A Conservation Assessment for the Coastal Forests and Mountains Ecoregion of Southeastern Alaska and the Tongass National Forest

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Southeastern Alaska (Southeast) encompasses one of the most significant areas of old-growth temperate rainforest in the world. Much of this region also comprises a unique assemblage of intact coastal watersheds that support abundant populations of fish and wildlife, including many species that have declined or become threatened in the southern portion of their historical ranges (for example, Pacific salmon [*Oncorhynchus* spp.], brown bear [*Ursus arctos*], and marbled murrelet [*Brachyramphus marmoratus*]).

A comprehensive understanding of the diversity, distribution, abundance, and management of terrestrial and aquatic ecosystems in Southeast is critically important for maintaining ecological integrity and biodiversity throughout this ecoregion. As an example, flood plain and karst (porous limestone substrate) forest communities represent small but important components of the forest ecosystems of Southeast. We estimate that a significant portion of the rare, large-tree flood plain and karst old growth (>50 % in some provinces) have been harvested in Southeast during the last century. This conservation assessment contains an analysis of the distribution, abundance and management of biologically important communities as a foundation to maintain the biological diversity of the region, conserve a wide range of species, and maintain ecosystem integrity.

Objectives

The major objectives of this conservation assessment include the following:

- Develop a systematic understanding of important aspects of the region's ecology;
- Develop detailed geographic information system (GIS) databases for selected (focal) resources;
- Assess the current condition and management status of focal species and ecological systems;
- Develop a process for ranking the ecological value of watersheds within biogeographic provinces throughout Southeast;
- Summarize ecological values of all watersheds for focal species and ecological systems (watershed matrix);
- Develop a geospatial decision support tool for conservation planning throughout Southeast and the Tongass; and
- Develop a conservation area design for the Tongass National Forest and southeastern Alaska.

STUDY AREA

Southeast, sometimes termed Alaska's Panhandle, is a coastal ecosystem of enormous biological richness and spectacular beauty distinguished by rainforests, glacial fiords, myriad rivers and streams, estuaries, mountains, and glaciers. Located between 55 and 60 degrees latitude, Southeast extends approximately 500 mi (800 km) northwest from the Canadian Border to Yakutat Bay and is about 120 mi (193 km) in width (Fig 1). Southeast covers a land area of approximately 21.6 million acres (8.7 million ha), of which about 90% is federal land. The Tongass National Forest—at 16.8 million acres (6.8 million ha)—encompasses nearly 80% of the land area of Southeast, and Glacier Bay National Park and Preserve covers about 2.7 million acres (1.1 million ha) of land area, or 12.5% of the region. Lands managed by the State of Alaska include the Haines State Forest (534,000 acres [216,100 ha]) and other smaller holdings distributed throughout the region, as well as all navigable waters and tidelands. Alaska Native Corporations own approximately 577,000 acres (233,500 ha) of land in Southeast.

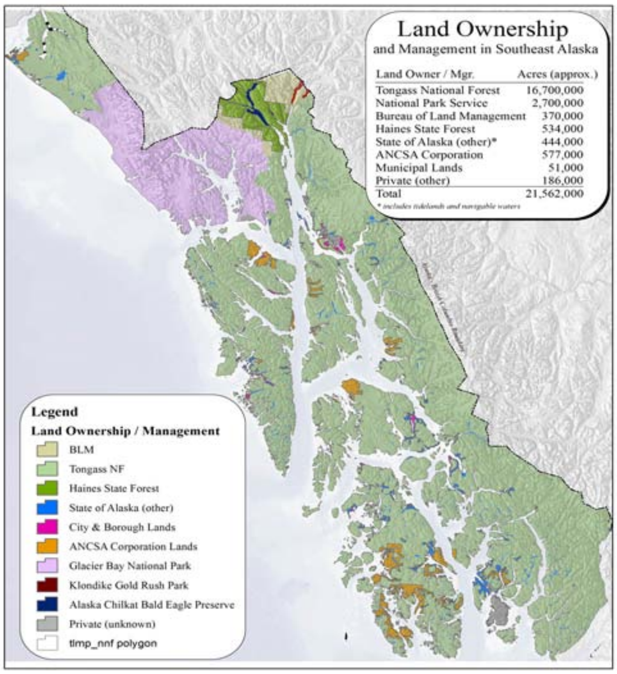

FIG 1. Generalized land ownership in Southeast Alaska

The climate of Southeast is maritime with cool, wet weather predominating throughout most of the year. Annual precipitation varies from about 26 in. (66 cm) in Skagway to more than 210 in. (533 cm) at Little Port Walter on southeastern Baranof Island. Snow is common in winter, and accumulations are most significant along the mainland and northern region.

Southeast is dominated by the Alexander Archipelago, made up of thousands of islands (including 5,568 > 1 acres [.4 ha] in size). This coastal ecosystem has a marine shoreline of more than 18,000 mi (30,000 km) with over 250,000 acres (101,200 ha) of intertidal habitats providing a rich environment that ranks among the most productive salmon spawning regions in the world. For ecological summaries of selected mammals, birds, and fish, refer to Chapters 6, 7, and 8.

Although Southeast is best known for its rainforest, more than 45% of the land area of the region is unforested rock, ice, alpine, or muskeg bog, and less than one-third of the land base of Southeast is considered productive forest land. Unlike most forest land to the south (which has been converted to younger forest stages), much of the forest land in Southeast is still old growth, dominated by western hemlock (*Tsuga heterophylla*)-Sitka spruce (*Picea sitchensis*). For a detailed description of Southeast forest habitats types, refer to Chapter 5.

Approximately 72,000 people live in Southeast distributed throughout approximately 30 communities, of which Juneau—the state capital—is the largest. Commercial forestry was a dominant industry in Southeast from the 1950s through the 1990s. Nearly 500,000 acres (202,347 ha) in the Tongass and over 300,000 acres (121,400 ha) in state and private lands throughout Southeast have been logged. Today the timber industry in Southeast is much smaller than it was during its peak. Commercial fishing, tourism, state and federal government, and the service sector are among the major economic drivers within the region today. For a detailed discussion about perspectives on human uses, refer to Chapter 9.

APPROACH

This section outlines the general approach of this conservation assessment including a brief discussion of methods used in defining ecological systems and focal species, geographic stratification, assessment of current condition and management status, and ranking of ecological variables.

Ecological Systems and Focal Species

A benchmark for effective conservation is to maintain species and ecological systems within their natural ranges of variability, including geographic distribution and spatial scales necessary to maintain genetic, population, and ecosystem processes (Noss et al. 1997, Poiani et al. 2000). The vast number of species composing the biological diversity of an ecoregion makes it impractical to assess and plan for each individual element of that diversity. The first step in any conservation assessment, therefore, is to identify a subset of species and ecological systems that represent major components of the diversity of an area. Focal targets (species and ecosystems) that are indicative of broader ecosystem processes, patterns of rarity, and vulnerability (potential or actual) were identified as surrogates for the broader range of species and ecological systems within the region (Groves 2003). This “coarse filter/fine filter” approach to biodiversity conservation is designed to strike a balance between manageability of information about biodiversity and insurance that key focal species and habitat types (ecological systems) are considered in the analysis.

Conservation Representation

We used the concept of representation to evaluate the degree to which focal species and ecological systems are protected within the current system of conservation areas. Representation provides a quantitative measure, and can be used to refer to the number of individuals, populations, total area of particular habitats, or simply the proportion of habitat values included within some level of conservation status (Groves 2003). Measurement of conservation representation is strongly dependent on the level of information available on the species or system of interest. For our purposes, we defined conservation representation as the percent of habitat for a species or ecological system included within an administratively or legislatively protected area. Protected areas included watershed-scale reserves, small-to-medium reserves as well as stand-level protections such as beach- and riparian-forest buffers. Where our best information was presence of a species (e.g., salmon), we measured representation as the percent of the stream length included within some conservation unit. Where our best information was simply a model of relative habitat value (as with bear, deer and murrelet), representation was measured as the percent of the total habitat value within a province that was included within some level of conservation status.

Geographic Stratification

An effective conservation strategy also requires a measure of the geographic distribution of conservation units and representation of the natural range of variability within which populations and ecosystems occur (Poiani et al. 2000). A well balanced geographic distribution is particularly important in Southeast where ecosystems are naturally fragmented by islands and steep glacial terrain, and isolated from the continent of North America by mountains and icefields along the coastal mountain range (MacDonald and Cook 1996, Cook and MacDonald 2001). This assessment used a regional geographic stratification based on Southeast biogeographic provinces (U.S. Forest Service [USFS] 2003) to ensure that conservation areas are sufficiently distributed among the islands and mainland of Southeast (Fig 2). In addition, watershed stratification (based on USFS Value Comparison Units [VCUs]) was used to measure conservation representation at a more localized scale.

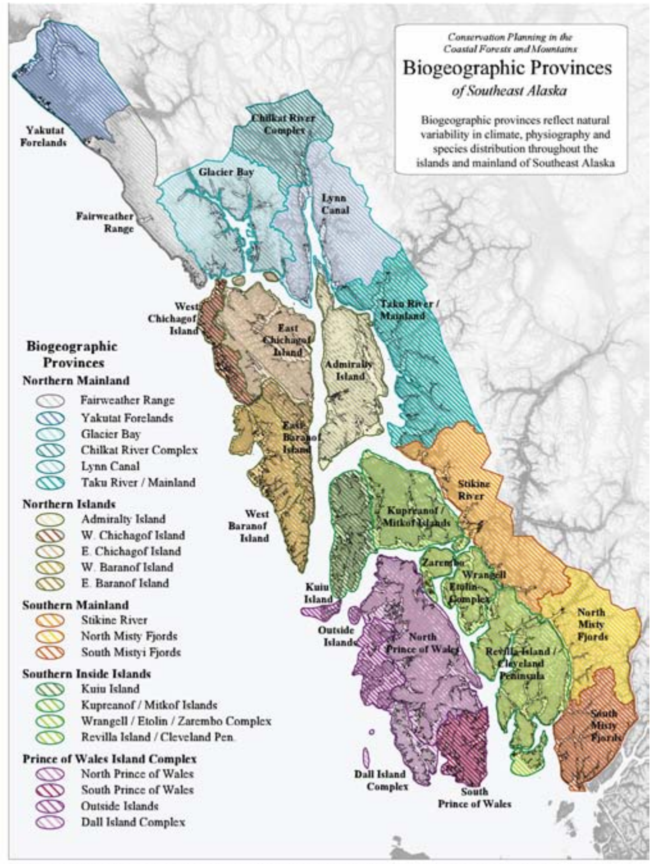

Figure 2. Biogeographic provinces were used to measure the geographic distribution of conservation representation throughout the islands and mainland of Southeast Alaska.

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Current Condition

To understand the current distribution and function of ecological systems, an understanding of the historical distribution is important. The effects of human activities on ecosystems in Southeast have varied with historical patterns of resource extraction, including the Russian trade in sea otter (*Enhydra lutris*) furs, the gold rush, exploitation of salmon and herring fisheries before Alaska statehood, and industrial-scale logging beginning in the 1950s. It is unfortunate that detailed documentation of historical conditions and quantification of resources extracted is not available. A retrospective analysis of the forest types harvested since 1986 was used to provide estimates of change since that time, and original habitat values for focal species were estimated by calculating preharvest conditions in the habitat capability models. Data were not available for forest types harvested prior to 1986, so we were unable to estimate conditions prior to that date. In general, early practices were more focused on logging the very large trees, and less restricted by regulations such as those protecting riparian buffers that were enacted in the years since 1980. As a result, estimates presented here are extremely conservative in regard to the percent change in distribution of large-tree forest types, particularly in flood plain areas that were the focus of much of the logging in the 1950s–1970s. In provinces where pre 1986 logging was concentrated on low-elevation karst or flood plain landforms (e.g., Kupreanof / Mitkof, Dall Island Complex, Etolin / Zarembo, North Prince of Wales, East Chichagof), the percentage of original large-tree forests harvested could be more than 50% higher than estimated here.

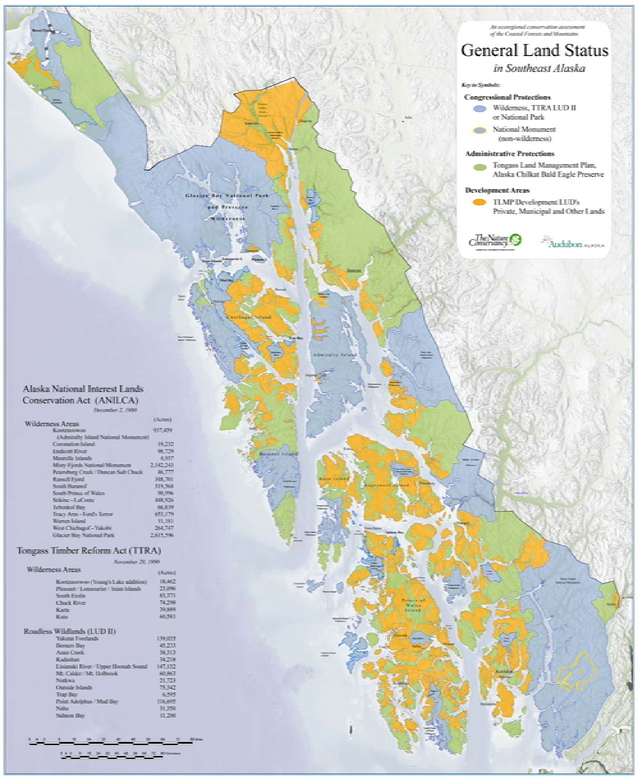

FIG 3. The mosaic of land management in southeastern Alaska includes protected areas established by Congress under the Alaska National Interest Lands Conservation Act (ANILCA) and the Tongass Timber Reform Act (TTRA), as well as administratively protected areas and areas open for development under the Tongass Land Management Plan, as well as state, municipal and other private lands.

Management Status and Scale

A mosaic of land ownership, management responsibility, and conservation measures apply throughout Southeast (Fig 1). Conservation areas were categorized by ownership, management agency, and the legislative or administrative basis for protection. These designations provided a measure of the longer-term stability of management prescriptions (Fig 3).

The degree to which habitat and ecosystem values are represented within functional landscapes as well as at smaller-scale reserves and buffers was measured by the spatial scale of conservation areas. The conservation of functional landscapes ensures connectivity among interacting components of natural ecosystems, including headwater streams to estuaries as well as flood plain forests with upland and alpine areas. Conserving functional landscapes is an important element for conservation of wide-ranging species such as salmon, bears, and wolves (*Canis lupus*). For purposes of this conservation assessment, landscape-scale conservation was defined as inclusion of entire watersheds from ridge top to ridge top and from headwaters to estuary within some level of protected status (Fig 4). A central element of the Tongass conservation strategy is a system of small and medium-sized old-growth reserves, within watersheds, that are intended to serve as linkages between larger conservation areas. These and other non-development land designations were considered as reserves on a sub-watershed scale. Finally, site-specific protection standards apply within development land designations and other lands, including buffers on riparian forests, beach and estuary fringe forests, and trees with eagle nests. These measures are critical to maintain ecological function within developed landscapes but are more sensitive to local area disturbance (such as stands blown over by wind), edge effects, and road impacts, and do not provide the same ecological context as larger reserves. Thus, development land designations within the Tongass and other federal, state, and private lands were considered part of the matrix of developed landscapes.

Ranking of Ecological Values

One of the major objectives of this conservation assessment was to develop a science-based process for ranking the ecological values of watersheds within biogeographic provinces distributed across Southeast and the Tongass. The ability to assess and rank ecological values will provide resource managers and conservationists a useful tool for setting conservation priorities and evaluating and refining reserve networks throughout Southeast.

While the ultimate benchmark for successful conservation is to maintain the diversity, natural distribution, and functional roles of species and ecological systems (Noss et al. 1997, Poiani et al. 2000), it was not practical to assess every species or habitat association. Instead, a representative set of focal targets were selected for this conservation assessment.

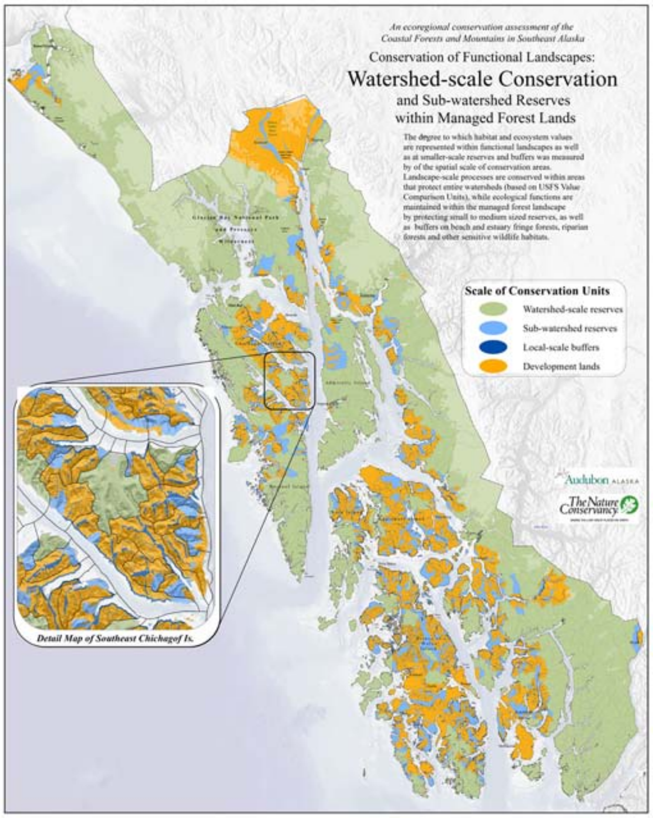

FIG 4. The existing conservation system in southeastern Alaska, primarily on the Tongass National Forest, is composed of landscape-scale units that protect entire watersheds, sub-watershed reserves, and local-scale buffers to protect riparian forests, beach and estuary fringe forests and other sensitive wildlife habitats.

In this context, ranking of ecological value was based on the co-occurrence of habitats needed to meet minimum representation goals for the focal species and ecological systems described below. This analysis was conducted by using the Marxan spatial optimization tool (Possingham et al. 2000) for developing and evaluating reserve networks based on explicit conservation goals. Marxan was used at a range of spatial scales, including (1) entire watershed units (VCUs), (2) core areas within biogeographic provinces, and (3) core areas within VCUs.

METHODS AND RESULTS

Database development

This conservation assessment synthesized geographic information for a wide range of resource values integrated across public and private lands. Primary input data included biogeographic provinces, vegetation and land cover, landform and soils, shoreline, watersheds, elevation, streams and lakes, spawning and rearing salmonid distribution, and wetlands (Fig. 5). Where possible, attributes and merged data from the Tongass National Forest were cross-referenced with other data sources into seamless layers for all of Southeast. For this purpose, Landsat Enhanced Thematic Mapper (ETM) imagery (current in 1999–2002) was acquired to fill gaps related to forest condition on private lands and to map estuaries in areas for which the National Wetlands Inventory was not yet complete (Landsat is a series of satellites that produce images of the earth). By scanning the earth at a variety of wavelengths, the satellites return information that can be used to inventory and analyze a variety of natural and human resources. Landsat 7 ETM facilitates mapping and monitoring for agriculture, forestry, land cover and land use, geology, hydrology, coastal resources, and the environment, and is suitable for scales of 1:50 000 to 1:100 000.)

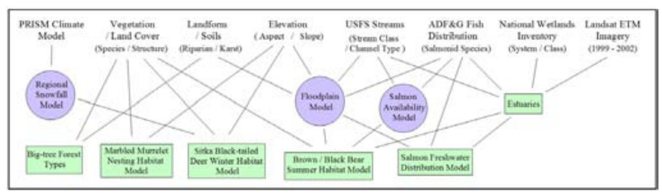

FIG 5. Primary data sources, key attributes and interim models used to evaluate geographic distribution of habitat values for focal species and ecological systems.

This conservation assessment was based on the most current and comprehensive data readily available; however, comprehensive field inventories and basic data on species distribution and habitat in this ecoregion are limited. These data gaps necessitated a number of working assumptions. First, because published data are limited for many targets, expert information was assumed to be a workable substitute. Second, models were assumed to be accurate enough to provide sufficient information at the watershed scale. Third, data from a wide variety of sources were compiled and used in the assessment; these data were collected at different times and at different scales. Because data for some targets are incomplete, some assumptions were made based on modeled information.

Coarse Filter: Terrestrial Ecosystems

Historically, the most detailed information on terrestrial ecosystems in Southeast has been collected for the purpose of timber inventory in and planning for the Tongass National Forest. Thus, while existing data have focused on estimation of timber production, information about the ecological structure of the forest and its habitat and ecosystem values has been limited or unavailable. An ecological classification provides a framework to synthesize complex patterns in biological communities based on the underlying processes of climate, geomorphology, geology, and hydrology. In Southeast, these concepts have been described at a regional scale by Nowacki et al. (2001) as well as at medium scales by others within the frameworks of land type associations (U.S. Forest Service 1996) and freshwater fluvial processes (Paustian 1992). At a finer scale, Caouette and DeGayner (2005) have described the structure of forest stands based on physical setting (soils, slope, and aspect), and others have described unique vegetative communities associated with specific features such as alluvial fans and karst formations (Baichtal and Swanston 1996, Shephard 1999). Although these efforts have provided the building blocks for an ecosystem classification, none have explicitly compiled such a classification, extended this understanding to areas outside the Tongass National Forest, or assessed the current and historical distribution of forest types throughout the region. For the purposes of this assessment, we developed a working classification of terrestrial ecosystems based on land cover, forest structure, landform and geology. This classification provided the foundation for mapping of focal targets used to represent forest ecosystem diversity.

Terrestrial ecological systems are defined as a group of plant community types (associations or alliances) that tend to co-occur within landscapes with similar ecological processes and environmental gradients (NatureServe 2003). Vegetation and physiographic data were combined to produce a classification system that uniformly covers the entire extent of the region (Table 1, Fig 6). This approach permitted a combination of physical and land cover data that is likely to capture more variation than either class alone, particularly in areas where detailed data on vegetation community composition and structure are not available. One challenge of a regional assessment in Southeast was to combine relatively high-quality data available from the Tongass with lower-quality data from adjacent state and private lands into a seamless and integrated map. The approach in this case was to develop a hierarchical system that allowed for the integration of the best existing information but also for a more general characterization when detailed data were lacking. Therefore, physiographic data such as landform and elevation can be key determinants among likely ecosystem types. This classification provided the framework from which finer-scale mapping of focal systems and habitat models were developed.

TABLE 1. Potential delineations of terrestrial ecosystem types were developed from a combination of vegetation/land cover and physiographic characteristics

Vegetation / Land Cover	Physiography	
Productive Old-growth big-tree oldgrowth medium-tree oldgrowth small-tree oldgrowth	*Landform Assoc.* coastal lowland valley floor hills mtn. slopes mtn. summits	*Glacial History* active glacial recent glacial inactive glacial post-glacial
2nd-growth (post-harvest)		
Other Forest Types montane / sub-alpine muskeg woodlands early succession forests deciduous forest	*Topography* elevation slope aspect position curvature	*Geology* granitic mafic / ultramafic metasediments sedimentary, - carbonate - (karst) - noncarbonate volcanic till lowlands
Nonforest Types alpine tundra low / tall shrub muskeg (peatland) herbaceous unvegetated	*Soil Hydrology* hydric non-hydric	

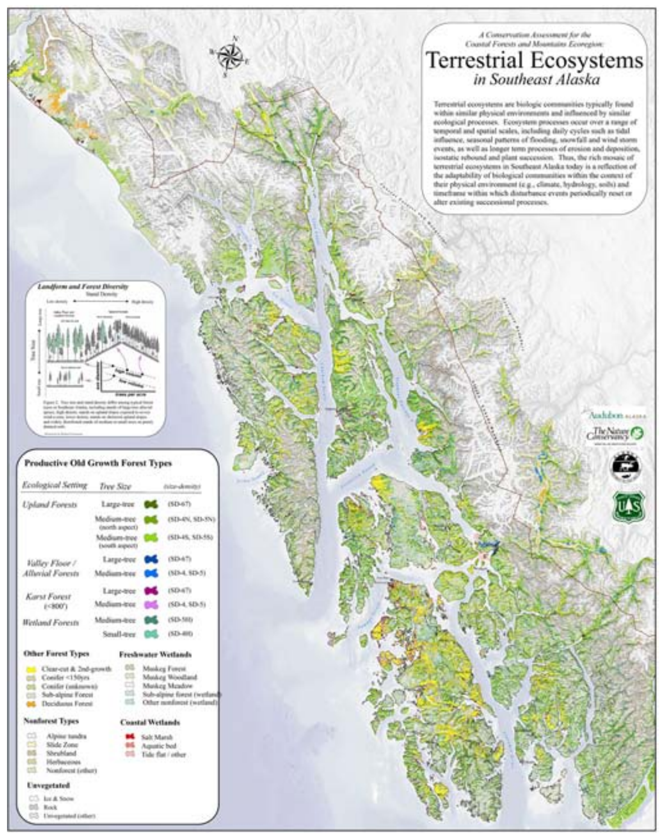

FIG 6. Terrestrial ecosystems were mapped at a regional scale by combining information on vegetation, wetland types, landform associations and karst from USFS and other sources.

Vegetation and land cover.—The Tongass Forest timber inventory provided the foundation for mapping of vegetation, and was augmented with timber inventory data from Haines State Forest and with classified Landsat Multi-spectral Scanner (MSS) imagery from the Interim Landcover Mapping Program of the U.S. Geological Survey. This imagery, in combination with 1997 USFS aerial photography allowed development of a reasonably current database of forest condition on USFS, state, and private lands across Southeast. Although land cover categories were limited by the resolution of information from management agencies, in general, it was possible to maintain consistency among general types throughout the region (Table 2).

TABLE 2. Generalized classification of vegetation and landcover in southeastern Alaska

	Land Management			Totals	
Land Cover	Tongass NF (acres)	Glacier Bay NP (acres)	Private / Other (acres)	(acres)	(%)
Productive Old Growth Forest					
POG - Large tree	534,516		54,355	588,871	2.7%
POG – Medium tree	3,679,543		456,679	4,334,410	19.8%
POG - Small tree	772,839		110,359	883,874	4.0%
Other Forests					
Clear-cut & 2nd-growth	466,056	200	320,029	786,285	3.6%
Conifer <150yrs	91,333	198,864	6,159	296,356	1.4%
Conifer forest (other)	91,617	134,614	226,373	452,604	2.1%
Deciduous forest	65,170		2,882	68,052	0.3%
Mixed forest	15,256		33	15,289	0.1%
Muskeg forest	1,133,245	0	47,013	1,180,258	5.4%
Muskeg woodland	1,253,607		37,210	1,290,817	5.9%
Sub-alpine forest	1,186,709		8,661	1,195,370	5.5%
Nonforest Vegetation					
Alpine tundra	540,044	2	4,247	544,293	2.5%
Slide zone	792,633	6	15,371	808,010	3.7%
Shrubland	952,257	112	9,608	961,977	4.4%
Herbaceous	18,667		3,613	22,280	0.1%
Nonforest (other)	186,494	632,374	240,479	1,059,347	4.8%
Freshwater wetlands					
Muskeg meadow	252,160		9,418	261,579	1.2%
Emergent wetlands	25,623	4,253	17,753	47,630	0.2%
River bar	20,077	11,797	23,030	54,904	0.3%
Lake	164,683	12,811	27,053	204,547	0.9%
River channel	36,690	60,809	46,678	144,178	0.7%
Coastal wetlands					
Algal bed	1,361	305	80,704	82,370	0.4%
Rocky shore	4,176	206	34,320	38,703	0.2%
Salt marsh	7,073	2,038	24,348	33,458	0.2%
Sand & gravel beach	10	3,031	2,754	5,795	0.0%
Tide flat	17	1,611	10,948	12,577	0.1%
Unconsolidated sediments	8,633	3,386	99,804	111,824	0.5%
Unvegetated lands					
Ice & Snow	2,189,317	1,158,675	248,252	3,596,244	16.4%
Unvegetated	2,299,167	472,273	227,576	2,999,016	13.7%
Urban	749		9,082	9,831	0.0%
Totals	16,789,724	2,697,370	2,404,791	21,891,885	100.0%

Landforms.—Landforms describe general topographic patterns that have a bearing on disturbance regime, climate, soils, hydrology, and vegetation. Source data on landform were obtained from the Tongass National Forest soils database. This information was interpreted by USFS scientists from aerial photography to describe landscape patterns of soils, vegetation, and landform, and was complete for all non-wilderness areas of the Tongass. For this information to be useful in a regional analysis, development of a comparable system for lands excluded from the original mapping was needed. Because landforms are defined physical topographic features, a digital elevation model was used to extend the mapping of landform associations. Most previous classifications operate by setting somewhat arbitrary thresholds that are assumed to be associated with landform distinctions. In large areas with diverse terrain, however, the physical characteristics of different landforms often overlap. To make objective and repeatable decisions where physical characteristics overlap based on statistical probability, a maximum likelihood classification model (Hengl and Rossiter 2003) was employed. The Tongass National Forest soils database was used to guide the maximum likelihood classification. This method is more accurate than setting arbitrary thresholds, because it statistically accounts for the natural variation in physical geography that was observed in aerial photography and in the field. Components of the landform model included elevation, slope, and topographic position index (TPI). The TPI is defined as the difference in elevation at a given location relative to the elevation of neighboring positions. Topographic position for each grid cell was modeled by using a neighborhood model for distance-weighted elevation difference (Fels and Zobel 1995):

Topographic position is the mean of the distance-weighted elevation differences between a given cell and all other cells within a specified search radius. The maximum search radius of 9,840 ft (3,000 m) (representing a tradeoff between identification of narrowest versus the widest river valley) was used. Categories of landform were derived from the Landform Association look-up tables for the soils database, and included Coastal, Lowlands, Valley Floor, Hills, Mountain Slopes, and Mountain Summits (Fig 7).

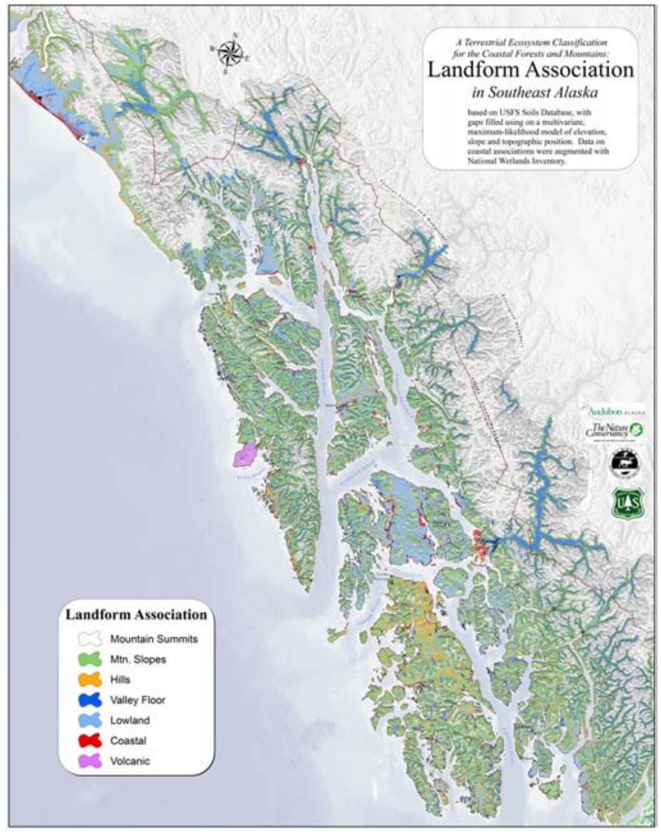

FIG 7. An integrated GIS database of landform association was developed using a multivariate classification of elevation, slope and topographic position based on air-photo interpreted landform data from the Tongass National Forest Soils database.

For more detailed descriptions of terrestrial habitats refer to Chapter 5 of this report.

Coarse Filter: Freshwater Ecosystems

Freshwater ecological systems consist of a group of interacting communities held together by shared physical habitats, environmental regimes, energy exchanges, and nutrient dynamics. Freshwater ecosystems are extremely dynamic in that they often change in terms of where (for example, a migrating river channel) and when (for example, seasonal ponds) they exist. Freshwater ecosystems fall into 3 major groups: standing-water ecosystems (e.g., lakes and ponds), flowing-water ecosystems (e.g., rivers and streams), and freshwater-dependent ecosystems that interface with the terrestrial world (e.g., wetlands and flood plain areas). Where freshwater ecosystems interface with the marine environment, they also form estuaries of significant ecological value.

Stream ecosystems were characterized based on fluvial process group in the USFS Stream Database (Paustian et al. 1992), and wetland habitats were described by using the National Wetlands Inventory

(Cowardin et al. 1979). Additional information on wetland habitat types was available in the Tongass National Forest soils database.

Although this report focuses on terrestrial ecosystems, anadromous salmon streams, flood plain forests, and estuaries are of special interest and are also included in this conservation assessment. For more detailed descriptions of freshwater habitats refer to Chapter 5 of this report.

Fine Filter: Focal Species and Systems

Classification of forest ecosystems.—Considerable diversity exists among forest types in Southeast. Although forested lands are extensive, differences in soil drainage result in widely divergent forest structure and stand dynamics. For example, forests growing at lower elevation on well-drained alluvial and flood plain soils are relatively rare, yet are very diverse and productive. Likewise, forests at low elevations on karst formations also produce stands of very large trees. Upland forests tend to be dominated by stands of western hemlock and mixed western hemlock-Sitka spruce.

To represent the diversity of ecological values associated with forest ecosystems, a general classification developed by Caouette and DeGayner (2005) was used based on tree size and stand density (Fig 8) and a geomorphic stratification grouped into flood plain and upland types as well as forests associated with karst landscapes. Stands of productive old growth (POG) were categorized based on a measure of quadratic mean diameter (QMD) into "large-tree" (>21 in [53 cm], "medium-tree" (17-21 in [43-53 cm], and "small-tree" stands (<17 in [43 cm]) using the USFS database on existing vegetation, historical information on forest structure contained in the 1986 Timtype database, and data on hydric (wet) soils contained in the National Wetlands Inventory (NWI) (Fig 8). Forest condition on private lands was estimated by using Landsat ETM (1999–2000) and USFS orthophotographs (1996). For lands within the Tongass National Forest, flood plain forests were identified based on the Tongass National Forest soils database. For lands outside the Tongass, a multivariate modeling approach was used.

Current condition of forest ecosystems.—Estimates of the original distribution of large-tree forest types were based on USFS timber inventories conducted in the early 1980s, and were available for approximately 242,221 acres (98,000 ha) or about 31% of the 786,285 acres (318,205 ha) that have been logged on public and private lands in Southeast. These data can be used to describe the selectivity of logging activities during that time, and estimate the original distribution of forest types throughout the region. Areas that were logged after 1986 consisted of approximately 29% of large-tree forest types, 65% of medium-tree types and 6% of small-tree productive old-growth types (Table 3). In comparison with the total abundance of these forest types, this results in a selectivity ratio of 2.89 for large-tree, 0.87 for medium-tree and 0.4 for small-tree forest types. Thus, large-tree forests were logged during this period at a rate that exceeded their proportional abundance by 2.89 times, and exceeded the proportional rate of logging on medium-tree and small-tree forest types by 333% and 720% respectively.

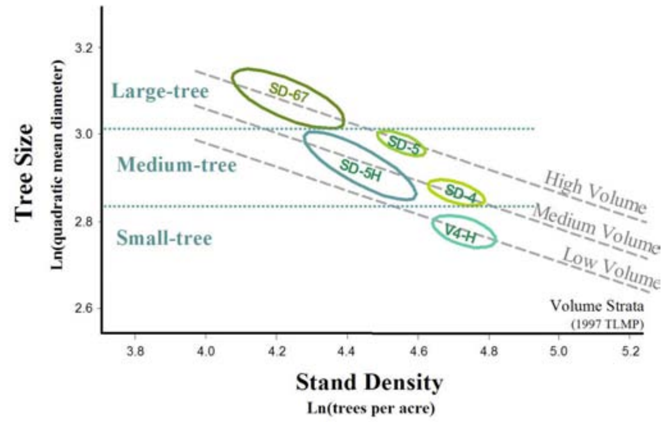

FIG 8. We adapted the system of Caoette and DeGayner (2005) to describe structural diversity among old growth forest types using tree size and stand density (log-transformed).

To estimate the regional distribution of large-tree forests on areas logged prior to that time and for other areas without a previous timber inventory, these coefficients of selectivity provide a conservative "best-guess" estimate. However, because early logging was highly selective for the most productive timber sites (Greeley 1953, Rakestraw 1981, USFS 2003), this assumption underestimates the proportion of large-tree forests that were logged. Moreover, in some provinces the most productive watersheds that currently remain intact are not comparable to the productivity of those highly productive watersheds that were logged in the early years. Logging regulations and guidelines have also changed over time further underestimating the original selectivity for large-tree forest types. For example, timber harvest that occurred before the 1979

TABLE 3. Rate of logging for forest types in southeastern Alaska, based on areas logged since 1986 for which data on previous forest structure was available (*n* = 242,221 acres)

	Forest types logged		Availability of forest types		
Forest types	(acres)	(% use)	(acres)	(% available)	Index of Selectivity [a]
Large-tree	70,839	29.3%	588,871	10.1%	2.89
Medium-tree	156,572	64.6%	4,334,410	74.6%	0.87
Small-tree	14,810	6.1%	883,874	15.2%	0.40
Total	242,221	100%	5,807,155	100.0%	

[a] Index of selectivity = % use / % availability

Tongass Land Management Plan and 1990 Tongass Timber Reform Act was much less restrictive of logging in the most productive flood plain forests than in more recent years. Indeed, many of the harvest units from the 50's, 60's and 70's are characterized by broad-scale clearing of flood plain forests in watersheds such as Katlian River and Nawkasina Sound on Baranof Island and Harris River and Staney Creek on Prince of Wales Island. Forestry standards implemented with the 1997 Tongass Land Management Plan revision further restricted logging in flood plain areas, beach and estuary fringe, and other forest types. Clearly, forest types logged after 1986 are not representative of those from earlier years, particularly related to logging in the most productive watersheds, and this assessment substantially underestimates the original distribution of these forest types.

In addition to being selective at the level of watersheds or forest stands, historic logging activity in Southeast has also occurred disproportionately on the most productive landforms. A simple comparison of the proportional abundance of productive forest lands with the proportion of logging activity that has occurred among elevation zones, landform associations, and karst landscapes reveals that logging has occurred disproportionately on karst lands and low elevation flood plain forests (Table 4). Indeed, while low elevation karst lands represented only 2.7% of all productive forests in Southeast, 15.1% of all logging activity has occurred in these areas for a rate of harvest 560% above proportional abundance. As a consequence, we estimate that at least 44% (and likely more than half) of all productive old-growth forests on karst lands in Southeast have been logged since 1954. Likewise, logging activity occurred in low elevation flood plain forests at a harvest rate 156% above the proportional abundance of these areas. These forest tree types are among the most productive terrestrial habitats of Southeast. Lower rates of logging are observed on other lowlands and all areas above 800 ft (244 m), with the exception of karst lands.

Region-wide, only 12% of all productive old-growth forest has been harvested since 1954 but at least 28% of Southeast's large-tree forest types have been cut (Table 5). It is important to recognize, however, that this percentage—derived from post 1986 selectivity coefficients—represents a significant underestimate of the original high-grading (cutting the best) of the large-tree stands. Based on the history and pattern of logging, it is likely that harvest of the rare large-tree stands has exceeded 50% of their original distribution in Southeast. Moreover, a comparison among provinces reveals that logging activity has occurred disproportionately among Southeast's biogeographic provinces in comparison to the availability of productive forest lands (Table 5). For example, North Prince of Wales Island originally contained 14% of productive forest lands but has been the location of 38% of all timber harvest in Southeast. As a consequence, 32% of all productive old growth and a conservative estimate of 40% of all large-tree forests have been logged within the North Prince of Wales Island province, which historically had the most abundant large-tree forests in all of Southeast. Other provinces with high rates of logging include Dall and Long islands, Kupreanof and Mitkof islands, Etolin and Zarembo islands, East Chichagof, and Outside islands. The highest rates

TABLE 4. Logging selectivity by landform associations in southeastern Alaska (index of selectivity estimated by the percent of logging that has occurred divided by the proportional distribution of productive old growth on each landform type).

Landform Association	Productive old growth (POG) (acres)	(%)	Timber Harvest (acres)	(%)	Percent of POG Cut (%)	Index of Selectivity[a]
Low elev. (<800')						
Karst[b]	151,429	2.7%	118,836	15.2%	44.0%	5.6
Valley floor	485,643	8.7%	106,402	13.6%	18.0%	1.6
Mtn. Slope	1,580,458	28.3%	254,133	32.4%	13.9%	1.1
Coastal	89,598	1.6%	12,696	1.6%	12.4%	1.0
Hills	487,937	8.7%	62,324	8.0%	11.3%	0.9
Lowland	649,427	11.6%	75,815	9.7%	10.5%	0.8
Volcanic	14,883	0.3%	1,252	0.2%	7.8%	0.6
Upper elev. (>800 ft)						
Karst[b]	84,792	1.5%	20,078	2.6%	19.1%	1.7
Hills	73,834	1.3%	7,833	1.0%	9.6%	0.8
Mtn. Slope	1,738,954	31.2%	116,179	14.8%	6.3%	0.5
Valley floor	95,229	1.7%	6,017	0.8%	5.9%	0.5
Volcanic	1,355	0.0%	35	0.0%	2.5%	0.2
Mtn. Summits	127,259	2.3%	1,688	0.2%	1.3%	0.1
Total	5,580,795	100.0%	783,288	100.0%	12.3%	

[a] Index of selectivity = % use / % availability
[b] This includes all landforms within karst areas.

of logging on the rare large-tree forest types have been on Baranof Island followed by Zarembo, Kupreanof and Mitkof islands. These are not among the most productive islands overall, but this exemplifies the clear trend toward logging of the most productive landscapes within all provinces (Table 5).

In contrast, provinces with low rates of logging (e.g., West Chichagof Island, Misty Fjords, and the mainland provinces from Lynn Canal. through Glacier Bay and Fairweather Icefield) do not contain significant areas of productive old-growth forest comparable to other provinces in the region (Admiralty being an exception).

Although our conservative estimate of the percentage of large-tree old-growth forest logged region-wide is 28%, it is likely that the actual percentage may be greater than 50%. And it is highly probable that the largest individual trees (>12 ft [3.6 m] in diameter) which once occurred in Southeast have largely been extirpated. At the province-scale, 8 provinces (E. Baranof, W. Baranof, Etolin/Zarembo, Kupreanof/Mitkof, Dall Is. Complex, Revilla/Cleveland, North Prince of Wales, and E. Chichagof) have conservatively lost from 40% to 67% of their original large-tree forests (Table 6). Four of those provinces (Etolin/Zarembo, Kupreanof/Mitkof, Revilla/Cleveland, and North Prince of Wales) still include 30-45% of their remaining large-tree old-growth stands in the timber base (Table 6).

The 6 biogeographic provinces in Southeast with the greatest abundance of large-tree old growth are Northern Prince of Wales, Admiralty Island, South Prince of Wales, East Chichagof, Kuiu, and Yakutat Forelands (Table 6). Admiralty, South Prince of Wales, Kuiu, and Yakutat retain more than 80% of their original large-tree forest. However, only Admiralty and Yakutat have watershed-scale reserves protecting more than 50% of their large-tree forests. The other provinces with substantial large-tree old growth rely primarily on sub-watershed reserves and old-growth buffers for protection. Only 7 of the 20 biogeographic provinces in Southeast, with significant quantities of productive old growth, include watershed-scale conservation that protects greater than 50% of the remaining large-tree forests

TABLE 5. Distribution of productive old-growth forest types and percent of timber harvest within 20 biogeographic provinces[a] in southeastern Alaska.

Province	Large-tree forests (acres)	Productive old growth (POG) (acres)	(%)	Timber harvest (acres)	(%)	% of original POG harvested (%)	% of original large-tree forest harvested[b] (%)	Index of Selectivity[c]
North Prince of Wales	130,649	632,303	11.33%	295,782	37.76%	31.87%	39.84%	2.59
Dall Island Complex	9,654	108,864	1.95%	26,885	3.43%	19.81%	44.89%	1.61
Yakutat Forelands	27,576	82,841	1.48%	18,290	2.33%	18.08%	16.25%	1.47
Kupreanof / Mitkof Islands	21,302	357,721	6.41%	67,619	8.63%	15.90%	48.15%	1.29
Etolin / Zarembo Island	12,128	230,651	4.13%	41,300	5.27%	15.19%	49.90%	1.23
E. Chichagof Island	37,775	438,249	7.85%	71,483	9.13%	14.02%	35.63%	1.14
Outside Islands	13,573	118,490	2.12%	18,404	2.35%	13.44%	28.40%	1.09
E. Baranof Island	2,016	91,309	1.64%	13,797	1.76%	13.13%	66.69%	1.07
Chilkat River Complex	20,984	138,538	2.48%	19,940	2.55%	12.58%	21.75%	1.02
Revilla Is. / Cleveland Pen.	32,045	580,282	10.40%	72,838	9.30%	11.15%	39.93%	0.91
South Prince of Wales	43,490	168,570	3.02%	17,881	2.28%	9.59%	10.74%	0.78
Kuiu Island	36,331	290,855	5.21%	29,670	3.79%	9.26%	19.28%	0.75
W. Baranof Island	4,795	236,137	4.23%	19,445	2.48%	7.61%	54.26%	0.62
Taku River / Mainland	23,914	344,340	6.17%	21,540	2.75%	5.89%	20.85%	0.48
Stikine River / Mainland	21,207	334,943	6.00%	15,031	1.92%	4.29%	17.17%	0.35
Admiralty Island	99,937	606,438	10.87%	27,103	3.46%	4.28%	7.35%	0.35
Lynn Canal / Mainland	16,748	212,334	3.80%	6,282	0.80%	2.87%	9.89%	0.23
North Misty Fiords	16,449	217,164	3.89%		0.00%	0.00%	0.00%	0.00
South Misty Fiords	14,171	316,370	5.67%		0.00%	0.00%	0.00%	0.00
W. Chichagof Island	2,023	74,397	1.33%		0.00%	0.00%	0.00%	0.00
All Provinces	586,766	5,580,795	100.00%	783,288	100.00%	12.31%	28.08%[b]	

[a] Glacier Bay and Fairweather Icefield provinces have little productive old growth and are not included

[b] Estimated by extrapolating the rate of logging of large-tree forests after 1986 from areas with known forest structure (29.3%) to all areas logged. This conservative approach substantially underestimates the actual extent of logging in these relatively rare forest types.

[c] index of selectivity equals the % of timber harvests divided by the % of original distribution of productive forests among provinces.

and only Admiralty and Yakutat include more than 25,000 acres (10,117 ha) of large-tree old growth (Table 6).

Northern Prince of Wales, which contained the greatest amount of large-tree old growth of any province in Southeast, still contains more of this rare forest type than any other province. However, most of those stands now occur in scattered, isolated patches. Only 13.5% of Prince of Wale's large-tree stands occur in watershed-scale reserves while 41% still exist in the timber base. Etolin/Zarembo and Kupreanof/Mitkof also have less than 25% of their remaining large-tree old growth in watershed-scale reserves while more than 40% exist in the timber base.

TABLE 6. Current condition and management status of large-tree old-growth forests among 20 biogeographic provinces[a] in southeastern Alaska.

	Current condition of large-tree forests			Management status and scale (% of current distribution)				
Province	Original [b] (acres)	Current (acres)	% large-tree forest intact	Watershed-scale reserves [c]	Sub-watershed reserves [d]	Buffers [e]	Timber base	All
E. Baranof Island	6,051	2,016	33.3%	43.9%	8.0%	25.1%	23.1%	100.0%
W. Baranof Island	10,483	4,795	45.7%	59.1%	15.9%	6.0%	19.0%	100.0%
Etolin / Zarembo Is.	24,208	12,128	50.1%	23.6%	24.2%	12.1%	40.1%	100.0%
Kupreanof / Mitkof Is.	41,080	21,302	51.9%	15.1%	25.0%	14.7%	45.2%	100.0%
Dall Island Complex	17,518	9,654	55.1%	42.6%	43.3%	1.5%	12.6%	100.0%
Revilla Is. / Cleveland	53,350	32,045	60.1%	41.7%	20.8%	7.5%	30.1%	100.0%
North Prince of Wales	217,166	130,649	60.2%	13.5%	31.4%	13.8%	41.3%	100.0%
E. Chichagof Island	68,684	37,775	64.4%	42.9%	14.7%	16.6%	25.7%	100.0%
Outside Islands	18,956	13,573	71.6%	41.9%	17.7%	12.0%	28.4%	100.0%
Chilkat River Complex	26,816	20,984	78.3%	0.9%	9.6%	0.0%	89.5%	100.0%
Taku River / Mainland	30,214	23,914	79.1%	18.0%	33.5%	9.4%	39.1%	100.0%
Kuiu Island	45,009	36,331	80.7%	31.6%	15.3%	10.6%	42.5%	100.0%
Stikine River/Mainland	25,604	21,207	82.8%	51.0%	12.4%	11.4%	25.1%	100.0%
Yakutat Forelands	32,926	27,576	83.8%	52.1%	10.5%	1.3%	36.1%	100.0%
South Prince of Wales Is.	48,720	43,490	89.3%	42.5%	17.9%	10.9%	28.7%	100.0%
Lynn Canal / Mainland	18,585	16,748	90.1%	41.9%	16.1%	7.6%	34.5%	100.0%
Admiralty Island	107,865	99,937	92.7%	88.1%	7.7%	0.1%	4.1%	100.0%
North Misty Fjords	16,449	16,449	100.0%	90.1%	2.6%	2.7%	4.6%	100.0%
South Misty Fjords	14,171	14,171	100.0%	99.7%	0.0%	0.0%	0.3%	100.0%
W. Chichagof Island	2,023	2,023	100.0%	99.3%	0.0%	0.0%	0.7%	100.0%
Grand Total	815,936	586,766	71.9%	43.0%	18.5%	8.4%	30.0%	100.0%

[a] Glacier Bay and Fairweather Icefield provinces have little productive old growth and are not shown
[b] Original distribution of large-tree forests was conservatively estimated based on selectivity of harvest in areas with documented timber inventory approx. from 1986 – present and underestimates the percentage of original harvest.
[c] Watershed-scale includes areas where non-development land-use designations encompass the entire watersheds
[d] Sub-watershed scale reserves are areas that include a portion of entire watersheds (VCU) within non-development status.
[e] Buffers include stand-level protections under the Alaska State Forest Practices Act as well as TLMP standards for riparian, estuary & beach fringe forests.

Deer winter habitat.—The Sitka black-tailed deer (*Odocoileus hemionus*) was selected as a focal species because deer occur throughout the Alexander Archipelago and much of the mainland coast and deer are closely affiliated with old-growth forest, which provides them with essential winter habitat (Wallmo and Schoen 1980, Hanley et al. 1989, Schoen and Kirchhoff 1990). The winter habitat capability model for deer was adapted as described in Suring et al. (1992), by using the Volume Strata classes as applied in the Tongass Land Management Plan (USFS 1997). This model provides a relative index of winter habitat values for deer, and was not used as a predictor of population size or carrying capacity. The ecological basis for development of this model is that periodic events of winter weather and availability of optimal habitat are generally considered to be important habitat-based factors that regulate deer populations in Southeast (Suring et al. 1992). This model estimates relative value of winter habitats based on physiography and land cover (Table 7). For more information on deer ecology in Southeast, refer to Chapter 6.1.

On the basis of expert review and examination of climatic data from communities in Southeast, the TLMP snow map was determined to inadequately represent the influence of winter weather on deer habitat. In March 2005, an interagency expert review workshop (including Alaska Department of Fish and Game [ADF&G], Audubon Alaska [Audubon], The Nature Conservancy [TNC], USFS, and U.S. Fish and Wildlife Service [USF&WS]) was convened to evaluate the parameters and appropriateness of the model for this application. As a result of this workshop, an updated model of relative snowfall that uses the PRISM climatic model (Daly et al. 2000) was developed. PRISM is an analytical model that uses point data and a DEM to generate gridded estimates of monthly and annual temperature, and incorporates a conceptual framework that addresses the spatial scale and pattern of orographic (relating to effects of mountains) processes. This model incorporated data from existing weather stations in Southeast during the period 1961–1990. At a regional scale, this model provided an adequate representation of snow depth and was an improvement over the previous snow map used in the 1997 TLMP. In general, this model recognizes that areas at lower elevations with more southerly exposures and with a forest canopy that provides snow interception and thermal cover constitute good habitat for deer during potentially limiting periods of winter weather. The importance of winter weather as a critical factor limiting deer populations varies among areas of Southeast as depicted by the snow map (Fig 9).

TABLE 7. Capability of winter habitats to support Sitka black-tailed deer under varying snow conditions (TLMP 1997).

Land cover	Snow	Aspect and Elevation (ft)											
		South			**West**			**East**			**North**		
		<800	800-1500	>1500	<800	800-1500	>1500	<800	800-1500	>1500	<800	800-1500	>1500
Old Growth High (VC[1] 5, 6, 7)													
	Low	1.30	0.65	0.00	1.04	0.52	0.00	0.78	0.39	0.00	0.65	0.33	0.00
	Inter.	1.00	0.50	0.00	0.80	0.40	0.00	0.60	0.30	0.00	0.50	0.25	0.00
	High	0.70	0.35	0.00	0.56	0.28	0.00	0.42	0.21	0.00	0.35	0.18	0.00
Old Growth Med (VC 4, hydric VC 5)													
	Low	0.63	0.32	0.00	0.50	0.25	0.00	0.38	0.19	0.00	0.32	0.16	0.00
	Inter.	0.45	0.23	0.00	0.36	0.18	0.00	0.27	0.14	0.00	0.23	0.11	0.00
	High	0.27	0.14	0.00	0.22	0.11	0.00	0.16	0.08	0.00	0.14	0.07	0.00
Old Growth Low (Hydric VC 4)													
	Low	0.39	0.20	0.00	0.31	0.16	0.00	0.23	0.12	0.00	0.20	0.10	0.00
	Inter.	0.30	0.15	0.00	0.24	0.12	0.00	0.18	0.09	0.00	0.15	0.08	0.00
	High	0.15	0.08	0.00	0.12	0.06	0.00	0.09	0.05	0.00	0.08	0.04	0.00
Non-CFL[2] (VC 3)													
	Low	0.33	0.16	0.00	0.26	0.13	0.00	0.20	0.10	0.00	0.16	0.08	0.00
	Inter.	0.25	0.13	0.00	0.20	0.10	0.00	0.15	0.08	0.00	0.13	0.06	0.00
	High	0.13	0.06	0.00	0.10	0.05	0.00	0.08	0.04	0.00	0.06	0.03	0.00
Shrub-Sapling CC[3] (0–25)													
	Low	0.75	0.38	0.00	0.60	0.30	0.00	0.45	0.23	0.00	0.38	0.19	0.00
	Inter.	0.25	0.13	0.00	0.20	0.10	0.00	0.15	0.08	0.00	0.13	0.06	0.00
	High	0.04	0.02	0.00	0.03	0.02	0.00	0.02	0.01	0.00	0.02	0.01	0.00
Poletimber CC (26–200)													
	Low	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
	Inter.	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
	High	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00
Other	All	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

([1] volume class, [2] commercial forest land, [3] clearcut)

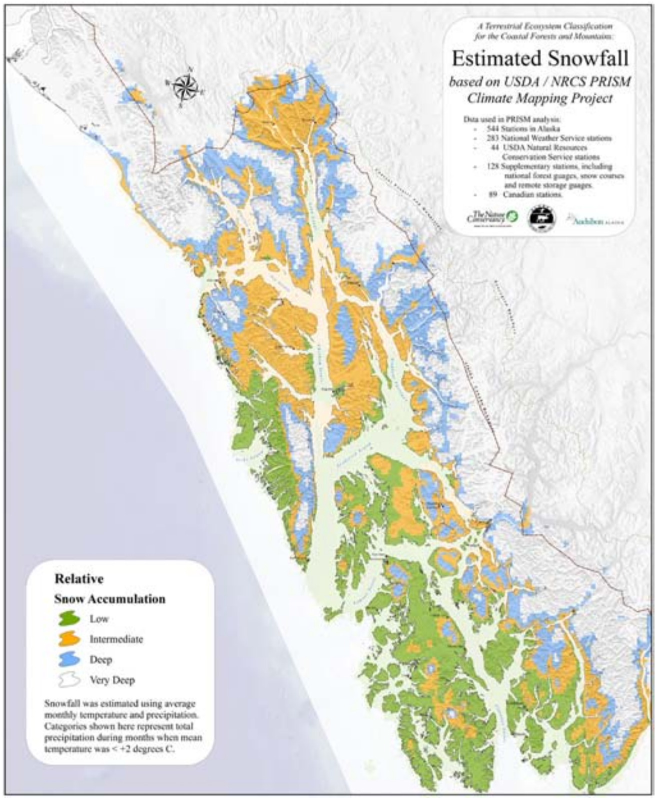

FIG 9. Snow accumulation was estimated using the PRISM climate model based on mean monthly temperature and precipitation.

The current condition and management status of Sitka black-tailed deer winter habitat capability were evaluated among 13 island provinces where deer have historically been abundant and/or common (Table 8). Mainland provinces were not included in this evaluation because deer are less abundant or do not occur in most mainland watersheds. Provinces which historically had the most abundant winter deer habitat capability were (in order of value) North Prince of Wales Island, Revilla Is / Cleveland Peninsula, Admiralty Island, East Chichagof Island, Kupreanof / Mitkof Islands, and Kuiu Island. Region-wide, the southern islands (south of Frederick Sound) contained approximately 70% of the original habitat capability of Southeast. As of 2002, 79% of the original deer habitat value still remains in Southeast. However, North Prince of Wales which originally had the most abundant winter deer habitat has lost an estimated 38% of its original habitat value as a result of cumulative timber harvesting. Other provinces where winter habitat capability has declined by more than 20% include East Baranof Island, East Chichagof Island, Etolin / Zarembo Complex, Dall Island Complex, and Kupreanof / Mitkof Islands. West Chichagof Island, Admiralty Island, South Prince of Wales Island, West Baranof Island, Kuiu Island, Revilla Island / Cleveland Peninsula, and the Outside Islands maintain (in descending order) the highest percentage of their original habitat values. Of these, the most abundant deer habitat occurs on Revilla / Cleveland, Admiralty, and Kuiu. Although Kuiu Island has abundant deer habitat, deer densities on this island are very low, perhaps as a result, in part, of high predator densities (e.g., wolf and black bear). Five provinces have watershed-scale reserves that encompass more than 50% of the winter deer habitat capability: West Chichagof Island, Admiralty Island, West Baranof Island, Outside Islands, and Kuiu Island. Region-wide, 31% of winter deer habitat capability is in the managed forest (available for timber harvest). The highest proportion of deer habitat in managed forest lands occurs in the Kupreanof / Mitkof (51%) and North Prince of Wales (46%) provinces. Recall that North Prince of Wales maintains the lowest proportion (62%) of its original deer habitat value and also has the lowest proportion (14%) of watershed-scale reserves, followed closely by Kupreanof / Mitkof (18%). Admiralty, Kuiu, and Revilla / Cleveland provinces currently have the most significant deer habitat capability in combination with significant conservation reserves.

Marbled murrelet nesting habitat.—The marbled murrelet was chosen as a focal species because it is dependant on old-growth forests for nesting habitat and occurs widely throughout the region. The species is listed as threatened in British Columbia and the lower 48 states where logging has greatly reduced the availability of suitable nesting habitat. Other factors may also affect marbled murrelet populations, including predation, adult mortality in fishing nets, and limited availability of forage fish in the marine environment. In this conservation assessment, the focus was on identifying and mapping the most suitable nesting habitat for these birds.

TABLE 8. Current condition and management status of winter habitat for Sitka black-tailed deer among 13 biogeographic provinces[a] in Southeast Alaska.

	Habitat Capability Index		Current Condition	Management Status and Scale[a] (% of current habitat value)				
Province	Original (1954)	Current (2002)	% of original habitat value	Watershed-scale reserves [b]	Sub-watershed reserves [c]	Buffers [d]	Managed Lands [e]	Total
North Prince of Wales Is.	367,482	228,626	62.2%	14.4%	28.9%	11.0%	45.8%	100.0%
E. Baranof Island	27,363	20,228	73.9%	31.9%	15.5%	15.3%	37.3%	100.0%
E. Chichagof Island	133,413	99,361	74.5%	33.7%	17.2%	12.0%	37.0%	100.0%
Etolin / Zarembo	79,706	61,695	77.4%	24.0%	25.6%	13.8%	36.6%	100.0%
Dall Island Complex	52,201	40,500	77.6%	29.9%	31.7%	4.1%	34.3%	100.0%
Kupreanof / Mitkof Islands	133,457	104,238	78.1%	18.1%	20.7%	10.2%	50.9%	100.0%
Outside Islands	56,691	47,481	83.8%	60.6%	10.3%	7.6%	21.5%	100.0%
Revilla Is. / Cleveland Pen.	185,399	157,353	84.9%	42.6%	14.8%	8.4%	34.2%	100.0%
Kuiu Island	122,904	107,144	87.2%	52.9%	10.6%	8.5%	28.0%	100.0%
W. Baranof Island	91,283	79,628	87.2%	62.7%	14.4%	3.1%	19.8%	100.0%
South Prince of Wales Is.	78,920	70,556	89.4%	48.2%	14.3%	9.5%	28.0%	100.0%
Admiralty Island	165,057	155,127	94.0%	91.7%	4.1%	0.1%	4.1%	100.0%
W. Chichagof Island	23,304	23,304	100.0%	94.9%	0.0%	0.0%	5.1%	100.0%
All Provinces	1,517,179	1,195,241	78.8%	43.5%	17.1%	8.0%	31.4%	100.0%

[a] Provinces on the mainland (Yakutat to South Misty Fjords) were considered as generally poor to negligible winter habitat for Sitka black-tailed deer and are not shown.
[b] Watershed-scale reserves include areas where legal or administrative protections encompass the entire watershed (VCU)
[c] Sub-watershed scale reserves are areas that include a portion of entire watersheds (VCU) within legal or administratively protected status.
[d] Buffers include stand-level protections under the Alaska State Forest Practices Act as well as TLMP standards for riparian, estuary & beach fringe forests.
[e] Managed lands include USFS timber base as well as all state, private and federal lands lacking explicit legal or administrative protections.

An interagency and university group of experts (including ADF&G, Audubon, TNC, UAF, USFS, and USF&WS) was convened to develop and evaluate a nesting habitat capability model based on data from Alaska and British Columbia. This model is based on stand age, forest structure, slope, and distance from shoreline (Table 9). Old-growth forests (>250 years) have the highest habitat value because they include canopy gaps that provide murrelets (which are fast fliers with limited maneuverability under the forest canopy) access to nest platforms. Younger stands are considered not suitable because of the relatively dense, uniform canopies, lack of large-diameter branches, and limited nest platform structures. Large-tree old growth was assigned higher values than medium and small-tree old growth because larger trees tend to have larger limbs, and thus more suitable nest platforms. The larger trees, which rise above the subdominant canopy layer, also provide easier access to the nest. Assignment of forest structure classes was based on the USFS TIMTYPE (timber type) database. Because of limitations in age characterization in these data, 150 years was used as the lower limit of old-growth characteristics.

Nesting habitat value increased with slope steepness up to 20 degrees, assuming that the upper crown of trees on such slopes is more exposed, and therefore more accessible to nesting murrelets and fledging young. It should be noted that members of the scientific community differ over the relative importance of slope as an indicator of marbled murrelet habitat. A radio-telemetry study in Southeast is currently monitoring and tracking 35 birds. This research, being conducted in a pristine area with no logging, should help refine the murrelet nesting model in the future.

The final habitat attribute is distance from shoreline. Marbled murrelets do not nest immediately near the shore; they have been found to fly as far as 30 mi (50 km) inland to nest sites. The aversion to shoreline habitat is presumably related to the increased numbers of avian predators (especially bald eagles [*Haiaeetus leucocephalus*), ravens (*Corvus corax*) and crows [*C. caurinus*) found along the beach fringe. The murrelet model assigns a low value to habitat from the beach to 984 ft (300 m) of the beach fringe, and high value beyond that distance (Table 9). Because most of the potential nesting habitat in Southeast is less than 30 mi (50 km) from the marine shoreline, habitat value was not reduced as distance from the coast increased. The results of new research initiated in summer 2006 should provide additional data for future refinements to the murrelet nesting habitat model. For more information on marbled murrelets ecology in Southeast, refer to Chapter 7.3.

TABLE 9. Habitat variables and suitability factors used to estimate relative value of forest stands for nesting by marbled murrelet in Southeast

Variable	Habitat Type	Suitability Index
Age Class	<150 years	0.00
	≥150 years	1.00
Tree Size		
	Small POG	0.50
	Medium POG	0.75
	Large POG	1.00
Slope	0–5	0.20
	5–10	0.40
	10–15	0.60
	15–20	0.80
	>20 degrees	1.00
Distance from shoreline	<984 ft	0.30
	>984 ft	1.00

The current condition and management status of nesting habitat for marbled murrelets were evaluated among 22 biogeographic provinces throughout Southeast (Table 10). The provinces with the most abundant murrelet nesting habitat in Southeast (in order of abundance) include North Prince of Wales Island, Revilla Island / Cleveland Peninsula, Admiralty Island, East Chichagof Island, and Taku River Mainland. Southeast-wide, 86% of the original murrelet nesting habitat (as of 2002) still remains. The provinces which have had the greatest reductions in habitat value are Prince of Wales (40% decline), Kupreanof / Mitkof, East Chichagof, and Etolin / Zarembo. Provinces which have the greatest proportion of nesting habitat allocated to the managed land base (with potential for timber harvest) include Chilkat River (90%), Kupreanof / Mitkof (59%), Etolin /Zarembo (49%), North Prince of Wales (47%), and East Chichagof (44%). Of those, Prince of Wales and East Chichagof represent a significant abundance of marbled murrelet nesting habitat in southern and northern Southeast, respectively. The provinces with the most abundant and secure murrelet nesting habitat include Revilla / Cleveland, Admiralty Island, Taku River mainland, and Stikine River mainland.

Salmon freshwater habitat.—Salmon were selected as focal species because spawning and rearing salmon are widely distributed in streams and rivers throughout Southeast and play a fundamental role in the ecology of coastal, freshwater, and terrestrial systems. Salmon are considered to be keystone species in Southeast because they transfer marine-derived nutrients into the terrestrial and freshwater ecosystems and many terrestrial and freshwater species and ecological processes are inextricably connected to salmon (Wilson and Halupka 1995). This conservation assessment includes consideration of 6 species of salmonids: chinook (*Onchorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*), pink (*O. gorbuscha*), and steelhead (*O. mykiss*). Available data on distribution and abundance of each species, as well as populations with unique life history, timing of spawning runs, and genetics were reviewed (For more information on salmon ecology in Southeast, refer to Chapter 8.) In addition, the limitations in existing data on salmon distribution and habitats were recognized. To improve ability to identify areas of likely salmon habitat in unmapped stream channels, as well as compare watersheds based on geomorphological characteristics, a landscape model was developed to identify flood plain habitats associated with documented anadromous fish streams.

TABLE 10. Current condition and management status of nesting habitat for marbled murrelet among 22 biogeographic provinces in Southeast Alaska.

	Habitat Capability Index		Current Condition	Management Status and Scale (% of current habitat value)				
Province	Original (1954)	Current (2002)	% of original habitat value	Watershed -scale reserves [a]	Sub-watershed reserves [b]	Buffers [c]	Managed Lands [d]	Total
North Prince of Wales	229,309	138,269	60.3%	17.7%	28.0%	7.3%	47.0%	100.0%
Kupreanof / Mitkof Is	96,196	76,516	79.5%	14.6%	21.4%	4.8%	59.2%	100.0%
E. Chichagof Island	131,045	104,324	79.6%	33.4%	16.6%	6.0%	44.0%	100.0%
Etolin / Zarembo Island	69,743	55,968	80.2%	20.7%	24.2%	6.6%	48.5%	100.0%
E. Baranof Island	26,185	21,216	81.0%	38.8%	14.1%	6.4%	40.7%	100.0%
Yakutat Forelands	10,788	9,008	83.5%	65.4%	15.4%	1.1%	18.0%	100.0%
Outside Islands	30,343	26,016	85.7%	67.2%	11.2%	4.4%	17.2%	100.0%
Dall Island Complex	30,233	25,995	86.0%	33.7%	34.1%	2.3%	29.8%	100.0%
Revilla Is. / Cleveland Pen.	177,284	153,666	86.7%	48.8%	14.5%	3.6%	33.1%	100.0%
South Prince of Wales	51,442	45,145	87.8%	46.8%	15.9%	5.9%	31.3%	100.0%
W. Baranof Island	54,306	48,136	88.6%	64.9%	15.0%	1.7%	18.4%	100.0%
Kuiu Island	81,973	72,720	88.7%	55.3%	10.4%	4.4%	30.0%	100.0%
Chilkat River Complex	46,220	41,653	90.1%	1.4%	8.5%	0.4%	89.7%	100.0%
Taku River / Mainland	103,942	96,974	93.3%	41.5%	18.6%	4.4%	35.5%	100.0%
Admiralty Island	160,117	151,858	94.8%	89.3%	8.4%	0.0%	2.3%	100.0%
Stikine River / Mainland	96,527	92,493	95.8%	54.8%	11.6%	3.8%	29.7%	100.0%
Lynn Canal / Mainland	56,045	54,238	96.8%	53.5%	15.4%	3.2%	27.9%	100.0%
Glacier Bay	26,789	26,693	99.6%	92.9%	6.5%	0.0%	0.5%	100.0%
South Misty Fjords	82,636	82,636	100.0%	99.8%	0.0%	0.0%	0.2%	100.0%
North Misty Fjords	62,528	62,529	100.0%	94.0%	2.9%	0.3%	2.8%	100.0%
W. Chichagof Island	15,939	15,943	100.0%	98.7%	0.0%	0.0%	1.3%	100.0%
Fairweather Icefields	8,049	8,051	100.0%	99.9%	0.0%	0.0%	0.1%	100.0%
All Provinces	1,647,641	1,410,048	85.6%	52.2%	14.4%	3.5%	29.9%	100.0%

[a] Watershed-scale reserves include areas where legal or administrative protections encompass the entire watershed (VCU)
[b] Sub-watershed scale reserves are areas that include a portion of entire watersheds (VCU) within legal or administratively protected status.
[c] Buffers include stand-level protections under the Alaska State Forest Practices Act as well as TLMP standards for riparian, estuary & beach fringe forests.
[d] Managed lands include USFS timber base as well as all state, private and federal lands lacking explicit legal or administrative protections.

The presence of salmon was estimated by using the ADF&G Fish Distribution Database (FDD). This database is recognized to under represent the total distribution of salmon because of its (1) strict criteria for listing and (2) lack of complete stream surveys. The alternative database is the USFS Stream Inventory, which attributes stream segments by potential for anadromous fish based on channel characteristics (Paustian et al. 1992). The USFS database is sensitive to 2 types of bias: (1) It does not account for stream barriers that limit the actual distribution of salmon; and (2) mapping effort was more intensive in areas where timber sales have occurred. In general, side channels that provide important habitat for salmon tend to be underrepresented both in the USFS and ADF&G data sets. The benefit of the USFS database is that it provides information on fluvial processes, which determine how streams function in the life histories of salmon, as well as the interactions of salmon with other species (for example, availability to bears).

A flood plain model was developed to associate Class I streams (potential anadromous) in the USFS database with occupied streams in the ADF&G database (Fig 10). This model was developed in ArcInfo GRID (an ESRI program) as a function of slope and distance from the stream. Class I streams within this anadromous flood plain are also likely to be used by salmon, and we believe provides a better estimate of total freshwater habitat than the FDD alone. Planning units were evaluated both on the number of species present as well as the estimated amount of habitat available. Moreover, flood plain forests associated with anadromous fish streams represent important riparian (streamside) habitat and provide large woody debris to freshwater systems.

In total, approximately 13,750 mi (22,000 km) of anadromous or potentially anadromous fish habitat were identified in Southeast (Table 11). Coho salmon was the species most widely distributed, followed by pink salmon, chum salmon, steelhead trout, sockeye and finally king salmon (Fig 11). North Prince of Wales Island contained the most anadromous freshwater habitat, followed by Yakutat Forelands, E. Chichagof Is., Kupreanof / Mitkok Islands and the Stikine River mainland. Anadromous habitat in transboundary watersheds outside of Alaska were not accounted for in this analysis. Prince of Wales Island contained more habitat occupied by coho salmon and steelhead trout than other provinces, while Yakutat forelands was notable for the predominance of sockeye salmon. King salmon were most widely distributed in the Yakutat forelands and Stikine River mainland, followed by north Misty Fjords and the Chilkat River. Admiralty Island contains the only populations of island-spawning king salmon in Southeast.

FIG 10. A landscape model was developed to associate off-channel stream habitat in the USFS stream database and flood plain forest lands with the documented presence of anadromous fish in the ADF&G Fish Distribution Database.

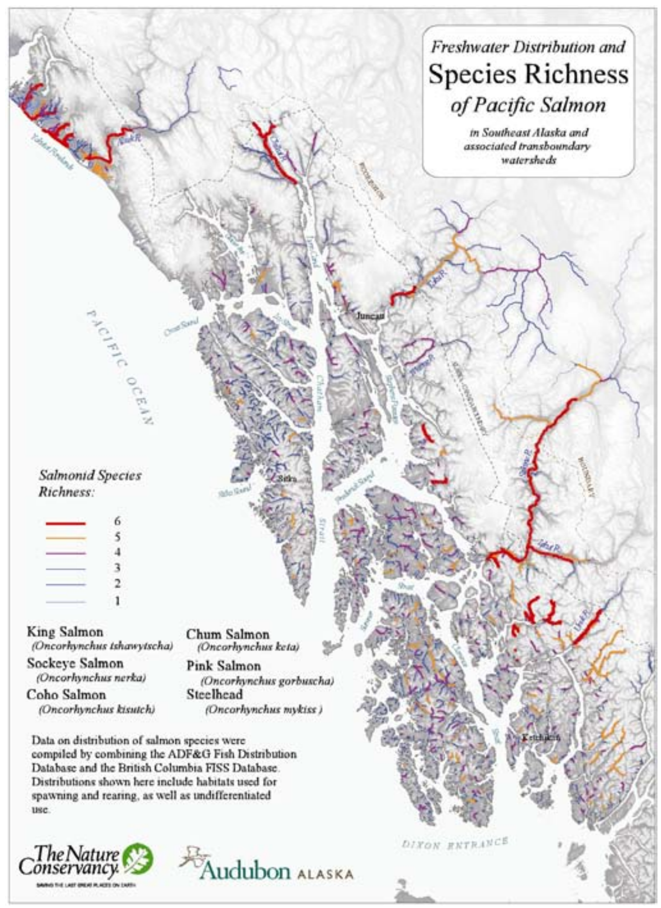

FIG 11. Freshwater distribution and species richness of Pacific salmon and steelhead trout in Southeast Alaska and and transboundary waters of British Columbia.

TABLE 11. Estimated freshwater distribution (miles) of salmon and steelhead trout species among 22 biogeographic provinces in Southeast Alaska.

Province	King salmon	Sockeye salmon	Coho salmon	Pink salmon	Chum salmon	Steelhead trout	All species
North Prince of Wales	0	358.0	1,904.4	1,141.1	739.8	781.9	2,044.2
Yakutat Forelands	516.0	754.1	1,376.3	431.8	340.7	391.7	1,426.4
E. Chichagof Island	0	102.8	938.5	825.1	761.0	78.4	1,078.9
Kupreanof / Mitkof Is.	0	106.1	1,010.2	508.5	418.4	480.3	1,066.5
Stikine River / Mainland	510.9	441.5	868.3	599.4	607.9	524.6	904.7
Revilla Is. / Cleveland Pen.	29.7	114.0	618.0	594.5	330.4	220.7	736.0
Chilkat River Complex	326.1	308.9	637.0	256.7	394.7	223.1	645.6
Admiralty Island	41.9	7.6	440.2	430.1	343.2	105.8	617.1
Kuiu Island	0	40.6	527.0	370.0	306.3	200.5	582.3
North Misty Fjords	400.1	76.5	488.2	427.9	516.9	340.9	571.6
Taku River / Mainland	173.4	294.0	501.6	486.0	436.4	196.1	570.8
W. Baranof Island	0	63.3	515.6	439.6	426.0	54.6	539.2
Lynn Canal / Mainland	0	99.5	443.7	258.1	387.4	99.8	534.9
South Misty Fjords	129.0	55.1	393.9	385.3	337.5	260.1	469.8
Etolin / Zarembo	0.0	21.6	307.8	186.2	120.6	114.9	332.1
Fairweather Icefields	209.2	263.5	264.8	99.5	131.7	115.1	317.1
Glacier Bay	0	110.2	201.1	142.5	192.7	43.4	304.7
South Prince of Wales	0	88.4	206.7	225.6	124.6	54.1	270.4
E. Baranof Island	0	13.4	234.5	198.2	202.0	6.1	237.7
Outside Islands	0	4.0	187.8	152.4	89.2	1.6	219.4
W. Chichagof Island	0	32.3	161.8	142.3	139.5	40.9	176.6
Dall Island Complex	0	23.9	119.5	125.5	76.4	20.3	147.3
Total	2,348.7	3,379.6	12,346.9	8,426.2	7,423.2	4,354.8	13,793.1

The condition and management status of flood plain forests associated with anadromous fish streams were evaluated among 22 biogeographic provinces in Southeast Alaska (Table 12). An estimated 20% of the approximately 500,000 acres of flood plain forests associated with anadromous fish have been logged since 1954. Highest proportion of logging of flood plain forests occurred on Baranof Island, North Prince of Wales, the Chilkat River and East Chichagof Island. Region-wide, approximately 51.7% of anadromous flood plain forests are within non-development designations, with 37.8% in watershed-scale reserves. Provinces with the lowest representation in watershed-scale reserves include the Chilkat River, (0%), North Prince of Wales (8.5%), Kupreanof / Mitkof (16.5%) and Dall Island Complex (18.5%). Provinces with highest levels of watershed-scale protection include Fairweather, Misty Fiords, West Chichagof Island, and Admiralty Island.

Brown bear summer habitat.—Brown bears occur throughout the mainland and northern islands of Southeast north of Frederick Sound. The species was selected as a focal species because of its large-area requirements and varied habitat use as well as its concentrated summer use of anadromous salmon runs and associated flood plain habitats. The brown bear represents an important umbrella species for maintaining ecosystem integrity throughout its range in Southeast and may also be considered a keystone species because of its role in transferring marine nutrients into the terrestrial environment. And because of its vulnerability to cumulative human activities, the brown bear serves as an indicator of wildland values. For more information on brown ecology in Southeast, refer to Chapter 6.2.

TABLE 12. Current condition and management status of flood plain forests associated with anadromous fish among 22 biogeographic provinces in southeastern Alaska.

	Condition of flood plain forests associated with anadromous fish		Management Status						
			Non-development LUDs			Development LUDs			
Province	Productive Forest (acres)	% of flood plain POG cut	Watershed -scale reserves [a]	Sub-watershed reserves [b]	All Non-devp	Buffers [c]	Managed Lands [d]	All Devp	Total
E. Baranof Island	10,653	40.7%	27.5%	9.3%	36.8%	48.6%	14.6%	63.2%	100.0%
North Prince of Wales	93,473	35.0%	8.5%	21.1%	29.6%	24.8%	45.6%	70.4%	100.0%
W. Baranof Island	19,280	32.8%	46.5%	10.3%	56.8%	23.6%	19.6%	43.2%	100.0%
Chilkat River Complex	15,951	30.4%	0.0%	31.7%	31.7%	6.4%	61.8%	68.2%	100.0%
E. Chichagof Island	50,882	24.6%	28.2%	10.2%	38.4%	34.3%	27.2%	61.5%	100.0%
Yakutat Forelands	18,508	20.4%	50.0%	8.5%	58.5%	7.3%	34.2%	41.5%	100.0%
Dall Island Complex	7,003	18.6%	18.5%	20.4%	38.9%	16.9%	44.2%	61.1%	100.0%
Stikine River / Mainland	35,206	18.5%	58.2%	5.8%	64.0%	17.4%	18.6%	36.0%	100.0%
Kuiu Island	25,041	17.4%	36.1%	20.0%	56.1%	21.9%	21.9%	43.8%	100.0%
Taku River / Mainland	23,254	15.0%	41.2%	8.1%	49.3%	14.9%	35.8%	50.7%	100.0%
Kupreanof / Mitkof Is	37,822	14.0%	16.5%	22.9%	39.4%	29.7%	30.8%	60.5%	100.0%
Admiralty Island	31,525	13.4%	84.2%	3.9%	88.1%	2.1%	9.8%	11.9%	100.0%
Revilla Is / Cleveland Pen	27,664	12.6%	29.7%	15.9%	45.6%	24.4%	30.0%	54.4%	100.0%
South Prince of Wales	10,921	12.6%	44.2%	13.4%	57.6%	20.0%	22.4%	42.4%	100.0%
Lynn Canal / Mainland	16,684	11.5%	27.4%	10.5%	37.9%	26.3%	35.8%	62.1%	100.0%
Etolin / Zarembo	12,921	10.9%	20.4%	31.3%	51.7%	25.2%	23.0%	48.2%	100.0%
Outside Islands	9,169	10.1%	51.9%	8.2%	60.1%	17.9%	21.9%	39.8%	100.0%
Fairweather Icefields	4,672	0.0%	99.3%	0.0%	99.3%	0.0%	0.7%	0.7%	100.0%
Glacier Bay	7,856	0.0%	72.8%	12.2%	85.0%	1.8%	13.2%	15.0%	100.0%
North Misty Fiords	12,471	0.0%	91.8%	3.5%	95.3%	3.5%	1.2%	4.7%	100.0%
South Misty Fiords	18,407	0.0%	99.4%	0.0%	99.4%	0.0%	0.6%	0.6%	100.0%
W. Chichagof Island	5,188	0.0%	97.1%	0.0%	97.1%	0.0%	2.9%	2.9%	100.0%
Grand Total	494,553	20.0%	37.8%	13.9%	51.7%	20.2%	28.2%	48.4%	100.0%

[a] Watershed-scale reserves include areas where legal or administrative protections encompass the entire watershed (VCU)
[b] Sub-watershed scale reserves are areas that include a portion of entire watersheds (VCU) within legal or administratively protected status.
[c] Buffers include stand-level protections under the Alaska State Forest Practices Act as well as TLMP standards for riparian, estuary & beach fringe forests.
[d] Managed lands include USFS timber base as well as all state, private and federal lands lacking explicit legal or administrative protections.

To evaluate areas as habitat for brown bear, the habitat capability model, developed by Schoen et al. (1994) and applied in the Tongass Land Management Plan (USFS 1997), was used for this conservation assessment. In March 2005, an interagency expert review workshop (including ADF&G, Audubon, TNC, USFS, and USF&WS) was convened to evaluate the parameters and appropriateness of the model for this application. This model was designed to evaluate habitat capability on a landscape scale based on (1) habitat characteristics and (2) proximity to human activity (Tables 13 and 14). Application of this model provided an index of relative habitat values at a landscape scale, and not prediction of density or population size. Availability of salmon is 1 primary characteristic of high-quality habitat for brown bear in late summer. Vegetation types specified in the model include flood plain forest, beach-fringe forest, upland forest, clearcut or second-growth, subalpine forest, avalanche slopes, alpine tundra, estuary, and other. Flood plain forests were identified by using a landscape model and were further subdivided by presence or absence of anadromous salmon (see description of landscape model of salmon habitat above).

A review of watershed values resulting from the original model revealed that the modified Ivlev's index (1961) was not sensitive to narrowly distributed but biologically important types (such as flood plain forests with salmon). To remedy this, the index value was revised based on a selection ratio: (SR = % used / % available) adjusted to range between 0 and 1 (SRadj = SR / SRmax) (Table 13).

A second modification to the model was related to both the presence of salmon and their availability for use by bears. Salmon presence was estimated by using the landscape model of salmon habitat (described above) based on the ADF&G Fish Distribution Database. Availability was estimated by using channel-type information from USFS streams database within this flood plain zone. Availability relates both the value as spawning habitat and "fishability" by bears for a specific type of channel. Channel types with high salmon availability include flood plain, alluvial fan, and small-to-medium estuaries (Paustian et al. 1992). Channels with low salmon availability include lakes, glacial rivers, palustrine (marsh) channels, contained channels (low to moderate gradient), and large estuarine channels.

TABLE 13. Habitat capability for brown bear habitats during late summer season in Southeast (based on Schoen et al. 1994)

Habitat	Use[a] (%)	Available[b] (%)	Selection[c] ratio	Habitat Capability Index[d]
Upland Forest				
Old Forest	24.5	55	0.45	0.04
Subalpine	5.2	10	0.52	0.05
Clearcut				0.01 [e]
Second Growth				0.00 [e]
Flood plain Forest				
Old Forest (high salmon)[f]	53.6	5	10.72	1.00
Old Forest (low salmon)[g]				0.70 [e]
Old Forest (not present)				0.40 [e]
Cut Forest (high salmon) [f]				0.30 [e]
Cut Forest (low salmon)[g]				0.20 [e]
Cut Forest (not present)				0.10 [e]
Other Forest				
Beach Fringe Forest	2	3	0.67	0.06
Estuary Fringe Forest				0.08 [e]
Non-Forest				
Avalanche Slope	5.5	5	1.10	0.10
Alpine	2.8	10	0.28	0.03
Estuary	5.3	2	2.65	0.25
Other	1.1	10	0.11	0.01

[a] Habitat use by radio-collared brown bears on Admiralty Island (n = 1,285 relocations)
[b] Availability of habitats on Admiralty Island study site
[c] Selection ratio: SR = (% Use / % Availability)
[d] Selection ratio scaled from 0 – 1 (HCI = SR_i / SR_{max})
[e] Index based on best professional judgment
[f] Stream types (fluvial process groups) with high salmon availability of salmon include flood plain, alluvial fan, and small-to-medium estuaries
[g] Streams with low salmon availability include glacial rivers, palustrine channels, contained (low and medium gradient), medium-gradient mixed containment, and large estuaries

TABLE 14. Reductions in brown bear habitat capability within zones of human activity in Southeast (Schoen et al. 1994)

Human Activity	Habitat reduction factor within zone of influence <1 mi (1.6 km)	 1- 5 mi (1.6–8.0 km)
Human Communities		
>1,000	0.0	0.3
501–1,000	0.0	0.5
10–500	0.3	0.6
<10	0.5	0.8
Roads connected to towns	0.4	0.7
Roads not connected to towns	0.6	0.9

Black bear (*Ursus americanus*) summer habitat.— Black bears occur throughout much of the mainland and southern islands of the Alexander Archipelago south of Frederick Sound. This species was selected as a focal species because of its large-area requirements and varied habitat use as well as its concentrated summer use of anadromous salmon runs and associated flood plain habitats. The black bear represents an important umbrella species for maintaining ecosystem integrity throughout its range in Southeast and may also be considered a keystone species because of its role in transferring marine nutrients into the terrestrial environment. For more information on black bear ecology in Southeast, refer to Chapter 6.3.

An interagency group of experts (representing ADF&G, USFS, USF&WS, Audubon, and TNC) reviewed the revised habitat capability model for brown bear described above and concluded that, in the absence of empirical data on black bear habitat relationships, the brown bear model provided a reasonable representation of summer habitat capability for black bear throughout its range in Southeast.

The current condition and management status of black and brown bear summer habitat capability were evaluated among 22 biogeographic provinces in Southeast (Table 15). Admiralty and East Chichagof provinces in northern Southeast originally contained the most abundant island habitat for brown bear in the region. The most abundant black bear habitat occurred on the southern island provinces of North Prince of Wales and Kupreanof / Mitkof. The most abundant mainland habitat for both species occurred in the Yakutat Forelands, Stikine River, and Taku River provinces. An estimated 26% of the original habitat has been impacted by development activity throughout all provinces in Southeast. The provinces with the greatest impacts on brown bear habitat were East Chichagof and East Baranof which retained 66% and 70% of their original habitat value, respectively. The provinces with the greatest impacts to black bear habitat were North Prince of Wales, Etolin /Zarembo Complex, Kupreanof /Mitkof, and Kuiu, which retained 48%, 65%, 67%, and 70% of their original habitat value, respectively. The Chilkat / Skagway rivers and Yakutat Forelands provinces are occupied by both black and brown bears and retained 60% and 72% of their original habitat values, respectively. Region-wide, 57% of bear habitat is protected in watershed-scale reserves. However, only 1% of the Chilkat Province and 15% of the North Prince of Wales Province is protected in watershed reserves. Other provinces with watershed-scale reserves representing less than 50% of the area include Kupreanof / Mitkof, Dall Island, Etolin / Zarembo, East Chichagof, and Revilla / Cleveland. Three provinces have more than 50% of bear habitat in development lands. These include the black bear provinces of Kupreanof / Mitkof (60%) and North Prince of Wales (57%) and the brown bear province of East Chichigof (51%). These 3 provinces have already lost a third to a half of their bear habitat values. The most productive brown bear provinces with the highest level of habitat protection include West Chichagof, Admiralty Island, West Baranof, and the Yakutat Forelands. The most secure black bear habitats in the southern islands include the Outside Islands, South Prince of Wales, and Kuiu Island. Throughout Southeast in general, habitat conservation measures are more robust for brown bears than black bears.

Estuaries.— Estuaries are among the most important coastal features, from the perspective of both resource conservation and resource development. Where freshwater meets saltwater a nutrient-rich environment supports large assemblages of marine and anadromous fish, invertebrates, migratory and resident birds, plants, and both terrestrial and marine mammals. Estuaries were selected as a focal resource because they serve as umbrellas for many species and species groups. These areas are also landscape features of substantial functional and structural complexity. Many

TABLE 15. Current condition and management status of brown and black bear habitat among 22 biogeographic provinces in Southeast Alaska.

	Habitat Capability Index		Current Condition	Management Status and Scale[a] (% of current habitat value)			
Province	Original (1954)	Current (2002)	% of original habitat value	Watershed reserves	Sub-watershed reserves	Development lands	Total
Yakutat Forelands	110,353	79,839	72%	75%	10%	15%	100%
Fairweather Range	31,363	29,134	93%	98%	0%	2%	100%
Glacier Bay	48,069	41,991	87%	87%	8%	5%	100%
Chilkat R. / Skagway R.	58,510	34,899	60%	1%	29%	70%	100%
Lynn Canal / Mainland	69,030	53,151	77%	58%	13%	29%	100%
Taku River / Mainland	96,393	81,530	85%	55%	11%	34%	100%
Stikine River / Mainland	105,983	92,320	87%	60%	10%	30%	100%
North Misty Fjords	77,659	74,094	95%	97%	1%	1%	100%
South Misty Fjords	90,685	87,677	97%	99%	0%	1%	100%
Admiralty Island	147,459	131,393	89%	90%	5%	5%	100%
E. Chichagof Island	157,022	103,236	66%	38%	11%	51%	100%
W. Chichagof Island	27,644	26,633	96%	96%	0%	4%	100%
E. Baranof Island	38,061	26,757	70%	52%	15%	33%	100%
W. Baranof Island	84,908	63,374	75%	73%	10%	17%	100%
Kuiu Island	80,061	56,031	70%	53%	12%	35%	100%
Kupreanof / Mitkof Islands	155,039	103,147	67%	17%	23%	60%	100%
Etolin / Zarembo Island Complex	68,920	45,018	65%	31%	22%	48%	100%
Revilla Island / Cleveland Peninsula	158,948	116,087	73%	45%	13%	42%	100%
North Prince of Wales Complex	291,486	138,822	48%	15%	28%	57%	100%
South Prince of Wales Island	48,179	41,339	86%	55%	11%	33%	100%
Outside Islands	32,774	25,416	78%	73%	7%	20%	100%
Dall Island Complex	24,830	21,033	85%	26%	27%	47%	100%
All Provinces	2,003,377	1,472,922	74%	57%	12%	31%	100%

[a] Landscape-scale conservation includes protection of entire watersheds (VCU), while reserves include all sub-watershed units. Matrix lands include private lands as well as the Tongass NF development land base that are available for timber harvest with stand-level protection according to the Alaska Forest Practices Act and TLMP standards for riparian buffers, beach fringe, eagle nests, etc.

estuaries and flood plains are small, because most watersheds are small and primarily rain-fed, but large estuaries fed by rivers, rain, glaciers, and permanent snow are common. Estuary occurrence data was derived from the intertidal emergent vegetation class (E2EM, M2EM) from the USF&W National Wetlands Inventory (NWI) data and supplemented by a supervised classification of Landsat ETM imagery for areas where NWI data were unavailable.

The Alexander Archipelago ranks among the largest and most complex estuarine systems on Earth, having a total water area of 11,861 mi^2 (30,721 km^2), a length greater than 344 mi (550 km), a width greater than 94 mi (150km), and an average depth of 502 ft (153 m). The entire archipelago represents a single estuarine complex, being a semi-enclosed by land and influenced by freshwater. Based on extrapolation of data from 141 flow stations in the region, we estimate that the total freshwater flow is approximately 900,524 ft^3/sec (25,500 m^3/sec). Indeed, a large number of estuaries occur at intermediate scales such as the complex fiord systems of Glacier Bay, as well as a very large number of individual estuarine streams that flow into salt water (Paustian et al. 1992). We developed a preliminary estuarine database in which each unit represents the point of intersection between a stream system and the salt water. Based on this definition, approximately 12,000 estuaries exist in Southeast. By imposing a minimum basin size of 100 ha, this number is reduced to 2,944 (Fig 12).

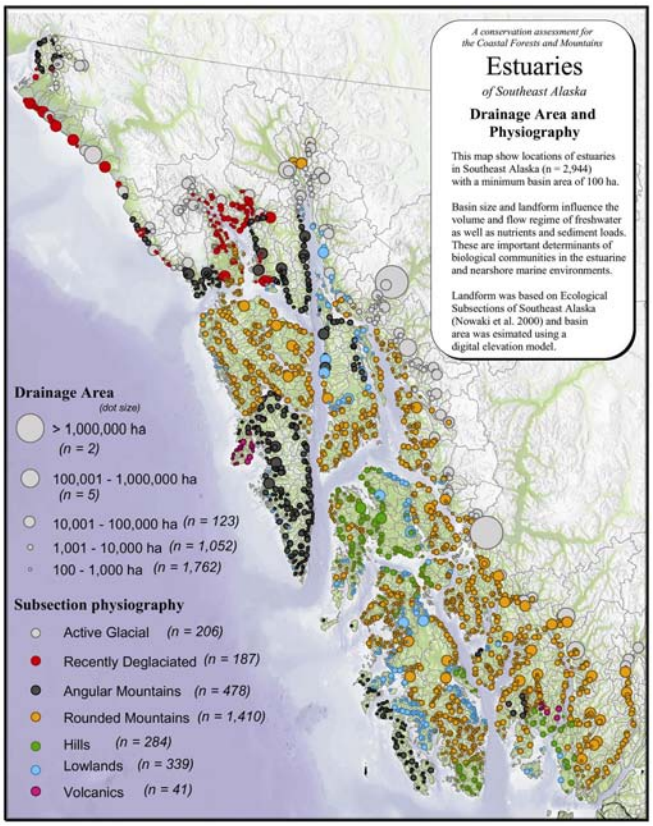

FIG 12. Estuaries of southeastern Alaska characterized by drainage area and watershed physiography

The top 100 estuaries in Southeast ranked by salt marsh habitat are listed in Table 16. The Stikine River Delta is by far the largest estuary in Southeast at 2,9180 acres (1,181 ha). Only 3 estuaries in Southeast have salt marsh habitats exceeding 1,000 acres (405 ha). Nine of the top 10 estuaries are mainland estuaries. The only island estuary system ranking in the top 10 is the Rocky Pass Complex (between Kupreanof and Kuiu islands) which ranks 7th in Southeast. Other important island estuaries ranking in the top 20 include (in descending order) Gambier Bay on Admiralty, Neka Bay on East Chichagof, Beardslee Islands in Glacier Bay, Castle River on Kupreanof, Kadashan River and Upper Tenakee on East Chichagof, Blind Slough on Mitkof, Upper Hoonah Sound on East Chichagof, and Pybus Bay on Admiralty. For ecological descriptions of Southeast estuaries refer to Chapter 5 of this report.

The distribution and management jurisdiction of salt marsh estuaries among Southeast's 22 biogeographic provinces is presented in Table 17. An estimated 42,740 acres (17,297 ha) of salt marsh estuaries occur in Southeast. The top 6 provinces for abundance of salt marsh estuaries (in descending order) are East Chichagof, Stikine River mainland, Kupreanof / Mitkof, Taku River mainland, Yakutat Forelands, and Admiralty. The State of Alaska has jurisdiction over 60% of Southeast's estuaries while the U.S. Forest Service manages 30%. The National Park Service manages a significant portion of estuaries in only 3 provinces: Glacier Bay, Fairweather Icefields, and Chilkat River Complex. Private ownership accounts for 9% of Southeast's salt marsh estuaries scattered through the region with the largest holdings in the Lynn Canal mainland and Dall Island Complex. Most of Southeast's estuaries are still largely intact but local habitat impacts have occurred around major communities (e.g., the Mendenhall Wetlands in Juneau).

TABLE 16. Top 100 estuaries in southeastern Alaska ranked by area of salt marsh habitat (acres)

Rank	Name	Salt Marsh (acres)	Rank	Name	Salt Marsh (acres)
1	Stikine River Delta	2,918	51	Chaik Bay	178
2	Mendenhall Wetlands	1,490	52	Ferbee River	168
3	Ahrnklin River	1,483	53	Gilbert Bay	168
4	Bradfield River	912	54	Humpback	165
5	Situk River	880	55	Seal Bay	163
6	Gustavus Forelands	857	56	Kah Sheets Bay	161
7	Rocky Pass Complex	793	57	Dry Bay (south)	158
8	Farragut Bay	743	58	Carroll Inlet	156
9	Dry Bay	724	59	Barnes Lake	151
10	Taku River	716	60	Hidden Inlet	151
11	Gambier Bay	677	61	Klawock Inlet	151
12	Neka Bay	620	62	Long Bay	151
13	Beardslee Islands	563	63	Saginaw Bay	148
14	Castle River	529	64	Big Salt Lake	148
15	Kadashan Bay	501	65	Sitkoh Bay	148
16	Upper Tenakee Inlet	489	66	Windham Bay	147
17	Blind Slough	484	67	Beecher Pass	147
18	Upper Hoonah Sound	432	68	Point Agassiz	143
19	Pybus Bay	422	69	Unuk River	143
20	Aaron Creek	405	70	Kadake Bay	142
21	Big John Bay	405	71	Dyea River	141
22	Grand Wash	380	72	Speel River	140
23	Gartina / Game Creek	358	73	Port Camden	140
24	Berners Bay	351	74	Gallagher Creek	138
25	Excursion River	329	75	Sandborn Canal	135
26	St. James Bay	316	76	Shinaku Inlet	131
27	Port Houghton	289	77	Fish Bay	130
28	Salmon Bay	262	78	Appleton Cove	126
29	Spasski Bay	262	79	Endicott Arm	126
30	Security Bay	249	80	Saltery Bay	125
31	Crab Bay	247	81	Point Couverden	119
32	Bartlett Cove	246	82	Exchange Cove	119
33	Chikaman River	240	83	Eagle River	116
34	Nakwasina Sound	232	84	Crab Bay	116
35	Petersburg Creek	231	85	Patterson Bay	116
36	Duncan Canal - North	225	86	Thorne Bay	114
37	Echo Cove	215	87	Holkham Bay	111
38	Adams Inlet	214	88	Ushk Bay	110
39	Hobart Bay	210	89	Whale Passage	109
40	Mud Bay	209	90	Marten Arm	108
41	Hamilton Bay	209	91	Chicken Creek	104
42	Davidson Glacier River	203	92	Seclusion Harbor	103
43	Akwe River	200	93	Admiralty Cove	101
44	Totem Bay	199	94	Slocum Inlet	99
45	Doame River	195	95	Khantaak Island	96
46	Portland Canal	193	96	Coffman Cove	96
47	Hood Bay	193	97	Dry Bay	95
48	Dangerous River	188	98	Chilkat River	95
49	Mitchell Bay	185	99	Twelvemile	94
50	Rowan Bay	179	100	Staney Creek	91

TABLE 17. Distribution and management jurisdiction of estuarine and marine emergent vegetation (salt marsh) habitat among 22 biogeographic provinces in Southeast Alaska.

	Estuaries[a]	Land Management / Ownership			
Biogeographic Province	Salt marsh (acres)	Tongass Natl. Forest (%)	National Park Service (%)	State of Alaska (%)	Private / Other (%)
E. Chichagof Island	6,808	18.5%	0.0%	71.8%	9.7%
Stikine River / Mainland	5,666	43.0%	0.0%	47.5%	9.5%
Kupreanof / Mitkof Is.	4,159	36.9%	0.0%	55.1%	7.9%
Taku River / Mainland	3,581	20.8%	0.0%	71.1%	8.2%
Yakutat Forelands	3,449	78.8%	0.0%	17.5%	3.7%
Admiralty Island	2,940	16.7%	0.0%	82.3%	0.9%
North Prince of Wales	2,745	10.9%	0.0%	77.0%	12.1%
Glacier Bay	2,328	0.0%	60.0%	27.2%	12.8%
Lynn Canal / Mainland	2,235	18.2%	0.0%	49.4%	32.5%
Kuiu Island	1,625	35.6%	0.0%	63.8%	0.6%
Revilla Is. / Cleveland Pen.	1,193	19.7%	0.0%	68.9%	11.4%
W. Baranof Island	1,058	50.2%	0.0%	43.4%	6.4%
South Misty Fjords	785	35.4%	0.0%	64.3%	0.3%
Etolin / Zarembo Is.	713	32.4%	0.0%	56.4%	11.2%
E. Baranof Island	702	32.2%	0.0%	67.7%	0.1%
North Misty Fjords	673	62.1%	0.0%	37.9%	0.0%
Chilkat River Complex	645	0.0%	16.6%	83.4%	0.0%
Fairweather Icefields	624	9.6%	51.4%	39.0%	0.0%
W. Chichagof Island	495	31.5%	0.0%	68.5%	0.0%
South Prince of Wales	162	36.4%	0.0%	57.5%	6.1%
Outside Islands	82	40.6%	0.0%	59.4%	0.0%
Dall Island Complex	72	17.6%	0.0%	46.8%	35.6%
Totals	42,740	29.7%	1.9%	59.8%	8.6%

[a] For the purpose of this analysis, estuaries were defined using the National Wetlands Inventory intertidal emergent vegetation (E2EM, M2EM) supplemented by a supervised classification of Landsat imagery for areas lacking NWI coverage.

Conservation of functional landscapes.—Southeastern Alaska is one of the few regions of the world where temperate rainforests still include fully functional landscapes including pristine watersheds, productive salmon runs and the full compliment of top predators. A simple comparison of watersheds with >95% of productive forest lands intact within watershed-scale conservation areas quickly reveals that much (71%) of the land base of Southeast still exists in intact watersheds (Fig 13). However, most (65%) of these lands occur on the rugged mainland coast and Glacier Bay. Morever, much (57%) of the original distribution of the most productive timber land (medium- and large-tree old growth) in Southeast exists in development LUDs or sub-watershed reserves. Admiralty Island is an exception to this generality as much of the island has been designated by Congress as Wilderness. Many of the protected intact watersheds on other islands have a relatively low amount of large-tree forest (e.g., west Chichagof, south Baranof, south Kuiu) (Table 6). Large intact areas within the development landscape include Windham Bay, Port Houghton / Farragut Bay, Tenakee Inlet, central Kupreanof Island, Cleveland Peninsula, Gravina Island, Cholmondeley Sound, East Kuiu Island, and Poison Cove / Ushk Bay among others. These areas provide unique opportunities for conserving rare, intact watersheds with high ecological values, including large-tree stands.

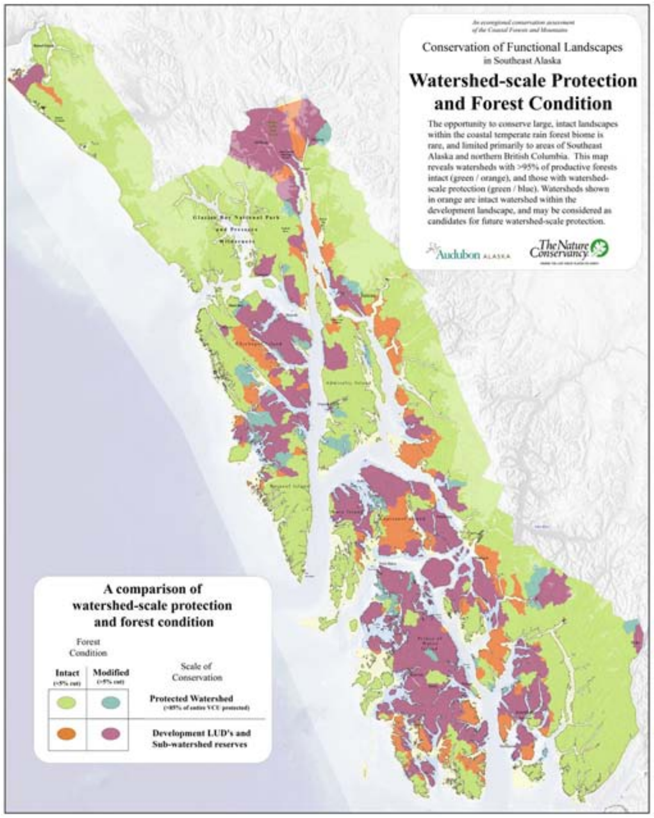

FIG 13. A comparison of watershed condition and protected status identifies opportunities for conserving intact watersheds with high ecological values.

RANKING RESOURCE VALUES

One of the major objectives of this conservation assessment was to develop a science-based process for ranking the ecological values of watersheds within biogeographic provinces distributed across Southeast and the Tongass. The ability to assess and rank ecological values will provide resource managers and conservationists a useful tool for setting conservation priorities and evaluating and refining reserve networks throughout Southeast.

Methods

Marxan optimization tool.—The Marxan spatial optimization tool (Possingham et al. 2000) was used in this conservation assessment to identify and rank areas of ecological and other values throughout Southeast. Marxan is a spatial optimization tool for developing and evaluating reserve networks based on explicit conservation goals. The utility of Marxan is to identify a set of areas that most efficiently meet specified goals for representation of conservation targets. Ecological rankings were based on the areas of highest concentration of habitat values for the suite of focal species and ecological systems selected with the minimum total area and maximum connectivity. Many conservation efforts have been based on manual mapping, simple overlay, and expert opinion to identify priority areas. As GIS-based tools and data have become more sophisticated and integrated into planning efforts, a greater level transparency and objectivity in site selection is possible. The optimization tools described here allow conservation planners to base evaluation of alternatives on explicit and quantitative criteria over a wider range of ecological and other values than previously available.

The Marxan software utilizes an algorithm called "simulated annealing with iterative improvement" as a method for efficiently selecting regionally representative sets of areas for conservation of biological diversity (Pressey et al. 1994, Csuti et al. 1997, Possingham et al. 2000). Simulated annealing is basically a complex computer search for an optimal solution. In order to identify these areas, Marxan examines each individual planning unit for the values it contains, including biodiversity elements as well as potential suitability factors. It then selects a collection of units to meet the conservation goals that have been assigned. The algorithm attempts to minimize portfolio "cost" while maximizing attainment of conservation goals in a compact set of sites. This set of objectives constitutes the "Objective Cost function:"

Total Portfolio Cost = (cost of selected sites) + (penalty cost for not meeting the stated conservation goals for each element) + (cost of spatial dispersion of the selected sites as measured by the total boundary length of the portfolio). More formally:

$$\textit{Total Cost} = \sum_i \textit{Cost site } i \ + \ \sum_j \textit{Penalty cost for element } j \ + \ w_b \sum \textit{boundary length}$$

Marxan arrives at a solution by randomly altering the set of units selected and evaluating the outcome. When sites are dropped from or added to a solution set, the total cost may increase (i.e., the solution worsens) or decrease (i.e., the solution improves). At first, increases in cost are tolerated because the solution set at this point is likely to be inferior. This ensures that a wide number of alternatives are considered. The rate at which the cost increase that is acceptable diminishes is known as the annealing schedule. As the program progresses and the solution improves, smaller and smaller cost increases are accepted until finally only changes in the portfolio that actually reduce cost are accepted. If enough runs are undertaken, a subset of superior solutions can be created.

In this conservation assessment, we programmed Marxan to perform 10 million iterative attempts to find the minimum cost solution per simulated annealing run and perform 10 such runs for each alternative conservation scenario we explored. Alternative scenarios were defined by varying the representation goals and boundary modifiers, and applying suitability factors based on influence of human activities (i.e., roads and logging) in each planning unit.

Varying the inputs to Marxan in order to assess the outcome, in terms of the planning units selected, allows portfolio design to be evaluated based on expert opinion, while quantifying the effects of such subjective decisions. An area consistently identified as part of the optimal solution under a range of scenarios is a robust solution that may be considered to have high biological value for the combined set of focal species and ecological systems, and is a useful element for the design of a regional conservation network (Pressey et al. 1994, Leslie et al. 2003).

Planning Units.—Two types of planning units were selected for these analyses. Watersheds represent an ecologically-based unit with functional cohesiveness (at least for some systems) and are relatively easily mapped. Secondly, watersheds correlate well with an existing inventory system called Value Comparison Units (VCU) used by the Tongass National Forest. Value Comparison Units are watershed-based units that have the additional advantage of encompassing estuaries and adjacent marine habitats associated with terrestrial drainage systems. In most cases, the VCU contains a cluster of coastal drainages for a single bay or small island. In rare cases, watersheds had been divided among several VCU along management or ownership boundaries. In addition, we used consistent criteria to delineate VCUs for the rest of Southeast, including Glacier Bay National Park and lands near Haines and Skagway.

Although watersheds are useful for landscape-scale comparisons of some ecological systems (e.g., salmon), they are less suitable for description of others (e.g., winter habitat for deer). Moreover, direct comparison among watersheds is confounded by differences in basin size. Thus, we developed a secondary planning unit based on hexagons of 247 acres (100 ha) in size. These units are of consistent size and shape and are a better representation of ecological processes at a sub-watershed scale.

Boundary Length Modifiers.—It is generally desirable for reserves in a portfolio to be both compact and comprised of adjacent planning units. For a conservation portfolio of a given size, the shorter the total boundary around selected planning units, the more compact the portfolio. We applied a range of Boundary Length Modifiers to arrive at a result that will be sensitive both to the patchy distribution of core habitat values while also identifying clusters of core areas within a biogeographic province. Thus, the sum of these solutions reflects both core habitat areas and corridors of connectivity. The boundary length modifier was not applied to scenarios based on watershed-scale planning units.

Repeat Runs.— For each scenario, defined by a representation goal, boundary length modifier and suitability factors, Marxan developed a set of runs (n = 10, each comprised of 10 million comparisons) to estimate an optimal portfolio. The score for each planning unit is the sum of runs in which it was selected as part of the most efficient solution.

Core Areas of Biological Value—A key concept in conservation planning is irreplaceability (Pressey et al. 1994, Margules and Pressey 2000, Pressey and Cowling 2001). Irreplaceability provides a quantitative measure of the relative contribution different areas make toward reaching conservation goals, thus helping planners choose among alternative sites. As noted by Pressey (1998), irreplaceability can be defined in 2 ways: 1) the likelihood that a particular area is needed to achieve an explicit conservation goal; or 2) the extent to which the options for achieving an explicit conservation goal are narrowed if an area is not conserved. Given the constraints under which the site selection algorithms operate, we can expect that summed solutions will describe a range of important conservation criteria including rarity, richness, diversity and complementarity. These criteria are optimized through the selection of a minimum set of planning units to meet goals for our conservation targets. The frequency with which planning units were selected as part of the best (i.e., most efficient) solution over a range of scenarios provides an index to the relative value of that site toward meeting conservation goals. When specifically applied to achieving goals for the range of focal species selected in this analysis (i.e., salmon, deer, bear, murrelet, estuary, large-tree forest) these areas were considered as “core areas” of ecological value.

Ranking of Watershed Ecological Values.— Marxan optimization scenarios based on watershed-scale planning units were applied to evaluate the relative contribution of watersheds in meeting representation goals. A range of scenarios (n = 5) were developed with representation goals set at 20%, 40%, 50%, 60% and 80% of existing habitat values within each biogeographic province. One series of scenarios were developed with the application of a suitability "cost factor" based on existing roads within each watershed (roadless scenario), while another series was developed without this constraint (unconstrained scenario). Top ranking watersheds within each series were considered as high-value watersheds and represent a range of conservation opportunities for intact and modified landscapes, respectively.

Spatial Optimization of Timber Supply.— While Marxan was originally developed as a tool for design of representative reserves for conservation of biodiversity, it can also be applied to evaluate an optimal design for production of timber. In this case, we sought to meet goals based on available timber volume within a set of constraints (cost function) including both economic factors that affect suitability of areas for production of commercial timber, as well as biodiversity values. Economic factors included operability type, distance to roads, and means of transport to the nearest mill. Biodiversity factors were represented by watershed rankings and core areas of biological value. Within this framework, a series of Marxan analyses were conducted to identify areas that provide a sufficient supply of timber in the minimum total area, with proximity to existing infrastructure and minimum overlap with core areas of biological value. The optimal solutions over a range of demand scenarios were combined as an index of relative suitability for timber production under economic and biodiversity constraints.

Integrated Conservation Area Design.—The ecological rankings of watershed values, core areas of biological value within watersheds, and the index of suitability for timber production were combined into a spectrum of conservation opportunities based on ecological value, habitat condition, and economic opportunity. The watershed context provided the primary, landscape-scale characterization, while "core areas" represent the highest concentrations of intact ecological values within watersheds. The relative index of timber suitability illustrates areas of commercial forest in proximity to existing infrastructure, and represents our estimate of the best opportunities for a sustainable timber industry within the constraints established based on well-distributed conservation of focal species and ecological systems.

Results

Conservation Analysis.—Core areas of ecological values were determined through Marxan analyses and mapped for large-tree old growth, black-tailed deer winter habitat, marbled murrelet nesting habitat, and brown and black bear summer habitat (Figs 14, 15, 16). These areas were reviewed by selected species experts from Southeast. In addition, aerial surveys were conducted by J. Schoen, D. Albert, and R. Carstensen during the summer of 2005 in a sample of watersheds to evaluate the relative reliability of core area maps and the large-tree map. The professional consensus from both reviews was that the Marxan maps represented a reasonable estimate of the core habitat values within

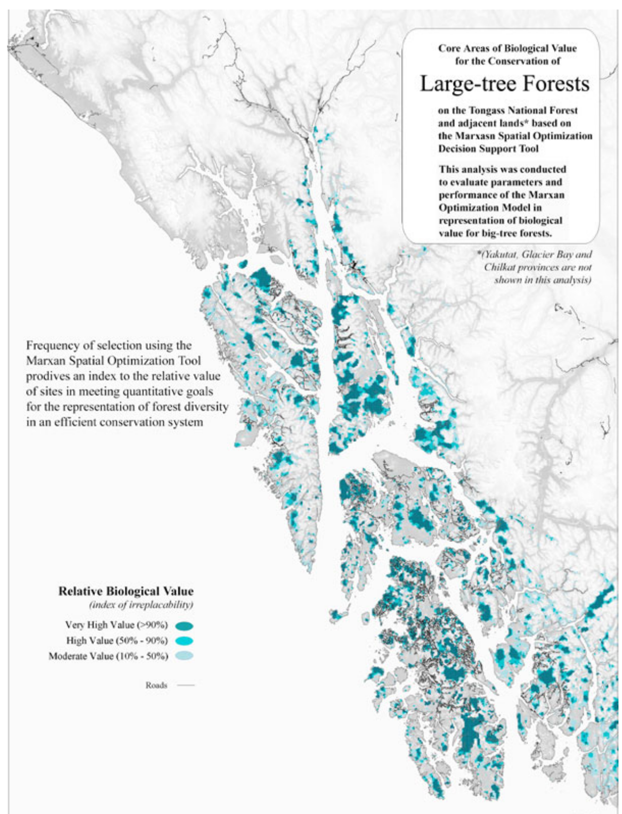

FIG 14. The Marxan Spatial Optimization Tool was used to identify areas providing high value for conservation of large-tree forests within each biogeographic province.

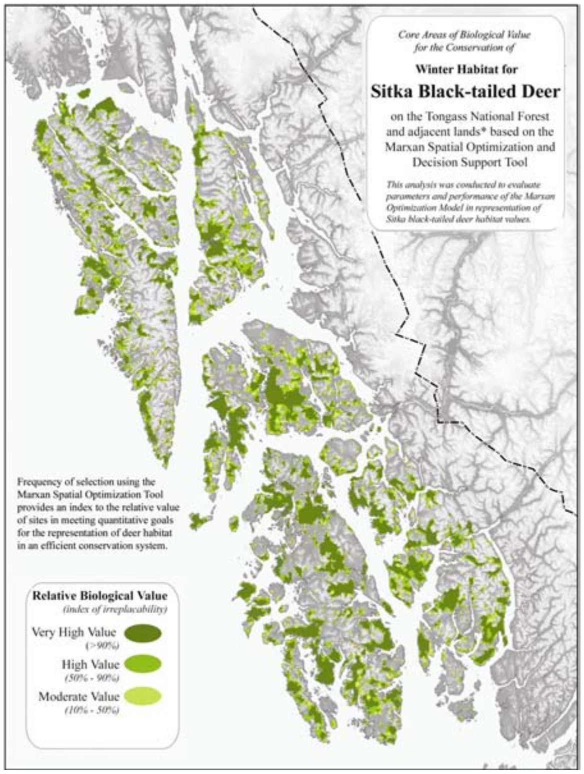

FIG 15. The Marxan Spatial Optimization Tool was used to identify areas with high value for conservation of winter habitat for Sitka black-tailed deer within each biogeographic province.

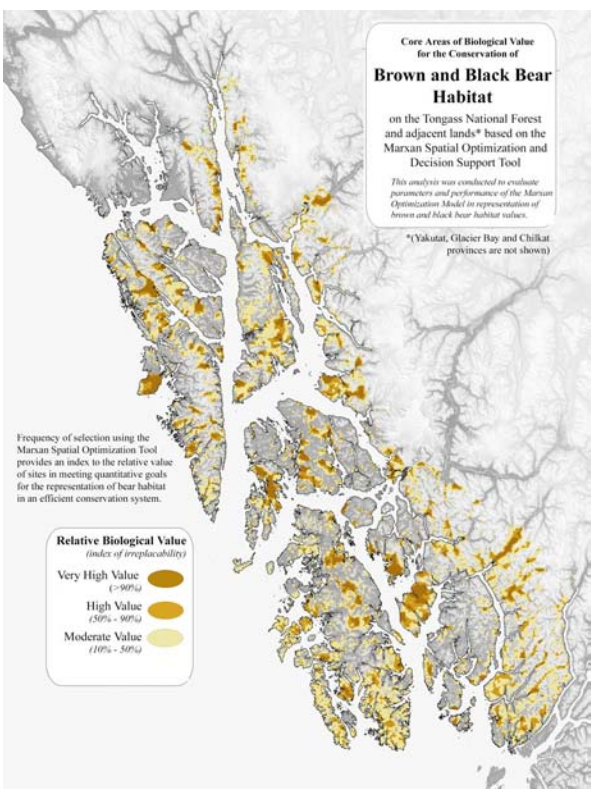

FIG 16. The Marxan Spatial Optimization Tool was used to identify areas with high value for conservation of summer habitat for brown and black bear within each biogeographic province.

watersheds and biological provinces. The productivity and diversity of watersheds for Pacific salmon and steelhead were also evaluated and mapped by Marxan analysis (Fig 17). This analysis was conducted at the watershed scale and considered both the amount of habitat and the relative rarity of species. It is important to recognize that the Marxan maps reflect the species' habitat models and large-tree distribution maps described earlier. The Marxan analysis simply identifies the most concentrated distribution of those habitat values across the landscape. This information will allow managers and conservationists to focus conservation efforts on the most important core areas of ecological value.

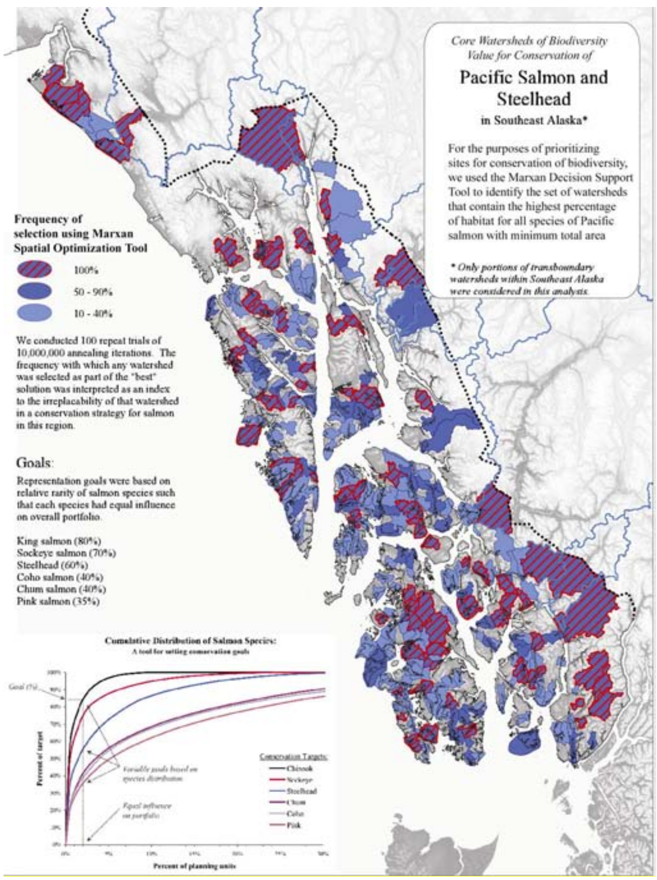

FIG 17. The Marxan Spatial Optimization Tool was used to identify watersheds with high value for the conservation of Pacific salmon and steelhead in southeastern Alaska.

Once we were satisfied that the habitat models and Marxan analyses were providing reasonable results for individual focal species and ecological systems, we conducted Marxan runs for all focal species and ecological systems combined (Fig 18). This analysis identified core areas of ecological values within each

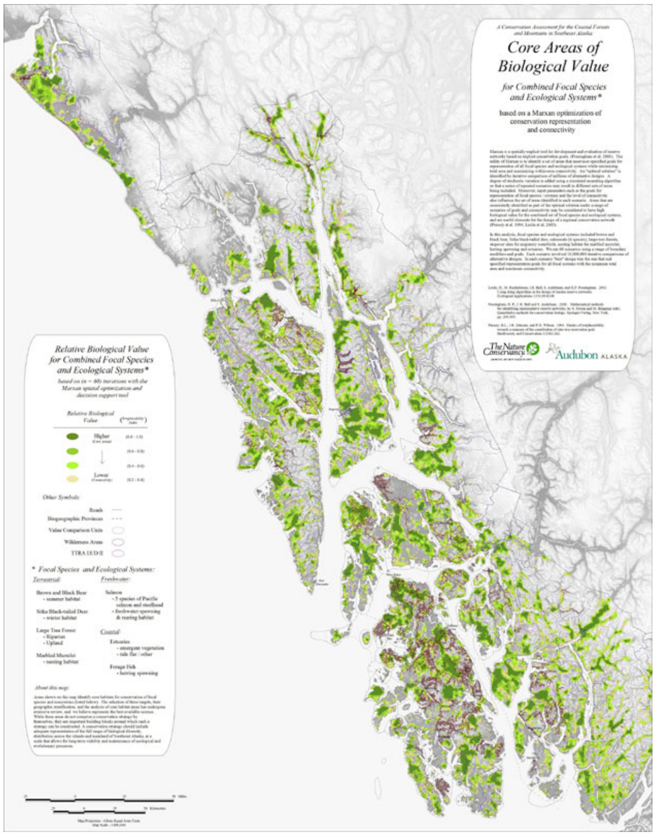

FIG 18. The Marxan Spatial Optimization Tool was used to identify core areas of biological value for conservation of focal species and ecological systems in each of 22 biogeographic provinces throughout southeastern Alaska.

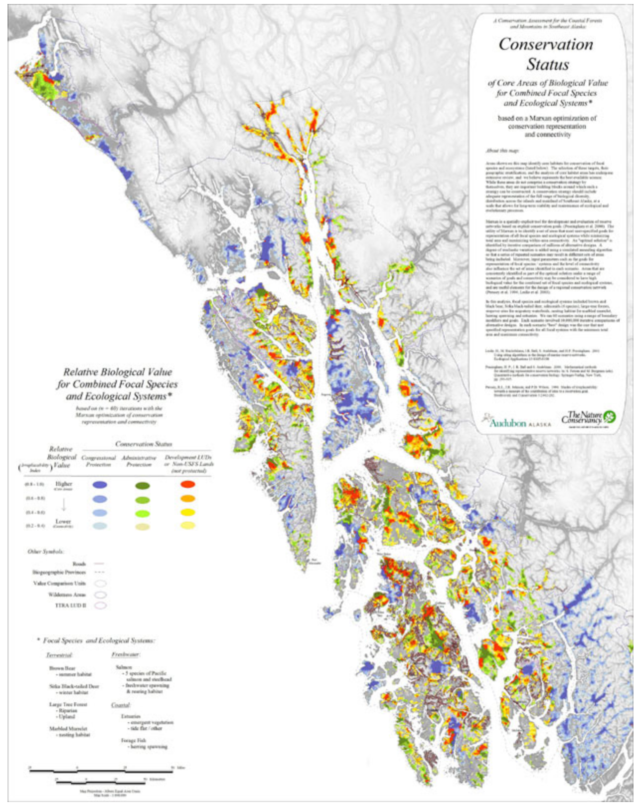

FIG 19. Conservation status of core areas of ecological values for combined focal species and ecological systems in southeastern Alaska.

biogeographic province throughout Southeast. The dark green areas of the map represent the top 20% of ecological values within each province while the lighter green represent the second 20% of ecological value. These core areas should be given high conservation priority in land management planning as they represent the optimal selection of sites that reflect the combination of freshwater salmon habitat, black and brown bear summer habitat, winter deer habitat, murrelet nesting habitat, distribution of large-tree old growth stands, and estuarine habitats within each province. Areas of lightest green and tan have lower habitat values than the core areas and might be considered important ecological linkages where they connect several dark green core habitats. This analysis of core areas will likely be most useful for land planning at the sub-watershed scale in identifying and evaluating the effectiveness and overlap of habitat conservation areas and old-growth reserves relative to core ecological values within watersheds.

An examination of current conservation status illustrates a high level of risk for many core areas of ecological value (Fig 19). This is essentially the same map of core ecological values (Fig 18) but the areas are color coded by degree of protection, including congressionally protected lands in shades of blue, administratively protected lands (under the 1997 Tongass Land Management Plan) in shades of green, and lands open for logging and other developments (including private and other lands) in shades of red and yellow. In each case, the darker shades indicate higher levels of ecological value. This map clearly identifies lands with high ecological values that have long-term conservation security (Congressionally protected) versus those core areas that have shorter-term administrative protections and those that are at highest risk in developed LUDs.

The fundamental conservation strategy of the 1997 Tongass Land Management Plan is based on identifying and protecting various sized habitat patches and habitat complexes (e.g., old growth reserves, riparian buffers, beach fringe buffers, and large, medium, and small habitat conservation areas [HCAs]) within watersheds (VCUs) as well as establishing forest-wide standards and guidelines for the protection of various resources. Protection of riparian buffers and large and medium HCAs, in particular, adds substantial value to the Tongass conservation strategy. In addition, designated wilderness areas and LUD II areas (established under the ANILCA and TTRA) also enhance conservation at the watershed scale. However, some important habitat types (e.g., large-tree old growth) are not adequately represented in conservation areas across the Tongass National Forest (including the 5.8 million acres [2.3 million ha] of Wilderness areas, refer to Chapter 3).

Although protecting habitat patches within watersheds has conservation value, substantial and different conservation benefits also accrue from protecting intact watersheds (Stanford and Ward 1992; Naiman et al. 1997, 2000; Pringle 2001; Baron et al. 2002). In order to identify conservation priorities at the watershed scale, we also conducted Marxan analyses at that scale within each biogeographic province. A series of scenarios was developed (n=50) to examine alternative conservation strategies across a range of goals for representation of focal species and ecological systems (range = 20%-80% of current distribution). A suitability cost for cumulative miles (km) of roads within watersheds as well as a base cost proportional to the total land area was included. This reduced the value of watersheds highly fragmented by logging and roads and also reduced the value of very small watersheds. Over these iterations, the frequency with which any watershed was identified by Marxan as part of the "best" solution, was considered an index to the relative value of that watershed as part of an efficient and representative conservation system within a province. Marxan analyses were completed to rank watershed values for conservation of focal species and ecological systems within biogeographic provinces throughout Southeast (Fig 20). Four tiers of ecological value are depicted in quartiles for each province. This map provides an objective, systematic comparison of watersheds with the highest value areas largely (but not entirely) reflecting intact or roadless watersheds. Another Marxan analysis was conducted at the watershed scale that removed the suitability cost for roads in recognition that some watersheds, previously logged and roaded, still maintain substantial ecological values within the management matrix. This analysis (depicted in Fig 21) identifies the top 2 tiers of ecological values from Figure 20 (in green on the map) but also identifies restoration opportunities (depicted in shades of red). These watersheds have had a history of development and habitat fragmentation but nevertheless retain substantial ecological values for the focal resources evaluated.

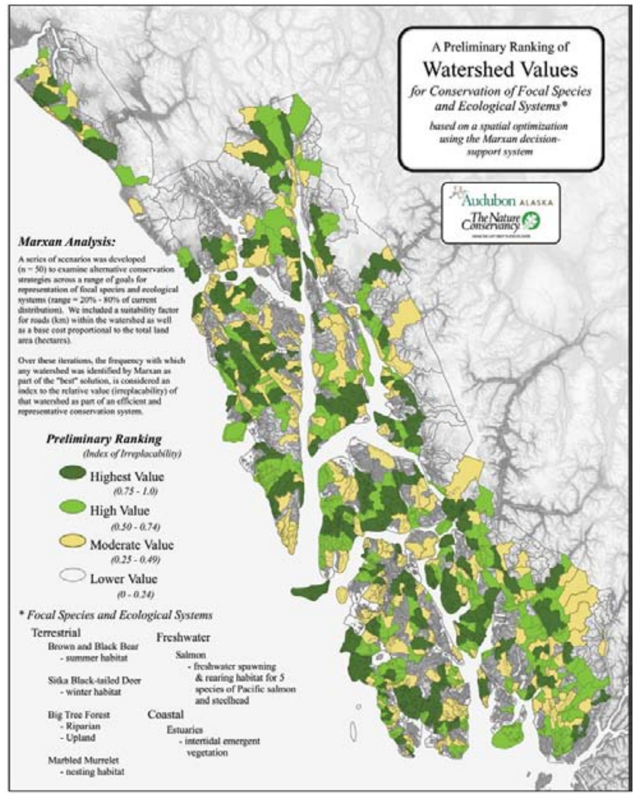

FIG 20. Preliminary watershed rankings for combined focal species and ecological systems within southeastern Alaska provinces.

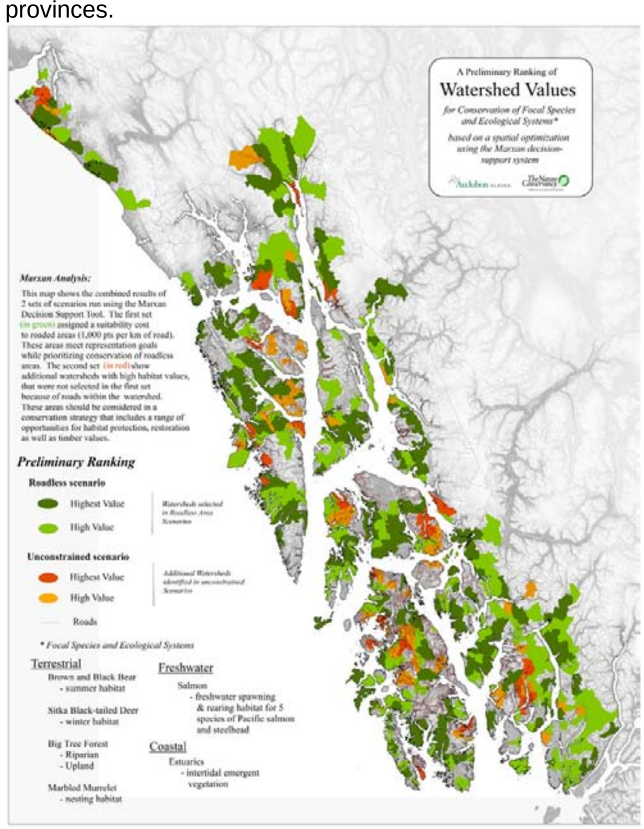

FIG 21. A preliminary ranking of watersheds for combined focal species and ecological systems based on primarily intact (green) and modified (red / orange) habitat values.

Combined Resource Analysis.—The combined ranking of ecological values at the watershed- and sub-watershed scales, along with the ranking of relative suitability for timber production provides an analytical framework for development of conservation and management prescriptions across a range of ecological conditions (Fig 22). For example, intact watersheds with highest concentrations of ecological values (shown in green) represent a globally rare opportunity for conservation of coastal rain forest ecosystems and associated species and are considered as high priorities for additional landscape-scale conservation. These watersheds contain approximately 34% of existing habitat values for all focal species and ecological systems combined (Table 18).

An important set of watersheds with high concentrations of ecological values but which have also sustained substantial roading and logging activity represent areas appropriate for a balanced prescription with emphasis on young-growth for timber production and restoration of habitat values for fish and wildlife. These areas are described as zones of "Integrated Management" (shown in orange, Fig 22) to emphasize the necessity to maintain critical ecosystem functions throughout the forest matrix and in the context of overall forest management objectives. Core areas of biological value within the Integrated Management Zone (shown in brown) represent the highest concentration of intact ecological values and, in this context, represent important opportunities for conservation of remaining old growth structural characteristics within the matrix and for enhancing connectivity among watersheds. Integrated Management Watersheds represent approximately 15% of existing habitat values for the combined focal species and ecological systems (Table 18).

Watersheds with lower ecological values are described as "intact" (<= 10% cut) or "modified" (>10% cut) based on the condition of original productive forest lands. "Lower Value – Intact Watersheds" (shown in gray, Fig 22) are typical of extensive areas of bedrock and glacial dominated landscapes along the mainland coast and southern and eastern Baranof Island. These areas contain lower ecological values, and represent approximately 10% of existing habitat for combined focal species and ecological systems (Table 18).

Watersheds with lower ecological values, past timber harvest activities, and the most substantial timber infrastructure (shown in light orchid, Fig 22) are described as "Timber Production Watersheds" and are generally the most appropriate areas for continued timber management. Within these watersheds, discrete areas with the highest suitability for timber production (shown in dark orchid) may provide the most appropriate sites for economic timber operations. In this way, objectives for efficient production of timber can be accomplished within a smaller land base, and allow greater flexibility for conservation of intact landscapes (within Conservation Priority Watersheds) and restoration within Integrated Management Watersheds. The primary underpinnings of this conservation strategy are to: (1) focus conservation on watersheds and sub-watershed core areas of highest ecological values; (2) concentrate timber production within the smallest land base and fewest miles (km) or roads and with the least cumulative impact on intact habitat values; and (3) facilitate a rapid transition from old-growth to second-growth timber harvest. These management actions are recommended to optimize the opportunity for maintaining the biodiversity and ecological integrity of the Southeast rainforest ecosystem while also providing for a sustainable timber industry within the region.

Conservation Priority Watersheds (Fig 22) within the Tongass National Forest, excluding congressionally designated Wilderness and LUD II lands, are listed (in ranked order) by province in Table 19. These largely intact watersheds generally encompass the highest current ecological values within each province and represent the first ecological priorities for conservation actions on the Tongass National Forest. It is important to recognize that these Conservation Priority Watersheds were ranked within biogeographic province not between provinces. A comprehensive protected areas strategy for the Tongass should consider including these high-value watersheds within each province's conservation network. This will maintain a geographic stratification within the region's overall protected areas strategy.

Integrated Management Watersheds (Fig 22) within the Tongass National Forest, excluding congressionally designated Wilderness and LUD II lands, are listed (in ranked order) by province in Table 20. These watersheds have had a history of intensive logging and roading but still retain substantial ecological values because they originally were some of the most productive watersheds in Southeast. Specific restoration opportunities include the North Prince of Wales, Revilla, Mitkof, Kuiu, and East Chichagof provinces.

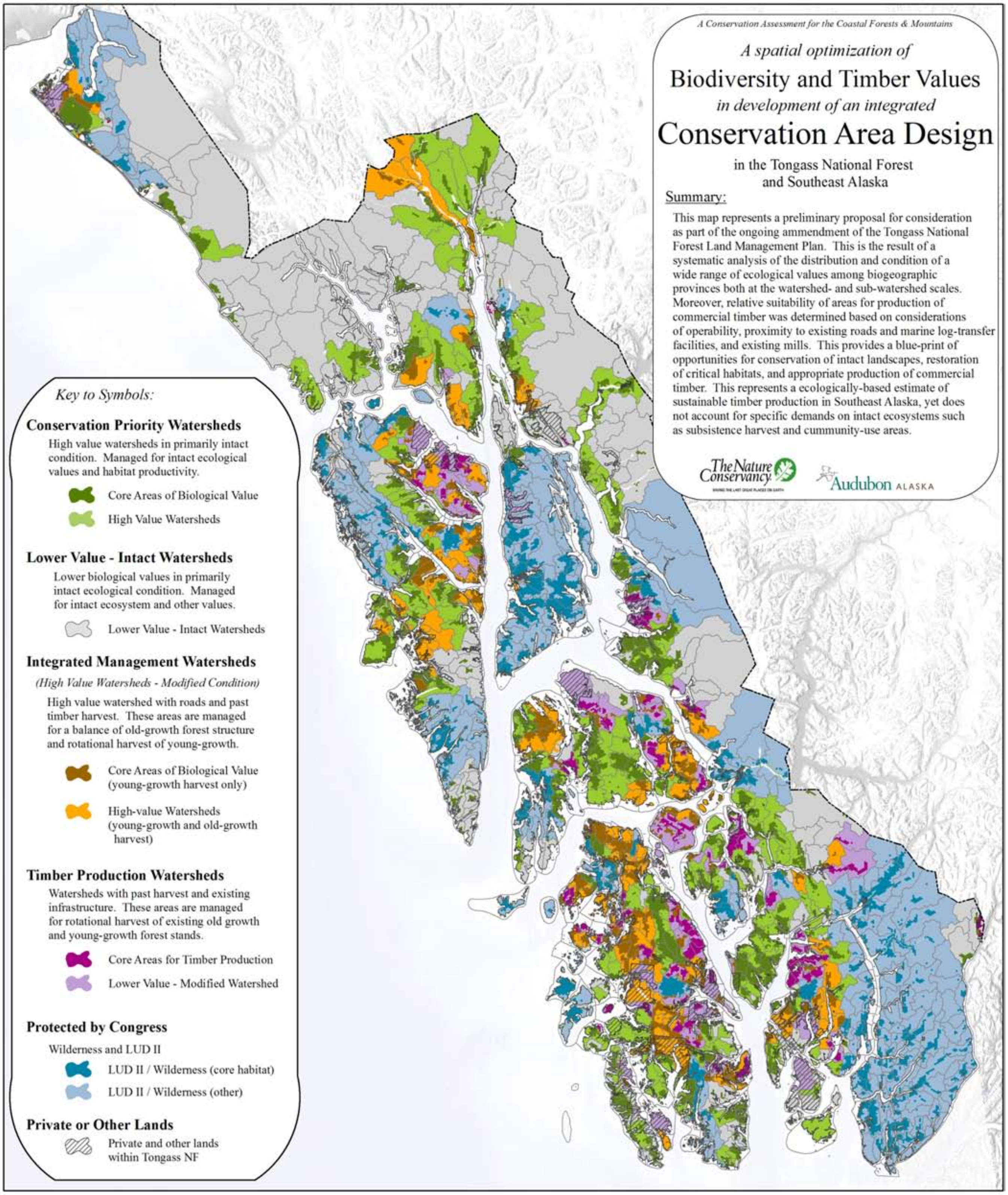

FIG 22. A spatial optimization of biodiversity and timber values in development of an integrated conservation area design in the Tongass National Forest and southeastern Alaska.

Table 18. Percent distribution of existing habitat values for focal species and ecological systems among watershed conservation priorities within the Integrated Conservation Area Design framework.

Focal Species and Ecological System	Distribution of habitat values among watershed conservation priorities (% of existing values)					
	Protected by Congress	Conservation Priority	Integrated Management	Lower Value Intact	Timber Production	Total
Large-tree Forest Types						
Riparian forest	43.4%	33.4%	16.1%	3.0%	4.2%	100.0%
Upland forest	31.5%	32.1%	25.1%	3.8%	7.5%	100.0%
Habitat Capability Models						
Brown & Black Bear	36.2%	34.1%	11.8%	11.8%	6.1%	100.0%
Sitka Black-tail deer	27.3%	36.0%	17.1%	9.8%	9.8%	100.0%
Marbled Murrelet	36.0%	31.9%	14.4%	9.4%	8.3%	100.0%
Freshwater Salmon Distribution						
King	36.9%	31.4%	19.9%	10.6%	1.1%	100.0%
Coho	23.3%	35.5%	20.9%	11.4%	8.9%	100.0%
Sockeye	32.4%	38.1%	13.0%	12.9%	3.5%	100.0%
Pink	28.0%	35.2%	20.6%	7.1%	9.0%	100.0%
Chum	29.1%	35.8%	21.0%	7.4%	6.7%	100.0%
Steelhead	30.5%	35.7%	20.7%	6.2%	6.9%	100.0%
All Focal Targets	31.7%	34.3%	15.3%	10.0%	8.7%	100.0%

TABLE 19. Conservation Priority Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on intact watersheds (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
East Chichagof Island	Chicken Cr	1960	100.0%	0.0%	21,436
	Poison Cove	2790	13.4%	85.9%	7,151
	Crab Bay	2320	14.6%	85.3%	11,017
	Goose Flats	2260	14.2%	85.8%	23,111
	Ushk Bay	2810	15.6%	80.3%	21,284
	Broad Island	2460	17.1%	82.8%	16,848
	Saltry Bay	2310	14.2%	85.8%	18,353
	Long Bay	2280	36.4%	63.6%	19,178
	Deep Bay	2800	12.8%	82.5%	18,180
	Seal Bay	2290	20.2%	79.8%	21,905
	Little Basket Bay	2400	19.0%	81.0%	10,155
	Whip Station	2210	90.7%	9.4%	4,546
	Neka Bay	2010	22.0%	78.1%	39,557
East Baranof Island	Saook Bay	2940	13.2%	86.8%	23,839
	Lake Eva	2950	99.7%	0.3%	12,395
	Deadman Reach	2890	47.4%	52.6%	8,125
	Kelp Bay - South Arm	3140	100.0%	0.0%	35,118
	Kelp Bay - Middle Arm	2980	51.7%	48.3%	27,746
West Baranof Island	Sitka Sound - Aleutkina Bay	3200	97.2%	2.8%	7,627
	Kruzof I. - Sea Lion Cove	3050	70.2%	29.9%	10,960
	Krestof Sound	3090	90.3%	9.7%	8,963
	Redoubt Lake	3500	95.3%	3.2%	28,147
	Deep Inlet	3220	100.0%	0.0%	6,954
	Salmon Lake	3230	13.6%	86.4%	7,663
	Fish Bay	2870	96.4%	3.6%	41,305
	Big Bear / Baby Bear	2880	17.6%	67.9%	7,141
	Kruzof I. - Mount Edgecumbe	3080	92.5%	7.5%	53,550
	Nakwasina Passage	3000	57.8%	42.2%	19,899
	Sukoi Inlet / N. Krestof	3030	39.6%	60.4%	18,138
	Big Bay	3490	92.9%	5.7%	9,414
Kuiu Island	Reid Bay	4160	17.6%	81.5%	16,043
	Kuiu - Salt Lagoon	4180	38.2%	61.7%	9,634
	Security Bay	4000	43.6%	54.6%	28,775
	Howard Cove	4100	99.9%	0.0%	12,752
	Kingsmill Point	4010	100.0%	0.0%	13,286
	Bay of Pillars	4030	99.8%	0.2%	29,886
	No Name Bay	4170	38.0%	61.9%	10,009

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 19 (cont.). Conservation Priority Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on intact watersheds (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
Kupreanof and Mitkof Islands	Lower Castle River	4350	58.6%	41.4%	32,318
	Rocky Pass	4280	92.9%	7.1%	48,412
	Lake Kushneahin	4310	19.8%	80.2%	22,500
	Colp Lake	4460	18.2%	81.6%	11,290
	Totem Bay	4320	16.4%	83.6%	42,544
	Big John Bay	4270	94.4%	5.6%	25,152
	Upper Castle River	4360	15.1%	84.9%	21,248
	Duncan Bay	4380	26.1%	73.9%	27,447
	Lovelace Cr	4300	19.7%	80.3%	14,563
	Towers Arm	4400	27.4%	72.0%	26,813
	Irish Lakes	4290	16.7%	83.3%	54,647
	Woewodski Island	4480	19.0%	78.4%	24,863
	Blind Slough	4510	83.1%	16.9%	9,614
Etolin / Zarembo / Wrangell Is.	Kunk Lake	4630	99.6%	0.4%	11,141
	Burnett Bay	4680	24.8%	75.2%	23,197
	Woronkofski Island	4610	9.4%	90.6%	14,532
	Streets Lake	4660	94.2%	5.9%	17,336
	Thoms Lake	4790	49.6%	45.5%	25,061
	Southwest Cove	4710	16.8%	83.0%	8,674
	Chichagof Pass	4620	18.7%	81.4%	16,290
	Mosman Inlet	4670	16.3%	83.8%	24,798
Revilla Is. / Cleveland Pen.	Union Bay	7090	99.2%	0.8%	14,642
	Port Stewart	7190	21.8%	78.2%	22,580
	Helm Bay	7160	98.5%	1.5%	17,079
	West Gravina Island	7620	79.8%	20.2%	8,792
	Yes Bay	7240	100.0%	0.0%	42,926
	Moser Bay	7430	19.0%	81.0%	14,044
	Spaceous Bay	7220	28.2%	71.8%	31,347
	Bostwick Inlet	7630	16.0%	84.0%	19,905
	SW Cleveland Peninsula	7120	53.1%	46.9%	14,584
	Vixen Inlet	7200	29.8%	70.2%	24,859
	Granite Cr CP	7170	38.9%	61.1%	10,280
	Deer Island	5250	28.4%	71.7%	9,329
	Behm Narrows	7310	99.9%	0.1%	19,765
	SW Cleveland Peninsula	7130	96.7%	3.3%	9,498
	Smugglers Cove	7150	98.5%	1.6%	13,920
	Emerald Bay	7210	67.1%	32.9%	8,011
	Swan Lake	7450	89.8%	10.1%	23,744

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 19 (cont.). Conservation Priority Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on intact watersheds (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
Revilla Is. / Cleveland Pen. (continued)	Bell Arm	7280	100.0%	0.0%	12,917
	Orchard Creek	7340	91.0%	8.9%	32,858
	Hickman Pt	7230	100.0%	0.0%	6,850
	Cannery Creek	7100	17.5%	82.5%	5,412
	California Cove	7580	96.5%	3.6%	11,594
	Betton Island	8641	91.8%	8.2%	5,432
	Duke Island	7670	99.7%	0.3%	39,263
	SE Thorne Arm	7600	17.4%	82.5%	11,127
	Reflection Lake	7270	100.0%	0.0%	11,117
	Upper Vixen	7180	26.2%	73.8%	11,850
	Sunny Bay	5260	20.4%	79.6%	17,659
North Prince of Wales	Cholmondeley Sound (West Arm)	6740	20.0%	80.0%	19,901
	Waterfall	6310	58.9%	41.1%	16,284
	Barns Lake	5520	48.6%	51.4%	9,695
	Sarkar Lakes	5541	100.0%	0.0%	24,949
	S. Honker Divide	5750	68.1%	31.9%	18,306
	Salt Lake Bay	5920	95.3%	4.7%	14,655
	NW Sukkwann Is	6710	55.0%	45.0%	22,844
	Whale Passage	5510	43.6%	56.4%	13,312
	Center Peak	5760	99.6%	0.4%	15,292
	McKenzie Inlet	6180	49.5%	50.5%	17,365
	S Sukkwan Is	6700	47.8%	52.2%	16,850
	Sweetwater Lake	5730	43.2%	56.8%	25,939
	Sunny Cove, Cholmondeley Sound	6750	36.5%	63.5%	6,570
	Lower Thorne River	5971	82.5%	17.5%	3,455
	Sukkwan Strait	6720	81.4%	18.6%	28,633
	Thorne River Falls	5780	49.5%	50.6%	6,411
	Tracodero Bay	6250	27.8%	72.2%	31,290
	Clover Bay	6170	76.0%	24.0%	14,207
	North Honker Divide	5740	78.7%	21.4%	26,681
	Cristoval Channel	5930	46.3%	53.7%	16,237
	Calder Bay	5311	23.0%	77.0%	15,907
	Port Estrella	6300	12.3%	87.7%	17,209
	Mt Francis	5410	65.0%	35.1%	6,059
	Davidson	5470	18.5%	81.5%	3,171
	Soda Bay	6320	9.6%	90.4%	14,470
	Nossuk Bay	5910	13.7%	86.3%	8,849
	Baird Peak	5820	13.8%	86.3%	4,124
	Trollers Cove	6150	24.0%	76.0%	10,012
	Control Lake / Upper Thorne	5960	76.3%	23.7%	12,602

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 19 (cont.). Conservation Priority Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on intact watersheds (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
South Prince of Wales	S Arm Moira Sound	6920	20.6%	78.9%	23,699
	Nutkwa Inlet	6850	7.7%	92.0%	18,158
	Kassa Inlet	6890	48.1%	50.0%	10,636
	Mabel Bay	6880	16.0%	84.0%	8,167
	Hidden Bay	6950	100.0%	0.0%	4,844
	Nichols Bay	7040	99.3%	0.0%	17,270
	Stone Rock Bay	7020	100.0%	0.0%	9,339
	Ingraham Bay	6940	43.5%	56.5%	6,200
Outside Islands	Port Santa Cruz	6340	28.1%	71.9%	11,631
	San Fernando - S	6280	100.0%	0.0%	9,960
	Port Refugio	6350	17.8%	82.3%	9,085
Dall / Long Islands	Bobs Bay	6390	16.8%	83.2%	6,081
	Essoway Lake	6590	97.1%	2.9%	14,136
	Waterfall Bay	6480	99.1%	0.9%	7,209
	McLeod Bay	6660	85.0%	15.0%	3,440
	Devil Cove	6460	61.9%	38.1%	7,120
	Hook Arm	6410	66.6%	33.4%	4,621
	Port Bazan	6560	32.8%	67.2%	14,908
	Datzkoo Hbr	6630	88.5%	11.5%	3,616
	Sea Otter Hbr	6420	77.6%	22.4%	7,105
	Welcome Cove	6470	100.0%	0.0%	3,634
	Meares Passage	6370	18.3%	81.7%	6,035
	Driver Bay	6400	40.5%	59.6%	3,079
	Gold Hbr	6510	95.3%	4.7%	5,469
	Fisherman Cove	6440	48.2%	51.8%	3,445
Lynn Canal / Mainland	Cowee Creek	230	10.6%	89.4%	26,936
	Pt. Couverden	1170	16.4%	83.6%	11,184
	Earth Station	1150	100.0%	0.0%	8,389
	Eagle / Herbert River	260	98.2%	1.8%	38,786
	Lincoln / Shelter Island	1240	32.8%	56.6%	8,084
	St. James Bay	1110	50.3%	39.5%	23,335
	Nun Mountain	1120	88.0%	11.9%	22,228
	Echo Cove	250	12.7%	65.9%	12,821
	Katzehin River	90	100.0%	0.0%	55,631
	Gilkey River	150	99.9%	0.0%	42,279
	Antler River	140	100.0%	0.0%	28,649
	Sullivan Mountain	950	19.9%	80.1%	16,303
	Dayebas Creek	80	100.0%	0.0%	10,907
	Pt. Danger	1080	9.0%	91.0%	3,633
	William Henry Bay	1070	61.4%	38.0%	7,488
	West Sullivan	970	17.1%	82.9%	6,659

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 19 (cont.). Conservation Priority Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on intact watersheds (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
Taku Mainland	Taku River	460	97.6%	2.4%	111,669
	Port Houghton Salt Chuck	790	27.5%	72.5%	42,519
	Port Houghton - Robert Is.	820	12.6%	86.6%	13,185
	Sandborn Canal	840	39.3%	60.7%	17,437
	Gilbert Bay	570	59.6%	40.4%	28,037
	Slocum Inlet	510	14.4%	85.6%	16,525
	Dry Bay	690	14.8%	85.2%	12,416
	Pt. Houghton - Dalgren	830	12.2%	87.8%	10,785
	Williams Cove	641	100.0%	0.0%	7,600
	Port Snettisham	550	28.8%	71.2%	22,293
	Limestone Inlet	530	100.0%	0.0%	9,960
	Taku Inlet	410	24.4%	75.6%	33,010
	Taku Harbor	520	9.4%	90.6%	6,950
	Sand Bay	680	10.3%	89.7%	8,227
	Heigs Peak	560	48.0%	52.0%	12,520
Stikine Mainland	Farugut Bay - S. Arm	900	94.6%	5.4%	27,851
	Marsha Peak	5010	9.2%	90.8%	28,180
	Madan Bay	5040	11.1%	88.9%	16,722
	Little Lake Eagle	5190	99.9%	0.1%	44,197
	Tom Creek	5100	70.6%	29.5%	27,274
	Cat Cr	870	12.1%	87.9%	14,029
	Marten Lake	5090	100.0%	0.1%	14,603
	N Arm Faragut Bay	890	14.2%	85.9%	17,299
	Virginia Lake	5020	13.0%	86.5%	30,947
	Blake Channel	5050	35.3%	64.8%	26,293
	Dry Bay-Grand Point	4830	5.3%	94.7%	10,737
	Oerns Creek	5080	100.0%	0.1%	13,590
	Aaron Creek	5030	99.9%	0.1%	45,572
Chilkat River Complex	Takhin River	Non-TNF	0.0%	100.0%	79,562
	Ferebee River	Non-TNF	0.0%	100.0%	57,711
	Davidson Glacier	Non-TNF	4.8%	95.2%	45,518
	Chilkat River	Non-TNF	32.6%	67.4%	80,645
	Upper Chilkat River	Non-TNF	11.5%	88.5%	67,752
	Garrison Glacier	Non-TNF	0.0%	100.0%	34,661
	Chilkoot River	Non-TNF	2.2%	97.8%	95,029
	Taiya River	Non-TNF	0.0%	91.9%	124,725
Yakutat Forelands	Ahrnklin River (estuary)	3710	99.8%	0.0%	7,264
	Ahrnklin River	3720	99.6%	0.4%	64,228
	Khantaak Islands	3680	25.5%	74.4%	4,015

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 20. Integrated Management Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on developed watersheds with high values and restoration opportunities (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
East Chichagof Island	Port Frederick Portage	2020	77.8%	22.2%	17,420
	False Island	2450	10.9%	89.0%	23,863
	Sitkoh Bay	2430	12.1%	87.9%	26,614
	Game Creek	2040	3.0%	97.1%	35,470
	Corner Bay	2360	10.7%	89.2%	11,582
	False Bay	2100	38.6%	61.5%	21,076
	Kennel Creek	2170	15.5%	84.5%	10,270
	Upper Mud Bay	1930	0%	100%	20,998
East Baranof Island	Appleton Cove	2930	12.1%	87.9%	13,871
	Peschani Point	2910	18.3%	81.7%	11,311
	Catherine Island	2970	40.2%	59.8%	15,858
	Rodman Bay	2920	11.5%	88.5%	25,200
	Kelp Bay - Portage Arm	2960	26.3%	73.7%	16,332
West Baranof Island	Sitka / Indian River	3110	60.7%	39.3%	21,119
	St. John the Baptist	3020	88.1%	11.9%	21,439
	Redoubt Bay	3210	20.0%	80.0%	9,441
	Shelikof Bay	3070	13.4%	86.6%	15,128
	Nakwasina River	2990	70.4%	29.6%	23,633
	Nakwasina Sound	3010	23.8%	76.3%	5,685
	Katlian Bay – North	3130	57.8%	42.2%	32,745
	Katlian Bay – South	3120	25.6%	74.4%	11,207
	Camp Coogan	3190	100%	0%	5,006
Kuiu Island	Saginaw Bay	3990	11.8%	88.2%	25,210
	Rowan Bay	4020	12.4%	87.6%	32,556
	Kadake Creek	4210	33.1%	66.9%	34,607
	Keku Islands	3980	20.6%	79.4%	14,208
Kupreanof / Mitkof Islands	Wrangell Narrows	4470	16.6%	83.2%	60,047
	Big Creek	4500	23.5%	76.5%	20,397
	Sumner Mountains	4520	19.1%	80.9%	30,907
Etolin / Zarembo / Wrangell	N. Wrangell Islands	4550	25.2%	74.8%	8,602
	Baht	4560	14.4%	85.6%	17,957
Revilla Island / Cleveland Peninsula	Buckhorn Lake	7530	18.3%	81.7%	32,452
	Salt Lagoon – Revilla	7470	13.4%	86.1%	20,334
	Carroll Creek	7440	22.3%	77.7%	32,051
	Carroll Inlet	7460	17.0%	83.0%	29,941
	Klu Creek	7330	32.4%	67.6%	16,767
	Settlers Cove	8642	41.7%	58.3%	15,620
	Ward Cove	7500	42.6%	57.5%	16,985
North Prince of Wales Island	Harris River	6220	13.8%	86.2%	26,536
	Shimaku Cr	5940	0.2%	99.8%	18,598
	Staney Creek (estuary)	5871	25.8%	74.2%	8,514
	Trout Cr	5430	34.6%	65.4%	16,085
	Port Protection	5270	76.4%	22.5%	8,380

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

TABLE 20 (cont.). Integrated Management Watersheds for combined focal species and ecological systems based on the Marxan spatial optimization tool parameterized with emphasis on developed watersheds with high values and restoration opportunities (refer to Conservation Area Design Map, Fig 22).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
North Prince of Wales Island (continued)	Sea Otter Sound	5550	35.6%	64.4%	15,568
	Lower Staney Creek	5880	12.4%	87.6%	26,662
	Edna Bay	5460	9.5%	90.5%	14,113
	Shaheen Creek	5890	46.0%	54.0%	20,725
	Control Lake	5950	11.4%	88.6%	20,761
	Flicker Creek	5290	14.7%	85.3%	14,913
	New Tokeen	5560	34.7%	65.3%	7,134
	Salt Chuck N. Karta	5980	21.4%	78.5%	12,686
	Red Lake	5330	17.6%	82.4%	13,347
	Thorne Bay	5860	19.1%	80.9%	15,582
	Klawock Lake & Inlet	6091	2.2%	97.8%	44,533
	Logjam Creek	5770	22.9%	77.1%	29,425
	Exchange Cove	5390	19.3%	80.7%	9,045
	Naukati Bay	5710	8.6%	91.4%	19,463
	Buster Bay	5300	15.1%	84.9%	11,005
	Red Bay	5320	13.2%	86.8%	15,594
	Salmon Bay Highlands	5340	38.8%	61.0%	8,633
	Salmon Bay Rapids	5350	24.9%	75.1%	6,727
	Colpoys	5341	24.3%	75.6%	2,030
	El Capitan Lake	5360	25.2%	74.8%	9,249
	El Capitan Peak	5371	17.4%	82.6%	9,614
	Whale Pass - Big Creek	5380	8.4%	91.6%	12,542
	Squaw Creek	5400	20.5%	79.5%	5,150
	Neck Lake	5500	17.6%	82.4%	10,623
	Sarheen Cove	5492	52.2%	47.9%	7,028
	Twelve Mile Arm	6210	32.8%	67.3%	28,337
	Head Trocodero Bay	6240	27.5%	72.5%	19,508
	Hydaburg River	6210	13.9%	86.1%	28,507
	Hetta Inlet	6730	4.3%	95.7%	39,814
Lynn Canal / Mainland	Montana Creek	280	68.6%	31.4%	8,900
	Homeshore (Icy Strait)	1200	10.5%	89.5%	12,444
	Ansley Basin	1180	40.1%	60.0%	13,594
	Peterson Creek / Eagle River	270	64.6%	35.5%	12,887
	Upper St. James River	1060	79.3%	17.2%	19,752
	Humpy Creek	1190	59.5%	40.5%	30,403
Stikine River / Mainland	Point Agassiz Peninsula	4890	17.1%	82.9%	40,522
	Eagle Bay	5200	50.7%	49.2%	18,216
	N Fork Bradfield River	5140	24.4%	75.6%	29,094

[a] Watersheds with >85% designated within legislatively protected areas are not shown.
[b] Development lands include areas available for timber harvest under the 1997 TLMP as well as private or other lands lacking administrative protection or conservation buffers.

WATERSHED MATRIX

The database used for the Marxan analyses and watershed rankings is presented in a watershed matrix (Excel spreadsheet) in Appendix B of this report. The watershed matrix lists every watershed in Southeast by name, VCU #, and province. The watersheds are listed for each province in the order of their within-province rank based on the Marxan watershed ranking and also identified by ecological tier rank (in quartiles). Individual focal resources (i.e., flood plain and upland large-tree and medium-tree old growth, salmon, deer, bear, murrelet, and estuary) are also ranked based on their habitat value within each watershed and the percentage habitat value that watershed represents within the province. Steelhead and each salmon species are listed individually as well as all salmon combined. The database for each watershed also includes the land area of the watershed, acreage (ha) logged, and miles (km) of roads within the watershed. This watershed matrix is a valuable database and provides the user with an opportunity to review and analyze the database in great detail.

CONSERVATION ASSESSMENT GIS DATABASE

The GIS database for this conservation assessment of southeastern Alaska and the Tongass National Forest has been packaged separately (and is available upon request on a DVD) with project files for viewing in Arc Reader, a share-ware utility for read-only access to GIS functionality. This set of GIS data layers and analyses have been compiled by The Nature Conservancy and Audubon Alaska as part of this conservation assessment. The GIS database contains the following elements:

1. Base Layers: Base layers contain basic cartographic elements such as locations of towns and a shoreline database for Southeast. It also includes land management, watershed and biogeographic provinces.
2. 1997 TLMP: These data were obtained from the Southeast Alaska GIS library and represent the primary elements of the TLMP conservation strategy, including VCU boundaries; land-use designations (LUDs), old-growth reserves (small, medium, large), riparian buffers (no-cut and uneven aged mgmt), beach fringe (no cut).
3. Ranking of Ecological Values: This section includes ecological ranking based on the Marxan Spatial Optimization Tool. Ecological rankings were based on the areas of highest concentration habitat values for the suite of focal species and ecological systems with the minimum total area and maximum connectivity. We conducted Marxan optimization analyses at a range of spatial scales to evaluate the biological significance of (1) entire watershed units (VCU) and (2) core areas within biogeographic provinces (regional significance).
4. Focal Species and Ecological Systems: These are the primary data layers that contributed to the ecological ranking. They include occupied freshwater salmon and steelhead habitat, a winter habitat capability model for Sitka black-tailed deer, a summer habitat capability model for brown and black bear, a model of nesting habitat capability for marbled murrelet, large-tree forest types (flood plain and upland), general vegetation and landcover, and landform association.
5. Shaded Relief: A shaded relief model of terrestrial and bathymetric terrain included for display purposes.

A user's guide for operating this GIS database is included in addition to Arc Reader 9.1. To view the GIS database, install ArcReader 9.1 and open "core_areas_of_biological_value.pmf". For best performance, we recommend that you copy the folder "X:/SE_Coastal_Forests_GIS" from the DVD to your local disk (~860 Mb) and run the application from there.

FULL PAGE FIGURES

Full page versions of the figures in this chapter are presented after the References Cited and are also available on the CD-Rom.

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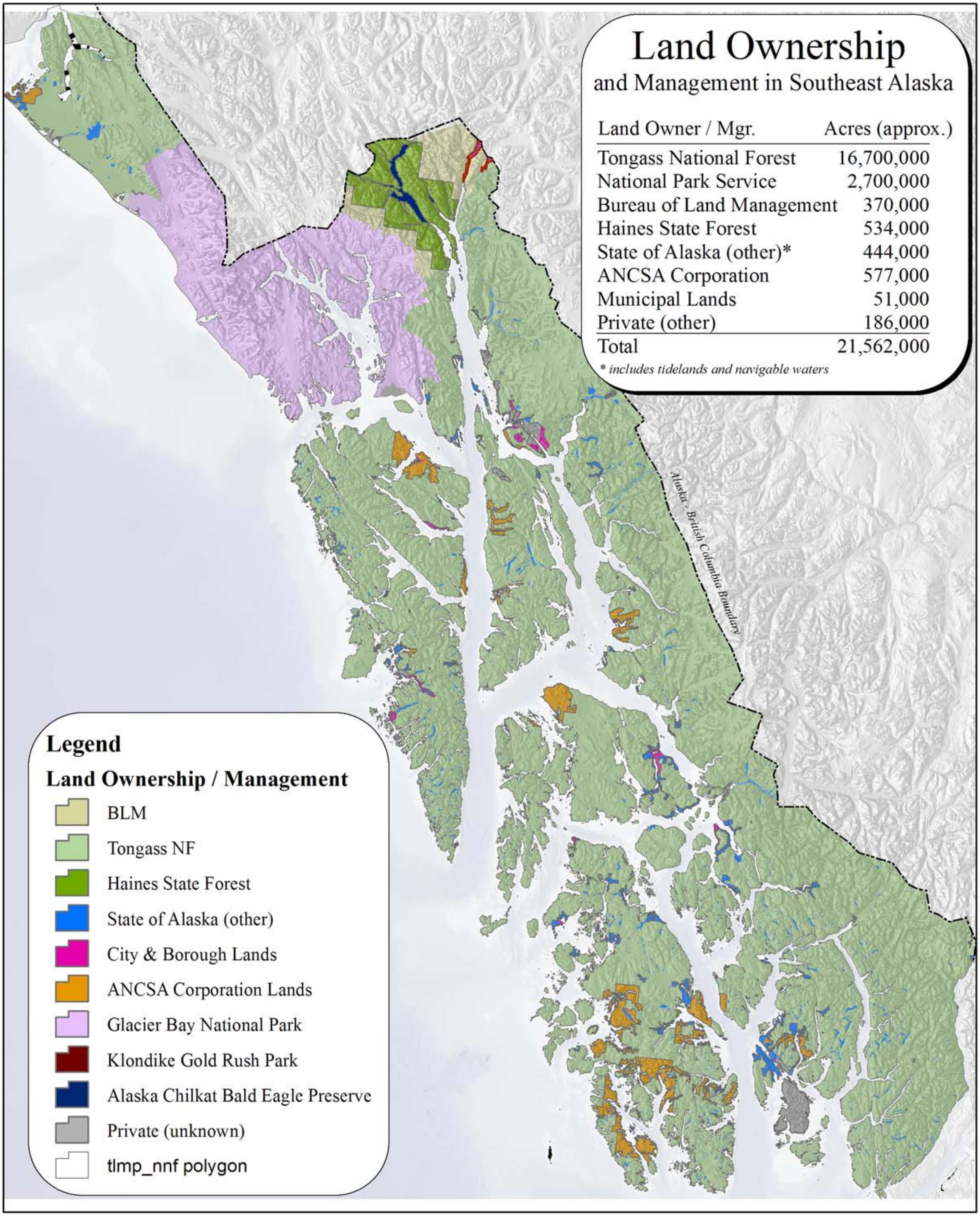


Land Ownership
and Management in Southeast Alaska
Land Owner / Mgr. Acres (approx.)
Tongass National Forest 16,700,000
National Park Service 2,700,000
Bureau of Land Management 370,000
Haines State Forest 534,000
State of Alaska (other)* 444,000
ANCSA Corporation 577,000
Municipal Lands 51,000
Private (other) 186,000
Total 21,562,000
* includes tidelands and navigable waters
Alaska - British Columbia Boundary
Legend
Land Ownership / Management
BLM
Tongass NF
Haines State Forest
State of Alaska (other)
City & Borough Lands
ANCSA Corporation Lands
Glacier Bay National Park
Klondike Gold Rush Park
Alaska Chilkat Bald Eagle Preserve
Private (unknown)
tlmp_nnf polygon

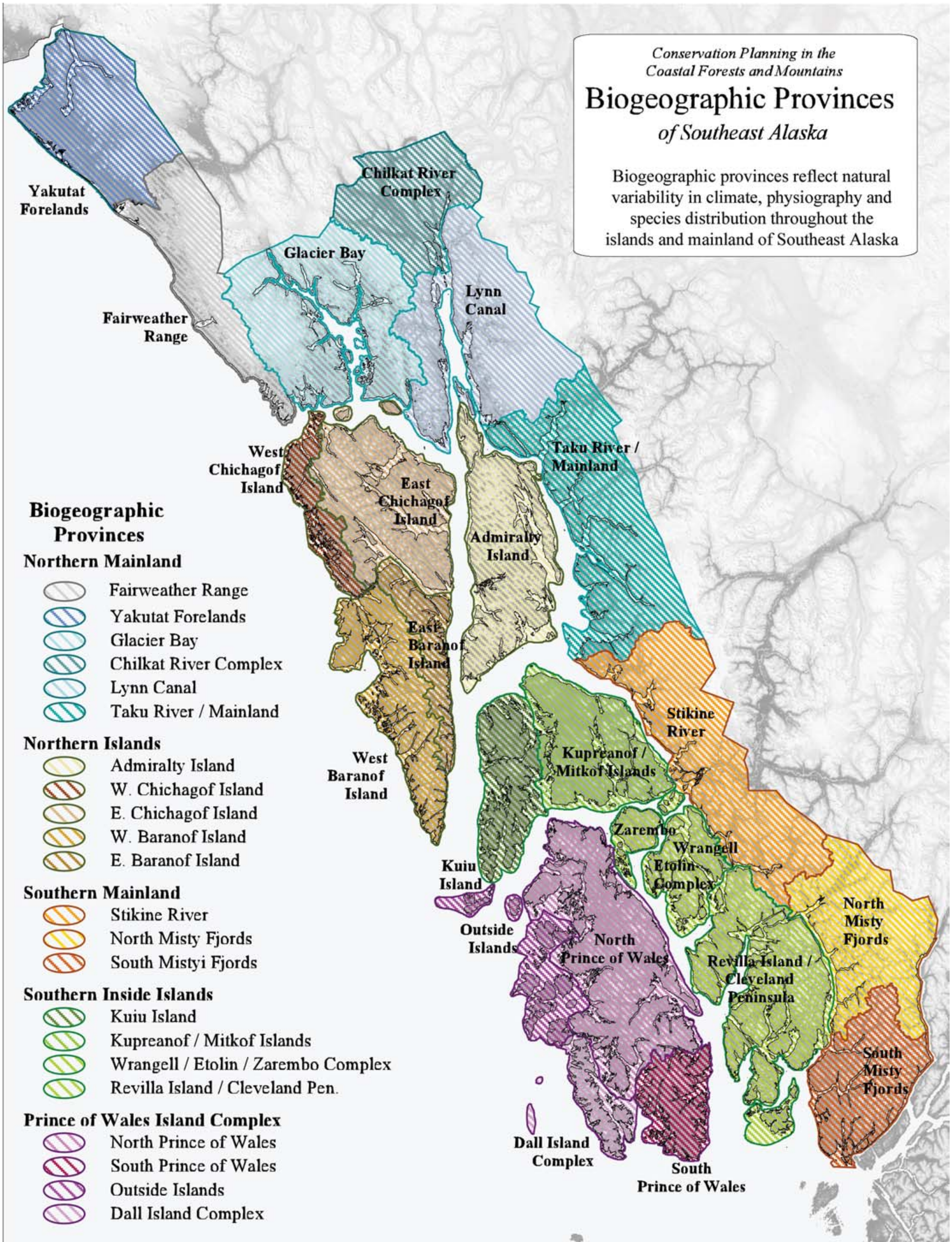
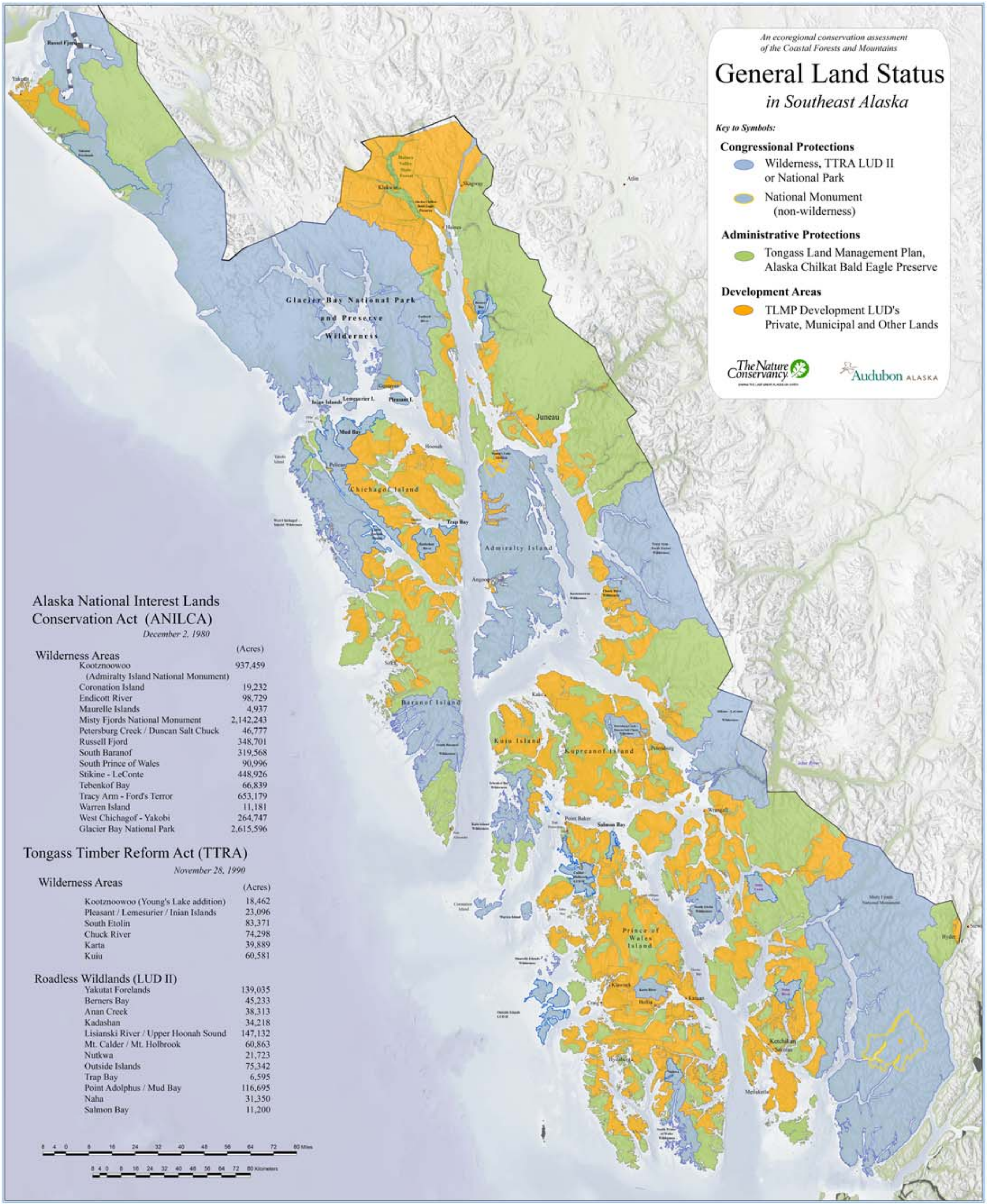
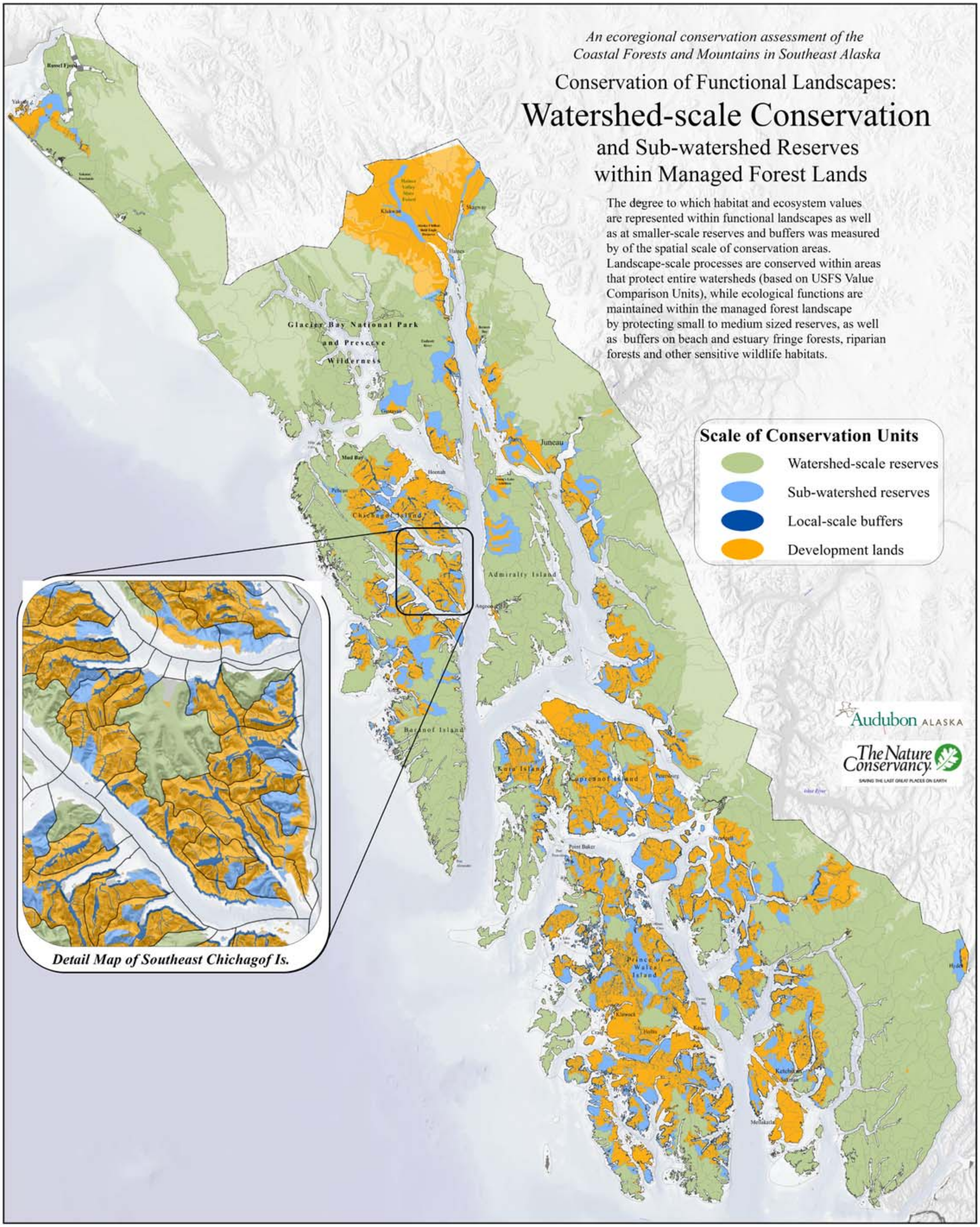
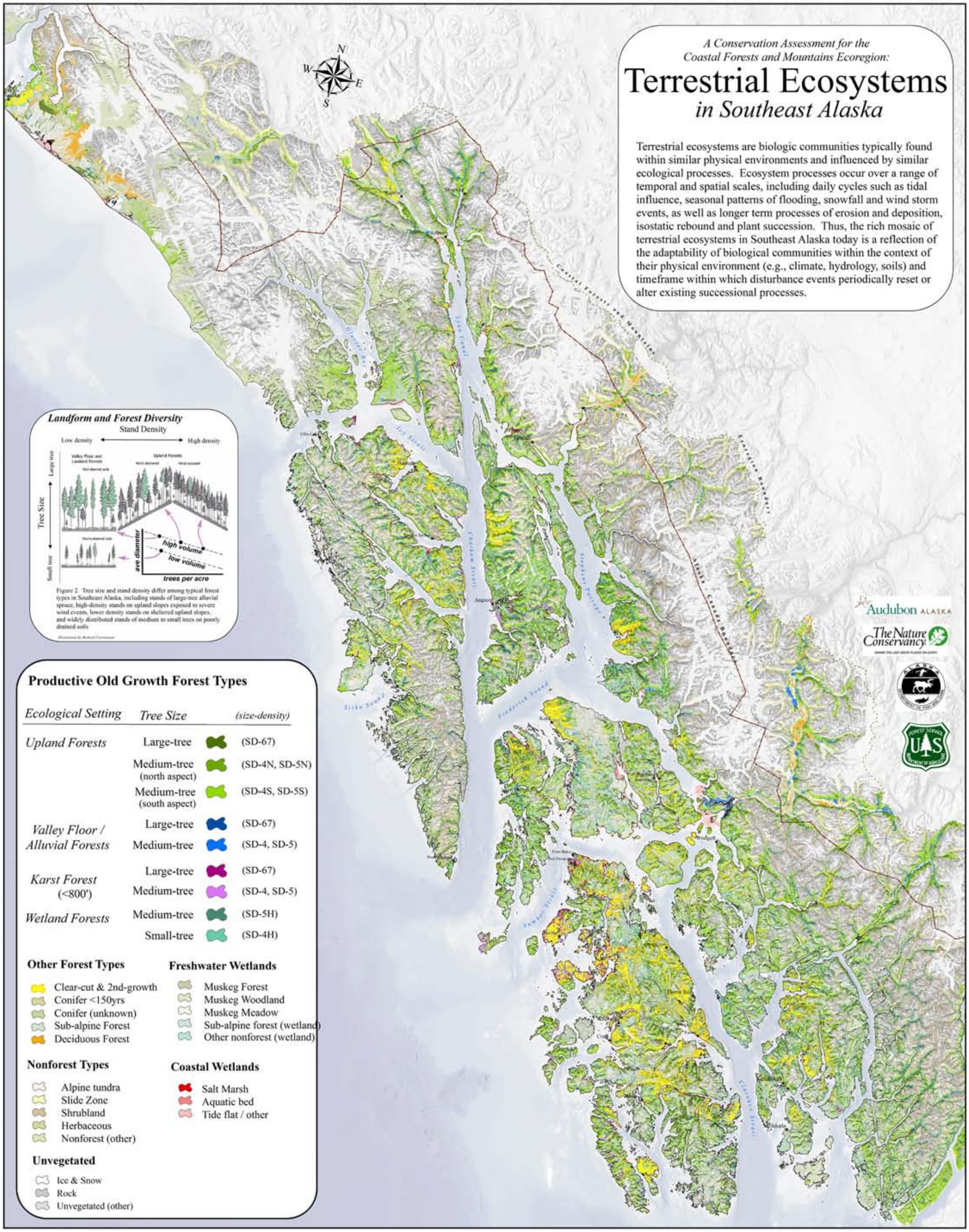


Figure 2. Biogeographic provinces were used to measure the geographic distribution of conservation representation throughout the islands and mainland of Southeast Alaska.

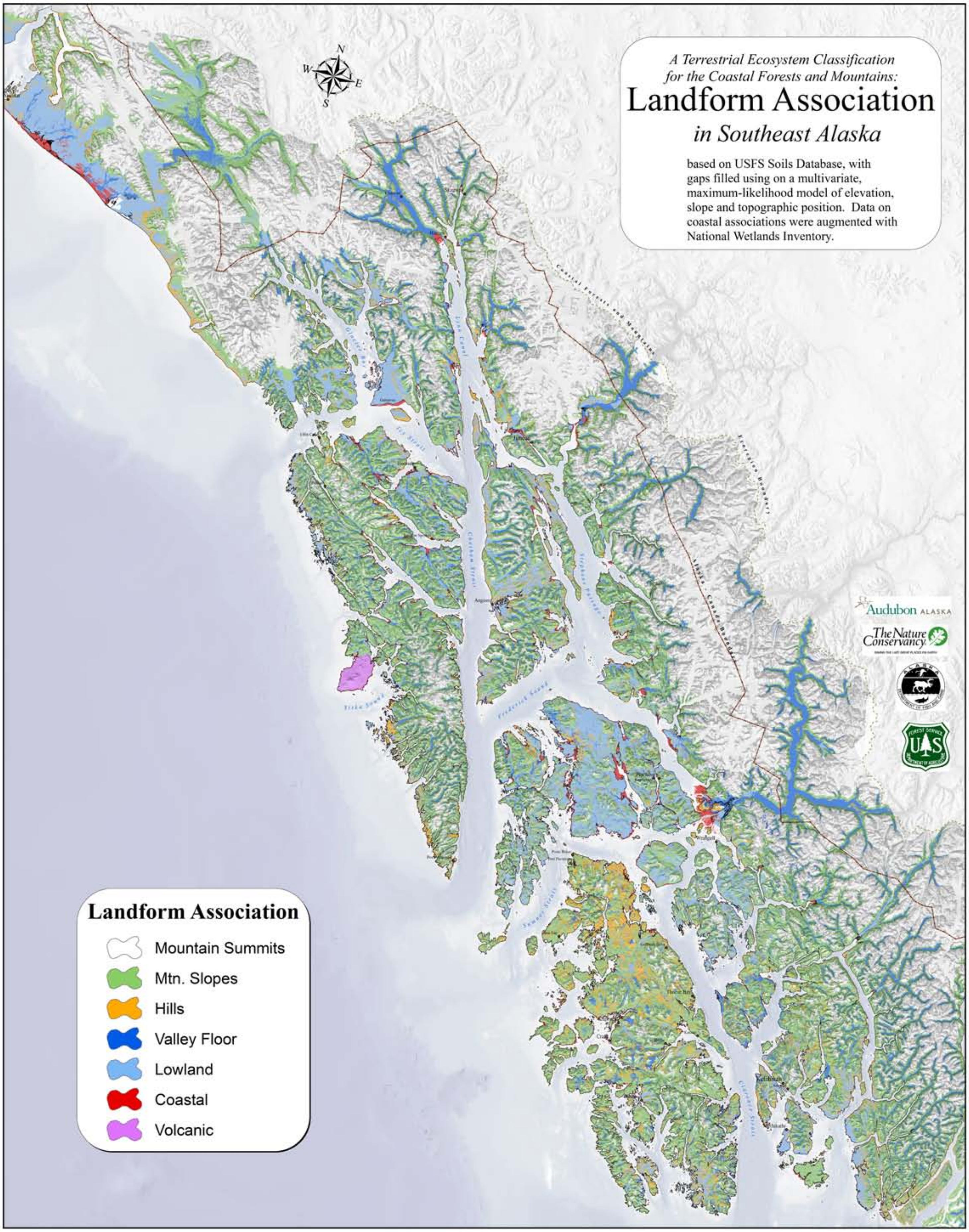


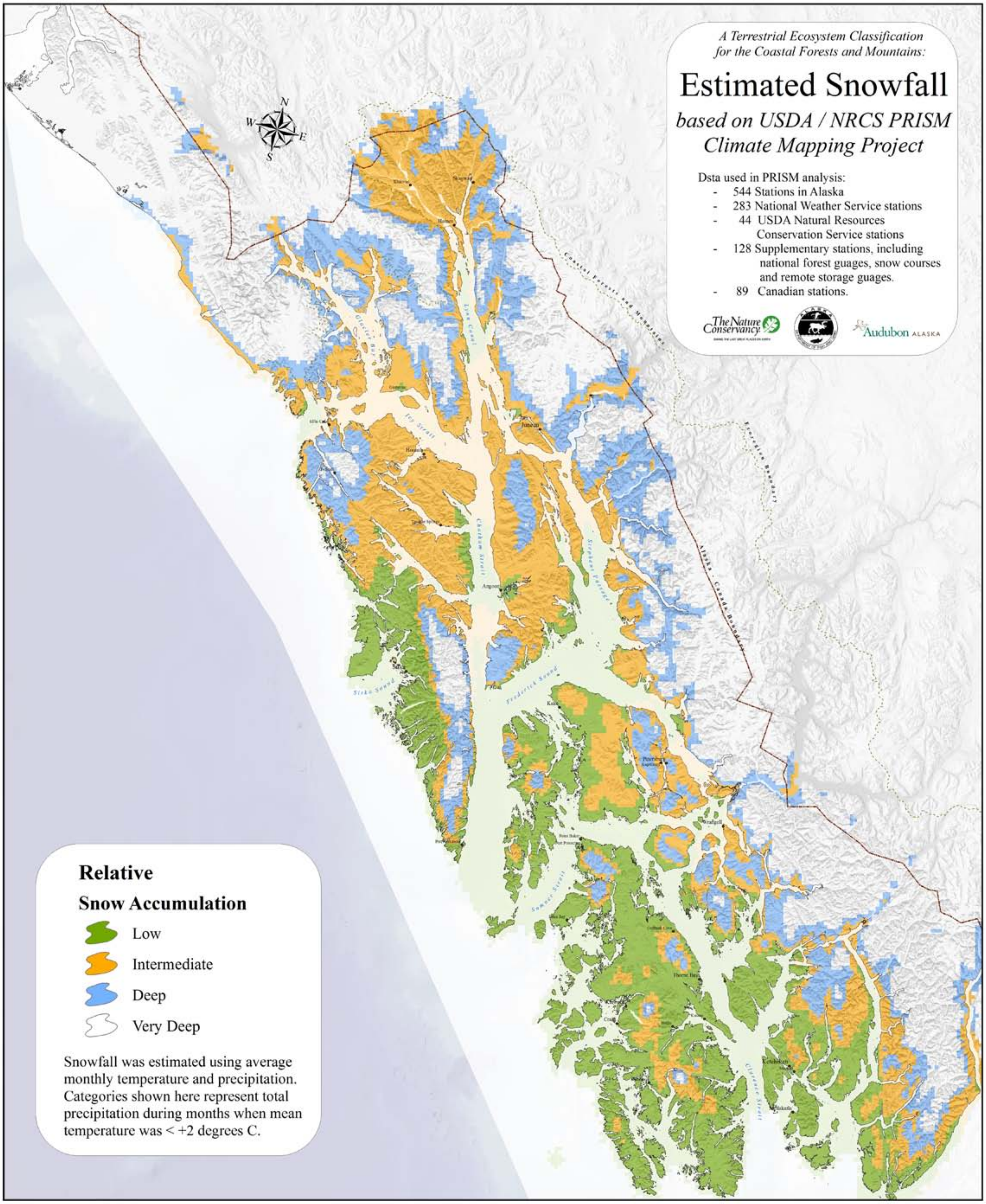
An ecoregional conservation assessment
of the Coastal Forests and Mountains
General Land Status
in Southeast Alaska
Key to Symbols:
Congressional Protections
Wilderness, TTRA LUD II
or National Park
National Monument
(non-wilderness)
Administrative Protections
Tongass Land Management Plan,
Alaska Chilkat Bald Eagle Preserve
Development Areas
TLMP Development LUD's
Private, Municipal and Other Lands
The Nature Conservancy
Audubon ALASKA
Glacier Bay National Park
and Preserve
Wilderness
Juneau
Chichagof Island
Admiralty Island
Baranof Island
Kuiu Island
Kupreanof Island
Prince of Wales Island
Skagway
Haines
Klukwan
Hoonah
Pelican
Mud Bay
Inian Islands
Lemesurier I.
Pleasant I.
Trap Bay
Angoon
Sitka
Kake
Petersburg
Wrangell
Point Baker
Salmon Bay
Klawock
Craig
Hollis
Kasaan
Ketchikan
Saxman
Metlakatla
Hydaburg
Hyder
Atlin
Alaska National Interest Lands
Conservation Act (ANILCA)
December 2, 1980
Wilderness Areas (Acres)
Kootznoowoo 937,459
(Admiralty Island National Monument)
Coronation Island 19,232
Endicott River 98,729
Maurelle Islands 4,937
Misty Fjords National Monument 2,142,243
Petersburg Creek / Duncan Salt Chuck 46,777
Russell Fjord 348,701
South Baranof 319,568
South Prince of Wales 90,996
Stikine - LeConte 448,926
Tebenkof Bay 66,839
Tracy Arm - Ford's Terror 653,179
Warren Island 11,181
West Chichagof - Yakobi 264,747
Glacier Bay National Park 2,615,596
Tongass Timber Reform Act (TTRA)
November 28, 1990
Wilderness Areas (Acres)
Kootznoowoo (Young's Lake addition) 18,462
Pleasant / Lemesurier / Inian Islands 23,096
South Etolin 83,371
Chuck River 74,298
Karta 39,889
Kuiu 60,581
Roadless Wildlands (LUD II)
Yakutat Forelands 139,035
Berners Bay 45,233
Anan Creek 38,313
Kadashan 34,218
Lisianski River / Upper Hoonah Sound 147,132
Mt. Calder / Mt. Holbrook 60,863
Nutkwa 21,723
Outside Islands 75,342
Trap Bay 6,595
Point Adolphus / Mud Bay 116,695
Naha 31,350
Salmon Bay 11,200
8 4 0 8 16 24 32 40 48 56 64 72 80 Miles
8 4 0 8 16 24 32 40 48 56 64 72 80 Kilometers


An ecoregional conservation assessment of the Coastal Forests and Mountains in Southeast Alaska
Conservation of Functional Landscapes:
Watershed-scale Conservation
and Sub-watershed Reserves
within Managed Forest Lands
The degree to which habitat and ecosystem values are represented within functional landscapes as well as at smaller-scale reserves and buffers was measured by of the spatial scale of conservation areas. Landscape-scale processes are conserved within areas that protect entire watersheds (based on USFS Value Comparison Units), while ecological functions are maintained within the managed forest landscape by protecting small to medium sized reserves, as well as buffers on beach and estuary fringe forests, riparian forests and other sensitive wildlife habitats.
Scale of Conservation Units
Watershed-scale reserves
Sub-watershed reserves
Local-scale buffers
Development lands
Audubon ALASKA
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Russel Fjord
Yakutat
Klukwan
Skagway
Haines
Glacier Bay National Park and Preserve Wilderness
Gustavus
Juneau
Mud Bay
Hoonah
Pelican
Chichagof Island
Admiralty Island
Angoon
Baranof Island
Kake
Kuiu Island
Kupreanof Island
Petersburg
Point Baker
Wrangell
Prince of Wales Island
Klawock
Craig
Hollis
Ketchikan
Metlakatla
Hyder
Detail Map of Southeast Chichagof Is.



A Conservation Assessment for the
Coastal Forests and Mountains Ecoregion:
Terrestrial Ecosystems
in Southeast Alaska
Terrestrial ecosystems are biologic communities typically found within similar physical environments and influenced by similar ecological processes. Ecosystem processes occur over a range of temporal and spatial scales, including daily cycles such as tidal influence, seasonal patterns of flooding, snowfall and wind storm events, as well as longer term processes of erosion and deposition, isostatic rebound and plant succession. Thus, the rich mosaic of terrestrial ecosystems in Southeast Alaska today is a reflection of the adaptability of biological communities within the context of their physical environment (e.g., climate, hydrology, soils) and timeframe within which disturbance events periodically reset or alter existing successional processes.
N
E
S
W
Coastal Forests and Mountains
Alaska - Canada Boundary
Lynn Canal
Glacier Bay
Icy Strait
Chatham Strait
Stephens Passage
Frederick Sound
Sitka Sound
Sumner Strait
Clarence Strait
Landform and Forest Diversity
Stand Density
Low density
High density
Tree Size
Large tree
Small tree
high volume
low volume
ave diameter
trees per acre
Figure 2. Tree size and stand density differ among typical forest types in Southeast Alaska, including stands of large-tree alluvial spruce, high-density stands on upland slopes exposed to severe wind events, lower density stands on sheltered upland slopes, and widely distributed stands of medium to small trees on poorly drained soils
Productive Old Growth Forest Types
Ecological Setting
Tree Size
(size-density)
Upland Forests
Large-tree (SD-67)
Medium-tree (north aspect) (SD-4N, SD-5N)
Medium-tree (south aspect) (SD-4S, SD-5S)
Valley Floor / Alluvial Forests
Large-tree (SD-67)
Medium-tree (SD-4, SD-5)
Karst Forest (<800')
Large-tree (SD-67)
Medium-tree (SD-4, SD-5)
Wetland Forests
Medium-tree (SD-5H)
Small-tree (SD-4H)
Other Forest Types
Clear-cut & 2nd-growth
Conifer <150yrs
Conifer (unknown)
Sub-alpine Forest
Deciduous Forest
Freshwater Wetlands
Muskeg Forest
Muskeg Woodland
Muskeg Meadow
Sub-alpine forest (wetland)
Other nonforest (wetland)
Nonforest Types
Alpine tundra
Slide Zone
Shrubland
Herbaceous
Nonforest (other)
Coastal Wetlands
Salt Marsh
Aquatic bed
Tide flat / other
Unvegetated
Ice & Snow
Rock
Unvegetated (other)
Audubon ALASKA
The Nature Conservancy


A Terrestrial Ecosystem Classification
for the Coastal Forests and Mountains:
Landform Association
in Southeast Alaska
based on USFS Soils Database, with gaps filled using on a multivariate, maximum-likelihood model of elevation, slope and topographic position. Data on coastal associations were augmented with National Wetlands Inventory.
Landform Association
Mountain Summits
Mtn. Slopes
Hills
Valley Floor
Lowland
Coastal
Volcanic
Audubon ALASKA
The Nature Conservancy
Coastal Forests and Mountains
Chatham Strait
Stephens Passage
Frederick Sound
Sitka Sound
Icy Strait
Sumner Strait
Clarence Strait
Lynn Canal
Glacier Bay
Juneau
Angoon



A Terrestrial Ecosystem Classification
for the Coastal Forests and Mountains:
Estimated Snowfall
based on USDA / NRCS PRISM
Climate Mapping Project
Dsta used in PRISM analysis:
- 544 Stations in Alaska
- 283 National Weather Service stations
- 44 USDA Natural Resources Conservation Service stations
- 128 Supplementary stations, including national forest guages, snow courses and remote storage guages.
- 89 Canadian stations.
The Nature Conservancy
Audubon ALASKA
N
W
E
S
Lynn Canal
Icy Strait
Chatham Strait
Stephens Passage
Frederick Sound
Sitka Sound
Sumner Strait
Clarence Strait
Juneau
Coastal Forests and Mountains
Alaska - Canada Boundary
Relative
Snow Accumulation
Low
Intermediate
Deep
Very Deep
Snowfall was estimated using average monthly temperature and precipitation. Categories shown here represent total precipitation during months when mean temperature was < +2 degrees C.

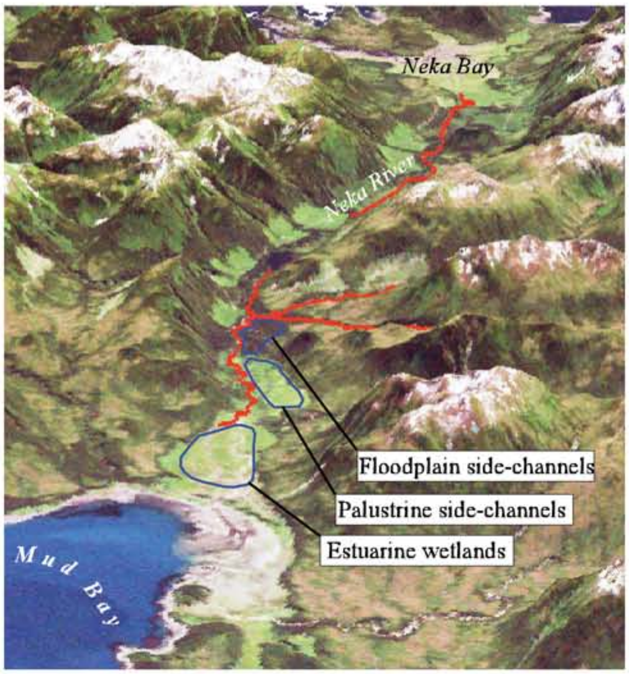
A Landscape-based model of salmon habitat in Southeast Alaska

Example: Coho Salmon in Mud Bay Watershed, Chichagof Island

Summary

The ADF&G Fish Distribution Database contains field-verified information on distribution of anadromous fish, but many streams have not yet been surveyed. The USFS Stream inventory contains better mapping of streams, and includes information on stream habitat, but salmon distribution is not verified and many smaller streams remain unmapped. We adopted a landscape-modeling approach to identify potential salmon habitat based on the ADF&G database and adjacent floodplain areas. Class 1 streams in the USFS inventory within anadromous floodplains also were considered likely habitat for anadromous fish. We believe this provides a better estimate of relative watershed values for salmon than one based on the ADF&G database alone.

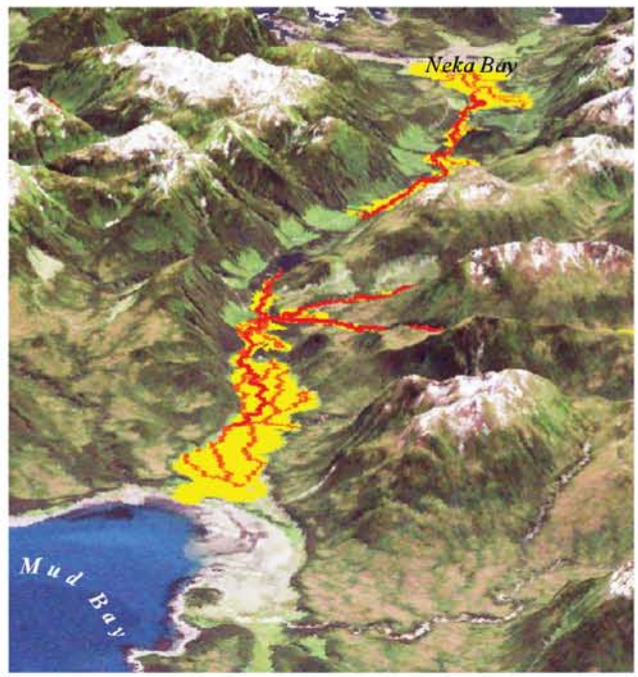
Existing Data and Data Gaps



Coho distribution based on the ADF&G Fish Distribution Database

Data Gaps: Adjacent areas with high probability of salmon habitat

Salmon Habitat - Floodplain Model



Coho distribution based on the ADF&G Fish Distribution Database

Floodplain Model

USFS Class 1 Streams (within anadromous floodplain)

Watershed Values

Our objective is to rank watersheds by their relative value as salmon habitat. We considered species richness as well as habitat capability. In this context, watersheds with extensive estuarine, palustrine and floodplain habitats are more valuable than narrow valleys with contained channels, but this difference would not be reflected using a simple linear estimator of salmon habitat. We believe that this landscape-based approach provides a better method for evaluation these important wetland features when used in combination with exsiting data on salmon distribution.

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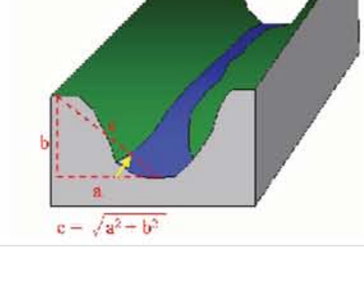
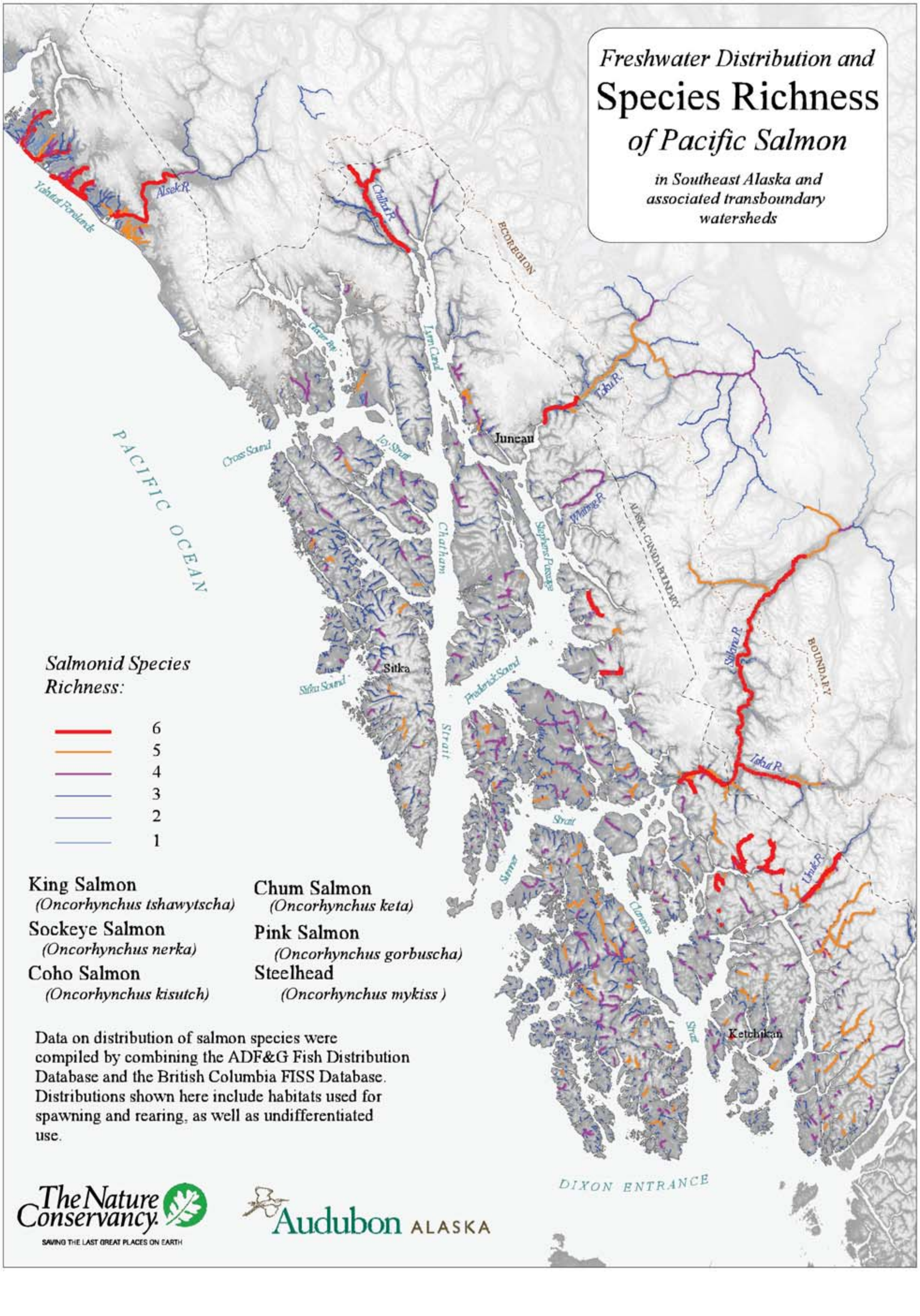
ALASKA DEPARTMENT OF FISH AND GAME

Floodplain Model

The floodplain model was developed using the PATHDISTANCE method (ESRI, ArcInfo GIS). Each cell is given a score or "cost" based on slope and distance to streams that represents the declining likelihood of salmon-associated wetlands or side-channels. Thresholds were set based on examination of existing stream data and satellite imagery. Class1streams from the USFS inventory within floodplain buffers were included as potiential habitat for spawning and rearing of anadromous fish.




Freshwater Distribution and
Species Richness
of Pacific Salmon
in Southeast Alaska and associated transboundary watersheds
PACIFIC OCEAN
DIXON ENTRANCE
Juneau
Sitka
Ketchikan
Alsek R.
Chilkat R.
Taku R.
Stikine R.
Iskut R.
Unuk R.
Whiting R.
Yakutat Forelands
Glacier Bay
Lynn Canal
Icy Strait
Cross Sound
Chatham Strait
Stephens Passage
Frederick Sound
Sitka Sound
Sumner Strait
Clarence Strait
ECOREGION
BOUNDARY
ALASKA - CANADA BOUNDARY
Salmonid Species Richness:
6
5
4
3
2
1
King Salmon (Oncorhynchus tshawytscha)
Sockeye Salmon (Oncorhynchus nerka)
Coho Salmon (Oncorhynchus kisutch)
Chum Salmon (Oncorhynchus keta)
Pink Salmon (Oncorhynchus gorbuscha)
Steelhead (Oncorhynchus mykiss)
Data on distribution of salmon species were compiled by combining the ADF&G Fish Distribution Database and the British Columbia FISS Database. Distributions shown here include habitats used for spawning and rearing, as well as undifferentiated use.
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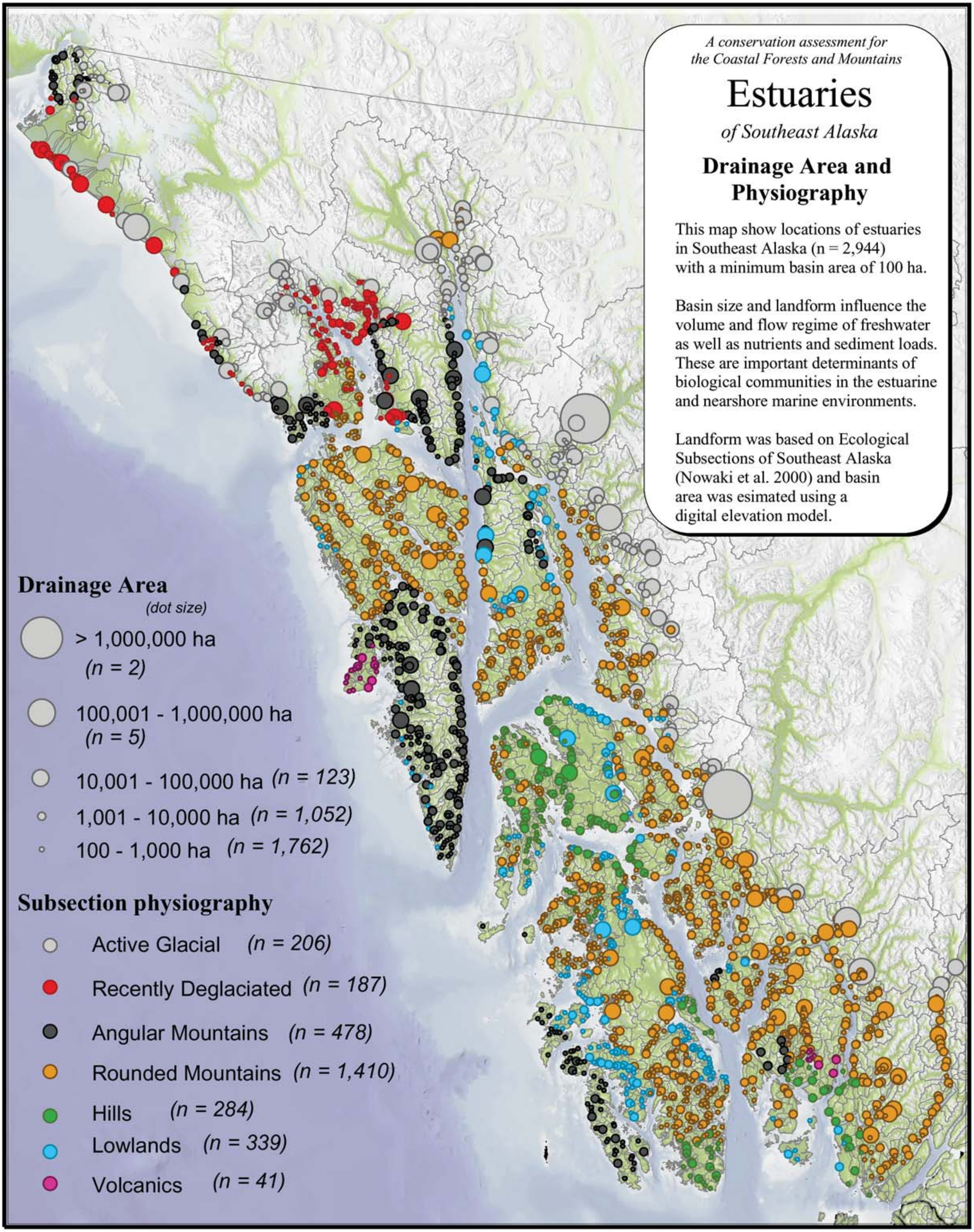
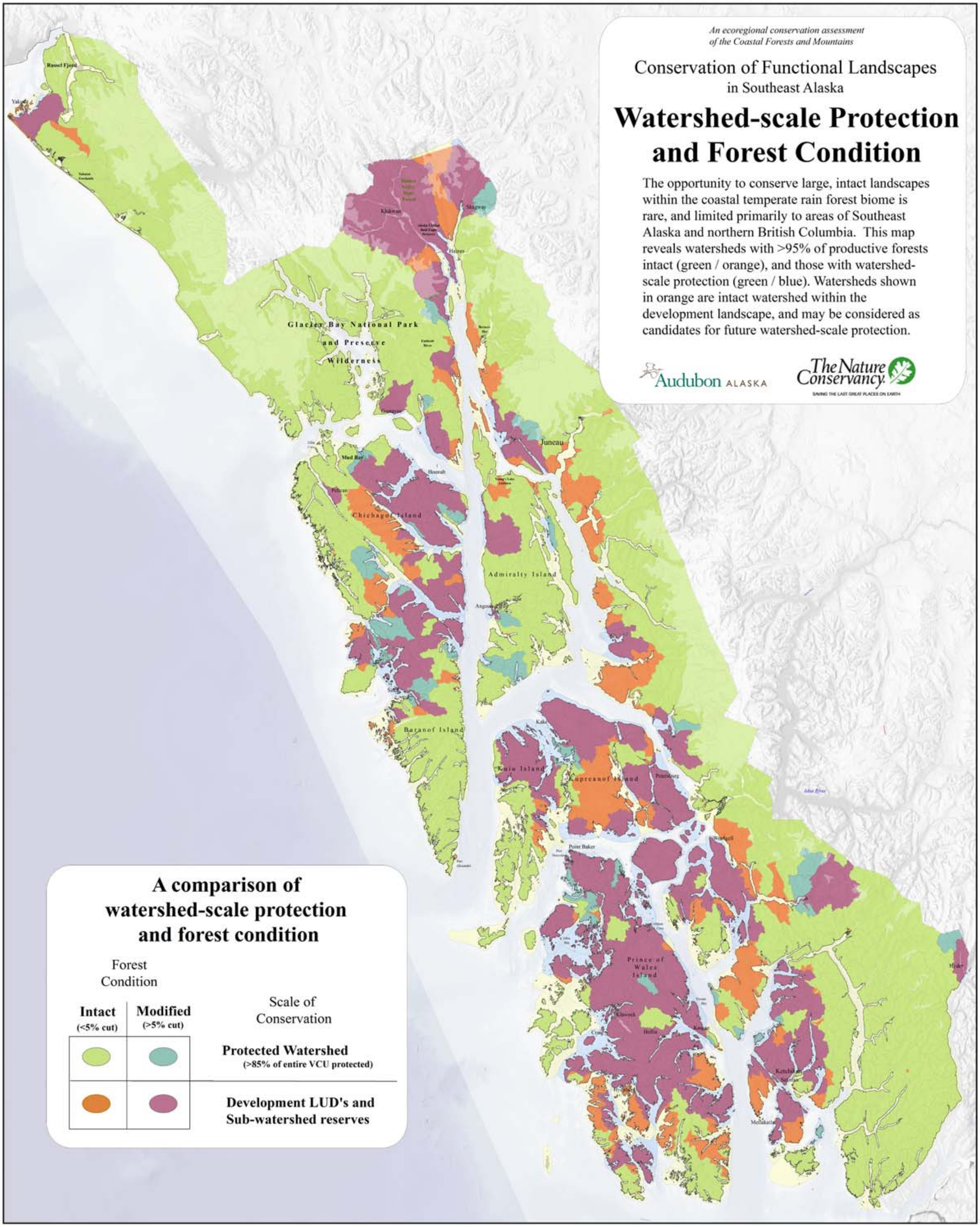
SAVING THE LAST GREAT PLACES ON EARTH
Audubon ALASKA



A conservation assessment for the Coastal Forests and Mountains
Estuaries
of Southeast Alaska
Drainage Area and Physiography
This map show locations of estuaries in Southeast Alaska (n = 2,944) with a minimum basin area of 100 ha.
Basin size and landform influence the volume and flow regime of freshwater as well as nutrients and sediment loads. These are important determinants of biological communities in the estuarine and nearshore marine environments.
Landform was based on Ecological Subsections of Southeast Alaska (Nowaki et al. 2000) and basin area was esimated using a digital elevation model.
Drainage Area
(dot size)
> 1,000,000 ha (n = 2)
100,001 - 1,000,000 ha (n = 5)
10,001 - 100,000 ha (n = 123)
1,001 - 10,000 ha (n = 1,052)
100 - 1,000 ha (n = 1,762)
Subsection physiography
Active Glacial (n = 206)
Recently Deglaciated (n = 187)
Angular Mountains (n = 478)
Rounded Mountains (n = 1,410)
Hills (n = 284)
Lowlands (n = 339)
Volcanics (n = 41)



An ecoregional conservation assessment of the Coastal Forests and Mountains
Conservation of Functional Landscapes in Southeast Alaska
Watershed-scale Protection and Forest Condition
The opportunity to conserve large, intact landscapes within the coastal temperate rain forest biome is rare, and limited primarily to areas of Southeast Alaska and northern British Columbia. This map reveals watersheds with >95% of productive forests intact (green / orange), and those with watershed-scale protection (green / blue). Watersheds shown in orange are intact watershed within the development landscape, and may be considered as candidates for future watershed-scale protection.
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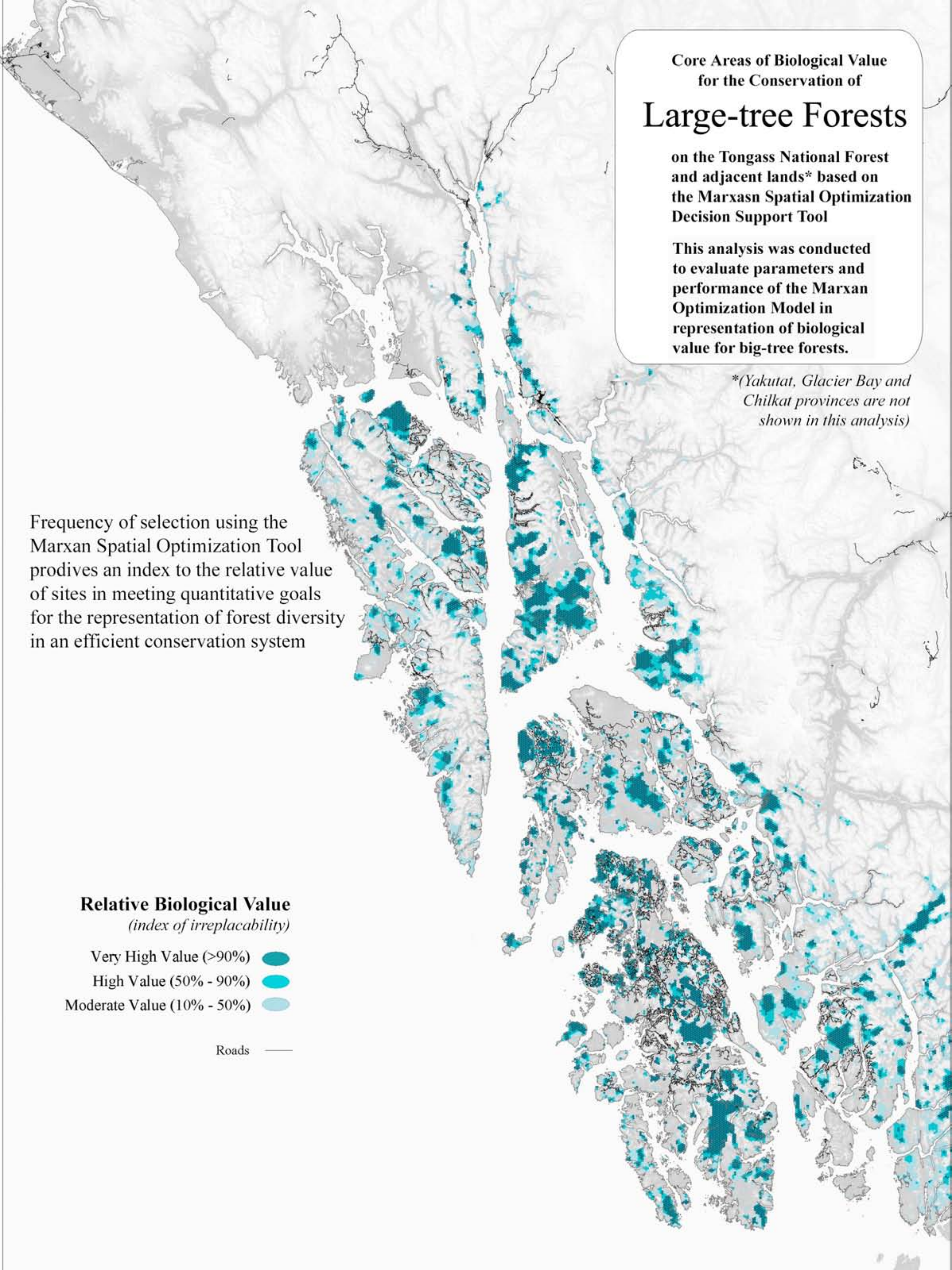
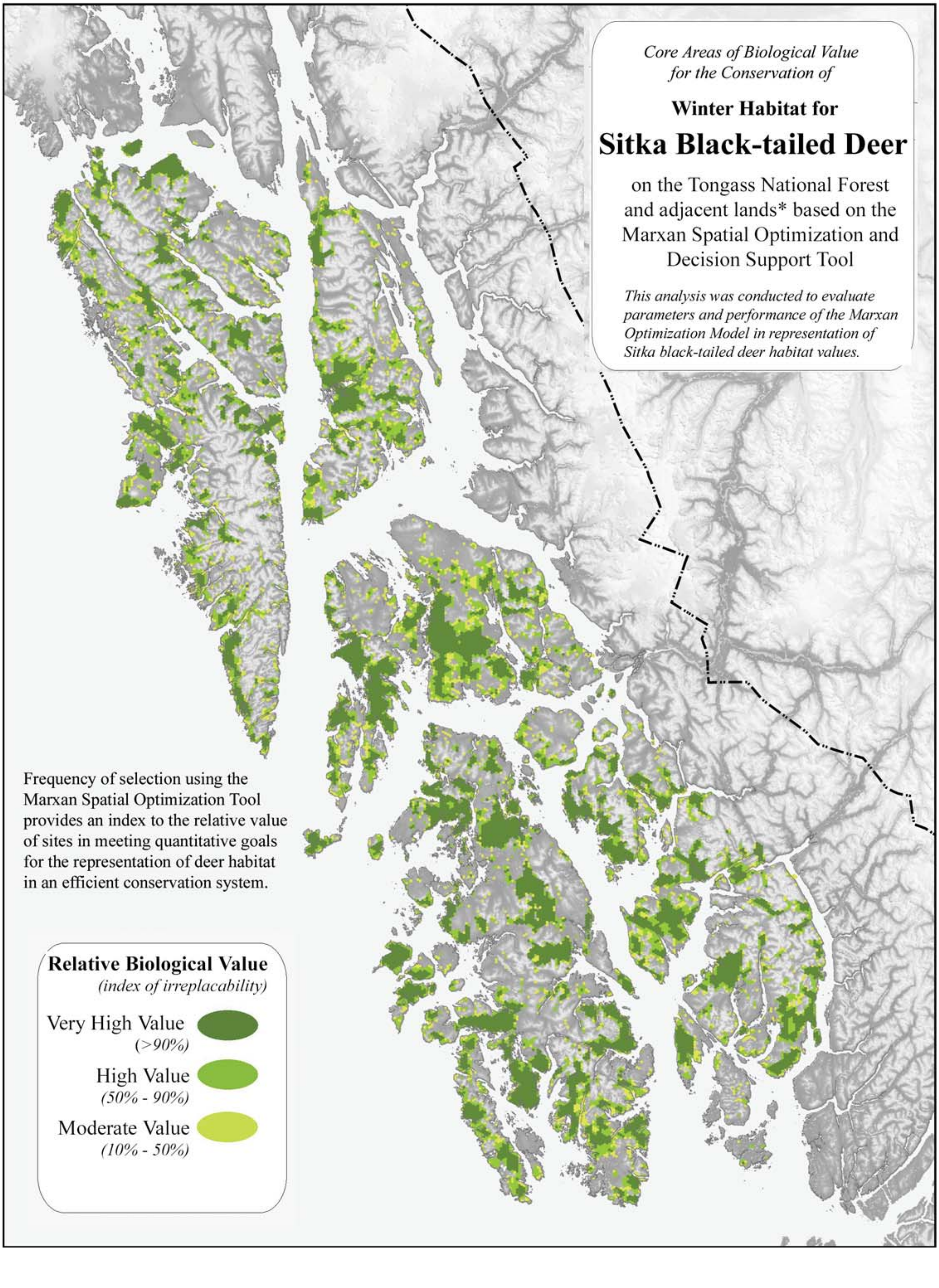
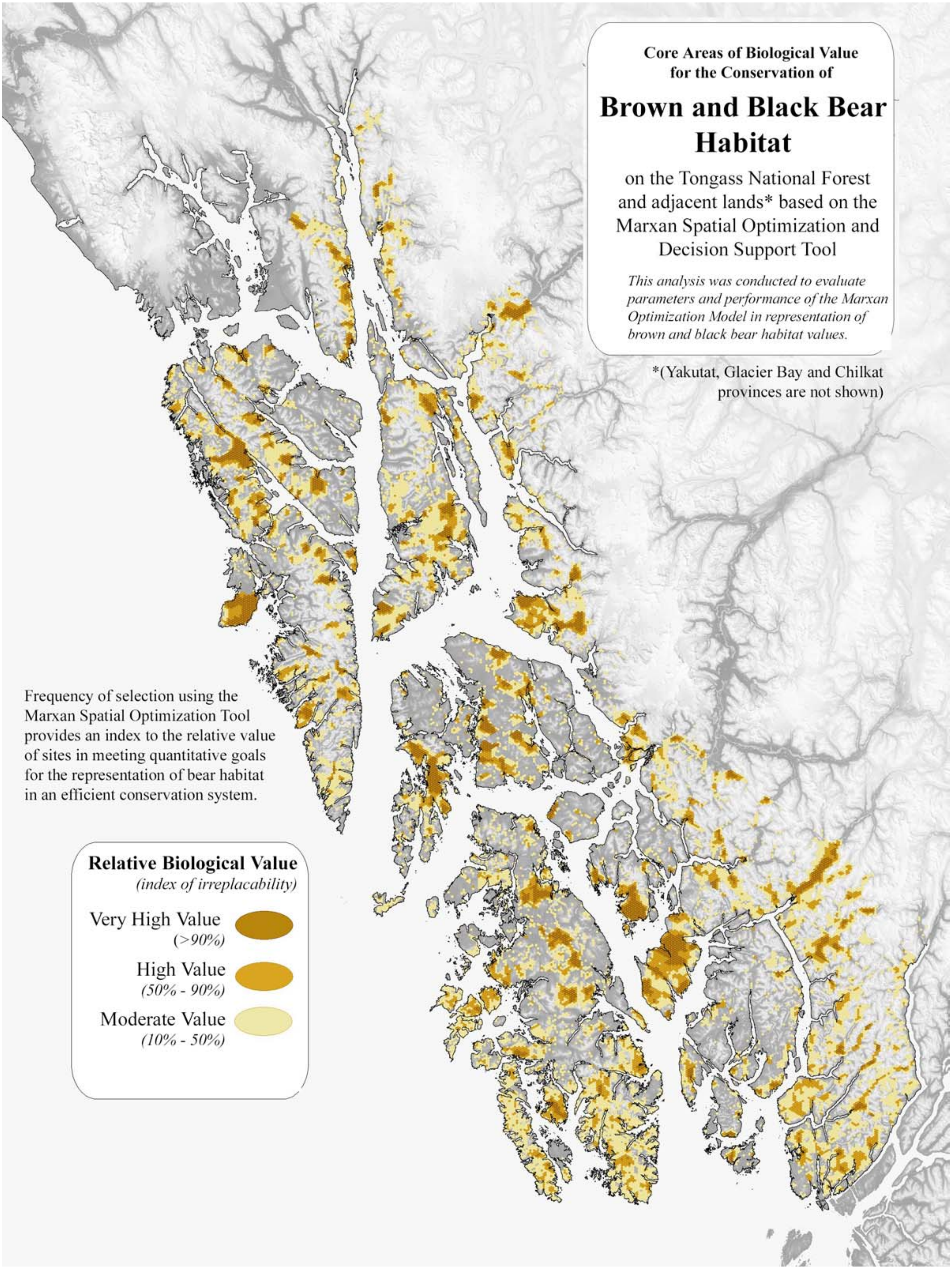
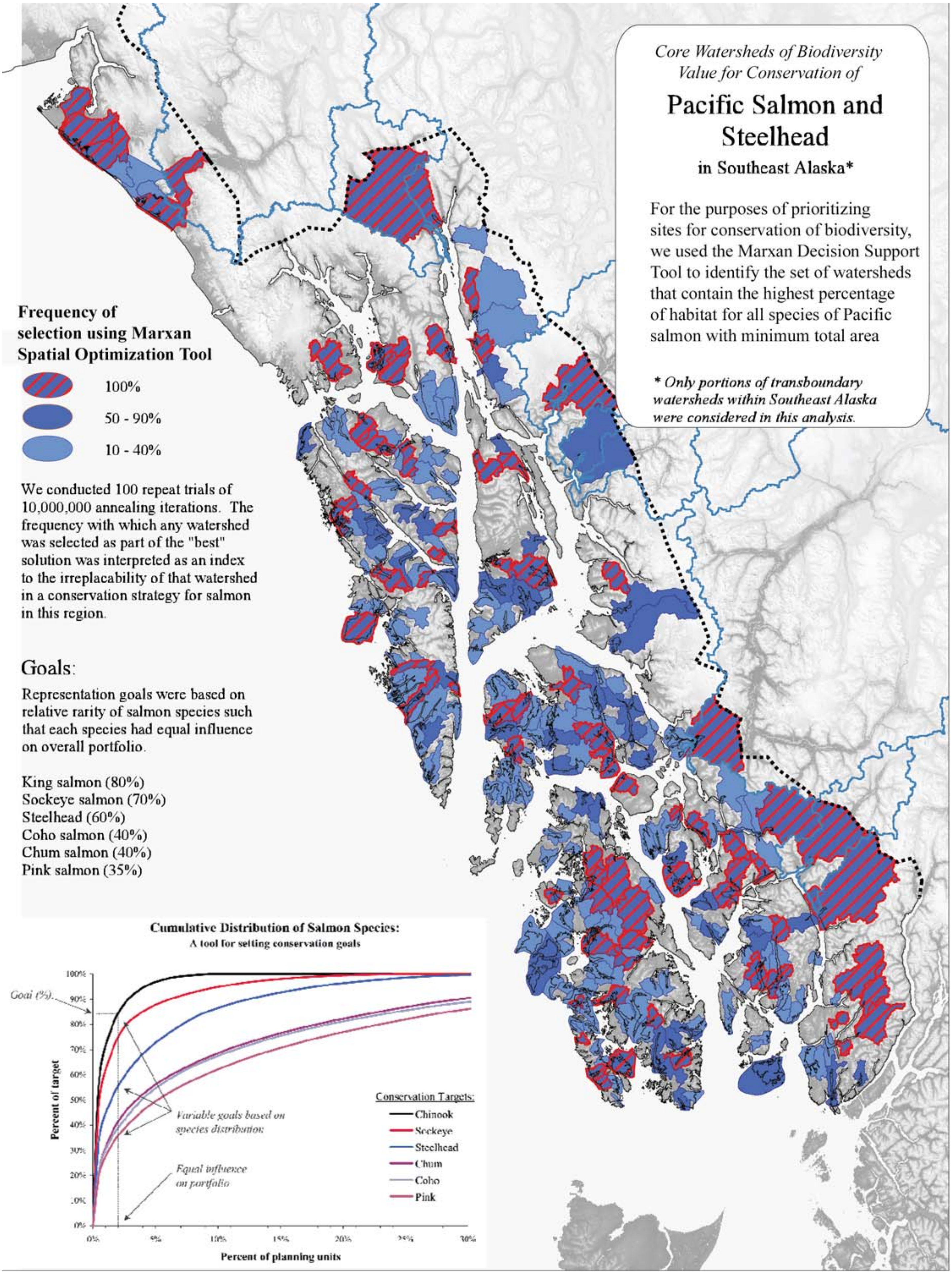
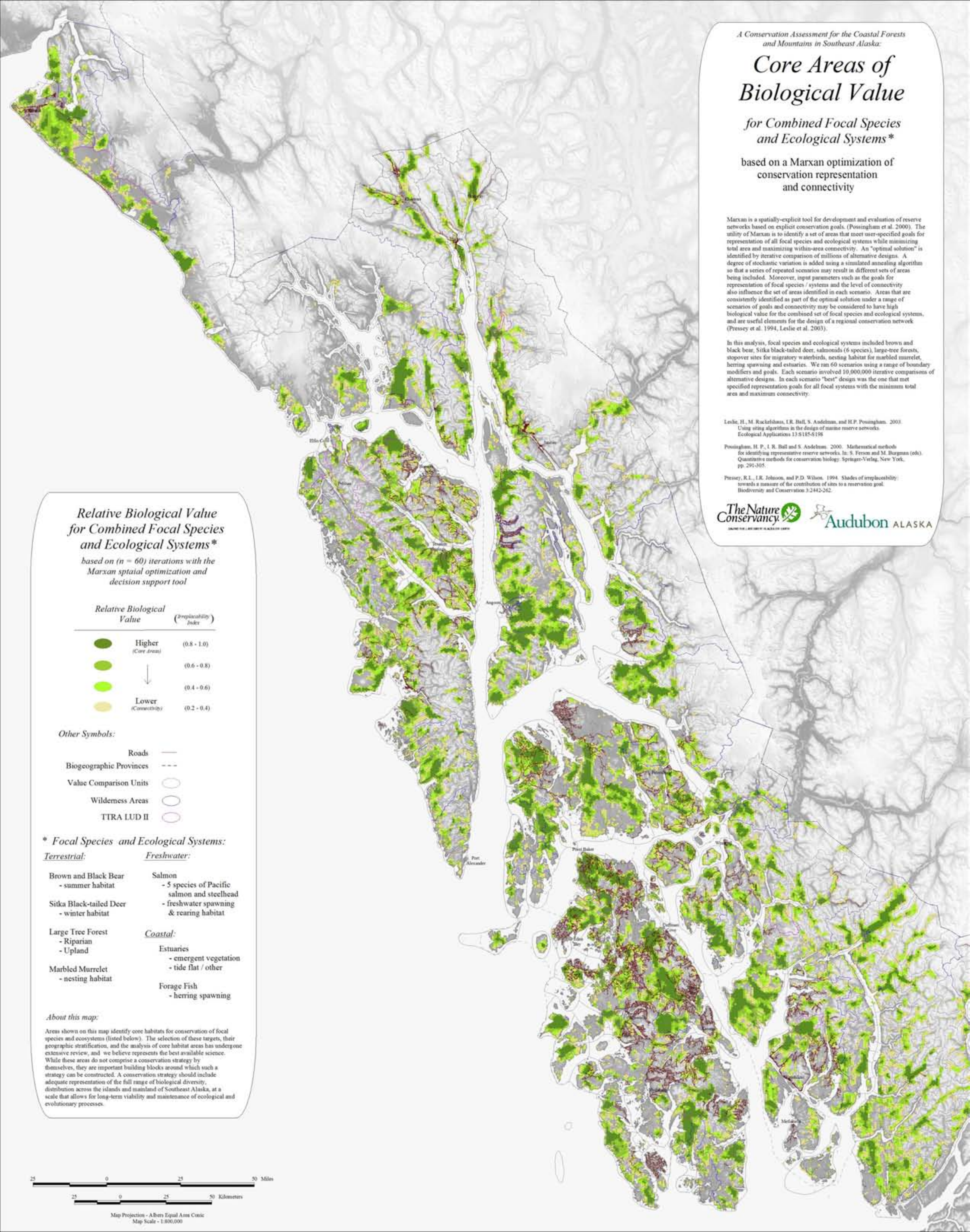
A comparison of watershed-scale protection and forest condition
Forest Condition
Intact (<5% cut)
Modified (>5% cut)
Scale of Conservation
Protected Watershed (>85% of entire VCU protected)
Development LUD's and Sub-watershed reserves
Russel Fjord
Glacier Bay National Park and Preserve Wilderness
Juneau
Haines
Skagway
Klukwan
Hoonah
Mud Bay
Pelican
Chichagof Island
Admiralty Island
Angoon
Baranof Island
Kake
Kuiu Island
Kupreanof Island
Petersburg
Point Baker
Wrangell
Prince of Wales Island
Klawock
Craig
Hollis
Ketchikan
Metlakatla
Hyder


Core Areas of Biological Value
for the Conservation of
Large-tree Forests
on the Tongass National Forest
and adjacent lands* based on
the Marxasn Spatial Optimization
Decision Support Tool
This analysis was conducted
to evaluate parameters and
performance of the Marxan
Optimization Model in
representation of biological
value for big-tree forests.
*(Yakutat, Glacier Bay and
Chilkat provinces are not
shown in this analysis)
Frequency of selection using the
Marxan Spatial Optimization Tool
prodives an index to the relative value
of sites in meeting quantitative goals
for the representation of forest diversity
in an efficient conservation system
Relative Biological Value
(index of irreplacability)
Very High Value (>90%)
High Value (50% - 90%)
Moderate Value (10% - 50%)
Roads


Core Areas of Biological Value
for the Conservation of
Winter Habitat for
Sitka Black-tailed Deer
on the Tongass National Forest
and adjacent lands* based on the
Marxan Spatial Optimization and
Decision Support Tool
This analysis was conducted to evaluate
parameters and performance of the Marxan
Optimization Model in representation of
Sitka black-tailed deer habitat values.
Frequency of selection using the
Marxan Spatial Optimization Tool
provides an index to the relative value
of sites in meeting quantitative goals
for the representation of deer habitat
in an efficient conservation system.
Relative Biological Value
(index of irreplacability)
Very High Value
(>90%)
High Value
(50% - 90%)
Moderate Value
(10% - 50%)


Core Areas of Biological Value
for the Conservation of
Brown and Black Bear Habitat
on the Tongass National Forest and adjacent lands* based on the Marxan Spatial Optimization and Decision Support Tool
This analysis was conducted to evaluate parameters and performance of the Marxan Optimization Model in representation of brown and black bear habitat values.
*(Yakutat, Glacier Bay and Chilkat provinces are not shown)
Frequency of selection using the Marxan Spatial Optimization Tool provides an index to the relative value of sites in meeting quantitative goals for the representation of bear habitat in an efficient conservation system.
Relative Biological Value
(index of irreplacability)
Very High Value
(>90%)
High Value
(50% - 90%)
Moderate Value
(10% - 50%)


Core Watersheds of Biodiversity Value for Conservation of
Pacific Salmon and Steelhead
in Southeast Alaska*
For the purposes of prioritizing sites for conservation of biodiversity, we used the Marxan Decision Support Tool to identify the set of watersheds that contain the highest percentage of habitat for all species of Pacific salmon with minimum total area
* Only portions of transboundary watersheds within Southeast Alaska were considered in this analysis.
Frequency of selection using Marxan Spatial Optimization Tool
100%
50 - 90%
10 - 40%
We conducted 100 repeat trials of 10,000,000 annealing iterations. The frequency with which any watershed was selected as part of the "best" solution was interpreted as an index to the irreplacability of that watershed in a conservation strategy for salmon in this region.
Goals:
Representation goals were based on relative rarity of salmon species such that each species had equal influence on overall portfolio.
King salmon (80%)
Sockeye salmon (70%)
Steelhead (60%)
Coho salmon (40%)
Chum salmon (40%)
Pink salmon (35%)
Cumulative Distribution of Salmon Species:
A tool for setting conservation goals
Goal (%)
Variable goals based on species distribution
Equal influence on portfolio
Conservation Targets:
Chinook
Sockeye
Steelhead
Chum
Coho
Pink
Percent of target
Percent of planning units



A Conservation Assessment for the Coastal Forests and Mountains in Southeast Alaska:

Core Areas of Biological Value

*for Combined Focal Species and Ecological Systems**

based on a Marxan optimization of conservation representation and connectivity

Marxan is a spatially-explicit tool for development and evaluation of reserve networks based on explicit conservation goals. (Possingham et al. 2000). The utility of Marxan is to identify a set of areas that meet user-specified goals for representation of all focal species and ecological systems while minimizing total area and maximizing within-area connectivity. An "optimal solution" is identified by iterative comparison of millions of alternative designs. A degree of stochastic variation is added using a simulated annealing algorithm so that a series of repeated scenarios may result in different sets of areas being included. Moreover, input parameters such as the goals for representation of focal species / systems and the level of connectivity also influence the set of areas identified in each scenario. Areas that are consistently identified as part of the optimal solution under a range of scenarios of goals and connectivity may be considered to have high biological value for the combined set of focal species and ecological systems, and are useful elements for the design of a regional conservation network (Pressey et al. 1994, Leslie et al. 2003).

In this analysis, focal species and ecological systems included brown and black bear, Sitka black-tailed deer, salmonids (6 species), large-tree forests, stopover sites for migratory waterbirds, nesting habitat for marbled murrelet, herring spawning and estuaries. We ran 60 scenarios using a range of boundary modifiers and goals. Each scenario involved 10,000,000 iterative comparisons of alternative designs. In each scenario "best" design was the one that met specified representation goals for all focal systems with the minimum total area and maximum connectivity.

Leslie, H., M. Ruckelshaus, I.R. Ball, S. Andelman, and H.P. Possingham. 2003. Using siting algorithms in the design of marine reserve networks. Ecological Applications 13:S185-S198

Possingham, H. P., I. R. Ball and S. Andelman. 2000. Mathematical methods for identifying representative reserve networks. In: S. Ferson and M. Burgman (eds). Quantitative methods for conservation biology. Springer-Verlag, New York, pp. 291-305.

Pressey, R.L., I.R. Johnson, and P.D. Wilson. 1994. Shades of irreplaceability: towards a measure of the contribution of sites to a reservation goal. Biodiversity and Conservation 3:2442-262.

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*Relative Biological Value for Combined Focal Species and Ecological Systems**

based on (n = 60) iterations with the Marxan sptaial optimization and decision support tool

Relative Biological Value	(*Irreplaceability Index*)
Higher (*Core Areas*)	(0.8 - 1.0)
	(0.6 - 0.8)
	(0.4 - 0.6)
Lower (*Connectivity*)	(0.2 - 0.4)

Other Symbols:

- Roads
- Biogeographic Provinces
- Value Comparison Units
- Wilderness Areas
- TTRA LUD II

* *Focal Species and Ecological Systems:*

Terrestrial:

Brown and Black Bear
- summer habitat

Sitka Black-tailed Deer
- winter habitat

Large Tree Forest
- Riparian
- Upland

Marbled Murrelet
- nesting habitat

Freshwater:

Salmon
- 5 species of Pacific salmon and steelhead
- freshwater spawning & rearing habitat

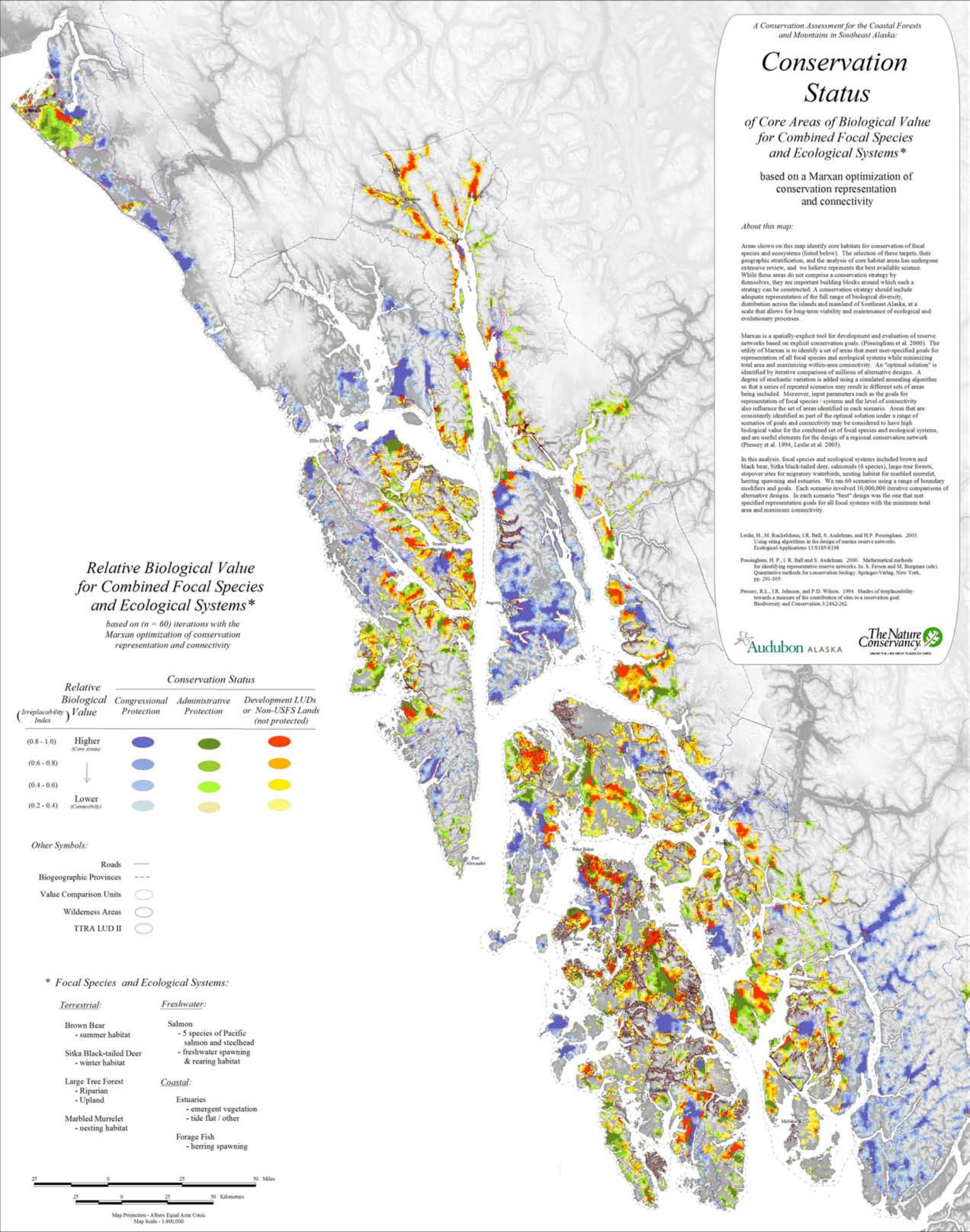
Coastal:

Estuaries
- emergent vegetation
- tide flat / other

Forage Fish
- herring spawning

About this map:

Areas shown on this map identify core habitats for conservation of focal species and ecosystems (listed below). The selection of these targets, their geographic stratification, and the analysis of core habitat areas has undergone extensive review, and we believe represents the best available science. While these areas do not comprise a conservation strategy by themselves, they are important building blocks around which such a strategy can be constructed. A conservation strategy should include adequate representation of the full range of biological diversity, distribution across the islands and mainland of Southeast Alaska, at a scale that allows for long-term viability and maintenance of ecological and evolutionary processes.



A Conservation Assessment for the Coastal Forests and Mountains in Southeast Alaska:

Conservation Status

*of Core Areas of Biological Value for Combined Focal Species and Ecological Systems**

based on a Marxan optimization of conservation representation and connectivity

About this map:

Areas shown on this map identify core habitats for conservation of focal species and ecosystems (listed below). The selection of these targets, their geographic stratification, and the analysis of core habitat areas has undergone extensive review, and we believe represents the best available science. While these areas do not comprise a conservation strategy by themselves, they are important building blocks around which such a strategy can be constructed. A conservation strategy should include adequate representation of the full range of biological diversity, distribution across the islands and mainland of Southeast Alaska, at a scale that allows for long-term viability and maintenance of ecological and evolutionary processes.

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Audubon ALASKA

The Nature Conservancy

A Preliminary Ranking of

Watershed Values

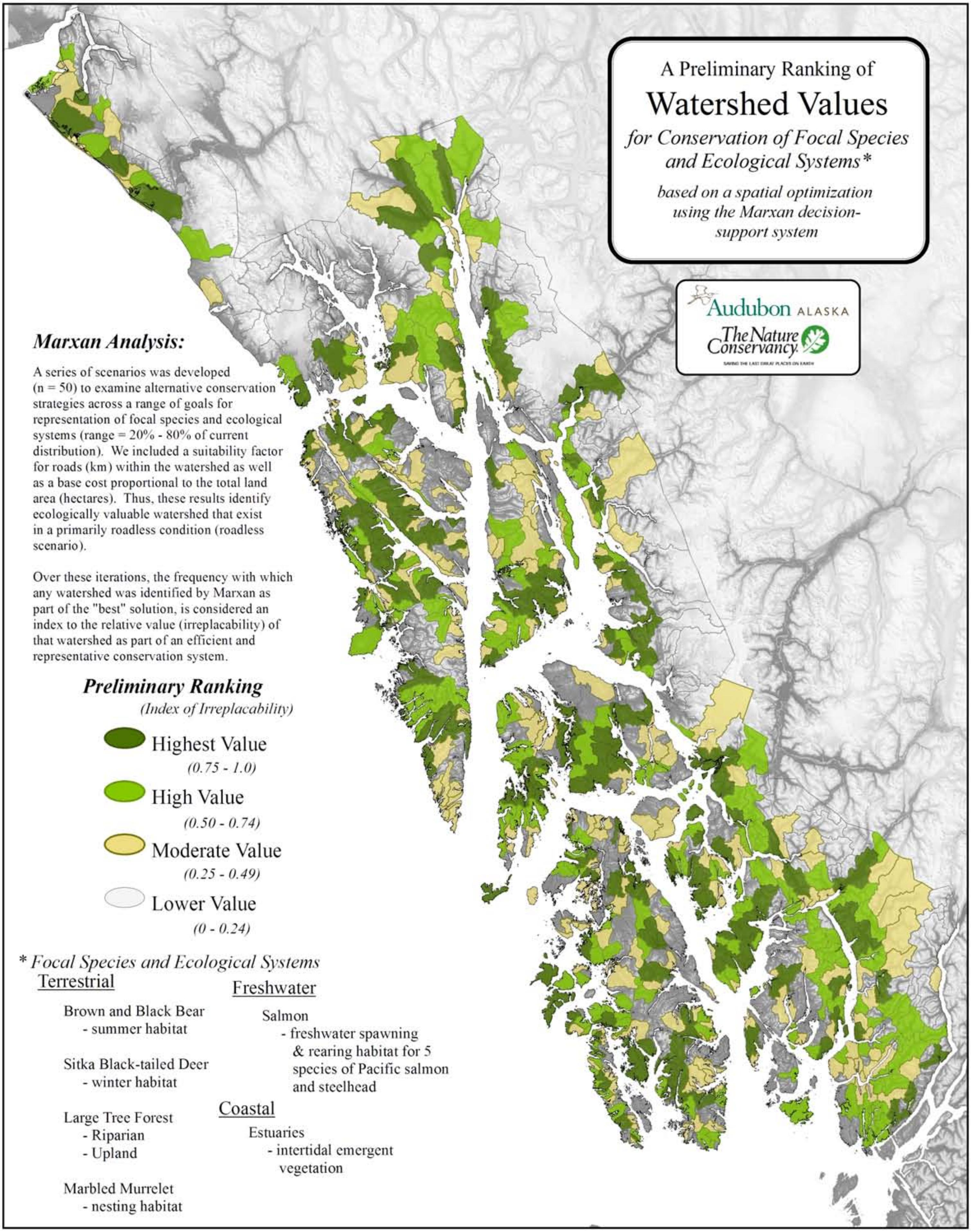
*for Conservation of Focal Species and Ecological Systems**

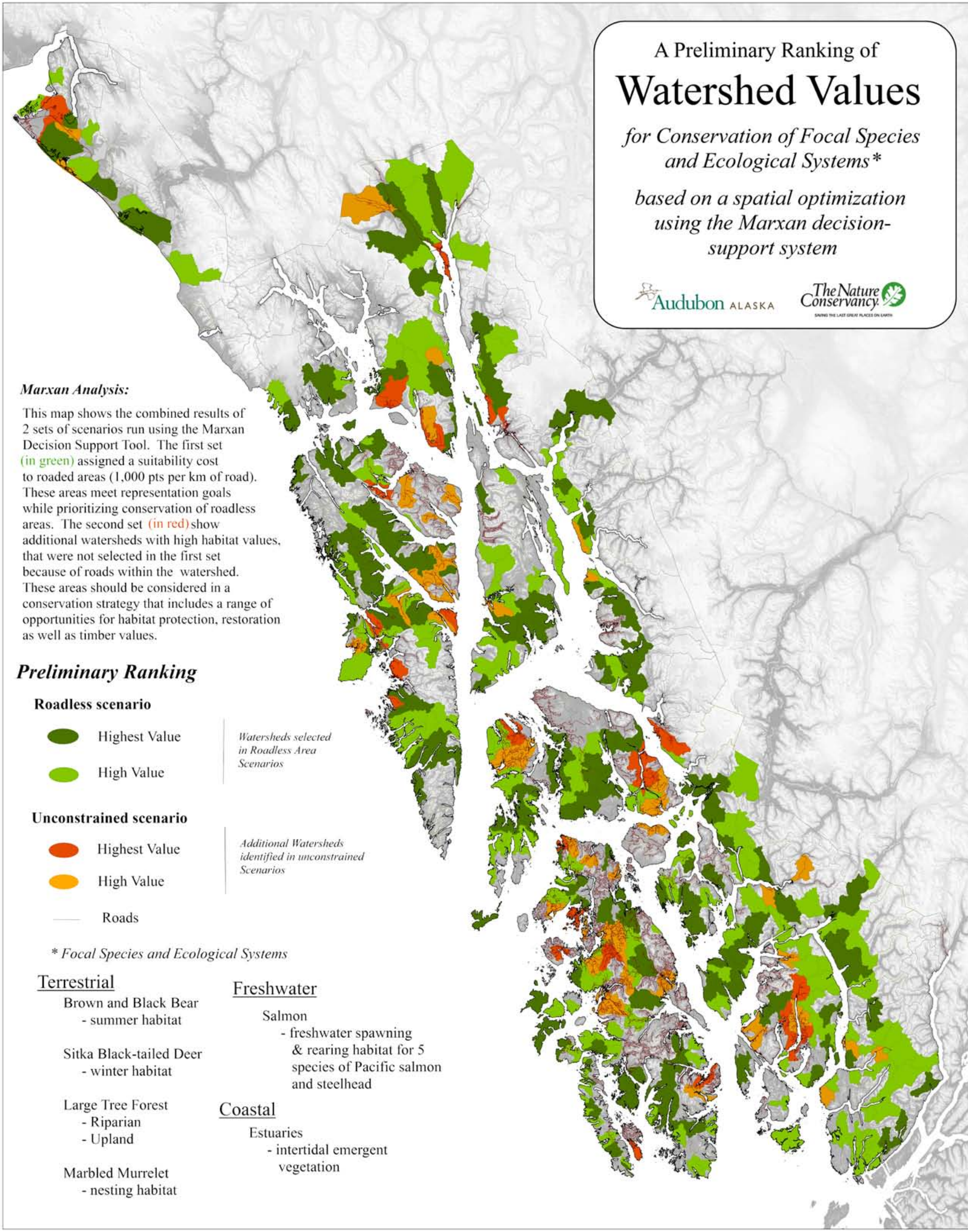
based on a spatial optimization using the Marxan decision-support system

Marxan Analysis:

A series of scenarios was developed (n = 50) to examine alternative conservation strategies across a range of goals for representation of focal species and ecological systems (range = 20% - 80% of current distribution). We included a suitability factor for roads (km) within the watershed as well as a base cost proportional to the total land area (hectares). Thus, these results identify ecologically valuable watershed that exist in a primarily roadless condition (roadless scenario).

Over these iterations, the frequency with which any watershed was identified by Marxan as part of the "best" solution, is considered an index to the relative value (irreplacability) of that watershed as part of an efficient and representative conservation system.




A Preliminary Ranking of
Watershed Values
for Conservation of Focal Species and Ecological Systems*
based on a spatial optimization using the Marxan decision-support system
Audubon ALASKA
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Marxan Analysis:
This map shows the combined results of 2 sets of scenarios run using the Marxan Decision Support Tool. The first set (in green) assigned a suitability cost to roaded areas (1,000 pts per km of road). These areas meet representation goals while prioritizing conservation of roadless areas. The second set (in red) show additional watersheds with high habitat values, that were not selected in the first set because of roads within the watershed. These areas should be considered in a conservation strategy that includes a range of opportunities for habitat protection, restoration as well as timber values.
Preliminary Ranking
Roadless scenario
Highest Value
High Value
Watersheds selected in Roadless Area Scenarios
Unconstrained scenario
Highest Value
High Value
Additional Watersheds identified in unconstrained Scenarios
Roads
* Focal Species and Ecological Systems
Terrestrial
Brown and Black Bear
- summer habitat
Sitka Black-tailed Deer
- winter habitat
Large Tree Forest
- Riparian
- Upland
Marbled Murrelet
- nesting habitat
Freshwater
Salmon
- freshwater spawning & rearing habitat for 5 species of Pacific salmon and steelhead
Coastal
Estuaries
- intertidal emergent vegetation