Brown Bear Distribution Model and Disturbance Study, Glacier Bay, Alaska, 2009-2011

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Introduction

Glacier Bay is a recently deglaciated fjord that extends more than 60 miles northward into the southeastern Alaska mainland. The rapid glacial retreat (250 years) has led to progressive exposure of new land surface. Terrestrial plant communities range from mature spruce-dominated forest at the mouth of the bay to open, very young, nearly bare ground surfaces in the mountainous upper reaches of the bay near the remaining tide-water glaciers. Throughout the length of the bay, the most productive terrestrial areas exist in the narrow belt of land immediately adjacent to the marine coastline. The bay is home to both coastal brown bears (*Ursus arctos*) and American black bears (*Ursus americanus*). Black bears tend to live in the forested areas of the lower bay, while brown bears dominate in the more open upper reaches of the bay. Population size, home range size, and detailed distribution of each species in the park are not well known, but two recent bear habitat research projects have shown that the immediate shoreline of Glacier Bay proper contains abundant and diverse bear forage and the most accessible terrain for travel (Partridge et al. 2009).

Glacier Bay is a dynamic landscape resulting from both natural processes such as retreating glaciers leading to species colonization and succession, as well as anthropogenic changes such as climate change and increasing human use. Species such as bears that are dependant on shoreline habitats must adapt rapidly to changes in food types and abundance as well as human disturbance and use patterns over a relatively short period of time. Brown bears have historically been and continue to be species of special management concern in Glacier Bay. Glacier Bay National Monument (established in 1925), was significantly expanded in 1939 to create a brown bear sanctuary due to public outcry over questionable state game management laws (Catton 1995). Brown bears also have one of the lowest reproductive rates of any terrestrial mammal (Bunnell and Tait 1981). In addition, brown bears in Glacier Bay must adapt to ecological changes at faster rates than most other species for the following reasons: 1) brown bears occupy the peri-glacial areas where the landscape changes occur most rapidly, 2) they occupy areas of open and steep terrain surrounded large ice fields where beach habitats are likely essential to survival, 3) they often occupy areas of the park where boaters concentrate, and 4) overall numbers in Glacier Bay proper are likely relatively low due to limited availability of habitat.

This project will examine current black and brown bear distribution in Glacier Bay and how this distribution relates to the number years of land exposure, as well as post glacial plant and stream succession. We will also conduct microsatellite genetic analysis of brown bear hair and tissue to determine contemporary population structure throughout the park and how it relates to landscape variables and surrounding populations.

Modeling the Effects of Glacial Retreat Post-glacial Plant Succession on Blacks and Brown Bear Distribution

Glacier Bay, Alaska serves as a model for climate change where physical and biological processes resulting from warming trends can be observed over a relatively short period of time. Glacier Bay proper has changed significantly in the past 250 years since the glacier filling the bay retreated over 50 miles leaving multiple deep fjords surrounded by young barren land. Subsequent plant and animal colonization has greatly altered the landscape and continues to do so to this day. Several plant species believed to be important to brown bears thrive in soils that have been free from ice approximately 50-150 years, creating a moving front of brown bear habitat that advances as the glaciers continue to retreat. This habitat may decline as ice-fields eventually disappear and less productive scrub and conifers replace prime brown bear foods.

Objectives
I hope to establish a current baseline of brown bear distribution as it relates to glacial retreat and post-glacial plant/stream succession for modeling future distribution. This model will serve two main functions: 1) to help us better understand the effects of climate change on brown bears in peri-glacial and/or sub-arctic regions; 2) to predict future bear activity in order to minimize bear-human conflicts when developing management plans, regulations, and/or planning infrastructure.

Hypotheses
1: The probability of occurrence of black and brown bears is not random across the landscape.
2: The number of years since deglaciation (and associated environmental covariates) affects black and brown bear distribution.

Landscape Genetics of Brown Bears

The population structure of brown bears in northern Southeast Alaska is largely unknown. Southeast Alaska has a long complex history of advancing and retreating glaciers and changing sea level throughout the Pleistocene and into the Holocene. The biogeographic history of mammals in this region is complex due to colonization from both northern and southern refugia, complicated by rugged terrain and ocean crossings that minimize connectivity throughout the region (Cook et al. 2006). Glacier Bay National Park is located on the mainland directly adjacent to the northern end of the Southeast Alaska Alexander Archipelago and is surrounded by mountains, glaciers and/or marine waters. The park encompasses a wide variety of landscape features, including: the lower portion of the large glacial fed Alsek River on the north, Gulf of Alaska shoreline on the west, Icy Strait shoreline on the south, Chilkat Mountains on the east, and the Fairweather Mountain Range and Glacier Bay proper in the center. Connectivity of mammalian metapopulations between these regions has not yet been explored. Glacial advance during the Little Ice Age filled Glacier Bay proper while many surrounding areas remained ice free and were likely refugia areas for mammals (Figure 1). Brown bears have recolonized Glacier Bay proper since the retreat of the glaciers beginning approximately 250 years ago. The source population of these immigrants is not known.

Paetkau et al. (1998) found that bodies of water 7 km or more wide greatly reduce male brown bear dispersal and 2-4 km wide reduce female dispersal. It is unknown how glacier covered mountains and extensive ice fields affect connectivity of brown bears, although these features were found to separate black bears into genetically distinct groups in Southeast Alaska (Peacock et al. 2007). Increased knowledge of the landscape genetics of brown bears in Glacier Bay National Park will help park managers make sound management decisions regarding bear conservation and bear-human conflict. Assessing reproductive barriers and connectivity between the Park and the Preserve may have implications on managing both habituated and hunted subpopulations. Identifying potential biological corridors will help inform the park's upcoming Backcountry Management Plan by steering human use away from these areas thereby increasing the protection of brown bears as well as the safety of people.

Landscape genetics of brown bears in the park will also contribute to basic knowledge of regional brown bear population structure. Preliminary genetic comparison of Glacier Bay proper brown bears showed that they have a closer genetic relationship to adjacent mainland bears in Kluane, Yukon, than to Chichagof Island bears (Paetkau 2004). Chichagof Island is approximately 8.5 km from the closest point of Glacier Bay National Park, with water crossings no greater than 3km using the Icy Strait islands, while Kluane is over 80 km over land. Because Glacier Bay lies directly between Kluane and Chichagof, a more detailed analysis of the genetic relatedness of Glacier Bay bears may answer some interesting questions about the transfer of individuals between these populations and original colonization routes of bears in Glacier Bay. Assessing population structure and connectivity of brown bears in the park will provide an important piece to the puzzle of regional bear populations, which may help managers in planning to reduce anthropogenic barriers to gene flow.

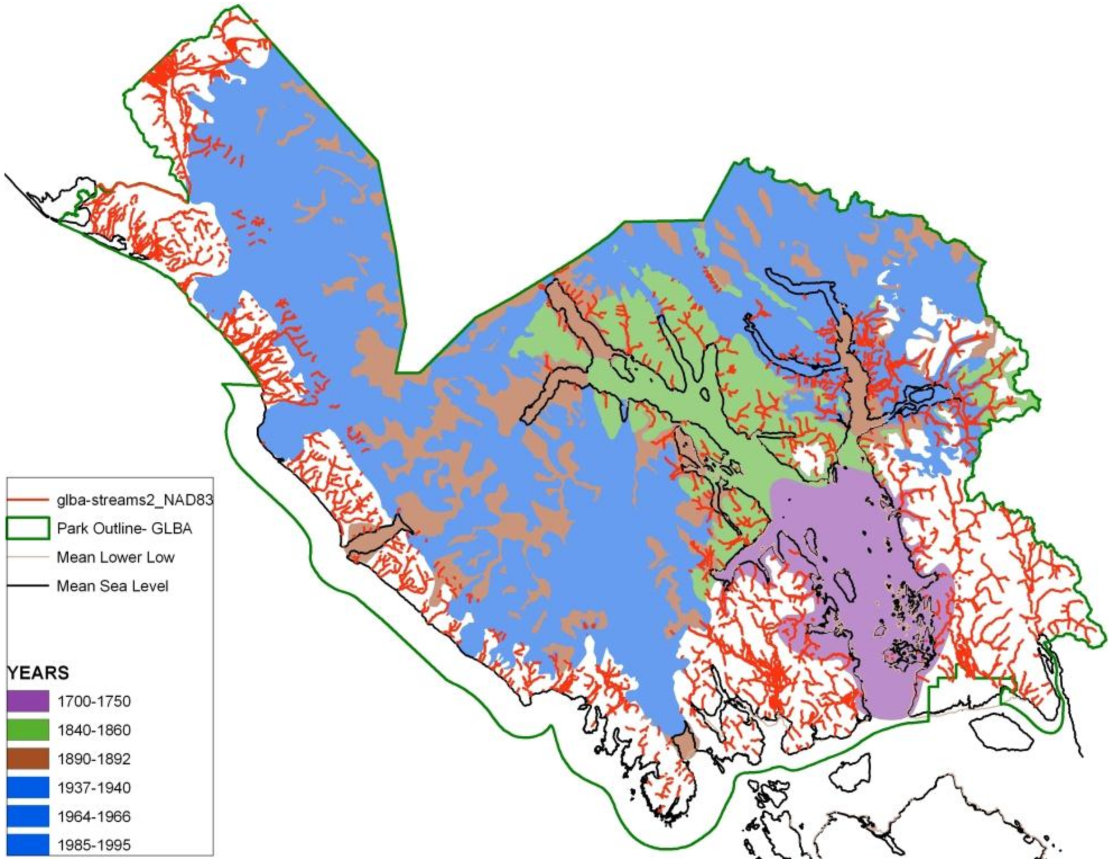

Figure 1. Recent glacial history of Glacier Bay National Park represented in number of years since glaciations. Areas of land without color were not glaciated in the Little Ice Age.

Objectives

The goal of this portion of the study is to examine population structure of brown bears in Glacier Bay in relation to the landscape and determine where genetic mixing occurs and where barriers to gene flow occur. From the population structure we hope to infer: 1) a landscape model that accurately represents the current structure of brown bear populations within the Park, 2) likely corridors connecting subpopulations, and 3) likely population sources and immigration routes of brown bear colonization into Glacier Bay after the Little Ice Age.

Hypotheses

1: Brown bears throughout Glacier Bay National Park show population structure related to landscape features.

2: Glacier covered mountains, ice fields, and marine fjords represent reproductive barriers (high resistance) to brown bears while valleys and river corridors represent routes of connectivity (low resistance) with surrounding populations.

Methods

Distribution

I will conduct a bear sign survey and DNA collection visit to each of 41 study sites 2-4 times per field season. The study sites are river/creek mouths chosen randomly across five strata categorized by number of years since deglaciation: <80, 80-120, 121-150, 151-300, and >300 (Figure 2). The amount of shoreline covered in the ground survey will be determined by the terrain available for sign surveys. A total size will be recorded for each study area. During the ground survey, 2-3 observers will search for bear scat, hair, and tracks. Hair collection will be enhanced with scented barb wire and/or carpet nailed to 1-3 trees per study site. One small sample from each scat will be collected along with discreet hair samples for genetic analysis, and footprints will be examined for species determination. Scat and hair samples will be stored and shipped to Wildlife Genetics International in accordance to their specifications.

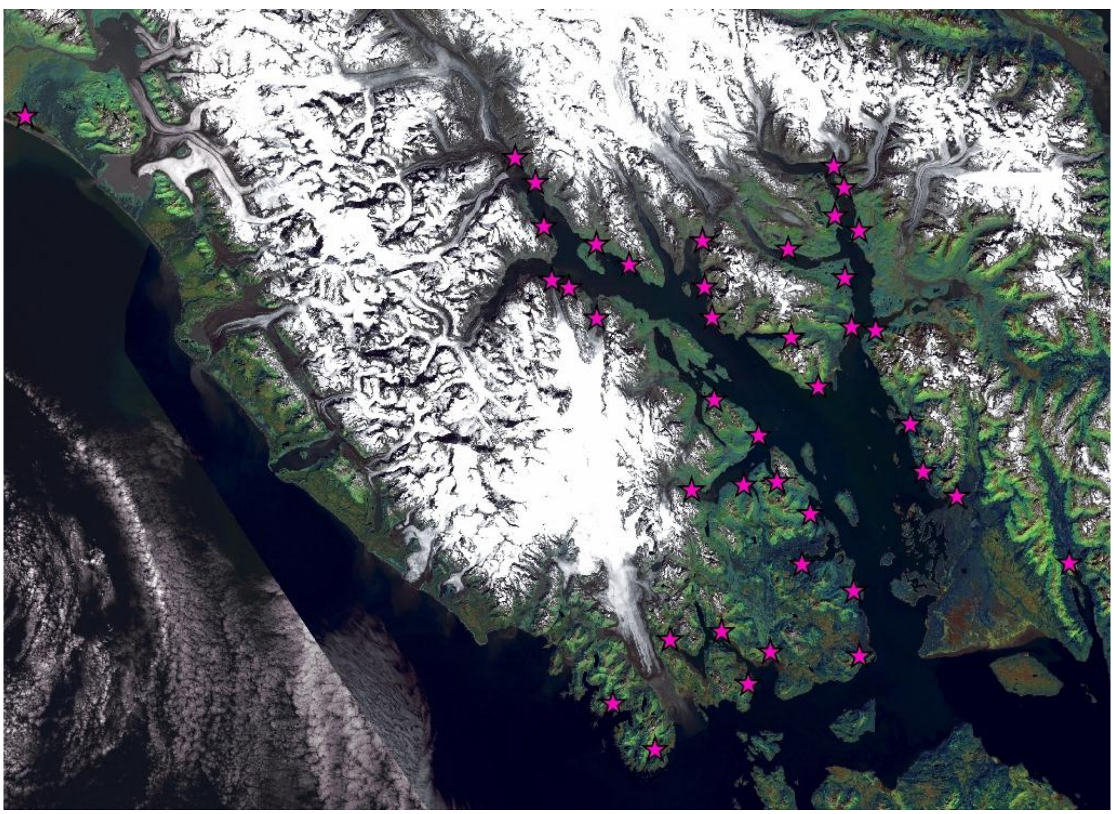

Figure 2. Pink stars represent 41 study area locations chosen randomly across five strata.

Landscape Ecology of Brown Bears

Brown bear hair will be collected from study sites as well as other coastal areas of Glacier Bay National Park. In addition, tissue samples from harvested brown bears will be obtained from Alaska Department of Fish and Game employees in Yakutat and Haines. Samples will be sent to Wildlife Genetics International for species determination using marker G10J prescreen, individual identification using 6-locus genotyping, and microsatellite genotyping of at least 60 individuals to 21 loci (Paetkau 2004).

Analysis

Distribution

Presence/absence of black and brown bears as well as site and survey covariates will be entered into the program PRESENCE. A two-species single state and single season occupancy analysis using a maximum likelihood approach will be run (MacKenzie et al. 2006). Detection covariates to be considered are: tide stage, study site size, season, effort (amount of time spent at site), and number of observers. Occupancy covariates to be considered include season, number of years since deglaciation of site, habitat type, successional stage of stream, and an index of habitat quality. Models of occurrence and co-occurrence will be projected and assessed with AIC weights. A logistic regression equation from the preferred model will be projected back to the study area and a map of occupancy probabilities across streams in Glacier Bay for each species will be created.

Landscape Ecology of Brown Bears

I will use spatial analysis of molecular variance (SAMOVA) to define most probable homogenous groups of populations based on genotypes and geographic areas (Dupanloup et al. 2002). Genetic structure will be tested for 8 geographic groups within or surrounding Glacier Bay National Park separated by ice fields or ocean, including: outer coast north, outer coast south, Icy Strait west, West Arm, East Arm, Icy Strait east, Yakutat forelands and Haines (Figure 3). I will also test these population groups against previously established populations from Chichigof Island and Kluane National Park.

If population groups are identified, I will use circuit theory to generate best fit isolation-by-resistance (IBR) models (MacRae 2006) using ArcGIS and Circuitscape. Potential landscape variables affecting gene flow include potential barriers (glaciers and marine waters), slope, elevation, landcover, and Euclidean distance.

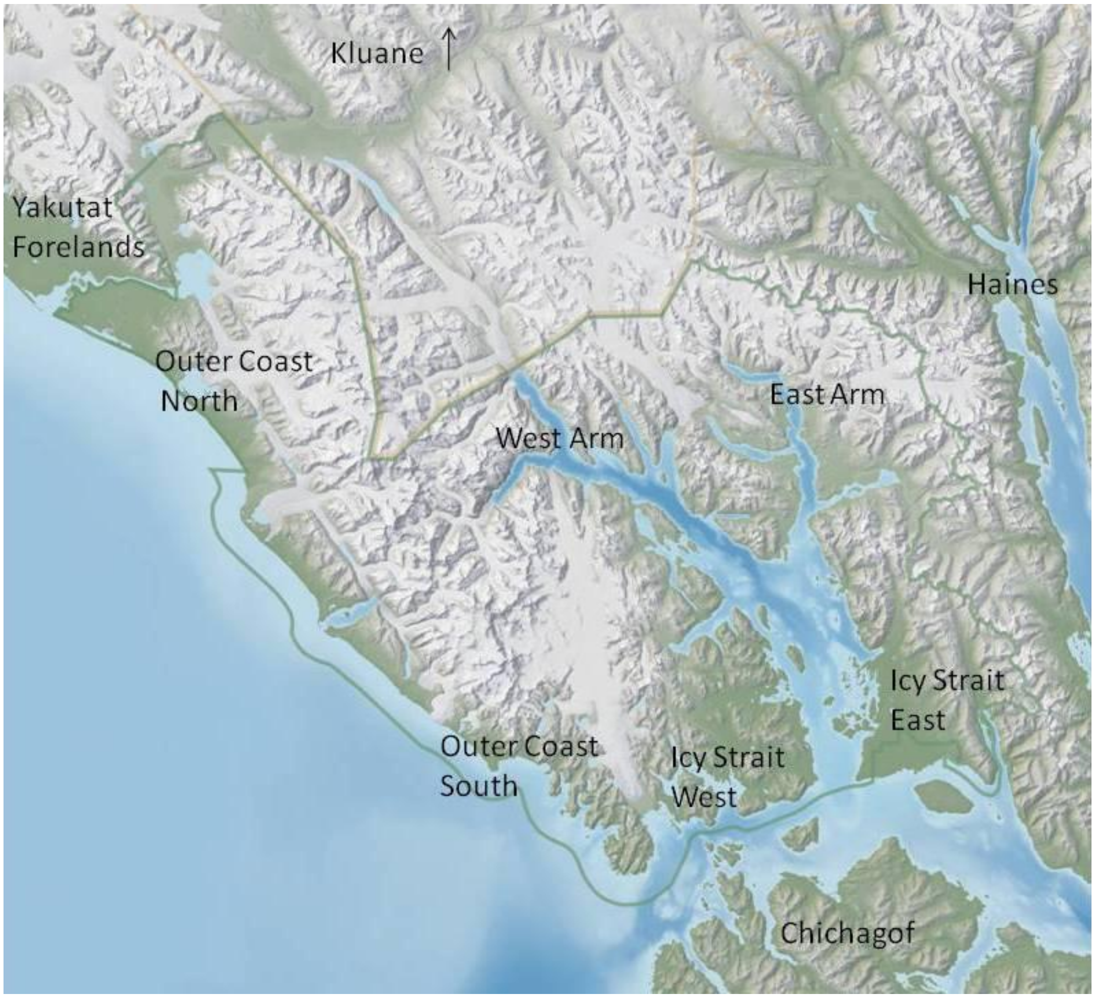

Figure 3. A priori defined groups of brown bear populations based on potential marine and glacial barriers.

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