Southeastern Alaska Conservation Strategy: A Conceptual Approach

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FIG 1. Gilbert Bay on the mainland south of Juneau. Additional protection for large intact watersheds is the key to an effective conservation strategy in southeastern Alaska. (John Schoen photo)

Coastal temperate rainforests are rare throughout the world. The largest temperate rainforest (representing about half of this ecosystem worldwide) occurs along the Pacific Coast from northern California through south coastal Alaska. Although the southern half of the Pacific rainforest has largely been developed, northern British Columbia and southeastern Alaska (Southeast) still retain large areas of intact forest. In fact, Southeast represents a significant portion (~30%) of the earth's remaining old-growth temperate rainforest.

Today, conservationists and resource managers have an extraordinary opportunity to conserve biological diversity and maintain ecosystem integrity throughout Southeast while balancing the diverse resource needs of local communities. We use the term biological diversity to encompass genes, species, populations, communities, ecosystems, and landscapes as well as their composition, structure, and function (Noss 1990). The term "ecological integrity" is defined by Poiani et al. (2000) as the ability to maintain component species and processes over long time frames. The time frame considered in this assessment is greater than 100 years.

To capitalize on this unique conservation opportunity, it is necessary to assess and refine the conservation strategy for Southeast and the Tongass National Forest (Tongass) before conservation options are foreclosed by substantial new development in roadless areas, forest fragmentation, and loss of rare, at risk habitats. The focus of this resource synthesis and conservation strategy was to assess original and current representation of focal resources (e.g., salmon habitat, deer habitat, large-tree old growth, etc.) across the region and identify areas of high ecological values (Chapters 2 & 3). This assessment also evaluated the cumulative ecological risks for focal species and ecological systems by biogeographic province throughout Southeast (Chapter 3). The goal of this strategy is to assist resource managers and conservationists in setting conservation priorities, minimizing environmental impacts of forest management activities, and maintaining the biodiversity and ecological integrity of Southeast's rainforest cosystem.

FOREST MANAGEMENT PRINCIPLES

The Ecological Society of America has developed a set of principles for managing national forests in the United States (Aber et al. 2000). Principles that are relevant to land management and conservation in Southeast and the Tongass include:

- Conservation of forest biodiversity requires reducing forest fragmentation by clearcuts and roads, avoiding harvest in vulnerable areas such as old-growth stands and riparian zones, and restoring natural structural complexity to cutover sites;
- Planning at the landscape level is needed to address ecological concerns such as biodiversity, water flows, and forest fragmentation;
- Despite natural disturbance and successional change, forest reserves are much more likely to sustain the full biological diversity of forests than lands managed primarily for timber production;
- Protection of water quality and yield and prevention of flooding and landslides require greater attention to the impacts of logging roads and recognition of the value of undisturbed buffer zones along streams and rivers;
- Traditional beliefs that timber harvesting can duplicate and fully substitute for the ecological effects of natural disturbance are incorrect, although newer techniques such as retaining trees and large woody debris on harvest sites can more closely mimic natural processes; and
- There is no scientific basis for asserting that silvicultural practices can create forests that are ecologically equivalent to natural old-growth forests, although our understanding of forest ecology can help restore managed forests to more natural conditions.

Additional land use principles from the Ecological Society of America (Dale et al. 2000) that are relevant to Southeast and the Tongass include:

- Examine the impacts of local decisions in a regional context;
- Preserve rare landscape elements, critical habitats, and associated species; and
- Retain large contiguous or connected areas that contain critical habitats.

TONGASS CONSERVATION STRATEGY

The conservation strategy underlying the 1997 Tongass Land Management Plan (TLMP) (USFS 1997a, b) was a significant improvement over the original plan. The fundamental conservation strategy of TLMP 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]) as well as establishing forest-wide standards and guidelines for the protection of various resources. Protection of riparian buffers and HCAs, in particular, add substantial value to the Tongass conservation strategy.

In addition, the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 and the Tongass Timber Reform Act (TTRA) of 1990 permanently protected 6,479, 963 acres (2,622,405 ha) of land in Southeast. This watershed-scale protection provides an important foundation for the Tongass Conservation Strategy. Except for Admiralty Island, however, forest diversity and biological values are relatively low in most of the congressionally designated wilderness and national park and preserve areas (Chapter 3, Fig 1). For example, 65% of intact watersheds occur on the rugged mainland coast and Glacier Bay (Chapter 2). Clearly, some important habitat types (e.g., large-tree karst and flood plain spruce) are not adequately represented in conservation areas across Southeast and the Tongass (Chapter 2, Table 6). In fact, 57% of the original distribution of the most productive timber land (medium- and large-tree old growth) in Southeast exists in development land use designations (LUDs) or sub-watershed reserves (Chapter 2). This is a common problem throughout the world as the most productive lands have generally been developed first and are usually significantly under-represented in conservation areas (Scott et al. 2001a, b, Lindenmayer and Franklin 2002).

Past forest management in Southeast has significantly altered the landscape (Chapter 2, Table 5). For example, based on a Forest Service landscape analysis of southeast Chichagof (Shephard 1999), timber harvest over the last 50 years has reduced the area of old-growth forest, decreased average old-growth block size, increased the distance between blocks, decreased the amount of core to edge old growth, and removed about 44% of the rare flood plain spruce stands (over 80% of flood plain spruce have been harvested in some watersheds). Similar landscape scale changes have also occurred on northern Prince of Wales, Mitkof, Kupreanof, and Zarembo islands, as well as some of the outer islands west of Prince of Wales (refer to chapters 2 and 4 for details).

The 1997 TLMP conservation strategy incorporates the protection of old-growth forest habitat through land use designations and HCAs, buffer areas, and standards and guidelines for the matrix between reserves. These tools were designed to maintain viable populations throughout the forest. In forest development areas, this approach is largely focused on protecting habitat patches within watersheds. Additional harvest of old growth under this approach will result in:

- Loss of additional old-growth forest habitat,
- Reduced forest and habitat diversity,
- Increased habitat and watershed fragmentation, and
- Cumulative ecological impacts from additional road construction.

This within-watershed approach to habitat protection assumes a complete knowledge of the habitat relationships of many species. Without such knowledge, it is impossible to know whether all the essential habitats have been adequately protected. At the scale of individual watersheds, protecting patches of forest habitat while logging adjacent areas and constructing roads will reduce ecosystem integrity of the watershed by removing important habitat types, risking increased sedimentation and changes to hydrology, and facilitating human access thus increasing pressure on sensitive populations. In addition, there is little long-term assurance that all the protected pieces will remain administratively protected or will not unravel from trees blowing down along the edges of old-growth reserves. Many of these concerns are minimized by protecting intact watersheds.

Although past harvest targeted the most accessible and highest quality timber types (e.g., flood plain spruce and karst old growth) (refer to tables 3-6 in Chapter 2), it is likely that economic factors will continue to focus harvest on the best, most accessible timber stands remaining. This pressure will further reduce habitat diversity within affected watersheds. The cumulative effects of past and future timber harvest of large- and medium-tree old growth—in combination with the extensive harvest on adjacent private lands—will likely reduce ecosystem integrity at the watershed scale. Biological diversity and ecosystem integrity may also be compromised on a multiple watershed or regional scale within some entire biogeographic provinces with a history of intensive timber harvest (e.g., northern Prince of Wales Island, Dall Island Complex, Kupreanof-Mitkof islands) (refer to Chapter 2, Table 6; Chapter 3, Fig 2, and Chapter 4). Loss of rare habitat types (e.g., large-tree old growth) will affect the fish and wildlife populations which selectively use those habitats.

In addition to habitat loss and reduced diversity, numerous scientific studies have also implicated forest roads as having negative effects on terrestrial and aquatic ecosystems (Trombulak and Frissell 1999, US Forest Service 2001). According to the US Forest Service (2001), "Undersirable consequences (of roads) include adverse effects on hydrology and geomorphic features (such as debris slides and sedimentation), habitat fragmentation, predation, road kill, invasion by exotic species, dispersal of pathogens, degraded water quality and chemical contamination, degraded aquatic habitat, use conflicts, destructive human actions (for example, trash dumping, illegal hunting, fires), lost solitude, depressed local economies, loss of soil productivity, and decline in biodiversity." Specifically regarding the Tongass, the panel of fish experts that evaluated the 1997 TLMP stated that "A reduction of road development in any alternative reduces risks to fish habitat." (Dunlap 1997). Because roads have potential for introducing varied impacts to both terrestrial and aquatic ecosystems, roadless areas provide a significant foundation for developing comprehensive regional conservation strategies (Strittholt and Dellasala 2001).

REFINING THE TONGASS CONSERVATION STRATEGY

Watershed-scale Conservation

Numerous ecological studies suggest that conservation action and management should take place at the scale of entire watersheds (Stanford and Ward 1992; Naiman et al. 1997, 2000; Pringle 2001; Baron et al. 2002). For example, many of the species and trophic systems of Southeast (e.g., salmon spawning and rearing and the interactions between wildlife species and salmon) tend to be strongly linked to key ecological processes at a watershed-scale (e.g., sedimentation, stream flow, and nutrient cycling). In fact, the productivity of coastal ecosystems is strongly linked to salmon populations which are considered "keystone" species (Willson and Halupka 1999). In addition, field studies suggest that watersheds are the appropriate scale to measure and manage cumulative human impacts. Measurable indicators tend to correlate with human activity data when measured at watershed scales (Karr 1991; Roth 1996; Muhar and Jungwirth 1998; Thorton 2000; Carignan et al. 2002; Pess et al. 2002). Thus, because watersheds define an appropriate ecological unit where human impacts tend to accumulate and can be measured and because of their value for key ecological processes and the global rarity of intact watersheds, identifying and representing a range of intact watersheds should be included as a part of any credible, systematic, science-based conservation analysis. In fact, the panel of fish experts evaluating the 1997 TLMP recommended that the most effective protection of fish habitat on the Tongass would be reserves that included entire watersheds rather than only parts of watersheds (Dunlap 1997). Bryant and Everest (1998) also emphasized the importance of watershed-scale conservation: "The presence, number and distribution of intact watersheds across the landscape of the TNF (Tongass National Forest) are critical elements for sustainable salmon populations in the face of habitat loss elsewhere in southeast Alaska and the Pacific Northwest."

The Tongass is naturally fragmented by islands and coastal ice fields and many of the islands have distinct climatic, floral, and faunal differences. This presents a challenge for conservation of biodiversity because insular populations have historically exhibited high risk of local extinction (Cook et al. 2001, also refer to Chapter 6.7). In this assessment, we used a geographic stratification based on biogeographic provinces (US Forest Service 2003) to insure that conservation areas are sufficiently distributed to maintain viable populations throughout Southeast (Chapter 2, Fig.2). An effective conservation strategy for Southeast and the Tongass should include a representative set of protected watersheds with high ecological values within each of the region's biogeographic provinces.

In recognition of the strengths and weaknesses of the 1997 TLMP conservation strategy, we recommend adding a complementary strategy of protecting additional intact watersheds. Protecting intact watersheds with high ecological values will:

- Maintain the natural range of variation of forest types (i.e., habitat diversity);
- Minimize habitat fragmentation within protected watersheds;
- Reduce road impacts; and
- Maintain ecosystem integrity within protected areas at the watershed and province scales.

Instead of cutting timber and building roads evenly distributed throughout a forested landscape, Franklin (1989) suggested aggregating impacts to minimize habitat fragmentation. Within the Tongass Forest's operable timber base (LUDs 3 & 4), aggregating timber harvest in fewer watersheds would enable the protection of an additional sample of intact watersheds with high ecological values. Aggregating timber harvest may also enhance efficiency of some timber operations. This landscape-scale approach (i.e., protecting more intact watersheds) would strengthen the 1997 TLMP conservation strategy and maintain conservation options over time. Protecting intact watersheds would essentially hedge our bets by maintaining conservation options in recognition of the high degree of uncertainty associated with ecological systems. Scientists and managers have incomplete knowledge of many of Southeast's ecological processes and species habitat requirements. We assume that by protecting intact watersheds—from ridge top to ridge top and headwaters to estuary—and their natural range of variability, ecological integrity within the watershed will be maintained. This landscape-scale strategy would also increase the probability of protecting wide-ranging species like brown bears and wolves that are placed at risk by expanding road systems and increased human access.

These recommendations are consistent with the 1994 TLMP peer reviewers' comments (Kiester and Eckhardt 1994) to keep landscape options open and not further fragment large blocks of high-volume (large-tree) old growth or eliminate rare, potentially important, habitat types. This complementary conservation strategy—protecting an additional sample of intact watersheds within each biogeographic province—also parallels the September 1997 joint statement of the peer review committee (Powell et al. 1997) which stated: "Perhaps of greatest concern is the failure to protect the Forest's remaining pristine watersheds."

Assessing Ecological Values of Watersheds

In the watershed strategy described in this report, we selected a suite of focal species and ecological systems to estimate ecological values at the watershed level. We used habitat capability models from the Tongass Land Management Plan (as modified by an interagency review group of wildlife experts) to assess the winter habitat value of deer and the summer habitat value for brown bear. We used the brown bear model to also represent black bear habitat. An interagency and university team of experts developed a nesting habitat model for marbled murrelets based on data from Alaska and British Columbia. Salmon spawning and rearing habitat was assessed by combining the ADF&G Fish Distribution Database (FDD) with the USFS Stream Inventory. An inventory of upland and riparian large-tree forests was assembled from USFS forest and soils inventory data. Estuary occurrence data were derived from the intertidal emergent vegetation class (E2EM) from the USF&WS National Wetlands Inventory (NWI) data and interpreted from Landsat ETM imagery for areas where NWI was not available.

To assess the relative ecological value of watersheds, watershed comparisons were made within biogeographic provinces (22 distributed throughout Southeast). Watershed value comparisons were conducted using the Marxan spatial optimization tool (Possingham et al. 2000, also refer to Chapter 2). Marxan is a spatially-explicit tool for developing and evaluating reserve networks based on specific conservation goals. 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. Using a simulated annealing algorithm, an "optimal solution" is identified by iterative comparison of millions of alternative designs. In this application, areas that were consistently identified as part of the optimal solution under a range of scenarios were considered to have high ecological value for the combined set of focal species and ecological systems, and therefore useful elements for the design of a regional conservation network (Pressey et al. 1994).

Marxan runs were conducted for individual variables as well as all variables combined and Southeast experts reviewed and evaluated the results.

The watershed analysis included the following variables:

Terrestrial:
- Brown & black bear summer habitat
- Black-tailed deer winter habitat
- Marbled murrelet nesting habitat
- Large-tree forest
  - Riparian
  - Upland

Freshwater:
- Salmon spawning and rearing habitat

Coastal:
- Estuaries

Marxan runs for all resources combined identified core areas of ecological values within watersheds (Chapter 2, Fig 18) as well as 4 tiers (quartiles) of ecological value (Chapter 2, Fig 20 & 21) at the watershed scale within provinces with the top 2 tiers representing 50% of ecological value within the province.

Assessing Timber Suitability of Watersheds

While Marxan was originally developed as a tool for conservation, it can also be applied to evaluate an optimal design for production of timber. We applied it to meet goals based on economic factors including operability type, proximity to existing infrastructure, and minimum overlap with core areas of biological value (Chapter 2). 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.

Conservation Area Design

The ecological ranking 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. This spatial optimization of biodiversity and timber values was used to develop an integrated conservation area design for the Tongass National Forest and southeastern Alaska (Fig 2). This map combines analyses for 1) the Marxan Core Areas of ecological values, 2) the Marxan top tier watersheds (top 50% of ecological values) for both intact (roadless) and modified (roaded) watersheds, and 3) Marxan timber suitability 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. For example, intact watersheds with highest concentrations of ecological values (shown in green, Fig 2) 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 1).

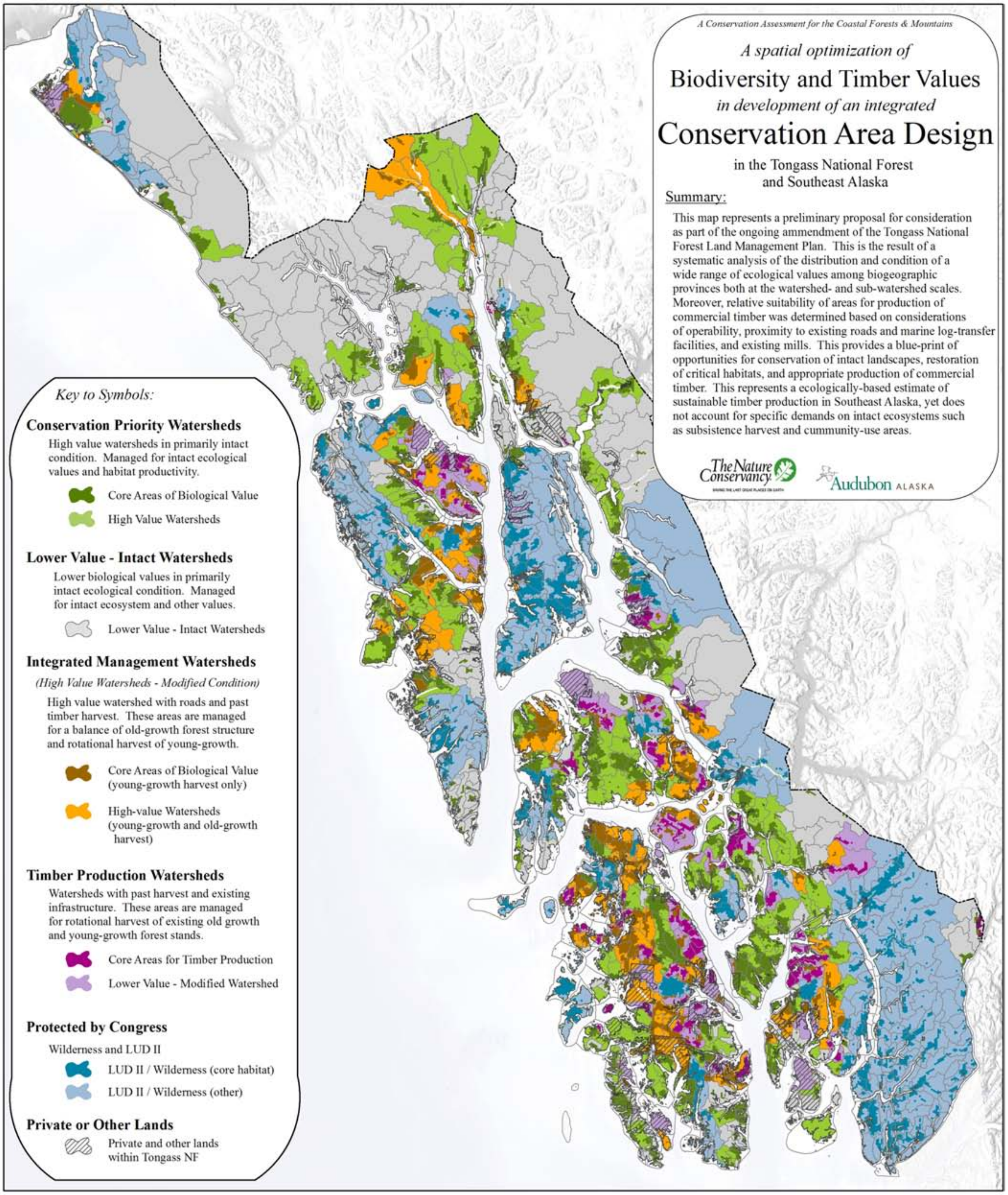

FIG 2. An integrated conservation area design based on spatial optimization of biodiversity and timber values in the Tongass National Forest and Southeast Alaska.

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 2) to emphasize the necessity to maintain critical ecosystem functions throughout the forest matrix 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 1).

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 2) 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 1).

Watersheds with lower ecological values, past timber harvest activities, and the most substantial timber infrastructure (shown in light orchid, Fig 2) 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 fewer roads, and allow greater flexibility for conservation of intact landscapes (within Conservation Priority Watersheds) and restoration (within Integrated Management Watersheds). Some of the Timber Production Watersheds also have brown core areas where old-growth conservation should be considered.

Congressionally protected lands (designated wilderness and LUD II areas) are shown as blue on the map and are unavailable for development. These watersheds contain approximately 32% of existing habitat values for all focal species and ecological systems combined (Table 1).

The primary underpinnings of this conservation strategy are to: (1) focus conservation on watersheds and sub-watershed core areas with the highest ecological values; (2) concentrate timber production within the smallest land base and with the least 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 2) within the Tongass National Forest, excluding congressionally designated Wilderness and LUD II lands, are listed (in ranked order) by province in Table 2. These largely intact watersheds generally encompass the highest ecological values within each province and represent some of the highest conservation priorities on the Tongass National Forest. Again, 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 2) within the Tongass National Forest, excluding congressionally designated Wilderness and LUD II lands, are listed (in ranked order) by province in Table 3. These watersheds have had a history of intensive logging and roading but still retain substantial ecological values because they were originally some of the most productive watersheds in Southeast. Specific restoration opportunities include the North Prince of Wales, Revilla, Mitkof, Kuiu, and East Chichagof provinces.

Analytical Tools

The watershed data for focal resources used in these analyses are included in the watershed matrix (Appendix B). The matrix (an excel spreadsheet) provides much of the details behind the maps. It is organized by province and rank orders watersheds by their combined ecological values. Ecological values for individual focal species and systems are also ranked along with the percentage value that resource contributes to the overall province. Each watershed has a VCU # and watershed name, a total Marxan score (range 0-50), and its rank within the 4 tiers (quartiles) of ecological value. Additionally, total watershed area, miles (km) of road, and acres (ha) clearcut are included in the matrix.

Finally, a selected set of GIS data layers were compiled for viewing in Arc Reader, a share-ware utility for read-only access to the GIS database (available upon request and packaged separately on DVD). This tool allows individuals to use a personal computer and scroll through a map of Southeast, at any scale, and apply a set of data filters to view landscape, habitat, and focal species data as well as ecological values of core areas, watershed (VCU) rankings, and TLMP land use designations and habitat reserves.

These maps, the watershed matrix, and GIS database provide useful tools for evaluating current conservation measures, setting conservation priorities, and refining the conservation strategy for Southeast and the Tongass. This assessment and analytical tools do not represent a final conservation strategy at this time but can be used for making informed, science-based, decisions as a conservation strategy for Southeast is further updated and refined. The data presented here summarize the ecological values of watersheds within provinces based on the focal species and systems selected for this analysis. Community and subsistence values are not included in this analysis but are important attributes that must also be incorporated into a conservation strategy for Southeast and the Tongass. Special features, such as unique fish stocks, endemic species, karst caves, and ecological connectivity should also be considered in developing an effective conservation strategy and can be incorporated as they become available.

SUMMARY OF CONSERVATION RECOMMENDATIONS

The ecological integrity (i.e., long-term productivity and resilience of fish, wildlife, and their habitats) of Southeast's rainforest ecosystem will depend, in large part, on balancing industrial development with sound conservation measures, including an expanded watershed-scale reserve system for this region. An expanded system of intact watershed reserves would complement the current TLMP conservation strategy and minimize risks to ecosystem integrity, including sensitive populations of fish and wildlife and rare habitat types (e.g., large-tree old-growth forests). The establishment of additional watershed reserves also would expand the scientific benchmark for monitoring future habitat and population changes and determining the cause of such change. This may become an important tool for evaluating the effects of global climate change in Southeast. Audubon Alaska and The Nature Conservancy have identified core areas of biological value as well as Conservation Priority Watersheds and Integrated Management Watersheds. To maintain ecosystem integrity and conserve fish and wildlife populations and the natural range of variability of habitat types, we recommend consideration of the following conservation measures throughout Southeast and the Tongass.

1. Maintain and expand the existing conservation reserve network to include additional intact watersheds (Conservation Priority Watersheds) throughout Southeast and the Tongass;
2. Each of Southeast's 22 biogeographic provinces should include a representative set of intact watershed reserves of high ecological value;
3. The watershed matrix ranks watersheds on their ecological values based on focal species and ecological systems. The highest ranked watersheds should be given conservation priority. Conservation Priority Watersheds have been mapped (Fig 2) and encompass the highest ecological values (for intact watersheds) within each province. Conservation Priority Watersheds may provide a useful template for expanding the watershed reserves in provinces with under-represented reserves;
4. Establish ecological restoration priorities for selected watersheds throughout Southeast and the Tongass;
5. Some provinces (e.g., North Prince of Wales, Kupreanof / Mitkof) have undergone substantial resource development activities and may be at risk of losing their ecological integrity. Developed watersheds which still maintain relatively high ecological values (e.g., Integrated Management Watersheds) have been mapped (Fig 1) and should be given first priority for restoration activities;
6. Establish scientific benchmarks for long-term ecological research and monitoring in selected watershed reserves within representative provinces distributed across Southeast;

7. Use the Arc Reader GIS database to review and refine the TLMP old-growth reserve structure;

8. Standards and guidelines strengthen conservation measures throughout the forest matrix and should be reviewed and revised, where appropriate, in consultation with species experts from state and federal resource agencies and universities;

9. Apply best management practices (e.g., TLMP conservation strategy including HCAs, OGRs, habitat buffers, standards and guidelines, and State Forest Practices Act guidelines) to resource development projects conducted in matrix lands throughout Southeast. Particular emphasis should be placed on maintaining riparian buffers and productive salmon spawning and rearing habitat throughout Southeast and the Tongass;

10. Consider establishing additional critical habitat areas surrounding state lands and waters that include high-value and/or sensitive fish and wildlife habitats and where multiple land or water jurisdictions overlap, consider developing co-management agreements to safeguard fish and wildlife habitat values.

TABLE 1. 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 2. 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 2).

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 2 (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 2).

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

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TABLE 2 (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 2).

Biogeographic Province	Watershed Name[a]	VCU	Administrative protection (%)	Development Lands[b] (%)	Acres
Revilla Is. /	Bell Arm	7280	100.0%	0.0%	12,917
Cleveland Pen.	Orchard Creek	7340	91.0%	8.9%	32,858
(continued)	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	Cholmondeley Sound (West Arm)	6740	20.0%	80.0%	19,901
of Wales	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

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TABLE 2 (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 2).

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

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TABLE 2 (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 2).

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 3. 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 2).

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

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TABLE 3 (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 2).

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.

REFERENCES

Aber, J., N. Christensen, I. Fernandez, J. Franklin, L. Hidinger, M. Hunter, J. MacMahon, D. Mladenoff, J. Poastor, D. Perry, R. Slangen, H. van Miergroet. Applying ecological principles to management of the U.S. National Forests. Issues in Ecology 6:1-20.

Baron, JS, NL Poff, PL Angermeier, CN Dahm, PH Gleick, NG Hairston, Jr., RB Jackson, CA Johnston, BG Richter, and AD Steinman. 2002. Meeting ecological and societal needs for freshwater. Ecological Applications 12:1247-1260.

Carignan, R., D'Arcy, P., Lamontagne, S. 2000. Comparative impacts of fire and forest harvesting on water quality in boreal shield lakes. Canadian Journal of Fisheries and Aquatic Sciences 57 (Supplement 2): 105-117.

Cook, J.A., Bidlack, A.L., Conroy, C.J., Demboski, J.R., Fleming, M.A., Runck, A.M., Stone, K.D. MacDonald, S.O., 2001. A phylogeographic perspective on endemism in the Alexander Archipelago of the North Pacific. Biological Conservation 97, 215 – 227.

Dale, V., S. Brown, R. Haeuber, N. Hobbs, N. Huntly, R. Naiman, W. Riebsame, M. Turner, and T. Valone. 2000. Ecological principles and guidelinies for managing the use of land. Ecological Applications 10:639-670.

Dunlap, R. 1997. Summary of the 1997 fish habitat risk assessment panel. Appendix 1 in C Shaw III. 1999. Use of risk assessment panels during revision of the Tongass Land and Reesource Management Plan. General Technical Report PNW-GTR-460. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Franklin, J. 1989. The "new forestry." J. of soil and water conservation 44:549.

Karr, J. R. 1991. Biological integrity: a long neglected aspect of water resource Management. Ecological Applications 1: 66-84.

Keister, A. and C. Eckhardt. 1994. Review of Wildlife management and conservation biology on the Tongass National Forest: A synthesis with recommendations. Pacific Northwest Research Station, USDA Forest Service, Corvallis, OR.

Lindenmayer, D. and J. Franklin. 2002. Conserving forest biodiversity: a comprehensive multiscaled approach. Island Press. Washington.

Muhar, S. and Jungwirth, M. 1998. Habitat integrity of running waters - assessment criteria and their biological relevance. Hydrobiologia, 386: 195-202.

Naiman, R.J., P.A. Bisson, R.G. Lee, and M.G. Turner. 1997. Approaches to management at the watershed scale. Pages 239-253, in: K. Kohm and J.F. Franklin (editors), Creating A Forestry for the 21st Century: The Science of Ecosystem Management, Island Press, Washington, D.C.

_____., R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience. 50(11):996-1011.

Noss, R. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4:355-364.

Pess, G. R., D. R. Montgomery, R. E. Bilby, A. E. Steel, B. E. Feist, and H. M. Greenberg. 2002. Landscape characteristics, land use, and coho salmon (Oncorhynchus kisutch) abundance, Snohomish River, Washington State, USA. Canadian Journal of Fisheries and Aquatic Sciences 59: 613-623.

Poiani K. B. Richter, M. Anderson, and H. Richter. 2000. Biodiversity conservation at multiple scales: functional sites, landscapes, and networks. BioScience 50:133-146.

Possingham, H., I. Ball and S. Andelman. 2000. Mathematical methods for identifying representative reserve networks. Pages 291-306 in Quantitative Methods for Conservation Biology. S. Ferson and M. A. Burgman. New York, Springer-Verlag.

Powell, R., D. McCullough, A. Hansen, et al. 1997. Joint statement of members of the Peer Review Committee concerning the inadequacy of conservation measures for vertebrate species in the Tongass National Forest Land Management Plan of Record. Unpublished letter to the Tongass Forest Supervisor, September, 1997.

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: 242-262.

Pringle, C. 2001. Hydrologic connectivity and the management of biological reserves: A global perspective. Ecological Applications 11:981-998.

Stanford, J. and J. Ward. 1993. An ecosystem perspective of alluvial rivers: connectivity and the hyporheic corridor. Journal of the North American Benthological Society 12:48-60.

Scott, J, R. Abbitt, and C. Groves. 2001a. What are we protecting? Conservation Biology in Practice 2:18-19.

_____. F. Davis, R. McGhie, R. Wright, C. Groves, and J. Estes. 2001b. Nature reserves: do they capture the full range of America's biological diversity? Ecological Applications 11:999-1007.

Shepard, M., L. Winn, B. Flynn, R.Myron, J Winn, G Killinger, J. Silbaugh, T. Suminski, K. Barkau, E. Ouderkirk, J. Thomas. 1999. Southeast Chichagof Landscape Analysis. USDA Forest Service General Technical Report R10-TP-68. 210 p.

Strittholt, J. and D. Dellasala. 2001. Importance of roadless areas in biodiveristy conservation in forested ecosystems: case study of the Klamath-Siskiyou ecoregion of the United States. Conservation Biology 15(6)1742-1754.

Trombulak, S., and C. Frissell. 1999. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

U.S. Forest Service. 1997a. Tongass land and resource management plan. R10-MB-338dd. U.S. Forest Service Alaska Region, Juneau, AK.

_____. 1997b. Tongass land management plan revision: final environmental Impact Assessment. R10-MB-338b. USDA Forest Service Alaska Region, Juneau, AK

_____. 2001. Forest roads: a synthesis of scientific information. General Technical Report PNW-GTR-509. Pacific Northwest Research Station

_____. 2003 Tongass land management plan revision: final supplemental environmental impact statement. R10-MB-48a. USDA Forest Service, Alaska Region, Juneau, AK.

Willson, Mary F., and Karl C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. Conservation Biology 9:489-497.