic microsatellite markers were sufficient to determine individual identification for the Berners Bay population. The 7 microsatellite markers used were G10J, G10B, G10M, G10U, Mu59, G10C, and G1D. We used the marker G10J to identify black bear samples. We reported the number of black bear samples collected, but we did not complete further analyses of the black bear data. Further error-reducing techniques were in accordance with methods of Paetkau (2003).

We monitored the collared bears throughout the year and kept track of times when the bears were radiocollared. Thus, we knew how many marked (radiocollared) brown bears we had during each period. In addition, we recorded all human-caused and natural mortalities.

Analysis methods

We used mark-recapture analyses (Williams et al. 2001) to estimate the number of brown bears in the Berners Bay study area for the period 2006–2008. Specifically, we used a robust design (Williams et al. 2001) where years are primary periods with 6 secondary sampling occasions within a year. In each year, the 4 middle sampling occasions (i.e., 2–5 excluding occasions 1 and 6) were based on DNA identification of individuals whose hair was snagged in a hair snare during the late summer. Detections during occasion 1 (early summer) and occasion 6 (autumn) were based on live captures and telemetry data. If a bear was either live-captured or known to be alive through telemetry (after the first capture for that bear), it was recorded as detected in all future spring or autumn capture sessions until it could no longer be tracked via telemetry or it was known to have died. Detections during the hair-snaring occasions were based only on actual hair snarings, irrespective of whether the bear was radiocollared.

The specific model we used was the Huggins model for the robust design (Williams et al. 2001). Under this model, the population is considered closed (i.e., no births, deaths, emigration, or immigration within years), but births (i.e., entries into the population) and deaths were allowed between years. Specifically, the parameters in the model are survival probability between years (S), detection probability (p), and emigration/immigration probabilities (γ'', γ'). Based on genetic and telemetry data, we believe the Berners Bay brown bear population is isolated from other brown bear populations, hence the probability of emigration was considered to be 0 (i.e., $\gamma'' = 0$, $\gamma' = 1$) in all models considered.

Population size (N) is not a parameter in the Huggins model, but is estimated as a derived parameter (Williams et al. 2001). We estimated population size separately for each sex and year combination. We considered 40 models, combinations of 5 structures for survival (function of year, sex, both, or constant), and 8 structures for capture probabilities (function of year, sex, occasion within year, type of sampling [i.e., hair snare or capture/telemetry], and interactions of these factors). The robust-Huggins model allows repeat captures within a year to have a different probability (c) than the initial capture probability. However, as most of our detections did not involve actual captures (e.g., hair snaring and telemetry) there was little reason to expect a behavioral response to capture; all models we considered had the same estimates for first and subsequent captures (i.e., $p = c$). Because of the very different nature of the telemetry occasions (i.e., occasions 1 and 6) and hair snaring occasions (i.e., occasions 2-4), all models we considered had different detection probabilities for each type of sampling.

We assessed each model based on the small-sample corrected version of Akaike's Information Criteria (AICc; Burnham and Anderson 2002), which balances how well the model fits the data with model complexity. AICc weights are based on the difference between AICc value for each model and that of the model with the lowest AICc. AICc weights are interpreted as the probability of each model relative to other models under consideration. Rather than base estimates on a single model, we computed weighted average estimates (i.e., model averaged estimates; Burnham and Anderson 2002) using the AICc weights; standard errors and confidence intervals also were adjusted using these weights and incorporating added variance due to model uncertainty.

Brown bear populations in Alaska and elsewhere are often referenced in terms of density (bears/1,000 km^2) (Miller et al. 1997, Schwartz et al. 2003). We also estimated the density of brown bears in our 1,323 km^2 intensive study area in terms of population density (N/1,000 km^2). However, comparability to other studies may be misleading as not all studies define suitable habitats the same.

Mortality

Human-caused mortality

We compiled and summarized the brown bear harvest information from Berners Bay south to Juneau in GMU 1C and north to the Katzehin River area in GMU 1D. ADF&G staff monitors hunter harvest of brown bears by our required sealing program. Every brown bear taken in Southeast Alaska must be presented to a representative of the ADF&G for sealing within 30 days of the kill. When a brown bear was sealed, the particulars of the hunt were recorded (location of the kill, number of day hunted, etc.), a tooth was extracted for ageing, and the skull was measured (length and width). During 2006–2011, we collected a tissue sample from every brown bear that was killed by humans in our greater study area for DNA analysis. The data were organized by regulatory year (1 July through 30 June).

Natural mortality

We recorded natural mortalities that occurred to radiocollared brown bears. Because the radiocollars had a mortality sensor embedded in the VHF transmitter, we could tell when the bear stopped moving. We investigated the site and reported the cause of death. Based on movement and temperature data stored in the collar, we could tell when the bear died, usually with an accuracy of 20–30 minutes.

Productivity

We recorded the reproductive status of our live-captured females. While helicopter darting, we examined whether females were accompanied by cubs, how many cubs, and the age of the cubs. In addition, we noted whether the female was lactating or in estrus (Craighead and Mitchell 1982). When foot-snaring adult female bears, we found it more difficult to observe cubs. Usually, the cubs remained in close proximity to the snare site, often resting with the female. However, additional observations of cubs after the capture event were difficult to collect given the rugged terrain and bears frequent use of forested habitats with thick cover. We defined litter size as the largest number of offspring seen with an individual adult female bear in any given year. We defined productivity as the average number of COY/adult females (age class $\geq$ 5) in our live-captured brown bears by year (Barnes and Van Daele 2008).

Population Genetic Structure

Genetic structure and gene flow of brown bear populations in Southeast Alaska, including the planned road corridor area, were determined based on an analysis of 20 microsatellite polymorphic loci within nuclear DNA (Paetkau et al. 1998, Pritchard et al. 2000, Waits and Paetkau 2005). We used allele frequencies to examine the amount of genetic structuring resulting from population isolation (Paetkau et al. 1997). This study extends previous work that examined gene flow in coastal and interior populations in Alaska (Talbot and Shields 1996, Paetkau et al. 1998), in British Columbia (Proctor et al. 2012), and Glacier Bay National Park (Lewis 2012).

We collected tissue and hair samples from brown bears in Southeast Alaska during 2006 to 2010. We focused our collections in 12 areas that we considered possible (a priori) populations. We knew less about Southeast's mainland coast, so we focused on GMU 1 and 5. We collected samples from several areas of GMU 1A (Misty Fjords area and the Unuk River); GMU 1B (Stikine River and Bradfield Canal); GMU 1C (Taku River south to Port Houghton, Berners Bay, and the Chilkat Range near Glacier Bay National Park); and GMU 1D (Skagway to the Chilkat Valley area). In addition, we collected samples from Yakutat Forelands of GMU 5A and Malaspina Forelands of GMU 5B. Given that we had access to the results from previous work on Admiralty, Baranof, and Chichagof islands, we collected sufficient tissue samples from harvested brown bears to have at least 30 samples from each island. These samples, along with the samples from the Bradfield and Unuk rivers, had already been analyzed at 7 microsatellite markers for individual identification. We extended the analysis to complete the full 20-marker set. Tissue samples (ear plugs or hair) were collected from all brown bears captured during this study. In addition, DNA samples were available from all bears hair-snared during the population inventory and all human-caused mortalities. Altogether, the population genetics dataset consisted of 295 complete 20-locus genotypes from brown bears across Southeast Alaska.

The DNA analysis was done by Wildlife Genetics International (Nelson, BC). The DNA extracted using the DNeasy tissue kits (Qiagen Inc., Mississauga, Ontario, Canada). We used the following markers: (G10J, G1A, G10B, G10H, G10M, G10U, MU50, MU59, G10C, CXX110, CXX20, G10L, G1D, G10P, G10X, MU23, REN145P07, Msut2, MU51, and CPH9). To eliminate genotypes created through genotyping error (Paetkau 2003), we further scrutinized 20 locus genotypes for close mismatches. We reran all pairs of samples that matched at 1, 2, or 3 loci to confirm the genotype or resolve errors (Paetkau 2003). Additional error-reducing techniques were in accordance with methods outlined by Paetkau (2003).

We used a Bayesian clustering approach (Program Structure 2.3.3; Pritchard et al. 2000) to determine population structure and gene flow in Southeast Alaska. This method identifies the presence of population structure, identifies distinct genetic populations, assigns individuals to populations, and identifies migrant and admixed individuals. We assumed a model in which there are K populations (where K may be unknown), each of which is characterized by a set of allele frequencies at each locus. We attempted to assign individuals to populations on the basis of their genotypes, while simultaneously estimating population allele frequencies. The method assumes that within populations the loci are at Hardy-Weinberg equilibrium. We chose the admixture model with correlated allele frequencies between populations with a 50,000 step burn in and 450,000 step Markov-chain Monte Carlo (MCMC) process. We evaluated the data for K = 5–9 by computing ln Pr (X/K). We looked for when ln Pr (X/K) was the greatest number. In addition, Program Structure provides ancestry estimates for each individual, or Q (the estimated membership coefficients for each individual in each cluster).

The parameter F_{ST} is the proportion of the variation in allele frequencies that is attributable to differences in populations. We computed pairwise F_{ST} with Genepop software (Rousset 2008) between of our brown bear populations. We transformed the matrix F_{ST} values into a Fitch-Margoliash tree. The Fitch-Margoliash method uses a weighted least squares method for clustering based on genetic distance (Fitch and Margoliash 1967).

Results

Brown Bear Capture

We captured 48 (22 males, 25 females, 1 unknown) brown bears 85 times during 2006 to 2010 (Fig. 3, Table 1). Age classes of the captured bears at the time of capture were 11 cubs/subadults (age class 0–4; 4 males, 6 females, 1 unknown) and 37 adults (age class ≥ 5; 18 males, 19 females). The oldest bear was determined to be 23 years. We used several methods to capture brown bears. We captured 14 (7 males, 7 females) with foot-snares during June around the lower Berners Bay, 13 (3 males, 10 females, 1 unknown) with foot-snares along the upper Berners River during November, 9 (5 males, 4 females) with a helicopter in the Berners Bay estuary during early July or mid-September, and 2 bears (1 male, 1 female) were free ranged in the upper Berners River in the autumn. We also captured (at different occasions) 11 brown bears (7 males, 4 females) using both foot snaring and helicopter techniques. Also, we captured 2 female bears by both foot-snares and free-range in the upper Berners River during autumn, and we captured 1 female bear by both helicopter darting in the lower bay and free-range in the upper Berners River during autumn.

We captured 51% of the brown bears within 1 km of the proposed road corridor. Of the remainder, we recorded 42% in the upper reaches of the Berners River (Fig. 3, Table 1).

GPS Location Data

We deployed GPS collars on 43 brown bears (21 males, 22 females) from June 2006 through November 2008 (Table 1). For

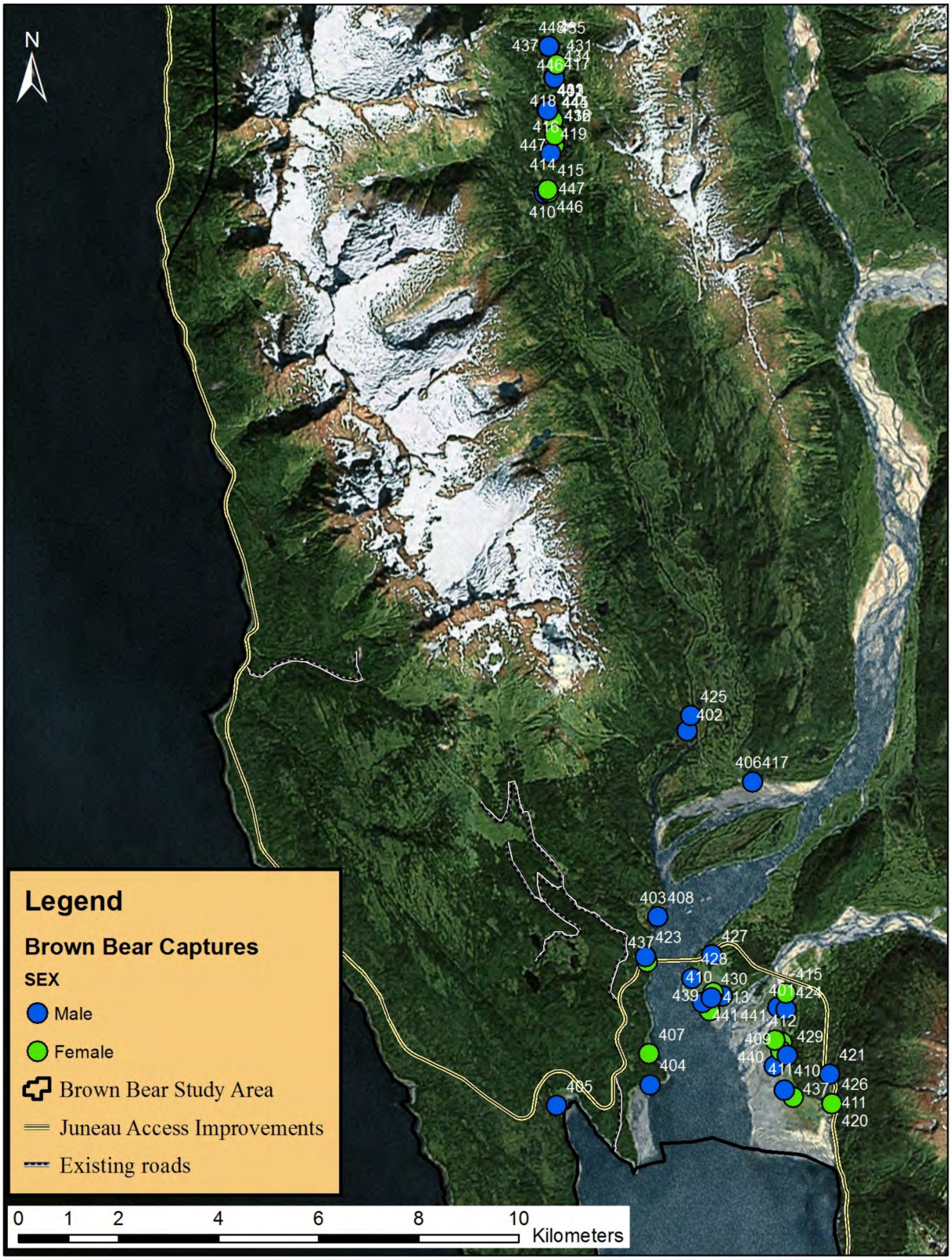


Figure 3. Brown bear capture locations in the Berners Bay area, Southeast Alaska, 2006 to 2010.

Table 3. The number of GPS locations collected for brown bears within each season for Berners Bay, Southeast Alaska.

Season	Dates	No. of locations	No. locations within 1.0 km of road alignment	Percent of locations within 1.0 km
Spring	04/01-05/31	17,330	2,482	14%
Early summer	06/01-07/15	48,178	21,509	45%
Late summer	07/16-09/15	76,785	23,551	31%
Autumn	09/16-11/30	46,235	12,565	27%
Winter	12/01-03/31	114	17	15%
Total		188,642	60,124	32%

some bears, we collected data for multiple periods because we were able to recapture them and deploy an additional radiocollar. A few collars failed to perform as expected due to a series of malfunctions. Five store-on-board collars (1 male, 4 females) did not release from the bears because the collars' release mechanisms malfunctioned. We were not able to retrieve these collars. Several collars stopped collecting GPS location fixes early due to antenna failure. Some bears damaged their collars (i.e., fighting with other bears, scraping on trees, rubbing on rocks, etc.). We had some collars fall off prematurely, especially after bears emerged from their dens and their necks were smaller than when collars were fitted. We processed all of the location data and prepared it for storage, display, and spatial analysis.

Between June 2006 and December 2010, we successfully collected 188,642 GPS locations from 35 individual brown bears (18 female and 17 male) (Fig. 4, Tables 1, 3). By season, we collected 17,330 locations in the spring, 48,178 in the early summer, 76,785 in the late summer, and 46,235 in the autumn (Table 3). We collected only a few locations in the winter; the collars typically do not collect GPS locations while bears are in dens.

HOME RANGE AND MOVEMENT PATTERNS

Home Range

Altogether, we collected sufficient data from 30 brown bears (17 male, 13 female) to examine home ranges and movement patterns. We calculated 100% convex polygon home ranges for these 30 brown bears (Fig. 5-6). Five female bears (416, 418, 431, 434, and 436) collected fewer than 300 successful fixes and were excluded from home range area analyses. The 30 remaining bears had more than 1,000 fixes and their collars collected an average of 6,263 locations, over a mean time span of 532 days (Table 4).

Male bears had a mean home range of 555 km^2 (SE = 125.5 km^2; range = 24 to 2,027 km^2) compared to the mean female home range of 147 km^2 (SE = 25.1 km^2; range = 39 to 357 km^2). Male brown bear home ranges were nearly 4 times larger than those of females (Table 5). Six male brown bear home ranges extended beyond the intensive

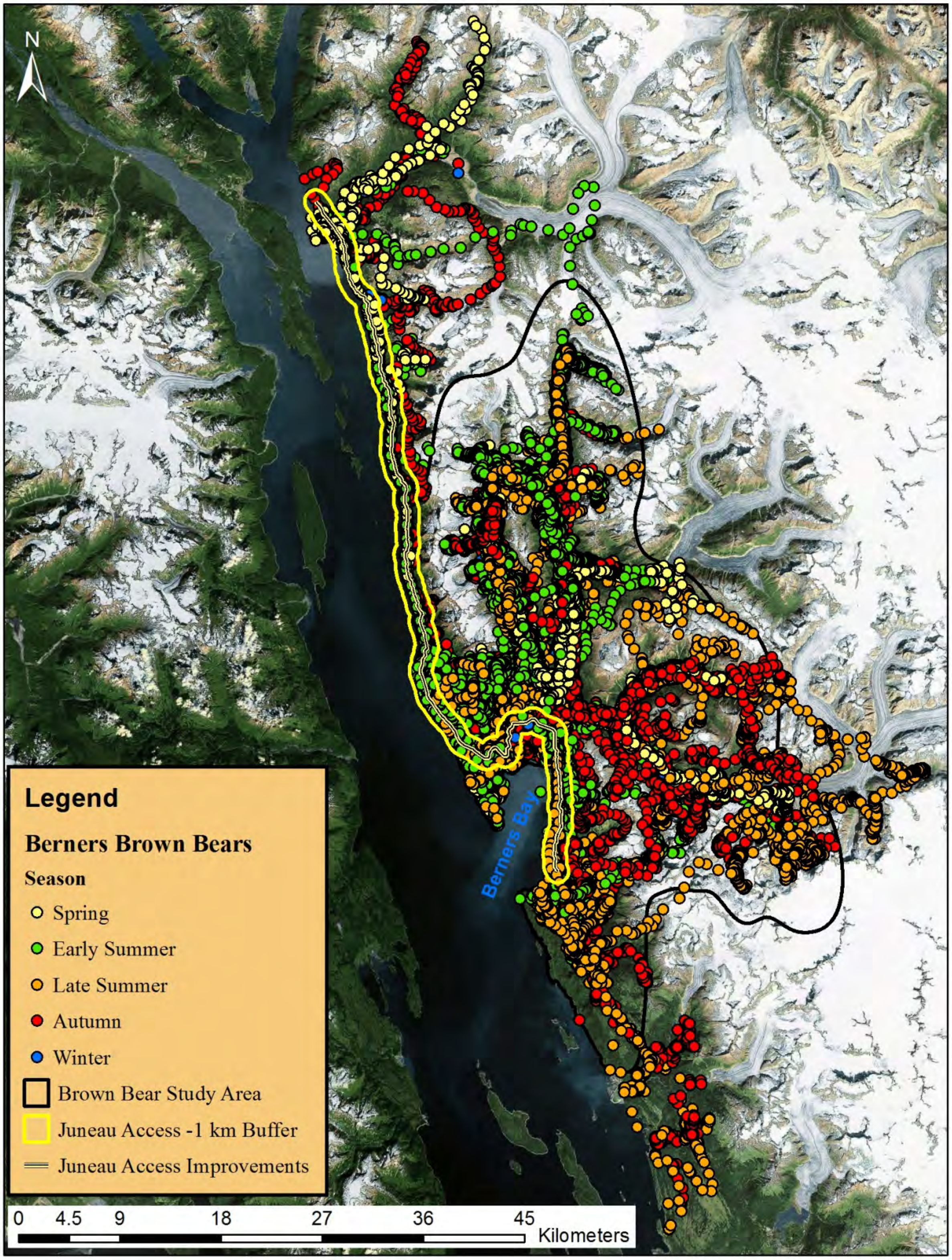


Figure 4. Seasonal brown bear GPS locations collected in the Berners Bay study area, 2006 to 2010.

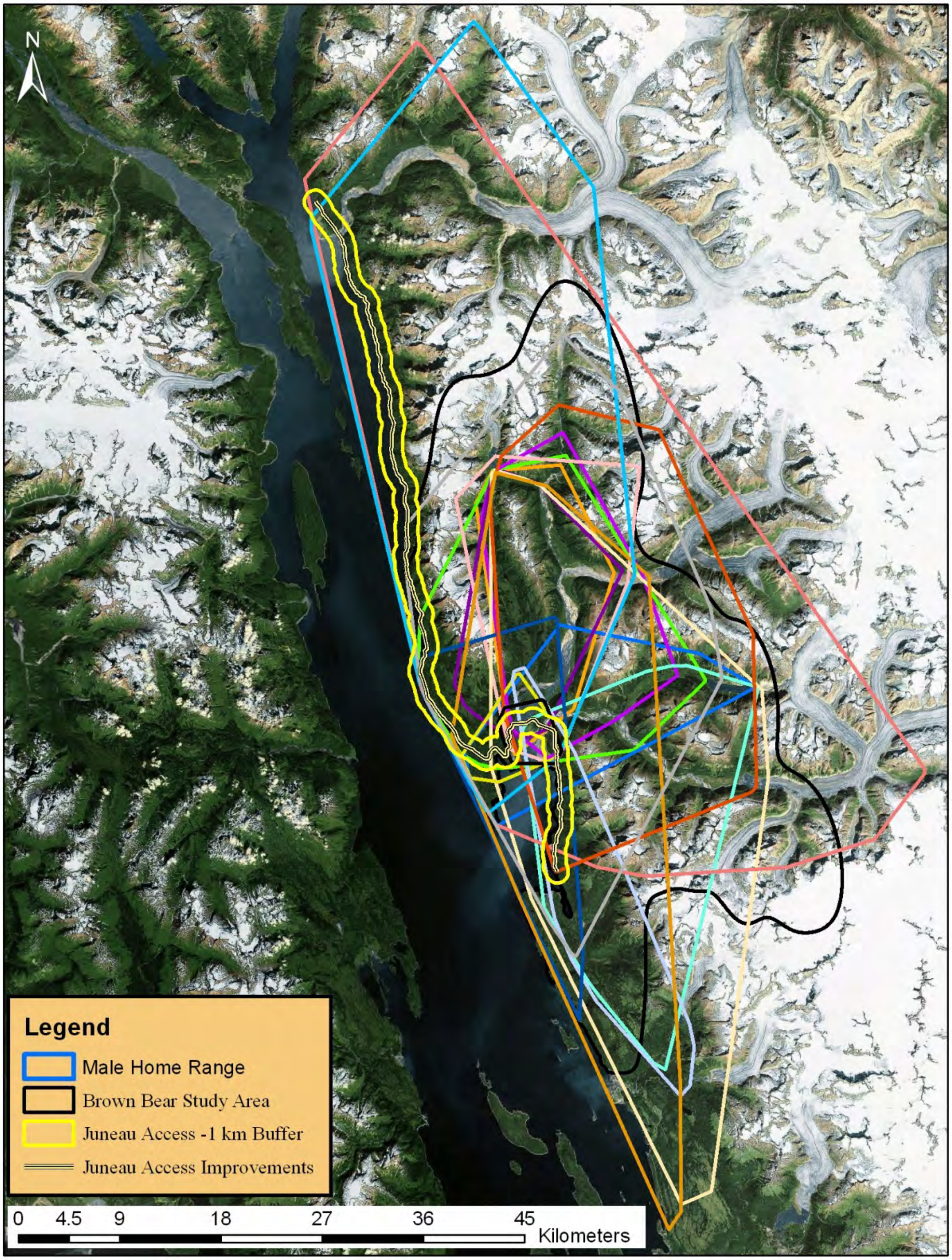


Figure 5. Home ranges, as represented by variously colored minimum convex polygons of a radiocollared sample of male brown bears in the Berners Bay study area, 2006 to 2010.

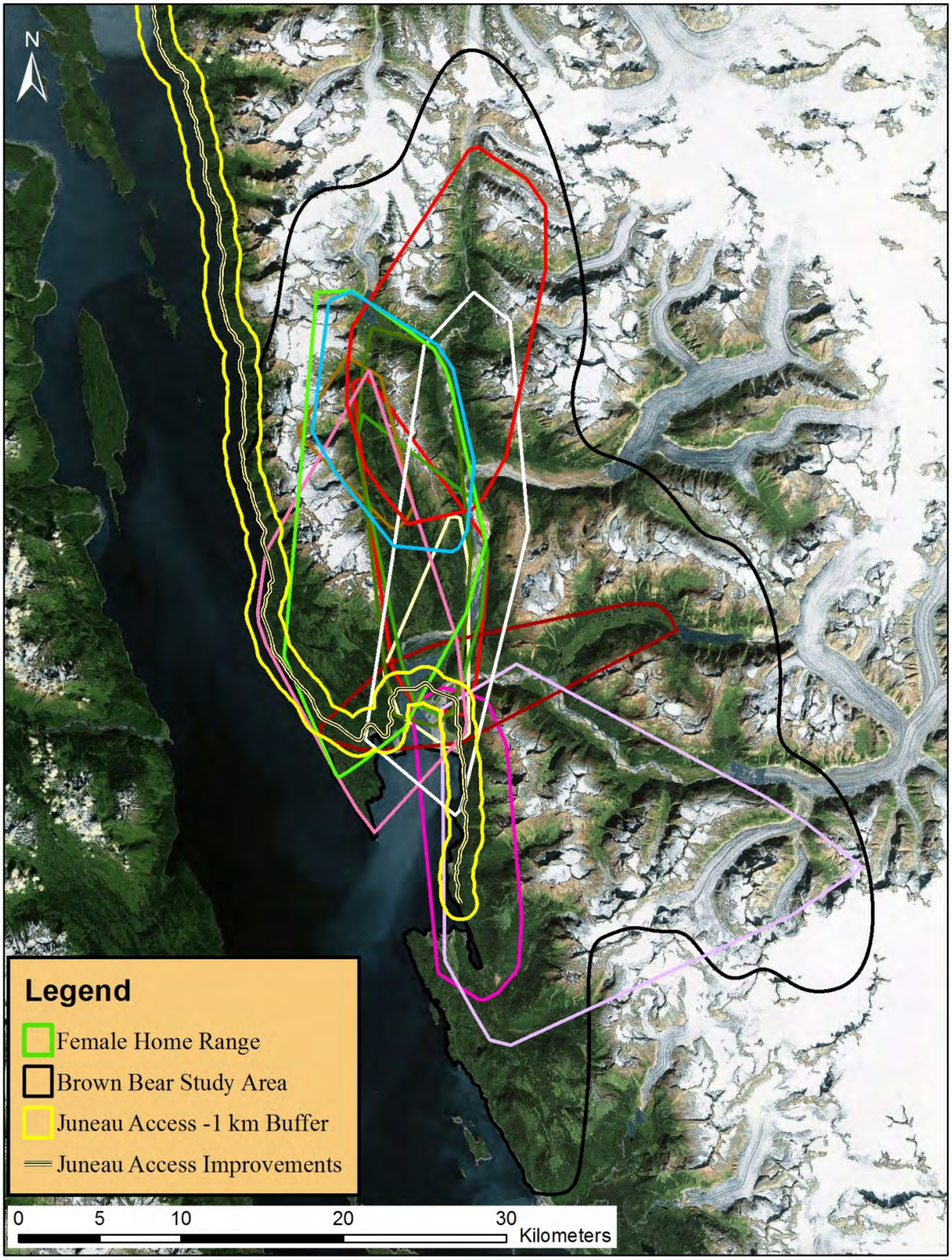


Figure 6. Home ranges, as represented by variously colored minimum convex polygons, of a radiocollared sample of female brown bears in the Berners Bay study area, 2006 to 2010.

Table 4. Summary of brown bear GPS locations in Berners Bay study area, Southeast Alaska.

Bear ID	Sex	No. of successful locations	First day	Last day	No. of days with locations	Home range size (km^2)	Locations within 1.0 km of road alignment
401	F	4416	06/10/2006	04/03/2007	297	99.5	yes
402	M	4009	06/11/2006	05/10/2008	699	206.5	yes
403	F	3068	07/01/2008	10/04/2008	95	47.8	yes
405	M	3453	06/11/2006	11/26/2006	168	471.1	yes
406	M	12465	06/12/2006	03/05/2010	1362	230.6	yes
410	M	6393	06/29/2006	05/28/2008	698	315.0	yes
411	F	6839	06/29/2006	07/24/2008	756	96.8	yes
412	F	4123	06/30/2006	11/07/2006	130	95.7	yes
414	F	4429	10/29/2006	06/23/2008	602	39.1	no
415	F	2867	10/31/2006	07/01/2008	609	87.2	yes
416	F	7	10/31/2006	11/16/2006	16	-	-
417	M	5391	11/1/2006	08/13/2008	651	220.6	yes
418	F	3	11/2/2006	05/19/2007	198	-	-
419	M	8364	11/2/2006	08/25/2008	662	301.5	yes
421	M	5680	06/17/2007	07/14/2008	393	987.0	yes
423	M	3181	06/18/2007	10/26/2007	130	48.4	yes
424	M	9467	06/19/2007	11/08/2008	508	463.4	yes
425	M	3420	06/19/2007	11/15/2007	149	209.4	yes
426	F	6544	06/20/2007	08/31/2008	438	356.8	yes
427	M	3761	07/06/2007	06/09/2008	338	252.0	yes
428	M	21978	07/07/2007	10/02/2009	818	2028.0	yes
429	M	7934	07/07/2007	08/31/2008	421	726.5	yes
430	M	4990	09/13/2007	09/11/2009	729	768.1	yes
431	F	296	10/31/2007	05/28/2008	210	-	-

432	F	3987	11/02/2007	06/20/2009	596	128.0	yes
433	M	5881	11/02/2007	06/13/2009	589	1260.1	yes
434	F	267	11/03/2007	12/27/2007	54	-	-
436	F	170	11/6/2007	11/21/2007	15	-	-
437	F	11386	06/13/2008	09/08/2011	1182	207.2	yes
439	F	4365	6/30/2008	06/24/2009	358	200.5	yes
440	M	1187	07/01/2008	08/03/2008	32	24.1	yes
441	M	13212	07/13/2008	12/06/2010	876	919.5	yes
444	F	5681	10/31/2008	08/14/2010	651	191.5	no
446	F	5786	11/1/2008	10/12/2010	710	111.33	no
448	F	3642	11/2/2008	09/1/2009	303	254.6	yes

Table 5. Home range area of brown bears in Berners Bay study area, Southeast Alaska, based on a 100% minimum convex polygon (MCP).

Gender	Sample size	Home range (km^2)
Male	17	555
Female	13	147
All bears	30	378

study area (Fig. 5), whereas female home ranges were largely bounded by the intensive study area (Fig. 6).

Throughout the year, the confluence of the major river systems at the Berners Bay estuary served as a central location for bear activity, especially in the early and late summer seasons. Some brown bears ranged south to Johnson, Davies, and Cowee creeks while other bears traveled up the Antler, Berners, Lace, and Gilkey rivers. Most brown bear home ranges intersected the vicinity of the road corridor in the estuary. We found that 27 of 30 collared bears shared a portion of their home range within the lower bay and the proposed road corridor. Only 3 adult female bears (414, 444, and 446), with or without cubs, exclusively occupied home ranges in the upper reaches of the watershed.

Five male bears made movements well beyond the Berners Bay intensive study area. Two adult male brown bears (428 and 433) traveled from the Berners Bay estuary to the Katzehin River in the spring season and returned to the study area before winter hibernation. In 2008, bear 428 traveled a minimum of 1,255 km before returning to the Gilkey River in late December to den for the winter. Eventually, a hunter harvested this bear in spring 2010 on the Katzehin River estuary. Male 425 traveled south into the Eagle River drainage in October 2007 and denned above Eagle Glacier Lake (Fig. 1). Male 421 traveled south as far as Tee Harbor and subsequently dropped his collar prematurely near Eagle River (Fig. 1). In addition, male 430 used areas south of Berners Bay.

We witnessed breeding activity by brown bears on or near the estuary during early summer. We captured 5 females that appeared to be in estrus during 16 June until 1 July (Table 1).

Movement Patterns

Our data showed brown bear use of habitats within 1.0 km of the proposed JAIP road corridor with 32% (60,124) of all successful locations occurring within this distance, particularly during the early (45%) and late summer (31%) seasons (Table 3). Locations in the autumn (27%) and the spring (14%) were also within 1.0 km of the proposed road corridor. Limited data were collected in winter, but some bears were present within 1.0 km of the road corridor (15%) during the typical denning period. Seasonal brown bear movement patterns identified areas where access to ephemeral resources exists, such as herbaceous vegetation in the estuary and salmon spawning reaches up the river systems. Habitats along the river valley bottoms were occupied throughout the year, but the extent to which they were used varied with season (Fig. 4).

Brown bear movement paths are displayed for each season (spring–autumn) to depict the generalized seasonal variation in travel routes and extents of the study area accessed; the figures are not intended to provide the fine scale resolution necessary to assess individual animal movements (Fig. 7-10). Given the short interval between consecutive locations (20–30 minutes), we were able to map movement paths with an acceptable level of accuracy. Brown bear paths consistently followed the river bottom in all seasons and, rather than ascend the mountains, bears would walk long distances to get to the other side of ridges. Seldom did the bears use high elevation habitat.

Bear crossings of the proposed road corridor

We estimated 3,074 bear crossing locations from the movement paths of 28 brown bears that traveled across the proposed road corridor (Fig. 11). Locations of bear crossings were not evenly distributed along the highway. The highest frequency of

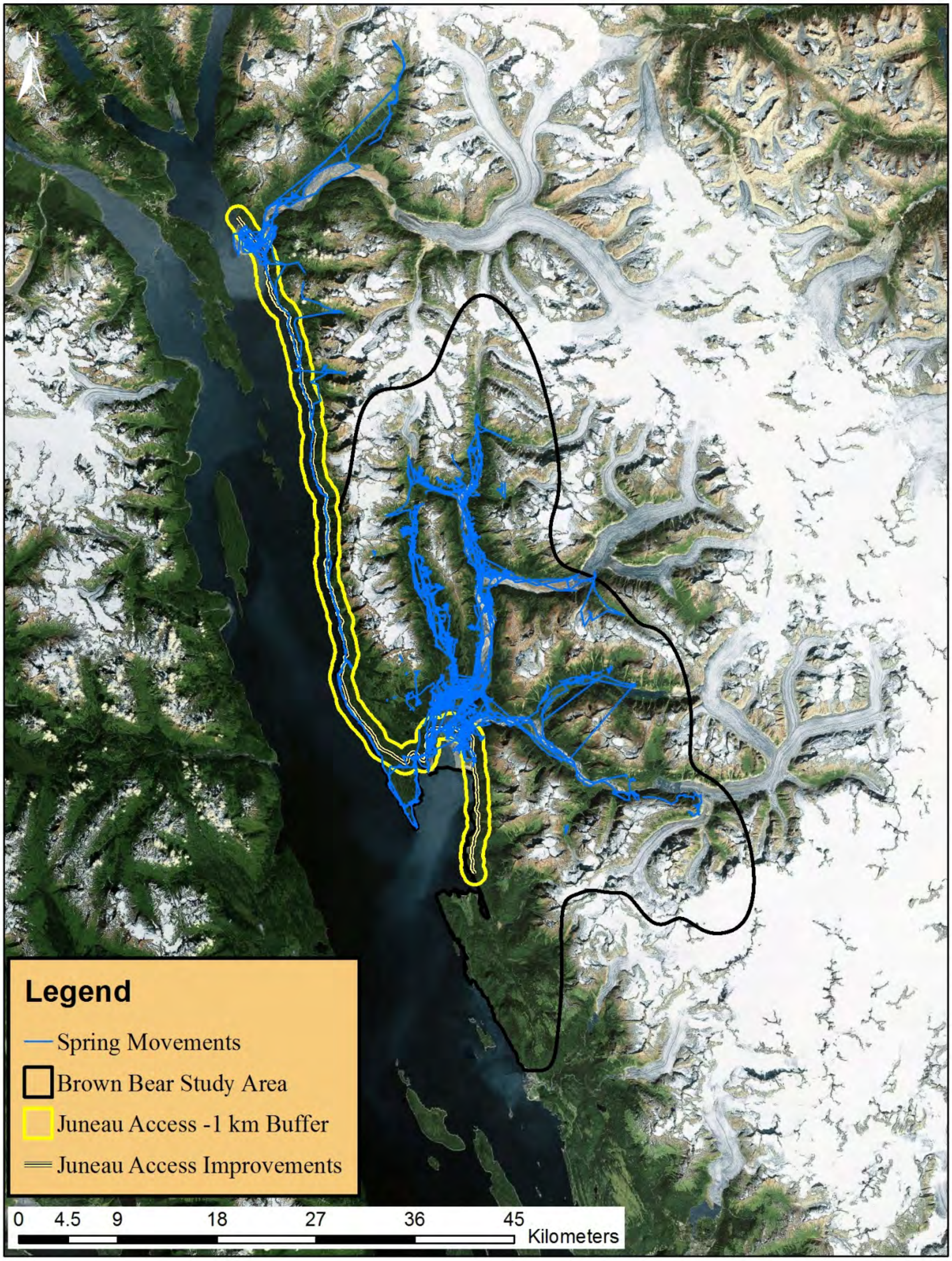


Figure 7. Brown bear movement paths during spring in the Berners Bay study area, Southeast Alaska, 2006 to 2010.

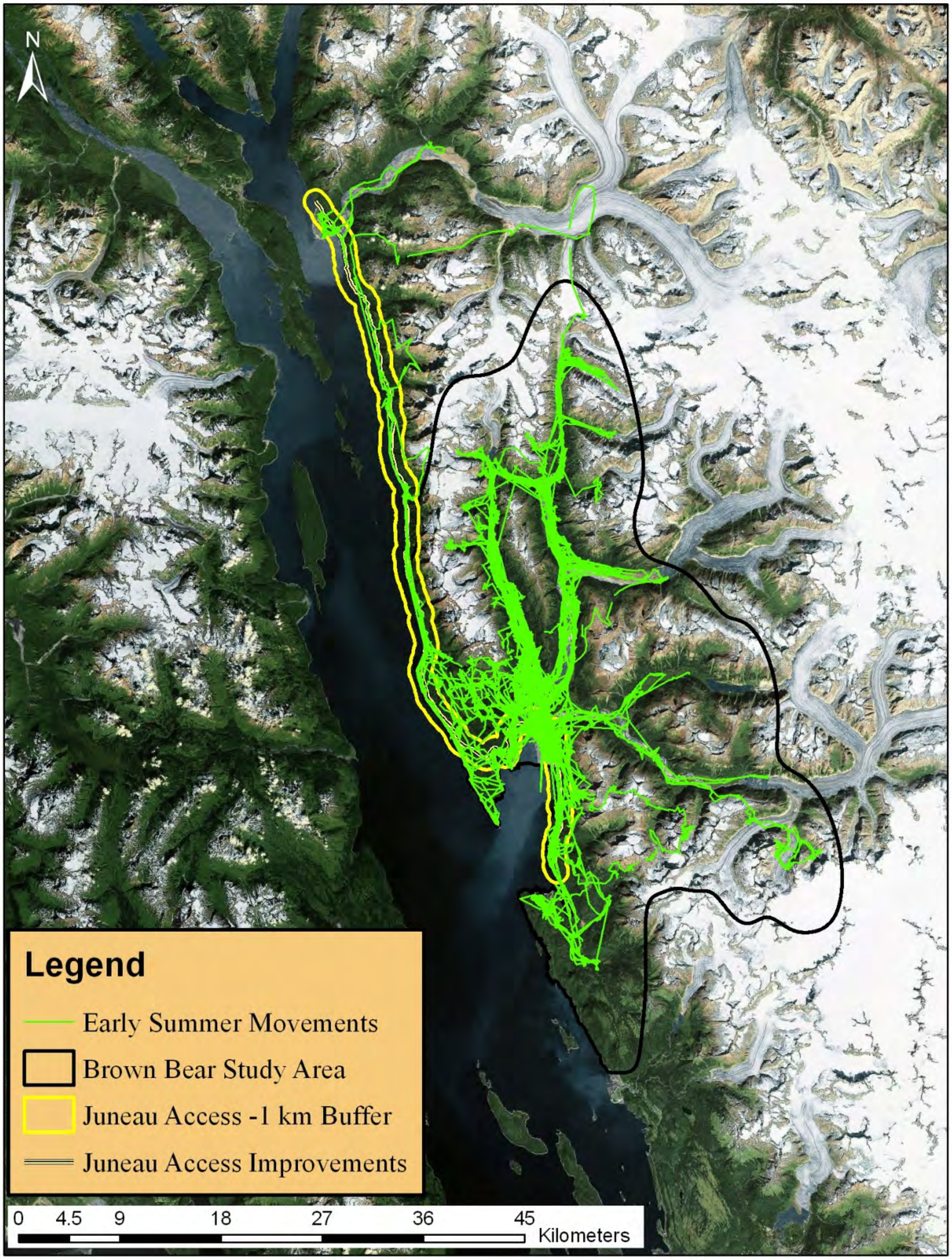


Figure 8. Brown bear movement paths during early summer in the Berners Bay study area, Southeast Alaska, 2006 to 2010.

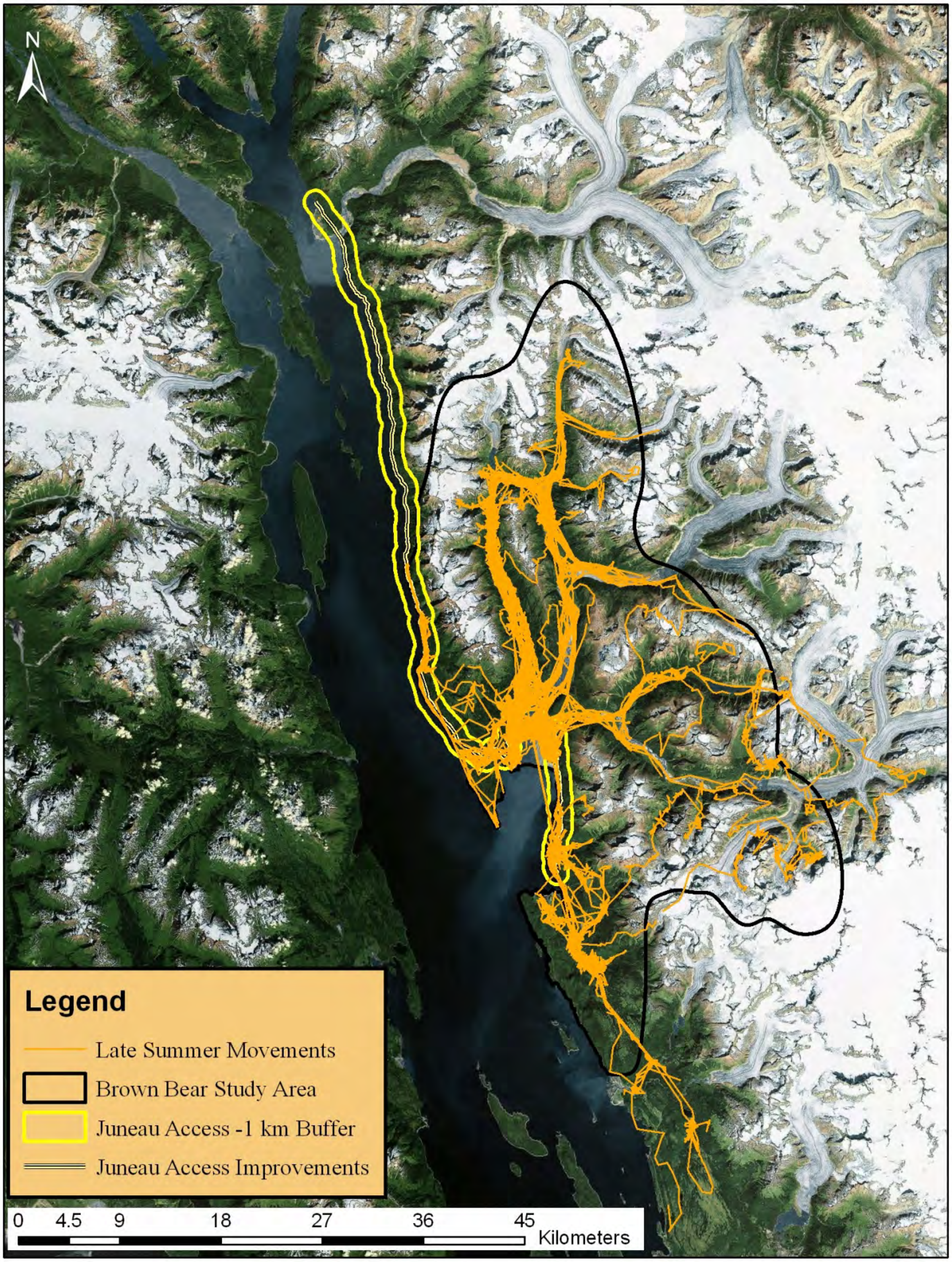


Figure 9. Brown bear movement paths during late summer in the Berners Bay study area, Southeast Alaska, 2006 to 2010.

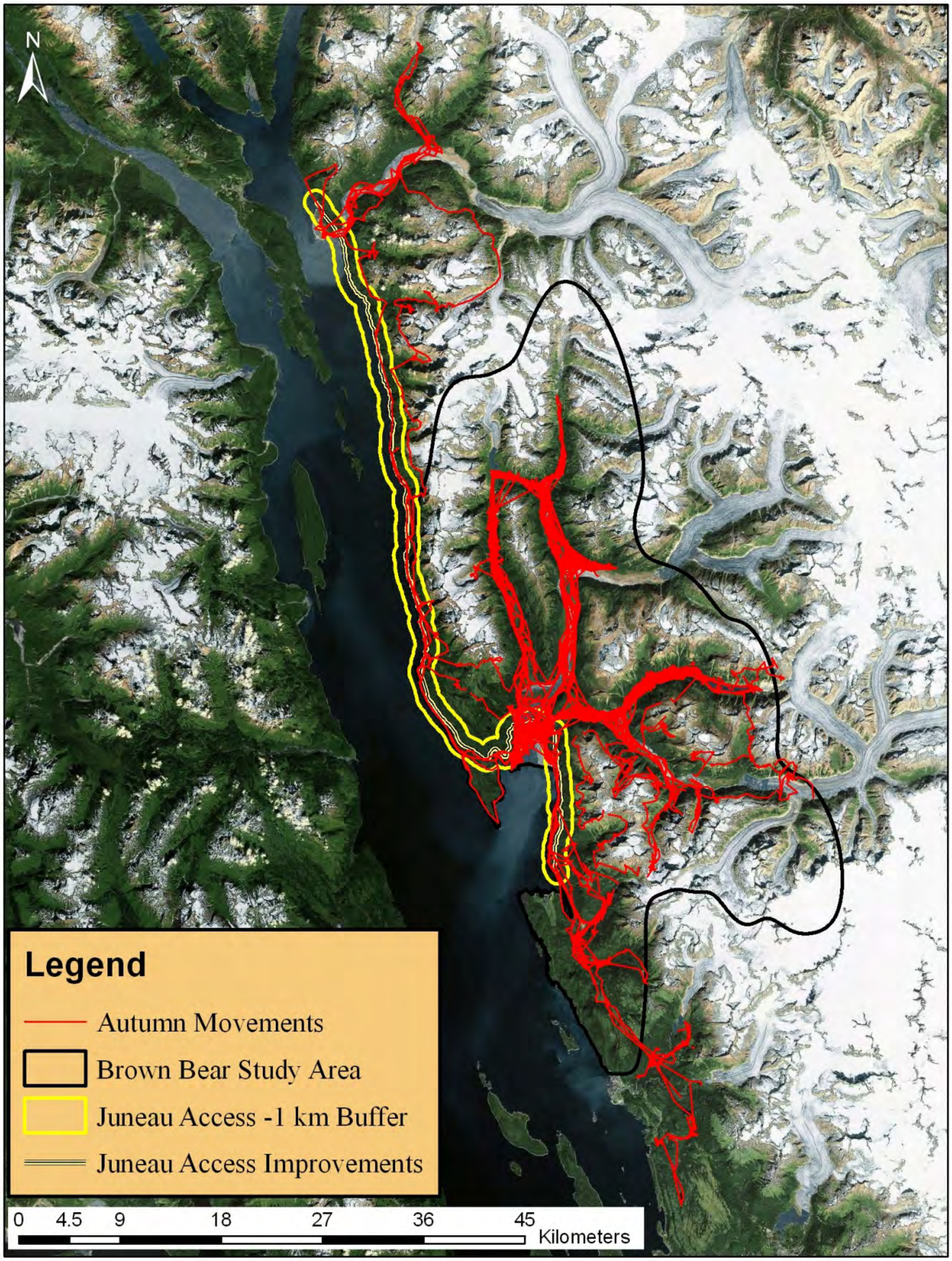


Figure 10. Brown bear movement paths during autumn in the Berners Bay study area, Southeast Alaska, 2006 to 2010.

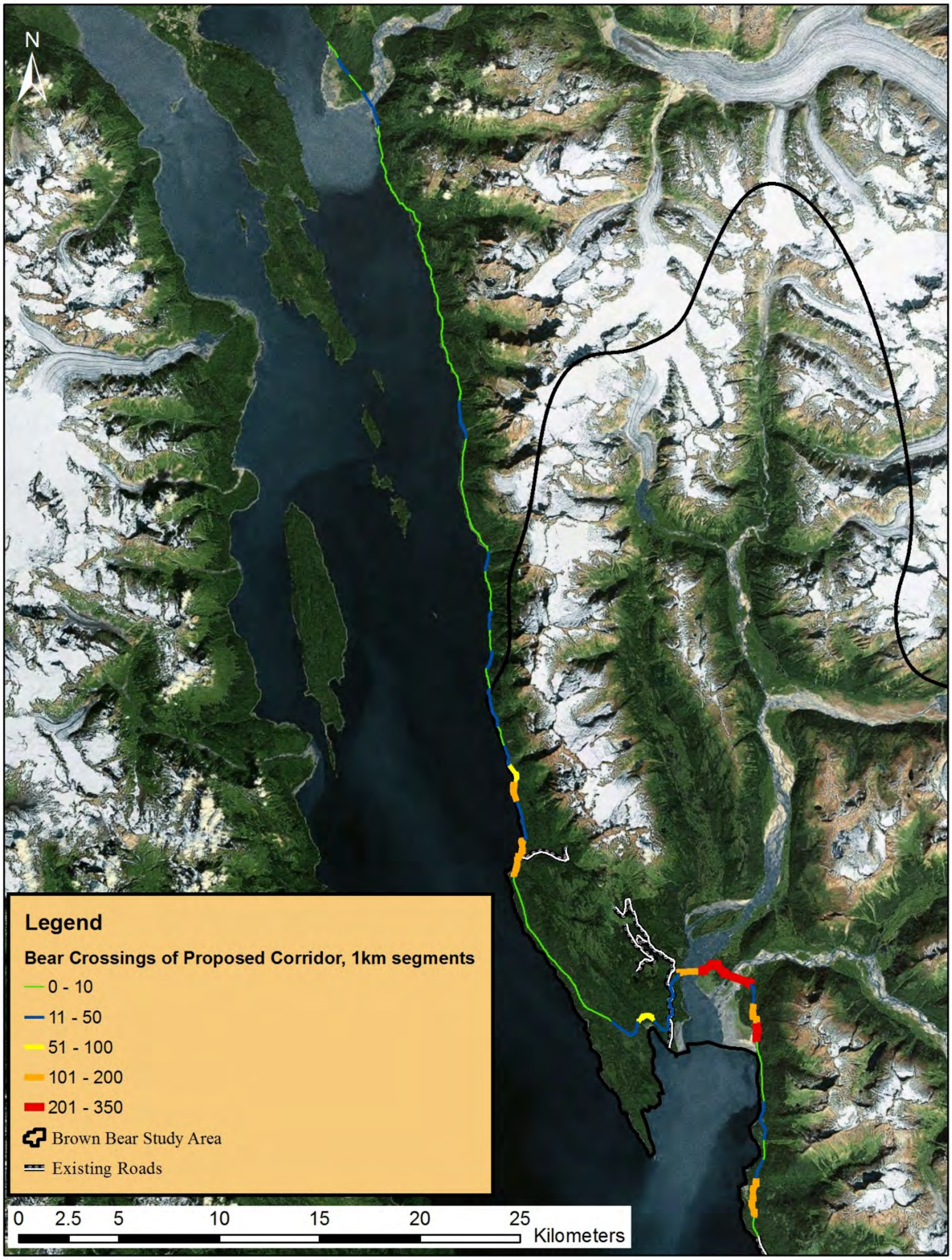


Figure 11. Frequency of brown bear movement paths crossing the proposed Juneau Access Improvements Project road corridor, 2006 to 2010.

brown bear crossings occurred where the road corridor crosses Sawmill Creek, the Berners Bay estuary between the Lace and Antler rivers, Slate Creek, Sweeny Creek, and Independence Lake Creek (Fig. 11).

For ease of interpretation and simple understanding of the methods used to illustrate bear crossing locations, we selected data from one female bear (432) to provide an example of seasonal use, movement paths, and estimated crossing location in the lower bay (Fig. 12). We displayed all point locations for late summer and autumn and the movement paths between those locations, and intentionally did not display road corridor structures on this figure. The movements of this female depict one example of how bears use the estuary and closed forest habitats.

We estimated 1,595 (51.8%) brown bear crossings along 7 km (9% of JAIP) of the proposed road corridor adjacent to the Berners Bay estuary, from just east of Antler Slough to west of the Lace River (Fig. 13). Bears frequently traveled near the shoreline of the Lace and Antler rivers and concentrated use in the braided channels of the Antler River (Fig. 13).

We found 528 (17.3%) bear crossings were associated with planned road structures in the Berners Bay estuary (Appendix A-F). Most bear crossings in locations associated with JAIP structures included Antler River (11.4%) and Antler Slough (0.7%) bridges and Lace River (4.1%) and Lace Slough (0.6%) bridges (Appendix F). Bear crossings near the Antler River underpass (0.5%) were higher than the underpass located near the Lace River (0.2%), but neither contained many bear crossings. Other segments to the west of the Lace River underpass (JAIP stations 700-712) were crossed more frequently than the segments intersected by the underpass. We found that the fine scale assessment of bear crossing locations indicated segments near the proposed underpass structures ranked higher than the segments intersected by the underpass structures.

At the proposed bridge sites, we tallied 157 bear crossings within 50 m of the edge of the stream. The most crossings within this distance were west of the Lace River bridge where we recorded 41 crossings. The current design of bridge structures would intersect 74 bear crossings. If bridge designs were maximized to increase the distance from the stream to the end of the bridge to 50 m, 83 crossings would be gained. At the Antler Slough and Lace Slough bridges, which extend only a short distance from the stream, an increase to 50 m would allow more bear crossings, 24 at the Antler Slough and 40 at the Lace Slough.

HABITAT SELECTION

<u>Resource Selection Function Model</u>

From 2006 through 2010, we recorded 48,178 GPS locations in the early summer and 76,785 GPS locations in the late summer on 17 male and 13 female brown bears (Table 3). We evaluated a suite of habitat and physical variables that we believed were important habitat factors after we removed variables with multicollinearities (Table 2). All brown bears showed a different proportional use of habitats than the availability of those habitats in the landscape. The means of the used points of physical features were also different from the available points (Table 6).

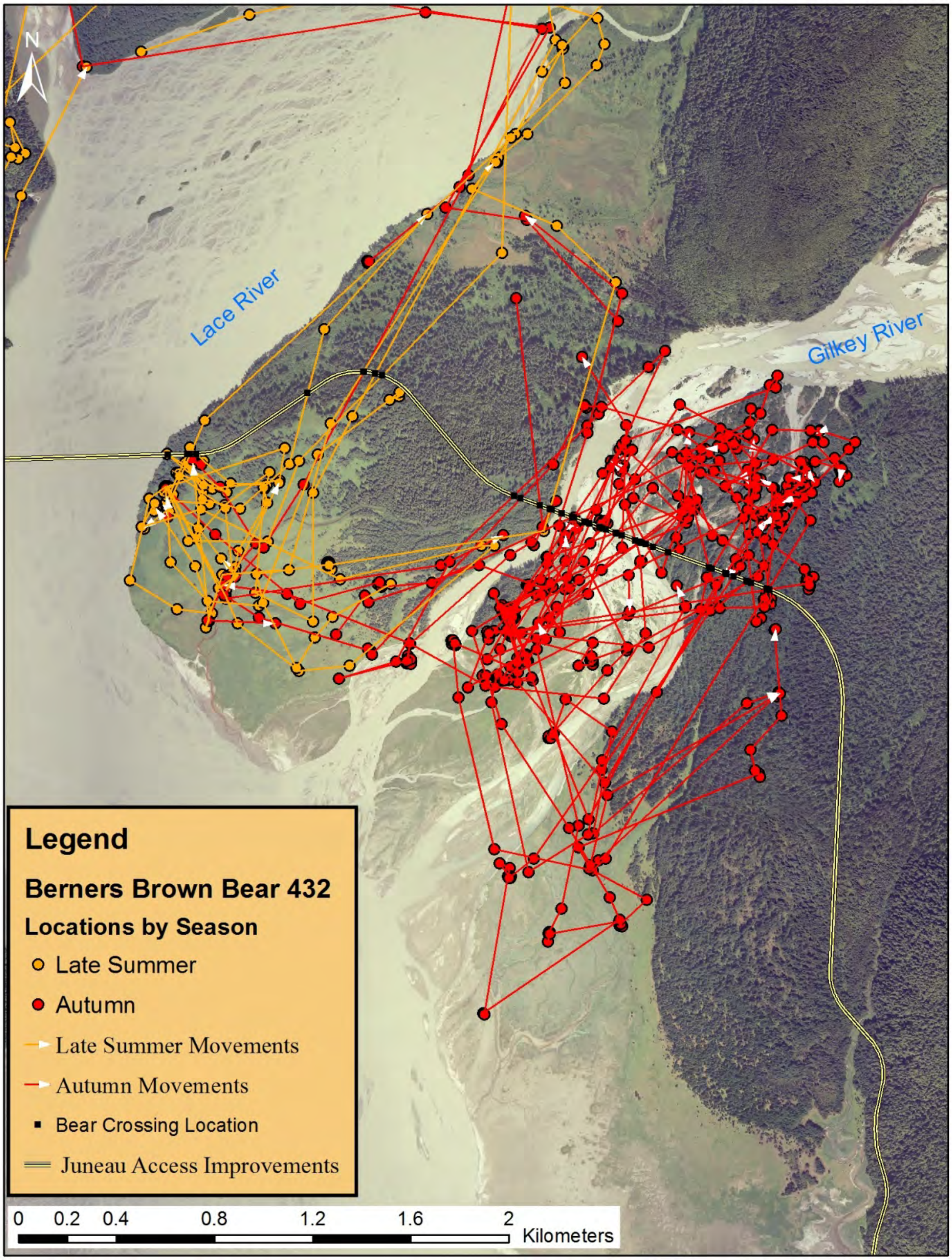


Figure 12. Late summer and autumn location data with movement paths of brown bear 432 to illustrate individual bear movements in the creation of crossing locations along the proposed JAIP road corridor.

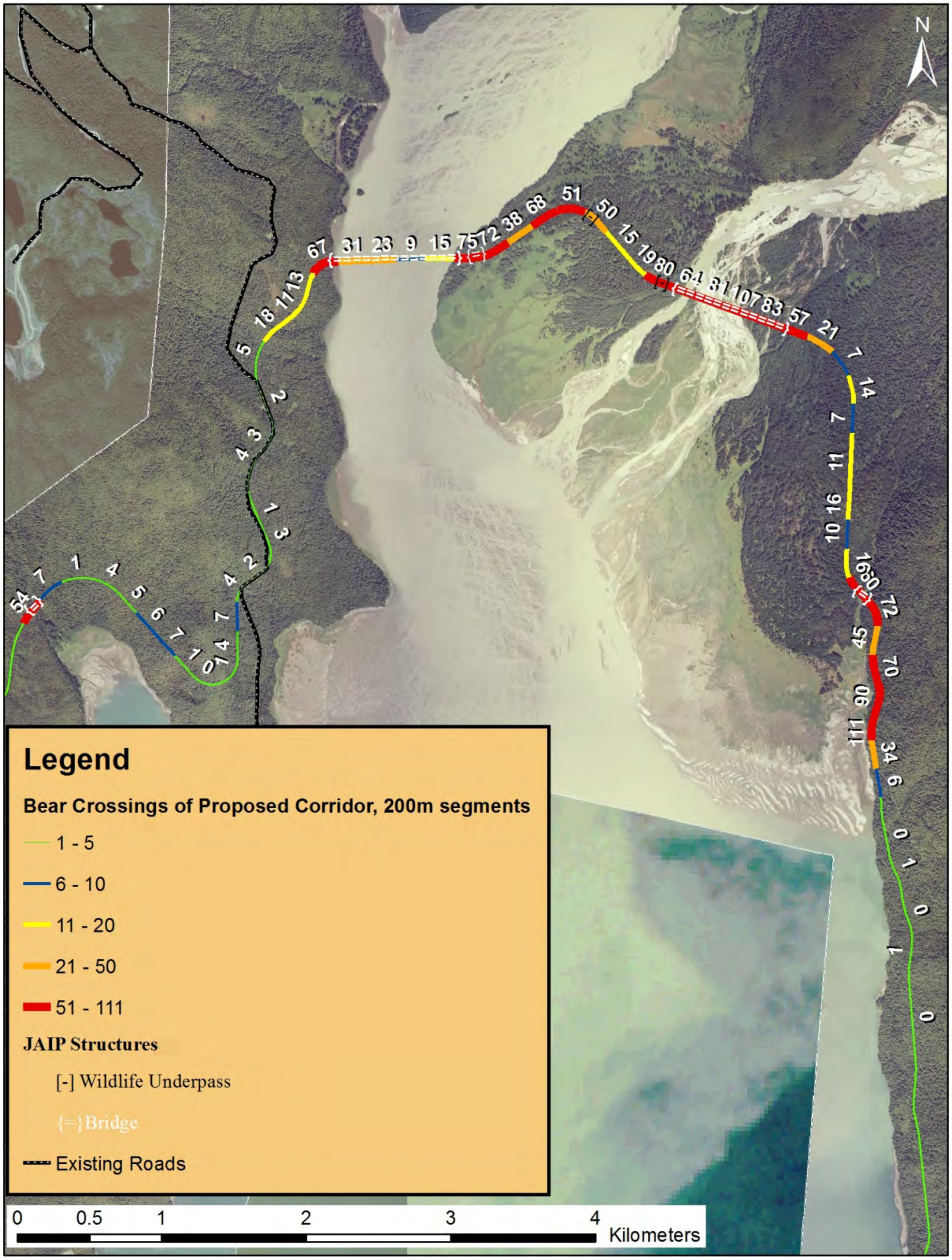


Figure 13. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor in and near the Berners Bay estuary, 2006 to 2010. The planned wildlife underpasses and the bridges are shown and the number of crossings within each 200 m segment is color coded and labeled.

Table 6. Mean terrain factor values by season for Berners Bay study area, Southeast Alaska. The locations for all brown bears were combined. Available points were randomly selected in the intensive study area at a density of 30 points per 1 km.

Terrain factor	Early summer	Late summer	Available points
Distance from spawning (m)	3,125	1,239	5,268
Riparian index	9,102	3,544	39,411
Slope (deg.)	13	9	23
Elevation (m)	162	82	696
Distance from estuary (m)	5,705	5,519	11,847

Early summer

Final RSF models for all brown bears for early summer included estuarine emergent, closed forest, open forest, scrub forest, shrub, herbaceous, beach, and unvegetated landcover habitat factors and riparian index as the lone physical terrain factor (Table 7, Fig. 14-15). Although some variability in habitat selection was observed between bears, the RSF is an average across all bears.

In the model with all bears, RSF scores decreased with increased riparian index values (Fig. 16). As you get father away from cataloged anadromous fish streams and encounter relatively more slope, the RSF scores go down quickly. Thus, estuarine emergent habitats that were located near a cataloged AWC stream had the greatest habitat value.

Table 7. Weighted factor coefficients in seasonal habitat selection (RSF) models for brown bears in Berners Bay, Southeast Alaska.

	Early summer	Late summer
<u>*Terrain Factor*</u>		
Distance from spawning (m)	NS	-0.6771
Riparian index	-1.2279	-1.9492
Distance from estuary (m)	NS	NS
<u>*Habitat Factor*</u>		
Closed forest	1.1930	1.1491
Open forest	1.3569	1.2178
Scrub forest	0.7825	0.7667
Estuarine emergent	3.5934	2.5310
Beach	0.8184	1.2323
Herbaceous	1.2479	0.4226
Unvegetated	1.7590	1.6371
Shrub	1.3014	0.9294

NS = not significantly different from 0 for that factor by season.

We found somewhat different model coefficients by gender (Table 8). Males were more strongly associated with riparian habitats and less associated with herbaceous and unvegetated habitat.

We projected habitat selection to the larger study area (Fig. 17). The output from this analysis was consistent with that of the Berners Bay intensive area, in that low-elevation areas near anadromous streams and estuarine emergent yielded high RSF scores. Some discrepancies between observed and expected RSF scores were seen in the mid-elevations of the Katzehin valley. This area has a combination of low-elevation and unvegetated habitat not seen in the Berners Bay area, for which the model was built.

Late summer

For late summer, brown bears selected distance to salmon spawning reaches and riparian index from the pool of physical terrain factors, and estuarine emergent, beach, closed forest, open forest, scrub forest, shrub, herbaceous, and unvegetated landcover as habitat factors (Fig. 18-19, Table 7). Although some variability in habitat selection was observed between bears, the RSF is an average across all bears. In the model with all bears, RSF scores decreased with increased riparian index values (Fig. 16). Compared to the early summer, brown bears in the late summer selected the riparian index more strongly than in the early summer. Proximity to salmon spawning reaches resulted in increased RSF score in the late summer (Fig. 20). Thus, estuarine emergent habitats that were located near a cataloged AWC stream that had spawning salmon had the greatest habitat value.

We found slight gender differences in models coefficients (Table 9). Males were more strongly associated with riparian habitats, especially salmon spawning reaches. For females, spawning reaches were not a significant factor and females' selection of riparian index was weaker.

We also projected habitat selection in the late summer to the greater study area (Fig. 21). This analysis was consistent with that of the Berners Bay modeling area, where low-elevation areas near spawning streams and the estuary yielded high RSF scores. In the Katzehin River valley, we observed some discrepancy between observed and expected RSF scores. Given the recent deglaciation of the Meade Glacier in this portion of the greater study area, there is a combination of low-elevation and unvegetated habitat not observed in the Berners Bay area, for which the model was built.

Model Validation

Spearman's rho values were largely > 0.9 with *P*-values < 0.05, suggesting strong model performance (Tables 10 and 11). In both the early-summer and late-summer models, 4 of the 5 cross-validation models (80%) met this criterion, which indicates useful models (Wiens et al. 2006. Adjusted R^2 from regression models were all ≥ 0.78, also indicating a strong correlation between observed and expected proportions.

Cross-validation 2 showed the lowest performance by far, with Spearman's rho not significant ($P > 0.05$) in either the early- or late summer models. One explanation for this cross-validation's poor performance is the selection of animals in the validation set. For example bear 426, 17-yr female, was randomly included in this validation set.

This bear spent an inordinate amount of time in unvegetated habitats in the upper Berners River, as she possibly reared cubs in 2008. The percentage of bear 426 points located in unvegetated habitats in early summer and late summer was 75% and 30% respectively, both the highest amongst all bears. Bear 426 had the only positive coefficient for riparian

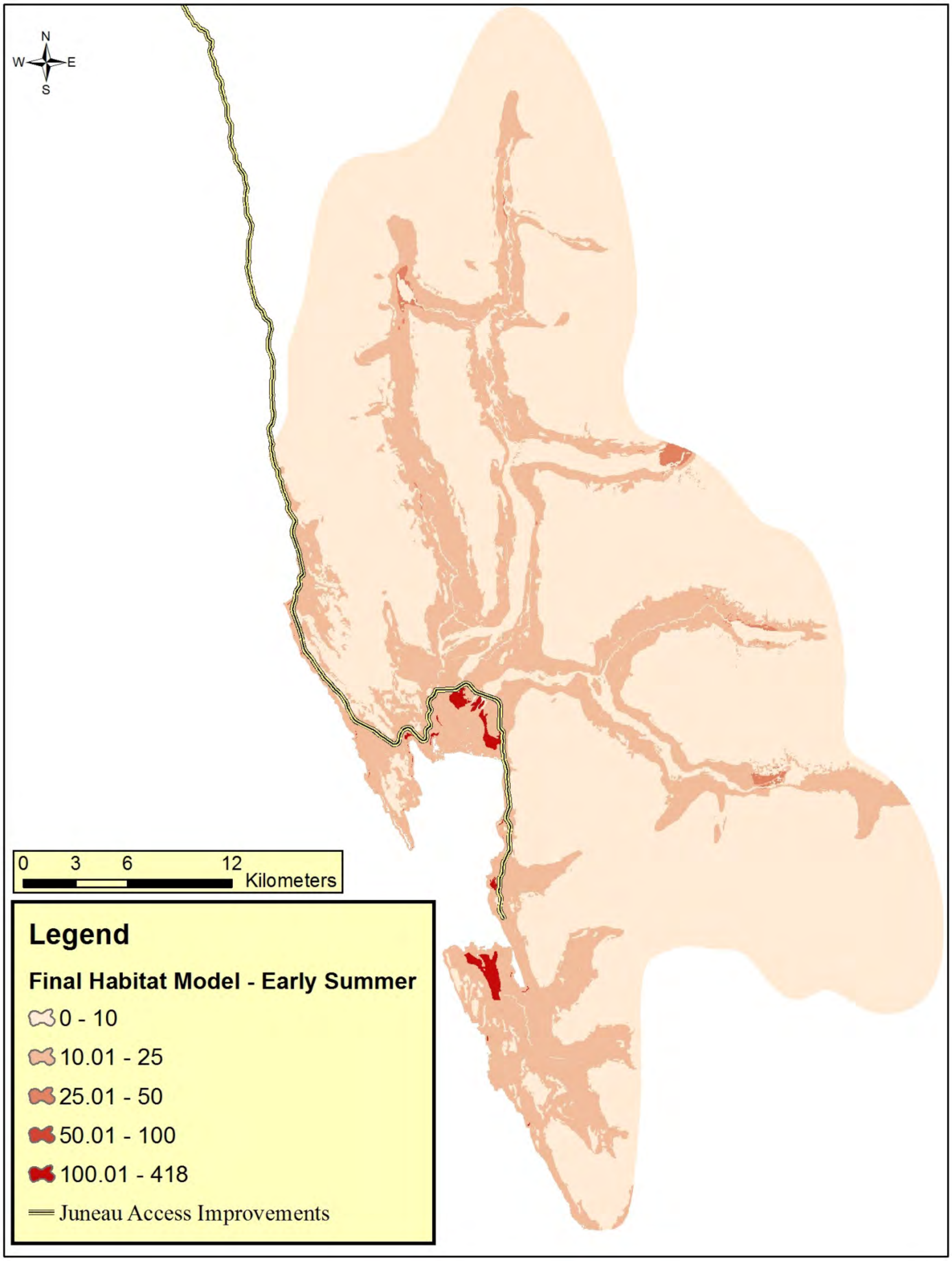


Figure 14. Map predicting relative probability of resource selection (RSF) during early summer for brown bear locations in Berners Bay, Southeast Alaska, 2006 to 2010.

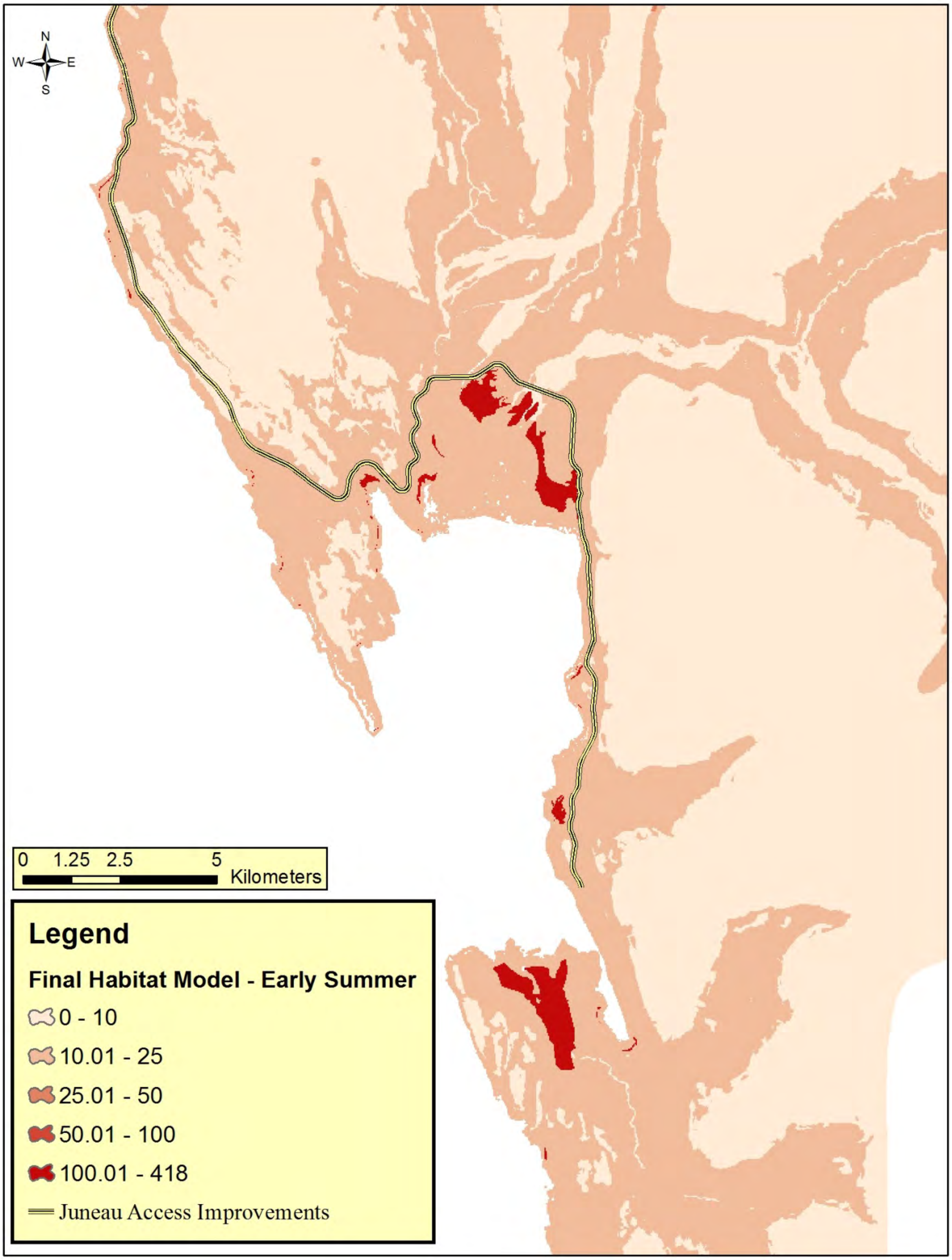


Figure 15. Map predicting relative probability of resource selection (RSF) during early summer for brown bear locations in Berners Bay, Southeast Alaska, focusing on the lower bay. Data collected from radiocollared brown bears, 2006 to 2010.

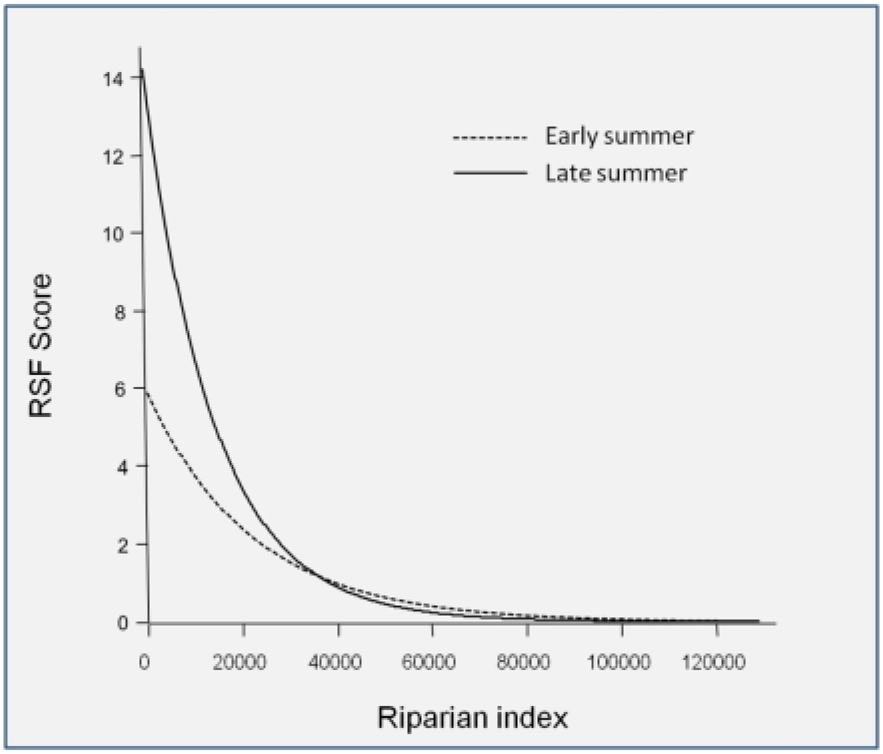


Figure 16. Effect of riparian index on RSF score for all brown bears in early and late summer in Berners Bay, Southeast Alaska, 2006 to 2010. Riparian index is a function of slope and distance from any ADF&G anadromous waters cataloged (AWC) streams.

Table 8. Weighted factor coefficients in seasonal habitat selection (RSF) models for brown bears by gender in early summer in Berners Bay, Southeast Alaska.

	Males	Females	All bears
Terrain Factor			
Distance from spawning (m)	NA	NA	NS
Riparian index	-3.1836	-0.8249	-1.22793
Habitat Factor			
Closed forest	1.1140	1.3552	1.1930
Open forest	1.3563	1.3583	1.3569
Scrub forest	0.7260	0.8890	0.7825
Estuarine emergent	3.7114	3.1837	3.5934
Beach	0.8159	NS	0.8184
Herbaceous	1.0772	1.6099	1.2479
Unvegetated	1.3777	2.0617	1.7590
Shrub	1.1296	1.6532	1.3014

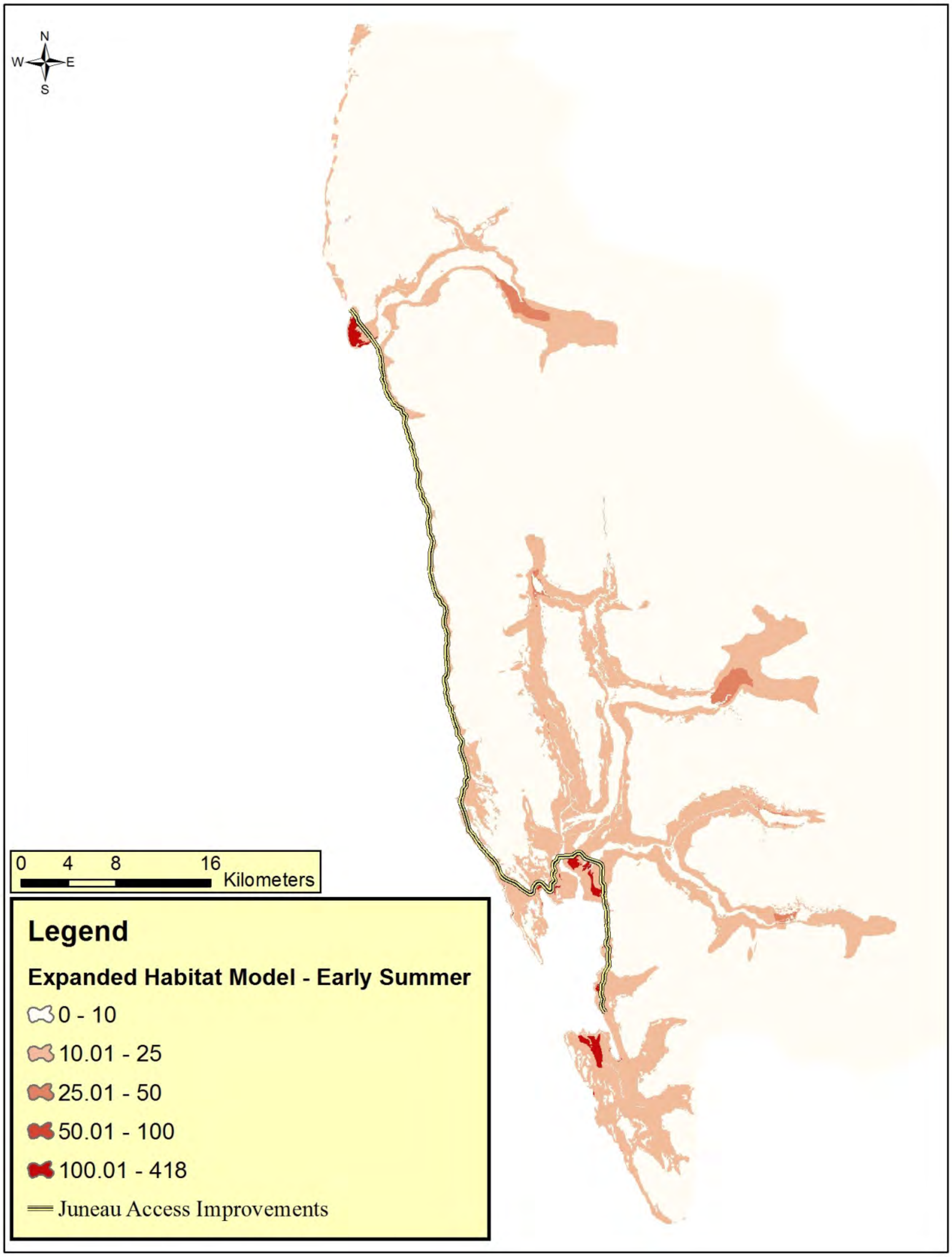


Figure 17. Map predicting relative probability of resource selection during early summer season for brown bears in the greater study area. Habitat selection based on brown bear locations for Berners Bay, Southeast Alaska, 2006 to 2010.

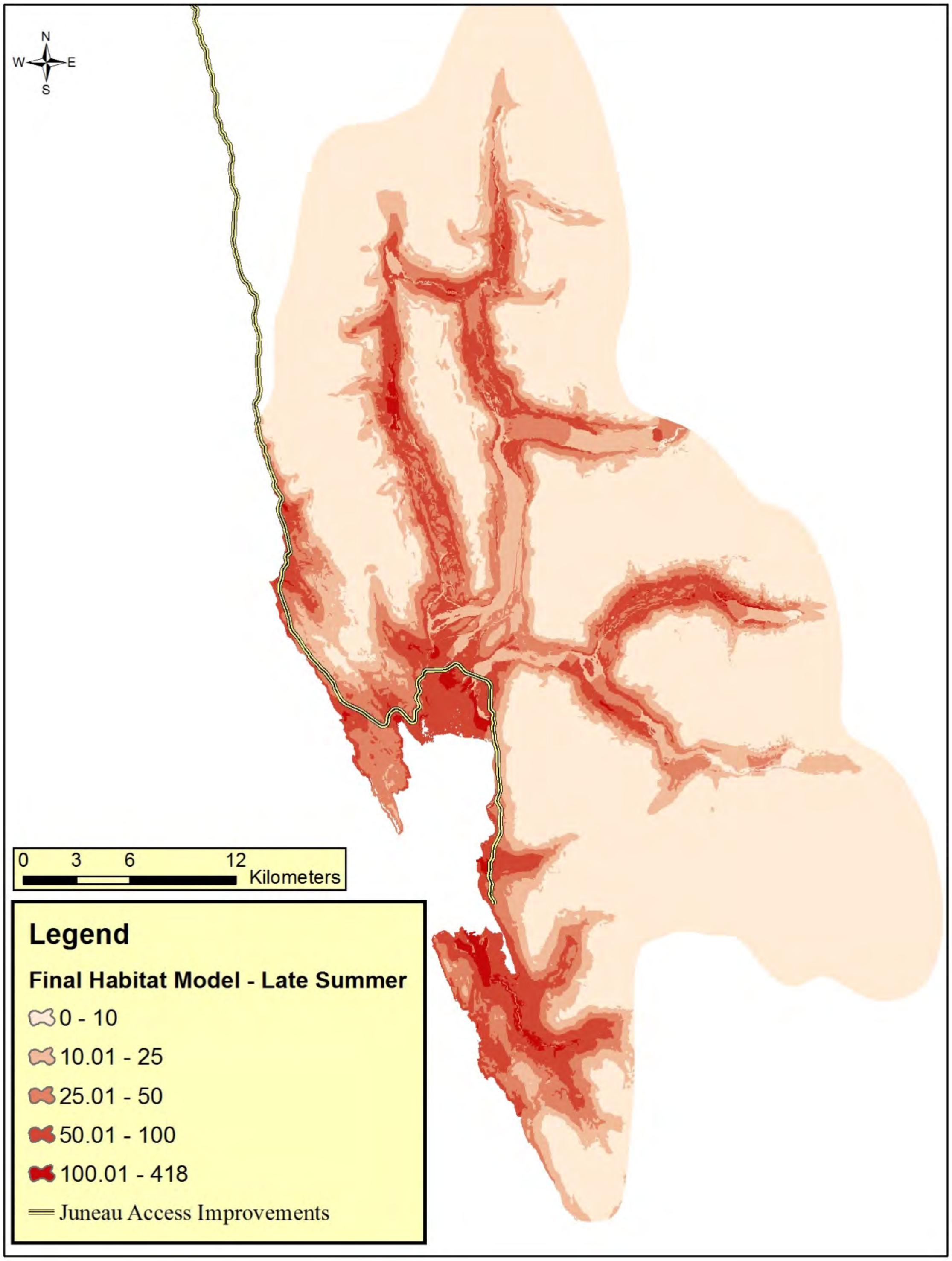


Figure 18. Map predicting relative probability of resource selection during late summer season for brown bears in Berners Bay, Southeast Alaska, 2006 to 2010.

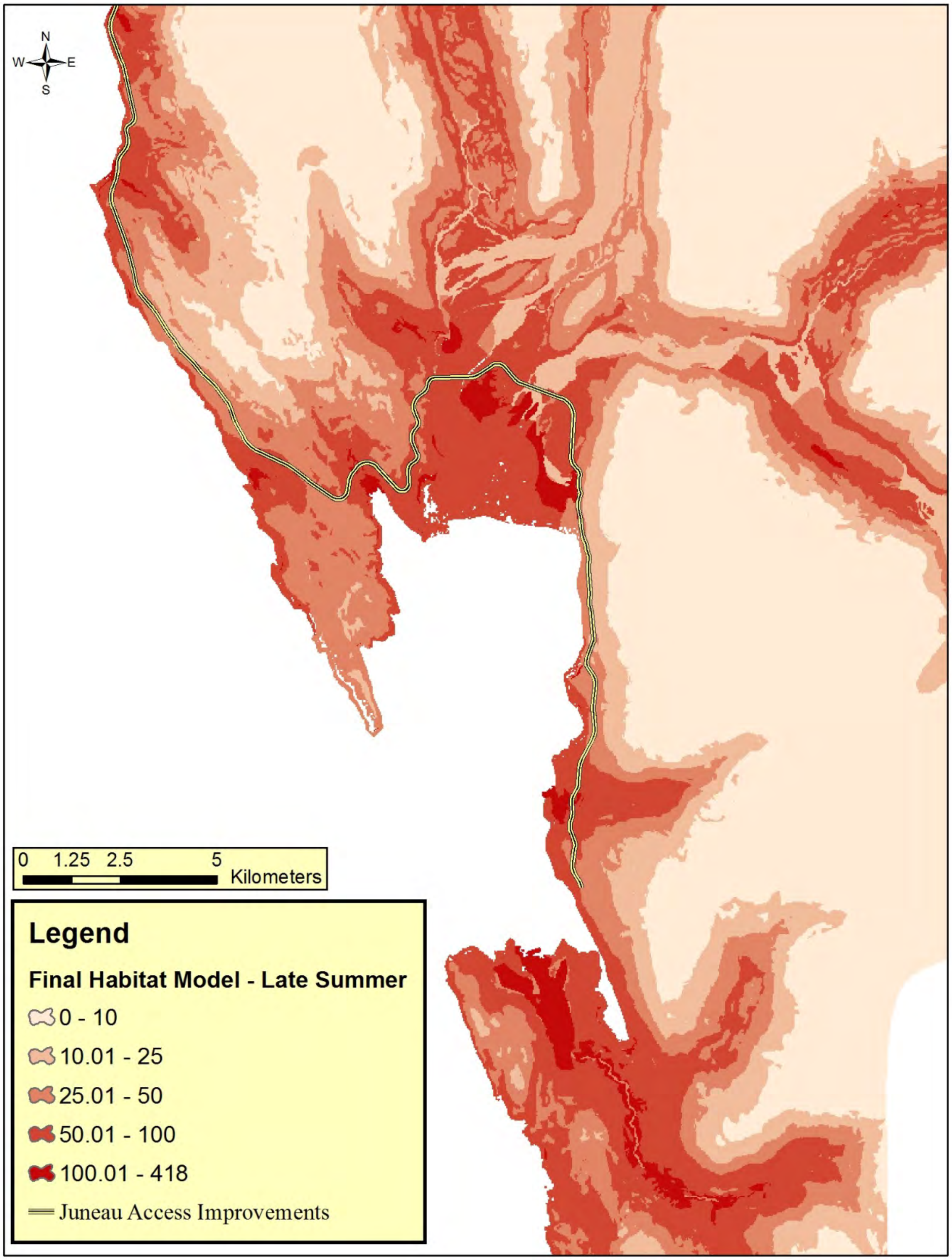


Figure 19. Map predicting relative probability of resource selection during late summer season for brown bears in Berners Bay, Southeast Alaska, focusing on the lower bay, 2006 to 2010.

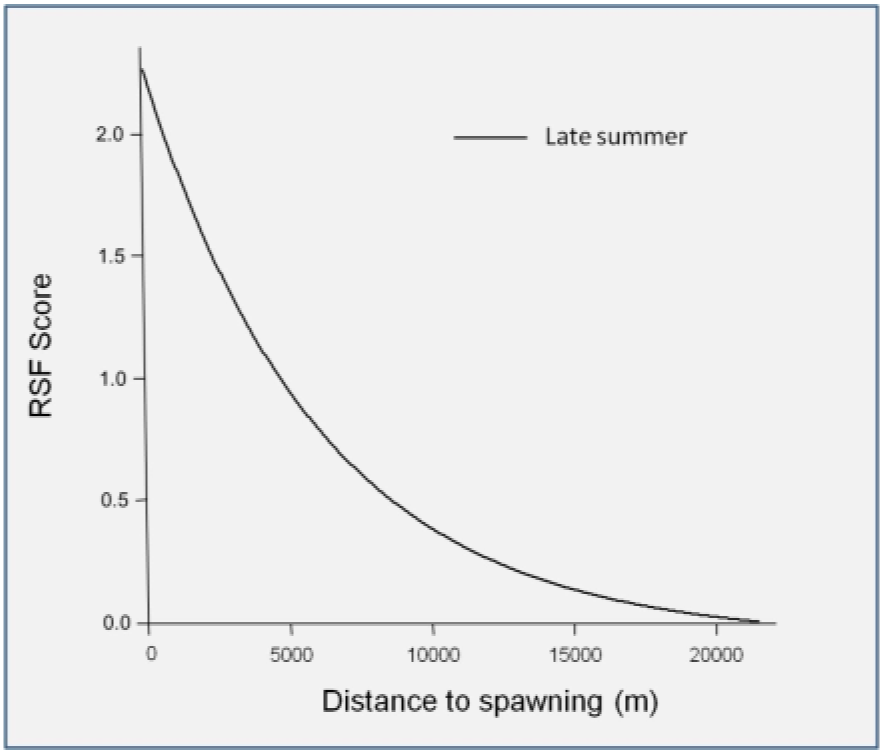


Figure 20. Effect of distance to spawning stream reaches on resource selection function (RSF) score for all brown bears during late summer in Berners Bay, Southeast Alaska, 2006 to 2010.

Table 9. Weighted factor coefficients in seasonal habitat selection (RSF) models for brown bears by gender in the late summer in Berners Bay, Southeast Alaska.

	Males	Females	All bears
<u>*Terrain Factor*</u>			
Distance from spawning (m)	-1.0197	NS	-0.6771
Riparian index	-2.6138	-1.3076	-1.9492
<u>*Habitat Factor*</u>			
Closed forest	1.2072	1.0221	1.1491
Open forest	1.3292	0.9385	1.2178
Scrub forest	0.7772	0.7420	0.7667
Estuarine emergent	2.6609	2.1663	2.5310
Beach	1.3571	0.8653	1.2323
Herbaceous	NS	NS	0.4226
Unvegetated	1.8203	1.2794	1.6371
Shrub	0.8139	1.1534	0.9294

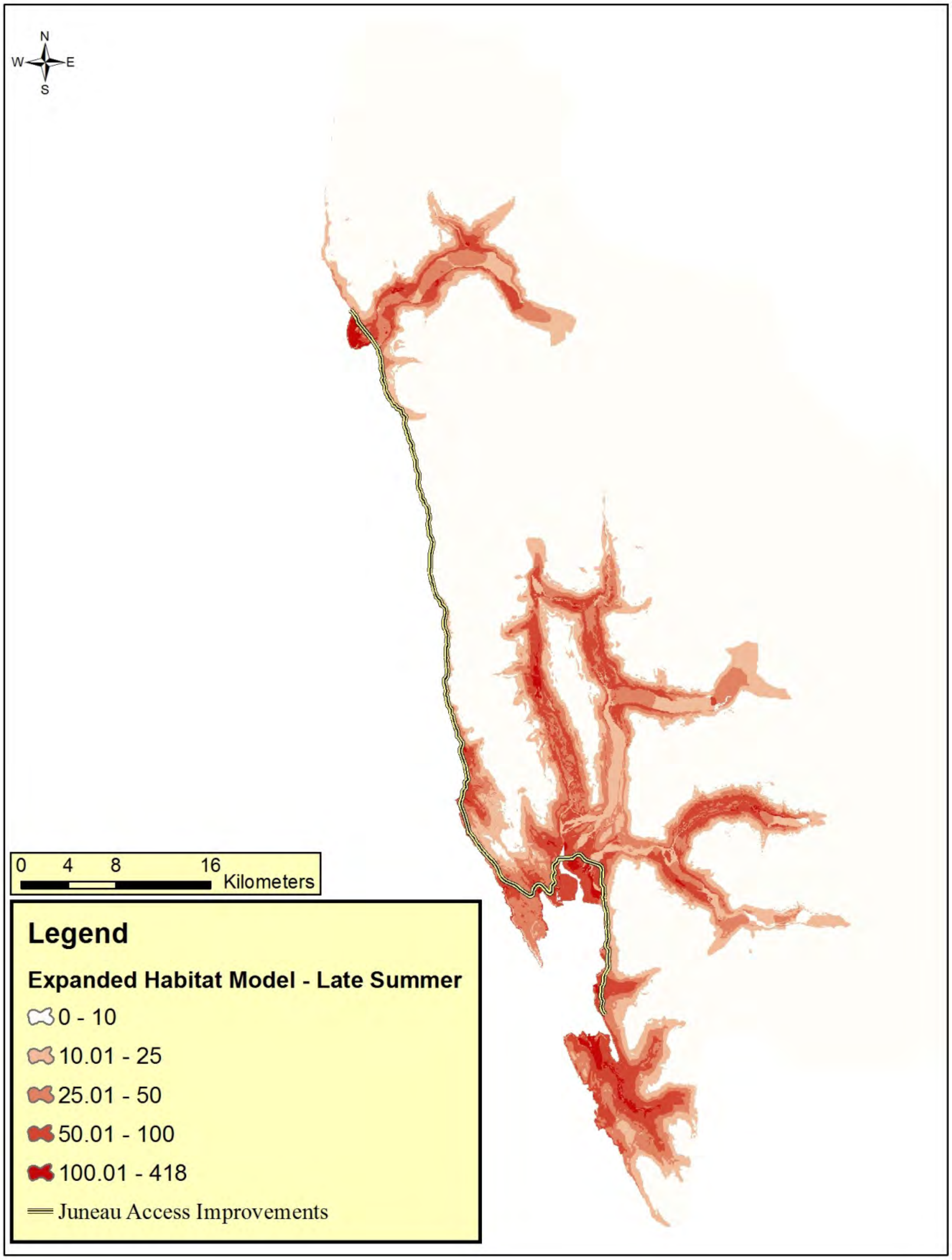


Figure 21. Map predicting relative probability of resource selection during late summer season for brown bears in the greater study area. Habitat selection based on brown bear locations for Berners Bay, Southeast Alaska, 2006 to 2010.

Table 10. Resource selection function (RSF) model performance on cross-validation for the early summer.

	Spearman's correlation		Linear regression				
			Slope		y-intercept		
Cross-validation	rho	*P*-value	Coefficient	Significant[a]	Coefficient	Significant[b]	Adjusted-R^2
1	0.96	< 0.001	2.08	Y	-0.11	Y	0.86
2	0.61	0.07	1.16	N	-0.02	N	0.84
3	0.99	< 0.001	1.59	Y	-0.06	Y	0.89
4	0.92	< 0.001	1.23	N	-0.02	N	0.91
5	0.94	< 0.001	2.02	Y	-0.10	Y	0.87
Mean	0.99	< 0.001	1.58	Y	-0.06	N	0.89

[a] If Y, slope significantly different than 1 ($P > 0.05$).
[b] If Y, y-intercept significantly different than 0 ($P > 0.05$).

Table 11. Resource selection function (RSF) model performance on cross-validation for late summer.

	Spearman's correlation		Linear regression				
			Slope		y-intercept		
Cross-validation	rho	*P*-value	Coefficient	Significant[a]	Coefficient	Significant[b]	Adjusted-R^2
1	0.96	<0.001	1.66	Y	-0.07	N	0.82
2	0.25	0.49	1.24	N	-0.02	N	0.89
3	0.98	<0.001	1.60	N	-0.06	N	0.79
4	0.78	0.01	1.44	N	-0.04	N	0.81
5	0.98	<0.001	1.66	N	-0.07	N	0.78
Mean	0.71	0.03	1.51	N	-0.05	N	0.83

[a]If Y, slope significantly different than 1 ($P > 0.05$).
[b]If Y, y-intercept significantly different than 0 ($P > 0.05$).

index among individual bear models in early summer, and the least negative coefficient for riparian index in late summer. Habitat selection models inclusive of all bears did not successfully describe the habitat selection of bear 426. This diminished the performance of habitat models on cross-validation.

Den sites

We visited 6 winter brown bear dens. All visited dens were in the closed forest. Three dens were up the Berners River, 1 was up Johnson Creek, 1 was near upper Slate Creek, and 1 was adjacent to Eagle River (Fig. 1). Two dens were in large, hollow live trees (Fig. 22), 2 were in rock cavities, and 2 dens had been excavated in the ground. Elevations at the den locations average 231 m (SD = 119).

POPULATION DYNAMICS

Abundance

During summer 2006, we deployed 91 hair snares at 9 locations over 4 sessions (Fig. 23, Table 12). These hair snares were first set on 27 July 2006 and checked on 4 August, 14–15 August, 21 August, and 28 August (Table 12). Altogether, we collected 172 hair samples and were successful in generating a DNA-based identity on 67% of the hair samples. From the hair snaring results, we identified 27 individual brown bears (9 M, 18 F). Individual bears were captured 1–3 times during the hair-snaring sessions. In addition, we identified 35 individual black bears from 75 samples.

During summer 2007, we deployed 119 hair snares at 12 locations over 4 sessions (Fig. 23, Table 13). These hair snares were first set on 23 July 2007 and checked on 31 July, 7 August, 15 August, and 22 August. Altogether, we collected 208 hair samples and were successful in generating a DNA-based identity on 72% of the hair samples. From the hair snaring results, we identified 43 (26 M, 17 F) individual brown bears. Individual bears were captured 1–6 times during this hair-snaring session. In addition, we identified 41 individual black bears from 81 samples.

During summer 2008, we deployed 165 hair snares at 18 locations (Fig. 23, Table 14), including new sites at Cowee, Independence Lake, Sweeny creeks, a new location in Antler River, and a couple of small tributaries on the upper Lace River. The new sites were selected based on GPS locations of bears at streams during the salmon spawning season during 2006 and 2007. By expanding our sampling in 2008, we believe that hair snares were set on all significant salmon-spawning streams in the study area (Fig. 2). Hair snares were first set on 23–24 July 2008 and checked on 30–31 July, 6–7 August, 14–15 August, and 21–22 August (Table 14). Altogether, we collected 220 hair samples and were successful in generating a DNA-based identity on 70% of our samples. From the hair snaring results, we identified 30 (12 M, 18 F) individual brown bears. Individual bears were captured 1–12 times during the hair-snaring sessions. In addition, we identified 53 individual black bears from 90 samples.

During our hair-snaring sessions over 3 years, we hair snared 76.6% of the bears that we live captured. The live-captured bears that we also hair snared ranged from age class 0 to 20, including 19.4% that were in age class 0–3. We did not find any difference between live-captured bears that we hair snared ($\bar{x}$ = 8.4) and those not hair snared ($\bar{x}$ = 6.4) (t_{45} = 0.96, $P > 0.05$), so we assumed that the different capture techniques sampled the same population component. In addition to the hair snaring, we had 2 live capture sessions each year, in June–July (early summer) and November (autumn) which we incorporated into the abundance and survival analyses. We also incorporated the periods when the bears were radiocollared into the analyses.

The top 6 models (combined model weight = 0.750) had the most influence on the population estimation and survival analyses, but we averaged all of the models. These models indicated the detection probability (p) was a function of sampling type (telemetry vs. hair snare) and gender; 3 of the 6 models had this pattern differing by year (Table 15). Capture probabilities ranged from 0.20 to 0.22 for hair snaring sessions and 0.35 to 0.60 for early summer/autumn capture/telemetry sessions (Table 16). For early summer/autumn capture/telemetry sessions, capture probabilities for females ranged from 0.36 to 0.42 and for males 0.52 to 0.59. The hair snaring results were very consistent and had little sex effect.

The population estimated for Berners Bay ranged from 29.9 to 37.5 for females and 14.4 to 29.2 for males (Table 17). Combining males and females, the estimates for the total population were 44.3 bears in 2006, 66.7 bears in 2007, and 60.4 bears in 2008. This resulted in a density estimate within our intensive study area of 33.5/1,000 km^2 (95% CI = 29.1–38.5) in 2006, 50.3/1,000 km^2 (95% CI = 45.7–55.4) in 2007, and 45.5/1,000 km^2 (95% CI = 41.3–50.3) in 2008.

Figure 22. A brown bear winter den in Berners Bay (bear 410). The den was located inside of a large (> 1.5 m DBH) western hemlock. The chamber was approximately 1.2 m x 1.2 m and contained a large pile of chewed-off shrub stems (mostly blueberry) and the tree was located on 40° slope.

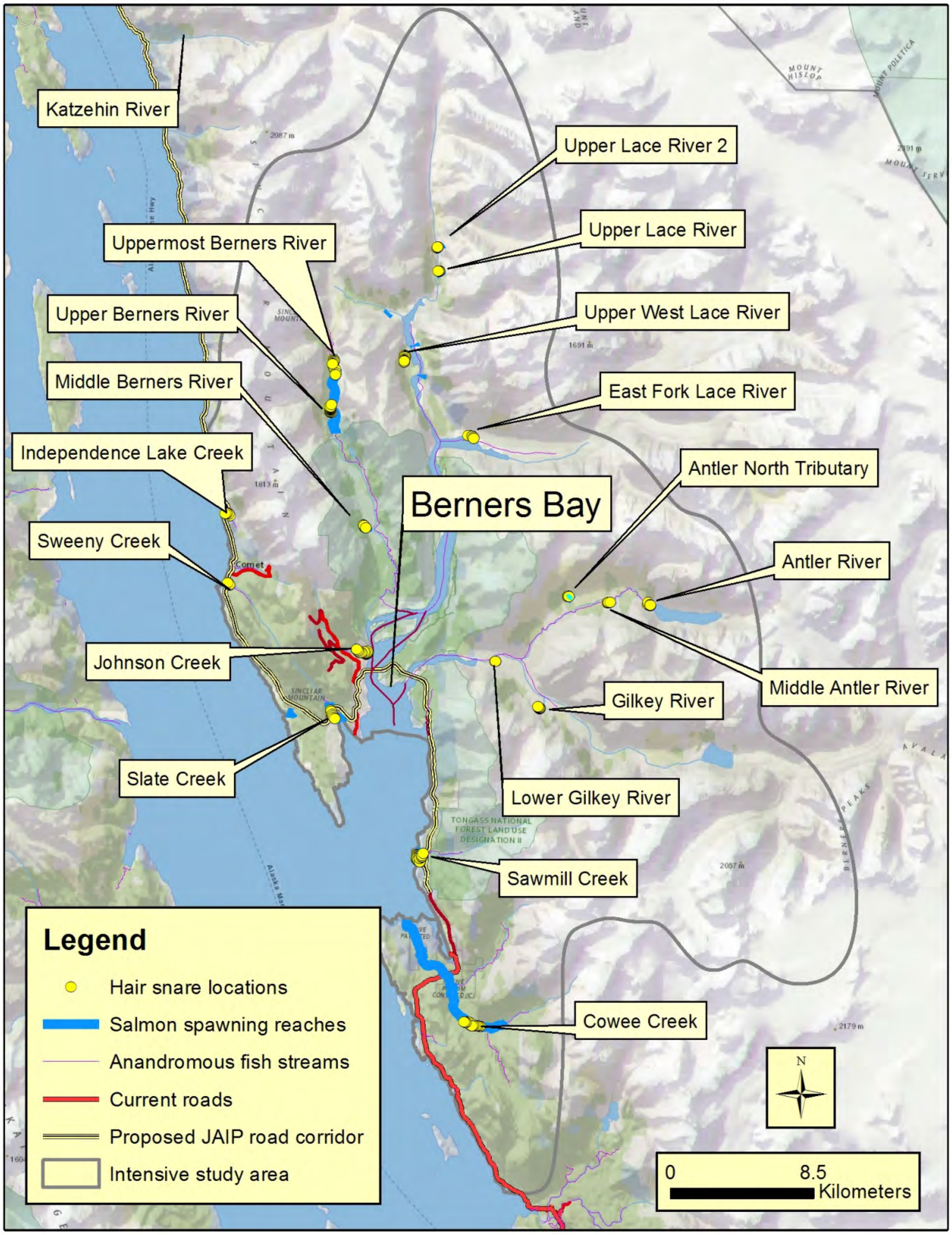


Figure 23. Hair snare locations in the Berners Bay study area, Southeast Alaska, 2006 to 2008. Sites at Cowee, Independence, and Sweeny creeks, upper Lace River, and Antler North Tributary Creek were added in 2008.

Table 12. Number of samples collected and bears identified at hair snare locations in the Berners Bay study area during 2006.

Location	No. sites	No. hair samples	Successful IDs	% successful	Brown bear samples	Black bear samples	Unique bears	
							Brown	Black
Streams								
Antler River	8	8	6	60	0	6	0	4
Gilkey River	7	14	9	71	0	9	0	5
Johnson Creek	17	38	24	63	12	12	7	4
Lower Gilkey River	3	3	1	33	0	1	0	1
Middle Antler River	6	5	4	80	2	2	1	2
Sawmill Creek	17	40	29	72	8	21	5	8
Slate Cove Creek	7	11	8	73	3	5	3	5
Upper Berners River	16	45	28	62	10	18	7	8
Upper West Lace River	10	8	6	75	5	1	5	1
Totals	91	172	115	67	40	75	28[a]	38[b]
Session[c]								
1		31	25	84	11	14	10	9
2		42	29	69	13	16	10	13
3		56	35	60	9	26	8	16
4		43	26	60	7	19	6	15

[a] Actual number of unique brown bears = 27 because 1 bear sampled at 2 sites;
[b] Actual number of unique black bears = 35 because 3 bears sampled at more than 1 site;
[c] Session dates: 1 = 27 July-4 August 2006; 2 = 5 August–15 August 2006; 3 = 16 August–21 August 2006; 4 = 22 August–28 August 2006.

Table 13. Number of samples collected and bears identified at hair snare locations in the Berners Bay study area during 2007.

Location	No. sites	No. hair samples	Successful IDs	% successful	Brown bear samples	Black bear samples	Unique bears	
							Brown	Black
Streams								
Antler River	6	2	1	50	0	1	0	1
East Lace River	6	2	2	100	2	0	2	0
Gilkey River	7	20	17	85	1	16	1	7
Johnson Creek	17	21	15	71	14	1	13	1
Lower Gilkey River	3	3	3	100	0	3	0	3
Middle Antler River	6	13	11	85	6	5	5	5
Middle Berners River	11	18	12	67	7	5	6	4
Sawmill Creek	17	23	15	65	8	7	6	3
Slate Creek	7	16	10	63	0	10	0	9
Upper Berners River	16	38	22	58	16	6	13	6
Uppermost Berners River	13	28	21	75	13	8	11	5
Upper West Lace River	10	24	21	88	14	7	10	5
Totals	119	208	150	72	81	69	67[a]	49[b]
Session[c]								
1		63	49	78	37	12	31	9
2		45	38	84	12	26	9	18
3		46	32	70	17	15	13	9
4		54	31	57	15	16	14	13

[a] Actual number of unique brown bears = 43 because some bears were sampled at multiple sites.
[b] Actual number of unique black bears = 41 because some bears were sampled at multiple sites.
[c] Session dates: 1 = 23–31 July; 2 = 1 August–7 August; 3 = 8 August–15 August; 4 = 16 August–22 August.

Table 14. Number of samples collected and bears identified at hair snare locations in the Berners Bay study area during 2008.

Location	No. sites	No. hair samples	Successful IDs	% successful	Brown bear samples	Black bear samples	Unique bears	
							Brown	Black
Streams								
Antler North Tributary	8	0	0	0	0	0	0	0
Antler River	8	0	0	0	0	0	0	0
Cowee Creek	17	38	23	61	1	22	1	17
East Lace River	7	10	8	80	8	0	7	0
Gilkey River	7	12	10	83	1	9	1	6
Independence Creek	8	18	14	78	1	13	1	10
Johnson Creek	17	14	7	50	5	2	3	2
Lower Gilkey River	3	1	0	0	0	0	0	0
Middle Antler River	7	3	2	67	1	1	1	1
Middle Berners River	11	9	7	78	5	1	5	1
Sawmill Creek	18	17	11	65	4	7	4	6
Slate Creek	7	12	5	42	1	4	1	3
Sweeny Creek	5	10	9	90	1	8	1	8
Upper Berners River	16	21	15	71	4	11	4	5
Uppermost Berners River	13	16	11	69	10	1	10	1
Upper Lace River	6	10	7	70	2	5	2	3
Upper Lace River #2	5	5	4	80	2	2	2	2
Upper West Lace River	10	24	20	83	16	4	8	3
Total	165	220	153	70	62	90	51[a]	68[b]
Session[c]								
1		43	32	74	19	13	12	10
2		38	27	71	14	13	12	11
3		71	51	72	18	33	17	22
4		68	43	63	11	31	10	25

[a] Actual number of unique brown bears = 30 because some bears were sampled at multiple sites.
[b] Actual number of unique black bears = 53 because some bears were sampled at multiple sites.
[c] Session Dates: 1 = 23–31 July; 2 = 1 August–7 August; 3 = 8 August–15 August; 4 = 16 August–22 August.

Table 15. Models and model selection criteria used in estimating Berners Bay brown bear population size and survival. We averaged all of the models, but the top 6 models (combined model weight = 0.707) had the most influence on the population estimation and survival analyses.

Model[1]	No. parameters	Δ AICc	AICc weight
S(~1) p(~telem*sex)	4	0.000	0.305
S(~1) p(~year*telem*sex)	8	1.737	0.128
S(~sex) p(~telem*sex)	5	1.993	0.113
S(~year) p(~telem*sex)	5	2.048	0.110
S(~year) p(~year*telem*sex)	9	3.662	0.049
S(~sex) p(~year*telem*sex)	9	3.809	0.045
S(~1) p(~hs*sex)	12	4.039	0.041
S(~year+sex) p(~telem*sex)	6	4.065	0.040
S(~1) p(~year*telem)	5	4.622	0.030
S(~year+sex) p(~telem*sex)	10	5.776	0.017
S(~1) p(~year*hs)	17	5.895	0.016
S(~year*sex) p(~telem*sex)	7	5.912	0.016
S(~year) p(~hs*sex)	13	6.213	0.014
S(~sex) p(~hs*sex)	13	6.223	0.014
S(~year) p(~year*telem)	6	6.575	0.011
S(~sex) p(~year*telem)	6	6.677	0.011
S(~year*sex) p(~year*telem*sex)	11	7.790	0.006
S(~1) p(~telem)	3	8.083	0.005
S(~sex) p(~year*hs)	18	8.124	0.005
S(~year) p(~year*hs)	18	8.135	0.005
S(~year+sex) p(~hs*sex)	14	8.414	0.005
S(~year+sex) p(~year*telem)	7	8.629	0.004
S(~sex) p(~telem)	4	10.086	0.002
S(~year) p(~telem)	4	10.137	0.002
S(~year+sex p(~year*hs)	19	10.373	0.002
S(~year*sex) p(~hs*sex)	15	10.473	0.002
S(~year*sex) p(~year*telem)	8	10.660	0.001
S(~year+sex) p(~telem)	5	12.153	0.001
S(~year*sex) p(~year*hs)	20	12.591	0.001
S(~year*sex) p(~telem)	6	14.165	0.000
S(~1) p(~year*hs*sex)	32	19.245	0.000
S(~year) p(~year*hs*sex)	33	21.727	0.000
S(~sex) p(~year*hs*sex)	33	21.775	0.000
S(~year+sex) p(~year*hs*sex)	34	24.276	0.000
S(~year*sex) p(~year*hs*sex)	35	26.709	0.000
S(~1) p(~year*time*sex)	38	31.562	0.000
S(~year) p(~year*time*sex)	39	34.153	0.000
S(~sex) p(~year*time*sex)	39	34.211	0.000
S(~year+sex) p(~year*time*sex)	40	36.822	0.000
S(~year*sex) p(~year*time*sex)	41	39.375	0.000

[1]Model notation: *S* = annual survival, *p* = detection probability; for all models γ'' = 0, γ' = 1, and *p* = *c*. Factors affecting either *S* or *p* for each model are listed within parentheses; ~1 indicates a constant (survival only), hs indicates *p* differs among occasions 2-4 (hair snare occasions), and also differs from occasions 1 and 6 (telemetry occasions), which have equal *p*; telem indicates a constant estimate of *p* for occasions 1 and 6, and a separate constant estimate for occasions 2-4.

Table 16. Capture probabilities for each session and year by sex for brown bears during 2006 to 2008 within Berners Bay, Southeast Alaska.

Parameter	Sex	Year, session	Estimate	SE	Lower 95%	Upper 95%
p	F	1,1	0.356	0.064	0.242	0.489
		1,2	0.216	0.040	0.147	0.306
		1,3	0.205	0.022	0.165	0.251
		1,4	0.207	0.023	0.164	0.256
		1,5	0.202	0.026	0.155	0.258
		1,6	0.356	0.064	0.242	0.489
		2,1	0.389	0.052	0.292	0.495
		2,2	0.222	0.054	0.133	0.347
		2,3	0.203	0.023	0.161	0.254
		2,4	0.207	0.022	0.167	0.254
		2,5	0.204	0.022	0.163	0.253
		2,6	0.389	0.052	0.292	0.495
		3,1	0.422	0.073	0.287	0.569
		3,2	0.215	0.040	0.146	0.305
		3,3	0.204	0.022	0.164	0.252
		3,4	0.209	0.023	0.166	0.259
		3,5	0.202	0.025	0.157	0.256
		3,6	0.422	0.073	0.287	0.569
	M	1,1	0.518	0.105	0.320	0.710
		1,2	0.208	0.024	0.165	0.259
		1,3	0.202	0.028	0.152	0.262
		1,4	0.204	0.024	0.160	0.255
		1,5	0.200	0.028	0.150	0.262
		1,6	0.518	0.105	0.320	0.710
		2,1	0.564	0.062	0.441	0.680
		2,2	0.215	0.044	0.139	0.315
		2,3	0.200	0.028	0.149	0.262
		2,4	0.204	0.023	0.163	0.253
		2,5	0.203	0.025	0.157	0.258
		2,6	0.564	0.062	0.441	0.680
		3,1	0.589	0.066	0.456	0.710
		3,2	0.207	0.023	0.165	0.258
		3,3	0.201	0.027	0.151	0.261
		3,4	0.206	0.024	0.162	0.259
		3,5	0.201	0.027	0.152	0.260
		3,6	0.589	0.066	0.456	0.710

p = capture probabilities;
Year 1 = 2006, 2 = 2007, and 3 = 2008;
Session 1 is early summer live-capture and telemetry; sessions 2-5 are summer hair snagging; session 6 is autumn live-capture and telemetry.

Table 17. Annual population estimates by each sex for brown bears during 2006 to 2008 within Berners Bay, Southeast Alaska.

	Females		Males		Total bears	
Year	*N*	95% CI	*N*	95% CI	*N*	95% CI
2006	29.9	27.5–34.8	14.4	13.5–17.2	44.3	38.5–51.0
2007	37.5	34.9–42.3	29.2	27.9–32.3	66.7	60.6–73.4
2008	34.6	32.3–39.2	25.8	24.7–28.6	60.4	54.7–66.6

Survival

The top models for survival had a simple structure with the top 2 models having constant survival and the remaining having only a single factor. Average model estimates of survival for age and year combinations were all similar, ranging from 0.827 for males between 2007 and 2008 to 0.839 for females between 2006 and 2007. The estimate for the top model with constant survival was 0.839 (95% CI = 0.732–0.908).

Mortality

Human-caused mortality

In the area including Berners Bay south to Juneau, we observed 16 human-related deaths of brown bears during regulatory years (1 July through 30 June) 2006 to 2011. The cause of death varied from 1 (female) illegal kill, 1 (male) taken in defense of life and property (DLP), 11 hunter kills (7 male, 4 females), and 3 (1 male, 2 females) deaths from research-related activities. Hunters took 5 brown bears (3 males, 2 females), marked during research activities. Two females were still wearing their radiocollars and 2 males were still eartagged. One male was no longer visually marked, but we verified his identity through a DNA sample collected during sealing.

Beginning in 1960 when brown bears were first sealed, we observed an average of 1.8 (SD = 1.5) brown bears killed by all human causes per year (Table 18). Hunting mortality has averaged 1.4 (SD = 1.3) per year since 1960. Recently, the average human-caused mortality per year has increased slightly from 1960–1989 ($\bar{x}$ = 1.6, SD = 1.3), 1990–1999 ($\bar{x}$ = 1.5, SD = 1.0), to 2000–2009 ($\bar{x}$ = 2.3, SD = 2.1) and 2010–2011 ($\bar{x}$ = 2.5, SD = 2.1). For the same period, the average hunter harvest per year in 1960–1989 ($\bar{x}$ = 1.4, SD = 1.4) was similar to the average during 2000-2009 ($\bar{x}$ = 1.5, SD =1.1). For the last 2 years, human-caused mortality per year has averaged 2.5 bears (SD = 2.1), all by hunters. Since 1960, the majority (79%) of the human-caused deaths were from hunting (Table 19).

In the area surrounding the Katzehin River, 16 (11 males, 5 females) brown bears have been killed since 1960, averaging 0.3 brown bears per year. Hunters, except for 1 male bear taken DLP in 2010, took all the brown bears. One tagged bear (428) that was originally captured in Berners Bay was shot in 2010.

Natural mortality

We recorded 5 (1 males, 4 females) natural mortalities of radiocollared brown bears. Four (1 male, 3 females) bears were killed by other bears or at least consumed by other bears. Based on movement and temperature data retrieved from the collar, female 401 (age class 5) died on 6 January 2007. On 28

Table 18. Human-caused mortality for brown bears in Berners Bay and the Katzehin River from 1960 to 2011, based on ADF&G sealing records.

	Berners Bay		Katzehin River	
Year	Mean	SD	Mean	SD
1960-1989	1.6	1.3	0.3	0.6
1990-1999	1.5	1.0	0.1	0.3
2000-2009	2.3	2.1	0.3	0.5
2010-2011	2.5	2.1	1.0	
Overall	1.8	1.5	0.3	0.5

Table 19. Causes of mortality for brown bears in Berners Bay from 1960 to 2011, based on ADF&G sealing records.

	Total	Male	Female	Unknown	Male %
Hunting	73	50	21	2	68
DLP	11	7	4	0	64
Natural/Unknown	9	2	4	3	22
Research	3	1	2	0	33
Illegal	5	4	1	0	80
All mortality	101	64	32	5	63

June 2007, we picked up the collar and examined the site, which was 450 m from the death location. We found that the carcass had been consumed by bears and likely dragged from its former position.

Female brown bear 422 (age class 9) was darted from a helicopter on 17 June 2007 near the Katzehin River estuary. We noted that she was in estrus. Two days later, we found her dead, partially consumed by a bear, near the capture location.

Two bears were consumed by other bears in the upper Berners River area. One male (age class 4) was found dead during November 2009, and 1 female bear (age class 12) was found in November 2010. Both of the bears were near the Berners River and had been consumed by other bears. Abundant spawning salmon were in the Berners River at these times.

We discovered a natural mortality (female age class 20+) on the Berners Bay estuary in spring of 2008. We determined the bear died on 2 December 2007. The bear was intact and found under a log.

Productivity

In 2006, we recorded 40% (4 of 10) of our live-captured adult females (age class ≥ 5) were accompanied by cubs (Table 1). One captured adult female was accompanied by 2 COY, 1 adult female was accompanied by a single 1-yr old cub, 1 female was accompanied 2 2-yr old cubs, and one adult female was accompanied by an unknown aged cub.

In 2007, 20% (1 of 6) of our adult females were accompanied by cubs (Table 1). One female was accompanied by 3 COY cubs.

In 2008, 62% (5 of 8) of live-captured adult females were accompanied by cubs (Table 1). One captured adult female was accompanied by 2 COY, 1 adult female was accompanied by a single 1-yr old cub, one adult female was accompanied 2 1-yr old cubs, 1 adult female was accompanied by 3 1-yr old cubs, and 1 adult female was accompanied pair of 2-yr old cubs.

From live trapping of brown bears, we recorded average litter sizes of 2.3 ±0.6 (n = 3) COY, 1.8 ±0.95 (n = 4) yearlings, and 2 (n = 2) 2-yr olds. In terms of productivity (average COY/adult female in age class ≥ 5), we recorded 0.2 in 2006, 0.5 in 2007, and 0.2 in 2008. For adult females with cubs, the age class of the females ranged from 7 to 20. We captured 4 females that were in estrus during 10 June through 18 June. The bears that were in estrus ranged from age class 4 to 9. We live-captured 5 more females (age class 4-6) that neither had cubs nor were in estrus.

Population Genetic Structure

We examined the genetic relationships of 12 postulated populations of brown bears in Southeast Alaska (Table 20). Our analysis using Program Structure (Pritchard et al 2002) assigned these 12 different populations into 8 identifiable genetic clusters (Fig. 24): Admiralty Island, Chichagof-Baranof Island complex, the Southern Mainland, Taku River south to Port Houghton, Berners Bay, Chilkat area including the Chilkat Range, Yakutat Forelands, and Malaspina Forelands. The samples collected from the Stikine River south including the Bradfield and Unuk rivers were grouped together as the Southern Mainland. Samples from north Lynn Canal (GMU 1D) were grouped with ones from the Chilkat Range of GMU 1C into the Chilkat group. We found that ln Pr (X/K) maximized at K = 8. We computed the proportion of membership of each pre-defined population in each of the 8 clusters (Table 21).

We calculated the matrix of F_{ST} values between populations (Table 22), and then we transformed the matrix F_{ST} values into a Fitch-Margoliash tree (Fig. 25). This simple graphical representation of population relationships emphasized the genetic extremes in the dataset. Baranof and Chichagof islands are shown at the end of a long branch opposite of the Southern Mainland. Admiralty Island forms its own cluster that is different from Baranof and Chichagof islands. Between the Southern Mainland and Yakutat Forelands, the remaining mainland populations are placed in order that reflects geography with the small steps between adjacent areas probably representing gradual genetic change over space. Berners Bay and Malaspina Forelands are exceptions to this trend forming large branches within the tree.

Of special note, we identified a discrete and stable genetic group in the Berners Bay area. Of 32 individuals sampled in our Berners Bay greater study area, 27 (84%) were assigned > 80% ancestry in this population. Surprisingly, one of our radiocollared bears (male bear 425) had Admiralty Island ancestry (Q = 0.976) and 1 bear (Q = 0.240) that had slightly mixed ancestry with the Admiralty Island group. In addition, we sampled 2 bears that had mixed ancestry with the Taku group and the Southern Mainland group (Q = 0.285 to 0.240) and 1 individual that had mixed ancestry with the Chilkat group (Q = 0.235). Conversely, 3

Table 20. Geographical areas and sample sizes for the genetics analysis of brown bears in Southeast Alaska.

Location	Sample size
1. Southern Mainland, the rest of GMU 1A	14
2. Southern Mainland, Unuk River (GMU 1A)	29
3. Southern Mainland, Stikine to Bradfield rivers including Bradfield Canal (GMU 1B)	31
4. Taku River to Port Houghton (GMU 1C)	10
5. Berners Bay, including from near Juneau to the Katzehin River (GMU 1C & 1D)	32
6. Chilkat area, including from Skagway to the west side of Lynn Canal within GMU 1D	30
7. Chilkat Range area, including west of Lynn Canal within GMU 1C	6
8. Yakutat Forelands (GMU 5A)	40
9. Malaspina Forelands (GMU 5B)	17
10. Admiralty Island (GMU 4)	30
11. Chichagof Island (GMU 4)	30
12. Baranof Island (GMU 4)	26
Totals	295

individuals that had ≥ 80% Berners Bay ancestry were sampled elsewhere, all in the Chilkat area. In addition, 2 bears had mixed ancestry (Q = 0.562 to 0.659) with the Chilkat group.

Discussion

Home Range and Movement Patterns

Home Range

Brown bear home range size is believed to be a function of population density and habitat quality (Schwartz et al. 2003). Bear populations in geographic regions with limited food resources and low population densities, such as the interior of Alaska (Reynolds 1980) and the Northwest Territories (Nagy and Haroldson 1990), tend to have the largest home ranges, while coastal islands with abundant salmon and high population densities provide for smaller home range sizes (Titus et al. 1999). Brown bear home ranges in Berners Bay were found to be between these 2 extremes. We assessed home range size using the minimum convex polygon method, which likely over-estimates the area used by bears, but it is a standard method used to compare findings among studies (McLoughlin et al. 1999).

Consistent with other studies throughout coastal Alaska, we found male brown bear home range size to be several times larger than female ranges (Schoen and Beier 1990, Titus et al. 1999, Van Daele 2007). Males are expected to have larger home ranges

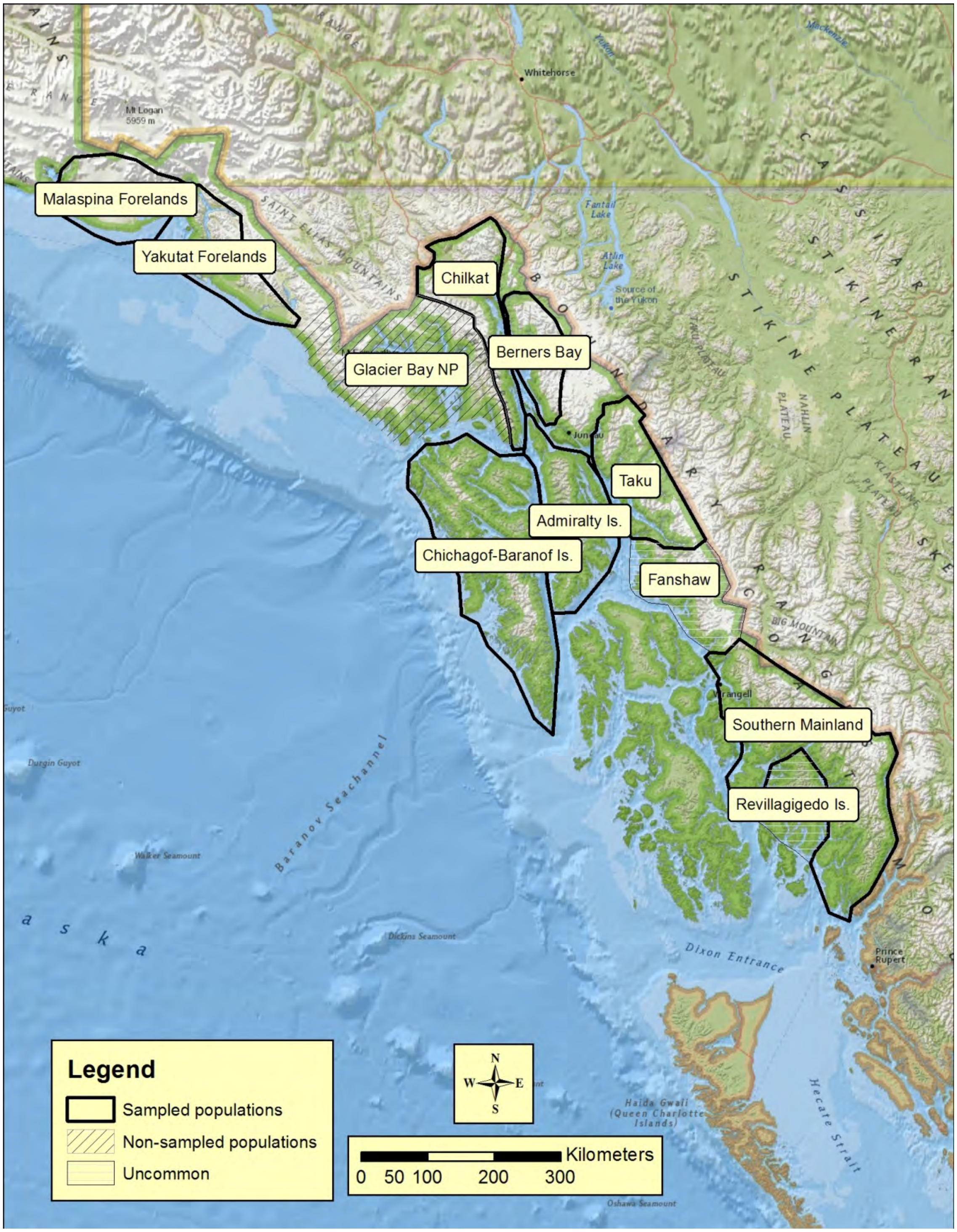


Figure 24. Genetically distinct clusters of populations of brown bears in Southeast Alaska determined from the Program Structure based on 20 microsatellite loci. We did not include any samples from Glacier Bay National Park in our analysis (see Lewis 2012). We did not obtain samples from the Fanshaw area and Revillagigedo Island because brown bears are uncommon there.

Table 21. Proportion of membership of each predefined geographical area in each of the 8 genetic clusters according to Program Structure. Clusters that are consistent with predefined geographical areas are marked in light blue.

Sample size	Geographical areas	Chilkat	Berners Bay	Admiralty Island	Baranof-Chichagof islands	Yakutat Forelands	South Mainland	Malaspina Forelands	Taku
14	1. Reminder of GMU 1A	0.011	0.008	0.005	0.003	0.007	0.938	0.008	0.021
29	2. Unuk R. (1A)	0.008	0.005	0.005	0.004	0.005	0.955	0.008	0.011
31	3. Bradfield R. (1B)	0.009	0.016	0.006	0.005	0.006	0.943	0.005	0.009
10	4. Taku R. (1C)	0.007	0.009	0.028	0.006	0.006	0.022	0.006	0.916
32	5. Berners Bay (1C & 1D)	0.027	0.877	0.041	0.006	0.008	0.016	0.004	0.022
30	6. Chilkat (1D)	0.722	0.108	0.015	0.010	0.094	0.010	0.013	0.028
6	7. Chilkat Range (1C)	0.440	0.310	0.172	0.006	0.042	0.011	0.004	0.016
40	8. Yakutat Forelands (5A)	0.020	0.013	0.014	0.025	0.875	0.005	0.040	0.007
17	9. Malaspina Forelands (5B)	0.006	0.009	0.004	0.005	0.013	0.005	0.952	0.005
30	10. Admiralty Island (4)	0.009	0.016	0.928	0.014	0.012	0.006	0.006	0.010
30	11. Chichagof Island (4)	0.005	0.003	0.005	0.967	0.004	0.004	0.009	0.003
26	12. Baranof Island (4)	0.011	0.006	0.006	0.960	0.005	0.003	0.005	0.005

Table 22. Matrix of pair wise F_{ST} values as estimated with the software Genepop. The locations of populations are shown in Figure 24.

Location	South Mainland	Taku	Admiralty Is.	Chichagof-Baranof is.	Berners Bay	Chilkat	Yakutat Forelands
Taku	0.097						
Admiralty	0.175	0.152					
Chichagof-Baranof	0.255	0.192	0.226				
Berners Bay	0.154	0.128	0.165	0.199			
Chilkat	0.120	0.082	0.106	0.133	0.055		
Yakutat Forelands	0.147	0.111	0.143	0.125	0.115	0.051	
Malaspina Forelands	0.177	0.155	0.195	0.192	0.189	0.107	0.097

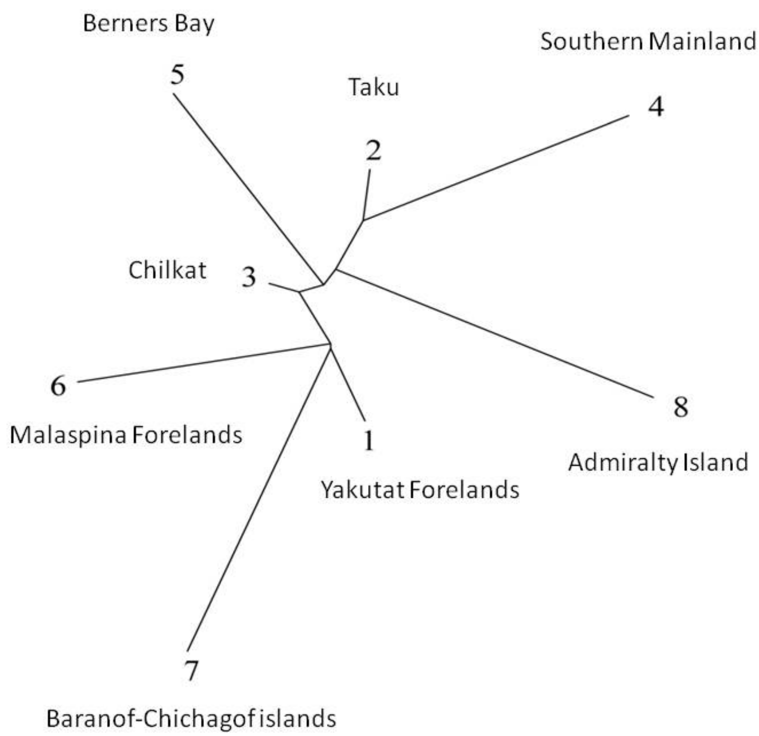


Figure 25. Fitch-Margoliash tree representing the F_{ST} matrix in Table 22. The locations of populations of brown bears in Southeast Alaska have been mapped in Fig. 24.

than females because they search farther for mates during the breeding season, and their larger body size requires an increased energetic demand (McNab 1963). Both male and female home range sizes in Berners Bay were larger than those of adjacent island populations in Southeast Alaska (Schoen and Beier 1990, Titus et al. 1999). Female home ranges were comparable to those found along the Unuk and Bradfield rivers (176 km^2) (Flynn et al. 2010) and Kodiak Island (129 km^2) (Van Daele 2007). This study adds to our understanding of Southeast Alaska mainland brown bear population home range size and provides a basis for which to compare future Southeast Alaska mainland studies.

Movement Patterns

Roads affect wildlife populations in various ways. Three of the more important effects are barriers to movement, increased vehicle collisions and associated road kills, and diminished habitat effectiveness. We found the greatest number of bear crossings within and adjacent to the major rivers and sloughs draining into Berners Bay. We found 51.8% of the bear crossings along 7 km of the proposed road corridor adjacent to the Berners Bay estuary. Movements through this area were extensive as bears access herbaceous vegetation in the emergent estuary habitats and travel along the edges of rivers in search of salmon.

We found 17.3% of the bear crossings were at locations associated with planned road structures in the Berners Bay estuary, mostly with planned bridges. We mapped 157 (9.8%) bear crossings within 50 m of stream edges where planned structures crossed a water body. We found that extending the planned bridges by 50 m would include a substantial number of bear crossings, especially at Antler and Lace sloughs. We found 0.9% (near Antler River) and 0.4% (near Lace River) of bear crossings were associated with the planned underpasses, a nearly double increase over those occurring just at the structure.

Previous research has documented the adverse effects of roads on brown bears; all have shown displacement and strong avoidance at distances ranging from 500 m to 3 km (Mattson et al. 1987, Kasworm and Manly 1990, and Gibeau et al. 2002). Studies of brown bear road crossings, including research on the Kenai Peninsula, Alaska, have found that most road crossings occurred during decreased traffic volumes and at night (Chruszcz et al. 2003, Waller and Servheen 2005, Graves et al. 2006). Female brown bears tend to remain farther from paved roads irrespective of habitat quality or temporal patterns, and the transportation corridor greatly restricted female movement (Gibeau et al. 2002, Proctor et al. 2005).

In this study, we display brown bear habitat use and movement patterns in the absence of a road, yet find the results of previous studies germane to ADF&G's management and understanding of how bears will respond before, during, and after construction. Most road-related bear research has occurred in regions with low bear densities and an absence of salmon. Southeast Alaska bears occur in higher densities and are dependent upon seasonal resources such as salmon and sedges that are at times only available near the estuary, and so bears may be compelled to behave differently than in other study areas. Unless there are sufficient mitigation measures, we can expect bears, especially females, to be displaced from important habitats adjacent to the road. Mitigation measures can play a critical role in maintaining landscape patterns and ecosystem functions.

Many good design, construction, and evaluation examples of wildlife crossing structures, such as minimum recommended dimensions for particular species, can be found in Clevenger and Huijser 2011. When comparing various wildlife underpass structures, open span wildlife underpasses with high structural openness (see Fig. 43. in Clevenger and Huijser 2011) have been found to provide the best performance for large mammals such as bears (Clevenger and Waltho 2000). Other actions, such as installing expansive roadside fencing to reduce mortality risk are believed to be beneficial, but the net effect of this approach is unknown as the fence barrier also restricts access to resources (Clevenger et al. 2001). Fencing in combination with wildlife crossing structures has been recommended, though population persistence largely depends on the population avoiding the road and reducing the probability of individual mortality (Jaeger and Fahrig 2004). Landscape overpass bridges have proven to be the optimum connectivity solution for brown bears and a diversity of wildlife species, including ungulates and other carnivores. Speed bumps and warning signs have also been successful at reducing vehicle speed and minimizing wildlife road kills. Bears' avoidance behavior and their extensive movement paths along the margins of streams necessitates bridge designs that minimize disturbance to riparian vegetation and maximize the height and distance of the bridge structure away from the banks of the rivers (see Fig 41. in Clevenger and Huijser 2011).

Increased road access associated with the Juneau Access Improvements Project will bring bears in greater conflict with people (McLellan and Shackleton 1988, Schoen et al. 1994, Suring et al. 2006). Some bears may cross the road surface, making them vulnerable to traffic accidents. Garbage or other human refuse, if present, will attract bears to areas of concentrated human use (Schoen et al. 1994, Titus et al. 1999). Hikers and campers will encounter bears while recreating. Conflicts between humans and brown bears because of these changes may result in increased bear mortality. Thus, human conflicts along the road corridor could create a population decline.

Brown bear hunting regulations would need to be modified to account for any demographic changes in the bear population, such as increased mortality, reduced productivity, or changing hunting vulnerabilities. New hunting seasons may need to be implemented and brown bear harvests more closely monitored. Additional restrictions on numbers of guides and nonresident hunters may also become necessary. Human access to important brown bear use areas may also need to be restricted, especially during certain times of the year.

HABITAT SELECTION

We found that collared bears made extensive use of the Berners Bay estuary, especially the emergent wetlands. In the early summer, estuarine emergent was the most selected habitat for brown bears (Table 7), both males and females. The RSF for estuarine emergent near anadromous fish streams was 418 times greater than the lowest habitat. Bears seemed to make extensive use of the lush herbaceous vegetation growing there, especially northern rice root and Lyngbye's sedge. Also, the bears selected riparian habitat, reflected by negative selection for the riparian index factor. Thus, the bears preferred to be at low elevation and near anadromous fish streams.

In the late summer, estuarine emergent was still the most important selected habitat for brown bears. The riparian index showed that the bears preferred to be at low elevation and near anadromous fish streams. Also, distance to spawning stream reaches was a significant negative coefficient, indicating bears' preference for salmon-spawning streams. Brown bears made extensive use of the coastal anadromous streams for example Cowee, Sawmill, Johnson, Slate, Sweeny, and Independence Lake creeks. A number of bears focused on spawning areas on the Berners River, especially the upper portion. We found few salmon-spawning reaches in the larger rivers of Berners Bay. We found a few places in the Lace, Gilkey, and Antler rivers (Fig. 2) but the spawning areas on these rivers were quite small and well spaced. We found that the bears used several reaches and spent considerable time travelling between them.

This spatial use pattern is quite different than observed on Admiralty and Chichagof islands (Schoen and Beier 1990, Schoen et al. 1994, Titus et al. 1999). Although brown bears used beach fringe and estuary habitat in the spring on Admiralty and Chichagof islands, they used alpine meadows frequently in the early summer (Schoen and Beier 1990, Titus et al. 1999). In early summer, Schoen and Beier (1990) found brown bear locations averaged 550 m in elevation on Admiralty Island and 259 m on Chichagof Island. In contrast, brown bears averaged 162 m in elevation in Berners Bay. By the late summer, brown bears on Admiralty and Chichagof islands selected salmon-spawning streams extensively (Schoen and Beier 1990). On Chichagof Island, Flynn et al. (2007) reported considerable sexual segregation by brown bears on spawning streams with large males being dominant. Schoen et al. (1987) reported that brown bear dens on Admiralty and Chichagof islands averaged 640 m in elevation and averaged 35° slope, considerably higher than those found in this study.

Schoen et al. (1994) developed a habitat capability model for brown bears in late summer for Southeast Alaska based on data from Admiralty and Chichagof islands. In their habitat capability model, they considered the late summer the most critical to brown bears when they are attracted to spawning salmon. In the final environmental impact statement (FEIS), DOT&PF (2006) referenced a 1997 application of the Schoen et al. (1994) habitat model that was used to predict possible impact to brown bears along the proposed road corridor. However, in this study we have discovered some important differences in brown bear habitat relationships in the Berners Bay study area. In particular, we found brown bears strongly selected estuarine emergent habitats in the early summer. In the late summer, brown bear selection of estuarine emergent habitats ranked higher than in Schoen's model. In Schoen's model, estuary habitats were still important, but ranked below riparian old-growth forest with spawning salmon.

POPULATION DYNAMICS

Abundance

We succeeded in our attempt to measure brown bear abundance in the Berners Bay area during 2006 to 2008. We estimated the brown bear population ranged from 29.9 to 37.5 for females and 14.4 to 29.2 for males. Combining males and females, the estimates for the total population were 44.3 bears in 2006, 66.7 bears in 2007, and 60.4 bears in 2008. Estimates for 2006, especially for males, are substantially lower than for 2007–2008. We had more collared bears available for the latter 2 years, with associated additional locations, within the study area. Also, we extended the area sampled and used more hair snares in the latter years. Consequently, we believe the estimates for 2007 and 2008 are more reliable than those for 2006.

We combined live-captures, radiotelemetry, and individual identifications from hair snagging (DNA) sessions into our estimate of abundance to improve precision. Combining detections from multiple data sources into single encounter histories yielded robust estimates with higher precision than a single–source approach (Kendall et al. 2009). Mark–recapture models can increase precision or reduce bias by more effectively modeling heterogeneity in capture probabilities by incorporating individual, group, and temporal covariates (Boulanger et al. 2008). Similarly to Kendall el al. (2009), we demonstrated that we detected bears of all sex-age classes. Therefore, our derived estimates reflect total population abundance. For monitoring trend and making meaningful comparisons of density among populations, it is important to know the sex-age classes of the population. From our hair snagging sessions, we achieved similar capture probabilities as Kendall et al. (2009).

Density of brown bears in Berners Bay was similar to the southern mainland of Southeast Alaska, but much lower than Admiralty and Chichagof islands. Flynn et al. (2010) estimated total population at 27 bears/1,000 km^2 (CI = 25–35) in 2005 and 44 bears/1,000 km^2 (CI = 41–53) in 2006 in the Bradfield Canal area and about 51 bears/1,000 km2 (CI = 34–68) in the Unuk River area in the southern mainland of Southeast Alaska. For additional comparison in Southeast Alaska, Miller et al. (1997) reported the brown bear density for all bears on Admiralty Island ranged 399/1,000 km^2 to 439/1,000 km^2 and on Chichagof Island the brown bear density was 318/1,000 km^2.

Survival

Using the mark-recapture approach, we estimated survival for all brown bears at 0.84 (95% CI = 0.73–0.91). We recorded 18 deaths of radiocollared brown bears, both from human (13) and natural (5) causes. This number of mortalities is a minimum because once the radiocollar fails we can no longer track the animal and do not know its fate. Hunters took 5 of our live-captured brown bears.

Titus and Beier (1994) estimated annual survival for 61 radiocollared adult brown bears on Northeast Chichagof Island at 0.84 for males and 0.96 for females. We have no additional survival estimates for brown bear populations in Southeast Alaska to compare to the survival rate that we measured in Berners Bay. This data need is fertile ground for further research. On the Kenai Peninsula, Farley et al. (2001) estimated the adult female survivorship ranged from 0.87 to 0.94. On Kodiak Island, Van Daele (2007) estimated adult male survivorship at 0.81 and adult females at 0.87.

Productivity

We gathered productivity data from our live-captured brown bears for the Berners Bay population. Because sample sizes are small, the data are imprecise, but they provide some indication of how productive the brown bear population is in Berners Bay. We found cubs accompanied 42% of the live-captured adult females during 2006-2008. Titus and Beier (1994) observed 51% and 55% of adult sows (age class ≥6) were accompanied by cubs on Chichagof and Admiralty islands during 1991 to 1994. In Kodiak, Barnes and Van Daele (2008) reported an overall mean annual litter production of 44%.

For our limited sample size, we recorded average litter sizes of 2.3 ±0.6 COY compared to 1.8 and 1.9 on Admiralty and Chichagof island during 1991 to 1994 (Titus and Beier 1994). Barnes and Van Daele (2008) reported mean litters sizes of COY varied from 2.3 to 2.5 on Kodiak Island.

In terms of productivity (average COY/adult female in age class ≥ 5), we recorded 0.2 in 2006, 0.5 in 2007, and 0.2 in 2008. On Kodiak Island, Barnes and Van Daele (2008) found weaned cubs/adult female (3-yr cubs/adult females ≥6) varied from 0.33 to 0.42. We had only 2 females that were accompanied by 2-yr old cubs in 3 years of study and no 3-yr cubs accompanied by adult females.

The Berners Bay brown bear population seems to be less productive than the ones on Admiralty, Chichagof, and Kodiak islands, but it is difficult to measure precisely because of low population numbers.

Population Genetic Structure and Ancestry

Our data indicated that brown bears in Southeast Alaska could be grouped into 8 distinct genetic clusters. Brown bears within Berners Bay are one of these unique genetic clusters with limited gene flow. Over 84% of the brown bears within Berners Bay area were assigned >80% ancestry in this population. Within Southeast Alaska, the Berners Bay area is the major exception to the pattern of gradual change over space that describes most of the mainland brown bear populations. Berners Bay acts more like an island, separated by glaciers and by steep topography along the coast. From our habitat selection and movement data, we now know that brown bears on the mainland coast seldom cross glaciers and large water bodies, using mostly riparian and beach habitats. In addition, we observed nearly all of the brown bears moved to the lower bay to breed in the Berners Bay estuary. Furthermore, the city of Juneau has separated Berners Bay from the Taku River valley and points south for the past 125 years. Of special note, the genetics of brown bears in Berners Bay have been more influenced by the oceanic island populations of GMU 4 than other mainland populations.

Our data builds on the genetic work by Talbot and Shields (1996) and Paetkau et al. (1998). Talbot and Shields (1996) found that brown bears from Admiralty, Baranof, and Chichagof islands all had different mtDNA haplotypes from coastal mainland brown bears. Paetkau et al. (1998) found that Admiralty Island and Baranof and Chichagof islands formed unique genetic clusters, but didn't feel these populations were completely isolated from the mainland coast. Also, Paetkau et al. (1998) didn't detect any unique genetic clusters on the mainland coast. This study went beyond that to analyze whether brown bears on the mainland coast of Southeast Alaska have any unique genetic structure, especially in regards to the population in Berners Bay.

Lewis (2012) found another genetic cluster for brown bears within Glacier Bay National Park (GLBA) between our Chilkat and Yakutat Forelands samples. She reported F_{ST} values between the GLBA population and West Glacier Bay (Yakutat Forelands) = 0.05; GLBA and East Glacier Bay (Chilkat) = 0.02; and West Glacier Bay and East Glacier Bay = 0.05. We found similar values of F_{ST} for our Yakutat Forelands and Chilkat populations (F_{ST} = 0.051), but we did not have any samples from Glacier Bay National Park for our study. Lewis (2012) found that the distribution of the populations of brown bears in Glacier Bay National Park spatially overlapped, but some of the bears were genetically distinct.

In the future, we want to combine our data with samples from surrounding brown bear populations in British Columbia and the Yukon to better understand factors that affect gene flow. Proctor et al (2012) found brown bear populations in the relatively undisturbed northwest British Columbia generally conformed to an isolation-by-distance paradigm, but extensive glaciers and icefields contributed to natural fragmentation. Southeast Alaska has greater coverage by glaciers, and consists of a vast numbers of islands separate by large fjords; factors likely conducive to population genetics structuring in brown bears, as has been seen in other mammal species (Cook et al. 2006).

Population Management

For the decade 2000–2009, the average human-caused mortality per year for brown bears in Berners Bay was 2.3 bears/year. With this harvest rate, we did not see an increase in population numbers during our study. In Kodiak, Van Daele (2007) recommends a harvest rate of 5.6–7.9% of the estimated independent (age class ≥4) brown bear population. If we assume that 81% of our population was in this same age class (age class ≥4, data from our live-captured bears), the harvest rate would have been 4.5% of the adult population over the period 2000–2009. With small population numbers of adult bears (i.e., 46 bears), 1 bear represents 2% of the adult population.

Unfortunately, we do not have a better measure of recruitment (i.e., maturing cubs). We could not aerially survey the bears because of the forest conditions. We could only record when our live-captured females were accompanied with cubs. We encountered few 2-yr old cubs in our captures, so we assumed that recruitment is probably low for the Berners Bay population.

Population geographic closure

Caughley (1977) defines a population as a group of interbreeding individuals having little contact or no contact with other such groups. From the radiotracking data and genetics information, we confirmed that the greater study area contained a population of brown bears. Furthermore, the bears of Berners Bay area are nearly demographically isolated with minimal immigration and emigration.

Summary

- We captured 48 (22 males, 25 females, 1 unknown) brown bears during 2006 to 2010. We recorded movements and habitat selection data on 30 brown bears (17 males, 13 females). We captured the bears in or near the Berners Bay estuary and upper Berners River along salmon-spawning streams.

- Male bears had a larger mean home ($\bar{x}$ = 555 km^2; range = 24 to 2,027 km^2) compared to females ($\bar{x}$ = 147 km^2; range = 39 to 357 km^2). Male brown bear home ranges were nearly 4 times larger than those of females. These home ranges were much larger than recorded on Admiralty and Chichagof islands.

- Brown bear use patterns were distributed throughout the 4 primary river systems within the Berners Bay watershed. Some brown bears captured in Berners Bay ranged south to Sawmill, Davies, and Cowee creeks and Eagle River while other bears traveled up the Antler, Berners, Lace, and Gilkey rivers. Other brown bears used Johnson and Slate creeks and the drainages entering Lynn Canal up to Independent Lake Creek.

- Throughout the year, the confluence of the major river systems at the Berners Bay estuary served as a central location for bear activity, especially in the early and late summer seasons. As the proposed road bisects the lower bay, most brown bear home ranges intersected the vicinity of the road corridor. We found that 27 of 30 collared bears shared a portion of their home range with the lower bay and the road corridor.

- We witnessed breeding activity by brown bears on or near the estuary from 10 June through 1 July.

- We found 32% (60,124) of all successful brown bear locations within 1.0 km of the JAIP road alignment, particularly during the early (45%) and late summer (31%) seasons. Even in other seasons, a substantial number of locations in the autumn (27%) and the spring (14%) were within 1.0 km of the road corridor.

- Brown bear paths consistently followed the river bottoms in all seasons, except when denning.

- We counted 3,074 bear crossing locations from the movement paths of 28 brown bears that crossed the proposed road corridor. Locations of bear crossings were not evenly distributed along the corridor. The majority of bear crossings (52%) were along 7 km of the road adjacent to the Berners Bay estuary. The most brown bear crossings were where the road corridor crosses Sawmill Creek, the entire Berners Bay estuary, Slate Creek, Sweeny Creek, and Independence Lake Creek.

- We found 528 (17.3%) bear crossings were associated with planned road structures in the Berners Bay estuary. Most bear crossings associated with JAIP structures included Antler River (11.4%) and Antler Slough (0.7%) bridges and Lace River (4.1%) and Lace Slough (0.6%) bridges. Bear crossings near the Antler River underpass (0.5%) were higher than the underpass located near the Lace River (0.2%).

- We divided habitat selection into the early and late summer time periods. The final model for early summer used the estuarine emergent, herbaceous, closed forest, open forest, shrub, beach, and unvegetated landcover habitats and riparian index physical variable to describe brown bear habitat selection.

- For late summer, we described habitat selection in terms of distance to salmon-spawning reaches and riparian index for physical variables and estuarine emergent, open forest, shrub, and unvegetated landcover for habitat variables.

- Our estimated population for Berners Bay ranged from 29.9 to 37.5 for females and 14.4 to 29.2 for males. Combining the estimates for male and females, the total population was estimated to be 44.3 bears in 2006, 66.7 bears in 2007, and 60.4 bears in 2008. In terms of density within our intensive study area (per 1,323 km^2), we estimated 33.6/1,000 bears km^2 in 2006, 50.4/1,000 km^2 in 2007, and 45.6/1,000 km^2 in 2008.

- We estimated survival for the entire population of brown bears at 0.84 (95% CI = 0.732–0.908). We have no other estimate of brown bear survival in Southeast Alaska.

- We have observed an average of 1.81 (SD = 1.43) brown bears killed by all human causes per year. Hunting mortality has averaged 1.40 (SD = 1.27) per year since 1960. Recently, the average human-caused mortality per year has increased slightly from 1960–1989 ($\bar{x}$ = 1.7), 1990- 1999 ($\bar{x}$ = 1.60, SD = 0.84), to 2000–2009 ($\bar{x}$ = 2.3).

- Based on 295 genetic samples from 8 brown bear populations throughout Southeast Alaska, brown bears of Berners Bay form a unique genetic cluster with limited gene flow. Thus, the Berners Bay bears are nearly demographically isolated.

Recommendations

Our recommendations are focused on several factors associated with the proposed JAIP road: 1) population management as it relates to brown bear mortality, and 2) highway design and mitigation as it pertains to disturbance, disruption, and displacement from habitats essential to foraging, breeding, resting, and other vital activities.

POPULATION MANAGEMENT

Brown bear mortality in the project area will be closely monitored by ADF&G staff. All mortalities, including vehicle collisions, defense of life and property kills, and hunter harvest will be considered when managing brown bear in the project area. If human-caused mortality exceeds guideline mortality levels, additional management actions by ADF&G will be necessary. Management actions could include shortening deadlines for harvest reporting to more closely monitor harvests, limiting the number of hunter permits, and changing season length and/or closing the season by emergency order. Any or all of these management tools could be used to keep the harvest within management objectives. The challenge will be in balancing hunter harvests and non-hunter mortality.

State hunting regulations prohibit hunting big game within one-quarter mile of Glacier Highway between Mile 0 and the northern bank of Peterson Creek near mile 23. Given vulnerably of brown bears in this area, ADF&G recommends that the BOG extend the big game hunting restriction to the entire road corridor. In addition to State of Alaska regulations governing big game hunting on the Juneau road system, the CBJ prohibits any person from discharging a firearm within one-quarter mile of any public or private street, road, or right-of-way or highway within the CBJ for public safety purposes. ADF&G recommends this municipal ordinance be applied to the JAIP road as it lies within the CBJ boundary. Restrictions on big game hunting and discharge of firearms could provide a buffer along the road corridor for public safety as well as wildlife viewing opportunities. Also, ADF&G would work with the FSB to establish federal regulations that mimic state regulations.

HIGHWAY DESIGN AND MITIGATION

The disturbance, disruption and displacement of bears from habitats essential to foraging, breeding, resting and other vital activities are our primary considerations in addressing highway construction and designs for mitigation. Establishing a road in this previously unroaded area will increase human access and levels of human activity, therefore increasing conflicts between bears and people. Effective highway designs and wildlife road crossing structures will help mitigate some of these problems.

Road

Wildlife underpasses should be located in areas where GPS locations indicate bears cross the proposed road corridor most often. We recommend shifting the northern underpass 0.25 km to the west where the greatest number of crossings occurred. The 200 m segment, with 68 crossing locations, provides access to the estuary from the forest and also connects the Lace River corridor to the estuary and forest. In addition to wildlife underpasses, bridges that span waterways or other geographical features will likely be used as wildlife passages and should be constructed to facilitate movement of brown bears. The distance between the proposed bridge abutments and supports and water bodies should be lengthened to provide travel corridors for bears. Although information from radiocollared bears has given us a good indication of the most used travel routes, bears' use of these areas may change when the road is in place due to the added disturbance, unfamiliarity of the landscape, and avoidance of people.

Even if wildlife underpasses are in place to facilitate bear movements under the road, some bears will likely cross over the road, creating a safety hazard for themselves and motorists. It is difficult to predict where crossings will occur after construction, but project planners should consider placing bear (wildlife) crossing signs at locations where bears are known to congregate based on GPS location data (e.g., Sawmill Creek, Antler Slough, Slate Creek). Whether or not bears cross at these locations, it is important to remind motorists of the potential for vehicle collisions with wildlife. Speed restrictions are recommended, particularly at night.

In the case of infrastructure built for public use, any amenities (e.g. refuse cans, restrooms) should be constructed with brown bears in mind to prevent animals' access to human waste, refuse, and food. Bears will exploit non bear-proof facilities, causing public safety concerns. The easiest solution is not to construct vehicle pullouts or public facilities, but if they are part of the project, they should be constructed to protect both bears and people.

<u>Human Activity</u>

In many of the areas mentioned above (based on aggregate GPS locations), brown bears will likely be visible to passing motorists. The Berners Bay estuary could become a major brown bear viewing area, especially during the early summer. To avoid disturbing bears and to provide for public safety, we recommend against constructing pullouts or parking areas on or near the estuary. In addition, we recommend restricting human access to salmon-spawning reaches like Sawmill, Slate, and Sweeny creeks in the late summer.

Acknowledgements

This project was primarily funded by FHWA and the DOT&PF, Division of Design and Engineering Services, through a Reimbursable Service Agreement (RSA). R. Yost (DOT&PF) arranged for the funding, provided project coordination, and reviewed drafts of this report. The ADF&G, Douglas Regional Office, provided additional funding, project supervision, administration, and additional staff. N. Barten, R. Scott, C. Rice, R. Woodford, and K. McCoy participated in the fieldwork. K. Titus and D. Larsen edited early drafts of this report and R. Scott and N. Barten contributed to the recommendations. L. Shaul, Commercial Fisheries Division, provided a camp at Berners River, and he and K. Crabtree assisted with the fieldwork. B. Winne and R. Madrid (Temsco Helicopters) and J. Kulbeth (NorthStar Helicopters), piloted helicopters during captures and other fieldwork. L. Bennett and D. Larsen provided fixed-wing piloting support. Dr. D. Paetkau, Wildlife Genetics International, contributed many useful insights into the genetics of brown bears, completed the DNA analysis, and contributed to the results of the genetic analysis.

Literature Cited

Alaback, P. 1988. Endless battles, verdant survivors. Natural History 97:45-48.

Alaback, P. and G. P. Juday. 1989. Structure and composition of low elevation old-growth forests in research natural areas of southeast Alaska. Natural Areas Journal 9:27-39.

Albert, D. and J. Schoen. 2006. A preliminary classification and conservation assessment of terrestrial ecosystems in Southeast Alaska. The Nature Conservancy, Juneau, AK, USA.

Arthur, S. M. and C. C. Schwartz. 1999. Effects of sample size on precision and accuracy of brown bear home ranges. Ursus 11:139-419.

Barnes, V. G., Jr. and L. J. Van Daele. 2008. Productivity of female brown bears on Kodiak Island, Alaska. Job completion report for Challenge Cost Share Project. Alaska Department of Fish and Game, Kodiak, Alaska, USA.

Beier, L. R., S. B. Lewis, R. W. Flynn, G. W. Pendleton, and T. V. Schumacher. 2005. A single-catch snare for the non-invasive collection of hair for genetic mark-recapture studies in brown bear. Wildlife Society Bulletin 33:766-773.

Ben-David, M., K. Titus, and L. R. Beier. 2004. Consumption of salmon by Alaska brown bears: a trade-off between nutritional requirements and the danger of infanticide? Oecologia 138:465-474.

Beyer, H. L. 2011. Geospatial Modeling Environment (version 0.5.5 Beta). (software). URL: http://www.spatialecology.com/gme.

Boyce, M. S., P. R. Vernier, S. E. Nielsen and F. K. A. Schmiegelow. 2002. Evaluating resource selection functions. Ecological Modelling, 157:281-300.

Boulanger, J., K. C. Kendall, J. B. Stetz, D. A. Roon, L. P. Waits, and D. Paetkau. 2008. Multiple data sources improve DNA-based mark recapture population estimates of grizzly bears. Ecological Applications 18:577–589.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and inference: a practical information theoretic approach, 2nd ed. Springer, New York, NY. USA.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons., New York, New York, USA.

Christensen, B. and C. Van Dyke. 2004. Brown Bear (*Ursus arctos*) habitat and signs of use: Berners Bay, Alaska Site Survey. SEAWEAD. http://www.seawead.org.

Chruszcz, B., A. P. Clevenger, K. Gunson, and M. L. Gibeau. 2003. Relationship among grizzly bears, highways and habitat in the Banff-Bow Valley, Alberta, Canada. Canadian Journal of Zoology 81:1378-1391.

Clevenger, A. P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology 14:47-56.

Clevenger, A. P., B. Chruszcz, and K. E. Gunson. 2001. Highway mitigation fencing reduces wildlife-vehicle collisions. Wildlife Society Bulletin 29:646–653.

Clevenger, A. P., and M. P. Huijser. 2011. Wildlife Crossing Structure Handbook Design and Evaluation in North America. FHWA-CFL/TD-11-003. Federal Highway Administration, Planning, Environment and Reality. Washington, DC, USA.

Cook, J. A., N. G. Dawson, S. O. MacDonald. 2006. Conservation of highly fragmented systems: The north temperate Alexander Archipelago. Biological Conservation 133:1–15.

Cowardin, L. M., V. Cater, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitat of the United States. FWS/OBS-79/31, Washington, DC, USA.

Craighead, J. J., and J. A. Mitchell. 1982. Grizzly bear. Pages 515-556 *in* J. A.

Chapman and G. A. Feldhamer, editor. Wild mammals of North America: biology, management, economics. John Hopkins University Press, Baltimore, MD. USA.

DOT&PF (Alaska Department of Transportation and Public Faciltities). 2006. Juneau Access Project. Final Environmental Impact Statement. Alaska Department of Transportation and Public Facilities. Juneau, Alaska. http://www.dot.alaska.gov/sereg/projects/juneau_access (Accessed 16 October 2012).

Gibeau, M. L., A. P. Clevenger S. H., J. Wierzchowski. 2002. Grizzly bear response to human development and activities in the Bow River Watershed, Alberta, Canada. Biological Conservation 103:227–236.

Graves, T. A., S. Farley, C. Servheen. 2006. Frequency and distribution of highway crossings by Kenai Peninsula brown bears. Wildlife Society Bulletin 34(3):800–808.

Graves, T. A., S. Farley, M. I. Goldstein, and C. Servheen. 2007. Identification of functional corridors with movement characteristics of brown bears on the Kenai Peninsula, Alaska. Landscape Ecology 22:765–772.

Farley, S, G. Hildebrand, G. Frate, T. Bailey, R. Ernst, L. Suring, W. Shuster, M. Tetreau, J. Schoen, and K. L. Lew. 2001. A Conservation Assessment of the Kenai Peninsula Brown Bear. Report from the Interagency Brown Bear Study Team. Alaska Department of Fish and Game, Anchorage, Alaska, USA.

Federal Highways Administration. 2006. Juneau Access Improvements Project. Record of Decision. Juneau, Alaska. http://www.dot.state.ak.us/stwdplng/projectinfo/ser/juneau_access.

Fieberg, J., J. Matthiopoulos, M. Hebblewhite, M. S. Boyce, and J. L. Frair. 2010. Correlation and studies of habitat selection: problem, red herring, or opportunity? Philosophical Transactions of the Royal Society B, 365:2187-2200.

Fitch, W. M., and E. Margoliash E. (1967). Construction of phylogenetic trees. *Science* 155:279-84.

Flynn, R. W., S. B. Lewis, L. R. Beier, and G. W. Pendleton. 2007. Brown bear use of riparian and beach zones on northeast Chichagof Island: Implications for streamside management in coastal Alaska. Final report. Division of Wildlife Conservation, Alaska Department of Fish and Game, Juneau, USA.

Flynn, R. W., S. B. Lewis, L. R. Beier, and G. W. Pendleton. 2010. Abundance, spatial relationships, and transboundary movements of brown bears on the mainland coast of Southeast Alaska. Final report. Division of Wildlife Conservation, Alaska Department of Fish and Game, Juneau, USA.

Helfield, J. M., and R. J. Naiman. 2006. Keystone interactions: salmon and bear in riparian forests of Alaska. Ecosystems 9:167–180.

Jaeger, J. A. G., and L. Fahrig. 2004. Effects of road fencing on population persistence. Conservation Biology 18(6):1651-1657.

Johnson, D. 1980. The comparisons of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Johnson, C. J., S. E. Nielsen, E. H. Merrill. T. L. McDonald, and M. S. Boyce. 2006. Resource selection functions based on use-availability data: theoretical motivation and evaluation methods. Journal of Wildlife Management 70:347-357.

Johnson, J., and P. Blanche. 2012. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southeastern Region, Effective June 1, 2012. Alaska Department of Fish and Game, Special Publication No. 12-07, Anchorage, USA.

Kasworm, W. F., and T. L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference on Bear Research and Management 8:79-84.

Kendall, K. C., J. B. Stetz, J. Boulanger, A. C. Macleod, D. Paetkau, G. C. White. 2009. Demography and genetic structure of a recovering grizzly bear population. Journal of Wildlife Management 73(1):3–17.

Lele, S. R., and J. L. Keim. 2006. Weighted distributions and estimation of resource selection probability functions. Ecology 87:3021-3028.

Lewis, T. M. 2012. Shoreline distribution and landscape genetics of bears in recently deglaciated fjord: Glacier Bay, Alaska. M. S. thesis. University of Alaska Fairbanks, Alaska, USA.

Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource selection by animals. Kluwer Academic Publishers, Dordrecht, Netherlands.

Martin, J. R. 1989. Vegetation and environment in old-growth forests of northern southeast Alaska: a plant association classification. M.S. thesis. Arizona State University, Tempe, Arizona, USA.

Matson, G., L. Van Daele, E. Goodwin, L. Aumiller, H. Reynolds, and H. Ristienko. 1993. A laboratory manual for cementum age determination of Alaska brown bear first premolar teeth. Matson's Laboratory, Milltown, Montana, USA.

Mattson, D. J., R. R. Knight, and B .M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research and Management 7:259-273.

McLellan, B. N., and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behavior, habitat use and demography. Journal of Applied Ecology 25:451-460.

McLoughlin, P. D., R. L. Case, R. J. Gau, S. H. Ferguson, and F. Messier. 1999. Annual and seasonal movement patterns of barren-ground grizzly bears in the central Northwest Territories. Ursus 11:79-86.

McNab, B. K. 1963. Bioenergetics and the determination of home range size. American Naturalist 97:133-140.

Miller, S. D., G. C. White, R. A. Sellers, H. V. Reynolds, J. W. Schoen, K. Titus, V. G. Barnes, Jr., R. B. Smith, R. R. Nelson, W. B. Ballard, C. C. Schwartz. 1997. Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133:1-55.

Mowat, G., and C. Strobeck. 2000. Estimating population size of grizzly bears using hair capture, DNA profiling, and mark-recapture analysis. Journal of Wildlife Management 64:183-193.

Nagy, J. S., and M. A. Haroldson. 1990. Comparison of some home range and population parameters among four grizzly bear population in Canada. International Conference on Bear Research and Management 8:227-235.

Paetkau, D. W., G. F. Shields, and C. Strobeck. 1998. Gene flow between insular, coastal and interior populations of brown bears in Alaska. Molecular Ecology 7:1283-1292.

Paetkau, D. W. 2003. An empirical exploration of data quality in DNA-based population inventories. Molecular Ecology 12:1375-1387.

Pritchard, J. K., M. Stephen, and P. Donnelly. 2000. Inference of population structure using multilocus genotype data. Genetics 155:945–959.

Porter, B. 2001. Unit 1 brown bear management report. Pages 1-17 *in* C. Healy, editor. Brown bear management report of survey-inventory activities 1 July 1998-30 June 2000. Alaska Department of Fish and Game. Juneau, USA.

Proctor, M., B. McLellan, C. Strobeck, and R. Barclay. 2005. Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. Proceedings of the Royal Society 272:2,409–2,416. Published online. doi:10.1098/rspb.2005.3246.

Proctor, M. B., D. Paetkau, B. N. McClellan, G. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm,' C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. D. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs 180:1–46.

R Development Core Team (2011). R A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Reynolds, H. V. 1980. North slope grizzly bear studies. Alaska Department of Fish and Game. Juneau, Alaska, USA.

Rousset, F. 2008. Genepop'007: a complete re-implementation of the genepop software for Windows and Linux. Molecular Ecology Resources 8:103–106.

Samson, F. B. and others. 1989. Conservation of rain forests in southeast Alaska: report of a working group. Transactions 54th North American Wildlife and Natural Resource Conference 54:121-133.

Schoen, J. W., L. R. Beier, J. W. Lentfer, and L. J. Johnson. 1987. Denning ecology of brown bears on Admiralty and Chichagof Islands. International Conference on Bear Research and Management 7:293-304.

Schoen, J. W. and L. R. Beier. 1990. Brown bear habitat preferences and brown bear logging and mining relationships in Southeast Alaska. Final Report. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration Project W-22-1, Study 4.22. Juneau, USA.

Schoen, J. W., R. W. Flynn, L. H. Suring, K. Titus, and L. R. Beier. 1994. Habitat-capability model for brown bear in Southeast Alaska. International Conference for Bear Research and Management 9:327-337.

Schwartz, C. C. and S. M. Arthur. 1999. Radio-tracking large wilderness mammals: integration of GPS and Argos technology. Ursus 11:261-274.

Schwartz, C. C., S. D. Miller, and M. A. Haroldson. 2003. Grizzly bear. Pages 556-586 *in* G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors. Wild Mammals of North America: Biology, Management, and Conservation. Second edition. Johns Hopkins University Press. Baltimore, Maryland, USA.

Suring, L. H., S. D. Farley, G. V. Hilderbrand, M. I. Goldstein, S. Howlin, W. P. Erickson. 2006. Patterns of landscape use by female brown bears on the Kenai Peninsula, Alaska. Journal of Wildlife Management 70:1580-1587.

Talbot, S. L. and G. F. Shields. 1996. Phylogeography of brown bears (Ursus arctos) of Alaska and paraphyly within the Ursidae. Molecular Phylogenetics and Evolution 5:477-494.

Taylor, W. P., Jr., H. V. Reynolds III, and W. B. Ballard. 1989. Immobilization of grizzly bears with tiletamine hydrochloride and zolazepam hydrochloride. Journal of Wildlife Management 53:978-981.

Titus, K., and L. R. Beier. 1994. Population and habitat ecology of brown bears on Admiralty and Chichagof islands. Progess Report. Alaska Department Fish and Game. Federal Aid in Wildlife Restoration Project W-24-2, Study 4.22. Juneau, AK, USA.

Titus, K., R. W. Flynn, G. W. Pendleton, and L. R. Beier. 1999. Population and habitat ecology of brown bears on Admiralty and Chichagof islands. Final Report. Alaska Department Fish and Game. Federal Aid in Wildlife Restoration Project W-27-3, Study 4.22. Juneau, AK, USA.

Titus, K., J. N Trent, L. D. Aumiller, J. H. Westlund, and M. Sigman. 1994. Managing brown bears as both game and nongame: Past experiences and future prospects. Transactions of the 59th North American Wildlife and Natural Resources Conference 59:353-362.

Van Daele, L J. 2007. Population dynamics and management of brown bears on Kodiak Island, Alasaka. PhD. thesis. University of Idaho, Moscow, ID, USA.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA, USA.

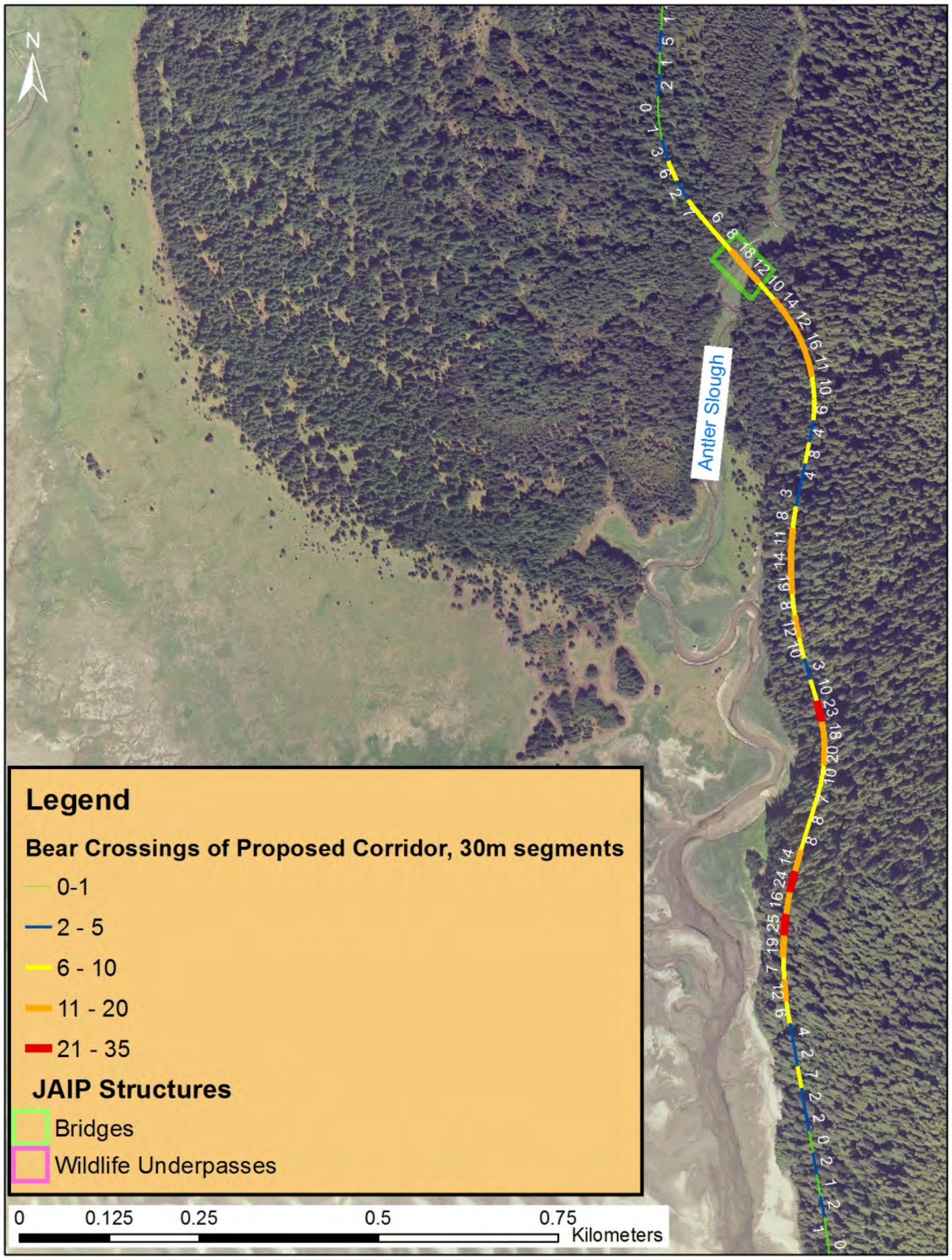
Waller, J. S., and C. Servheen. 2005. Effects of transportation infrastructure on grizzly bears in northwestern Montana. Journal of Wildlife Management 69(3):985–1000.

Wiens, T. S., B. C. Dale, M. S. Boyce, G. P. Kershaw. 2006. Three way k-fold cross-validation of resource selection functions. Ecological Modelling 212:244-255.

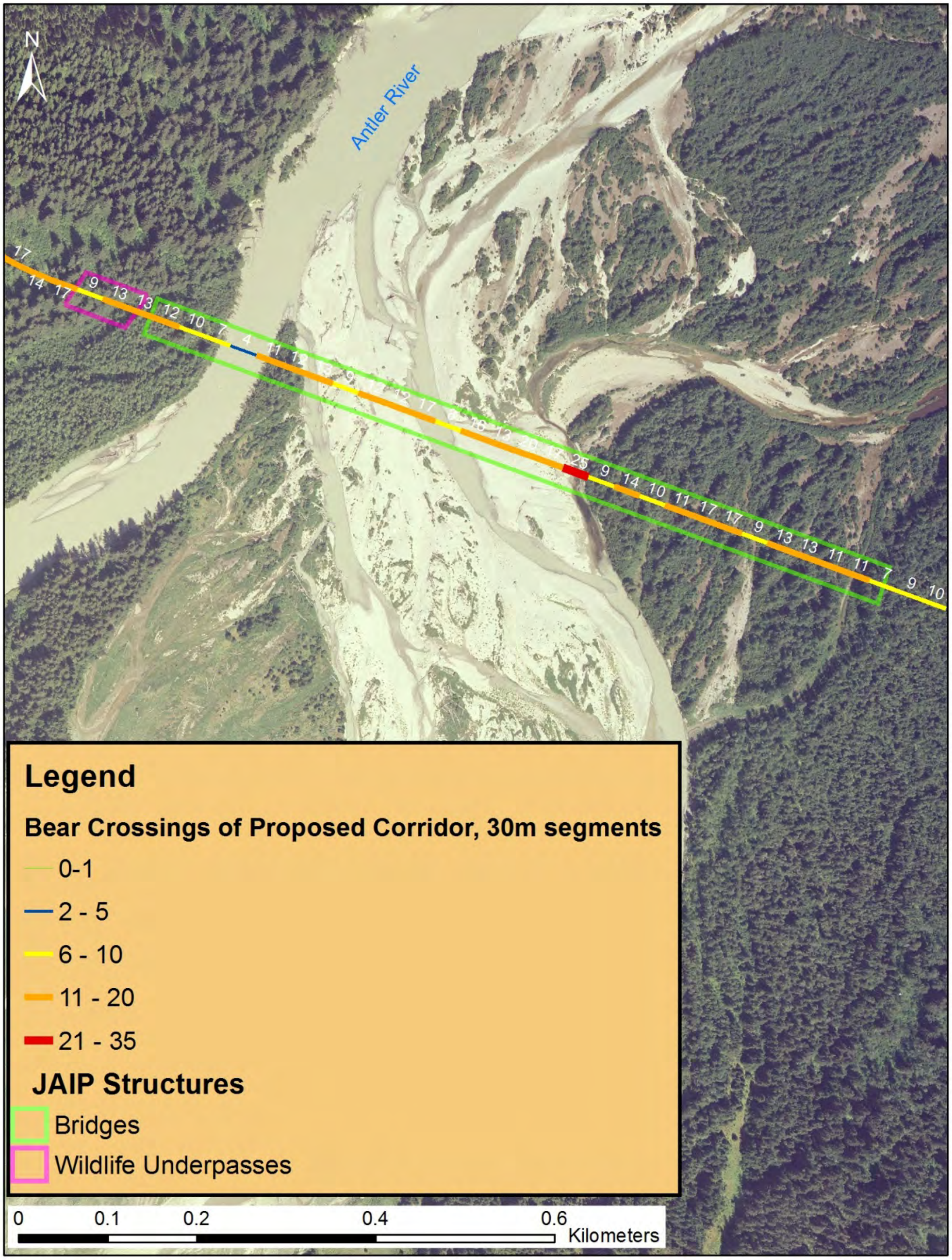
White, K. S., D. P. Gregovich and G. W. Pendleton, N. L. Barten, R. Scott, A. Crupi and D. N. Larsen. 2012. Mountain goat population ecology and habitat use along the Juneau Access road corridor, Alaska. Final wildlife research report. ADF&G/DWC/WRR-2012-02. Alaska Department of Fish and Game, Juneau, AK. USA.

Woods, J. G., D. Paetkau, D. Lewis, B. N. McLellan, M. Proctor, and C. Strobeck. 1999. Genetic tagging free ranging black and brown bears. Wildlife Society Bulletin 27:616-627.

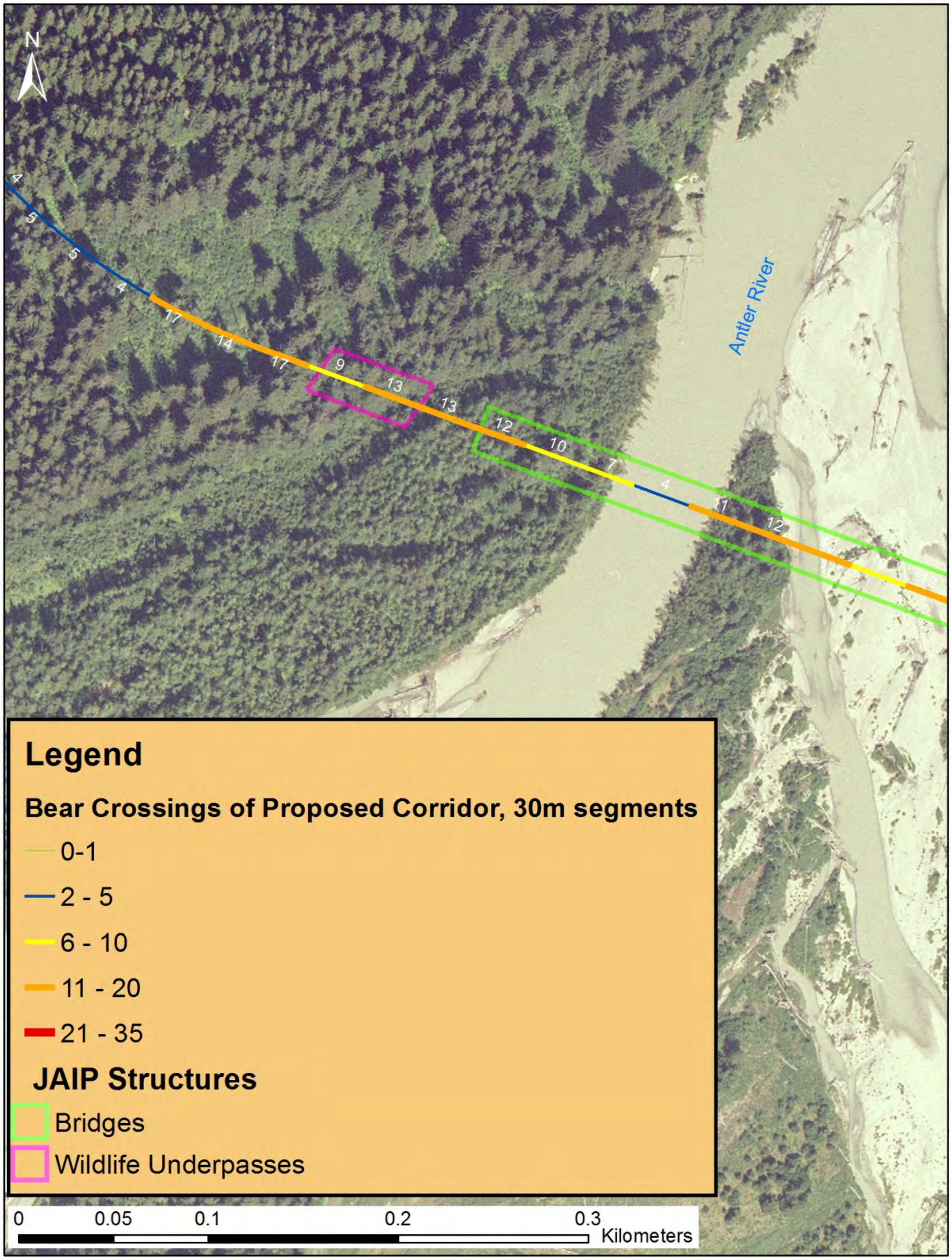
Appendices



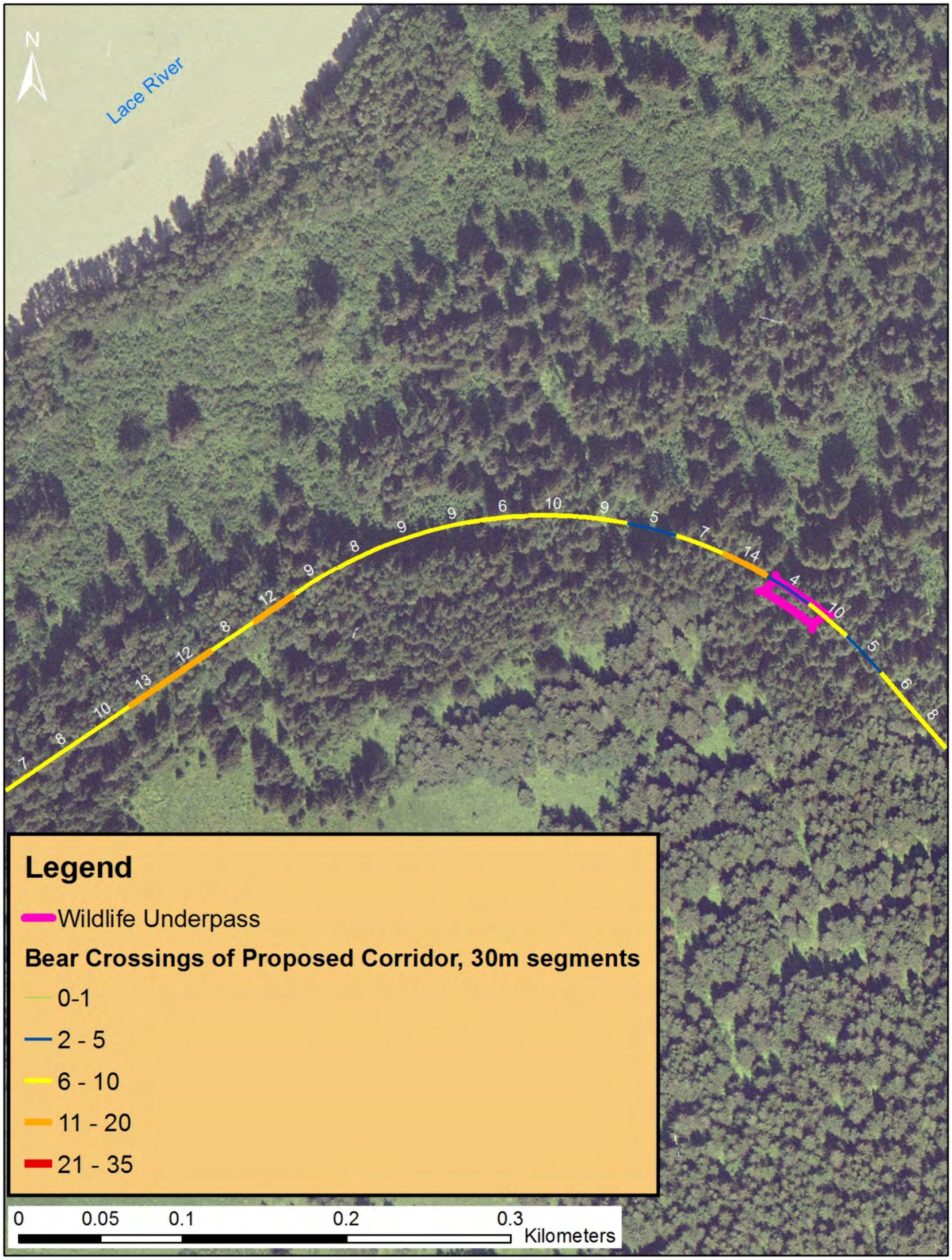
Appendix A. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor near Antler Slough in the Berners Bay estuary, 2006 to 2010. The planned bridge is shown and the number of crossings within each 30 m segment is color coded and labeled.



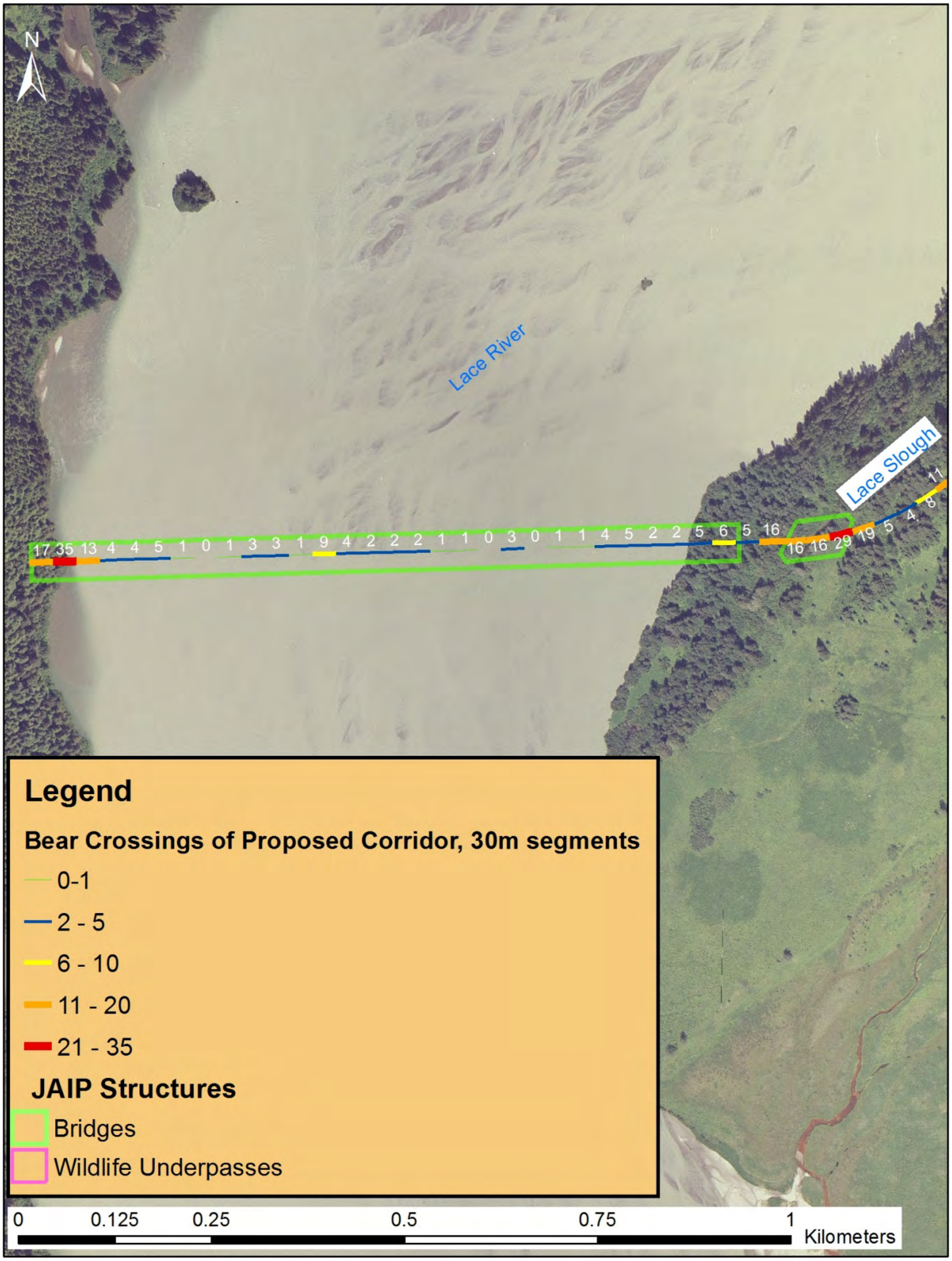
Appendix B. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor near Antler River in the Berners Bay estuary, 2006 to 2010. The planned underpass and bridge are shown and the number of crossings within each 30 m segment is color coded and labeled.



Appendix C. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor near Antler River in the Berners Bay estuary, 2006 to 2010. The planned underpass and bridge are shown and the number of crossings within each 30 m segment is color coded and labeled.



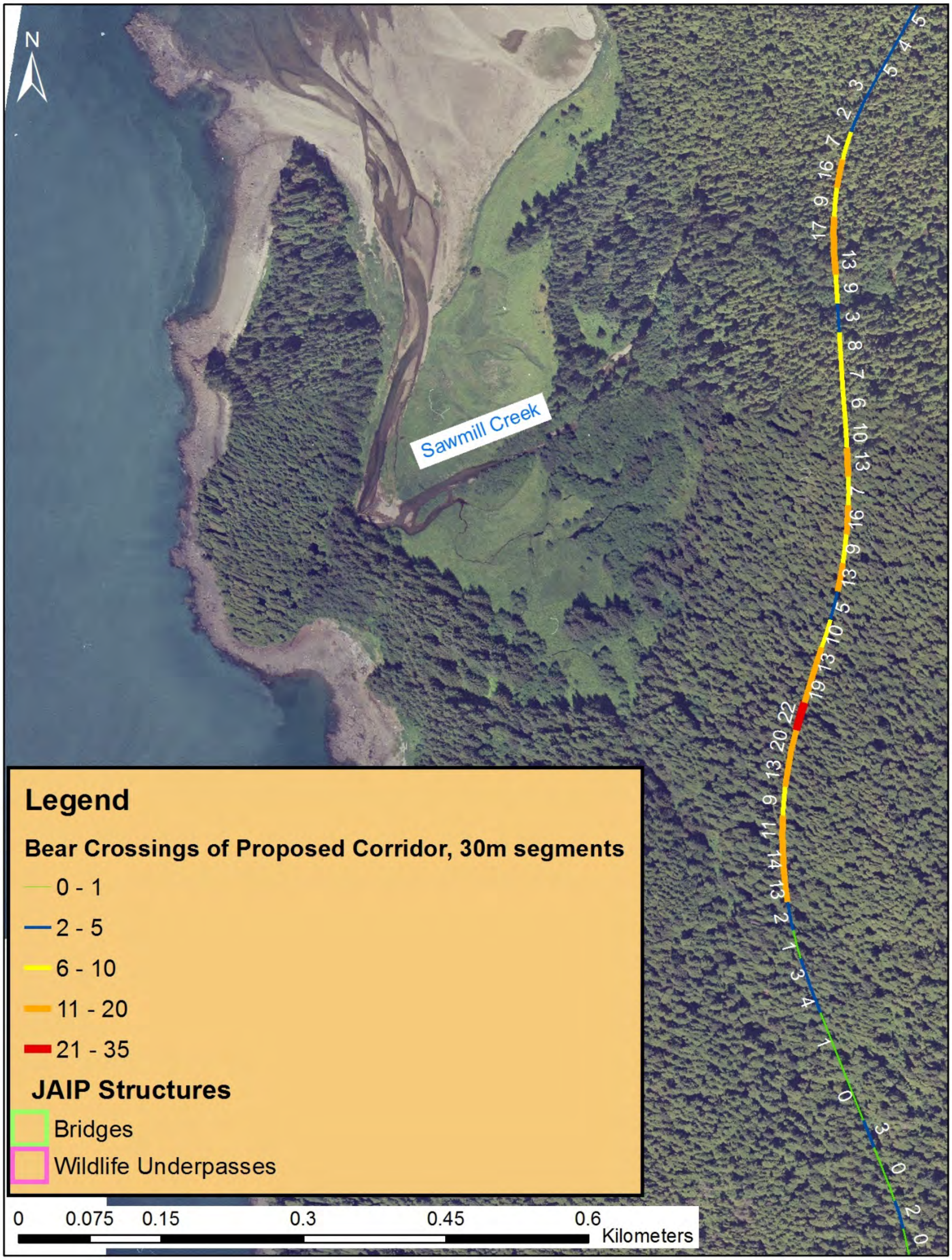
Appendix D. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor south of the Lace River near the Berners Bay estuary, 2006 to 2010. The planned underpass is shown and the number of crossings within each 30 m segment is color coded and labeled.



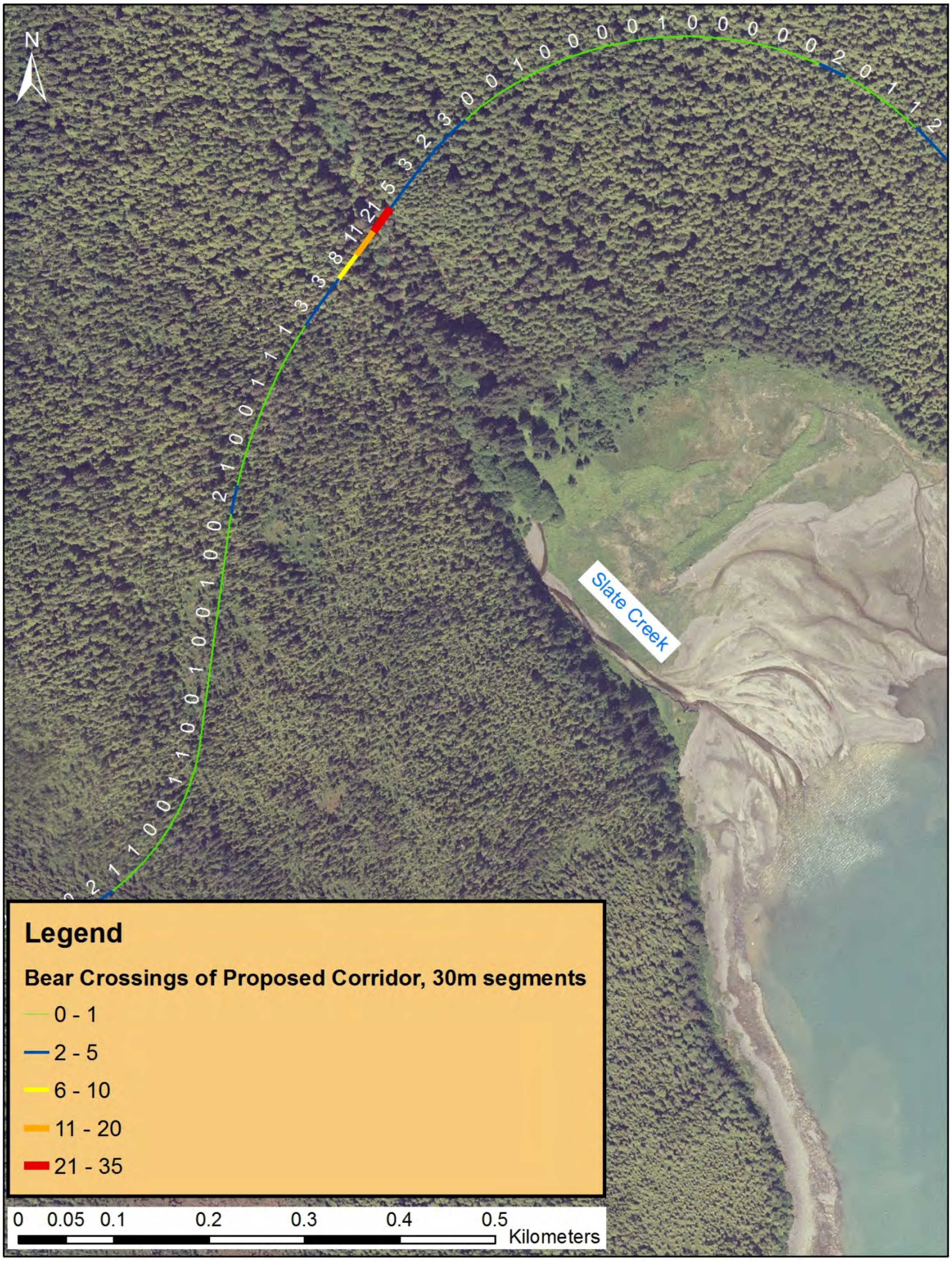
Appendix E. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor near Lace River and Lace Slough in the Berners Bay estuary, 2006 to 2010. The planned bridges are shown and the number of crossings within each 30 m segment is color coded and labeled.

Appendix F. Frequency of brown bear crossings at planned bridges and underpasses along the proposed Juneau Access Improvements Project (JAIP) road corridor in the Berners Bay estuary, 2006 to 2010. Reported is the frequency of bear crossings at locations within the associated planned structures along the proposed road corridor.

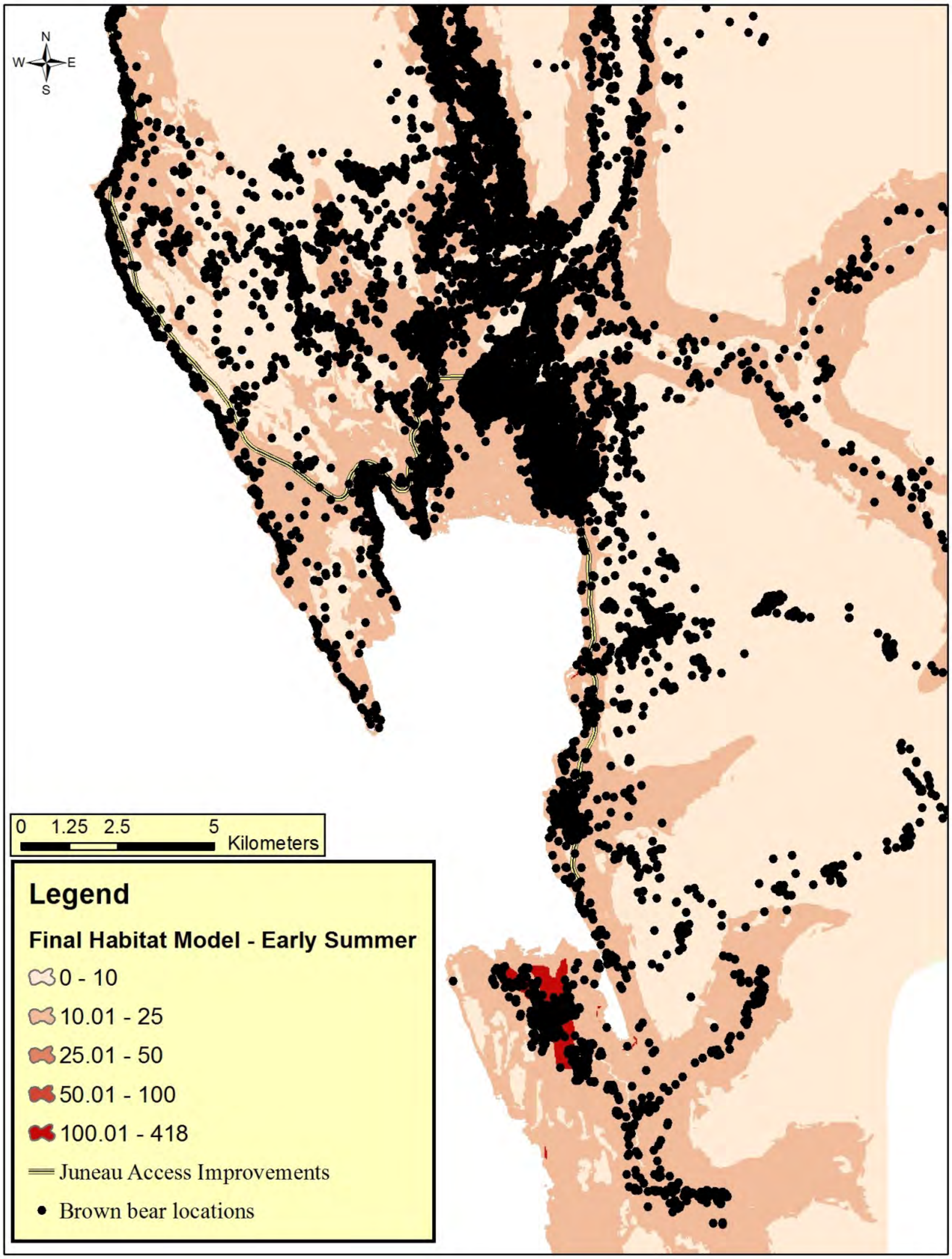
JAIP crossing structure	JAIP station	Bear crossing frequency	%
Antler Slough bridge	628-630	20	0.7
Antler River bridge	641-668	347	11.4
Antler River underpass	670-672	14	0.5
Lace River underpass	694-695	6	0.2
Lace Slough bridge	724	17	0.6
Lace River bridge	728-756	124	4.1
All structures		528	17.3



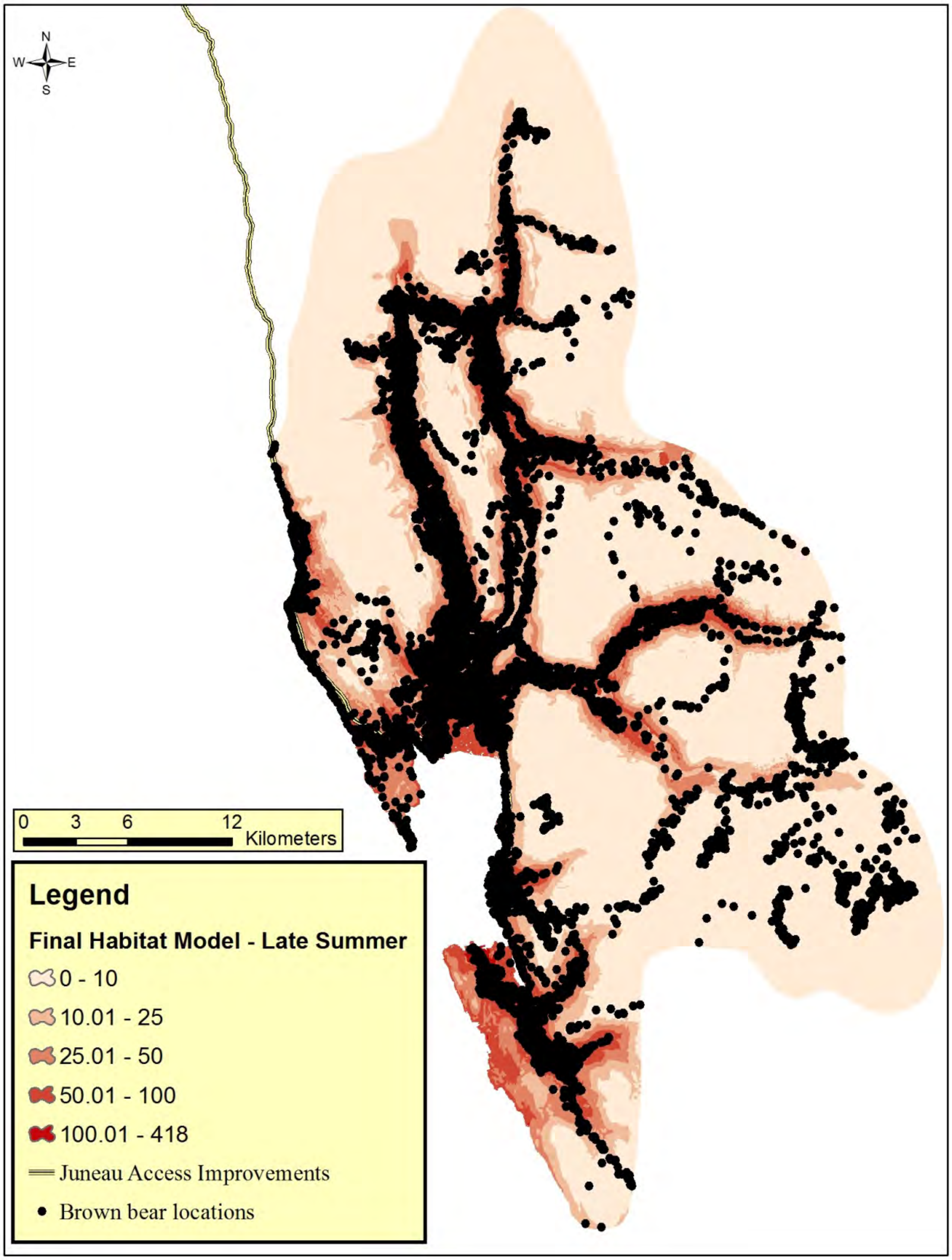
Appendix G. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor at Sawmill Creek in Berners Bay, 2006 to 2010.



Appendix H. Frequency of brown bear crossings along the proposed Juneau Access Improvements Project road corridor at Slate Creek in Berners Bay, 2006 to 2010.



Appendix I. Map predicting relative probability of resource selection (RSF) during early summer for brown bear locations in Berners Bay, Southeast Alaska, focusing on the lower bay. All the brown locations from data collected 2006 to 2010 are also shown.



Appendix J. Map predicting relative probability of resource selection during late summer season for brown bears in Berners Bay, Southeast Alaska. All the brown bear locations from data collected from 2006 to 2010 are also shown.

Appendix K. Proportional use of habitats by brown bears by season in Berners Bay, Southeast Alaska, 2006 to 2010. All brown bears combined. Available points were randomly selected in the intensive study area at a density of 30 points per 1 km.

Habitat	Early summer	Late summer	Available points
Beach	0.023	0.034	0.011
Estuarine emergent	0.210	0.092	0.004
Herbaceous	0.049	0.021	0.019
River bottom	0.039	0.050	0.029
Shrub	0.210	0.184	0.134
Scrub forest	0.065	0.125	0.105
Open forest	0.180	0.279	0.123
Closed forest	0.098	0.173	0.076
Unvegetated	0.119	0.032	0.490

Appendix L. Captures and fates of brown bears in Berners Bay greater study area during 2006 to 2011, Southeast Alaska. The WGI ID is the number assigned by Wildlife Genetics International from the DNA analysis. All captured brown bears were assumed to be alive upon recapture or when the radio signal was still on active mode. Death of a collared bear was determined from finding remains. Hunter-killed bears were from ADF&G sealing records.

Bear	WGI ID	Capture date	Data begins	Data stopped	Collar on bear until	Fate
401	6001	06/10/2006	06/10/2006	01/04/2007	01/04/2007	Dead: 01/04/2007; natural death
402[a]	6002	06/11/2006	06/11/2006	07/19/2006	09/01/2006	Alive: recaptured 11/02/2006
402[b]	6002	11/02/2006	11/02/2006	06/08/2007	09/01/2007	Alive: recaptured on 11/03/2007
402[c]	6002	11/03/2007	11/03/2007	05/10/2008	06/19/2008	Alive: recaptured on 06/19/2008
402[d]	6002	06/19/2008			06/30/2008; Collar not initialized	Dead: 09/15/2010; hunter kill
403	6003	06/11/2006			Not collared	Alive: recaptured 07/01/2006
403[a]	6003	07/01/2008	07/01/2008	10/04/2008	10/04/2008	Dead: 10/04/2008; hunter kill
404	6004	06/11/2006			Not collared; no data;	
405	6005	06/11/2006	06/11/2006	11/26/2006	11/26/2006	Alive: 09/28/2007
406[a]	6006	06/12/2006	06/11/2006	05/21/2007	05/21/2007	Alive: 07/02/2008; recaptured
406[b]	6006	07/02/2008	07/02/2008	09/21/2008	09/21/2008	Alive: 07/06/2009; recaptured
406[c]	6006	07/06/2009	07/06/2009	03/05/2010	6/25/2010	Alive: 6/25/2010
407	6007	06/12/2006			Collar not retrieved	Alive: 10/09/2009;
408	6008	06/13/2006			VHF collar	Alive: 07/13/2008
409	6009	06/27/2006			Collar not retrieved	Alive: 07/13/2008;
410[a]	6010	06/29/2006	06/29/2006	11/20/2006	11/20/2006	Alive: 07/06/2007; recaptured
410[b]	6010	07/06/2007	07/06/2007		11/06/2007	Alive: 11/06/2007; recaptured
410[c]	6010	11/06/2007	11/06/2007	05/28/2008	05/28/2008	Alive: 07/29/2008
411[a]	6011	06/29/2006	06/29/2006		10/24/2006	Alive: 5/11/2007
411[b]	6011	06/19/2007	06/19/2007	07/24/2008	10/16/2008	Dead: 05/13/2010; hunter kill
412	6012	06/30/2006	06/30/2006	11/07/2006	11/07/2006	Alive: 07/27/2007
413	6013	07/06/2006			Collar not retrieved	Alive: 05/20/2011;
414	6189	10/29/2006	10/29/2006	06/23/2008	06/23/2008	Alive: 06/24/2008
415[a]	6190	10/31/2006	10/31/2006	06/12/2007	06/12/2007	Alive: 06/29/2007

Bear	WGI ID	Capture date	Data begins	Data stopped	Collar on bear until	Fate
415[b]	6190	07/07/2007	07/07/2007	10/10/2007	10/10/2007	Alive: 10/10/2007
415[c]	6190	10/31/2007			Collar not initialized	Alive: 06/30/2008
415[d]	6190	06/30/2008	06/30/2008	07/01/2008	07/01/2008	Dead: 07/01/2008; natural
416	6191	10/31/2006	10/31/2006	11/16/2006	11/16/2006	Alive: 04/02/2007
417[a]	6192	11/01/2006	11/01/2006	11/13/2006	Collar malfunction	Alive: 06/15/2007; recaptured
417[b]	6192	06/15/2007	06/15/2007	11/11/2007	04/02/2008	Alive: 04/02/2008
417[c]	6192	07/13/2008	07/13/2008	08/13/2008	08/13/2008	Alive: 08/13/2008
418[a]	6193	11/02/2006	11/02/2006	05/19/2007	09/14/2007	Alive: 07/02/2008; recaptured
418[b]	6193	07/02/2008			Collared	Alive: 10/31/2008; recaptured
418[b]	6193	10/31/2008			05/20/2011; Collar not retrieved	Alive: 05/20/2011
419[a]	6194	11/02/2006	11/02/2006	06/05/2007	06/19/2008	Alive: 06/19/2008; recaptured
419[b]	6194	06/19/2008	06/19/2008	08/25/2008	08/25/2008	Alive: 08/25/2008
420[a]	6089	06/17/2007			Didn’t change collar	Alive: 06/18/2007; recaptured
420[a]	6089	06/18/2007			05/20/2010; collar not retrieved	Alive: 05/20/2010;
421	6196	06/17/2007	06/17/2007	07/14/2008	10/31/2008	Dead: 5/18/2012; hunter kill
422	6063	06/17/2007			06/17/2007	Dead: 06/17/2007; killed by other bear
423	6198	06/18/2007	06/18/2007	10/23/2007	10/23/2007	Alive: 10/23/2007
424a	6199	06/19/2007	06/19/2007	11/13/2007	07/01/2008	Alive: 07/01/2008; recaptured
424[b]	6199	07/01/2008	07/01/2008	11/08/2008	11/08/2008	Dead: 05/23/2009; hunter kill
425	6200	06/19/2007	06/19/2007	11/15/2007	03/07/2008	Alive: 03/07/2008
426	6030	06/20/2007	06/20/2007	08/31/2008	08/31/2008	Alive: 08/31/2008
427	6018	07/06/2007	07/06/2007	06/09/2008	06/30/2008	Alive: 06/30/2008
428[a]	6203	07/07/2007	07/07/2007	06/30/2008	06/30/2008	Alive: 07/13/2008; recaptured
428[b]	6203	07/13/2008	07/13/2008	10/02/2009	10/02/2009	Dead: 05/16/2010; hunter kill
429	6204	07/07/2007	07/07/2007	08/31/2008	08/31/2008	Alive: 08/31/2008
430[a]	6323	09/13/2007	09/13/2007	07/15/2008	07/15/2008	Alive: 07/15/2008
430[b]	6323	07/15/2008			Collared.	Alive: 6/26/2009

Bear	WGI ID	Capture date	Data begins	Data stopped	Collar on bear until	Fate
430[b]	6323	10/20/2008	07/15/2008	10/13/2008	06/26/2009; Didn't change collar	Alive: 06/25/2009
430[c]	6323	06/25/2009	06/25/2009	09/11/2009	09/11/2009	Alive: 10/11/2009
431[a]	6232	10/31/2007	10/31/2007	05/28/2008	05/28/2008	Alive: 07/07/10
431[a]	6232	07/07/2010			Removed collar	Alive: 07/07/2010; recapture
432	6045	11/02/2007	11/02/2007	06/20/2009	06/20/2009	Alive: 06/21/2009
433[a]	6086	11/02/2007	11/02/2007	09/01/2008	09/01/2008	Alive: 09/01/2008
433[b]	6086	11/06/2008	11/06/2008	06/12/2009	11/10/2009	Dead: 11/10/2009; other bear
434[a]	6305	11/03/2007			Didn't change collar	Alive: 11/05/2007; recaptured
434[a]	6305	11/05/2007	11/03/2007	12/20/2007	12/20/2007	Dead: 12/20/2007; natural
436[a]	6375	11/06/2007	11/06/2007	11/21/2007	02/11/2008	Alive: 07/03/2008
436[b]	6375	07/03/2008	07/03/2008	07/04/2008	07/04/2008	Dead: 07/04/2008; natural
437[a]	6443	06/13/2008	06/13/2008	06/25/2009	06/25/2009	Alive: 06/25/2009
437[a]	6443	10/18/2008			Didn't change collar	Alive: 06/25/2009; recaptured
437[b]	6443	06/25/2009	06/25/2009	09/08/2011	09/08/2011	Alive: 09/08/2011
438	6280	06/15/2008			05/20/2011; Didn't get collar back	Alive: 05/20/2011
439[a]	6141	06/30/2008	06/30/2008	06/25/2009	06/25/2009	Alive: 06/25/2009
439[b]	6141	06/25/2009	06/25/2009	07/11/2009	07/11/2009	Alive: 07/11/2009
440	6095	07/01/2008	07/01/2008	08/03/2008	08/03/2008	Alive: 08/03/2008
441[a]	6558	07/13/2008	07/13/2008	09/24/2008	10/31/2008	Alive: 10/31/2008; recaptured
441[b]	6558	10/31/2008	10/31/2008	06/24/2009	06/24/2009	Alive: 06/24/2009; recaptured
441[c]	6558	06/24/2009	06/24/2009	12/06/2010	09/08/2011	Alive: 09/08/2011
442	6667	10/18/2008			Not collared; No data	Alive: 10/18/2008
443	6534	10/18/2008				Dead: 10/18/2008; capture
444	6172	10/31/2008	10/31/2008	09/09/2010	09/09/2010	Alive: 09/09/2010
445	6269	10/31/2008			Not collared; no data	Alive: 10/31/2008
446[a]	6231	11/01/2008	11/01/2008	09/08/2010	10/12/2010	Alive: 11/06/2008; recapture
446[a]	6231	11/06/2008	11/01/2008	09/08/2010	10/12/2010; same collar	Dead: 10/12/2010; killed by a bear

Bear	WGI ID	Capture date	Data begins	Data stopped	Collar on bear until	Fate
447	6238	11/01/2008			Not collared	Alive: 11/01/2008; cub of #446
447	6238	11/07/2008			Not collared	Alive: 11/07/2008; cub of #446
448	6265	11/01/2008	11/01/2008	09/01/2009	09/01/2009	Alive: 09/01/2009; cub of #446
449[e]		11/04/2007			Not collared	Alive: 11/04/2007; #415's cub
019009[f]	6215	09/25/2008			Non-captured	Dead: 09/25/2008; hunter kill
019010[f]	6665	09/25/2008			Non-captured	Dead: 09/25/2008; hunter kill
018997[f]	6207	05/23/2008			Non-captured	Dead: 05/23/2008; hunter kill
517825[f]	6419	05/25/2007			Non-captured	Dead: 05/25/2008; hunter kill

[a] The first collar on an individual bear.
[b] The second collar on an individual bear.
[c] The third collar on an individual bear.
[d] The fourth collar on an individual bear.
[e] A COY cub that we didn't process because the sow (#415) was nearby.
[f] Hunter-killed bears that were sampled as part of the DNA analysis.

Back cover photos: *Top*—Brown bear cub waiting for our crew to process her mother near Berners Bay, Southeast Alaska, ©2008 ADF&G, photo by LaVern Beier. *Bottom*—The Berners Bay estuary during early June showing abundant emergent herbaceous vegetetion. ©2007 ADF&G, photo by LaVern Beier.