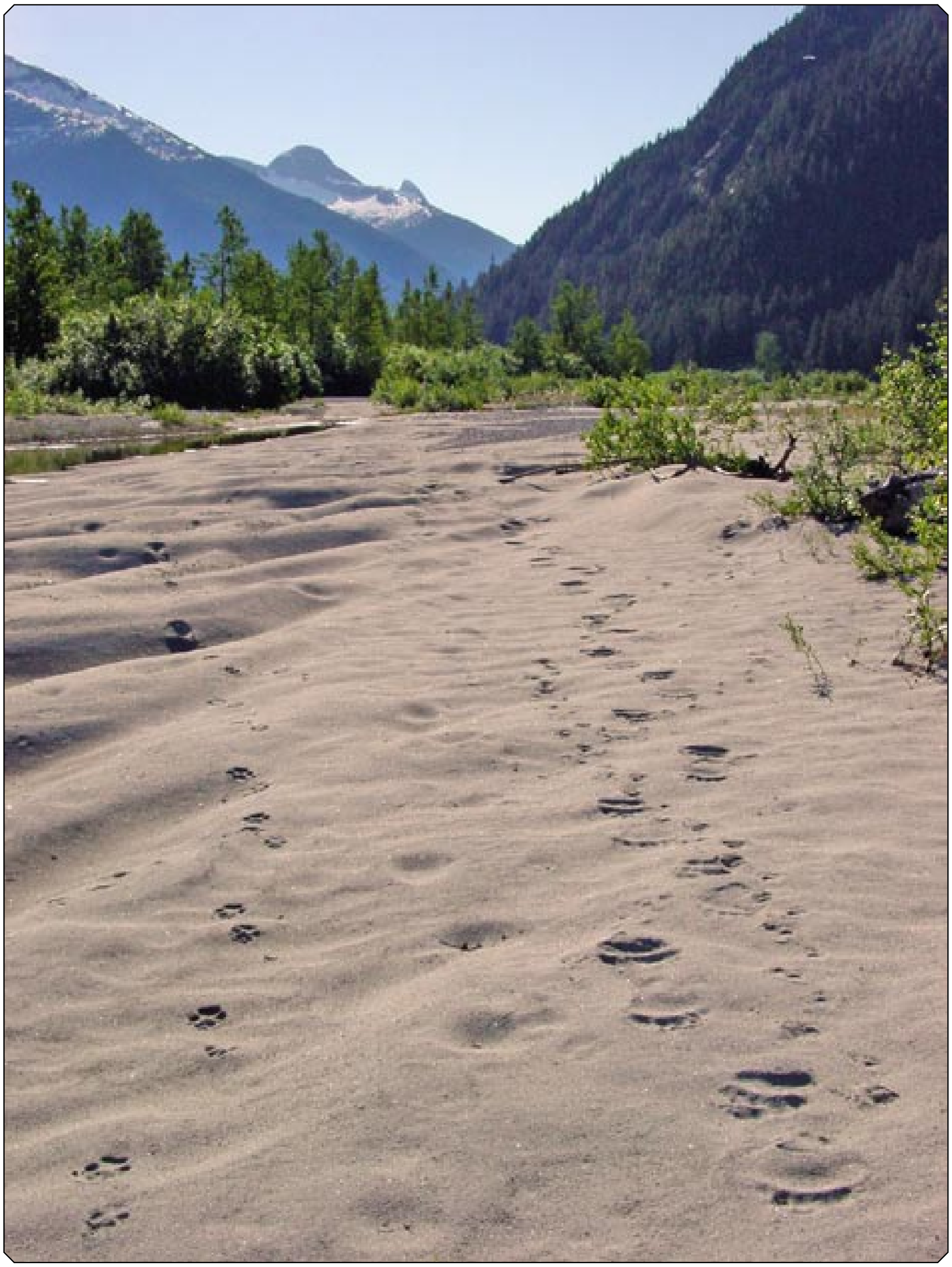
Appendix 1: Research Proposal

Brown Bear (Ursus arctos) Habitat Values and Signs of Use in Southeast Alaska: A high resolution approach to multiple-scale information needs

(Includes methods used in the Berners Bay Report - pages 17-22)



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Brown Bear (Ursus arctos) Habitat Values and Signs of Use in Southeast Alaska:
A high resolution approach to multiple-scale information needs

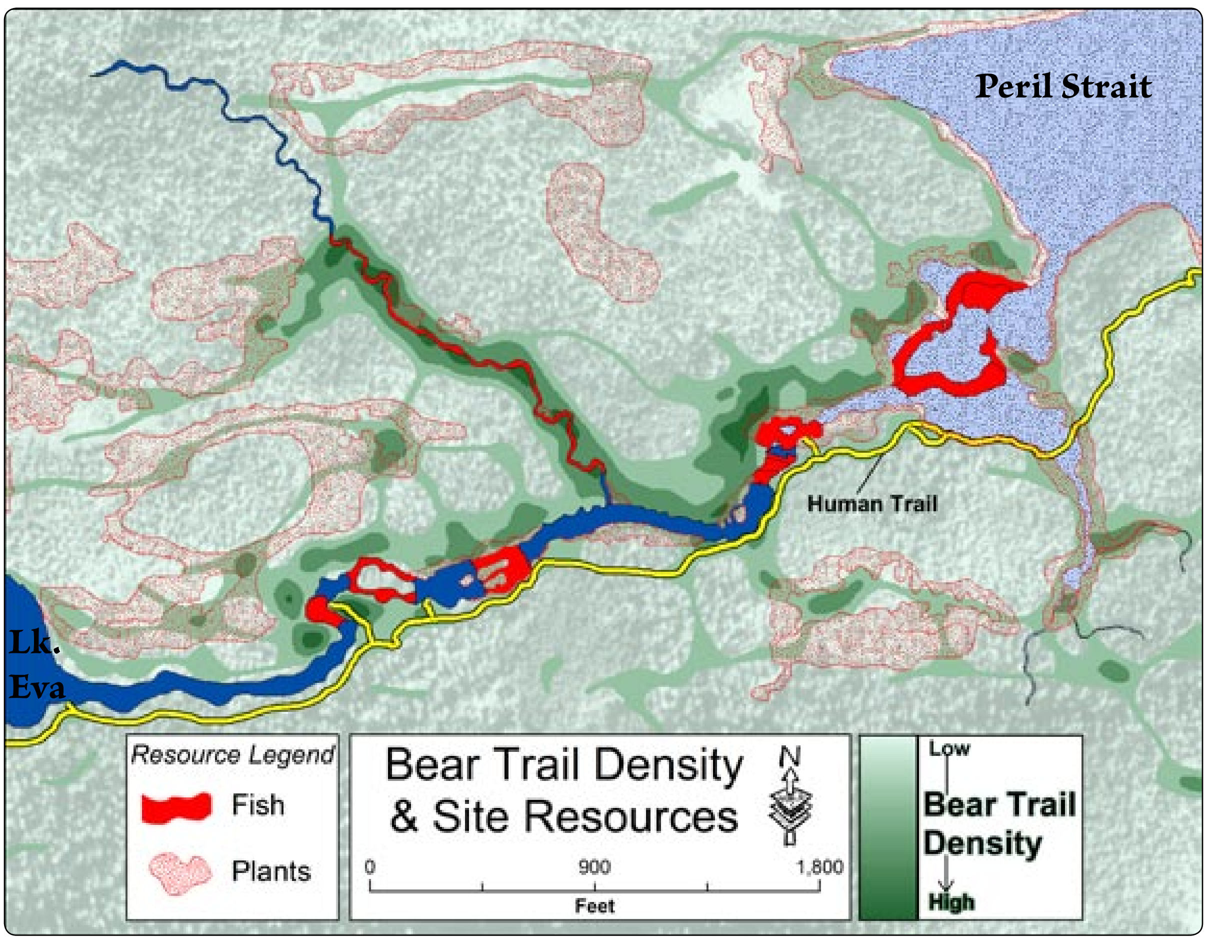
ABSTRACT

The purpose of the project described by this research proposal is to address information needs for brown bear habitat planning efforts at multiple-scales. The crux of the work will be applying a rapid habitat assessment and bear use survey protocol (brown bear quick cruise[1]) to investigate correlations between recorded bear sign, habitat features (food and cover values) and alternate measures of bear activity (telemetry data and isotope analysis of tree rings for marine derived nutrients). Results of pilot investigations (Fig. 1) on Admiralty, Baranof and Chichagof (ABC) islands demonstrated potentially significant correlations between bear sign densities and habitat qualities (Christensen, et al. 2003, Christensen, et al. 2004). These correlations suggest that bear sign can be used as a proxy for short and long-term bear activity patterns and a predictor for habitat value. Efforts to make the BBQC statistically robust will result in a rapid and inexpensive means for improving brown bear habitat assessment and monitoring at multiple-scales.

The goals of this project are to:

1. Investigate correlations between perennial bear sign and habitat features (i.e. food and cover values).
2. Validate the BBQC with telemetry data and isotope analysis of marine derived nutrients in vegetation); and
3. Adapt the BBQC to provide high resolution[2] data for site-level planning and for integration with broad scale habitat management.

Fig. 1. This figure compares bear trail density and food availability in the lower Lake Eva watershed of Baranof Island. For this figure I used Arcview™ Spatial Analyst to describe the trail density spectrum measured at this site using the BBQC. I overlaid the resource data from the stream and vegetation surveys to consider spatial correlations.

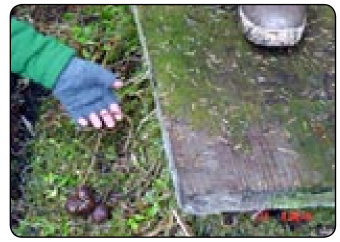


[1]The brown bear quick cruise (BBQC) terminology follows work done by Kirchoff et al. for Sitka black-tailed deer.

[2] Resolution in this context derives from the ratio of information to area, e.g. more information per unit area = higher resolution.

INTRODUCTION

Brown bear habitat management in southeast Alaska is a complex system of conflicting interests set within a highly dynamic ecosystem and occurring across a broad range of spatial and temporal scales. Increased demand for recreation and tourism opportunities in the past five years (USDA Forest Service, 2002), brown bear viewing in particular, has been added to resource managers' already challenging list of responsibilities. Resource managers are tasked with providing for timber, mining, tourism, recreation, hunting, and subsistence interests, and are held to the stipulations of Wilderness mandates, habitat stewardship, and population viability. Brown bear habitat management is further complicated by jurisdictional fragmentation, a scarcity of high resolution habitat data, and the challenges associated with applying management recommendations across spatial scales.



An understanding of habitat use patterns is an important component in assessing the effectiveness of conservation strategies for brown bear population dynamics and viability (Craighead 2002). In a scientific review of the Tongass Land Management Plan, McLellan identified the need for an inexpensive, extensive monitoring method for modeling bear habitat use and demographics (1994). Craighead et al. and researchers with the Alaska Department of Fish and Game (ADF&G) are currently building on the work of Schoen et al. (1994) by re-modeling brown bear habitat values for much of southeast Alaska using telemetry data and expert opinion approaches. Both ventures hold promise for contributing to regional planning efforts but will likely continue to face similar challenges to those that the previous generation brown bear habitat capability model (HCM) faced; namely, existing habitat data is too coarse for the fine-scaled analysis needed in site-level planning. On-the-ground development activities (e.g. logging and tourism activity) involve little more than applying the somewhat arbitrary stream and estuary buffer prescriptions (though neither are currently employed in tourism management). The question of whether the buffers are adequate for insuring the integrity of brown bear ecology has not been effectively tested.

The BBQC methods and protocols included in this proposal were adapted from techniques originally designed by H. Lentfer and G. Streveler to assess the potential impact of a hydroelectric project to bear habitat use (Fig. 2). In subsequent years I refined and applied these methods to four additional sites in the northern half of Southeast Alaska. In these studies I looked at the relationship between brown bear habitat use and recreation, tourism, and road development (Christensen, et al. 2001, 2002, 2003). The core protocols of the BBQC have already provided valuable information to these fine-scale planning efforts. With additional

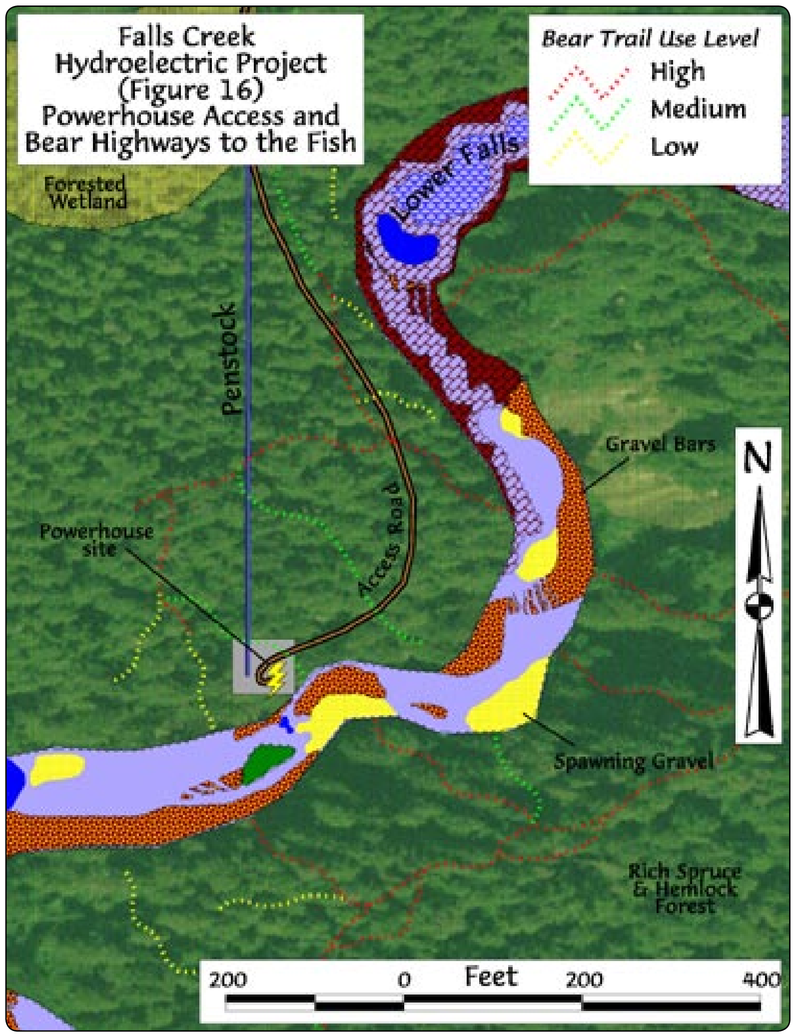


Fig. 2. This is a figure from the Falls Creek Hydroelectric Project Environmental Assessment. It suggests that bear trail concentration and geometry are due in part to stream features that influence salmon availability, i.e. spawning gravel and gravel bars locations. (Lentfer & Streveler 1999).

refinement the approach could be suited to information needs at additional scales.

Relevant Scales	Information Needs
Site	• Assessing site suitability and the impacts of various development activities. • Monitoring the effects of site development.
Site - Landscape	• Assessing the effectiveness of riparian, estuarine and beach buffers in protecting long-term patterns of brown bear habitat use.
Landscape - Regional	• Improvement of current and future broad-scale (regional) brown bear habitat models.

Justification

Brown bears are one of six species recognized in the Tongass Land Management Plan (TLMP) as having *special management concern*. This status is based on several biological and human related factors that make this species' long-term viability particularly vulnerable. These factors include: 1) a history of depletion; 2) an unusually slow reproductive rate; 3) pressures imposed by hunting and timber harvest; and 4) critical habitat needs of bears overlap with high human use areas (USDA Forest Service 1997; Suring, et al.. 1993).

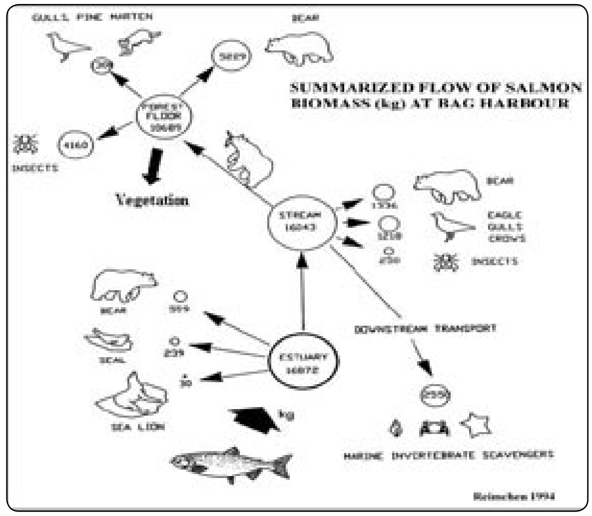


Fig. 3. (above) was created by Dr. Tom Reimchen in 1994 to illustrate the flow of marine derived nutrients via the immediate beneficiaries of spawning salmon. The photo below captures bear trail patterns at an estuary-forest habitat interface. Viewing bear trails as akin to primary arterials in an important "vascular" system; it may be useful to describe correlations between bear sign and marine derived nutrient levels in riparian vegetation to test buffer adequacy.

For scientists and managers brown bears are important indicators of ecosystem health. They are one of thirteen management *indicator species* identified in TLMP. Management indicator species are defined as "vertebrate or invertebrate species whose response to land management activities can be used to predict the likely response of other species with similar habitat requirements" (USDA Forest Service TLMP, 1997). Because brown bear home ranges can cover between 15-40 square miles (L. Beier pers. comm.) and occur across a diverse habitat mosaic, conservation of their habitat benefits a large number of species.

Applications

Filling site-level information needs - Southeast Alaska habitat data is too coarse to adequately meet information needs associated with site-level analysis. Habitat conservation goals must be integrated with site-level planning and adapted to on-the-ground reality to achieve their lofty ideals . There is a long overdue need for an effective and inexpensive method to rapidly assess brown bear habitat for planning and monitoring site-level development activities. Titus and Schoen (1993) suggested that monitoring methods to count bear tracks, trails, and day beds should be explored further. The BBQC provides a rapid and inexpensive means of assessing and monitoring habitat conservation strategies at site-level spatial extents.

Testing the adequacy of riparian buffers - Brown bears play important functional roles in forest ecology. Recent studies have shown that bear foraging behavior (Fig. 3) is important to the transport of marine derived nutrients into terrestrial ecosystems (Reimchen 1994; Willson et al. 1998; Hocking et al. 2002). These studies use isotope analysis of nitrogen and phosphoros levels in riparian vegetation to identify the source of nutrients important to terrestrial productivity, i.e. the fertilizer effect of the bear-salmon relationhsip. It is likely that the ecological function of the salmon-bear-forest cycle is critical to maintaining healthy riparian ecosystems. The dynamics between salmon, bears, and forest ecology are complex and vary significantly from site to site. Non-adaptive broad-scale management prescriptions are ill-suited to insuring the healthy function of such systems. Riparian buffer distances, for example, would better serve ecosystem integrity if they were geared to protecting the functional role of salmon in forest ecology v.s. being aimed primarily at salmon productivity. Because bears are a primary distributor of salmon derived nutrients to terrestrial systems, bear trails may provide an indicator of the spatial extent of salmon fertilization in the forest ecosystem. Applying the BBQC in riparian zones whose vegetation has been surveyed for concentrations of marine derived nutrients could provide an adaptive means of measuring the effectiveness of riparian buffers.

Contributions to habitat modelling - The resolution of existing habitat data and the expense of acquiring telemetry data make expert opinion and telemetry based models difficult to validate and confidently apply to the wide variety of habitat mosaics encountered in southeast Alaska. The BBQC protocol may provide a partial remedy for this circumstance. If correlations between telemetry data and bear sign are found to be strong the BBQC methods will provide a rapid and inexpensive means of validating broad-scale model predictions and adapting them to a greater variety of habitat mosaics. Furthermore, a systematic application of the BBQC protocol could lead to the development of a multiple-scale brown bear habitat model. Edwards et al. (2002) has shown that when results from models based on site specific, landscape, and regional scales are combined the resultant multiple-scale models tend to be the best overall predictors.

Site Selection

The BBQC is designed to adapt to most physiographic conditions encountered in southeast Alaska. In the initial phases of this project the focus will be on applying the methods to estuary areas, anadromous stream corridors, and their immediate ecological context on the ABC islands. Estuarine meadows and anadromous riparian corridors have been identified as areas of concern by resource managers because of their critical importance to population viability (Suring et al. 1993; Hilderbrand et al. 1999) and there is sufficient bear and human use overlap that "negative" interactions through habitat modification, displacement from preferred habitats and/or physical and mental stress may occur (Owens 2004). The Unit Four Brown Bear Management Team (BBMT) described these areas as "Human/Bear High Use Zones" and suggested they "may require additional management attention to ensure continued access by bears to these key habitats, and that human/bear interactions are not detrimental to either species" (Alaska Board of Game 2000).

The focus in the first phase of this project will be in studying the spatial correlation between habitat quality and bear sign in support of an effort to provide an adaptive habitat model that is relevant to fine-scaled considerations. Toward those ends site selection will be guided by the following:

- Sampling will provide an adequate range of habitat variability for modeling fine-scaled bear-habitat dynamics on the ABC islands;
- Surveys will be conducted in areas where telemetry studies have been done to provide opportunities for cross validation and to explore linkages between scales; and
- Perennial bear sign patterns will be compared through surveys conducted in second growth and old growth sites in order to better understand the dynamics of trade-off relationships under different mosaics of habitat resources (i.e. plant foods, salmon, and cover resources).

SURVEY METHODS

The BBQC is designed to test for correlations between bear sign and habitat features and provide high resolution data for site-level planning. There are three categories of data collected in the process:

1. Perennial bear sign (trails, beds, and trees)
2. Ephemeral bear sign (scat, bed activity, and signs of feeding)
3. Habitat features (plant resources and stream characteristics).

The focus of the BBQC may vary depending on research goals. Assessment and modeling may only require perennial sign and habitat surveys. Monitoring plans would likely incorporate ephemeral sign surveys.

Data is collected with a GPS receiver capable of relatively accurate (.1-10 meter) measurements below dense canopy. Receivers store point, line, and polygon shape files. Data is downloaded to a laptop computer on a daily basis for storage and initial processing.

MAPPING PERENNIAL BEAR SIGN

Perennial bear signs are marks left on the landscape from seasonally repeated patterns of bear activity that typically persist for more than a year after use has ended[3]. Three common types of perennial bear sign are documented at each site, including: trail networks, sign trees, and bedding areas. Perennial bear sign data is collected in four phases: 1) pre-field review, 2) intuitive controlled survey, 3) investigative survey, and 4) transect survey. Protocols are adapted from those used by the U.S. Forest Service and Bureau of Land Management (Hibler and O'Dell 1998; USDA and USDI 1999).

Pre-field review

The goal of the pre-field review process is to identify potential focal areas for field surveys that have a relatively high probability of exhibiting concentrated perennial bear sign. Focal areas are selected at this stage based on the distribution and abundance of food resources, cover availability, and topography. Aerial imagery, vegetation data, anadromous stream data, and elevation data are synthesized with GIS software to produce a map of focal areas for field surveys.

Intuitive Controlled Survey

Intuitive controlled survey methods are used to navigate between focal areas identified in the pre-field review and to search for additional areas of concentrated bear sign. Intuitive controlled surveys are commonly used by inventory specialists who are responsible for accurately surveying large areas in a time efficient manner (Colclazier 2000). While en route between focal areas the entire survey area is walked to adequately assess and characterize the majority of habitat features that influence patterns of bear activity. When the surveyor arrives at a focal area (that was predetermined in the pre-field review or encountered during the field visit), an investigatory field survey is conducted.

Perennial bear trail and an active sign tree near White Rock, Chichagof Island.

[3] I classify bear sign as perennial or ephemeral. Perennial signs are considered persistent enough to be observable for several years, even without continued activity (like well worn trails and scratch trees). Ephemeral signs are those that tend not to be observable for more than one year (e.g. scat, digging, grazing, & salmon carcasses).

Intuitive controlled surveys are aided by the use of pocket stereoscopes or "3D-viewers" (Fig. 4). The viewers provide a three-dimensional perspective on aerial infrared imagery. The viewers enable the field crew to maximize the range of habitat coverage while minimizing area traversed, and improve the crew leader's ability to interpret habitat and topographic data. This streamlines efforts to find additional focal areas.

Fig. 4. Using the 3D viewer: Slides of paired aerials are placed in the viewer for the same effect (but more field-friendly) you get from a stereoscope and aerial prints (inset is 1/2 of viewer).

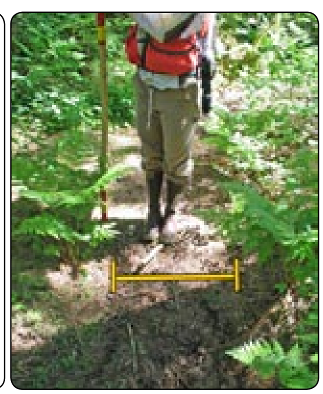
Investigatory survey

The goal of investigatory surveys is to map brown bear trail networks, sign trees, and beds at the focal areas identified in pre-field review and intuitive controlled surveys. Investigatory surveys employ "rules of thumb" to identify, describe, and record bear sign, including:

Trails

- Perennial bear trails are identified by definitive widths (Fig. 5) and vegetation wear qualities.
- The locations of definitive trail widths are recorded and all trails are classified as heavy, moderate or low vegetation wear.
- In the absence of definitive trail width and/or vegetation wear bear trails are identified with the aid of corroborative evidence, i.e bear hair on brush (Fig. 6), sign trees, hotfeet[4], and claw marks on roots and logs that cross the trail. Because bear and deer use of trail networks overlap, evidence of deer use should also be collected (hair and antler rubs). Trails with predominantly bear sign will be classified as bear/deer trails, trails with predominantly deer sign will be clasified as deer/bear trails.
- Perennial bear trails are mapped to the extent of the focal area or to their dispersal point.
- Each branch and trail ending is recorded as either connective (trails that clearly keep going) or dispersal (trails that become indiscernible) to characterize network complexity, suggest relationships with features outside the focal area, and provide a reference point for completing the network map.

Fig. 5. Bears have the widest gait of any animal on Admiralty, Baranof and Chichagof islands. The rule of thumb demonstrated here is - if you can place your feet together in a trail and still have room for the palm of your hand to either side its likely a bear trail.



[4]Hotfeet is a term I use to describe a special kind of bear sign where repeated use and consistent walking patterns result in "cookie cutter" style depressions in the vegetation mat (see photo above). I often find hotfeet at trail junctions and associated with sign trees. In light of studies that describe mammal's ability to recognize the sex, reproductive status, individual identity, and even the mood of an individual that left scent-marks (Firestein 2001) I consider both hotfeet and sign trees a means for intra-specific communication that could be critical to avoiding conflict, finding suitable mates, and overall "bear management" of overlapping home ranges.

Trees

- Points are created for trees that exhibit bite and claw marks, bear hair in bark and sap, or a "polishing" of tree surface with "hot-feet " or evidence of repeated urination (Fig. 7).
- Tree data include descriptive attributes for type (rub, bite, scratch), frequency of use (long-term or short-term), sign age (modern or ancient), tree species, diameter at breast height (DBH), and condition (live or dead).

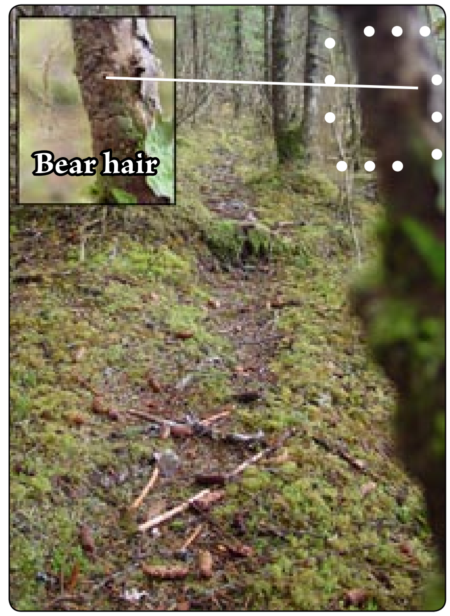


Fig. 6. Corroborative evidence - This trail was identified with help from abundant bear hair on the brush next to the path.

Beds

- Points are established for each bedding area and assigned a class based on bed concentration.
- Class 1 bedding areas are comprised of 3 beds or less within a 50 meter radius.
- Class 2 bedding areas are comprised of 4-10 beds within a 50 meter radius.
- Class 3 bedding areas are comprised of more than 10 beds within a 50 meter radius.
- The presence of associated cover features (trees, root wads, rocks, and steep slopes) are recorded for each bedding area.
- Bedding areas are recorded as active or inactive based on fresh scat presence and/or evidence of recent bowl activity (Fig. 8).

Fig. 8. An active bedding area on the escarpment lip above the Pack Creek estuary. Notice how moist & recently compacted the bed bowl appears.

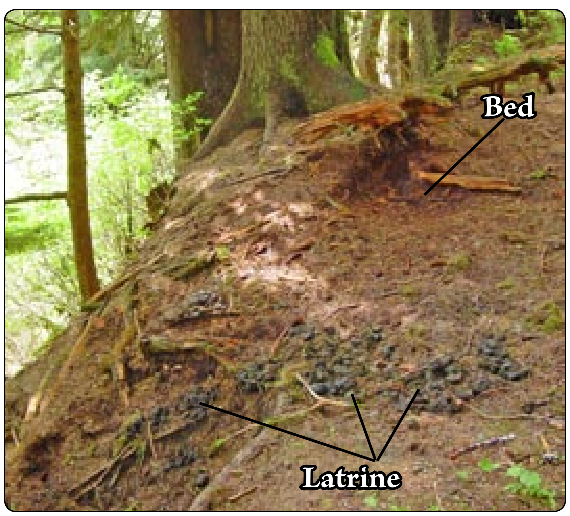


Fig. 7. Sign trees exhibiting bite, claw and rub marks, bear hair, and associated hotfeet.

Transect Surveys

Transect surveys are conducted in areas where sign density is too high for detailed mapping. Transect surveys also provide statistical linkages between sample areas. Transects are established in high density areas at the perimeter and at evenly spaced intervals to form a sample grid. Field personnel walk the sample grid and record point data for trails, bedding areas, and sign trees. This provides an estimate for sign density in the areas encompassed by the perimeter transect. Transects are established through intuitive control and investigative survey areas so that data from the high density areas are comparable. These 'comparison transects' also provide a means for double checking the distribution of sign density recorded by the intuitive controlled and investigative surveys, and a potential means for comparing data between survey areas.

MAPPING EPHEMERAL BEAR SIGN

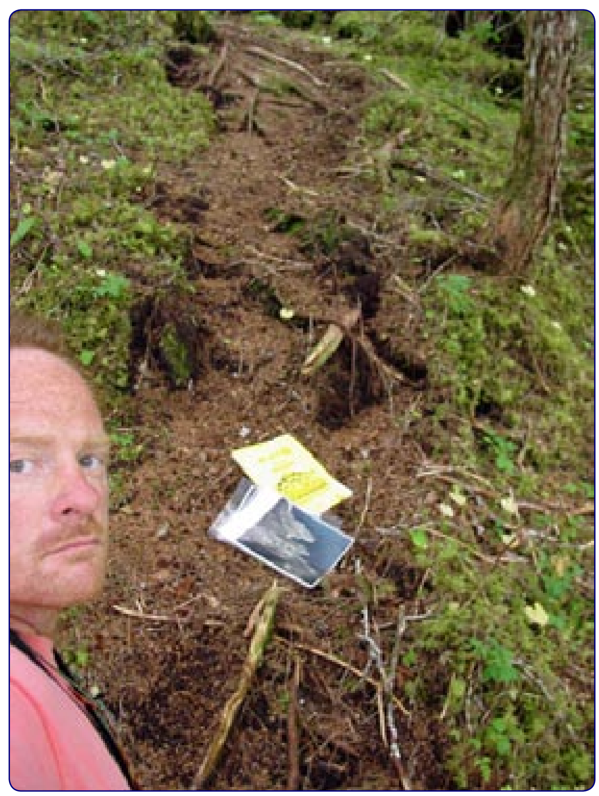
Bear sign is considered ephemeral if it will not persist for more than one year. There is a great variety of ephemeral sign left as evidence of bear activity in southeast Alaska, including but not limited to: scat, hair, signs of bed activity, signs of digging activity, signs of tree activity, bear foraged salmon carcasses, signs of grazing, and tracks. Ephemeral sign is useful for corroborating and understanding the patterns of perennial sign, providing site specific natural history information, and for monitoring efforts. The techniques described here are intended primarily for long-term monitoring of bear habitat use patterns.

Brown bear using a well worn trail near Lake Eva.

I have found that the types of bear sign most suited for long term monitoring in southeast Alaska are scat, bed activity, and salmon carcasses. Because inter-annual variation in resource productivity is common in southeast Alaska, especially in the case of pink salmon availability, it is necessary to monitor for at least 3 years before credible patterns may begin to emerge as a baseline. Retrospective analysis may be useful if ephemeral sign surveys are conducted in an area where detailed perennial sign data are available (Christensen, VanDyke 2003). In all cases, ephemeral sign surveys are not well suited to detect small changes in population (Kendall 1992) or habitat use, but can be useful for providing spatially explicit evidence of substantial changes in population or traditional use patterns.

Site selection & Establishing Transects

Site selections for monitoring activity is largely dependent on management goals and site suitability. Efforts should be made to aquire baselines and/or establish control sites prior to management action in order to take into account the role that inter-annual resource availability may play in monitoring results.



Low-tech scat survey on trail near Lake Eva.

As a general rule I recommend establishing transects along perennial bear trails for assessing impacts to traditional travel routes, just inside the forest and meadow interface to assess impacts to meadow habitat availability, and along the margins of anadromous streams for assessing impacts to salmon availability. I also recommend sampling grids for bedding area activity near estuary and riparian resources. Transect lengths and widths, and quadrat sizes will vary depending on available personel and the confidence level that is required for the management situation. Transects and bedding area grids should cover no less than 1/10 of the total monitoring area (meadow-forest interface, bedding area, anadromous reach, etc.), and visual observation extents (widths) should include at least a couple meters to each side of the trail/ transect route.

Data Collection
Depending on the spatial accuracy desired, data collection may be accomplished via a range of technologies; from the use of high end GPS solutions to a write in the rain notebook and a compass. Because ephemeral sign does not persist for long periods of time and repetitive visits by researchers would likely influence local bear behavior it is necessary to prescribe a sufficent, yet prudent level of sample intensity. Depending on sign type and local weather I suggest a sampling regime of once every 2-4 weeks.

Fig. 9. Bear canine marks & no-brainer salmon carcasses.

Scat
Scat locations are collected along with composition information. I use five categories to describe dominant components, or for combinations in a matrix, including: herbaceous, sedge/grass, berries, salmon, other meat. Additional detail on the type of components (i.e. species) are collected when possible. To insure that scat are not double-sampled they are destroyed (kicked) after they are recorded. For these surveys I recommend a "once a month" sampling regime with an emphasis on scat composition and age.

Carcasses
Location and species information are collected for bear foraged salmon carcasses found along transect lengths. For a salmon carcass to qualify as 'bear-foraged' it has to show obvious signs of bear interaction such as claw marks, bite marks, or no-brainers (Fig. 9). Sampled carcasses must be marked by the surveyor to prevent repeated counting. For these surveys I recommend a "once every two weeks" sampling regime.

Scat comprised of sedge. The dark coloration indicates that this scat is not a fresh one.

Beds
Bed activity is determined through the condition of the soil in the bed lining, the presence or absence of recent excavation and/or compaction, and associated latrines (Fig. 10). Dispersing latrines is not advisable as it may effect bear bed selection. For these surveys I recommend a "once a month" sampling regime with an emphasis on scat composition and age.

Fig. 10. Bear bed comparison. On the left Dr. Flory points out a pair of day beds. The presence of forest litter, lack of compaction, and absence of scat indicates a state of inactivity. At center I am standing next to a bed with a moist and recently compacted bowl; probably bear activity but potentially deer use as well. At right - active bedding area that is clearly the work of a bear. Notice the moist & recently compacted bowl & numerous scats nearby.

Mapping vegetation resources

Current vegetation modeling efforts provide good maps of broad cover classes at regional scales, but typically provide no information on the structure of the covertype, or the spatial distribution of structure within the covertype (Edwards 2002). Structural qualities of covertypes, especially those relating to food and cover availability, are particularly relevant to understanding fine-scale brown bear habitat use. The BBQC integreates a high resolution vegetation survey in which plant communities are mapped onto a pre-field map overlay for ground-truthing and assigning food and cover values.

Fig. 11. Meadow and shrub communities are indicated by the blue and pink shades in this color infra-red photo of Swan Cove.

pre-field review

GIS software is used to spatially reference a variety of aerial images for the study area and to digitize primary plant community types into a polygon-based map overlay. Infrared and near infrared aerials are used to delineate meadow and open shrub communities (Fig 11). Forest types are inferred from color and texture qualities visible in high resolution true color aerials (Fig 12).

field survey

After the pre-field plant community layer is completed it is taken into the field for ground-truthing. Control points are established in representative community types. Each control point is visited and a forest or meadow survey plots is established (see Appendix 1 for survey plot protocol and example community types). Each survey plot is surveyed to ground-truth the pre-field community type designations and to collect bear food and cover availability information (Fig. 13).

Intuitive controlled survey methods are used to investigate the accuracy of community type boundaries and classifications. Additional control points are established in areas with unique bear resources (relative to neighboring polygons) or judged to have been miss-interpreted in the pre-field mapping. Plant community types are adapted from The Alaska Vegetation Classification (Viereck et al 1992) to reflect brown bear habitat needs (i.e. food and cover availability).

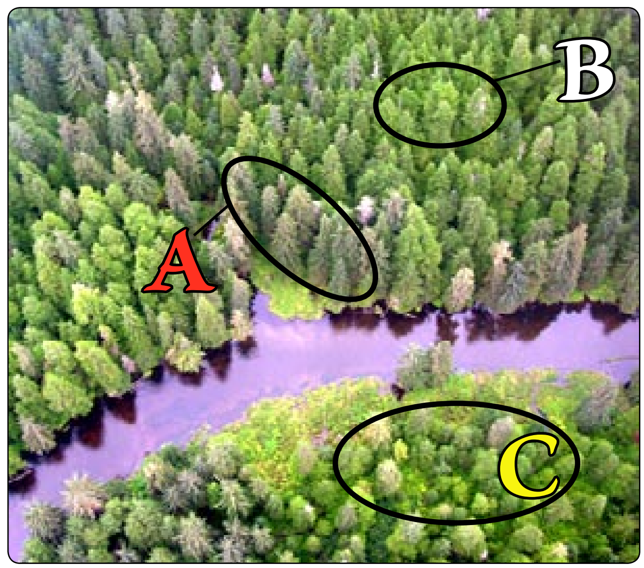


Fig. 12. Forest types shown in the "bluer" shades of green at (A) are Sitka Spruce trees; the lighter shades of green are Western Hemlock trees (B). The coarseness of forest texture in these aerials provided information on the percentage of canopy closure and tree age distribution. Coarse textures were typically associated with multi-aged, open canopy forests (C), with greater light penetration, and more significant shrub layers. Smooth canopies (B) indicated even age, closed canopies affording low light penetration, and very little under story.

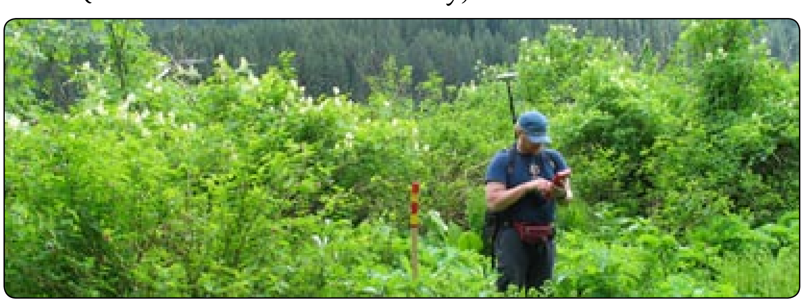


Fig. 13. Ground-truthing vegetation in a complex mosaic of mesic herbaceous meadow and tall shrub thicket. The stake with the yellow and red handle marks the center of the sample plot (control point).

Mapping stream characteristics

The availability of salmon greatly influences the quality of habitat for bears. Mean bear body size, litter size and population density increase proportionally with salmon availability (Hilderbrand 1999). BBQC stream survey methods provide a rapid, simple, and flexible protocol that is sensitive to relationships between signs of bear activity and stream characteristics. This technique has been developed to gather high resolution data for land managers to predict and better understand what parts of anadromous streams are most important to brown bear access to salmon. Anadromous streams are surveyed from the estuary zone to the end of relevant reaches. A two person team works in tandem with a laser range finder and GPS data logger to sub-divide the streams into sample area "cells" 50 meters in length (Fig. 14 & 15). The cell size is selected to provide a logical sub-unit for looking at relationships between stream qualities influencing access to salmon and a discreet measure of bear activity (i.e. bear trail per cell) and may vary with stream size.

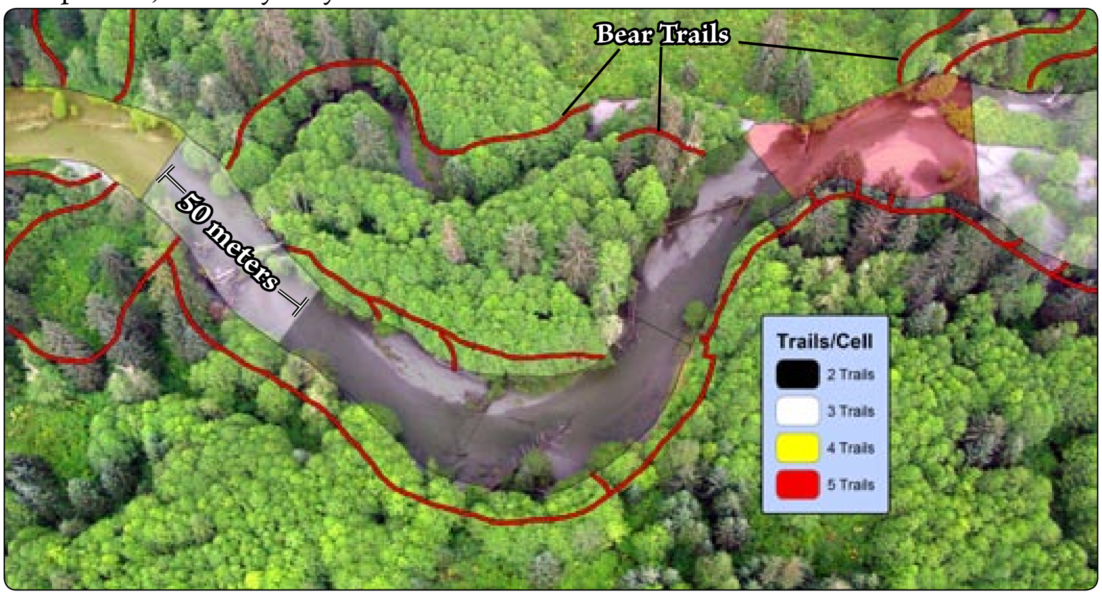


Fig. 14. This is an example of the "cellular" sub-divisions used in stream surveys. The purpose is to compare signs of stream access to features that effect salmon availability.

Bear trail access to an anadromous stream.

Once a stream cell is delineated the field crew walks throughout the sub-unit and conducts visual surveys for:

1. Percent & type of spawning habitat,
2. Percent of shallow (.3m or less) riffle,
3. Typical left and right bank heights,
4. Typical left and right bank heights,
5. Gravel bar coverage,
6. Barriers to fish movement,
7. Fishing platforms (logs, rocks, banks)
8. Bear trail access points.

Data for each cell is stored in point files. Positions are also recorded for photographic examples.

Fig. 15. Dr. Flory demonstrating the use of the laser range finder (right) and the GPS (left) to describe creek survey cells.

Spawning gravel sizes at left are in pink and chum ranges, larger gravels at right are suited primarily for chum.

ANALYSIS

Models built solely at coarse spatial scales and using only vegetation type are likely to be less accurate when fine-scale associations with structural attributes are strong (Edwards 2002). Fine scale food and cover qualities are vital to understanding brown bear habitat dynamics but they currently "slip under the radar" of the cover types that are used in Tongass habitat assessments. My analysis goals for this project are to:

1. Test for correlations between perennial bear sign, habitat features, concentrations of marine derived nutrients in vegetation, and telemetry data.
1. Model fine-scale habitat values for brown bears and attempt to validate existing broad-scale models.
2. Explore statistical linkages between fine and broad-scale models.
3. Develop a hierarchical approach for BBQC protocols that modifies sampling intensity based on the confidence levels necessary for management action.
4. Adapt monitoring techniques to incorporate a statistical basis for 1) transect establishment, and 2) measuring significant change in patterns of bear activity over time.

Timeline

Fall 2004	• Identification of sample areas, methodology finalized. • Begin collaboration outreach.
Winter 2004/2005	• Course work in Montana. • Preparation of base maps, forms and other field essentials.
Summer 2005	• Field work in Southeast Alaska.
Fall 2005	• Data analysis.
Winter 2005/2006	• Course work in Montana. • Interim report completed.
Summer 2006	• Field work in Southeast Alaska.
Fall 2006	• Data analysis.
Winter 2006/2007	• Course work in Montana. • Interim report completed.
Summer 2007	• Field work in Southeast Alaska.
Fall 2007	• Data analysis.
Winter 2007/2008	• Course work in Montana. • Interim report completed.
Summer 2008	• Field work in Southeast Alaska.
Fall 2008	• Data analysis.
Winter 2008/2009	• Final report completed.
Spring 2009	• Dissertation published.

Budget

I expect the budget to run approximately $60,000 per year plus tuition, books, etc. This will cover 2-3 field teams for 8-10 weeks of data collection and all post season data analysis. I will include an itemized budget in the next draft.

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Appendix 1: Plant community Survey plot protocols and type descriptions

Initially prepared by Dr. Aaron Wells

Plot Establishment

Aerial photographs of the study areas are examined prior to entering the field in order for the researchers to familiarize themselves with the major plant communities at each study site and develop an initial strategy for sampling the vegetation. Waypoints are established at each of the major plant communities identified from the aerial photography and entered into a Geographic Positioning System for increased efficiency in the field. Once in the field, vegetation plots are established at each plant community identified by a waypoint. After arriving at a given plant community, plot center is established at a location where the plot boundaries encompass a representative sample, based on floristic composition, of the community. Given the objective to identify distinct plant communities and ground truth the aerial photography the boundary of plant communities, or ecotones, were avoided during sampling. Traveling between waypoints, researchers observe the variety of different communities and have the option to establish plots intuitively based on distinctions in vegetation and environment too subtle to be noticed on the aerial photographs. Intuitive controlled sampling provides the field researcher with flexibility in sampling, resulting in a more complete assessment in locations where field reconnaissance is logistically difficult or impossible.

Many thanks to Dr. Aaron Wells for developing the covertype framework and ground-truthing protocols.

Plot Sampling

Tree dominated communities (>10% cover of tree >5" dbh) are sampled using a one-tenth acre circular plot (Avery and Burkhart, 2002). Basal area tallies of tree species are taken using a BAF 20 prism. Percent foliar cover for each taxa (see below) are recorded in increments of 1%, 3%, 5% and 10% and every 5% thereafter. Tree species foliar cover are stratified by height into those individuals greater than two meters and less than two meters.

Shrub (<10% tree and >10% shrub cover) and herbaceous (<10% tree and shrub cover) dominated communities are sampled using plots with a total area of 50m^2. The shape of the plot is generally rectangular (5x10m), but is not fixed prior to survey in order to allow flexibility in sampling for oddly shaped communities. Percent foliar cover for each taxa are recorded as described above.

Elevation, aspect, slope, soil drainage class (Soil Survey Division Staff, 1993), and landform (USDA,NRCS, 2002a) are recorded at each community. Global Positioning System coordinates are recorded at plot center for use in ArcView GIS. Photographs are also taken at plot center.

Low Marsh (Lyngbye's Sedge Habitat Type)
Carex lyngbei
CALY3

The Lyngbye's sedge habitat type occurrs in the mid-upper intertidal zone along beaches, sloughs, and streams. Lyngbye's sedge (*Carex lyngbei*) in the low marsh habitats forms a thick graminoid layer with scattered silverleaf (*Potentilla anserina*) throughout. Common spikerush (*Eleocharis palustris*) co-occurred with Lyngbye's sedge at some locations. Lyngbye's sedge is a common salt tolerant sedge found along a majority of the Alaska coast. Tenacious, aggressive rhizomes hold soil particles together during tidal flux while the dense stems strain sediments from tidal waters providing the initial stages of beach succession.

Viereck et al. (1992) describe two similar types as follows: Level III: wet graminoid herbaceous (III.A.3) → Level IV: halophytic sedge wet meadow → Level V: *Carex lyngbei*; Level III: Wet Graminoid Herbaceous (III.A.3) → Level IVi: Halophytic Sedge Wet Meadow → Level V: *Carex lyngbei - Potentilla egedii.*

High Marsh (Rye Grass Habitat Type)
Elymus mollis
ELMO9

The beach rye habitat type occurrs within the upper most tidal zones in sandy - small gravel. Often this habitat type occurrs directly adjacent to and slightly higher in elevation (<.5 to a few meters) than the Lyngbye's sedge covertype. The early stages of the beach rye habitat type feature a thick litter layer resulting in a near monoculture of beach rye (*Elymus mollis*) with scattered silverleaf (*Potentilla anserine*). Forbs such as cow parsnip (*Heracleum lanatum*), riceroot (*Fritillaria camschatcensis*), and angelica (*Angelica* spp.) tend to become more prominent in later stages of the type as it began to grade towards herbaceous meadow. Beach rye is a rhizomatous, sod-forming grass important in beach dune stabilization and represents a secondary stage in beach succession throughout southeast Alaska.

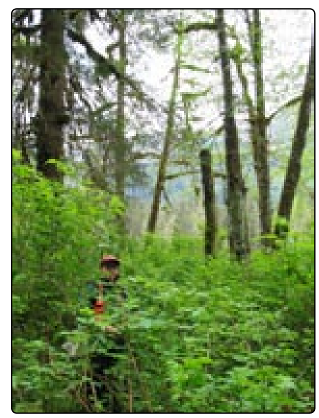
Viereck et al. (1992) describe a similar type as follows: Level III: Dry Graminoid Herbaceous (III.A.I) → Level IVa: Elymus → Level V: *Elymus arenarius - Potentilla egedii.*

Herbaceous Meadow (Cow Parsnip - Rice Root - Buttercup Habitat Type)
Heracleum lanatum - Fritillaria camschatcensis - Ranunculus occidentalis
HELA4 - FRCA5 - RAOC

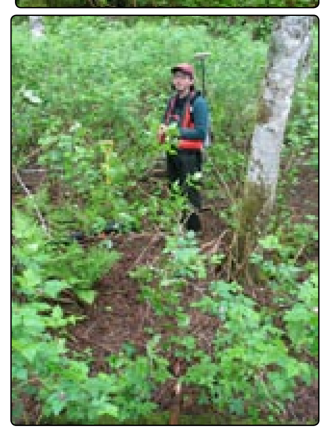
The cow parsnip - rice root - western buttercup habitat type occurrs in the upper reaches of beach meadows and along stream terraces. Floristically, the early stages of this type often resemble the later stages of the beach rye habitat type with beach rye at low abundance and dominance shifting to forbs, primarily cow parsnip (*Heracleum lanatum*), riceroot (*Fritillaria camschatcensis*), and western buttercup (*Ranunculus occidentalis*). Other species include: angelica (*Angelica* spp.), largeleaf avens (*Geum macrophyllum*), seashore plantain (*Plantago macrocarpa*), lady fern (*Athyrium filix-femina*), twisted stalk (*Streptopus* spp.), shooting star (*Dodecatheon* spp.), and wild iris (*Iris* spp.). The typically rich herbaceous layer points to the nutrient rich and highly productive alluvial soils supporting these sites.

Viereck et al. (1992) describe a similar type as follows: Level III: Mesic Forb Herbaceous (III.B.2) → Level IVc: Large Umbel → Level V: *Heracleum lanatum - Athyrium filix-femina - Angelica lucida*.

Riparian Forest (Red Alder - Sitka Spruce/ Salmonberry Mixed Forest Floodplain Habitat Type)
Alnus rubra - Picea sitchensis/ Rubus spectabilis
ALRU2 - PISI/ RUSP



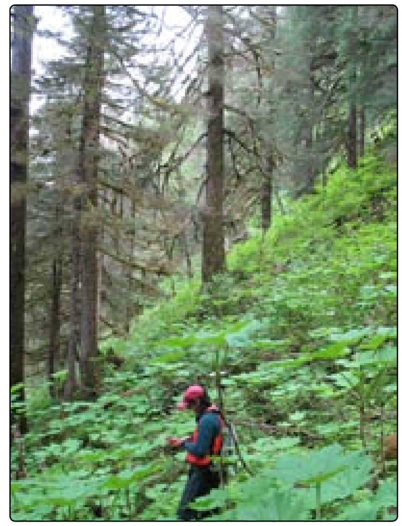
The red alder - Sitka spruce/ salmonberry mixed forest floodplain occurs on floodplains and stream terraces. Red alder (*Alnus rubra*), Sitka spruce (*Picea sitchensis*), or a mixture of these two species tend to dominate (≥60% foliar cover) the overstory tree layer (add cottonwood for mainland sites). Western hemlock (*Tsuga heterophylla*) is present in later successional stages of this type. Salmonberry (*Rubus spectabilis*) is always present forming a thick, tangled, tall shrub layer. Stink currant (*Ribes bracteosum*) is almost always present, sometimes co-dominant with salmonberry. Devils club (*Oplopanax horridus*) and elderberry (*Sambuccus* spp.) are almost always present at low abundance (<15%). The typically sparce herbaceous layer may include green false hellebore (*Veratrum viride*), twisted stalk (*Streptopus* spp.), skunk cabbage (*Lysichiton americanus*), enchanters nightshade (*Circaea alpina*), threeleaf foamflower (*Tiarella trifoliata*), and oak fern (*Gymnocarpium dryopteris*).



Red alder is an important early colonizer of freshly deposited alluvial material. The roots of red alder form a unique relationship with bacteria allowing the fixation of airborne nitrogen into organic forms useable by plants. Pure stands of red alder merge into mixed stands of red alder and Sitka spruce as one moves away from the stream and toward more infrequently flooded fluvial surfaces. Pure stands of Sitka spruce with scattered western hemlock represent the final floristic phase of this type.

Viereck et al. (1992) describe a pure red alder type: Level III: Closed Broadleaf Forest (I.B.1) → Level IVa: Red Alder → Level V: *Alnus rubra*; and a similar Sitka spruce type: Level III: Closed Needleleaf Forest (I.A.1) → Level IVa: Sitka Spruce → *Picea sitchensis/ Oplopanax horridus - Rubus spectabilis/ Cornus canadensis* ; but the mixed red alder - Sitka spruce type with salmonberry understory is unclassified under their Level III: Closed Mixed Forest (I.C.1).

Gappy Conifer (Sitka Spruce - Western Hemlock/ Devil's Club Habitat Type)
Picea sitchensis - Tsuga heterophylla/ Oplopanax horridus
PISI - TSHE/ OPHO



The Sitka spruce - western hemlock/ devil's club habitat type occurs on alluvial plains, stream terraces, colluvial terraces, and steep sideslopes. Sitka spruce (*Picea sitchensis*) dominates the overstory with western hemlock (*Tsuga heterophylla*) almost always present as a subdominant. Devil's club (*Oplopanax horridus*) frequently occurs with coverage ranging from 20 - near 100 percent. Other shrubs that may be present include stink currant (*Ribes bracteosum*), Salmonberry (*Rubus spectabilis*) and blueberry (*Vaccinium* spp.) with coverages often directly related to canopy closure and side light availability. Forbs may include twisted stalk (*Streptopus* spp.), skunk cabbage (*Lysichiton americanus*), enchanters nightshade (*Circaea alpina*), threeleaf foamflower (*Tiarella trifoliata*), false lily of the valley (*Maianthemum dilatatum*), oak fern (*Gymnocarpium dryopteris*), and spreading woodfern (*Dryopteris expansa*).

Sitka spruce is a shade intolerant tree species often found on moist, well-drained sites such as floodplains, alluvial terraces, and sideslopes (USDA, NRCS, 2002). Western hemlock is a shade tolerant tree species often found co-occurring with Sitka spruce. The Sitka spruce - western hemlock/ devil's club habitat type is intermediate along the forest succession gradient in southeastern Alaska. Given enough time without disturbance western Hemlock will come to dominate these sites. Devil's club is a common tall shrub on well-drained sites in southeast Alaska.

Viereck et al. (1992) describe a similar types as follows: Level III: Closed Needleleaf Forest (I.A.1) → Level IVc: Sitka Spruce - Western Hemlock → Level V: *Picea sitchensis - (Tsuga heterophylla)/ Oplopanax horridus/ Lysichiton americanus.*

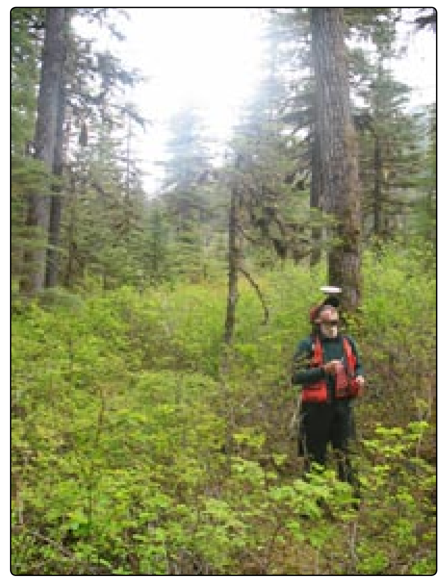
Closed Conifer (Western Hemlock - Sitka Spruce/ Blueberry/ Skunk Cabbage Habitat Types)
Tsuga heterophylla - Picea sitchensis/ Vaccinium spp./ *Lysichiton americanus*
TSHE - PISI/ VACCI./ LYAM3

The western hemlock - Sitka spruce/ blueberry/ skunk cabbage habitat type occurs on reasonably well drained benches, northern slopes and anywhere a mature forest may grow. Western hemlock (*Tsuga heterophylla*) typically dominates the overstory with Sitka spruce scattered throughout. Blueberry species (*Vaccinium* spp.) form a conspicuous shrub layer with common occurrences of rusty mensiesia (*Menziesia ferruginea*). Devil's club is often present at low abundance (≤5%). Upon closer inspection, trailing raspberry (*Rubus pedatus*) can always be found trailing along the ground. Important herbaceous species include: skunk cabbage (*Lysichiton americanus*), twisted stalk (*Streptopus* spp.), false lily of the valley (*Maianthemum dilatatum*), goldthread (*Coptis* spp.), bunchberry (*Cornus canadensis*), lady fern (*Athyrium filix-femina*), and spreading woodfern (*Dryopteris expansa*).

The western hemlock - Sitka spruce/ blueberry/ skunk cabbage habitat type represents an important final stage in forest succession in southeast Alaska. These are sites that have been stable long enough for the most shade tolerant tree species to reach dominance. Soil development is typically high compared to surrounding younger landforms resulting in subsurface clay layers that impede water drainage thus shifting the competitive advantage from Devil's club to blueberry. Poor drainage may result from factors other than the soil including landform slope or concave microtopography. Skunk cabbage was usually found growing in such concavities.

Viereck et al. (1992) describe this type as follows: Level III: Closed Needleleaf Forest (I.A.1) → IVd: Western Hemlock - Sitka Spruce (Western Redcedar) → Level V: *Tsuga heterophylla* - (*Picea sitchensis*)/ *Vaccinium* spp. / *Lysichiton americanus*.

Wetland Forest (Hemlock/ Blueberry Bog Periphery Ecotone)
Tsuga spp./ *Vaccinium* spp.
TSME/ VACCI.



The mountain hemlock/ blueberry habitat type occurrs along the periphery of bogs and fens. Mountain (*Tsuga mertensiana*) and western (*T. heterophylla*) hemlock are typically present at equal low abundance (<40% combined cover) with scattered Sitka spruce (*Picea sitchensis*) throughout. Blueberry (*Vaccinium* spp.) and rusty menziesia (*Menziesia ferruginea*) form a thick tall shrub layer between the open tree canopy. The herbaceous layer typically consists of skunk cabbage (*Lysichiton americanus*) with false lily of the valley (*Maianthemum dilatatum*), goldthread (*Coptis* spp.), and bunchberry (*Cornus canadensis*) sometimes present. The hemlock/ blueberry bog periphery ecotone is a narrow strip of vegetation occurring between the sphagnum bog habitat type, some fen habitat types, and the western hemlock - Sitka spruce/ blueberry/ skunk cabbage habitat type.

Viereck et al. (1992) describe a two similar types but this exact type is yet unclassified. Level III: Open Needleleaf Forest (I.A.2) → Level IVc. Mountain Hemlock → *Tsuga mertensiana*/ *Vaccinium* spp. - *Cassiope mertensiana*; Level III: Open Needleleaf Forest (I.A.2) → Level IVc. Mountain Hemlock → *Tsuga mertensiana*/ *Vaccinium* spp. - *Cladothamnus pyroliflorus*/ *Fauria crista-galli*.

Bog (Sphagnum Bog Habitat Type)
Sphagnum spp.
SPHAG2

The sphagnum bog habitat type occurrs where drainage is poor and acid chemistry dominates the soil and water qualities. Sphagnum moss (*Sphagnum* spp.) is always present forming a nearly continuous "carpet". Shore pine (*Pinus contorta contorta*), mountain hemlock (*Tsuga mertensiana*), dwarf Sitka spruce (*Picea sitchensis*), or an absence of tree species altogether. Decumbent ericaceous shrubs are common including crowberry (*Empetrum nigrum*), bog rosemary (*Andromeda polifolia*), Labrador tea (*Ledum groenlandicum*), and blueberry (*Vaccinium* spp.). Cloudberry (*Rubus chamaemorus*) is an important component of the low shrub layer (for bears) when percent cover is high. Some forbs occur: pondlily (*Nuphar polysepala*), skunk cabbage (*Lysichiton americanus*), bunchberry (*Cornus canadensis*), roundleaf sundew (*Drosera rotundifolia*), deercabbage (*Fauria crista-galli*), and broadleaf starflower (*Trientalis borealis*). A variety of grasslikes are found acrossvarious sample sites including: spikerush (*Eleocharis* spp.), water sedge (*Carex aquatilis*), manyflower sedge (*Carex pluriflora*), and slender cottongrass (*Eriophorum gracile*).

Viereck et al. (1992) describe three types at various levels that represent the range of variation present in the sphagnum bog habitat type including: Level III: Needleleaf Woodland (I.A.3) → IVa: Lodgepole Pine → *Pinus contorta/ Empetrum nigrum*; Level III: Dwarf Tree Scrub Woodland → IVb: Mountain Hemlock → *Level V: unclassified*; Level III: Ericaceous Dwarf Scrub → *Level IV: Crowberry → Empetrum nigrum/Spagnum spp.*

Fen (Water Sedge/Herbaceous Fen Habitat Type)
Carex aquatilis
CAAQ

The water sedge fen habitat type occurrs on steep, seepy meadows, floodplains, and adjacent to beaver ponds. The water sedge fen habitat type is typically located where freshwater saturates the soil but is continually replenished with fresh, aerated water or on saturated, fluvially active surfaces.

Water sedge (*Carex aquatilis*) forms a thick graminoid cover with scattered forbs including marsh marigold (*Caltha* spp.), skunk cabbage (*Lysichiton americanus*), buckbean (*Menyanthes trifoliata*), Canadian burnet (*Sanguisorba canadensis*), and lady fern (*Athyrium filix-femina*) throughout. Bulrush (*Scirpus* spp.) is often observed co-occurring with water sedge at one unsampled site.

Viereck et al. (1992) describe this type as follows: Level III: Wet Graminoid Herbaceous (III.A.3) → Level IVf: Subarctic Lowland Sedge Wet Meadow → Level V: *Carex aquatilis*.

Salmonberry Thicket (Salmonberry Habitat Type)
Rubus spectabilis
RUSP

The salmonberry habitat type occurs on avalanche chutes, colluvial toes and alluvial plains. Salmonberry (*Rubus spectabilis*) forms a dense, sometimes impenetrable, thicket often sharing dominance with elderberry (*Sambuccus* spp.) and stink currant (*Ribes bracteosum*). Herbaceous species may be all but absent from the thickest of sites where sunlight rarely reaches the understory. More open examples of this type may include cow parsnip (*Heracleum lanatum*), skunk cabbage (*Lysichiton americanus*), stinging nettle (*Urtica dioica*), and lady fern (*Athyrium filix-femina*).

Salmonberry, a rhizomatous shrub capable of rooting from broken and buried stems (USDA, NRCS, 2002), is very well adapted to the annual disturbance events characteristic of these sites, and is also an indicator of disturbance. The thick stands of salmonberry combined with dense roots provide a buffering effect against powerful springtime flood events. Salmonberry, once established, is self-perpetuating and may remain the dominant shrub until a large enough disturbance removes the aggressive rhizomes providing a competitive advantage to other species.

The salmonberry habitat type is unclassified by Viereck et al. (1992) but may fall under their Level III: Closed Tall Scrub (II.B.1) and Level III: Open Tall Scrub (II.B.2).

Alder Thicket (Sitka Alder Habitat Type)
Alnus sinuata
ALSI3

The Sitka alder habitat type occurs on avalanche chutes, colluvial toes and alluvial plains. Sitka alder (*Alnus sinutata*) forms a thick, closed canopy (75%) shrub layer with only trace amounts of devil's club (*Oplopanax horridus*), elderberry (*Sambuccus* spp.), salmonberry (*Rubus spectabilis*), and stink currant (*Ribes bracteosum*). Lady fern (*Athyrium filix-femina*) often dominates the herbaceous layer (60%) with trace amounts of skunk cabbage (*Lysichiton americanus*), twisted stalk (*Streptopus* spp.), and oak fern (*Gymnocarpium dryopteris*) scattered throughout. Sitka alder, an early successional, nitrogen fixing species, is one of the first to colonize rocky streambanks, floodplains, and avalanche paths providing initial soil stabilization and enrichment.

Viereck et al. (1992) describe this type as follows: Level III: Closed Tall Scrub (II.B.1) → Level IVb: Alder → Level V: *Alnus sinuata*.