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WRI REPORT

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MAPPING UNDISTURBED LANDSCAPES IN ALASKA

Overview Report

MAPPING UNDISTURBED LANDSCAPES IN ALASKA

AN OVERVIEW REPORT



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ACRONYMS

ANCSA	Alaska Native Claims Settlement Act
AVHRR	Advanced Very High Resolution Radiometer
BLM	Bureau of Land Management
CBI	Conservation Biology Institute
CITES	Convention on International Trade in Endangered Species
ESRI	Environmental Systems Research Institute, Inc.
FLF	Forest Landscape Fragments
FWS	Fish and Wildlife Service (within the US Department of Interior)
GIS	Geographic Information Systems
GFW	Global Forest Watch
IFLs	Intact Forest Landscapes
IRAs	Inventoried Roadless Areas
MODIS	Moderate Resolution Imaging Spectroradiometer
NPS	National Park Service
TM	Thematic Mapper
TIGER	Topologically Integrated Geographic Encoding and Referencing (US Census Bureau Maps and Cartographic Resources)
USGS	United States Geological Survey
USFS	US Forest Service (within the Department of Agriculture)
VCF	Vegetation Continuous Fields
WWF	World Wildlife Fund for Nature

EXECUTIVE SUMMARY

The forests of Alaska are important from various perspectives (including ecological, scientific, economic, social, and ecological) as well as at different scales, from local to global. Alaska contains the largest area of forest landscapes (about 79 million hectares) as well as the largest extent of protected forest areas (over 40 million hectares) in the United States. The presence of significant expanses of undisturbed forest landscapes offers a full range of management options—from protection to development—which is the subject of ongoing public debate, at the national and state levels.

Alaska's boreal forests are of great scientific importance, especially for monitoring and measuring the effects of global climate change. Rapid changes here are a barometer for future impacts in the lower 48 states. Nearly 90 percent of Alaskan forest land is boreal (i.e., northern) forest, a biome widely recognized as instrumental in stabilizing global climate by sequestering carbon. The other 10 percent of Alaskan forests are coastal temperate rainforests, a rare and globally significant ecosystem type. Southeast Alaska is home to the Tongass National Forest, the world's largest intact coastal temperate rainforest; all told, the Alaskan panhandle contains about a fifth of the world's remaining coastal temperate rainforests.

Forests are also of tremendous economic and social importance to Alaska. Forest-related industries are major sources of employment as well as revenues for funding schools and social services. A large number of Alaskans live in rural communities where forest-based subsistence (including hunting and fishing) is an integral part of the economic and social web.

PURPOSE OF THIS REPORT

Given the importance of Alaska's forests, having baseline information about their extent, location, and condition is crucial to decision-making about their protection and use. This report presents the results of an effort by Global Forest Watch (GFW) and its partners to map the undisturbed forest landscapes of the northern forests using medium-resolution satellite imagery. This is the first time undisturbed forest landscapes in Alaska have been comprehensively and consistently mapped. The maps and analysis contained in this report are designed to provide information that is relevant to the design and implementation of management and conservation plans for these lands. This information also provides a benchmark that will be useful in monitoring future changes to forest landscapes in Alaska.

This study does not aim to prescribe policy recommendations, but rather to help organizations, research institutions, and the public better understand the condition of Alaska's forest landscapes and to inform public debate about the protection and use of these forests. This report is intended to be useful for various audiences, including decision-makers and managers charged with overseeing the protection and use of Alaskan forests. The report could also be of interest to local communities affected by decisions regarding forest management and protection.

MAPPING APPROACH AND CRITERIA FOR DETERMINING FOREST INTACTNESS

The mapping approach and analytical methods used to conduct this study build on previous mapping efforts by GFW, including mapping of intact forest landscapes in the northern forests of Russia and Canada, as well as in the coastal temperate rainforests of Chile. For the purposes of this study, intactness has a two-part definition—that is, an intact forest landscape is one that (a) meets or exceeds a minimum size threshold, and (b) lacks evidence of direct human development.

Size is important for intactness because landscape size can have a significant impact on ecological processes. In general, large expanses of landscape contain more species, support larger populations of a given species, and are more resilient with respect to recovery from natural disturbance agents, such as fire, wind, freezing, flooding, landslides, insects, and disease.

The second aspect of our operational definition of intactness concerns detecting evidence of human disturbance. Intact landscapes do not have to be pristine in a strict, absolute sense, but rather they are forest areas showing no visible sign of human disturbance, such as road building, oil and gas pipelines, and timber extraction.

DEFINITION OF INTACT FOREST LANDSCAPES (IFLs)

A forest landscape is a natural mosaic of forests intermixed with wetlands, rivers, lakes, and other naturally treeless areas. Parcels of forest landscape that were both significantly large and free of visual evidence of disturbance were mapped and classified as intact forest landscapes (IFLs) and forest landscape fragments (FLFs), according to size thresholds and other mapping criteria. In Alaskas boreal region, we applied size thresholds and criteria established by GFW and its partners in mapping other boreal forests: that is, a size threshold of 50,000 ha for IFLs, with a minimum width of 2 km.

In Alaska's boreal region, we applied size thresholds and criteria established by GFW and its partners in mapping other boreal forests: that is, a size threshold of 50,000 ha for IFLs, with a minimum width of 2 km.

However, mapping criteria developed for boreal forests might not be suitable for all types of forest landscapes. For instance, within the coastal temperate rainforests of Alaska, the topography and other landscape characteristics naturally fragment the forest, and large-scale catastrophic disturbances are relatively rare. Accordingly, we have established a minimum size threshold of 5,000 ha for IFLs in the coastal temperate rainforests of Alaska. (Note that the 5,000-ha threshold was also used by GFW and its partners in mapping relative intactness of forest landscapes in Chile, where mountainous terrain likewise interrupts the contiguity of forests.)

Another distinctive element in the forest landscape of Alaska is the presence of more than 27,000 forested islands smaller than 500 ha, most of which have never been impacted by industrial development. In the case of Alaska, we created a special category for mapping and characterizing these islands as intact because they are significant as a whole and because they remain free of visible human disturbance although they do fall below the size criteria in a strict sense.

DEFINITION AND IMPORTANCE OF FOREST LANDSCAPE FRAGMENTS (FLFs)

Forest landscape fragments (FLFs) are smaller-sized but still noteworthy areas of undisturbed forest that do not fall within the size thresholds of IFLs. In boreal forests, this includes areas of undisturbed forest of at least 5,000 ha, but not exceeding 50,000 ha.

In southeast Alaska, FLFs are especially important because the coastal temperate rainforest is such a rare ecosystem type, and smaller tracts of undeveloped forest are of global significance. Thus, in order to map and characterize ecologically significant remaining tracts of undeveloped coastal temperate rainforest in Alaska, we extended the analysis to map FLFs of at least 500 ha, but not exceeding 5,000 ha. Although such forest parcels may not be too large, they are important to analyze since they represent a considerable fraction of the world's remaining contiguous tracts of coastal temperate rainforest.

Figure 1 shows the different thresholds for IFLs and FLFs.

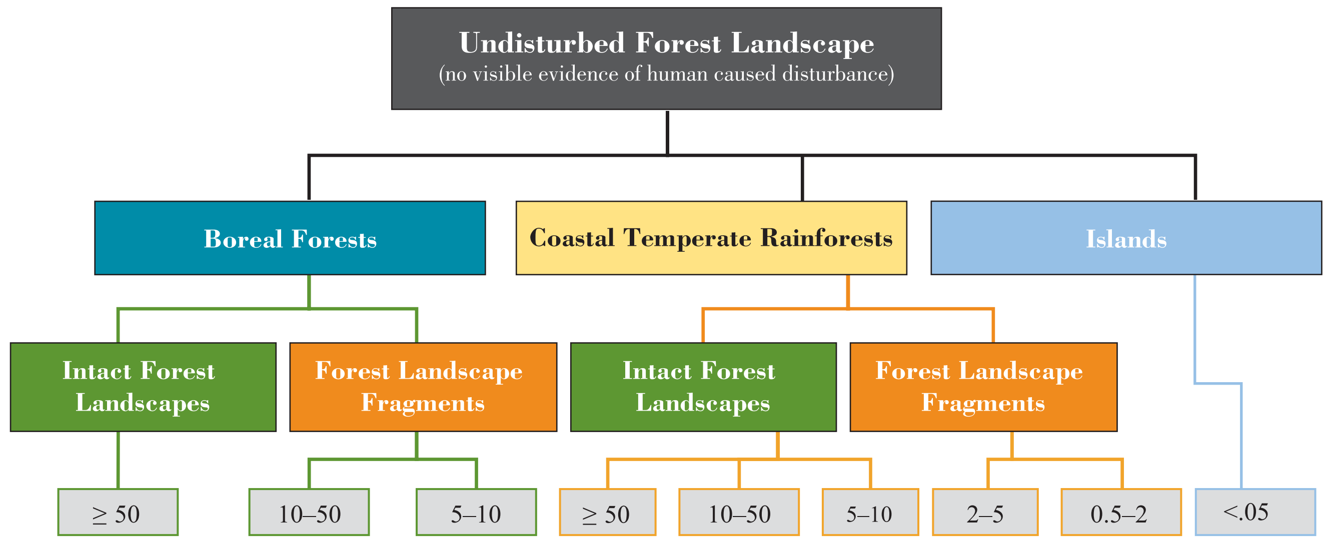
ANALYTICAL METHODS

The mapping and analysis of Alaska's Intact Forest Landscapes (IFLs) and Forest Landscape Fragments (FLFs) were carried out using a modified version of the method developed by Yaroshenko et al. (2001), Aksenov et al. (2002), and Lee et al. (2003 and 2006) to map forest intactness in Russia and Canada as well as by Neira et al. (2002) in Chile.

Analyses were performed in a Geographic Information Systems (GIS) environment using GIS and satellite imaging software. The study area was delineated using datasets on vegetation, land cover, elevation, and forest condition from various sources. To facilitate interpretation and communication of results, the study area was divided into five ecologically distinct zones. The boreal forest comprises three zones (Cook Inlet Taiga, Copper Plateau Taiga, and Interior Alaska), while the coastal temperate rainforest contains two zones (Kenai-Yakutat and Tongass).

We used a two-step approach to map IFLs and FLFs. The first step was to eliminate areas showing evidence of

FIGURE 1 **CLASSIFICATION AND SIZE THRESHOLDS FOR BLOCKS OF UNDISTURBED FOREST LANDSCAPE IN ALASKA'S BOREAL AND COASTAL TEMPERATE FORESTS (thousands of ha)**



human impact using existing GIS data layers. Since disturbance is more easily identified than its absence, we initially considered all areas within the forest boundary to be intact, and then systematically eliminated disturbed areas based on detectable evidence.

The second step involved systematic review, visual inspection, and interpretation of satellite imagery to delineate additional areas of human impact. Following visual inspection of satellite imagery on its own, the satellite images were then overlaid with GIS disturbance layers, which helped guide identification of additional disturbances. The resulting blocks of undisturbed forest were then evaluated to identify those that meet the size thresholds for IFLs or FLFs.

To further characterize Alaska's IFLs and FLFs, we conducted several additional analyses— examining ownership and protection status, forest composition, and fire disturbances.

LIMITATIONS OF THE ANALYSIS

Our approach is based on the presumption of intactness, the methods used in this study are liable to result in some degree of overestimation of the extent of intact forest landscapes. Signs of disturbance are more likely to have been missed than to have been mistakenly found where none exists (although this is also possible).

For instance, signs of disturbance (such as altered forest composition and structure) might not have been evident in the satellite imagery used. For many parts of Alaska, cloud cover frequently obscures satellite scenes and limits the images available for analysis; thus, the time baseline for the analysis becomes the range of available images free of clouds. The use of older imagery (in some areas, dating from the mid-1980s) could also overestimate the area of IFL and FLF because evidence of more recent disturbance is not captured.

Another limitation of the analysis is the lack of capacity, due to financial constraints, to conduct groundtruthing of the results. As an alternative, the analytical methods and results have been subject to external review by identified expert groups and individuals.

RESULTS

The total extent of forest landscapes in Alaska is some 79 million ha, of which almost 90 percent (70 million ha) is located in the boreal region and about 10 percent (9 million ha) in the coastal temperate rainforests of southeast Alaska.

Our study area was drawn to include areas with at least 10 percent of forest canopy coverage. To facilitate interpretation and communication, the study area was divided into five ecologically distinct zones using the ecoregion classification developed by the Worldwide Fund for Nature.

Size and Distribution of IFLs

Intact forest landscapes (IFLs) cover about 67 million ha, making up some 85 percent of the total study area.

- For the boreal region of Alaska, IFLs occupy just over 59 million ha. The share of total land area occupied by IFLs varies considerably among the three boreal eco-zones, with IFLs covering some 88 percent of the total area of Interior Alaska, versus 65 percent in the Copper Plateau Taiga and 35 percent in the Cook Inlet Taiga.
- Large individual forest blocks make up a substantial percentage of each of the boreal eco-zones. In Interior Alaska, the two largest forest blocks (one of 18 million ha and another of 13 million ha) account for more than half of the total IFL area in this eco-zone.
- In the coastal temperate rainforests of Southeast Alaska, IFLs occupy more than 7.5 million ha, with some 85 percent of the Tongass zone and 80 percent of the Kenai-Yakutat zone classified as IFLs.
- Almost 28,000 undisturbed islands were mapped, comprising some 60,000 ha of intact forests. More than 80 percent of these islands are located in the Tongass Zone.

Size and Distribution of FLFs

- Forest landscape fragments (FLFs) make up 1.2 million ha of Alaska's forests, or about 1.5 percent of the study area.
- Two thirds of FLFs are located in the boreal region. FLFs are distributed unequally among the three boreal zones, with almost half found in the Copper Plateau zone (the smallest of the three zones by land area), slightly less than a third in Interior Alaska, and the remaining 20 percent in the Cook Inlet zone.
- FLFs account for 14 percent of the total land area of the Copper Plateau, versus 12 percent for the Cook Inlet zone, and less than 0.4 percent of Interior Alaska.
- About 80 percent of temperate FLFs by number and by area are found in the Tongass zone.

Ownership and Protection Status

- Land ownership within the study area is almost 60 percent federal, 28 percent state, 10 percent native corporations, and 2 percent private.
- In boreal forests, ownership of IFLs and FLFs is dominated by the state of Alaska, the Bureau of Land Management, and the U.S. Fish and Wildlife Service. In addition, the National Park Service also 6 million ha of IFLs and FLFs in Interior Alaska.
- In coastal temperate rainforests, most of the land in IFLs and FLFs falls under the management of U.S. Forest Service in Tongass and Chugach National Forests. The state of Alaska and native corporations also own significant percentage of coastal temperate IFLs and FLFs.
- Some 35 percent of IFLs and FLFs (almost 24 million ha) is strictly or moderately protected. The proportion of IFLs with protected status is the same in boreal forests and coastal temperate rainforests, while the share of FLFs with protected status is 21 percent in boreal forests and 32 percent in coastal temperate rainforests.
- The share of IFLs with protected status varies considerably among the five eco-zones covered by this study. The eco-zones with the largest share of protected IFLs are the Tongass zone (41 percent) and Interior Alaska (36 percent). The proportion is lowest in the Cook Inlet zone (17 percent).
- The highest proportion of protected FLFs is found in the Kenai-Yakutat zone, where almost half of FLFs are protected. Eco-zones with the smallest proportion of FLFs with protected status are Interior Alaska and the Copper Plateau.
- Undisturbed islands have a low level of nominal protection, that is, about 14 percent in the Tongass zone and 13 percent in Kenai-Yakutat. However, many islands are de facto protected from industrial development by virtue of their isolation.
- The area of IFLs covered by inventoried roadless areas (IRAs) includes some 2.5 million ha in the Tongass National Forest and 950,000 ha in the Chugach National Forest in the Kenai-Yakutat zone. Adding these IRAs to the network of protected lands would double the area of IFLs under protection in the coastal region of Alaska.

Forest Composition and Fire Disturbance

- About 28 percent of boreal IFLs consist of non-forest cover, with the remainder divided nearly equally between forest cover of low (10-30 percent) and moderate (30-60 percent) density. These proportions were similar in each of the three boreal eco-zones.
- Results for land cover of boreal FLFs were more variable. In the Interior Alaska and Cook Inlet zones, forest cover in FLFs was generally higher than in IFLs, with some 50–60 percent of FLFs covered by moderate to dense forest cover. However, FLFs in the Copper Plateau zone contained almost no dense forest cover and only 10-20 percent of land area was covered with moderate forest canopies.
- Forest cover in IFLs and FLFs was highest in the Tongass zone. Overall, some 40 percent of intact landscapes in the Tongass zone were classified as commercial forest, with higher proportions occurring in the smaller size categories of forest blocks.
- Analysis of fire data from the Alaska Fire Service shows that about 10.5 million ha (18 percent) of IFLs and FLFs in boreal Alaska burned between 1950 and 1990. From 1990 to 2002, the area of Alaska's boreal forests affected by fire disturbance ranged from a high of nearly 1.3 million ha in 1990 to a low of about 18,000 ha in 1995.

CONCLUSIONS AND NEXT STEPS

Making specific policy or management recommendations is beyond the scope of this mapping effort. However, information such as the results presented in this report must be taken into consideration in making decisions related to the protection and sustainable use of these natural landscapes.

Boreal Region

In Alaska's boreal region, the footprint of human activities is becoming more apparent, as technological development enables larger populations to move farther north into colder climates. For instance, Interior Alaska is the only region with growing employment in the timber sector.

Forest stands with a larger representation of more commercially valuable forest species, such as white spruce (*Picea glauca*), quaking aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*), will most likely be the focus of future harvesting in Interior Alaska. Other factors—such as patterns of land ownership as well as location and extent of transportation networks—will also play a key role in determining areas targeted for timber production. Detailed understanding of these key socioeconomic drivers should be combined with essential environmental information, such as the results presented in this analysis, in order to ensure sound planning for and management of natural resource use in this region.

Although a majority of forest landscape in the Copper Plateau Taiga remains intact, this region is vulnerable to increasing pressure from human uses. Recreational activities have increased significantly in some areas over the last two decades, and natural gas interests seek to build another 800-mile pipeline from the North Slope to the southern coast of Alaska. With a high concentration of wetlands and lakes, the Copper Plateau is an important breeding area for many waterfowl, including the trumpeter swan (*Cygnus buccinator*), a globally vulnerable species. Since less than a third of intact forests occur in designated protected areas, future development should be monitored carefully to assure that ecological integrity is maintained as human uses continue to move into the region.

As the State of Alaska continues to grow economically and demographically, the Cook Inlet zone is likely to be subject to intense development pressures. Conservation and management of the remaining undisturbed forest landscapes in this zone will require extensive involvement and coordination of various owners, including the state (64 percent) native corporations (8 percent), and private individuals (8 percent). Given the relatively low level of protection (17 percent) of IFLs in this region, retaining undeveloped landscapes while enabling needed economic activities will require careful balancing of conservation and development priorities.

Coastal Temperate Forests

With 84 percent of its coastal temperate frests intact (as defined in this analysis), but only 35 percent of these under formal protection status, Alaska holds unprecedented opportunities for conservation of this rare and globally important biome.

In the Tongass Zone, significant intact portions of the coastal temperate rainforest remain unprotected. As the single largest forestland manager, the US Forest Service will continue to play a key role balancing the conservation of critically important areas, meeting the economic needs of the state, meeting the needs of the timber industry, and responding to the demands of the public.

Next Steps

The results presented in this report provide a valuable baseline for future studies of Alaska's forest landscapes. Indeed, this analysis was intended to facilitate informed and constructive discussion on these areas, as well as provide a context for more detailed mapping. Routine monitoring of IFLs and FLFs—including changes in ownership, protection status, forest composition, and forest stressors—should be carried out and made publicly available. Such efforts would make a significant contribution to the design, implementation and monitoring of progress of sustainable forest management and conservation plans at the state and national levels, as well as to global and national forest assessments as called for by a growing number if international accords, including the Montreal Process Criteria and Indicators (Montreal Process Working Group 2005) and the Convention on Biological Diversity.

The satellite imagery used for the analysis presented here was adequate for this first iteration of mapping of Alaska's undisturbed forest landscapes. However, newer, relatively cloud-free imagery is becoming more commonly available and could be used to produce a second, more refined iteration. Refinements will and should be made in future assessments as better satellite sensors and spatially explicit data become available and accessible, including data on roads, managed forests, and energy exploration and development. This will bring additional accuracy in the classification and delineation of IFL and FLF areas and will provide information at spatial scales of greater usefulness to practical land management and international accounting.

Another important area for expansion is the identification of sensitive areas that deserve special attention due to their ecological characteristics. One such effort is the definition of High Conservation Value Forests under Principle 9 of Forest Stewardship Council's forest certification guidelines. The results presented in this report will be extremely useful in providing data to inform mapping of sensitive areas as well as to expand ongoing dialogue aimed at balancing environmental, social and economic concerns about the management and protection of undisturbed forest landscapes.

1. INTRODUCTION

Much of the world's forest cover has been affected by various human activities, and relatively undisturbed forest landscapes are becoming subject to rapid transformation in many places (Bryant et al. 1997). In the United States, most of the forest landscapes in the lower 48 states have experienced significant transformation. However, a considerable extent of forest landscape with no visible sign of human disturbance remains in the state of Alaska. About a third of the total land area of Alaska is forested, and Alaska contains the largest area of forest landscapes (about 79 million hectares) as well as the largest extent of protected forest areas (over 40 million hectares) in the United States.

The forests of Alaska are important from various perspectives (including economic, social, and ecological) as well as at different scales, from local to global. The presence of significant expanses of undisturbed forest landscapes offers a full range of management options—from protection to development—which are the subject of ongoing public debate, at the national and state levels. Given the importance of Alaska's forests, having baseline information about their extent, location, and condition is crucial to decision-making about their protection and use.

IMPORTANCE OF ALASKA'S BOREAL FORESTS IN STABILIZING GLOBAL CLIMATE AND MEASURING THE IMPACTS OF CLIMATE CHANGE

Nearly 90 percent of the total forested land area of Alaska is boreal (i.e., northern) forest, occurring in the heart of the state (Eastin and Braden 2000). Alaska's forests constitute 2.5 percent of the world's boreal forest area, a biome widely recognized as instrumental in stabilizing global climate by sequestering carbon.

Alaska's boreal forests are important for measuring the effects of global climate change because rapid changes here are a barometer for future impacts in the lower 48 states, according to meteorological experts. Since Polar Regions warm faster, a decade of change in the Arctic region is a preview of 25 years of change at more temperate latitudes (Weise 2006).

One key trend that deserves monitoring is climate-induced changes in the cycle of forest fires. Fires have long been an integral part of the forest ecology in boreal Alaska. However, warmer climatic conditions have been changing the biology of Alaska's boreal forests, and these changes are upsetting the balance in the cycle of forest death and regeneration (Joling 2006). In recent years, warming trends have accelerated the conditions conducive to forest fires, and an increased land area within Alaska's boreal forests is experiencing more days in which conditions are ideal for big fires to start. The spring melt has been coming earlier, exposing dead grass in the forest understory before the ground is warm enough to support new growth. Warmer spring weather then dries the newly exposed dead grasses, which become tinder.

As a result, Alaska is experiencing more fires, bigger fires, and fires that burn hotter and more severely. Moreover, the interval between major fires is growing shorter. Recent fire seasons in Alaska have been extreme, with two of the worst in the state's history occurring in the past 3 years. The worst on record was in 2004, when 6.6 million acres (about 2.7 million ha) burned. In 2005, Alaska had its third worst season ever, with 4.4 million acres (1.8 million ha) burned. Over the course of these 2 years, fires burned a quarter to a third of forest area in the hardest hit, northeastern part of the state.

Another key indicator of climate change impacts in Alaska's boreal forests is pest damage. Pests once held in check by winter cold—such as the spruce budworm, aspen leaf miner, and spruce bark beetle—are now flourishing. Insect outbreaks have killed more than 4 million ha of

Alaska's forests in the past 15 years, according to biologists (Weise 2006).

IMPORTANCE OF ALASKA'S COASTAL TEMPERATE RAINFORESTS AS A RARE AND GLOBALLY SIGNIFICANT ECOSYSTEM TYPE

About 10 percent of Alaska's forests are coastal temperate rainforests, a rare and globally significant ecosystem type (Eastin and Braden 2000). Coastal temperate rainforests are an important source of timber throughout the world, due to their extraordinary productivity and highly valued wood products from conifer species.

North America houses the world's largest expanse of coastal temperate rainforests, but Alaska has retained the largest, undisturbed tracts of these forests, as the majority of coastal forests in California, Oregon, and Washington State have already been altered by human development. Located in southeast Alaska, the Tongass National Forest is the world's largest intact coastal temperate rainforest. Overall, the Alaskan panhandle contains about a fifth of the world's remaining coastal temperate rainforests (Berman et al. 1999), with some 40 percent of the Alaskan coastal forest under some level of protection. Southeast Alaska is the last place in the United States where the ecological integrity of this globally outstanding biome can be maintained.

ECONOMIC IMPORTANCE OF FORESTS WITHIN ALASKA

Alaska's forests contribute to the statewide economy and local community livelihoods in local communities through commercial and subsistence harvest of timber and non-timber products. The share of economic output attributable to the forestry, fishing, and agriculture sector was .86 percent in 2004, with an additional 0.5 percent of economic output coming from direct manufacturing of lumber and wood products (Department of Commerce 2006).

Within the United States, Alaska is the third largest exporting state for forestry and logging products (2003 data). (Alaska Forest Association 2003) However, wood products had been increasingly being exported to Asia in their raw state, leading to declines in processing and manufacturing jobs and soft export markets result in little or no timber export. Communities living in timber-producing regions of Alaska are doubly impacted by declines this industry, since it is a source not only of employment and but also of funding for schools and social services.

Forest ecosystems also make a large, albeit indirect, contribution to the Alaskan economy via the tourism, sport hunting and fishing, and commercial fishing sectors. It is difficult to quantify the economic value of the ecosystems services provided by forests, since these services generally flow outside of economic markets and are provided free of charge. However, their value underlies economic activity in many different sectors and is undoubtedly of major importance. For instance, forest wilderness and the wildlife it supports are key ingredients for the tourism sector, Alaska's seventh largest industry and second largest private-sector employer, which generated 2002 revenues of $2.4 billion (Global Insight 2004).

Forests also play a role in sustaining species popular among Alaska's sport hunters, such as Sitka deer, moose, bears, caribou, and others. Revenues from hunting activities totaled some US$397 million in 2001 (IAFWA 2002).

Another key economic contribution of Alaska's forests is through the subsistence economy. Some 20 percent of Alaskans live in rural communities, most of which depend on subsistence hunting and fishing. The estimated "replacement value" of the food obtained through subsistence activities exceeds $218 million annually (Alaska Department of Fish and Game 2000). Besides food, Alaska's rural communities derive essential social values from forests, including spiritual values and community well-being.

PURPOSE OF THIS REPORT

This report presents the results of an effort by Global Forest Watch (GFW) and its partners to map the undisturbed forest landscapes of Alaska using medium-resolution satellite imagery. The purpose of this effort has been to develop, for the first time, a baseline of information about the extent, location, and condition of undisturbed forest lands in Alaska that is relevant to the design and implementation of management and conservation plans for these lands. This information also provides a benchmark that will be useful in monitoring future changes to forest landscapes in Alaska, including disturbances associated with human activities as well as other sources of alteration, such as the effects of changing climate on forest fires, insert infestations, and other forest characteristics.

As described in detail in following sections of this report, mapping efforts focused on parcels of forest landscape that are both significantly large and free of visual evidence of disturbance from human activities, such as road building, oil and gas pipelines, and timber extraction.

These landscapes were mapped and classified as intact forest landscapes (IFLs) and forest landscape fragments (FLFs), according to size thresholds and other mapping criteria described below. The analysis also incorporates datasets on forest characteristics that are relevant to management and conservation of these landscapes, including ownership, protection status, forest composition, and fire disturbance. This project represents the first time that such datasets have been standardized and integrated for the entire state of Alaska.

The results of this mapping and analysis are intended to increase knowledge and awareness of the location, extent, and condition of intact forest landscapes and forest landscape fragments in Alaska, using a mapping scale that is relevant to decision-making on land management. This study does not aim to prescribe policy recommendations, but rather to help organizations, research institutions, and the public to better understand the condition of Alaska's forest landscapes and to inform public debate about the protection and use of Alaskan forests. For instance, this information and analysis could be significant for efforts to conserve Alaska's biodiversity, support sustainable forestry, increase understanding of the impacts of global climate change, and encourage opportunities for sustainable fishing, hunting, and tourism.

This work builds on previous mapping efforts by GFW, including mapping of intact forest landscapes in the northern forests of Russia (Yaroshenko et al. 2001; Aksenov et al. 2002), Canada (Lee et al. 2003), and Sweden (Hájek 2002). In 2002, GFW completed a first draft global map of intact forests throughout the boreal biome (Aksenov et al. 2002a). GFW and its partners have also mapped undisturbed forests in the coastal temperate rainforests of Chile (Neira et al. 2002).

CONTENTS AND INTENDED AUDIENCE

Following this introduction, Section 2 of the report provides a detailed review of criteria used to map, classify, and analyze undisturbed forest landscapes in Alaska. Section 3 presents the results of mapping and analysis, including findings on the size and distribution of intact forest landscapes, the size and distribution of forest landscape fragments, and the results of additional analyses related to ownership, forest composition, and fire disturbance. In Section 4, we present conclusions and discuss priorities for further work. The report also contains various appendices, including a more detailed description of analytical methods, more detailed statistical data on results, further information on the external review process used in preparing this report, and additional background information on the ecological characteristics of Alaska's boreal zones and coastal temperate rainforests.

This report is intended to be useful for various audiences, including decision-makers and managers charged with overseeing the protection and use of Alaskan forests. The report could also be of interest to local communities affected by decisions regarding forest management and protection.

It is hoped that this report provides additional information that will facilitate a more constructive debate around the management and conservation of Alaska's forests."

2. MAPPING APPROACH AND CRITERIA

To map Alaska's intact forest landscapes (IFLs) and forest landscape fragments (FLFs), GFW and its partners used an approach similar to that used in GFW's mapping efforts in other boreal forests (i.e., Canada and Russia) and coastal temperate rainforests (i.e., Chile). The approach centers on identifying parcels of forest landscape that are both significantly large and free of visual evidence of human disturbance as indicated by medium-resolution satellite imagery.

2.1 CRITERIA FOR DETERMINATION OF INTACTNESS

There is no place on Earth that has not been influenced by humans in some way. However, some places have been affected more directly and to a larger degree than others. Ecological components in forest landscapes begin to disappear and become more degraded as the impacts from human use grow and persist over time.

In the scientific literature, the term intactness refers to an ecosystem in which ecological processes function within natural limits and are maintained over time (Anderson 1991). Intact ecosystems have the ability to stay organized or self-correcting in the face of disturbances. They are able to maintain biodiversity and ecosystem functionality over time, not in a fixed sense, but rather as a dynamic property (O'Neill et al. 1986; Hollings 1992).

For the purposes of this study, intactness has a two-part definition—that is, an intact forest landscape is one that a) meets or exceeds a minimum size threshold, and b) lacks evidence of direct human development. Each aspect of this definition is discussed in turn below.

Relationship of Size to Intactness: Why Size Matters

Landscape size can have a significant impact on ecological processes. In general, large expanses of landscape contain more species and support larger populations of a given species, with greater genetic variability (Lindenmayer and Franklin 2002). Thus, they are more resilient than smaller land parcels with respect to recovery from natural disturbance agents.

To be considered intact, forest landscapes should be large enough to provide effective habitat for local species with large home ranges, and should also be large enough to recover from natural disturbances while maintaining key structures and functions. To define intactness, there is no single minimum size threshold that can be applied to all forest landscapes. This remains an active area of research, but enough is known to provide guidance for mapping intactness. Threshold definitions can be guided by the best available science and balanced by the pragmatism needed to identify a mappable threshold. It might be better to address questions such as how much natural forest area remains, in what configuration and protected to what degree.

Size thresholds for intactness should reflect the scale of the dominant natural disturbance agent in a particular landscape and should provide an area large enough to allow for likely recovery from the disturbance regime.[1] Forests are subject to a variety of natural disturbance agents, including fire, wind, freezing, flooding, landslides, insects, and disease. In Alaska's boreal forests, fire is the primary natural disturbance agent. During the fire season, the average area burned can be as large as 400,000 ha (Shulski et al 2005).

Size thresholds for intactness should also be chosen to ensure that they provide functional habitat blocks for local species with large home ranges. For example, black bears require a forest area of 40,000 ha to support a population of 50 to 200 bears, depending on habitat quality (Rudis and Tansey 1995).

Detecting Evidence of Human Disturbance

The second aspect of our operational definition of intactness concerns detecting evidence of human disturbance. Intact landscapes do not have to be pristine in a strict, absolute sense, but rather they are forest areas showing no visible sign of human disturbance. Based on this premise, this study set out to delineate the least transformed portions of the forest landscape.

Visible signs of human disturbance includes such infrastructure features as roads and railroads; pipelines and power lines; cities, towns, and villages; logging sites (especially clearcuts); active mining infrastructure; oil and gas wells; and, military waste sites. Areas in which such disturbances were visibly evident in medium-resolution satellite imagery were systematically removed in order to eliminate non-intact areas.

However, some human activities were considered as background (i.e., non-significant) influence rather than disturbance. These included historic forms of human activity and more recent examples, such as hunting and fishing, gathering non-timber forest products, and past selective logging of trees. In this study, these human influences were treated as a factor in the evolution of today's forest landscapes rather than as disturbances. In addition, industrial activities that occurred in the past but which could not be detected or confirmed by remote sensing using recent Landsat imagery were also considered as background influences.

Although global and regional-scale human influences, such as air pollution and global climate change, may have affected the forest landscape of Alaska, these disturbances could not be properly assessed at this time and hence were not included within the scope of human-caused disturbances.

Within the context of this study, all forest fires were considered to be part of the natural landscape of boreal Alaska. This is an important difference from the approach used by GFW in Russia, where human-caused fires are a significant factor and the mapping criteria and methodology were designed to distinguish between natural and human-caused fires. In Alaska, more than 90 percent of the forest area burned is due to fires started by lightning strikes (Davis 1983; McGuiney et al. 2005; Boles and Verbyla 2000) and there are comparatively few boreal forest areas that have not burned in the last 200 years.

2.2 DEFINITION OF INTACT FOREST LANDSCAPES (IFLs)

For the purposes of this study, an intact forest landscape (IFL) is defined as a contiguous mosaic of natural habitats in the forest landscape that exceeds a specified threshold and lacks visual evidence of significant human disturbances that can be perceived through recent satellite imagery. An IFL does not necessarily consist of old trees, and it may not even be entirely forested. An IFL may contain a contiguous mosaic of naturally occurring ecosystems —including forests, treeless areas, bogs, water bodies, tundra and rock outcrops—that occur in a forest zone. In addition, an IFL is generally assumed to be free from significant human influence for long enough (6-7 decades) that the features of the landscape are formed by naturally occurring ecological processes (including disturbance regimes and regeneration processes).

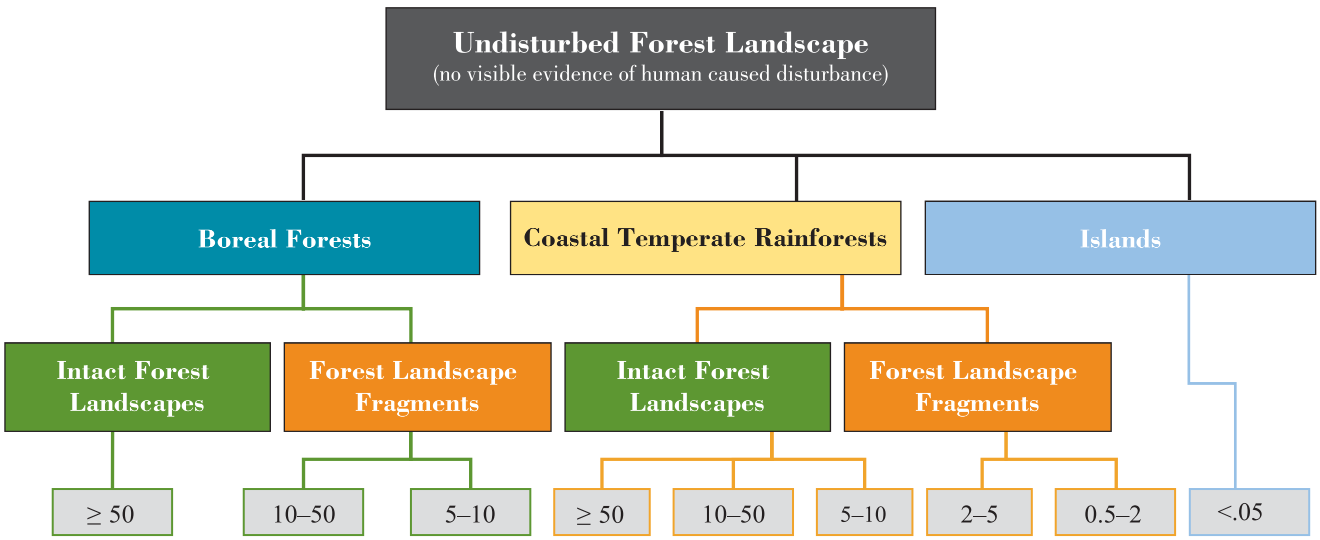
In mapping of boreal forests worldwide, GFW and its partners have established a size threshold of 50,000 ha for IFLs, with a minimum width of 2 km (Aksenov et al. 2002a). The same threshold was also applied by Greenpeace (2006) to map intact forest landscapes worldwide, and it is also applied in mapping Alaska's boreal forests (see Figure 1).

However, mapping criteria developed for the boreal forests might not be suitable for all types of forest landscapes. For instance, the coastal temperate rainforests of Alaska are ecologically distinct, with key differences in topography and disturbance regimes. This means that using different threshold values in different forest landscapes may be warranted.

Within the coastal temperate rainforests of Alaska, the topography and other landscape characteristics naturally fragment the forest. Moreover, large-scale catastrophic disturbances are relatively rare. Thus, modifying the minimum threshold for intactness to fit the unique spatial requirements of ecological processes in the coastal temperate rainforests and to reflect the discontinuous terrain of this forest landscape are justified.

Accordingly, we have established a minimum size threshold of 5,000 ha with a minimum 500 m width for IFLs in the coastal temperate rainforests of Alaska (see Figure 1). Note that the 5,000-ha threshold was also used by GFW and its partners in mapping relative intactness of forest landscapes in Chile, where mountainous terrain also interrupts the contiguity of forests (Neira et al. 2002).

FIGURE 1 **CLASSIFICATION AND SIZE THRESHOLDS FOR BLOCKS OF UNDISTURBED FOREST LANDSCAPE IN ALASKA'S BOREAL AND COASTAL TEMPERATE FORESTS (thousands of ha)**



Another distinctive element in the forest landscape of Alaska is the presence of more than 27,000 forested islands smaller than 500 ha, most of which have never been impacted by industrial development. In the case of Alaska, we created a special category of intactness for mapping and characterizing these undisturbed islands although they fall below the size criteria.

As shown in Figure 1, this study tracks a total of three size classes of IFLs in Alaska's coastal temperate rainforests (i.e., >5,000–10,000 ha; >10,000–50,000 ha; >50,000 ha); undisturbed islands (smaller than 500 ha) as well as IFLs exceeding 50,000 ha in boreal Alaska.

2.3 DEFINITION OF FOREST LANDSCAPE FRAGMENTS (FLFs) AND WHY THESE TRACTS ARE IMPORTANT

Forest landscape fragments (FLFs) are smaller-sized but still noteworthy areas of undisturbed forest that do not fall within the size thresholds of IFLs. In boreal forests, this includes areas of undisturbed forest of at least 5,000 ha, but not exceeding 50,000 ha. Lee et al. (2006) have mapped FLFs in Canada. As shown in Figure 1, this study tracks FLFs in Alaska's boreal forests in two different size classes: 5,000–10,000 ha and >10,000–50,000 ha.

In southeast Alaska, FLFs are especially important because the coastal temperate rainforest is such a rare ecosystem type, and smaller tracts of undeveloped forest are of global significance. Thus, in order to map and characterize ecologically significant remaining tracts of undeveloped coastal temperate rainforest in Alaska, we extended the analysis to map FLFs of at least 500 ha, but not exceeding 5,000 ha. As shown in Figure 1, we track coastal region FLFs in two size classes: 500–2,000 ha and >2,000–5,000 ha. Although such forest parcels may be too small to withstand large-scale disturbances, they are important to analyze since they represent a considerable fraction of the world's remaining contiguous tracts of coastal temperate rainforest.

3. METHODS

Mapping and analysis of Alaska's Intact Forest Landscapes (IFLs) and Forest Landscape Fragments (FLFs) were carried out using a modified version of the method developed by Yaroshenko et al. (2001), Aksenov et al. (2002), and Lee et al. (2003), to map forests in Russia, Canada, as well as by Neira et al. (2002) to map forests in Chile. Changes in the approach were made to address specific characteristics of the Alaskan landscape.

The map of global Intact Forest Landscapes (Greenpeace 2006) also applies the method developed for Russia and Canada. Because of the adaptations to the method, our results show a greater percentage of IFLs for Alaska.

All analyses were performed in a Geographic Information Systems (GIS) environment using ESRI ArcGIS version 8.3 and satellite imaging software from Leica Geosystems Geographic Imaging (ERDAS Imagine).

3.1 DELINEATION OF THE STUDY AREA

The study area was delineated using datasets on vegetation, land cover, elevation, and forest condition from various sources, including the U.S. Geological Survey (USGS), the Bureau of Land Management/National Park Service, the University of Maryland, and Ecotrust. (For more detailed information on datasets used, see Appendix 1.) The boundaries of the study area were drawn to include any pixel with at least 10 percent forest canopy coverage. For Southeast Alaska, glaciers larger than 10,000 ha were excluded based on data prepared by the Alaska Department of Natural Resources. The 10 percent canopy coverage threshold is different from the Canada, Russia and global maps of IFLs, and it intends to capture the sparsely treed landscapes in the southwestern portion of Alaska.

To facilitate interpretation and communication of results, the study area was divided into five ecologically distinct zones using the ecoregion classification developed by the Worldwide Fund for Nature (WWF) as well as the USGS land cover classification. The boreal forest comprises three zones (Cook Inlet Taiga, Copper Plateau Taiga, and Interior Alaska); while the coastal temperate rainforest contains two zones (Kenai-Yakutat and Tongass) (see Map 1 in Map Section).

- In the boreal forest, **Interior Alaska** is largely separated from the two other boreal zones by massive mountain ranges (i.e., the Alaska Range and the Talkeetna Mountains). This relative geographic isolation results in different ecological features in Interior Alaska than in the other boreal zones. The terrain consists primarily of rolling hills and extensive flat bottomlands along several major meandering rivers. Extreme climatic conditions are common, with temperatures varying as much as 90°C from summer to winter. Because of the long, cold winters and the warm, short summers, growing seasons are short and result in very tight growth rings, making the wood prized for its strength and delicate beauty (Alaska Forest Association 2003).
- The **Cook Inlet Taiga** is the most intensively utilized natural region in Alaska, with considerable urban and residential development. The Cook Inlet watershed—containing Alaska's largest city, Anchorage—is home to nearly two thirds of the state's population. Compared to other parts of Alaska, the climate is mild, with temperatures ranging from -3 to 3°C and moderate rainfall (300 mm to 810 mm). Agriculture, timber harvesting, and oil and gas mining are significant economic activities (Brabets et al. 1999).
- The **Copper Plateau Taiga** is located on a plain resting on the site of a large Pleistocene lake. Although annual precipitation is relatively low (250-500 mm), the soils are poorly drained and the area remains very wet throughout the year. About 35 percent of the land area (1.2 million ha) has been classified as wetlands (Hall

et al. 1994). The average annual temperature is about −2°C, with about 70 frost-free days during the summer.

Within the coastal temperate rainforest, the Tongass and Kenai-Yakutat zones are separated by a line following the Malaspina Glacier. These eco-zones are distinct based on differences in their patterns of precipitation (type, amount, and spatial distribution) and their summer temperatures (Alaback 1995).

- The **Kenai-Yakutat zone** is subpolar, with lower percentages of forest cover, composed primarily of stunted spruce and hemlock. Much of the annual precipitation is in the form of snow.
- In the more southerly **Tongass zone**, more productive forests, wetlands, and subalpine meadows predominate. More densely forested and dominated by Sitka spruce, western hemlock (*Tsuga heterophylla*), and western red cedar. Precipitation is mixed with considerable summer rains.

(For further information on the ecological characteristics of Alaska's boreal and temperate forests, see Appendix 2.)

3.2 MAPPING INTACT FOREST LANDSCAPES AND FOREST LANDSCAPE FRAGMENTS

We used a two-step approach to map IFLs and FLFs. The first step was to eliminate areas showing evidence of human impact using existing GIS data layers.

Step 1: Elimination of Areas with Detectable Human Disturbances Using Existing GIS Data Layers

Since disturbance is more easily identified than its absence, we initially considered all areas within the forest boundary to be intact, and then systematically eliminated disturbed areas based on detectable evidence. To detect the most obvious signs of human disturbance, we used datasets on: roads, rail, pipelines, and power lines from the U.S. Bureau of the Census; active mines and mineral plants from the USGS; towns and oil and gas wells from the Alaska Department of Natural Resources; military waste sites from the U.S. Environmental Protection Agency and U.S. Department of Energy; forest roads and clearcuts from the Chugach and Tongass National Forests; and local roads from the Kenai Peninsula Borough. (For more information on these datasets, see Appendix 1).

For this step we used different techniques in boreal forests versus coastal temperate rainforests. In *boreal forests*, we used a buffering approach, which involved creating buffers around detectable evidence of human infrastructure or activities, and then eliminating the buffered zones from the mapped area. Table 1 outlines the buffering distances for various types of human infrastructure, including the buffers used in GFW's Russia and Canada mapping studies as well as this Alaskan study.

Compared with the approaches used to map IFLs in the boreal forests of Canada and Russia, the main difference was in the treatment of roads. In this Alaskan study, we created wider buffer zones around roads and towns—that

TABLE 1 BUFFERING OF HUMAN INFRASTRUCTURE FEATURES IN MAPPING ALASKA'S BOREAL FORESTS, COMPARED WITH BUFFERING USED IN CANADA AND RUSSIA MAPPING STUDIES

Feature	Buffering Used in Alaska Mapping Study (km)	Buffering Used in Canada Mapping Study (km)	Buffering Used in Russia Mapping Study (km)
Roads, Rail, and Other Transportation Infrastructure	5	1 and .5	1 and .5
Pipelines and Power Lines	1	.5	1 and .5
Small Cities, Towns, and Villages	5	1	1
Active Mines and Mineral Plants	1	1	1
Oil and Gas Wells	1	1	1
Winter Roads	0	–	–
Military Waste Sites	1	1	1

Sources: Lee et al. 2003 and Aksenov et al. 2002.

is, 5 km versus the 1-km buffer used in Canada and Russia. This modification was based on input from expert reviewers, who indicated that use of all terrain vehicles (ATVs) near paved roads is more common in this setting (many Alaskans use ATVs for various purposes, including hunting, fishing, and hauling water) and leads to greater forest disturbance within a wider zone. On the other hand, winter roads and trails indicated on the roads data layer were considered to be less permanent on the landscape, less accessible to ATV users, and mostly used by native populations for background (non-significant) human activities.

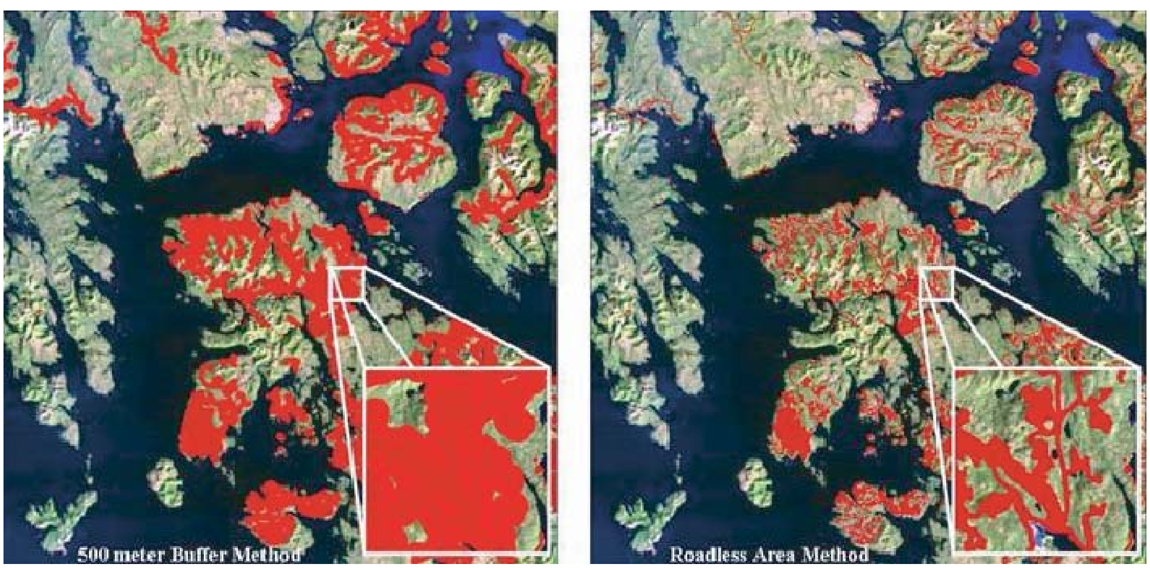
The results from the buffering operations were then combined into a single, human-impact zone in the boreal region and this layer was then erased from the forest landscape extent. Isthmuses (or land bridges) that did not meet the minimum width criteria of 2 km were cut into two separate blocks, and blocks smaller than 5,000 ha were deleted.

For *coastal temperate rainforests*, we used a different approach to eliminate areas of known human infrastructure and disturbance. Because we had access to finer-scale mapping data on human disturbances in Alaska's coastal temperate rainforests, we relied on a technique known as neighborhood analysis, which produced better results than the buffering approach used in mapping human disturbances in boreal forests.

In neighborhood analysis, GIS mapping techniques are used to examine the relationships between a given data cell and similar surrounding data cells. For instance, land use in a certain area can be analyzed by looking at surrounding areas and their uses.

Figure 2 shows the differences in the results produced by these two techniques in examining intactness in forest landscapes. At the finer scale of the roads datasets available for Alaska's coastal temperate rainforest (i.e., 1:24,000 datasets from the USFS for the Chugach and Tongass National Forests and from the Borough Council of the Kenai Peninsula), buffering these linear features eliminates forest lands that are still intact (see Figure 2, left side), while the more refined mapping technique of neighborhood analysis generated a more accurate picture of intactness in forest landscapes with some road development (Figure 2, right side). This greater level of accuracy proved to be necessary for mapping intact forest

FIGURE 2 | **COMPARISON OF TECHNIQUES FOR ELIMINATING AREAS WITH EVIDENCE OF HUMAN DISTURBANCE USING GIS DATA LAYERS**



Caption: For finer-scale datasets, buffering infrastructure features (image at left) eliminates some forest land that is still intact, while the more refined mapping technique of neighborhood analysis (image at right) produces a more accurate picture of forest intactness (green-shaded map areas) in a landscape with some road development.

landscapes within the coastal temperate rainforests of the Alaskan archipelago.

Besides road datasets, the analysis also used detailed datasets on areas of clearcutting from the U.S. Forest Service as well as from local government bodies in the Kenai Peninsula. We combined these with data on regional roads, railroads, and pipelines to create a map layer with a complete picture of human disturbances in temperate forests in Alaska. Using this data layer, we excluded all map areas immediately adjacent to roads or included in clearcuts. We then examined the resulting blocks of forested land, located isthmuses and land bridges less than 0.5 km wide, and divided these into two separate blocks.

Step 2: Identify Further Areas of Visible Human Disturbance Using Recent Satellite Imagery

After locating and eliminating areas of forest disturbance detected in the previous step, we then carried out the second part of our two-step process—that is, systematic review, visual inspection, and interpretation of satellite imagery to delineate additional areas of human impact.

We used 75 satellite scenes, spanning the period from 1985 to 2001 and covering the full extent of the study area in both boreal forests and coastal temperate rainforests (see Map 2). At the time when the analysis was conducted, the Landsat imagery used provided the highest level of resolution available at an affordable cost.[2]

Using imagery covering such a broad time period was necessary because of the frequent and heavy cloud cover experienced in much of the study area. The oldest satellite data was used where needed to obtain relatively cloud-free images of forests zones with little or no human activity (including a large portion of the Alaskan boreal forest where timber production is unprofitable due to high extraction costs). We emphasized use of more recent imagery for locations experiencing relatively high levels of human activity and forest disturbance, such as southeast Alaska and the area around Fairbanks.

This second step in the mapping process starts with identification of disturbances based on visual inspection of satellite imagery alone, with the display enhanced to increase contrast between vegetation and bare soil to emphasize disturbed terrain, such as new roads and other human infrastructure. Significant disturbances visible in this imagery included urbanization, logging sites (especially clearcuts), some mining infrastructure, and linear features such as roads, railroads, and pipelines. Using visual inspection of satellite imagery, impacts of industrial forest cutting from as far back as 1930s and 1940s can still be detected; but selective logging along rivers cannot.

Following visual inspection of satellite imagery on its own, the satellite images are then overlaid with GIS disturbance layers, which help guide identification of additional disturbances. The resulting blocks of undisturbed forest are then evaluated to identify those that meet the size thresholds for IFLs or FLFs.

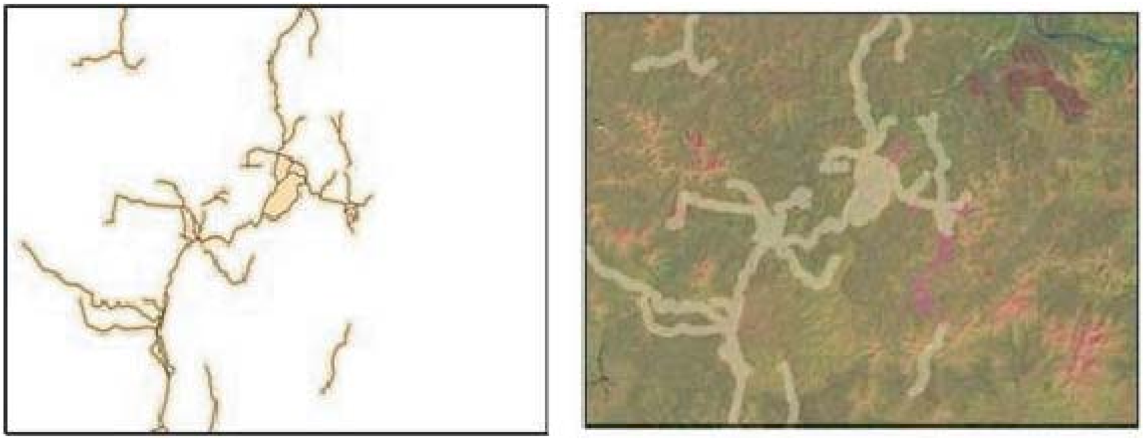
Figure 3 shows an example of this two-step process, with the results from step 1 (i.e., elimination of areas with detectable human disturbances using GIS data layers) shown on the left, and the results from step 2 (i.e., visual identification of further human disturbance using satellite imagery) shown on the right.

3.3 ADDITIONAL ANALYSES

To further characterize Alaska's IFLs and FLFs, we conducted several additional analyses, examining ownership and protection status, forest composition, and fire disturbances.

- **Ownership and protection status** were evaluated using the Protected Areas Database compiled by the Conservation Biology Institute (Della Salla et al. 2001) and data from the 1995 Tongass National Forest Land Management Plan. Categories of ownership included federal, private, state, and native lands. We designated lands as "protected" if they met the criteria for Status 1 or Status 2 according to the USGS Gap Analysis system (see Box 1).[3] In addition, we examined data from the U.S. Forest Service on Inventoried Roadless Areas (IRAs) for the Tongass and Chugach National Forests in order to assess the potential to expand the protection status of IFLs and FLFs in Southeast Alaska (see Maps 3 and 4).
- To further characterize **forest composition**, we collected and analyzed various land cover datasets. It has been an ongoing challenge to map vegetation in Alaska because of the large land area, fine mosaic of different land cover types, high variability of forest cover, and abundance of shrub habitat. For boreal Alaska, we used various land cover datasets—from the University of Maryland as well as BLM and USGS land cover classifications based on Landsat imagery—and categorized forest landscapes into four groups

FIGURE 3 **TWO-STEP PROCESS FOR DETECTING AREAS OF HUMAN DISTURBANCE IN ALASKA'S FOREST LANDSCAPES**



Caption: In the first step (left), areas of human disturbance are eliminated using GIS data. In the second step (right), satellite images are overlaid with mapped disturbances identified in step 1 and additional disturbances (shown in magenta) are digitized, buffered, and eliminated.

according to percentage of forest cover (see Map 5). For coastal temperate rainforests, we used a USGS classification based on Landsat imagery, supplemented by more recent data from the NPS for Kenai Fjords National Park and from Ecotrust for the Tongass zone. Based on this data, forest landscapes in the Kenai-Yakutat zone were categorized into simple vegetation classes, while in the Tongass zone, forest landscapes were categorized primarily according to harvestable versus non-harvestable timber.

- Spatially explicit **fire** data was obtained from the Alaska Fire Service (AFS). These data were evaluated and mapped to create summary statistics for each IFL showing areas covered by fire scars within the last half century.

3.4 LIMITATIONS OF THE ANALYSIS

The accuracy of our maps varies across Alaska, depending largely on quality, quantity and scale of available information. Most of the information used is compliant with standards established by the Federal Geographic Data Committee. Datasets for boreal forests were accurate at 1:100,000 scale while maps for coastal temperate forests at 1:24,000. Overall, the intended scale of use is 1:100,000.

Because our approach is based on the presumption of intactness, the methods used in this study are liable to result in some degree of overestimation of the extent of intact forest landscapes. Signs of disturbance are more likely to have been missed than to have been mistakenly found where none exists (although that is also possible).

For instance, signs of disturbance (such as altered forest composition and structure) might not have been evident in the satellite imagery used. For many parts of Alaska, cloud cover frequently obscures satellite scenes and limits the images available for analysis. Ideally, analysis of IFLs and FLFs would be based on cloud-free images of identical vintage; in reality, the time baseline for the analysis is determined by the range of available images. The use of older imagery (in some areas, dating from the mid-1980s) could also overestimate the area of IFL and FLF because evidence of more recent disturbance is not captured.

Another limitation of the analysis is the lack of capacity, due to financial constraints, to conduct groundtruthing of the results. As an alternative, the analytical methods and results have been subject to external review by identified expert groups and individuals. Three separate review processes were conducted: review of our initial draft methodology; review of a second iteration of the methods and some draft results at a workshop in Anchorage in No-

BOX 1

GAP PROTECTION CATEGORIES

The Gap Analysis Program (GAP) is an effort led by the US Geological Survey to promote biodiversity conservation by developing and sharing information on where species are located and how the lands they inhabit are being managed for their long-term survival.

"Gap analysis" is a scientific technique for identifying the degree to which animal and plant communities are represented in a network on protected areas. Species and communities that are not adequately represented constitute "gaps" in conservation efforts (USGS 2003).

Part of the GAP methodology includes a land-stewardship classification scheme that characterizes land management according to the resource manager's intent to maintain biodiversity. The scheme is predicated on the assumption that retention of natural land cover is of prime importance to maintaining biodiversity (Noss et. al 1995, cited in USGS 2000). Based on this assumption, GAP identifies four management status categories, which are generally defined as follows:

Gap Status 1

An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
Examples: National Parks, Nature Preserves, Wilderness Areas.

Gap Status 2

An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
Examples: State Parks, National Wildlife Refuges, National Recreation Areas

Gap Status 3

An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.
Examples: National Forests, most Bureau of Land Management Land, Wildlife Management Areas

Gap Status 4

There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

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vember 2002; and review of a draft research report by an expert panel. (For specific details about the review process, see Appendix 3.)

Slight errors may also have been introduced by some biases in the datasets used for this analysis. For instance, available GIS data on insect infestations is somewhat biased, since it is based on sightings, which tend to be concentrated along major roads, rivers, and utility networks. Although insect damage was considered to be a "background" rather than a human-caused disturbance, the extent of intact forest might have been overstated where salvage logging has taken place after insect infestations, especially on state and private lands.

BOX 2

BRIEF HISTORY OF LAND OWNERSHIP IN ALASKA

Land ownership in Alaska has been strongly influenced by key historical events as well as traditional patterns of land use and land tenure established by the native peoples of Alaska.

In the mid-1700s, Russian traders arrived in Alaska, attracted by the abundance of sea otters and seals. They established small, scattered trading posts and settlements. The primary "landowners" during this period were native Alaskans. Numbering some 75,000 people from 11 different cultures speaking 20 different languages, native Alaskans lived throughout this large territory, living intimately with their natural environment (Swanton 1952).

One cultural grouping is the Athabascan people, who traditionally lived in the boreal forests of Interior Alaska, along five major rivers: the Yukon, Tanana, Susitna, Kuskokwim, and Copper. They were highly nomadic peoples, traveling in small groups (20-40 individuals) to fish, hunt, and trap (Alaska Native Heritage Center 2003).

Inhabiting the temperate rainforests of southeast Alaska were native peoples—including the Eyak, Tlingit, Haida, and Tsimshian—who shared a common and similar Northwest Coast Culture (with important differences in language and clan system). The Eyak, Tlingit, Haida, and Tsimshian lived under a complex social system and depended on the abundance of marine life for food and the forests for shelter. Each local group (300-500 individuals) had one permanent winter village close to the sea or rivers for easy access to fish and shelter, and one or more seasonal camps used for hunting and gathering at other times of the year (Alaska Native Heritage Center 2003).

On October 18, 1867, the U.S. federal government purchased Alaska from Russia. The new Alaska Territory encompassed some 150 million ha, about one fifth the size of the continental United States. Alaska remained a U.S. territory for the next 92 years, before becoming the 49^{th} state in 1959.

At statehood, the federal government granted the new state ownership of 28 percent of its total land area (approximately 42 million ha). These land grants covered a variety of state purposes, including communities, forestry, and schools, among others (Alaska Department of Natural Resources 2000; Kehoe 1992).

In 1971, Congress passed the Alaska Native Claims Settlement Act (ANCSA), which extinguished native land claims to almost all of Alaska in exchange for about one ninth of the state's land plus $962.5 million in compensation. Thirteen regional corporations were formed to receive land and money distributed under ANCSA. After lengthy negotiations between government officials and the Alaska Federation of Natives, ANCSA eventually transferred title of almost 18 million ha of state lands to 12 regional corporations and 224 local village corporations. (The thirteenth regional corporation received a cash settlement only, on behalf of Alaska natives living outside of the state.) These regional corporations were established using a corporate model and each was expected to operate like a business, including making a profit, with the shareholders being the native people themselves (Kehoe 1992; Alaska DNR 2000). ANCSA fundamentally changed the relationship between native peoples and the land from one of co-ownership of shared land and resources to one of corporate shareholding.

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Our results should not be viewed as the final step in the research on the ecological integrity of the Alaskan forest landscape. Instead, these results should be viewed as a big step forward in our knowledge, yet far from being perfect, due to limitations in time and resources, as well as limitations of the method used and the human factor.

4. RESULTS

The total extent of forest landscapes in Alaska is some 79 million ha, of which almost 90 percent (70 million ha) is located in the boreal region and about 10 percent (9 million ha) in the coastal temperate rainforests of southeast Alaska (see Maps 6-8).

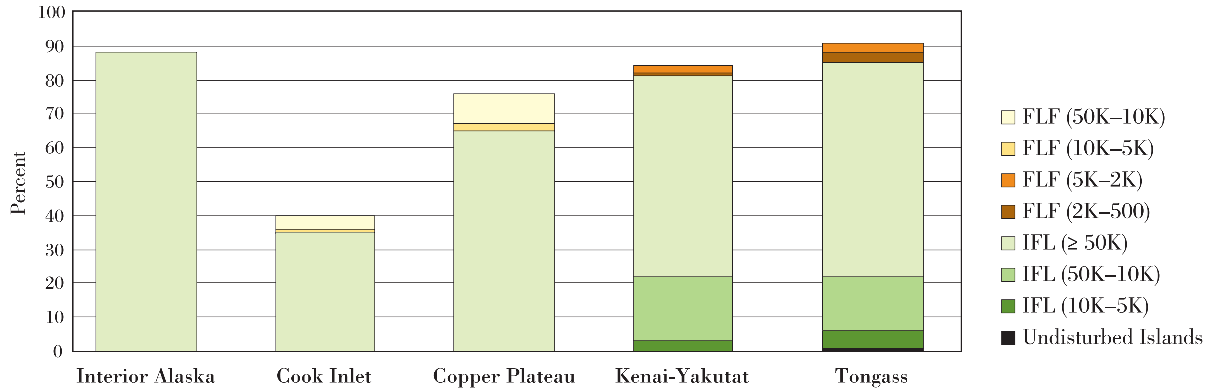
SIZE AND DISTRIBUTION OF IFLs

- Intact forest landscapes (IFLs) cover about 67 million ha, making up some 85 percent of the total study area.
- For the boreal region of Alaska, IFLs occupy just over 59 million ha (see Map 6 and Appendix Table A4.1). The share of total land area occupied by IFLs varies considerably among the three boreal eco-zones, with IFLs covering some 88 percent of the total area of Interior Alaska, versus 65 percent in the Copper Plateau Taiga and 35 percent in the Cook Inlet Taiga (see Figure 4).
- Large individual forest blocks make up a substantial percentage of each of the boreal eco-zones. In Interior Alaska, the two largest forest blocks (one of 18 million ha and another of 13 million ha) account for more than half of the total IFL area in this eco-zone. In the Copper Plateau, the eight largest IFL blocks total some 2.3 million ha, while in the Cook Inlet, only two blocks account for more than 1 million ha of intact forest landscape.
- In the coastal temperate rainforests of Southeast Alaska, IFLs occupy more than 7.5 million ha (Maps 7 and 8), with some 85 percent of the Tongass zone and 80 percent of the Kenai-Yakutat zone classified as IFLs.
- For both the Tongass and Kenai-Yakutat zones, almost three quarters of the land area is occupied by IFLs in the largest size class (i.e., > 50,000 ha). However, many of the individual blocks in this category are dominated by habitats that are naturally treeless.
- The largest block of intact forest landscape in the Tongass Zone is nearly 480,000 ha, or some 9 percent of the total IFL area in this zone.
- IFLs in the smaller size classes account for only 27 percent of the overall IFL area of Alaska's coastal temperate rainforests. However, these smaller blocks occupy many of the lower elevation and near shore sites that are most productive, most diverse biologically, and most threatened by human development.
- Almost 28,000 undisturbed islands were mapped, comprising some 60,000 ha of intact forests. More than 80 percent of these islands are located in the Tongass Zone.

SIZE AND DISTRIBUTION OF FLFs

- Forest landscape fragments (FLFs) make up 1.2 million ha of Alaska's forests, or about 1.5 percent of the study area.
- Two thirds of FLFs are located in the boreal region. FLFs are distributed unequally among the three boreal zones, with almost half found in the Copper Plateau zone (the smallest of the three zones by land area), slightly less than a third in Interior Alaska, and the remaining 20 percent in the Cook Inlet zone.
- FLFs account for 14 percent of the total land area of the Copper Plateau, versus 12 percent for the Cook Inlet zone, and less than 0.4 percent of Interior Alaska (see Figure 4 and Appendix Table A4.1).
- FLFs in Alaska's coastal temperate rainforests occupy nearly 475,000 ha in some 285 individual blocks. About 80 percent of temperate FLFs by number and by area are found in the Tongass zone.

FIGURE 4 | **SHARE OF ALASKA'S LAND AREA IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS, BY FOREST ZONE**



OWNERSHIP AND PROTECTION STATUS

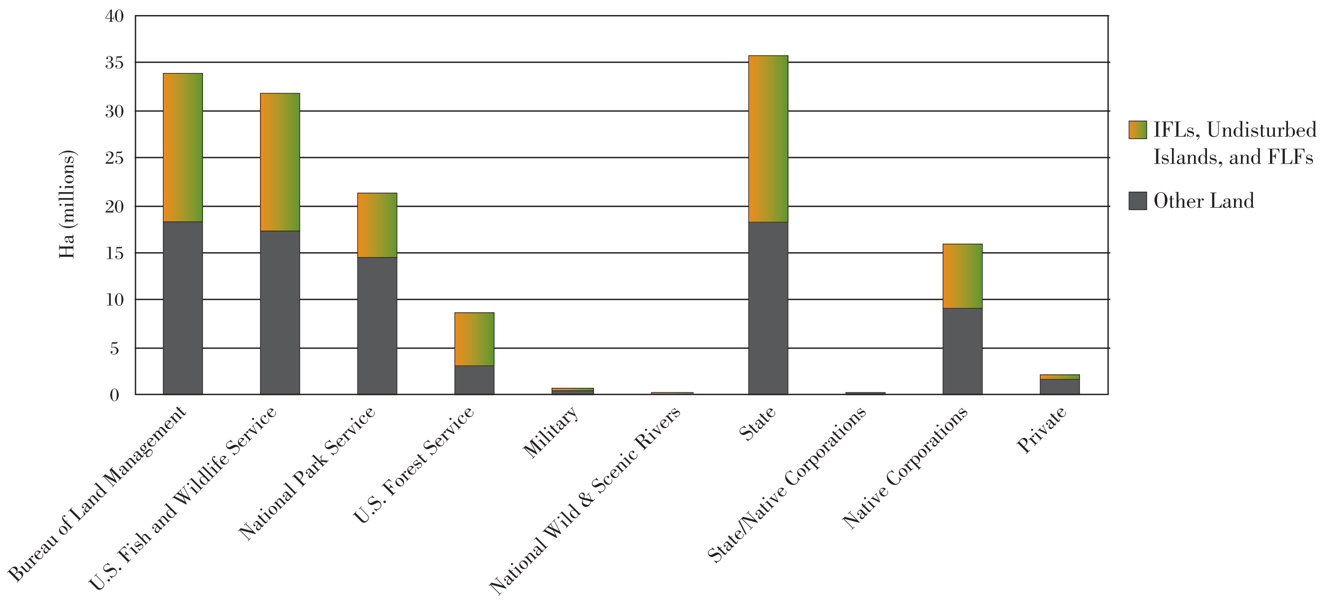
- Land ownership within the study area is almost 60 percent federal, 28 percent state, 10 percent native corporations, and 2 percent private. (For background on the history of land ownership in Alaska, see Box 2.) The share of land owned that is forested varies considerably by agency; for instance, 70 percent of the land owned by the U.S. Forest Service is forested, but only 39 percent of the land owned by the National Park Service is forested (see Table 2).
- In boreal forests, ownership of IFLs and FLFs is dominated by the state of Alaska, the Bureau of Land Management, and the U.S. Fish and Wildlife Service (see Figures 5 and 6 and Appendix Table A4.2). In addition, the National Park Service also 6 million ha of IFLs and FLFs in Interior Alaska.

TABLE 2 | **OVERVIEW OF LAND OWNERSHIP IN STUDY AREA AND STATEWIDE IN ALASKA**

	Ownership in Study Area		Statewide Ownership		
	Extent of Land in Study Area (000's of ha)	As Share of Study Area (%)	Total Area Owned (000's of ha)	As Share of Total Land Area (%)	Percent Forested (%)
Federal	47,076	59.1	96,894	64.2	49
Bureau of Land Management	17,361	21.8	33,967	22.5	51
U.S. Fish and Wildlife Service	14,453	18.1	31,921	21.1	45
National Park Service	8,277	10.4	21,248	14.1	39
U.S. Forest Service	6,167	7.7	8,743	5.8	70
Military	543	0.7	719	0.5	75
National Wild & Scenic Rivers*	275	0.3	295	0.2	93
State	22,208	27.9	35,862	23.7	62
State/Native Corporations	157	0.2	253	0.2	62
Native Corporations	8,187	10.3	15,861	10.5	52
Private	2,023	2.5	2,082	1.4	97
Total	79,652	100.0	150,951	100.0	–

*__Note:__ Jointly managed by the BLM, the NPS, the USFW, and the USFS, under system created by the US Congress in 1968 via the Wild and Scenic Rivers Act.

FIGURE 5 | **LAND OWNERSHIP IN ALASKA BY AGENCY (millions of ha owned) AND SHARE OF LAND IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS**



- In coastal temperate rainforests, most of the land in IFLs and FLFs falls under the management of U.S. Forest Service in Tongass and Chugach National Forests (see Figures 5 and 6). The state of Alaska and native corporations also own significant percentage of coastal temperate IFLs and FLFs.
- Some 35 percent of IFLs and FLFs (almost 24 million ha) is strictly or moderately protected. The proportion of IFLs with protected status is the same in boreal forests and coastal temperate rainforests, while the share of FLFs with protected status is 21 percent in boreal forests and 32 percent in coastal temperate rainforests (see Figure 7).
- The extent of protected IFLs and FLFs is 21 million ha in boreal forests versus 2.8 million ha in coastal temperate rainforests.
- The share of IFLs with protected status varies considerably among the five eco-zones covered by this study. The eco-zones with the largest share of protected IFLs are the Tongass zone (41 percent) and Interior Alaska (36 percent). The proportion of IFLs with protected status is lowest in the Cook Inlet zone (17 percent), while the figures for the Copper Plateau and Kenai-Yakutat are 24 percent and 23 percent, respectively (see Figure 7).
- The highest proportion of protected FLFs is found in the Kenai-Yakutat zone, where almost half of FLFs are protected. Eco-zones with the smallest proportion of FLFs with protected status are Interior Alaska and the Copper Plateau (see Figure 7).
- The largest size class of IFLs (> 50k ha) has the highest proportion with protection status (35 percent in the boreal region and almost 40 percent in the coastal temperate region). (See Figure 8).
- Undisturbed islands have a low level of nominal protection, that is, about 14 percent in the Tongass zone and 13 percent in Kenai-Yakutat. However, many undisturbed islands are de facto protected from industrial development by virtue of their isolation.
- The area of IFLs covered by inventoried roadless areas (IRAs) includes some 2.5 million ha in the Tongass National Forest and 950,000 ha in the Chugach National Forest in the Kenai-Yakutat zone. Adding these IRAs to the network of protected lands would double the area of IFLs under protection in the coastal region of Alaska (see Figure 9, Appendix Table A4.4,

FIGURE 6 | **SHARE OF LAND OWNERSHIP IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA'S BOREAL AND COASTAL REGIONS, BY AGENCY**

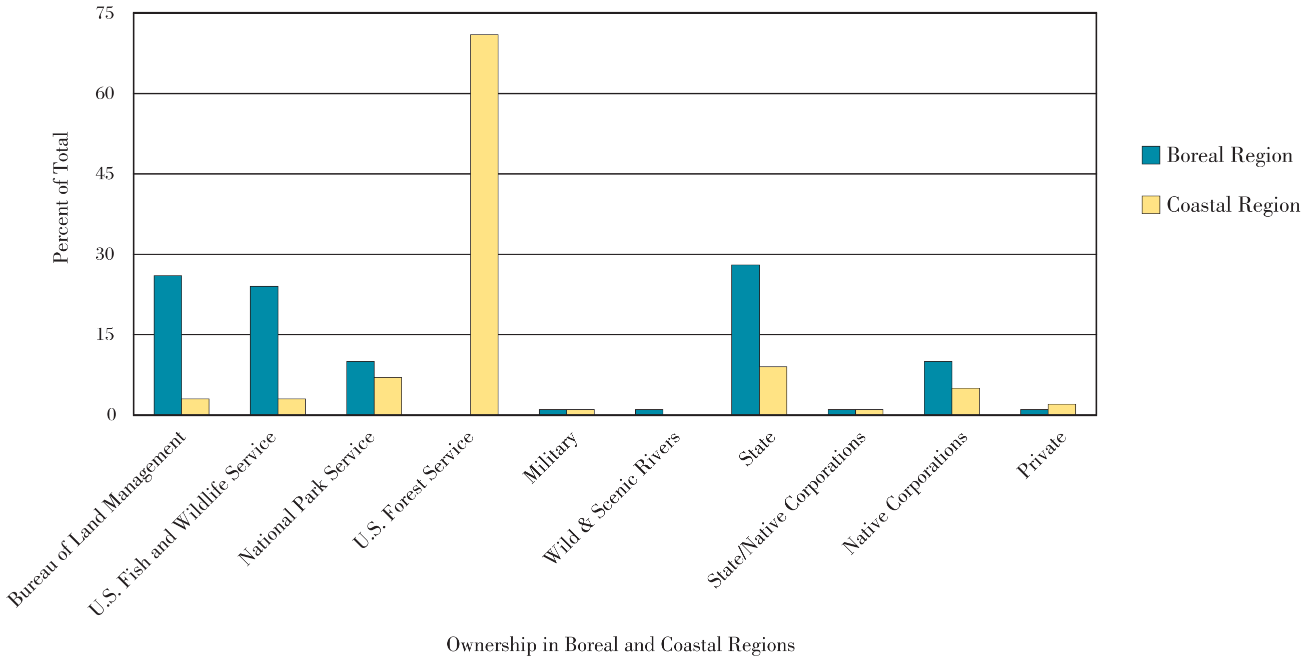


FIGURE 7 | **SHARE OF INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS WITH PROTECTED STATUS, BY FOREST ZONE**

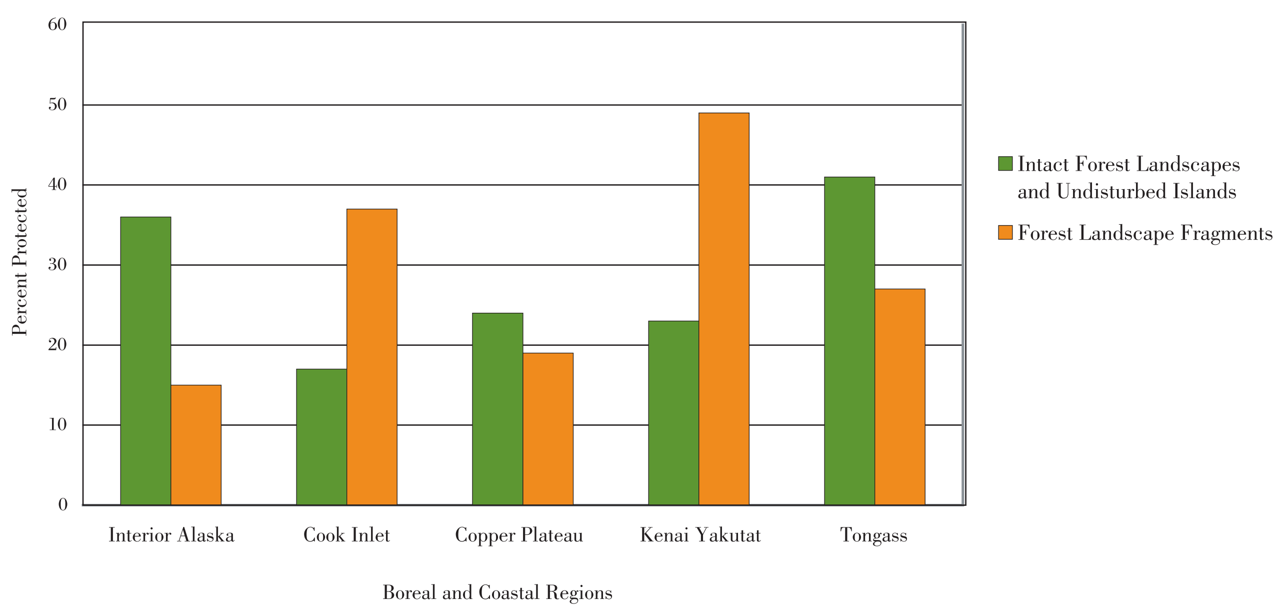


FIGURE 8 | **SHARE OF INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS WITH PROTECTED STATUS, BY SIZE CLASS**

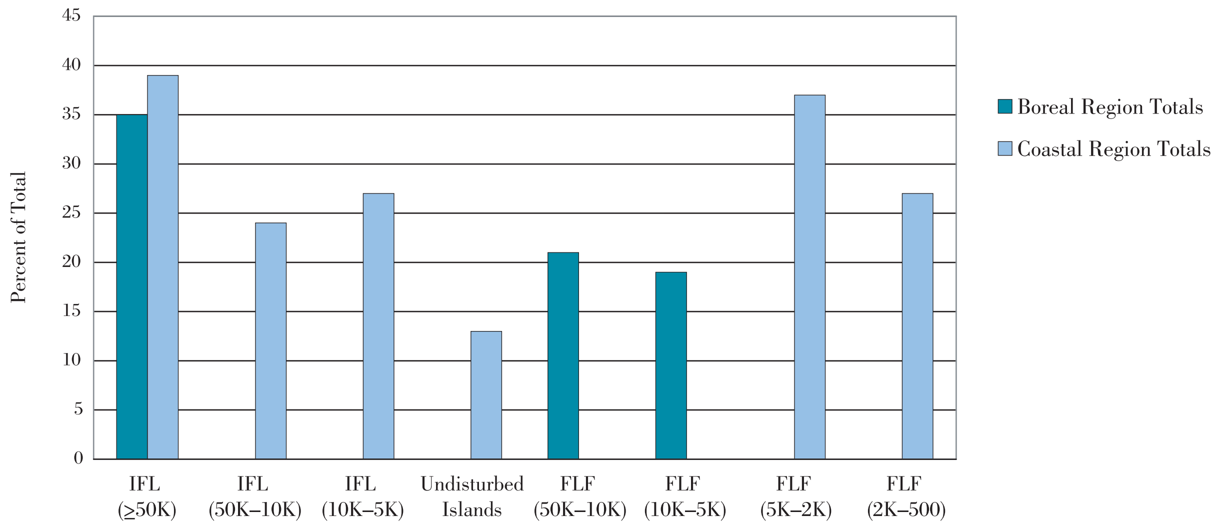
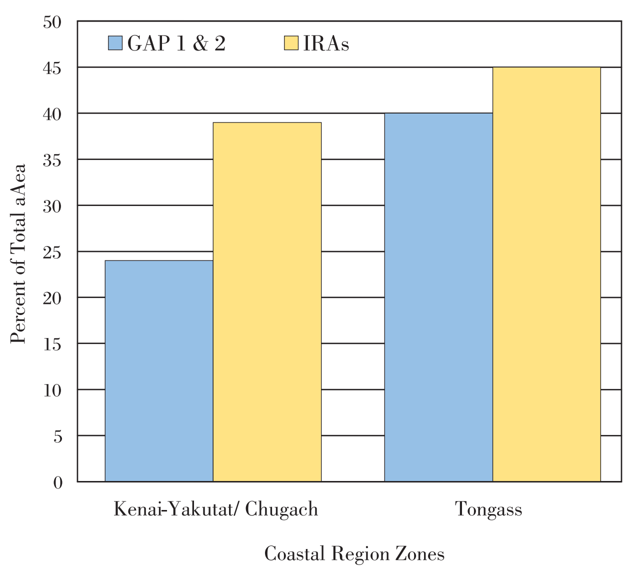


FIGURE 9 | **SHARE OF INTACT FOREST LANDSCAPES AND UNDISTURBEED ISLANDS WITH PROTECTED STATUS VERSUS SHARE IN INVENTORIED ROADLESS AREAS, BY FOREST ZONE IN ALASKA'S COASTAL REGION**

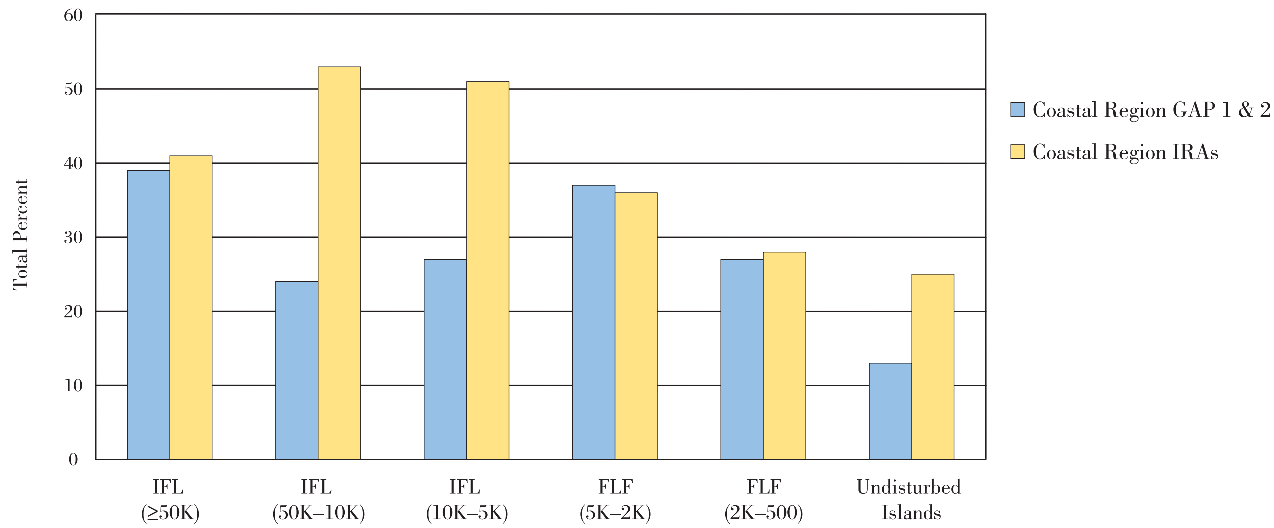


and Maps 9–10). The share of IFLs with protected status would rise from 40 percent to 80 percent for the largest size class of IFLs, and from 25 percent to more than 75 percent for second largest size class of IFLs. For the largest FLFs, the proportion with protected status would double from 35 percent to more than 70 percent, and protected undisturbed islands would rise from less than 15 percent to about 40 percent (see Figure 10).

FOREST COMPOSITION AND FIRE DISTURBANCE

- Results of the analysis of land cover in IFLs vary according to the dataset used. According to the VCF (Vegetation Continuous Fields) dataset developed by the University of Maryland, about 28 percent of boreal IFLs consist of non-forest cover, with the remainder divided nearly equally between forest cover of low (10–30 percent) and moderate (30–60 percent) density. Dense forest canopies (60–100 percent) are rare, occupying only 3 percent of the land area of boreal IFLs (see Figure 11, Map 11). These proportions were similar in each of the three boreal eco-zones.
- However, using a different land cover dataset yielded different results. Analysis of the Landsat TM-based classifications, which are at a finer resolution but cover a smaller extent of the boreal forest landscape, indicates

FIGURE 10 **SHARE OF INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS WITH PROTECTED STATUS VERSUS SHARE IN INVENTORIED ROADLESS AREAS, BY SIZE CLASS**



that the IFLs are much less forested, with 43 percent of the total IFL area covered by non-forest vegetation (versus the 28 percent figure derived using the VCF dataset).

- Results for land cover of boreal FLFs were more variable. In the Interior Alaska and Cook Inlet zones, forest cover in FLFs was generally higher than in IFLs, with some 50–60 percent of FLFs covered by moderate to dense forest cover (see Figure 11). However, FLFs in the Copper Plateau zone contained almost no dense forest cover and only 10–20 percent of land area was covered with moderate forest canopies.

- In the coastal temperate rainforests, only 30 percent of IFLs and FLFs in the Kenai-Yakutat zone were classified as forested (see Figure 12, Map 12). Smaller blocks tended to contain higher proportions of forest cover; for example, almost 50 percent of the total area of larger FLFs (>2,000–5,000 ha) and undisturbed islands was categorized as forested.

- Forest cover in IFLs and FLFs was highest in the Tongass zone. Overall, some 40 percent of intact landscapes in the Tongass zone were classified as commercial forest, with higher proportions occurring in the smaller size categories of forest blocks (see Figure 13, Map 13). Non-commercial forests make up only a small percentage of land cover (1–2 percent each for the six size categories), while non-forest vegetation (such as wetlands and herbaceous cover found in rocky, high-elevations sites) accounts for some 35–40 percent of total area for most size categories.

- Analysis of fire data from the Alaska Fire Service shows that about 10.5 million ha (18 percent) of IFLs and FLFs in boreal AK burned between 1950 and 1990 (Map 14). From 1990 to 2005, the area of Alaska's boreal forests affected by fire disturbance ranged from a high of nearly 6.59 million ha in 2004 to a low of about 18,000 ha in 1995 (Figure 14). The next highest number of burned areas was in 2005 (4.4 million ha) and in 1990 (1.3 million ha.)

FIGURE 11 **DISTRIBUTION OF FOREST CANOPY COVER IN INTACT FOREST LANDSCAPES AND FOREST LANDSCAPE FRAGMENTS IN ALASKA'S BOREAL REGION, BY SIZE CLASS AND FOREST ZONE**

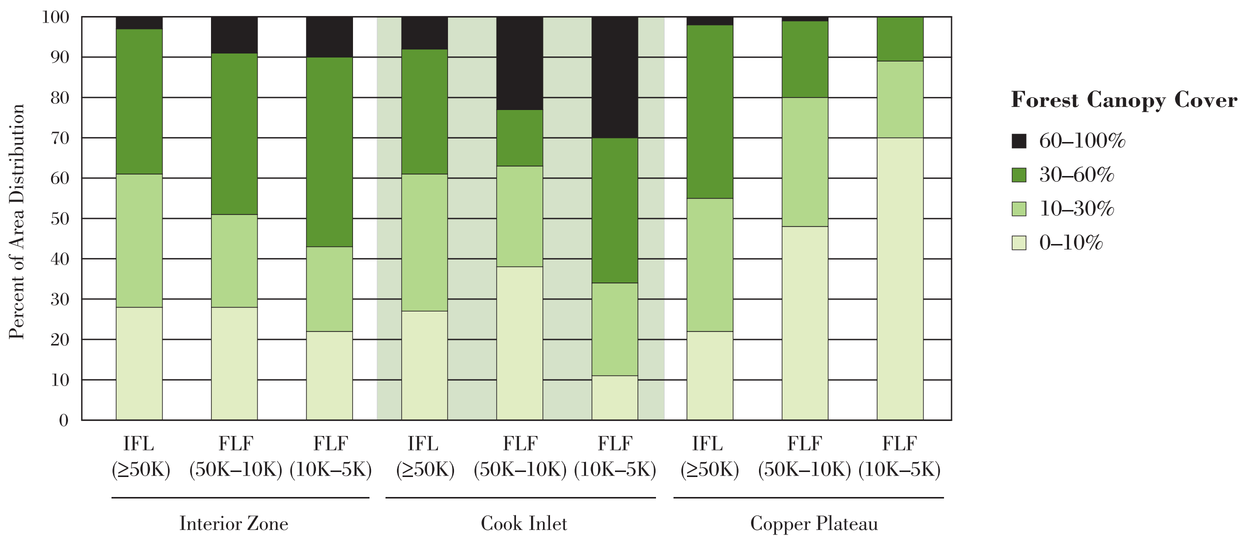


FIGURE 12 **DISTRIBUTION OF LAND COVER TYPES IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN KENAI-YAKUTAT ZONE**

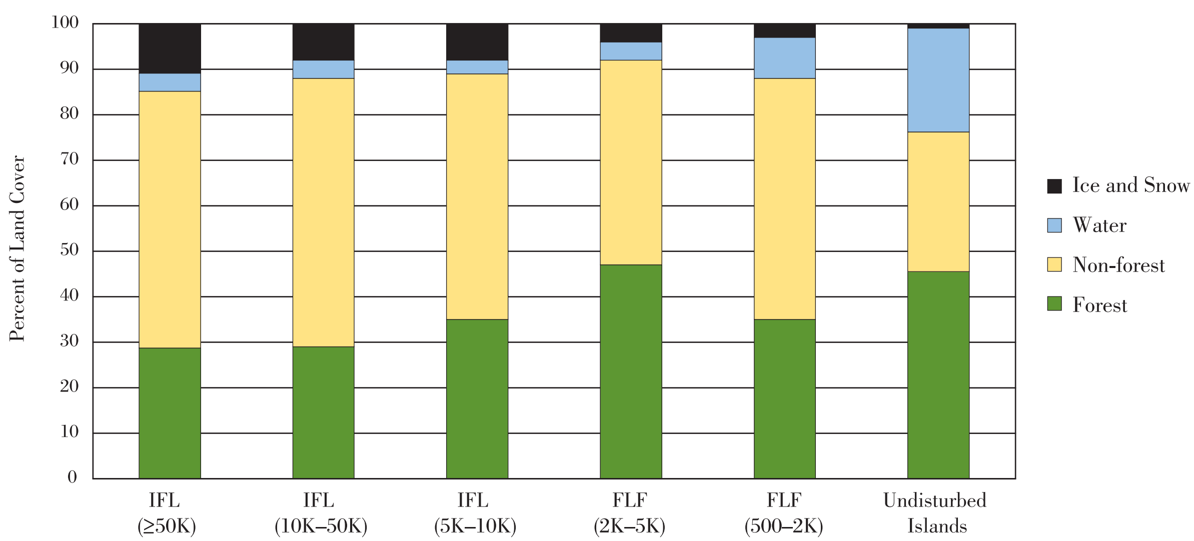


FIGURE 13 **DISTRIBUTION OF LAND COVER TYPES IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN TONGASS ZONE**

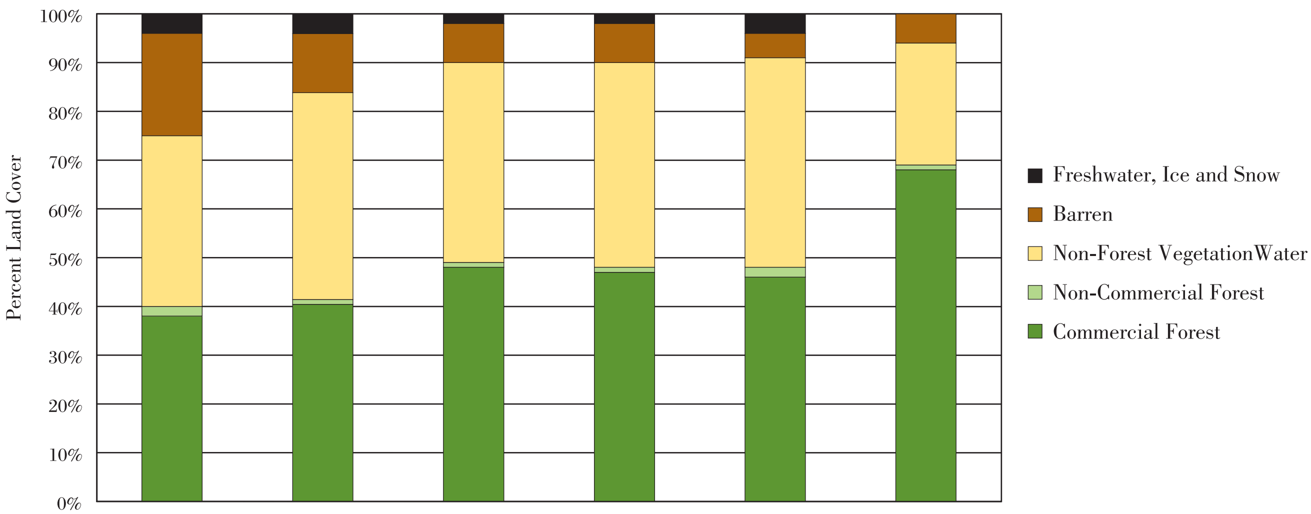
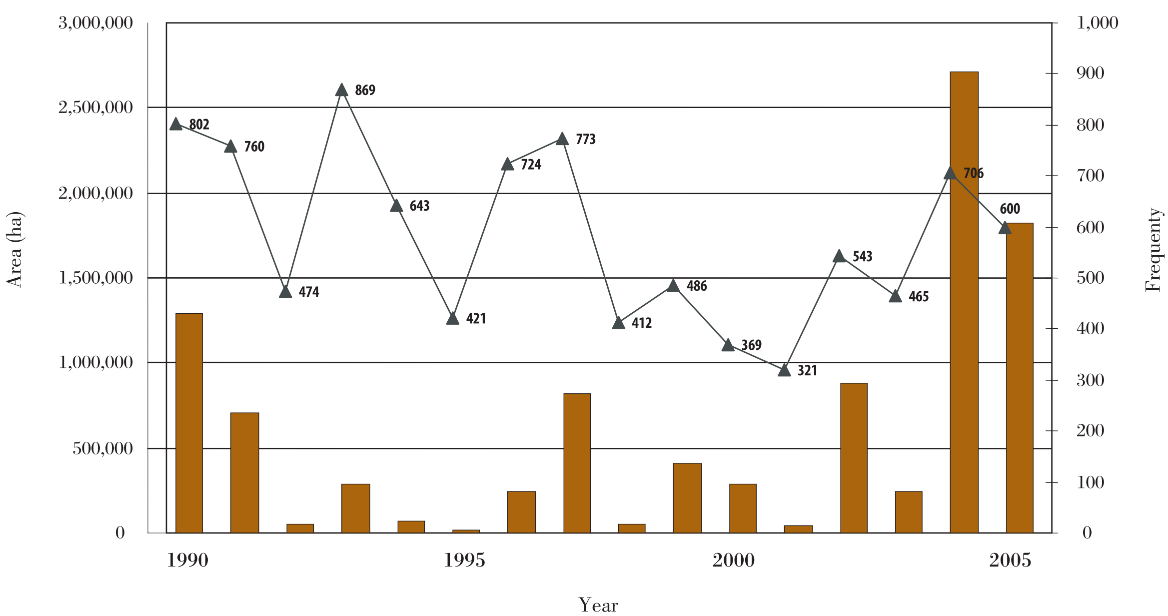


FIGURE 14 **AREA AND FREQUENCY OF FOREST FIRES IN ALASKA'S BOREAL REGION, 1990–2005**



5. CONCLUSIONS AND NEXT STEPS

Alaska represents a unique opportunity for conservation of undisturbed forest landscapes. It boasts a higher degree of forest intactness (85 percent, as defined in this report) than in any other U.S. state and the largest area (more than 147 million ha) of undisturbed forest land.

Making specific policy or management recommendations is beyond the scope of this mapping effort. This map-based analysis can support evaluations of the economic, social, and environmental costs and trade-offs of potential land use decisions. It can be used to assess current forest status, to inform the dialogue about zoning and management plans, and support constructive negotiations with industry and civil society stakeholders.

The availability of this kind of information is especially crucial given the challenging economic situation that forms the backdrop for land use decisions in Alaska. For instance, Alaska's poverty rate is significantly higher than the U.S. average and the cost of living in the state's four largest cities ranks among the most expensive in the United States. A majority of job opportunities are currently found in relatively low-wage service sectors, and employment is declining in high-wage sectors such as oil and gas, mining, and forestry.

BOREAL REGION

In Alaska's boreal region, the footprint of human activities is becoming more apparent, as technological development enables larger populations to move farther north into colder climates. For instance, Interior Alaska is the only region with growing employment in the timber sector (Department of Commerce 2005), although to date activity has been limited to relatively small-scale business operations (Alaska Forest Association 2003).

Forest stands with a larger representation of more commercially valuable forest species, such as white spruce (*Picea glauca*), quaking aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*), will most likely be the focus of future harvesting in Interior Alaska. Other factors—such as patterns of land ownership as well as location and extent of transportation networks—will also play a key role in determining areas targeted for timber production. Detailed understanding of these key socioeconomic drivers should be combined with essential environmental information, such as the results presented in this paper, in order to ensure sound planning for and management of natural resources use in this region.

Other human activities to monitor include construction of major highways and pipelines as well as mineral exploration and mining. Highways could potentially affect the movement of large mammals, since these roads give hunters access into the mountains, creating a zone of relatively higher hunting pressure along the highway corridors (Ricketts et al. 1999). Although no final decision has been made, planning for a second trans-Alaskan or trans-Canada pipeline is underway, and decision-makers need to explore the potential impact on arctic migratory species as well as large home-range species.

Future development of the Interior Alaska zone will, to some extent, modify the intact character of its forest landscapes. Decisions related to the future of these landscapes and its people must ensure long-term environmental sustainability while contributing to healthy communities and economies. Particular attention should be focused on any changes in forest composition, abundance of selected species, and alterations in ecosystem processes.

As the State of Alaska continues to grow economically and demographically, the Cook Inlet zone is likely to be subject to intense development pressures. Containing Anchorage, Alaska's largest city, this zone is home to nearly two thirds of the state's population and is already the most intensively utilized natural region in Alaska. Another notable feature of the Cook Inlet zone is the local spruce beetle epidemic, one of the largest forest pest outbreaks on record, which has necessitated salvage logging of infested forests to halt the pest's spread as well as to reduce fire risk from accumulation of inflammable fuels (i.e., vast areas of dead trees).

Conservation and management of the remaining undisturbed forest landscapes of the Cook Inlet zone will require extensive involvement and coordination of various owners, including the state (64 percent) native corporations (8 percent), and private individuals (8 percent). Given the relatively low level of protection (17 percent) for IFLs in this region, retaining undeveloped landscapes while enabling needed economic activities will require careful balancing of conservation and development priorities.

Although a majority of the forest landscape in the Copper Plateau Taiga remains intact, this region is vulnerable to increasing pressure from human uses. Recreational activities have increased significantly in some areas over the last two decades, and natural gas interests are attempting to build another 800-mile pipeline from the North Slope to the southern coast of Alaska. With a high concentration of wetlands and lakes, the Copper Plateau is an important breeding area for many waterfowl, including the trumpeter swan (*Cygnus buccinator*), a globally vulnerable species. Since less than a third of intact forests occur in designated protected areas, future development should be monitored carefully.

COASTAL TEMPERATE FORESTS

With 84 percent of its coastal temperate forests intact (as defined in this analysis), but only 35 percent of these under formal protection status, Alaska holds unprecedented opportunities for conservation of this rare and globally important biome.

To take advantage of these opportunities, development and conservation needs within this biome, must be balanced. This is a particular challenge in Alaska where forest uses are sometimes in competition with each other, there is no consensus on land use regimes, and the remote state's location makes it dependent on its largest landowner, the federal government, for revenue.

For example, in the Kenai-Yakutat zone heavy recreational use and onshore development are in conflict with a $70 million annual salmon sport fishery. These competing land uses intensify human impacts on water bodies and forests, while complicating tradeoffs.

In the Tongass Zone, significant intact portions of the coastal temperate rainforest remain unprotected. As the single largest forestland manager, the US Forest Service is challenged to conserve critically important areas, meet the economic needs of the state by ensuring the continuation of federal funding, meet the needs of the timber industry, and respond to the demands of the public.

NEXT STEPS

The methods and results presented in this report provide a valuable baseline for future studies of Alaska's forest landscapes. Routine monitoring of IFLs and FLFs—including changes in ownership, protection status, forest composition, and forest stressors—should be carried out and made publicly available.

Such efforts would make a significant contribution to global and national forest assessments, as called for by a growing number if international accords, including the Montreal Process Criteria and Indicators (Montreal Process Working Group 2005) and the Convention on Biological Diversity (CBD). The work reported on here represents an important data source for undertaking such assessments.

The satellite imagery used for the analysis presented here was adequate for this first iteration of mapping of Alaska's undisturbed forest landscapes. However, newer, relatively cloud-free imagery is becoming more commonly available and could be used to produce a second, more refined iteration. Refinements will and should be made in future assessments as better satellite sensors and spatially explicit data become available, including data on roads, managed forests, and energy exploration and development. This will bring additional accuracy in the classification and delineation of IFL and FLF areas and will provide information at spatial scales of greater usefulness to practical land management and international accounting.

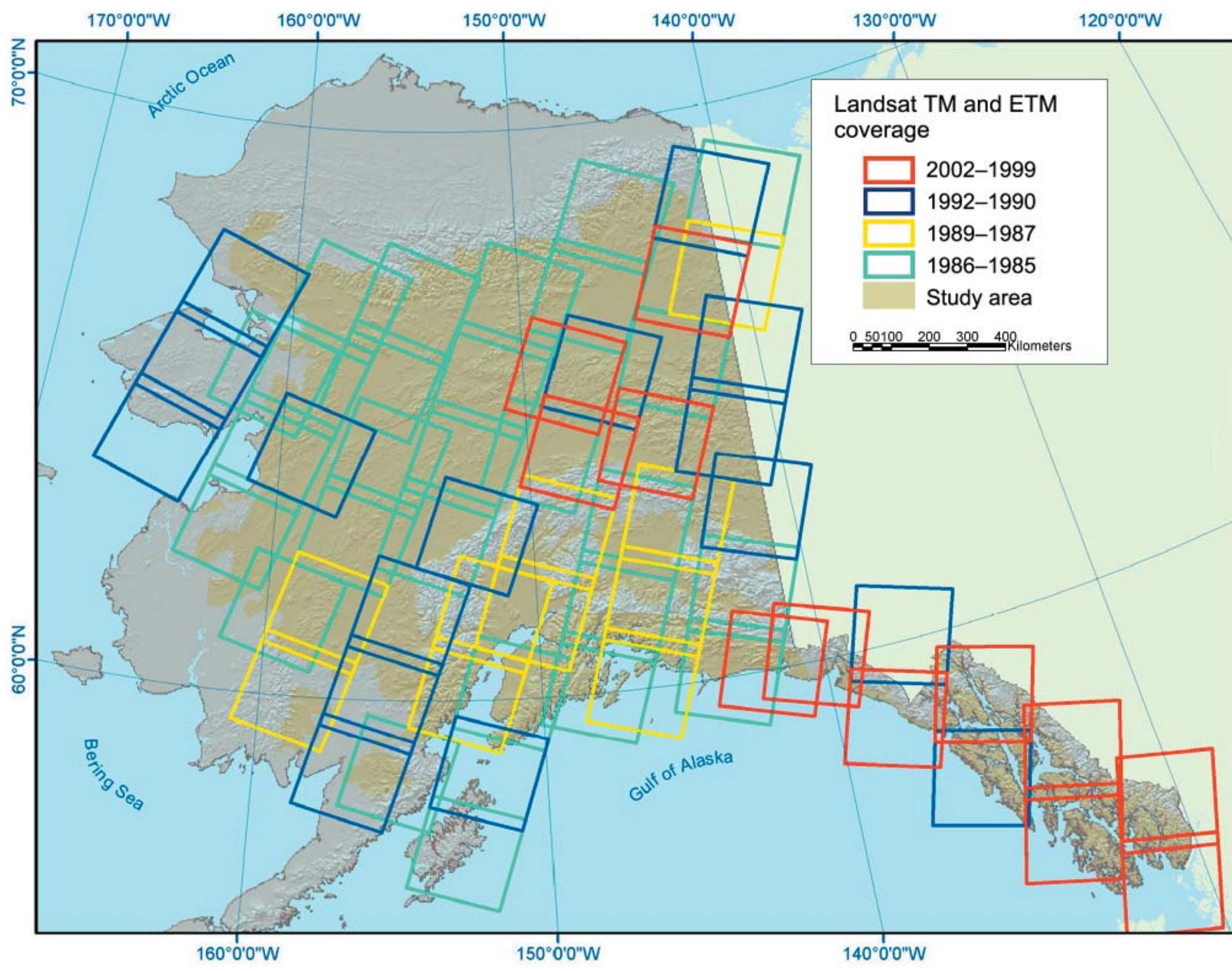
Another important area for expansion is the identification of sensitive areas that deserve special attention due to their ecological characteristics. One such effort is the definition of High Conservation Value Forests under Principle 9 of Forest Stewardship Council's forest certification guidelines. The results presented in this report will be extremely useful in providing data to inform mapping of sensitive areas as well as to expand ongoing dialogue aimed at balancing environmental, social and economic concerns about the management and protection of undisturbed forest landscapes.

NOTES

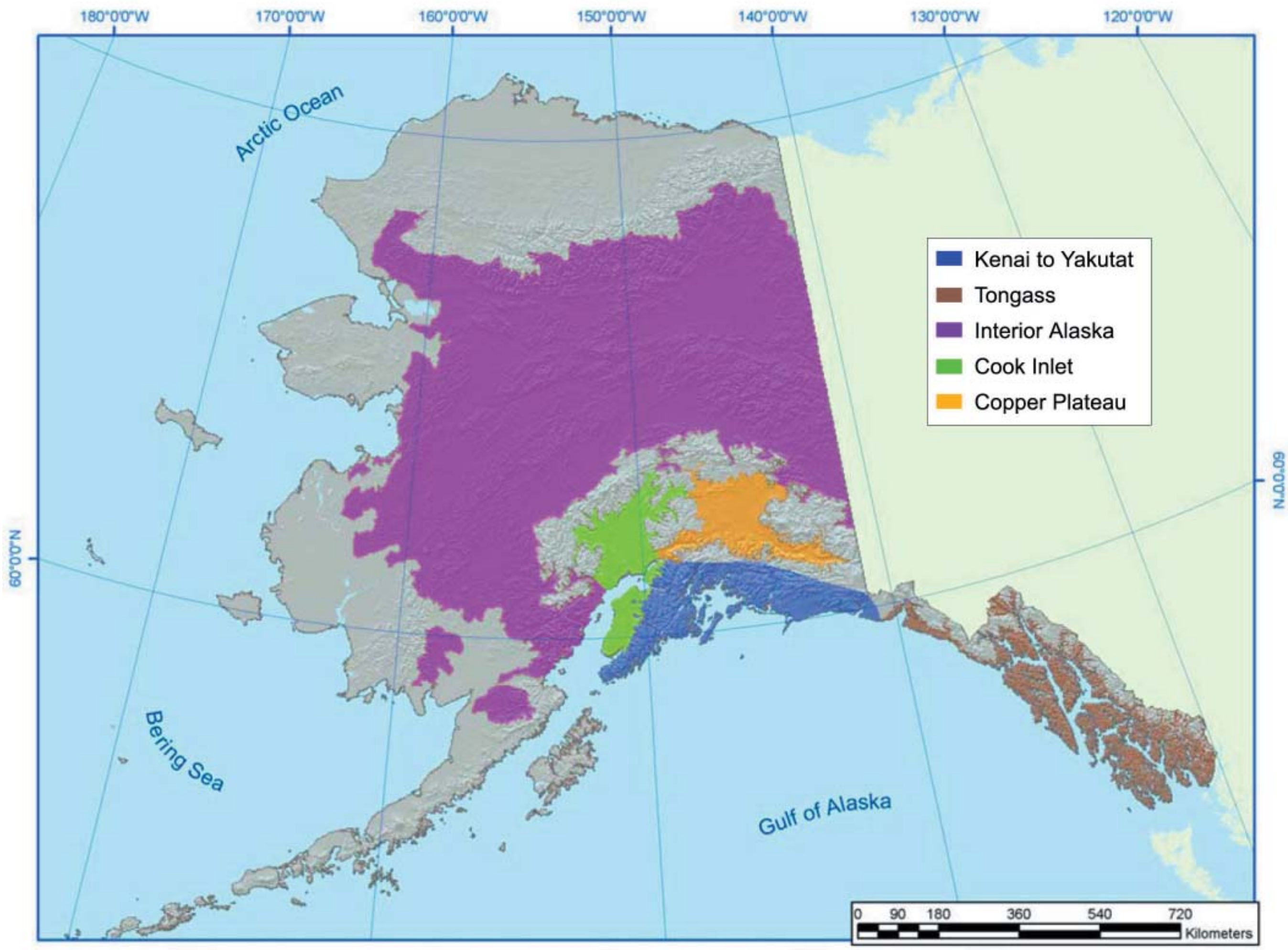
1. Two approaches have been proposed to determine the minimum area needed for recovery after disturbance. The first approach (Shugart and West 1981) is to multiply the mean patch size of disturbance by 50. In Alaska's boreal forests this will result in a size threshold of 30,000 ha (mean patch size of fire disturbance = 600 ha x 50), which is much smaller than the average area burned in dry seasons (400,000 ha). The second approach (Anderson 1999) is to multiply by four the size of the largest and more severe disturbance event. This would require a size threshold of 1,600,000 ha (using the 400,000 ha x 4).
2. After the GIS analysis was completed, NASA made available at no charge more recent satellite imagery (i.e., Landsat ETM images for 1999–2001), which was not used in this study.
3. Although Gap Analysis datasets have not been produced for the state of Alaska, we are using the USGS Gap Analysis classification to define to what extent IFLs are being protected.

6. MAP SECTION

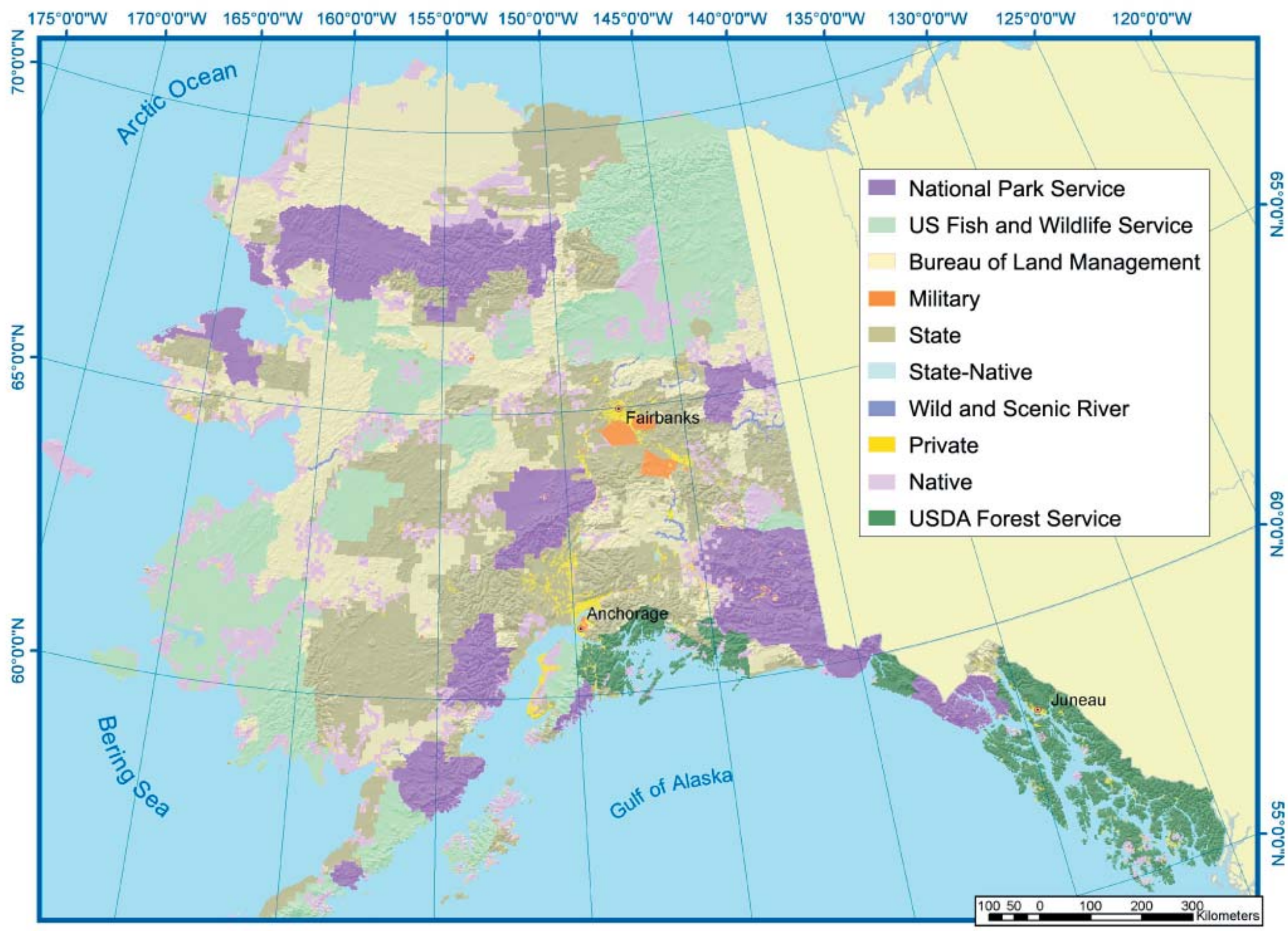
MAP 1 | STUDY AREA AND DISTRIBUTION OF SATELLITE IMAGERY USED IN THIS ANALYSIS



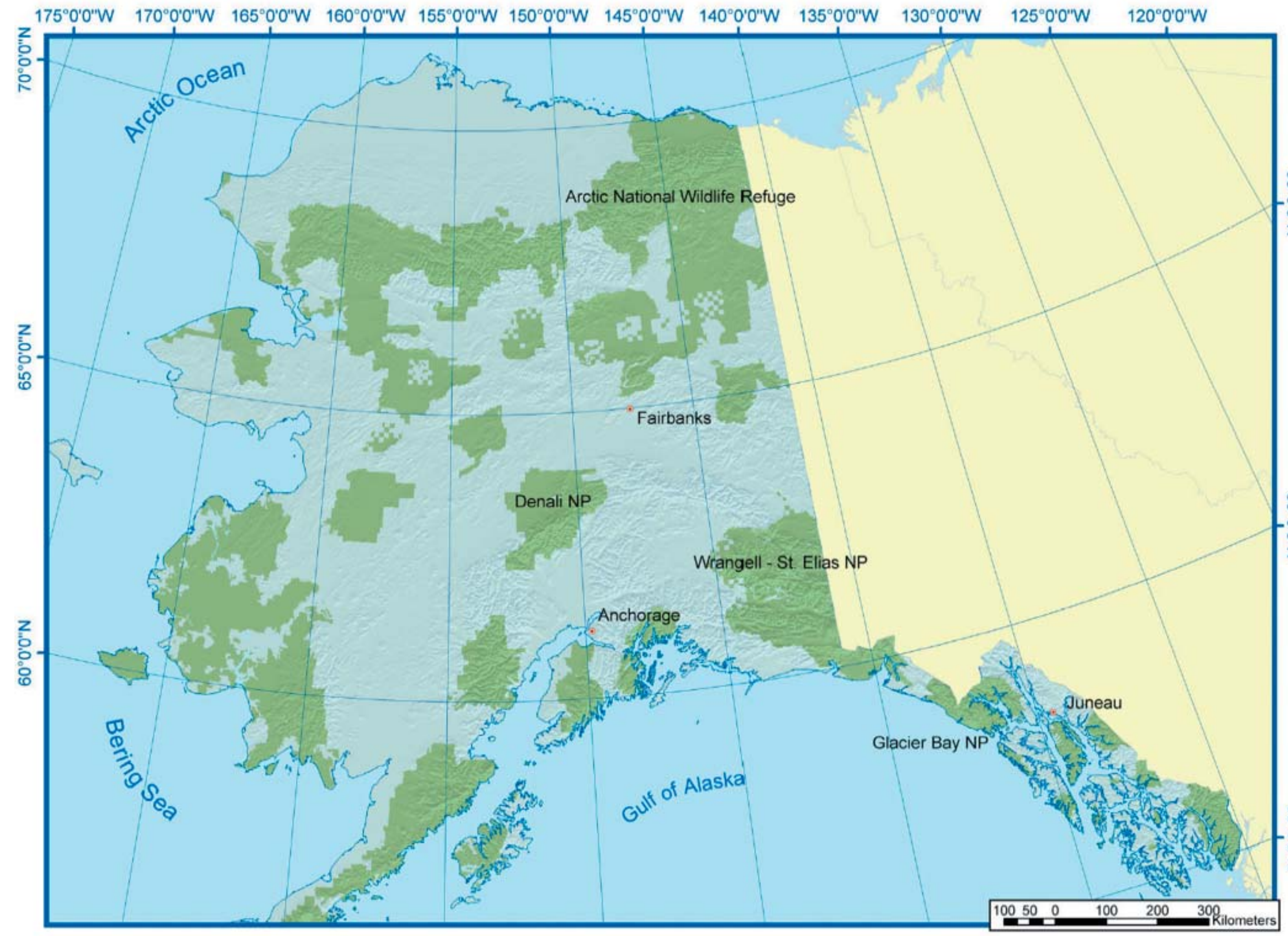
MAP 2 | ECOLOGICAL ZONES DEFINED IN THE STUDY AREA



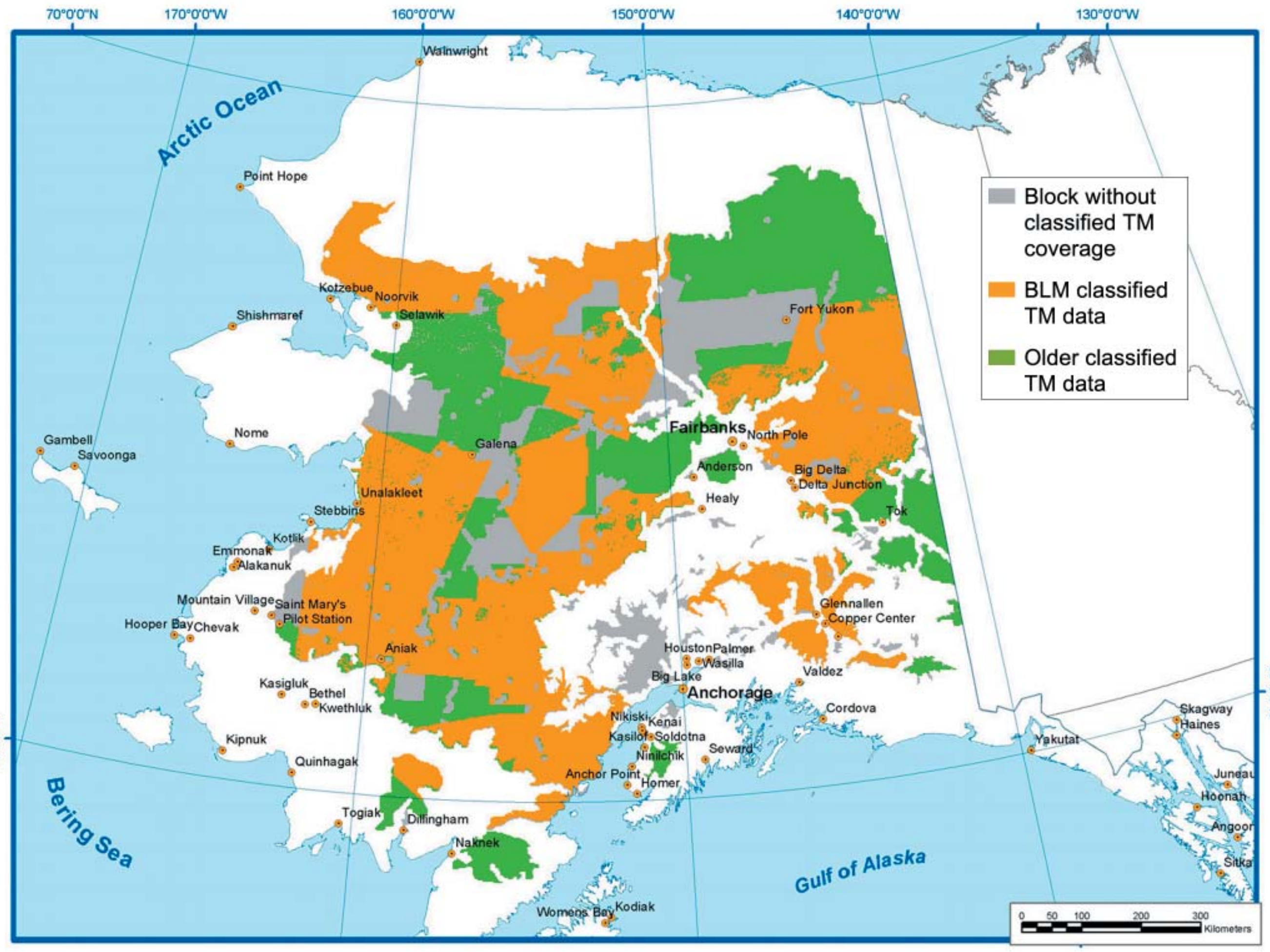
MAP 3 | OWNERSHIP MAP



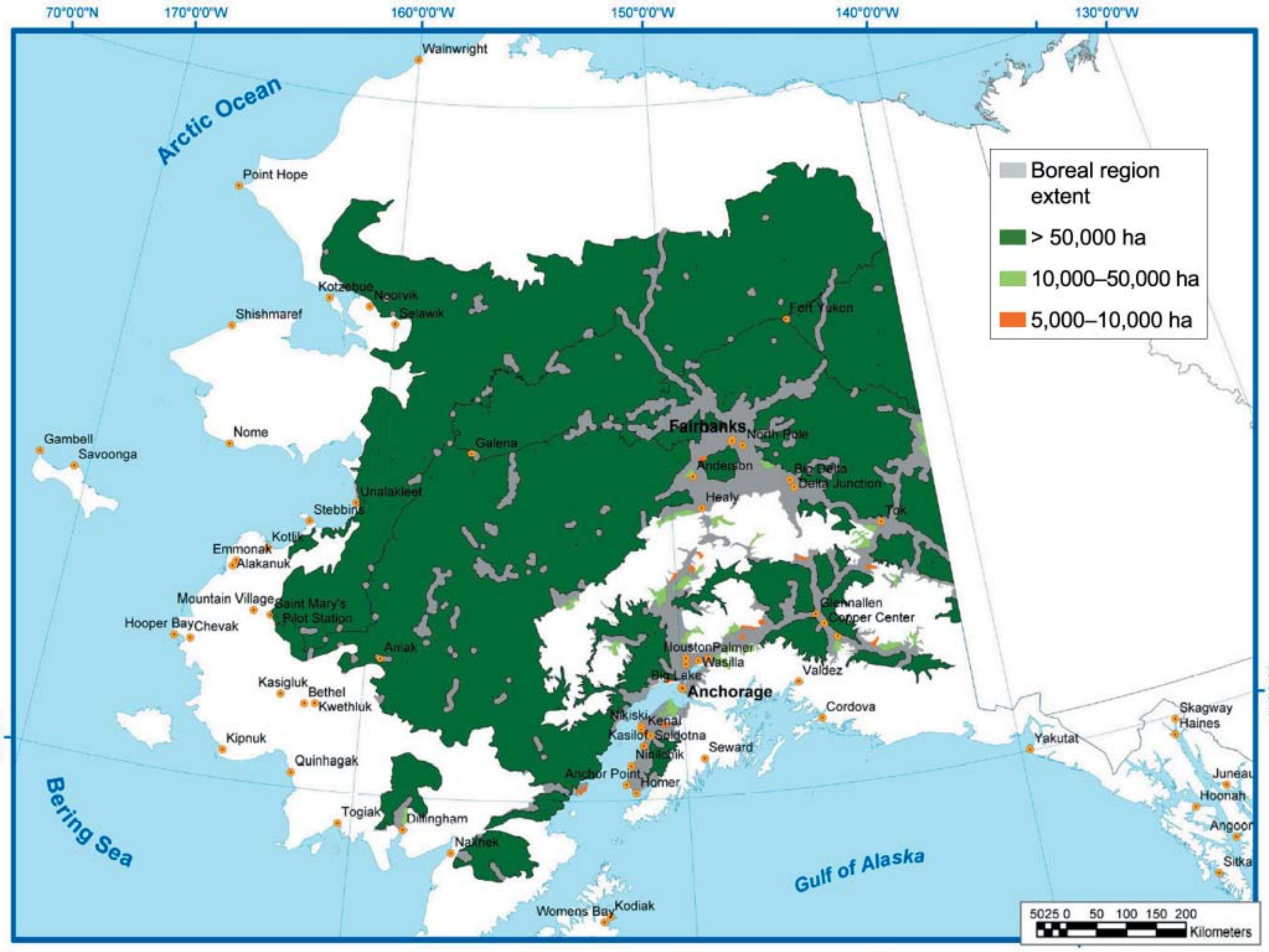
MAP 4 | PROTECTED AREAS IN ALASKA



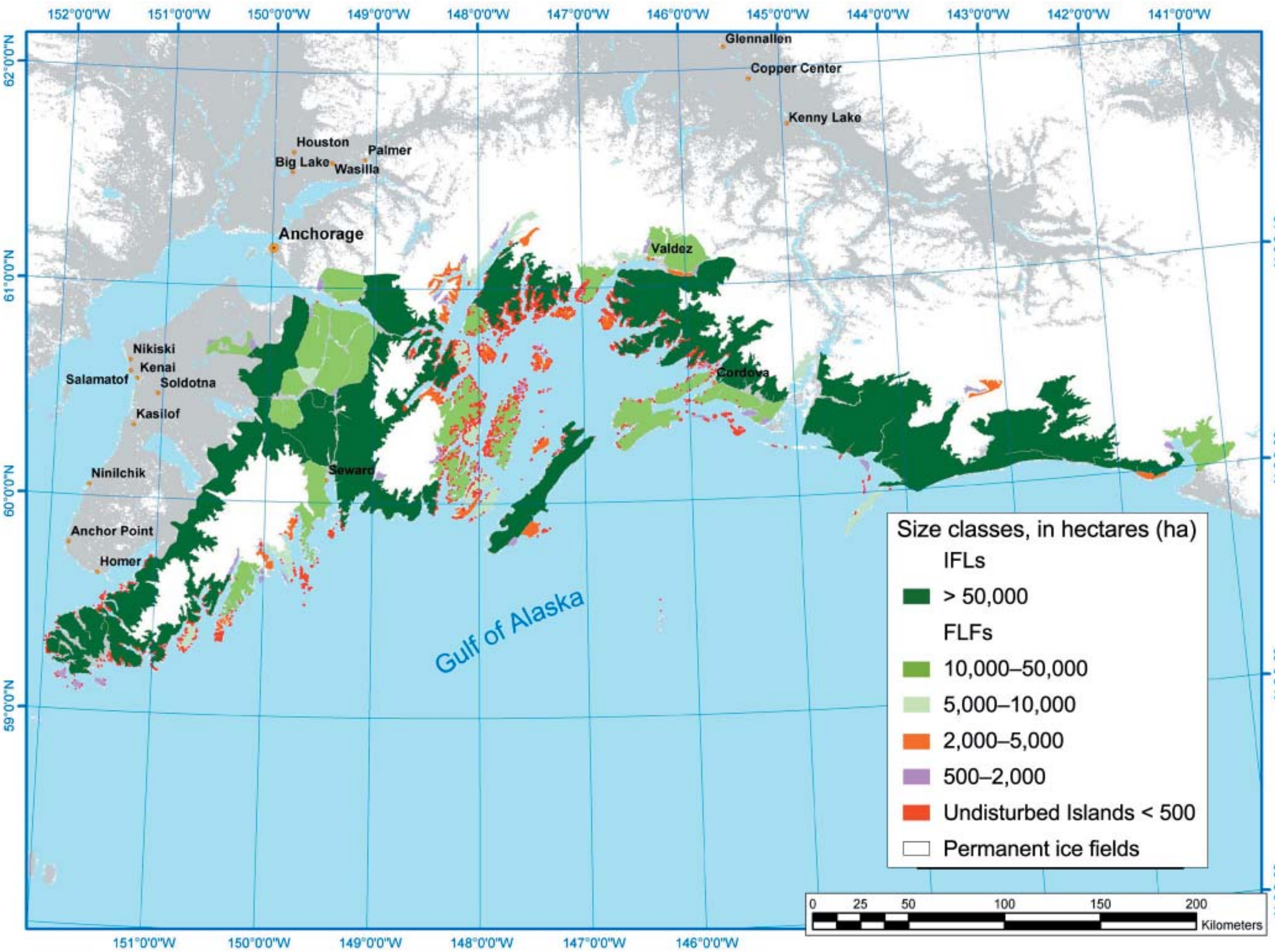
MAP 5 | DATA SOURCES FOR THE ANALYSIS OF FOREST COMPOSITION IN BOREAL FORESTS



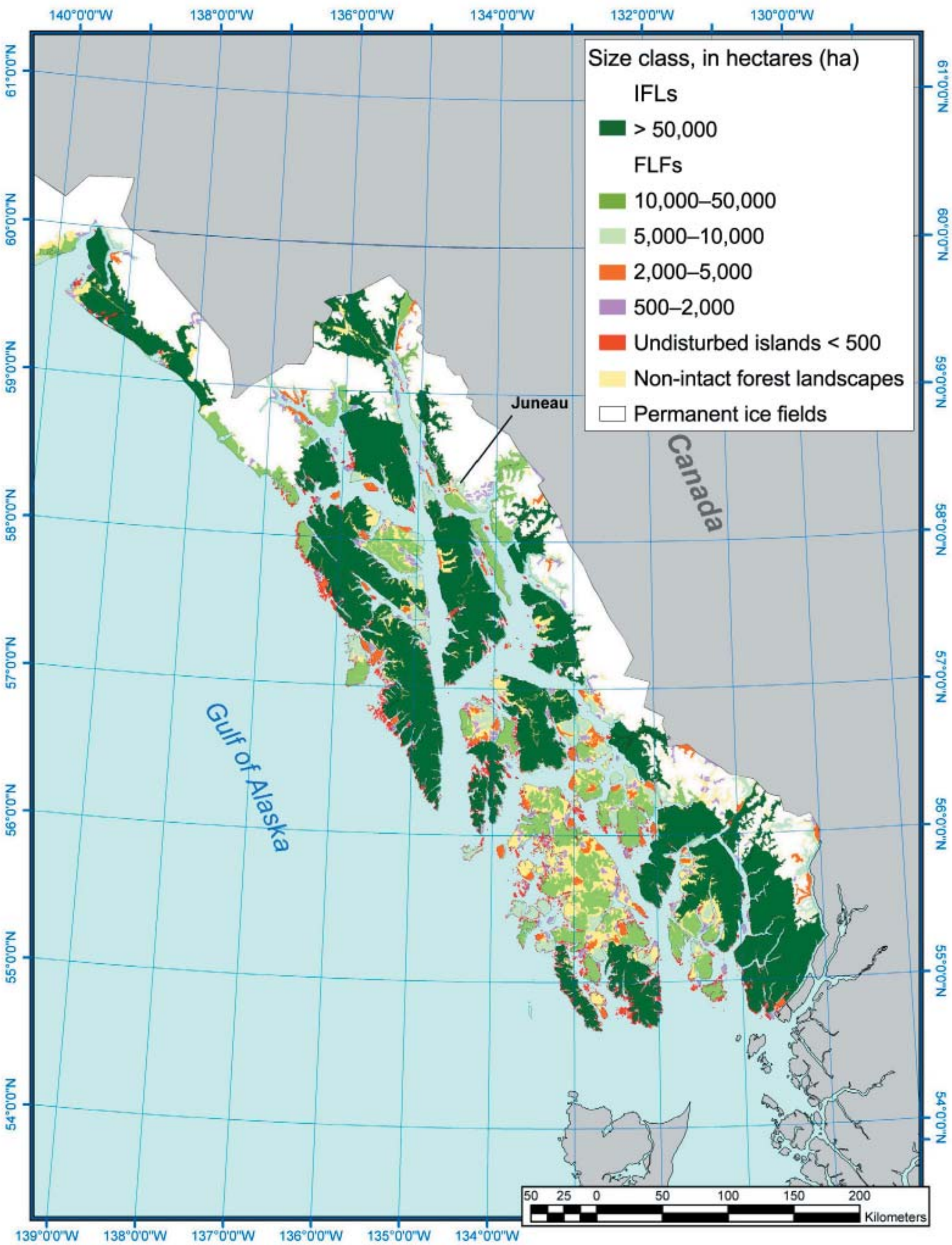
MAP 6 | IFLs AND FLFs IN THE BOREAL REGION



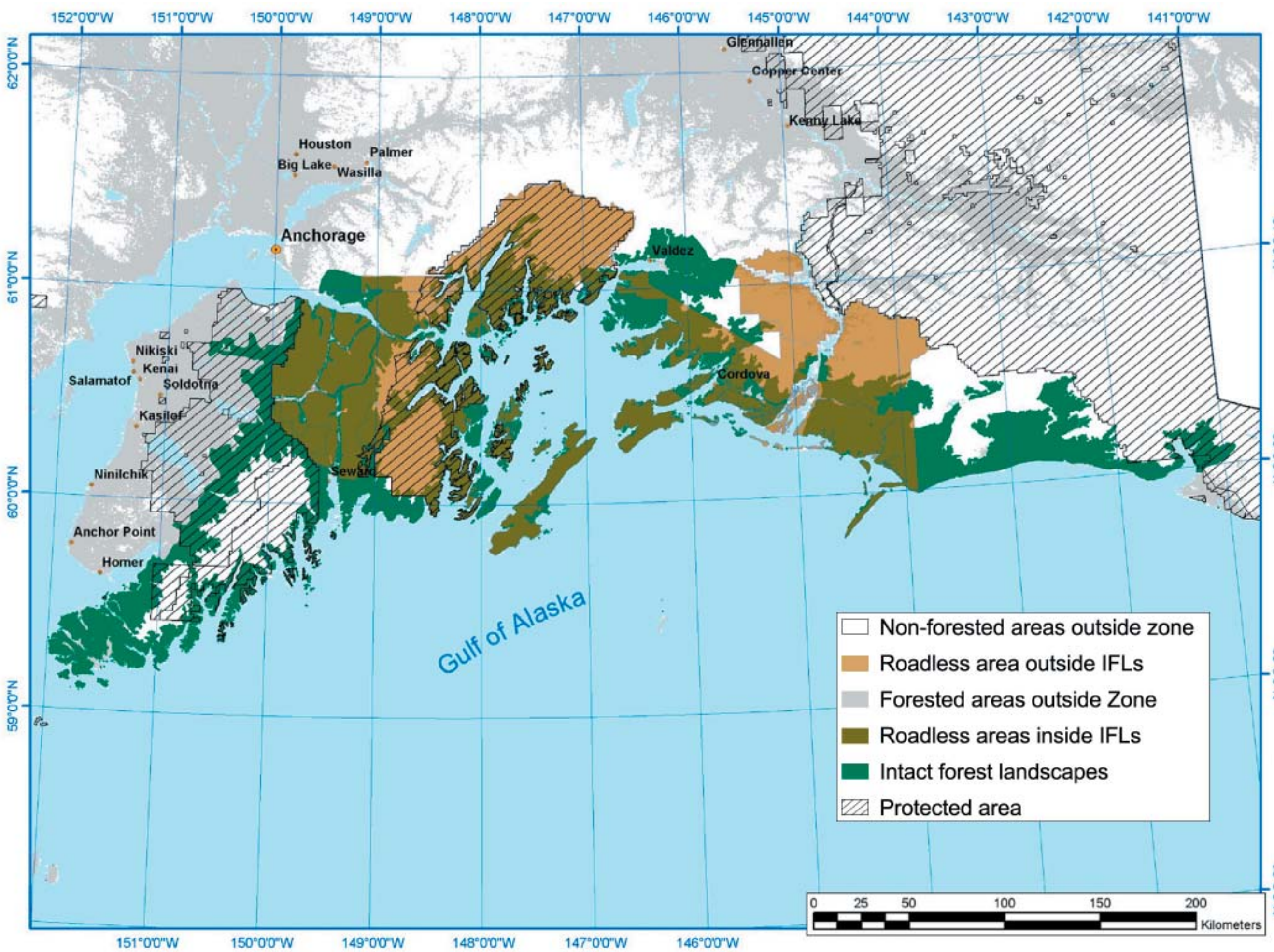
MAP 7 | IFLs, UNDISTURBED ISLANDS, AND FLFs IN THE KENAI-YAKUTAT ZONE



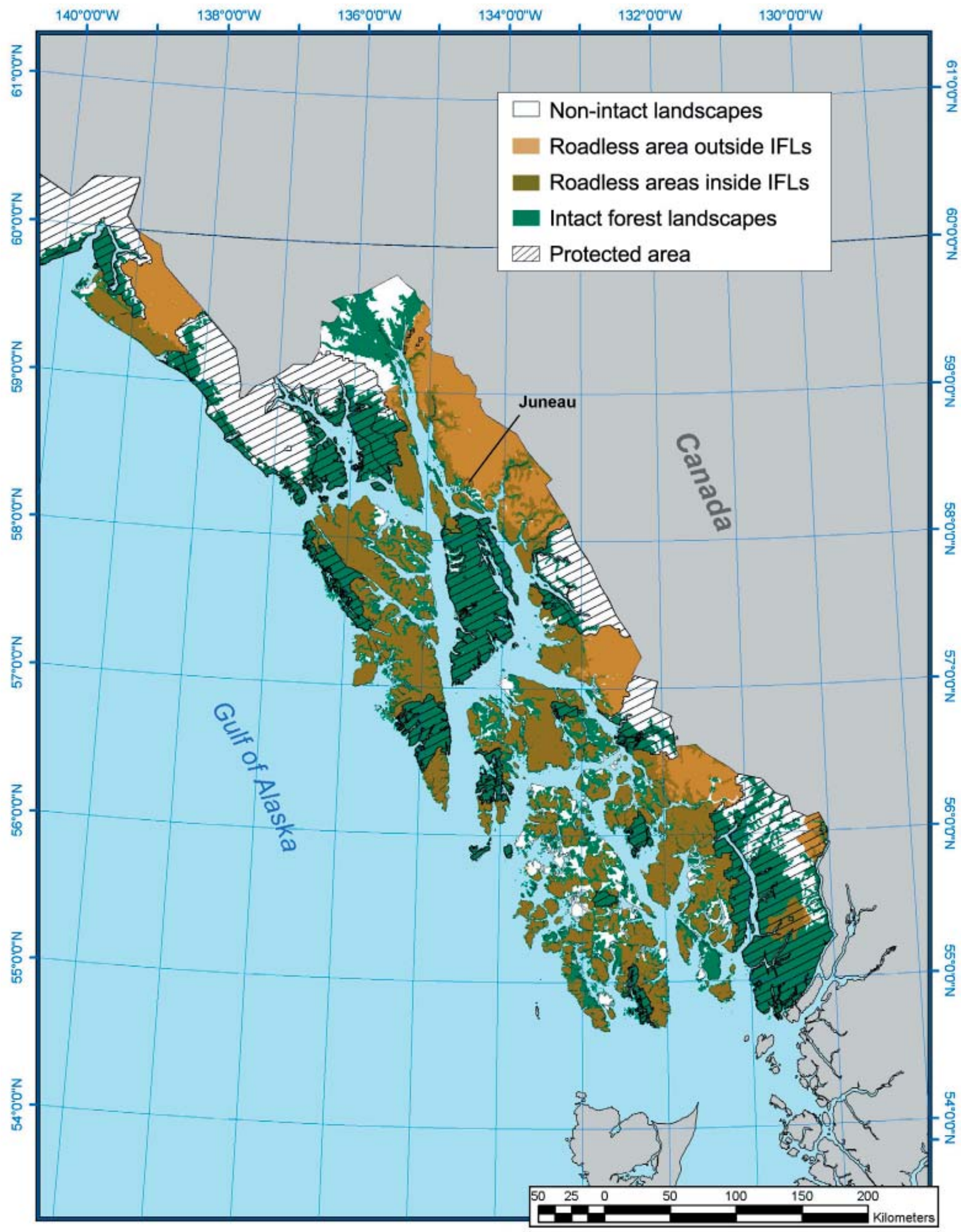
MAP 8 | IFLs, UNDISTURBED ISLANDS, AND FLFs IN THE TONGASS ZONE



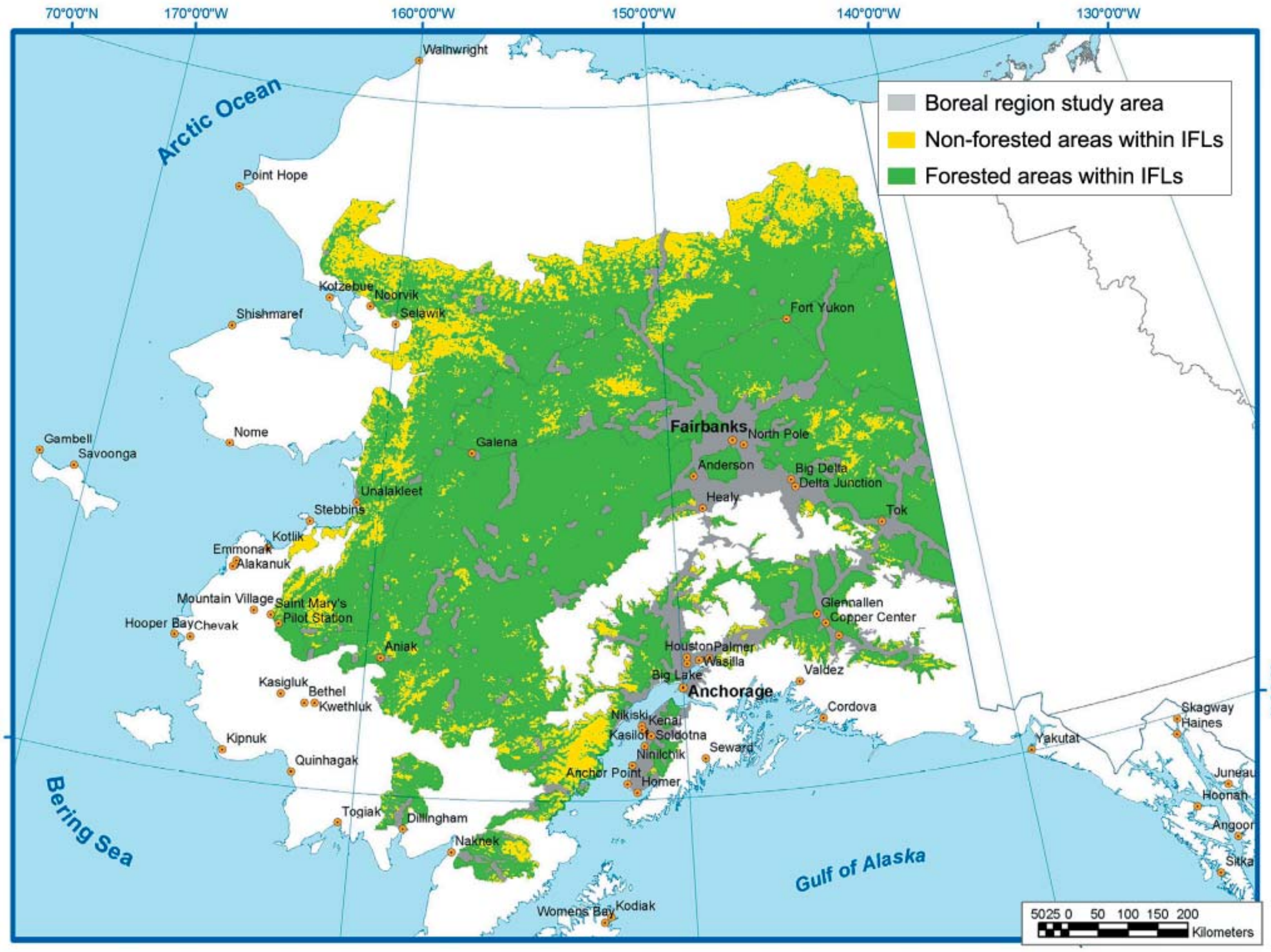
MAP 9 | IFLs, UNDISTURBED ISLANDS, AND FLFs IN THE KENAI-YAKUTAT ZONE



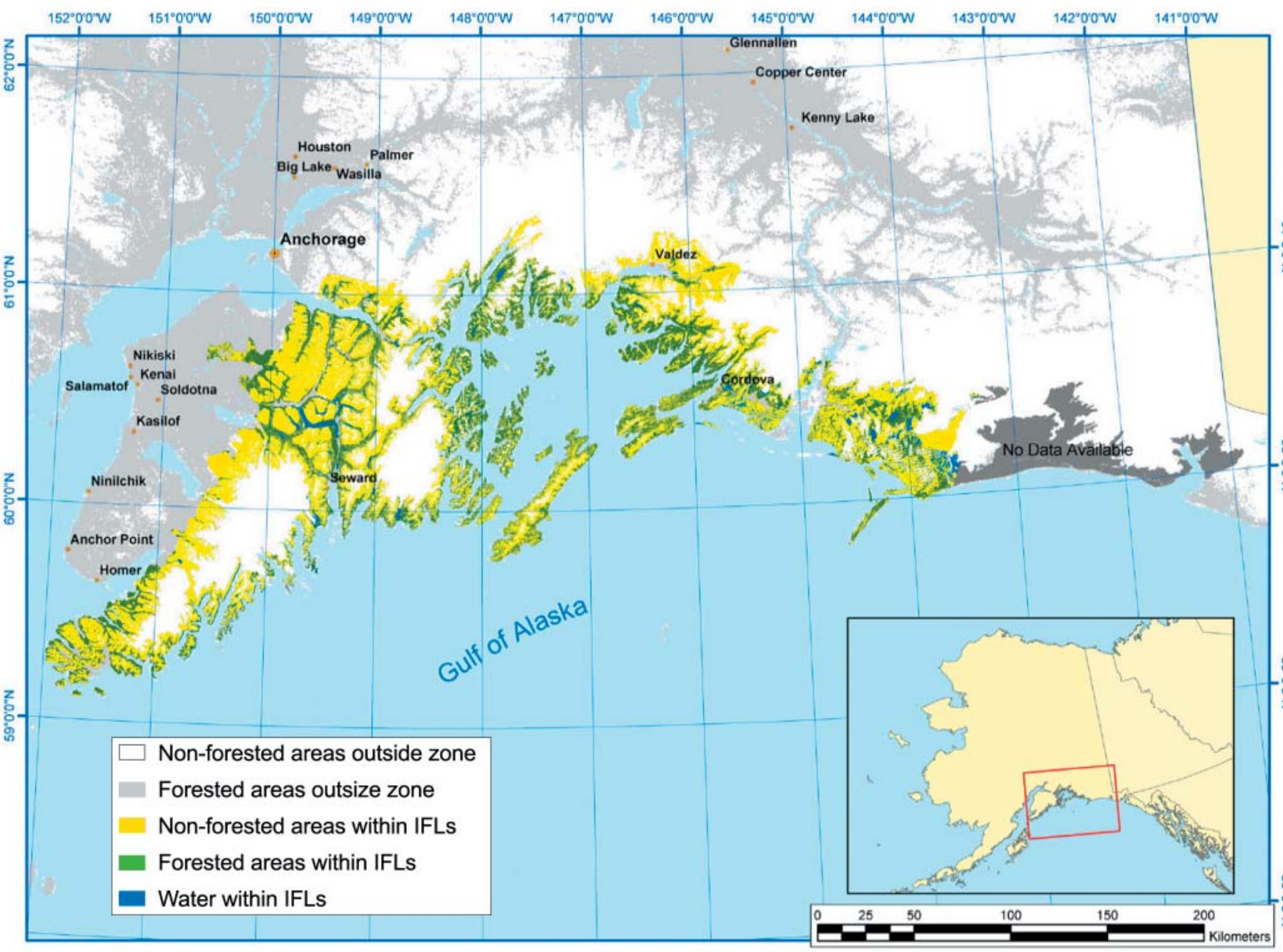
MAP 10 | IFLs, UNDISTURBED ISLANDS, FLFs, PROTECTED AREAS AND IRAs IN THE TONGASS ZONE



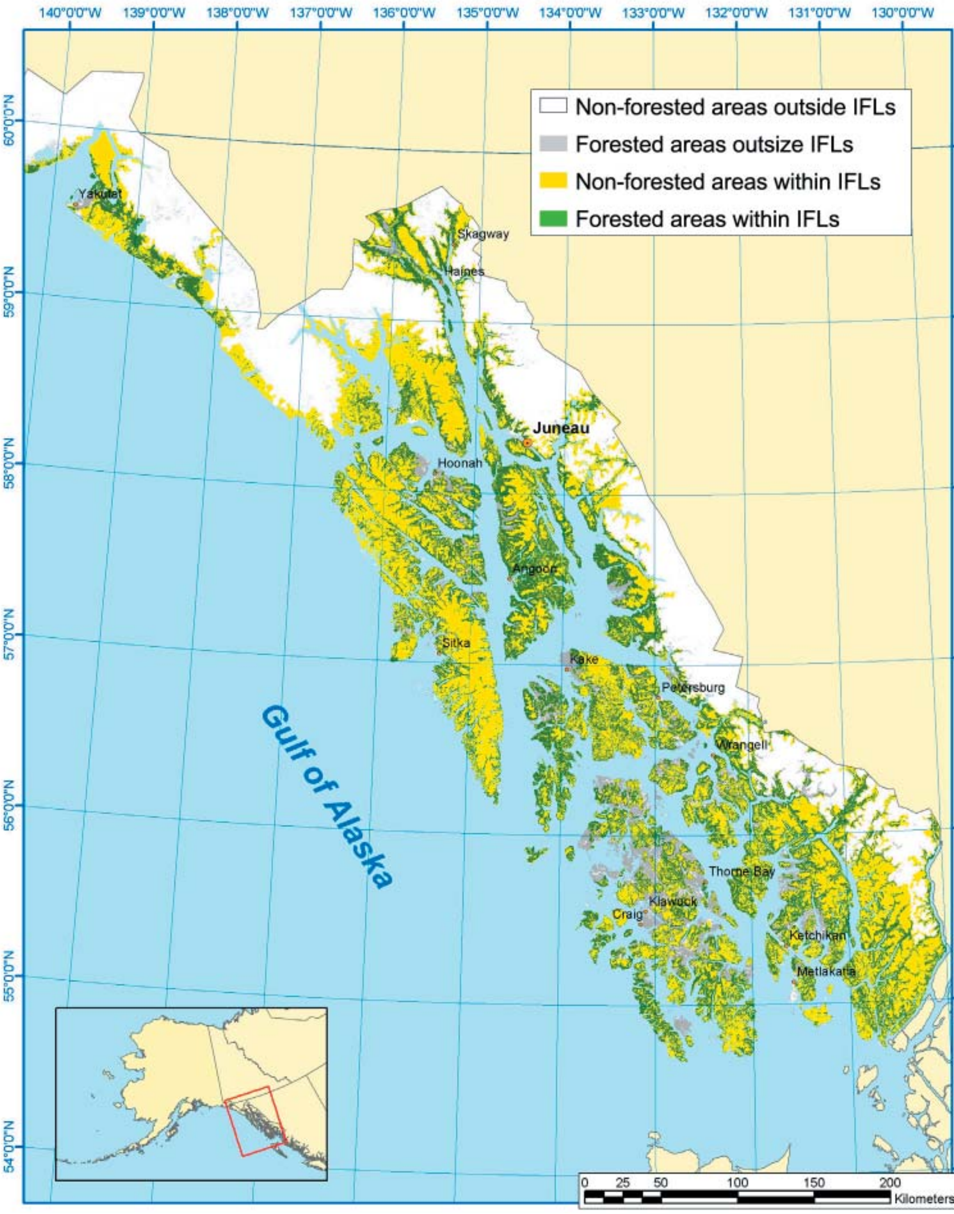
MAP 11 | FORESTS AND NON-FOREST VEGETATION IN IFLs AND FLFs IN THE BOREAL REGION



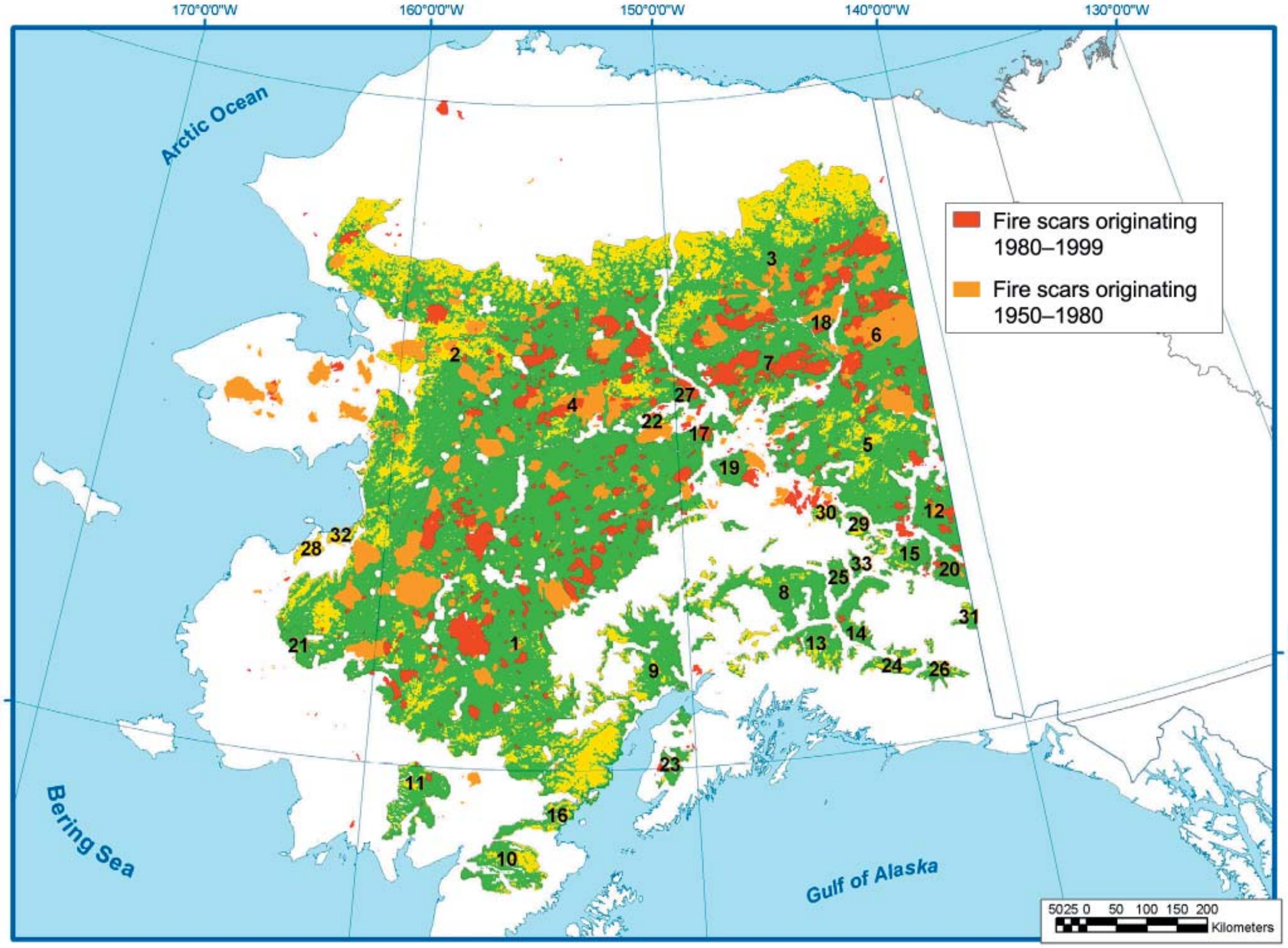
MAP 12 | FORESTS AND NON-FOREST VEGETATION IN IFLs, UNDISTURBED ISLANDS, AND FLFs IN THE KENAI-YAKUTAT ZONE



MAP 13 | FORESTS AND NON-FOREST VEGETATION IN IFLs, UNDISTURBED ISLANDS, AND FLFs IN THE TONGASS ZONE



MAP 14 | FIRE DISTURBANCES IN BOREAL IFLs AND FLFs



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APPENDIX 1

DETAILED METHOD

All analyses were performed in the GIS environment using ESRI ArcGIS and Leica's Imagine software. All imagery and ancillary data layers were converted to Albers projection.

DELINEATION OF THE STUDY AREA

The following datasets were used to delineate the study area:

Dataset	Source	Scale/ Resolution
Vegetation Continuous Fields (VCF)	University of Maryland	500 m x 500 m
Vegetation Classification from Landsat 5 TM Imagery (1980s)	U.S. Geological Survey	30 m x 30 m to 50 m to 50 m
Vegetation Classification from Landsat 5 and 7 TM Imagery (1990s-2001)	Bureau of Land Management/ National Park Service	1 Km x 1 Km
AVHRR Global Land Cover Database	U.S. Geological Survey	1 Km x 1 Km
Elevation – Digital Elevation Model (DEM)	U.S. Geological Survey	1 Km x 1 Km
Forest Condition – SE Alaska	Ecotrust	30 m x 30 m
Terrestrial Ecoregions	WWF	
State boundaries	ESRI	
Glaciers	Alaska Department of Natural Resources	1:2,000,000

The study area was digitized as a polygon guided initially from the Vegetation Continuous Fields (VCF) dataset and modified with more detailed landcover imagery from Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper (ETM+) some of which was classified by the USGS, BLM/NPS and Ecotrust (Map 1).

The VCF is derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) acquired and composited twice a month between 2000 and 2001. The layer presents percentage tree canopy cover by pixel (Hansen et al. 2003). VCF data (any pixel >10 percent forest canopy cover and consistent with FAO 2001 definitions) was checked against raw and classified Landsat imagery, which coves over 95 percent of the state of Alaska.

VCF data appeared to underestimate canopy cover along portions of the northern extent and overestimate canopy cover along the southwestern portion of the state where tall shrublands are common. Along these two border areas, the Landsat imagery was preferred to determine the boundary.

Using the imagery as the background, the forest extent boundary was digitized on the screen. The boundaries were generalized to eliminate isthmuses of forests (anything less than 2 km wide), and all blocks smaller than 5,000 ha were excluded.

For Southeast Alaska, a centerline along the mountain ranges was digitized framing the entire coastal region. All glaciers that were >10,000 ha based on classified Landsat 5 TM imagery were excluded based on a glaciers data layer. All other land areas were considered in the assessment.

Using WWF's Terrestrial Ecorregions classification and the AVHRR data from the USGS, the study area was divided in five zones: Interior Alaska, Cook Inlet, and Copper Plateau in boreal Alaska, and the Kenai-Yakutat and Tongass zones in the coastal temperate rainforest.

IFL AND FLF MAPPING USING A TWO-STEP APPROACH

Step 1: Mapping Human Disturbances Using Existing GIS Data Layers

The following datasets were used in this step:

Dataset	Source	Scale/Resolution	Geographic Coverage
TIGER Roads, Rail and Misc. Trans	US Bureau of the Census	1:100,000	Boreal
TIGER Pipelines and Power Lines	US Bureau of the Census	1:100,000	Boreal
TIGER Hydrography	US Bureau of the Census	1:100,000	Boreal
Active Mines and Mineral Plants	U.S. Geological Survey	1:1,000,000	Boreal
Oil and Gas Wells	Alaska Department of Natural Resources	1:100,000	Boreal
Towns	Alaska Department of Natural Resources	1:100,000	Boreal
Military Waste Sites	US EPA & Dept. of Energy	1:100,000	Boreal
Forest Roads	Chugach National Forest	1:24,000	Kenai
Forest Type Data (Clearcuts)	Chugach National Forest	1:24,000	Kenai
Kenai Borough Roads	Kenai Peninsula Borough GIS	1:24,000	Kenai
Kenai Clearcuts	Kenai Peninsula Borough GIS	1:24,000	Kenai
Forest Roads	Tongass National Forest	1:24,000	Tongass
Clearcuts Database	Tongass National Forest	1:24,000	Tongass

For the ***boreal region***, datasets were buffered by specified distances to approximate the extent of human and industrial impact on the landscape. The results from the buffer operations were then combined into a single polygon file. This layer was then erased from the forest landscape extent. Isthmuses (or land bridges) that did not meet the minimum width criteria of 2 km were cut into two separate blocks. Blocks smaller than 5,000 ha were deleted.

For the ***coastal temperate forest***, a different approach was used to eliminate known human and industrial development. Finer-scale disturbance data was available in the geographically confined setting of the Southeast Alaska archipelago, including more detailed (1:24,000) roads data layers and a spatially explicit clearcut logging database for the region, which were provided by the U.S. Forest Service. This finer-scale information enabled use of a more refined mapping technique relying on neighborhood analysis rather than buffering.

All areas immediately adjacent to roads or included in the clearcut databases for the Chugach and Tongass National Forests were excluded from potential intact forest landscapes. The resulting blocks were examined and isthmuses of forests smaller than 500 m were split into two distinct blocks.

Neighborhood analysis was then used to delineate IFLs and FLFs in the coastal temperate rainforest. Specific steps were:

1. Roads, railroads and utility lines were combined into a single data layer. Adjacent files were appended as needed. The resulting vector file was converted into GRID using a 10m x 10m resolution.
2. An initial roadless areas layer was created using the **Search Distance** function in ArcView on the roads with a 10-m grid cell size for the full extent of the coastal temperate rainforest area. The function **Neighborhood Statistics** was used on the results. The parameters were set to calculate neighborhood maximum using a 10 x 10 moving window. The **Reclass** function was used to reclassify values: from 0-70 to 1; from 70.001-150 to 2; and from 150.001-max to 3. This last class represents the potential roadless areas.

3. The grid was re-converted to a polygon file by running the **Gridpoly** command in ArcView. Potential roadless areas (class 3) were **re-selected**.
4. Roadless areas from the previous step were buffered by 75 m.
5. Roadless areas <500 ha were removed.
6. Additional industrial human disturbances were incorporated through visual interpretation of satellite imagery. Using the **Erase** command, all areas within roadless blocks disturbed by industrial human activities. Resulting blocks were examined to cut out isthmuses and/or land bridges.
7. Different class sizes of IFL and FLF were created using the **Reselect** command. Categories were: (1) >50,000 ha; (2) >10,000–50,000 ha: (3) >5,000–10,000 ha; (4) >2,000–5,000 ha; and, (5) 500–2,000 ha.

Step 2: Mapping Human Disturbances Using Satellite Imagery

Satellite images were the main source of information for the second step of the intactness analysis. Satellite images were visually examined and any evidence of human impact (e.g. new roads) was digitized. In the assessment, we used 77 Landsat 5 TM and Landsat 7 ETM+ satellite scenes from 1985 to 2000 (see table next column).

Each scene was displayed increasing the contrast between vegetation and bare soil and emphasizing disturbed terrain such as new roads or oil pad infrastructure. The buffers and ancillary data layers were displayed over the top of the imagery to help guide in finding additional disturbances. Each image was scanned at 1:50,000 scale to identify human disturbances not included in any of the ancillary data layers. Additional disturbances were digitized as lines, and areas as polygons.

Path	Row	Year	Path	Row	Year
54	21	1989	71	16	1991
54	22	1989	71	19	1995
56	20	1989	72	13	1986
56	21	1986	72	14	1986
58	19	1991	72	15	1986
58	20	1990	72	16	1986
60	19	1992	72	17	1991
62	18	1993	72	18	1991
64	16	1991	72	19	1991
64	17	1986	74	15	1986
64	18	1986	74	16	1986
65	14	1993	74	17	1989
65	15	1992	74	18	1989
66	13	1995	75	13	1986
66	14	1995	75	14	1986
66	15	1995	75	17	1985
66	16	1995	76	15	1991
66	17	1987	76	15	1991
66	18	1987	77	13	1986
67	12	1991	77	14	1986
67	13	1986	77	16	1986
67	14	1986	77	17	1995
67	15	1986	78	14	1985
67	16	1986	80	13	1992
67	17	1986	80	14	1992
67	18	1986	80	15	1992
69	14	1991	67	15	2002
69	15	1991	70	14	2001
69	16	1989	63	18	2001
69	17	1989	67	13	2001
69	18	1986	69	15	2001
69	19	1991	54	21	2000
69	20	1986	54	22	2000
70	12	1986	56	20	2000
70	13	1986	56	21	2000
70	14	1986	58	19	2000
70	15	1986	58	20	2000
70	17	1987	60	19	2000
70	18	1987			

ADDITIONAL ANALYSES

Ownership and protected status, forest composition, and fire disturbances were evaluated and summarized in an attempt to further describe the condition of IFLs and FLFs.

Ownership and Protected Status

Ownership and protected status were evaluated based on the following available datasets:

Dataset	Source	Scale/Resolution
Alaska Land Status	Alaska Dept. of Natural Resources	1:63,500
Protected Areas Database	Conservation Biology Institute	1:250,000
Tongass Conservation Plan	Tongass National Forest	1:63,500
Inventoried Roadless Areas	Tongass and Chugach National Forests	1:63,500
WWF Ecoregions	World Wildlife Fund	1:1,000,000

Forest Composition

General forest composition was evaluated based on the following available datasets:

Name	Source	Scale/ Resolution	Geographic Coverage
Vegetation Continuous Fields (VCF) – MODIS	University of Maryland	500m × 500m	Boreal Zone
Vegetation Classification from Landsat 5 TM imagery 1980s	U.S. Geological Survey	30m x 30m to 50m × 50m	Boreal Zone
Vegetation Classification from Landsat 5&7 TM imagery 1990s–2001†	Bureau of Land Management / National Park Service	30m x 30m	Coastal Temperate Rainforest Zones
Forest Condition	Ecotrust	30m × 30m	Tongass
Timber type	U.S. Forest Service	varied	Tongass and Chugach National Forests

† The following BLM land cover classification were used for the assessment of forest composition of IFLs and FLFs in the Boreal Region: Galena MOA/Nowitna NWR, Gulkana, Innoko, Naknek MOA, Northern Yukon MOA, Southern Yukon MOA, Steese-White Mountains, Stoney River MOA, Susitna MOA, Tanana Flats, Tiekel, and Yukon-Charley/Black River/Fortymile.

For ***boreal Alaska***, three different landcover classifications were used since none of them provided information for the entire study area: the VCF data depicting percentage of canopy cover developed by the University of Maryland; the BLM vegetation classification data from Landsat 5 TM imagery; and earlier (1980s) Landsat 5 TM classification for portions of the state by the USGS. While VCF data covers all the state, both the BLM and USGS land cover classifications are more detailed. About 70 percent of the Boreal Region is covered by the BLM land cover classification while another 17 percent is covered by the USGS classification. The remainder (essentially Landsat TM data areas) accounted for 12 percent (Map 3).

For the ***coastal temperate rainforest***, classification of Landsat TM imagery by the USGS was used, supplemented by newer data for the Kenai Fjords National Park by the National Park Service. Finally, forest composition data provided by Ecotrust and based on Landsat TM was used for the Tongass zone.

Using the VCF landcover, summary statistics were generated for all IFLs and FLFs in boreal Alaska showing percent forest canopy cover classes tabulated for (1) 0 percent-10 percent, (2) 10 percent–30 percent, (3) 30 percent-60 percent, and (4) 60 percent 100 percent. For comparison, the IFLs were also analyzed using the BLM and USGS land cover classifications and summary statistics were generated for forest, non-forest, and water.

For the Kenai-Yakutat Zone, summary statistics for the IFLs and FLFs were created using simple vegetation classes derived from the USGS and NPS landcover. For the Tongass, summary statistics were created for IFLs and FLFs using the Ecotrust classification, which focused primarily on discriminating between harvestable and non-harvestable timber categories.

Fire Disturbance

Fire disturbance was evaluated in the IFLs and FLFs using the Fire scars dataset from 1955-1999 from the Alaska Fire Service. The resolution of the dataset is 1:63,360.

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APPENDIX 2

ECOLOGICAL CHARACTERISTICS OF ALASKA'S FOREST BIOMES

Alaska contains two principal forest biomes: the boreal (i.e., northern) forest region, which covers over 70 million ha (approximately 47 percent of the state) and the coastal temperate rainforest, located in the southeastern part of the state, stretching in a narrow band along the coast from the southern islands of the Alexander Archipelago north to Prince William Sound and the Kenai Peninsula.

Alaska's boreal forests can be classified in three distinct ecozones: Interior Alaska; Cook Inlet Taiga; and Copper Plateau Taiga. These zones share many general, physical, and biological characteristics, but they are distinctive expressions of the boreal forest.

INTERIOR ALASKA

Interior Alaska extends from the Yukon Territory of Canada in the Richardson Mountains and continues west through the heart of Alaska to the Bering Sea. Within the state, Interior Alaska is bounded by the Brooks Range in the north and the Alaska Range in the south.

The terrain consists primarily of rolling hills and extensive flat bottomlands along several major meandering rivers, including the Yukon, Porcupine, Tanana, and Kuskokwim. Elevations range from sea level to approximately 600 m.

Extreme climatic conditions are common, with temperatures varying as much as 90° C from summer to winter. Because of the long, cold winters and the warm, short summers, growing seasons are short and, as a result, annular growth rings in the region's timber are very tight, making the wood prized for its strength and delicate beauty (Alaska Forest Association 2003). Precipitation varies, ranging from 250 mm per year in western portions to 550 mm in eastern portions. Permafrost is mostly continuous in the northern portion and discontinuous in the central and southern portions. Wildfire, usually ignited by lightning, is the major disturbance regime, occurring approximately every 50 to 70 years.

The interaction of several environmental variables (including topography, drainage, and soil productivity) produces a mosaic of forest and non-forest habitats. Restricted drainage due to permafrost results in an extensive wetland system. Marshes, shrub thickets, small ponds, and forested islands are common throughout the lowlands and broad interior valleys. The lowland portions contain 60 to 70 percent wetland cover, while highland areas are generally characterized by 40 to 55 percent wetland cover (Hall et al. 1994).

Black spruce (*Picea mariana*) is the dominant, most widespread conifer species, often merging with bogs dominated by graminoids (i.e., grasses) and scrub communities of willow (*Salix* spp.), alder (*Ulnus* spp.), and dwarf birch (*Betula glandulosa*) to form muskeg landscapes. Elevation strongly influences vegetation. Conifer stands in uplands and on south-facing slopes are dominated by white spruce (*Picea glauca*); common understory species are green alder (*Alnus viridis* ssp. *crispa*), Bebb willow (*Salix bebbiana*), Labrador tea (*Ledum decumbens*), alpine blueberry (*Vaccinium uliginosum*), and lingonberry (*Vaccinium vitis*). Lowlands and north-facing slopes are dominated by black spruce with understories of tamarack (*Larix laricina*) and paper birch (*Betula papyrifera*).

Well-drained uplands support broad-leaved deciduous forests of quaking aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and paper birch, underlain with mats of bunchberry (*Cornus canadensis*), twinflower (*Linnaea borealis*), and wintergreen (*Pyrola* spp.). Floodplains, on the other hand, support balsam poplar, white spruce, paper birch, mountain alder (*Alnus incana*), and willow.

Tree species with the highest commercial values are white spruce, quaking aspen, and paper birch (Alaska Forest Association 2003).

Fire is an important component of boreal forest systems in Alaska, strongly influencing species composition. Fires tend to temporarily remove conifers, favoring paper birch and quaking aspen over the short term. In time, natural succession leads to re-emergence of conifer domination (van Cleve et al. 1991). Fires are relatively frequent, yielding a patchwork landscape of stands that vary in age and species composition. Stands rarely persist more than 170 years in an undisturbed condition (van Cleve et al. 1983).

Other vegetation communities in Interior Alaska include steppe communities and dune systems. Steppe vegetation spreads on certain south-facing slopes, forming islands within a forest matrix. Extensive fields of sand, deposited by glaciers, support a small number of species, including certain endemics.

The wildlife is diverse, particularly bird species, including waterfowl, shorebirds, passerines, raptors, and other forest-dwelling species. The population of trumpeter swans (*Cygnus buccinator*) has been growing since the 1980s (Conant et al. 1991, 1993) while tundra swans (*Cygnus columbianus*) have been expanding their range into some parts of the boreal forest (Wilk 1993; Kessel and Gibson 1994). Canvasbacks (*Aythya valisineria*) and white-fronted geese (*Anser albifrons*) utilize the area during summer, along with shorebirds, such as common snipes (*Gallinago gallinago*), yellowlegs (*Tringa* spp.), and spotted sandpipers (*Actitis macularia*).

Passerines (primarily songbirds that migrate to breed) include declining summer populations of Swainson's thrushes (*Catharus ustulatus*), yellow warblers (*Dendroica petechia*), orange-crowned warblers (*Vermivora celata*), and white-crowned sparrows (*Zonotrichia leucophrys*) (Kessel and Gibson 1994). Loss of wintering habitat in Central and South America has been implicated in the decline of summer populations of passerines (Greenberg 1992). Common wintering passerines include common ravens (*Corvus corax*), gray jays (*Perisoreus canadensis*), boreal chickadees (*Poecile hudsonicus*), black-capped chickadees (*Poecile atricapillus*), and redpolls (*Carduelis* spp.).

Raptors include the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), northern goshawk (*Accipiter gentilis*), and American kestrel (*Falco sparverius*).

Figure A2 1 Muskeg and black spruce (light green) and white spruce (dark green) along better drained sites near Fairbanks (Credit: L.B. Brubaker).

Rock (*Lagopus mutus*) and willow ptarmigan (*Lagopus lagopus*) and several grouse species also inhabit the forests.

The interface between the boreal forest and surrounding montane habitats creates conditions that support diverse species of mammals. Grizzly bears (*Ursus arctos*), gray wolves (*Canis lupus*), and wolverines (*Gulo gulo*) often cross the transition zone between habitats. These species are considered vulnerable species, species of international concern, or both under the Convention on International Trade in Endangered Species (CITES, 2005; Hemley 1994). Caribou (*Rangifer tarandus*) also inhabit the area.

The snowshoe hare (*Lepus americanus*) and the lynx (*Lynx canadensis*) also are important species in this ecosystem. The snowshoe hare is the dominant herbivore and a source of prey for many species, and is thus regarded as a keystone species (Henry 2002). The population density of snowshoe hares peaks every 8 to 11 years and then crashes dramatically. Studies in Alberta have recorded peak densities of more than 5,000 hares per square mile, followed by crashes in which population densities plummet as low as 50 hares per square mile. After crashing, population densities remain low before recovering in 3 to 4 years. Populations of lynx, the main predator of the hare, rise and fall in tandem with those of the hare, fluctuating within cycles that generally last about 10 years.

Interior Alaska encompasses the ranges of three caribou herds—Porcupine, Central Arctic, and Western Arctic (Klein 1991; Cronin et al. 1998). In particular, the Porcupine herd utilizes the northeastern portion of Alaska and the Yukon during the winter, including the Whitestone River and Eagle Plains during winters of shallow snow, and the Chandalar River and Arctic Village during winters of deeper snow (Porcupine Caribou Technical Committee 1993).

Fish assemblages contain as many as 22 species (Morrow 1980). Of these, Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*Oncorhynchus keta*), coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), sheefish (*Stenodus leucichthys*), humpback whitefish (*Coregonus oidschian*), round whitefish (*Prosopium cylindraceum*), least cisco (*Coregonus said*), arctic grayling (*Thymallus arcticus*), lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*), and burbot (*Lota lota*) are harvested for human consumption. About one fifth of the total sport fishery activity in Alaska is focused on Interior Alaska (Mills 1994).

COOK INLET TAIGA

Nestled between Mt. McKinley and the Alaska/St. Elias Range, the Pacific Coastal Mountains, and the Cook Inlet, the Cook Inlet ecoregion comprises the lowland area that surrounds the northern portion of Cook Inlet as well as the northwestern third of the Kenai Peninsula.

Long histories of glaciation, dating back to the Pleistocene, have affected both streamflow fluctuation and instream particle suspension (Brabets et al. 1999; Darova and Scott 1998). Soils containing loess deposits from glacial floodplains and volcanic ash overlie glacial deposits. Compared to other parts of Alaska, the climate is mild and with moderate rainfall (300 mm to 810 mm).

The landscape encompasses coniferous, broadleaf, and mixed forests, dominated by black spruce, white spruce, sitka spruce (*Picea sitchensis*), quaking aspen, balsam poplar, cottonwood, alder, and willow. However, areas of low scrub, tall scrub, low scrub bog, mesic graminoid, graminoid herbaceous, and wet forb herbaceous communities can also be found. The land area of this ecoregion totals some 7,830 sq km, of which about 30 percent has been classified as wetlands (Hall et al. 1994).

Wildfire and infestations of spruce bark beetle play a significant role in forest processes and facilitate renewal of forest stands. Spruce beetles can kill 80 to 90 percent of mature spruce trees in a single stand (Matthews 1997). Direct and indirect effects of beetle infestations include changes in relative abundance of various wildlife species, long-term stand conversion, increased susceptibility to fire hazard, and altered hydrologic processes. Some areas have been damaged more than others. The western side of the inlet (Anchor Point on the Kenai Peninsula and the upper Copper River) has been less affected, while much of the southern portion of the Kenai Peninsula has lost over 80 percent of its susceptible spruce trees to beetle infestation (Matthews 1997). In addition to forest disturbance by infestations, wildfires occur relatively frequently, particularly in dry years. Fires range in size from 1 ha to more than 2,200 ha, averaging some 160 ha (Ricketts et al. 1999).

The Cook Inlet ecoregion is remarkable for its wildlife diversity, particularly in the Kenai River watershed. All five species of Pacific salmon—chinook, chum, coho, pink, and sockeye (*Oncorhynchus nerka*)—live here. About 4 million salmon are taken annually from the Cook Inlet watershed (Brabets et al. 1999).

Terrestrial systems also support an array of top-level predators that depend on thriving salmon stocks. Brown bears, wolves, coyotes (*Canis latrans*), and wolverines exist at population levels within their natural ranges of variation (Ricketts et al. 1999). The Kenai River is also home to the second highest concentration of over-wintering American bald eagles in Alaska. Additionally, waterfowl, including trumpeter swans and almost the entire population of Wrangell Island snow geese (*Chen caerulescens*), utilize the mouth of the Kenai River and Trading Bay during the spring migration.

COPPER PLATEAU TAIGA

The Copper Plateau is a plain resting on the site of a large Pleistocene lake. Nestled between the Alaska/St. Elias Range and the Pacific Coastal Mountains, the ecoregion lies between 420 and 900 m above sea level. Although annual precipitation is relatively low (250-500 mm), soils are poorly drained and the area remains very wet throughout the year, dotted with numerous lakes, wetlands, and areas of permafrost. About 35 percent of the land area has been classified as wetlands (Hall et al. 1994). The average annual temperature is about -2° C, with about 70 frost-free days during the summer.

Thriving in these wet conditions are coniferous forests and woodlands dominated by black spruce. Wetlands are blanketed by sedges and herbaceous species, with areas of low scrub bog in which birch species and ericaceous shrubs are prevalent. Mixed forests, dominated by white spruce, black cottonwoods, and quaking aspen, are found only on south-facing slopes, gravelly moraines, or sites with exceptional drainage.

In this relatively small area, wildlife is varied. Many migratory bird species find excellent nesting habitat in the numerous lakes and wetlands. The North Central portion provides breeding habitat for a large population of trumpeter swans considered vulnerable under CITES (YDRR 1996, CITES 2005). Predator populations, including black bear (*Ursus americanus*), brown bear, and wolverines, thrive relatively unaltered, while the Nelchina caribou herd migrates through the western part of the area. Finally, the Copper River supports strong runs of chinook salmon and sockeye salmon, along with arctic grayling (*Thymallus arcticu)* and burbot (*Lota lota*).

ALASKA'S COASTAL TEMPERATE RAINFORESTS

Coastal temperate rainforests in Alaska stretch in a narrow strip along the coast from the southern islands of the Alexander Archipelago north to Prince William Sound and the Kenai Peninsula. Nestled between the Pacific Coastal Mountain icefields and tundra and the Gulf of Alaska and North Pacific, the ecoregion comprises thousands of islands, long coastal valleys, and alluvial fans. Elevation rises from sea level to over 1,000 m, with the higher elevations located in the Alexander Archipelago.

The climate exhibits a maritime influence, with heavy rainfall and moderate temperatures. The average annual precipitation varies from 760 to 5,590 mm, with greater amounts of rainfall in the Alexander Archipelago. Due to irregular landforms, climate characteristics remain highly variable and localized.

Because of numerous microcontinental collisions, the geology of Southeast Alaska is very complex. Limestone is scattered throughout the Tongass zone in a seemingly random pattern and caves of various sizes abound. These karst areas allow for better drainage and the limestone-based soils are less acidic, favoring very large tree growth. Unlike the boreal forest, wildfires are infrequent. Glacial outburst floods and tectonic events have had significant impacts on the landscape, but windthrow (i.e., the uprooting and felling of trees by the wind) constitutes the most widespread and important natural disturbance agent (Harris 1989).

Wetlands prevail in the ecoregion, particularly in the Alexander Archipelago; about 35 percent (1.5 million ha) of the land on and near the Alexander Archipelago has been classified as wetlands (Hall et al. 1994).

Diversity of tree species and other vegetation diminishes as latitude increases. Alaback (1995) distinguishes a subpolar zone, which runs from the Kenai Peninsula to Yakutat (or the Kenai to Yakutat zone), and a perhumid zone, which includes everything from Yakutat south to British Columbia (or the Tongass zone). Forest landscapes in the subpolar zone contain lower percentages of forest cover and are generally composed of stunted spruce and hemlock. In this zone, much of the annual precipitation is in the form of snow. The perhumid zone is more densely forested and dominated by Sitka spruce, western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Precipitation is mixed, with considerable summer rains.

Alder, cottonwood, and birch typically dominate low-lying areas and major river channels, while western red cedar and salal (*Gaultheria shallon*) are common in the southern Alexander Archipelago. Coastal areas support willows, sedges, and sphagnum mosses; higher elevations contain alpine tundra heath meadows and barrens.

Windthrow leads to large-scale stand replacement in certain areas, such as wind-prone aspects (Nowacki and Kramer 1998).Young, even-aged forest stands resulting from windthrow (and, to a greater degree, clear-cutting) exhibit less biological diversity than do old-growth forests (Alaback 1982; Schoen et al. 1988). Additionally, species composition in the new growth generally differs from that

Figure A2.2: Copper River Delta within the Chugach National Forest, Kenai to Yakutat zone (Credit: USDA Forest Service).

of the pre-disturbance condition (Alaback 1982; Kirchhoff and Schoen 1987).

Largely due to the land-water interface and the latitudinal gradient, wildlife is diverse. Bird species, in particular, exhibit great diversity along the length of the coast, which remains a major migration route for Pacific Flyway birds, such as sandhill cranes (*Grus canadensis*). The entire population of dusky Canada geese (*Branta canadensis occidentalis*) nests in and around the Copper River Delta, while Vancouver Canada geese (*Branta canadensis fulva*) utilize the southeastern portion of the ecoregion. Trumpeter swans (*Cygnus buccinator*) are common, along with Pacific loons (*Gavia pacifica*), common loons (*Gavia immer*), and Bonaparte's gulls (*Larus philadelphia*).

Marbled murrelets (*Brachyramphus marmoratus*) nest primarily in old-growth forests and less commonly on the ground. Other forest-nesting species include Kittlitz's murrelets (*Brachyramphus brevirostris*), red-breasted sapsuckers (*Sphyrapicus ruber*), Pacific-slope flycatchers (*Empidonax difficilis*), and golden-crowned kinglets (*Regulus satrapa*). Raptors, such as nesting bald eagles, peregrine falcons, and northern goshawks, also prevail in the region.

Along with avian species, the coastal temperate rainforest hosts a variety of terrestrial and marine mammals, amphibians, reptiles, and fish. Physical fragmentation throughout the ecoregion creates natural barriers to movement for some mammal species. For example, Sitka black-tailed deer (*Odocoileus hemionus*) inhabit all of the larger islands of the Alexander Archipelago, while its main predator, the Alexander Archipelago wolf (*Canis lupus ligoni*), occupies only the islands south of Frederick Sound, isolated from other wolf populations by water and mountain barriers (Person et al. 1996).

Similarly, brown bears inhabit the Admiralty, Baranof, and Chichagof (ABC) islands, while black bears and wolves are limited to the southern islands. Despite this

Figure A2.3: Eastern side of Lynn Canal in the northern part of the Tongass National Forest, just north of Berners Bay (Credit: USDA Forest Service)

fragmentation of the landscape, exchanges between smaller clusters of islands have been reported for some species, such as wolves (Paquet pers. comm.). Additionally, over 30 mammal taxa are endemic, and more than 10 additional taxa are endemic, to the ecoregion (MacDonald and Cook 1994).

Several species of mammals have been introduced into this ecoregion, including such game species as Roosevelt elk (*Cervus canadensis roosevelti*, introduced on Afognok Island), moose (introduced in the Copper River Delta), and mountain goat (*Oreamnus americanus*, introduced on Baranof Island). Muskrat (*Ondatra zibethica*), beaver (*Castor canadensis*), marten (*Martes americana*), mink (*Mustela vison*), snowshoe hare (*Lepus americanus*), and red squirrel (*Tamiasciurus hudsonicus*) were introduced to various islands as potential sources of pelts for the fur trade.

For some species, Alaska's coastal temperate rainforests constitute core habitat, that is, habitat essential for the long-term survival of the species. Thus, the loss of old-growth forests can affect these species dramatically. For instance, Sitka deer rely on old-growth forests for forage and refuge from heavy snowfall in winter. Large land clearings reduce the availability of winter refuges, allowing forage to be covered in deep snow (Wallmo and Schoen 1980; Schoen et al. 1988). This loss of core forest habitat can lead to reduced abundance of deer, which in turn strongly affects wolf populations, which rely on deer as a food source. Forest loss also affects wolf populations through increased trapping pressure, which often coincides with road development that accompanies logging activities (Person et al. 1996). Habitat fragmentation and loss also threatens populations of northern goshawks and marbled murrelets, both of which favor intact, old-growth habitat.

Marine mammals inhabiting this ecozone include Steller (i.e., Northern) sea lions (*Eumetopias jubatus*) and sea otters (*Enhydra lutris*), which are common throughout Prince William Sound. Humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) can be found in the adjacent marine habitats. The complex ecological relationships between Steller sea lions, sea otters, and killer whales (*Orcinus orca*) have been disrupted by commercial fishing activities.

The coastal temperate rainforest also contains unique, highly diverse amphibian species, including the western toad (*Bufo boreas*), Cascades spotted frog (*Rana pretiosa*), wood frog (*Rana sylvatica*), roughskin newt (*Taricha granulosa*), northwestern salamander (*Ambystoma gracile*), and long-toed salamander (*Ambystoma macrodactylum*). The common garter snake (*Thamnophis sirtalis*), also native to this area, represents is the only reptile extant in Alaska.

Fish species are diverse and play an ecologically significant role as a principal food source for numerous terrestrial populations. Rainbow trout, cutthroat trout (*Oncorhynchus clarki*), eulachon (*Thaleichthys pacificus*), and Dolly Varden (*Salvelinus malma*) are among the 35 fish species found in this ecoregion (Morrow 1980). Chinook, chum, coho, pink (*Oncorhynchus gorbuscha*), and sockeye salmon are the most important species commercially.

Salmon and salmon eggs are consumed by many species (in addition to humans) in southeastern Alaska, including at least 16 mammal species, 31 bird species, and 11 fish species (Willson and Halupka 1995). Bald eagles and brown bears both rely on salmon carcasses (Armstrong 1995; Schoen and Beier 1990; Schoen et al. 1994), while arctic terns (*Sterna paradisaea*), great blue herons (*Ardea herodias*), and river otters (*Lutra canadensis*) prey on three-spine sticklebacks (*Gasterosteus aculeatus*), and greater yellowlegs (*Tringa melanoleuca*) consume staghorn sculpins (*Leptocottus armatus*) (O'Clair et al. 1992). Interestingly, the largest known concentration of bald eagles centers around spawning chum salmon near Haines (4,000 eagles) and spawning eulachon in the Stikine River (1,500 eagles; Armstrong 1995).

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APPENDIX 3

REVIEW PROCESS

A key principle of Global Forest Watch is that transparency and accountability are essential for improving natural resources management. To this end, we solicited experts and stakeholders to review the methods, results, and products of this project through a process involving three key components: a initial review of study methods in the summer of 2002; a workshop in which experts reviewed final study methods and initial map results in November 2002; and dissemination of a draft version of this report, including detailed methods and GIS datasets, to invited reviewers between late 2005 and early 2006.

Reviewers were drawn from various sectors, such as:

- federal agencies, including the U.S. Forest Service-Alaska, the Bureau of Land Management, and the U.S. Fish and Wildlife Service
- state agencies, including the Alaska Department of Fish and Game
- environmental NGOs, including the Sitka Conservation Society, The Nature Conservancy, Ecotrust, Audubon Society, Greenpeace, Forest Watch British Columbia, Global Forest Watch Canada, and the International Socio-Ecological Union
- academia and research institutions, including Pacific University, the University of Maryland, and TerreVista
- forest products industry, including Weyerhaeuser
- local communities, including the Tanana Chiefs Conference.

Summarized below are the major comments received from reviewers, followed by information about how these comments were addressed by the study team. For full documentation of review comments and study team response, please contact the World Resources Institute.

DELINEATION OF THE STUDY AREA

Comment: Reviewers suggested using additional datasets, such as the BLM's planning areas map, to cover forested areas that were omitted in initial delineation of study area.

Comment: A reviewer recommended using the Digital Elevation Model to define the study area, in order to provide an appropriate mask for higher-elevation areas that are unlikely to contain forests.

Response: The study area was re-mapped using additional datasets (as well as the USGS' vegetation classification), including: the BLM/National Park Service vegetation classification from the late 90s and early 2000; the University of Maryland's VCF map; the USGS' Digital Elevation Model; and a map of forest conditions from Ecotrust (see Appendix 1 for details).

CONCEPTS AND DEFINITIONS: INTACT FOREST LANDSCAPES

Comment: Reviewers found the concept of intact forest landscapes (IFLs) confusing, especially because it includes areas that may not be naturally forested. Reviewers recommended clarifying the definition and stating it up front in the final report.

Comment: Some reviewers suggested a change in terminology from "Intact Forest Landscapes" to "Intact Landscapes with Forests."

Response: We retained the term "Intact Forest Landscapes" in order to ensure consistency with other GFW mapping efforts. Definitions have been re-stated to clarify concepts, and are presented in a special section at the beginning of the final study report. The revised definitions state explicitly that IFLs do not necessarily consist of old trees, may not even be entirely forested, and may contain a contiguous mosaic of naturally occurring ecosystems —including forests, treeless areas, bogs, water bodies, tundra and rock outcrops—that occur in a forest zone.

CONCEPTS AND DEFINITIONS: FOREST LANDSCAPE FRAGMENTS

Comment: Reviewers noted that the term "Forest Landscape Residual" implies that these parcels are remainders of something that was once larger, when in fact, most landscapes in Alaska were never larger than they are now.

Response: The term "Forest Landscape Fragments" was introduced as a replacement for "Forest Landscape Residuals." This new term has since been used by Global Forest Watch Canada in published reports on the mapping of smaller blocks of forest landscapes.

BUFFERS

Comment: Reviewers noted that a 1-km buffer for roads was conservative, especially given the increase in the use of all-terrain vehicles (ATVs), with roads as launching points. Reviewers suggested increasing the buffer for roads to 5 km, perhaps retaining the 1-km buffer for historical trails (used for dog sleds and snowmobiles). Reviewers also recommended reducing the 1-km buffer for railroads to 500 m and suggested that we consider increasing the buffer around small towns and villages and buffering major navigable rivers by 1-km.

Response: We increased the buffering around roads, small towns and villages to 5 km. We retained the buffering of railroads at 1 km, because the reduction to 500 m did not significantly alter the results of the analysis. We did not buffered major navigable rivers. Except from the areas where navigable rivers and human settlements overlap, we did not find significant evidence of industrial-scale human impacts in the zone between 1 km and 5 km from rivers. (Note that, as defined in this study, historic forms of human activity and their more recent analogues, such as hunting, fishing, and gathering of non-timber forest products, are considered to be non-significant, background influences rather than forest disturbances.)

SIZE THRESHOLDS

Comment: Reviewers were confused by the different size thresholds chosen to define IFLs and FLFs in the boreal and coastal temperate forests, and the way in which these thresholds were presented in the draft report. Reviewers suggested applying labels consistent with the biomes and defining categories by patch size.

Response: We retained a classification scheme that is differentiated by forest biome, principally to maintain consistency with previous GFW mapping of boreal forests in Russia and Canada while also recognizing and accounting for the ecological distinctions and differences in natural disturbance regimes between the two forest biomes. To clarify presentation of the classification scheme in the final study report, we added a figure (Figure 1) that shows the different thresholds by biome and revised the labeling of size classes in tables and figures.

Comment: Some reviewers were concerned that the 50,000-ha threshold for IFLs might not be sufficient, since boreal fires greater than 50,000 ha have occurred several times since 1950. Conversely, other reviewers urged us to maintain consistency with size thresholds used by GFW forest mapping in Canada and Russia.

Comment: Reviewers expressed concern about the >2,000 ha threshold for the coastal zone because at this threshold linear disburbances (e.g. roads) may violate the integrity of smaller ecological units such as watersheds, resulting in a non-intact forest landscape.

Response: We retained size thresholds that are consistent with previous GFW mapping of boreal forests in Canada and Russia and coastal temperate forests in Chile. For coastal temperate forests, we understand the concern, but the only alternative left was to consider only the really large blocks.

Comment: Reviewers noted that size thresholds for 10,000 ha and 50,000 ha would be the most useful to Alaskan land managers. Reviewers suggested doing the analysis at the level of ecological units (ecoregions) and producing an index of roadlessness or intactness that factors-in the block size.

Response: We agree with the suggestion; however, we were not able to pursue this approach because of a lack of funds.

ISLANDS

Comment: Reviewers noted that the criteria used to define intact forest landscapes (IFLs)—specifically, tracts of forest of sufficient size to provide habitat for species with large home ranges and to recover from natural disturbance events—do not hold in the case of islands.

Response: Agreed. However, while individual islands may not meet the size criteria for intact forest landscapes, islands as a whole are significant. Therefore, we created a special, independent category for islands.

Comment: Reviewers objected to the fact that islands smaller than 500 ha in the coastal temperate rainforest biome were classified as IFLs, while undisturbed boreal forest islands larger than 500 ha were not. A reviewer suggested considering redefining terms so that intact forest landscapes are always larger than forest landscape fragments.

Response: Reviewers raise a legitimate point. The new, independent category for islands resolves this inconsistency.

AGE OF SATELLITE IMAGERY

Comment: A few reviewers expressed concern about the age of the satellite imagery used. Other reviewers noted that little development has occurred in Interior Alaska, mostly in limited areas of high quality forest, and major forest change in this zone is largely attributable to natural disturbance by fires.

Response: We obtained more recent images for forest areas in which most change was suspected. Older imagery was used for areas where no roads exists, where there is no industrial forest extraction, and where timber extraction is not economically feasible.

Comment: A reviewer recommended adding text to the final report describing how the age of satellite imagery affects the resulting maps and analysis.

Response: Information added; see section 3.4 of this report.

DISTURBANCE REGIMES

Comment: Some reviewers suggested discriminating between natural and anthropogenic fires; however, the majority of the reviewers considered that fire is part of the natural landscape dynamics.

Response: Fire was treated as a natural event and part of the natural disturbance regime in boreal forests.

Comment: Reviewers noted that our maps did not reflect some large prescribed fires, including one in the Kenai Wildlife Refuge.

Response: More recent fire data was obtained and incorporated. Although individual prescribed-fire events may be large, most prescribed fires are small and non-significant compared to the area burned by naturally occurring fires.

Comment: Some reviewers suggested accounting for insect and disease disturbance, which cause high levels of forest damage in boreal zones.

Response: The degree to which human activity has altered the frequency and magnitude of insect and disease disturbances is not well understood. Existing datasets of insect infestations and diseases present an ellipsoid pattern along roads and linear features, indicating that this data may be biased. Insect infestations do occur along roads and sometimes are also linked to power lines; however, surveys are often based on prior sightings of forest damage in particular areas (especially along rivers) rather than more general, unbiased assessments of larger forest blocks. Note that some of the impacts of insect and disease disturbance are likely captured by visual detection of salvage logging in satellite imagery; such logging often occurs after infestation of forests on state and private lands.

APPENDIX 4

STATISTICAL DATA

TABLE A4.1 **NUMBER AND AREA OF INTACT FOREST LANDSCAPES, ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA, BY REGION AND ZONE**

	Intact Forest Landscapes *Area in ha (# IFLs)*				**Total FLFs and Undisturbed Islands**	**Forest Landscape Fragments** *Area in ha (# FLFs)*				**Total FLFs**
	(>50K ha)	**(>10K–50K ha)**	**(>5K–10K ha)**	**Undisturbed Islands**		**(>10K–50k ha)**	**(5K–10K ha)**	**(>2K–5K ha)**	**(500–2K ha)**	
Boreal Region										
Interior Alaska	55,719,624 (23)				*55,719,624 (23)*	222,539 (9)	22,688 (3)			*245,227 (12)*
Cook Inlet	1,148,442 (2)				*1,148,442 (2)*	131,936 (6)	23,027 (3)			*154,963 (9)*
Copper Plateau	2,330,627 (8)				*2,330,627 (8)*	312,843 (10)	64,470 (8)			*377,313 (18)*
Total Boreal	*59,198,693 (33)*				*59,198,693 (33)*	*667,318 (25)*	*110,185 (14)*			*777,503 (39)*
Coastal Region										
Kenai-Yakutat	1,763,994 (11)	572,255 (22)	82,893 (19)	10,256 (5,173)	*2,429,398 (5,225)*			64,902 (12)	40,434 (36)	*105,336 (48)*
Tongass	3,782,019 (19)	968,049 (47)	325,751 (45)	50,063 (22,475)	*5,125,882 (22,586)*			189,303 (61)	178,862 (176)	*368,165 (237)*
Total Coastal	5,546,013 (30)	1,540,304 (69)	408,644 (64)	60,319 (27,648)	7,555,280 (27,811)			254,205 (73)	219,296 (212)	473,501 (285)

TABLE A4.2 OWNERSHIP OF INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA, BY REGION AND ZONE

	Boreal Region Area owned in ha (percent of total)*				Coastal Region Area owned in ha (percent of total)*			*Combined Boreal and Coastal*
	Interior Alaska	**Cook Inlet**	**Copper Plateau**	*Total Boreal*	**Kenai-Yakutat**	**Tongass**	*Total Coastal*	
BLM	14,685,178 (26)	25,807 (2)	744,683 (27)	*15,455,668 (26)*	166,025 (6)	47,250 (<1)	*213,566 (3)*	*15,669,234 (23)*
FWS	13,465,144 (24)	195,120 (15)	657,488 (24)	*14,317,752 (24)*	205,212 (8)	0	*205,212 (8)*	*14,523,289 (21)*
NPS	6,212,098 (11)	46,141 (3)	0	*6,258,239 (40)*	108,639 (4)	467,056 (8)	*575,695 (7)*	*6,833,934 (10)*
USFS	0	0	0	*0*	1,206,102 (48)	4,463,981 (81)	*5,670,083 (71)*	*5,670,083 (8)*
Military	179,087 (<1)	0	0	*179,087 (<1)*	0	740 (<1)	*740 (<1)*	*179,828 (<1)*
Wild & Scenic Rivers	162,298 (<1)	0	40,619 (1)	*202,917 (<1)*	0	0	0	*202,917 (<1)*
State	15,194,457 (27)	834,180 (64)	922,053 (34)	*16,950,690 (28)*	496,935 (20)	239,170 (4)	736,105 (9)	*17,686,795 (26)*
State/Native Corporations	33,579 (<1)	521 (<1)	16,248 (<1)	*50,348 (<1)*	24,156 (1)	5,714 (<1)	29,870 (<1)	*80,218 (<1)*
Native Corporations	5,853,923 (10)	100,101 (8)	271,336 (10)	6,225,360 (10)	273,802 (11)	137,078 (3)	410,880 (5)	*6,636,240 (10)*
Private	179,087 (<1)	101,535 (8)	55,513 (2)	*336,135 (<1)*	53,863 (2)	132,958 (3)	186,821 (2)	*522,956 (<1)*
Total	*55,964,851 (100)*	*1,303,405 (100)*	*2,707,940 (100)*	*59,976,196 (100)*	*3,027,917 (100)*	*6,378,778 (100)*	*9,406,695 (100)*	*69,382,891 (100)*

* Percentages indicate share of total IFL and FLF area by zone.

TABLE A4.3 **PROTECTION STATUS OF INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA, BY REGION AND ZONE**

	Intact Forest Landscapes Area with protected status, in ha (percent of total)				*Total IFLs and Undisturbed Islands*	Forest Landscape Fragments Area with protected status, in ha (percent of total)				*Total FLFs*
	(>50K ha)	(>10K–50K ha)	(>5K–10K ha)	Undisturbed Islands		(>10K–50k ha)	(5K–10K ha)	(>2K–5K ha)	(500–2K ha)	
Boreal Region										
Interior Alaska	20,197,247 (36)				***20,197,247 (36)***	33,550 (15)	0 (0)			***33,550 (15)***
Cook Inlet	195,418 (17)				***195,418 (17)***	47,235 (36)	9,798 (43)			***57,033 (37)***
Copper Plateau	562,352 (24)				***562,352 (24)***	60,318 (19)	10,872 (17)			***71,190 (19)***
Total Boreal	***20,955,017 (35)***				***20,955,017 (35)***	***141,103 (21)***	***20,670 (19)***			***161,773 (21)***
Coastal Region										
Kenai-Yakutat	382,356 (22)	151,504 (26)	25,383 (31)	1,343 (13)	***560,586 (23)***			35,013 (54)	16,367 (40)	***51,380 (49)***
Tongass	1,780,139 (46)	227,017 (23)	83,594 (26)	6,807 (14)	***2,077,557 (41)***			58,113 (31)	42,475 (24)	***100,588 (27)***
Total Coastal	***2,142,495 (39)***	***378,521 (24)***	***108,977 (27)***	***8,150 (13)***	***2,638,143 (35)***			***93,126 (37)***	***58,842 (27)***	***151,968 (32)***

TABLE A4.4 **INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA: AREA WITH PROTECTED STATUS VERSUS ROADLESS AREAS, BY ZONE**

	Intact Forest Landscapes and Islands Area in ha (percent of total)*				Forest Landscape Fragments Area in ha (percent of total)*		
	(>50K ha)	(>10K–50K ha)	(>5K–10K ha)	Undisturbed Islands	(>2K–5K ha)	(500–2K ha)	*Combined IFLs and FLFs*
With GAP 1 OR 2 Status							
Kenai-Yakutat	382,356 (22)	151,504 (26)	25,383 (31)	1,343 (13)	35,013 (54)	16,367 (40)	***611,966 (24)***
Tongass	1,760,139 (46)	227,017 (23)	83,594 (26)	6,807 (14)	58,113 (31)	42,475 (24)	***2,178,145 (40)***
Coastal Region GAP 1&2	*2,142,495 (39)*	*378,521 (24)*	*108,977 (27)*	*8,150 (13)*	*93,126 (37)*	*58,842 (27)*	*2,790,111 (35)*
Within Inventoried Roadless Areas (IRAs)							
Chugach IRAs	666,831 (38)	271,219 (47)	20,561 (25)	4,089 (40)	10,429 (16)	9,520 (23)	***982,649 (39)***
Tongass IRAs	1,604,739 (42)	553,101 (57)	188,325 (58)	11,276 (22)	82,353 (43)	52,366 (29)	***2,492,160 (45)***
Coastal Region IRAs	***2,271,570 (41)***	824,320 (53)	***208,886 (51)***	***15,365 (25)***	92,782 (36)	61,866 (28)	***3,474,809 (43)***
Kenai-Yakutat GAP 1&2 plus IRAs	1,049,187 (59)	424,723 (74)	45,944 (55)	5,432 (53)	45,442 (70)	25,887 (64)	***1,594,615 (63)***
Tongass GAP 1&2 plus IRAs	3,364,878 (89)	780,118 (80)	271,919 (83)	18,083 (36)	140,466 (74)	94,841 (53)	***4,670,305 (85)***
Coastal Region GAP 1&2 plus IRAs	*4,414,065 (80)*	*1,202,841 (78)*	*317,863 (78)*	*23,515 (39)*	*185,908 (73)*	*120,728 (55)*	***6,264,920 (78)***

*Percentages are based on the area protected compared to against the total area of IFL for each category.

TABLE A4.5 | **DISTRIBUTION OF FOREST COVER CLASSES IN BOREAL REGION INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN ALASKA, BY ZONE***

	Area (in ha) of Intact Forest Landscapes and Undisturbed Islands (percent of total) (>50K ha)	Forest Landscape Fragments Area in ha (percent of total)		Total IFLs, Undisturbed Islands, and FLFs**
		(>10K–50k ha)	(5K–10K ha)	
0–10 **percent forest canopy cover**				
Interior Alaska	15,520,877 (28)	61,452 (28)	4,607 (22)	15,586,936
Cook Inlet	305,274 (27)	72,936 (38)	2,453 (11)	380,663
Copper Plateau	521,182 (22)	101,058 (48)	45,074 (70)	667,314
Boreal Region	***16,347,333 (28)***	***235,446 (38)***	***52,134 (49)***	***16,634,913***
>10–30 **percent forest canopy cover**				
Interior Alaska	18,705,510 (33)	51,703 (23)	44,267 (21)	18,801,480
Cook Inlet	391,286 (34)	46,927 (25)	4,920 (23)	443,133
Copper Plateau	178,306 (33)	68,081 (32)	11,888 (19)	258,275
Boreal Region	***19,275,102 (34)***	***166,711 (27)***	***61,075 (20)***	***19,502,888***
>30–60 **percent forest canopy cover**				
Interior Alaska	20,072,534 (36)	89,104 (40)	9,566 (47)	20,171,204
Cook Inlet	361,441 (31)	26,100 (14)	7,791 (36)	395,332
Copper Plateau	989,321 (43)	40,141 (19)	7,321 (11)	1,036,783
Boreal Region	***21,423.296 (36)***	***155,345 (25)***	***24,678 (23)***	***21,603,319***
>60–100 **percent forest canopy cover**				
Interior Alaska	1,423,057 (3)	19,666 (9)	2,088 (10)	1,444,811
Cook Inlet	90,187 (8)	42,908 (23)	6,407 (30)	139,502
Copper Plateau	41,485 (2)	1,174 (1)	26 (0)	42,685
Boreal Region	***1,554,729 (3)***	***63,748 (10)***	***8,522 (8)***	***1,626,998***

*Based on VCF data. **Percentages may not add due to rounding.

TABLE A4.6 **DISTRIBUTION OF LAND COVER TYPES IN INTACT FOREST LANDSCAPES, UNDISTURBED ISLANDS, AND FOREST LANDSCAPE FRAGMENTS IN THE COASTAL REGION OF ALASKA, BY ZONE***

	Intact Forest Landscapes and Islands Area in ha (percent of total)				Forest Landscape Fragments Area in ha (percent of total)		
	(>50K ha)	**(>10K–50K ha)**	**(>5K–10K ha)**	**Undisturbed Islands**	**(>2K–5K ha)**	**(500–2K ha)**	*Total IFLs and FLFs*
Kenai-Yakutat							
Forest	420,432 (29)	145,775 (29)	27,821 (35)	4,253 (46)	24,338 (47)	12,608 (35)	***635,227 (30)***
Non-forest	831,591 (56)	294,892 (49)	42,499 (54)	2,885 (31)	23,407 (45)	19,187 (53)	***1,214,461 (57)***
Water	61,049 (4)	20,490 (4)	2,645 (3)	2,112 (23)	1,959 (4)	3,141 (9)	91,396 (4)
Ice and snow	154,414 (11)	38,741 (18)	6,437 (8)	85 (1)	2,127 (4)	1,266 (3)	203,070 (9)
Totals (land portion only)*	***1,467,486 (100)***	***499,898 (100)***	***79,402 (100)***	***9,335 (100)***	***51,831 (100)***	***36,202 (100)***	***2,144,154 (100)***
Tongass							
Commercial forest	1,434,882 (38)	387,415 (40)	156,346 (48)	27,615 (68)	89,382 (47)	81,081 (46)	***2,176,721 (40)***
Non-commercial forest	74,693 (2)	9,221 (1)	4,359 (1)	375 (1)	1,315 (1)	3,061 (2)	93,024 (2)
Non-forest vegetation	1,308,644 (35)	410,500 (42)	132,291 (41)	10,072 (25)	78,734 (42)	76,481 (43)	2,016,722 (37)
Barren	795,692 (21)	118,094 (12)	27,063 (8)	2,235 (6)	15,188 (8)	9,435 (5)	967, (4)
Freshwater, ice, and snow	167,525 (4)	42,565 (5)	5,650 (2)	29 (<1)	4,574 (2)	7,376 (4)	222,069
Totals	***3,781,436 (100)***	***967,795 (100)***	***320,059 (100)***	***40,326 (100)***	***189,193 (100)***	***177,434 (100)***	***5,476,243 (100)***

*Based on Landsat 5 TM image classification.
** Percentages may not add due to rounding.

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