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Extensive, strategic assessment of southeast Alaska's vegetative resources

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Abstract

Effective natural resources management requires knowledge of the character of resources and of interactions between resource components. Estimates of forest and other vegetation resources are presented to provide managers with information about the character of the resource. Slightly less than half (48%) of southeast Alaska has some type of forest land cover, about 29% has nonforest vegetation, and the remaining 33% is barren or water. Most forest land (85%) and nonforest vegetation (77%) is managed by the U.S. Forest Service, Alaska Region (Region 10), Tongass National Forest. Estimates of change (excluding timber harvest) are presented for the forest component of the resource base. In general, forest growth exceeds mortality by a ratio of roughly 3 to 2.

With the framework of the Alaska vegetation classification system (AVCS) as a basis, vegetation types were described and species richness and diversity values among the modified AVCS types were estimated. The highest species richness of vascular plants in closed forest occurs in the western hemlock-Alaska cedar type, the lowest in the Sitka spruce type. In the open forest category, the highest species richness is in the mixed conifer type and the lowest is again in the Sitka spruce type.

Keywords: Alaska (southeast); Inventory; Forest; Vegetation

1. Forest inventory and analysis and Alaska Region, historical perspective

Forest Inventory and Analysis (FIA) is a nationwide project of the USDA Forest Service. Various legislative acts (the McSweeney–McNary Act of 1928, the National Forest Management Act of 1976, and the Forest and Rangeland Renewable Resources Research Act of 1978) direct the secretary of agriculture to collect, analyze, and report information about renewable resources on the nation's forest, range, and related lands. More recent legislation, the Agriculture Research, Extension, and Education Reform Act of 1998, broadened the scope of resource measurements and began conversion from a periodic inventory to a continuous inventory that uses a consistent sample design conducted in all states simultaneously.

Work units located at Forest Service research stations conduct forest resource inventories throughout the United States. The FIA program of the Pacific Northwest Research Station (PNW), headquartered in Portland, Oregon, is responsible for inventories in

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the states of Alaska, California, Hawaii, Oregon, and Washington. Objectives of these inventories include provision of renewable resource data and information to characterize the amount, kind, condition, ownership, rates of accumulation or deterioration, and interrelationships of renewable resources.

The USDA Forest Service's Alaska Region (R10) and the FIA program of PNW have long cooperated to coordinate inventory activities. Beginning in the 1950s the PNW Alaska Forest Survey unit in Juneau established and remeasured timber inventory plots located on the Tongass National Forest (TNF). In the early 1970s, FIA conducted a reinventory of all forested lands in southeast Alaska across all ownerships. Alaska Region assumed responsibility for strategic inventory on TNF lands in 1973. Both FIA–PNW and R10 enjoyed close physical coordination until 1978 when the PNW–FIA unit was relocated to Anchorage. They then developed an intra-agency agreement (IAA) to preserve and extend the legacy of cooperation. Throughout the 1980s, R10 conducted forest inventories on R10 lands by using a variety of sampling designs. By 1993 the need for regionwide, consistent, updated inventory data was recognized. Under the annually updated IAA, FIA agreed to assume responsibility for design, data collection, compilation, and reporting. The inventory was broadened to include all vegetated land across all ownerships, and data collection began in 1995. The agreement between R10 and FIA served as a national model and remained in place until FIA, nationwide, assumed responsibility for strategic inventories on all national forest lands.

2. Role of FIA inventory in Tongass Land Management

2.1. Strategic scale and spatial nature

Management of areas as large as the Tongass National Forest requires an understanding of extensive, available resources. Various types of information are available to the regional manager. A variety of focused research efforts provide valuable knowledge and information about the nature, character, and behavior of individual components of the resource. Understanding of the vegetative setting in which these components interact can be provided by FIA inventory.

Financial, logistic, and temporal constraints prohibit conducting an inventory that simultaneously satisfies the needs of strategic and project-level planners. Data that can be used to address regional planning needs must be available within reasonable timeframes to a level of estimation precision amenable to informed decision making.

The inventory design relies on a systematic grid of plots. Although an extensive, systematic plot distribution may not be most efficient for representative sampling of the range of bioenvironmental combinations, this unbiased sample distribution facilitates description of spatial characteristics of the resource.

When combined with geographic information systems (GIS) data, description of additional resource characteristics such as patchiness, plant community context, and complexity is possible. Also, predictive modeling that uses spatially identified ground truth data, in concert with GIS data, can better describe nonsampled areas.

2.2. Physical and social context

The FIA vegetation resources inventory plots are distributed across the entire landscape, regardless of ownership. The "all owners" nature of the inventory can facilitate land management planning within the appropriate social context. All management activities have an effect on adjoining interests, and public land resource managers can benefit from examination of those effects.

Awareness of the management context (neighborhood) provides a valuable added dimension to National Forest System (NFS) resource management. Sensitivity analyses can be included in examination of alternative management options by examining data from adjoining ownerships and projecting the impact on those resources of proposed management activities on NFS lands. Public evaluation of management alternatives can be enhanced by inclusion of this added dimension to planning.

Because the inventory sample was systematic, and all plots with vegetation were visited, a consistent, unbiased sample of vegetation in southeast Alaska is available for the first time. A variety of data were collected that help broaden understanding of factors influencing resource dynamics. These data include stand and tree measurements; vegetation presence, diversity, and structure; downed wood; physiographic conditions; wildlife observations such as animal sign; land cover and vegetation type; and basic soil information.

Use of the resource for nontraditional forest products is becoming an important management consideration. Pharmaceutical corporations, in identifying new drugs by researching native medicinal herbs, are among a growing number of consumers showing significant interest in nontree outputs. These interests may conflict with intellectual property rights (traditional knowledge) and native values of honoring plants and subsistence harvest. The inventory can describe the extent of various plant materials and inform management decisions about permitting their use and harvest.

2.3. Climatologic and physiographic influences on vegetation

The physiographic regions of southeast Alaska are complex, resulting from the collision of several crustal plates with the North American continent. Although the islands look similar, most do not share a common origin.

The climate is maritime, with cool summers, moderate winters, high humidity, high precipitation, considerable cloudiness, little freezing weather near sea level, and an average temperature of 40 °F. Although temperature is moderated by the ocean influence, precipitation and temperature gradients do occur. Cool Pacific air masses release moisture as they are lifted over mainland mountains. Precipitation generally increases with elevation on the windward side of mountains. Areas on the leeward side generally have considerably less precipitation. Temperature extremes increase with distance from coastline and with elevation. Some mainland valleys are influenced by cold air washing down from glaciers and ice fields, in some cases lowering local temperatures by several degrees during the growing season. All these differences affect plant distribution and growth and account for much of the heterogeneity of plant communities in this area (Selkregg, 1976).

Climate and physiography of the region affect development of soils and plant communities in other ways. The area has undergone repeated glaciations. Glaciers sculpted the land and removed soils down to bedrock. As they retreated, they deposited glacial till and flooded much of the recently exposed land near sea level. Poorly drained soils, derived from compacted glacial till, cover much of the gently sloping land below 460 m, whereas soils formed over exposed granite bedrock remain shallow and also poorly drained. Others, formed on soft limestone, are better drained. Islands and benches adjacent to the Stikine River benefit from the deposition of silt from interior winds blowing down the river during winter when sandbars and mudflats are exposed. The loess soils that have been deposited owe their high pH and lack of a deep organic layer to the yearly deposition of this wind-deposited silt. These soils are less acidic, with generally more productive vegetative communities. In other areas, high precipitation and cool temperatures have slowed decomposition of organic matter, making the soils more acidic. These sites are covered with a thick duff layer, high in organic matter and constantly moist. Such conditions severely limit the amount of nutrient available to plants on these sites, thereby lowering their productivity.

Wind is another major influence on vegetation patterns in this region. Wind acts in concert with root rot and mistletoe weakening of tree stems. As wind uproots trees or breaks tree stems, it can create forest gaps (Wittwer, 2000). If larger areas are affected, it may create stands of even-aged forest or two-aged forests if only part of the stand is destroyed. Stands that regenerate after major wind disturbance usually have more Sitka spruce (*Picea sitchensis* (Bong.) Carr.) than do old-growth stands. Wind disturbance usually occurs during fall and winter cyclonic storms that typically move along the North Pacific from west to east. Powerful southeast winds occur along the leading edge of these storms as the winds rotate in a counterclockwise direction. These winds are often funneled up straits, and wind velocities are increased. Consequently, ridges with southeast exposure are more likely to experience catastrophic windthrow than are leeward slopes, north and east slopes. Local areas also are influenced considerably by winds funneling down drainages from the coastal mountains. Where such winds are of sufficient intensity, frequency, and coldness, they create exposed landscapes devoid of trees.

Forests extend from sea level to about 800 m. Stands with greatest tree volume are generally near tidewater with stand heights and wood quality diminishing with increasing elevation. Interspersed among the forest stands are muskeg plant communities growing on deep organic soils and dominated by plants such as mosses, sedges, rushes, and ericaceous shrubs that tolerate saturated soils. Between the forests and muskegs, open forests grow on wet organic soils. These open stands of mixed conifers generally have grown more slowly than other forest types occurring in the area. They have a dense shrub layer with many species, thereby making them important food and cover areas for wildlife (Selkregg, 1976). The other major groups of plant communities are the subalpine and alpine types that occur above timberline (about 800 m). Heath shrubs, grasses, and low-growing forbs such as deer-cabbage (*Fauria crista-galli* (Menzies) Makino) dominate these types. Trees are occasional, stunted, and shrublike owing to short, cool summers, extended snowpack, and strong winds. The southeast Alaska vegetated landscape is a mix of old-growth, wind-disturbed even- and uneven-aged forests, open forest, muskegs, alpine areas, grass flats, barren areas, and lakes.

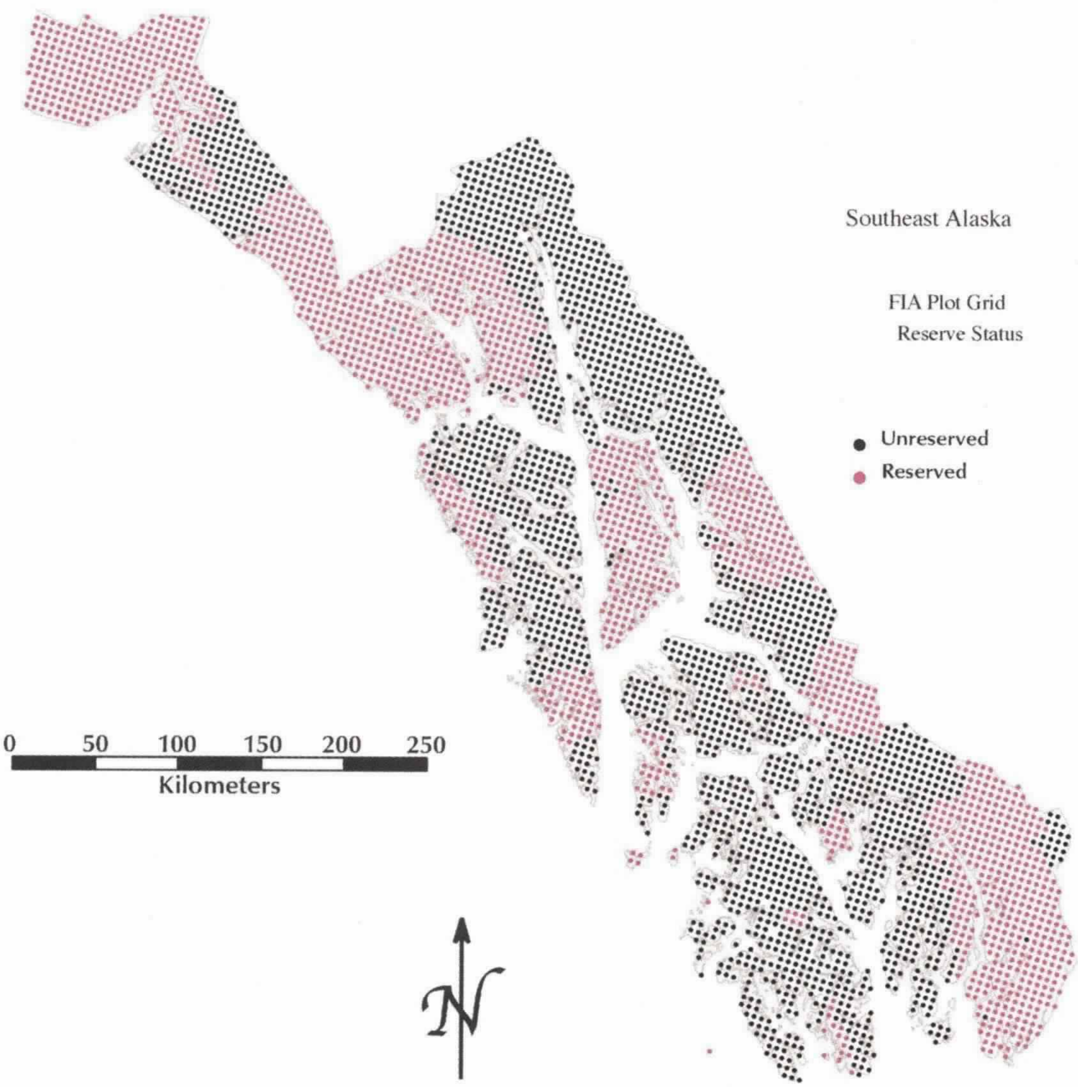

Fig. 1. Sample plot locations for the 1995–2000 vegetation resources inventory of southeast Alaska.

3. Inventory description

The vegetation resources inventory of southeast Alaska used a single-phase systematic grid sample design. A grid with a random starting point and a spacing of 4.8 km was used to define potential ground plot locations. Plots were established at each grid intersection; no sample for stratification was conducted. Sampling intensity was chosen to meet sampling error guidelines of ±3% per 405 thousand hectares for productive forest area and ±10% per 28 million cubic meters for net volume. A total of 3946 plots were located within southeast Alaska.

Ground plots were 1-ha circles. Land cover and vegetation type were visually interpreted for each plot by using high-resolution orthophotoquads and high-resolution satellite imagery. Plots that were barren or covered with ice and snow were not visited on the ground. All vegetated plots, except those in wilderness and similarly reserved areas, were visited on the ground (Fig. 1.) No ground sampling occurred in reserved areas (e.g., wilderness areas and national monuments) owing to restrictions regarding helicopter use. There were 1865 plots within reserved areas. Ground-visited plots were mapped for condition class and subsampled by a cluster of four, 7.3-m fixed-radius subplots. From the first, centrally located subplot, three other subplots were located 37 m north, southeast, and southwest, respectively. Condition classes were defined by differences in land cover type, forest density, forest stand size, and forest stand origin. Field plot design is detailed in Scott and Bechtold (1995).

Trees, if present, were sampled at each of the four sub-plots. Seedlings and saplings were also sampled with a 2-m fixed radius micro-plot centered at each sub-plot. Horizontal and vertical vegetation structure was assessed at the first point in each vegetation type. Data collection procedures are detailed in USDA Forest Service (1995–2000).

4. Analysis of inventory data

4.1. Spatial analyses

In 1999, FIA initiated and entered into a research joint venture agreement (RJVA) with the Center for Biodiversity and Conservation, University of Leeds, United Kingdom. The RJVA, titled "Biodiversity Analyses of Southeast Alaska GRID Inventory Data", was designed to examine biodiversity and conservation issues through novel spatial analyses. Primary objectives were to interpolate tree species abundance within the survey area, determine environmental limits of individual species distributions, and test whether these changed at distributional boundaries.

Regarding tree species abundance, Corne et al. (2000) applied artificial neural network (ANN) methods to predict forest characteristics such as crown closure, tree species, and size/structure distribution in southeast Alaska. Artificial neural networks are computational tools that can approximate solutions to a problem by finding patterns and relationships in a database of examples representative of the problem. Beale and Jackson (1990) discussed the history and technology of ANNs.

Species generally become rarer and more patchily distributed as the margins of their ranges are approached. Lennon et al. (2002) examined tree species occurrence where some key environmental factors are at particularly favorable levels. They quantified marginality by using spatial distributions of eight tree species across the ground-visited inventory plots in southeast Alaska. For each species, they derived a site core/margin index by using a three-dimensional trend surface generated from logistic regression on site coordinates. For each species, the relationship among slope and aspect and site marginality was then compared for occupied and unoccupied sets of sites. Overall, they found that several tree species tended to occur in especially favorable sites in marginal areas.

4.2. Vegetation resources assessment

4.2.1. Forest

Estimation of land cover and forest resource attributes such as area and volume was accomplished with ratios-of-means estimators by using ground-plot data as recommended by Zarnoch and Bechtold (2000).

Forests do not uniformly cover the southeast Alaska panhandle. Slightly more than half the inventory area is nonforest. Nonforest areas include alpine zones, regions of ice and snow, barren areas, and lakes and rivers.

The dominant land manager in southeast Alaska is the Tongass National Forest. Almost three-quarters of the land area is under TNF management. The TNF land

Table 1
Area of forest and nonforest, by owner, southeast Alaska, 2000

Owner	Forest (thousand hectares)	Nonforest (thousand hectares)	Total (thousand hectares)
National forest	3785.8	3069.1	6855.0
Other federal	250.1	1527.7	1777.8
State and local	157.8	168.3	326.2
Private	255.8	39.7	295.4
All owners	4449.5	4804.9	9254.4

management task is made more complex by the variety of landscapes and land covers with which the TNF must cope. Only 55% of the land managed by TNF is forested (Table 1). The remainder is a mosaic of nonforest conditions, at times interspersed with forested conditions, which directly affects management choices and results.

In contrast, land management alternatives for private owners are possibly more narrowly focused on those involving forest management. Although private owners manage just over 3% of the total land base, almost 87% of their land is forested.

4.2.1.1. Timberland. The southeastern panhandle has about 4.4 million hectares of forest on it, but less than half (37%) of this forest is considered timberland. Timberland is the component of the forest that can produce at least 1.4 m^3 of wood, per hectare, per year at culmination of mean annual increment. Additionally, timberland must be accessible for sampling and available, or potentially available, for production of wood products. Ground data are necessary to accurately establish timber productivity levels. Therefore, plots, or portions of plots, that could not be accessed on the ground, are not included in development of estimates of timberland. Forested land can be inaccessible for two reasons; either it is physically impossible to access because of terrain considerations, or access was restricted, as in the case of wilderness areas where efficient access was not possible. Also, forests in reserved areas such as wildernesses and national monuments are unavailable for timber harvest and thus do not contribute to estimates of timberland.

The TNF manages 84% of all timberland in southeast Alaska (Table 2). The highest ratio (70%) of timberland to all forest land is found on lands held by state and local agencies. The concentration of timberland on privately owned forest land is also relatively high at 62%. Timberland composes just 36% of the TNF forest land total.

Management of forest lands for timber production typically focuses on the timberland segments of the resource. Contrasting visions of forest land management within the federal government versus among the public, along with the degree to which timberland makes up an owner's forest land resource base, directly informs management decisions. The TNF, with its large land base and relatively small proportion of timberland to all forest land must address a complex land management environment.

4.2.1.2. Forest type. Forest resource management relies in large measure on grouping of trees into categories having similar characteristics. One way of aggregating trees into similar groupings is through forest type descriptions. Forest types used here were developed through cluster analysis (FASTCLUS [SAS,

Table 2
Area of timberland and other forest land by owner, southeast Alaska, 2000

Owner	Timberland (thousand hectares)	Other forest (thousand hectares)	Total (thousand hectares)
National forest	1385.2	2400.6	3785.8
Other federal	2.4	247.7	250.1
State and local	110.1	47.8	157.8
Private	160.3	95.5	255.8
All owners	1657.9	2791.5	4449.5

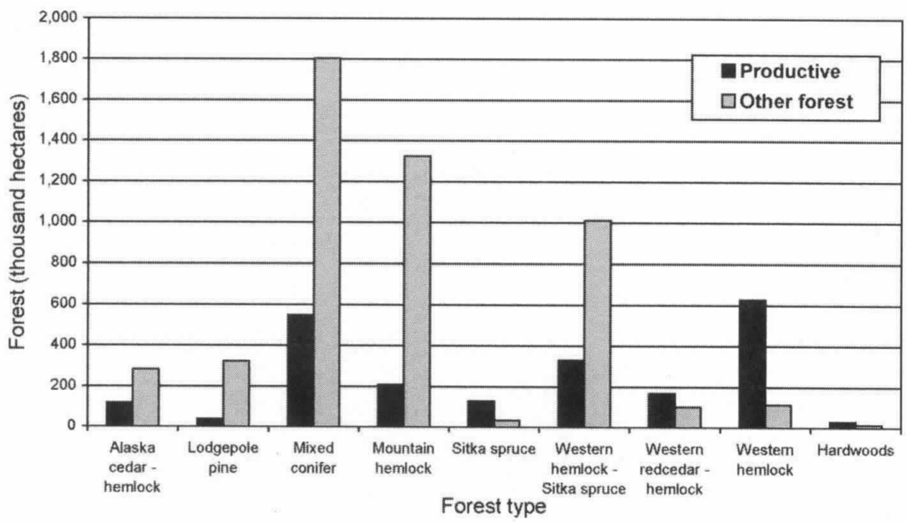

Fig. 2. Area of timberland and other forest land by softwood forest type, southeast Alaska, 2000.

1990]) of inventory data collected between 1995 and 1998 in southeast Alaska (van Hees et al., 2001). The cluster analysis grouped sampled forested conditions according to species stocking levels. Forest type definitions were developed from the cluster analysis, and descriptive names were assigned to the clusters.

Although determination of forest type for timberland requires tree stocking information, forest type for the inaccessible component of the "other" forest land category could be estimated. Estimated forest type for inaccessible forest land was assessed either by visual inspection on the ground from a nearby location, visual

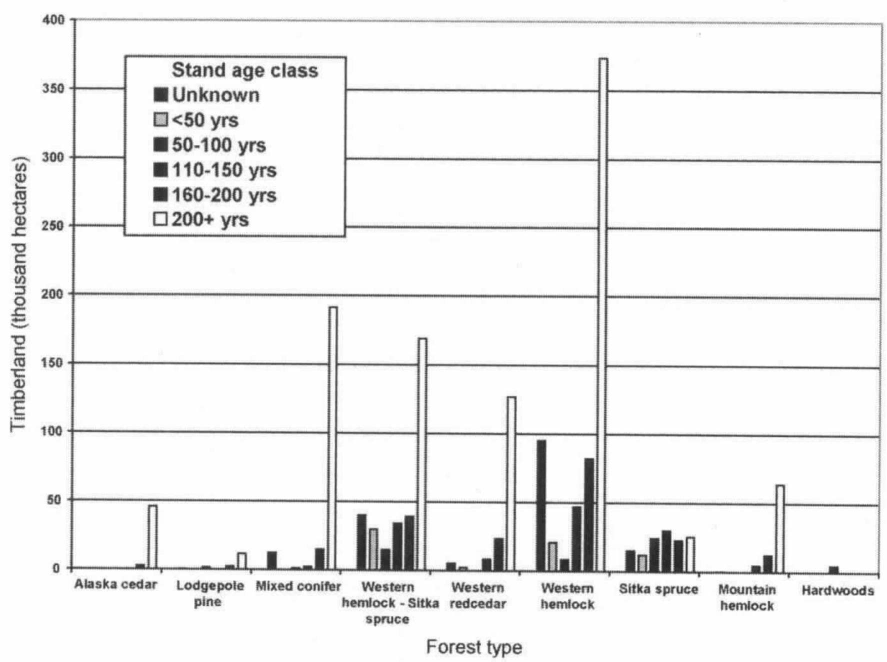

Fig. 3. Area of timberland by forest type and stand age class, southeast Alaska, 2001.

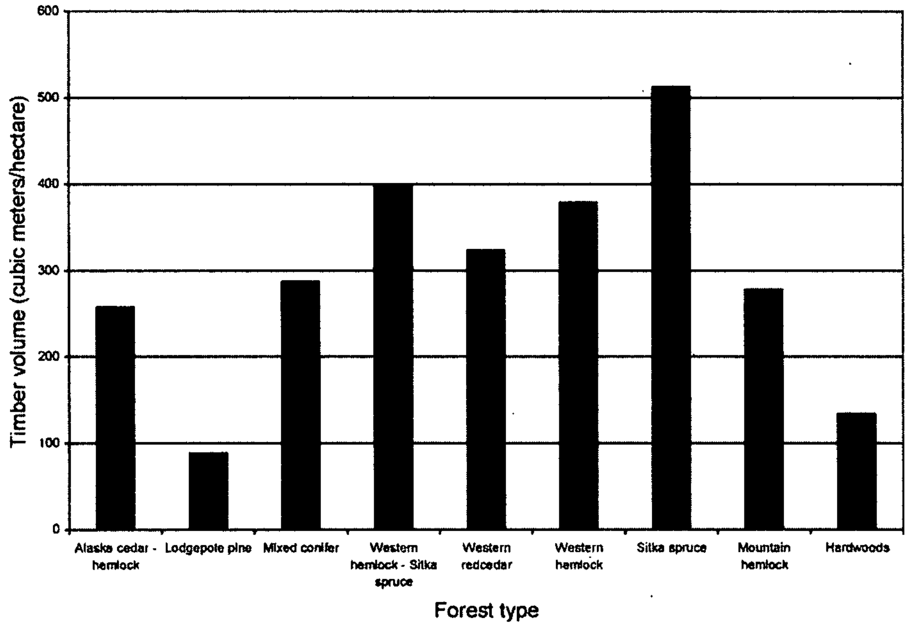

Fig. 4. Net volume per acre on timberland, by forest type, southeast Alaska, 2000.

inspection by low-altitude over-flight, or from remotely sensed imagery.

Nearly all forestland of the southeast, over 98%, is composed of a softwood forest type. Hardwood forest types make up less than 2% of the forest land. Within the timberland component, dominant types are western hemlock (38%), western hemlock-Sitka spruce (20%), mixed conifer (13%), and western redcedar-hemlock (10%) (Fig. 2.) Sitka spruce, as a pure type makes up only 8% of timberland.

Mountain hemlock and Alaska cedar-hemlock types tend to occupy low-productivity sites such as wet, boggy areas, or, in the case of Alaska cedar, rocky areas such as avalanche chutes and rocky ridges. This tendency is reflected by the observation that the two types are minor components of timberland with 5 and 3% of the area, respectively.

4.2.1.3. Stand age. The bulk of the timberland in southeast Alaska, 61%, is made up of stands over 200 years old. An additional 12% are less than 200 years old but more than 150 years old (Fig. 3.) Although this inventory was not designed to estimate areas of cutover forest, those softwood stands that are less than 100 years old likely include logged areas along with areas of stands that suffered catastrophic change such as windthrow.

The "unknown" category reflects locations where field crews were unable to obtain a reliable measure of age from available trees either on the plot itself or nearby off the plot.

Almost all sampled hardwood types (83%) are generally less than 150 years old. In general, hardwoods are not as long-lived as softwoods. These acreages likely do not reflect logging activity or natural disaster, rather, the normal lifespan of the respective tree species.

4.2.1.4. Volume per hectare. The concentration of timber per unit area is an important consideration guiding management. Different forest densities have implications for wildlife habitat management, assessment of carbon sequestration, and viability of timber harvest operations, which can depend heavily on wood volume per hectare.

The average timberland hectare, across all forest types and owners, has about 357 m^3 of net volume on it. Net volume is gross volume less deductions for rot and missing bole sections. There are large differ-

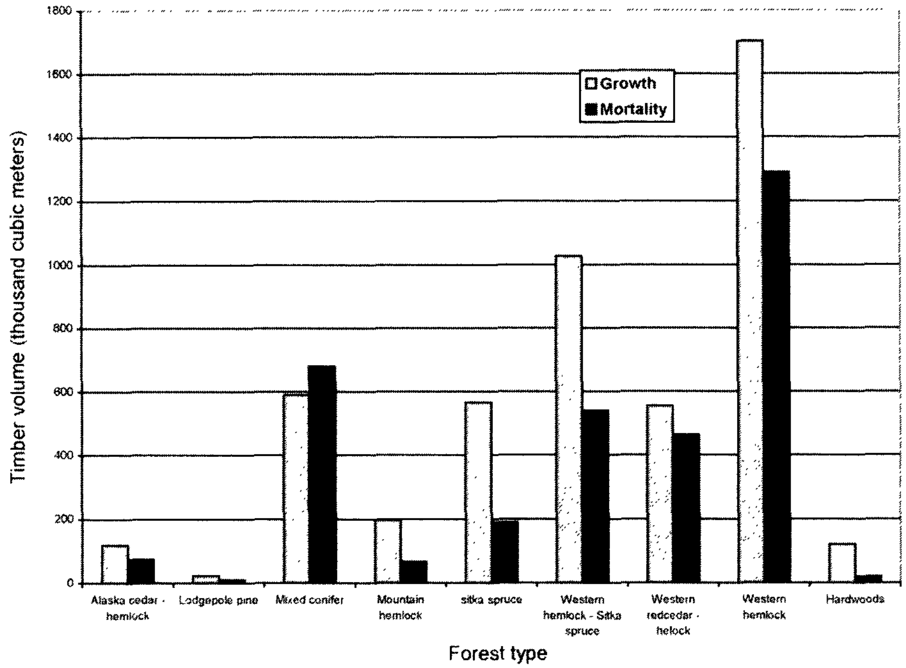

Fig. 5. Timber growth and mortality by forest type, southeast Alaska, 2000.

ences by forest type (Fig. 4.) Within the softwood forest types, lodgepole pine (*Pinus contorta* Dougl. Ex Loud.), which tends to occupy lower productivity sites in southeast Alaska, has the lowest per-hectare volume (88 m^3). Sitka spruce, however, thrives in the southeast and has the highest volumes per hectare (513 m^3).

Relatively low volume per hectare for hardwood forest types is not necessarily reflective of low site productivity. Hardwoods do not attain the physical size or age typical for softwoods, suggesting low volumes per hectare are not unexpected. Additionally, low sampling intensities in these types can lead to significant variance for these estimates.

4.2.1.5. Growth and mortality. Once a manager knows the character of trees available and how they are distributed, some measure of the degree to which the resource quantity increases or decreases is needed to augment the management picture. The FIA inventories assess this change through estimates of growth and mortality.

Estimation of tree growth is best accomplished through repeated measurement, over time, of the same trees. Initial inventories such as this, must rely on another method to estimate growth. Field data collection included retrieval of increment cores to measure 10-year radial growth. On each plot with forested conditions, the trees sampled for growth were the first live trees tallied in each 5-cm diameter class, by species, for trees greater then or equal to 12.5 cm in diameter at breast height. From the measures of 10-year radial growth, average annual diameter change was estimated and then used to estimate average annual change in tree volume.

Average annual mortality estimates derive from the volume of trees that died in the last 5 years. As is the case with growth, estimation of tree mortality is best accomplished through repeated measurement, over time, of the same trees. For this initial measurement, field crews estimated, from the physical condition of the dead tree, whether the tree had died within 5 years prior to the date of measurement.

In general, the forests of southeast Alaska are adding wood volume faster than they are losing it. Overall, net growth, the excess of growth over mortality, was 1.58 million cubic meters (Fig. 5). Only one forest type, the mixed conifer type, showed a negative net change, indicating that mortality exceeded growth.

4.2.2. Vegetation classification and nonforest description

4.2.2.1. Land cover and vegetation classification. Vegetation types were described by using the framework of the Alaska vegetation classification system (AVCS) developed by Viereck et al. (1992). The framework was designed to describe existing vegetation, not potential vegetation, based on percentage of foliar cover. It uses a hierarchical classification containing five levels of resolution (levels 1 through 5). All vegetation types in the system must have at least 2% plant foliar cover to be considered a "vegetated" type. All other lands are considered to be unvegetated or barren. For the purposes of this inventory, FIA added barren and water "types" and further described these by using several categories such as ice and snow, rock, water, etc.

The AVCS was initially developed for interior Alaska. It was extended to southeast Alaska based on review of the literature and previously described types known to exist in the area. The classification was developed with plant communities as the basic element and by grouping or aggregating those based on similarity of composition by species. The broadest and most generalized level (level 1) consists of forest, scrub, and herbaceous. These are further subdivided to describe plant communities. The first three levels of this classification system are shown in Table 3. This inventory used the general outline of AVCS in categorizing vegetation communities, and added additional types as field experience demonstrated gaps in identified types, such as the addition of salmonberry and alder-salmonberry types in the tall scrub categories. In addition, the meaning of the level 3 classification of dwarf scrub was changed to accommodate classification by remote sensing. In our classification, level 3 dwarf scrub is divided among open and closed types rather than dryas, ericaceous, and willow categories, which are not identifiable from the aerial photography used for the inventory. Use of photo classification was important for inaccessible areas, such as wilderness, where helicopter access was restricted and ground-sampling costs would have been prohibitive.

Note that there are important differences between the last published version of AVCS and our inventory classes. A comprehensive discussion and listing of these differences is beyond the scope of this paper.

Table 3
Alaska vegetation classification system

Level 1	Level 2	Level 3[a]
Forest	Needleleaf	Closed (60–100% canopy closure) Open (25–59% canopy closure) Woodland (10–24% canopy closure)
	Broadleaf	Closed (60–100% canopy closure) Open (25–59% canopy closure) Woodland (10–24% canopy closure)
	Mixed	Closed (60–100% canopy closure) Open (25–59% canopy closure) Woodland (10–24% canopy closure)
Scrub	Dwarf tree	Closed (60–100% canopy closure) Open (25–59% canopy closure) Woodland (10–24% canopy closure)
	Tall (>1.5 m)	Closed (75–100% canopy closure) Open (25–74% canopy closure)
	Low (0.2–1.4 m)	Closed (75–100% canopy closure) Open (25–74% canopy closure)
	Dwarf (<0.2 m)	Closed (75–100% canopy closure) Open (25–74% canopy closure)
Herbaceous	Graminoid	Dry Mesic Wet
	Forb	Dry Mesic Wet
	Bryoid	Moss Lichen
	Aquatic	Freshwater Brackish Marine

[a] Level 3 of dwarf scrub was modified for this inventory from dryas, ericaceous, and willow categories to closed and open categories because of remote sensing limitations in determining small shrub species on aerial photographs.

4.2.2.2. Species richness and diversity. A comparison of species richness and diversity values among the modified AVCS types is shown in Table 4. This is not a complete listing of plots; plots were screened for recent logging and other disturbance impacts, and types with fewer than four locations were not included. Locations with multiple measured points were combined; this table represents unique location and type combinations. We used Whittaker's (1972) three kinds of diversity measures. Gamma diversity is the total number of species across all locations. Alpha diversity is cal-

Table 4
Species diversity in modified Alaska Vegetation Classification System (AVCS) level 4 types, southeast Alaska, 2000

Modified AVCS level 4 types	No. of locations	Vascular plants			All plants		
		Gamma[a] (no. of species)	Mean alpha[b]	Beta[c]	Gamma[a] (no. of species)	Mean alpha[b]	Beta[c]
Closed Sitka spruce forest	35	114	16.3	6.99	172	26.5	6.49
Closed western hemlock forest	223	137	17.2	7.97	219	29.0	7.55
Closed Sitka spruce–western hemlock forest	57	110	19.4	5.67	171	30.5	5.61
Closed western hemlock–Sitka spruce forest	86	127	19.7	6.45	200	32.5	6.15
Closed western hemlock–Alaska cedar forest	93	123	21.6	5.69	199	33.8	5.89
Closed mountain hemlock forest	44	115	18.2	6.32	185	31.1	5.95
Closed western hemlock–western redcedar forest	66	103	19.8	5.20	173	31.7	5.46
Closed mixed conifer forest	128	159	24.0	6.63	246	36.3	6.78
Open Sitka spruce forest	21	95	17.2	5.52	137	27.0	5.07
Open western hemlock–Sitka spruce forest	25	128	25.7	4.98	175	37.2	4.70
Open mountain hemlock forest	83	171	22.8	7.50	245	35.1	6.98
Open mixed conifer forest	204	191	27.0	7.07	286	38.5	7.43
Open western hemlock forest	25	92	18.2	5.05	149	30.6	4.87
Open Sitka spruce–western hemlock forest	6	65	18.3	3.55	85	26.0	3.27
Open western hemlock–Alaska cedar forest	30	106	24.0	4.41	165	35.6	4.63
Open western hemlock–western redcedar forest	11	60	21.2	2.83	93	31.8	2.92
Open lodgepole pine forest	13	87	26.7	3.26	124	36.4	3.41
Woodland lodgepole pine forest	30	107	23.7	4.51	147	33.9	4.34
Woodland western hemlock–Sitka spruce forest	4	53	23.7	2.24	75	33.2	2.25
Woodland mountain hemlock forest	29	140	25.2	5.56	190	36.2	5.25
Woodland mixed conifer forest	31	109	26.3	4.14	156	35.5	4.38
Woodland black cottonwood forest	6	38	9.7	3.92	59	15.0	3.93
Closed mountain hemlock dwarf-tree nonforest	8	63	20.1	3.13	102	31.2	3.27
Open mountain–hemlock dwarf-tree nonforest	22	119	21.6	5.51	169	31.5	5.37
Open mixed conifer dwarf-tree nonforest	12	92	25.8	3.57	126	36.1	3.49
Open lodgepole pine dwarf-tree nonforest	7	62	21.9	2.83	91	31.3	2.91
Woodland mixed conifer dwarf-tree nonforest	5	59	27.6	2.14	79	36.8	2.14
Woodland lodgepole pine dwarf-tree nonforest	5	49	21.4	2.29	63	28.4	2.22
Woodland mountain hemlock dwarf-tree nonforest	20	123	24.2	5.08	158	32.8	4.82
Closed tall scrub alder	58	181	15.9	11.38	229	21.0	10.45
Closed tall scrub alder-willow	5	65	20.0	3.25	80	25.6	3.13
Closed tall scrub salmonberry	11	73	16.3	4.48	96	22.1	4.34
Closed tall scrub alder-salmonberry	24	91	14.8	6.15	124	20.0	6.20
Open tall scrub willow	4	52	21.0	2.48	63	25.2	2.50
Open tall scrub alder	33	171	18.3	9.34	219	23.9	9.16
Open tall scrub alder-willow	6	81	23.2	3.49	98	29.2	3.36
Open tall scrub alder-salmonberry	9	82	20.3	4.04	103	26.2	3.93
Closed low scrub ericaceous	4	66	24.2	2.73	81	29.2	2.77
Open low scrub ericaceous shrub bog	14	74	23.6	3.14	102	33.7	3.03
Open low scrub sweetgale-graminoid bog	7	58	15.9	3.65	69	18.4	3.75
Open low scrub copperbush–blueberry	8	87	23.6	3.69	112	31.9	3.51
Open low scrub copperbush	8	98	28.6	3.43	123	37.4	3.29
Dwarf scrub vaccinium tundra	4	55	17.2	3.20	79	25.0	3.16
Dwarf scrub crowberry ericaceous tundra	7	103	23.0	4.48	136	32.3	4.21
Dwarf scrub cassiope ericaceous tundra	47	173	17.8	9.72	226	25.6	8.83
Wet sedge meadow tundra	10	84	20.8	4.04	105	26.8	3.92
Wet sedge-herb meadow tundra	8	77	23.7	3.25	93	31.5	2.95
Fresh sedge marsh herbaceous	14	84	15.2	5.36	105	19.5	5.36

Table 4 *(Continued)*

Modified AVCS level 4 types	No. of locations	Vascular plants			All plants		
		Gamma[a] (no. of species)	Mean alpha[b]	Beta[c]	Gamma[a] (no. of species)	Mean alpha[b]	Beta[c]
Subarctic lowland sedge-moss bog meadow	4	63	23.7	2.66	80	31.2	2.56
Alpine herbs tundra	4	68	24.2	2.81	84	31.2	2.69
Mixed herbs herbaceous	12	156	27.8	5.61	186	33.0	5.64
Mesic ferns subarctic herbaceous	4	56	25.2	2.22	66	30.0	2.20
Fresh herb marsh	4	53	16.0	3.31	58	18.2	3.19

[a] Total number of species across all locations.
[b] Average species richness per plot.
[c] Gamma/alpha: measure of data heterogeneity.

culated here as the average species richness per plot. Beta diversity is a measure of heterogeneity in the data, which we calculated by using the ratio of the total number of species to the average number of species (gamma over alpha).

The highest species richness of vascular plants in closed forest occurs in the western hemlock-Alaska cedar type (21.6), the lowest in the Sitka spruce type (16.3). In the open forest category, the highest species richness is in the mixed conifer type (27.0) and the lowest is again in the Sitka spruce type (17.2). Diversity comparisons among the nonforest types are hampered by the low numbers of plots in some types. In general, there are fewer sampled plots in the nonforest category. In scrub types, the alder-willow types had the highest richness among vascular plants. Alder-salmonberry had the lowest species richness.

Among the low and dwarf scrub categories, low scrub copperbush had the highest species richness (28.6). Dwarf scrub vaccinium tundra had the lowest value (17.2). In the sedge-grass-herbaceous types, mixed herbs had the highest richness value

Table 5
Area by vegetation type group/land cover class, Alaska Vegetation Classification System (AVCS) level, and owner, southeast Alaska, 2000

Vegetation type/land cover class (AVCS level)	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Vegetation type (level 2)					
Needleleaf forest	3734.6	250.1	149.5	224.5	4358.8
Broadleaf forest	19.2		5.9		25.0
Mixed needleleaf-broadleaf forest	5.3		2.3	2.3	10.0
Dwarf tree scrub	159.1		0.6	8.1	167.8
Tall scrub	259.2	11.4	44.8	5.0	320.4
Low scrub	101.2		4.1	30.8	136.1
Dwarf scrub	175.5	9.4	14.7	4.7	204.2
Scrub, unclassified	369.5	204.1	9.4		582.9
Herbaceous	194.7	37.5			232.2
Graminoid	61.3		7.6		68.9
Forb herbaceous	50.0	2.3	2.3	3.7	58.4
Lichen/moss	2.6			2.3	5.0
Aquatic	1.9				1.9
Land cover (level 1)					
Barren	1578.4	1229.1	72.6	9.7	2889.7
Water	140.5	34.1	12.3	6.6	193.4
All types	6854.2	1777.9	326.1	297.7	9255.9

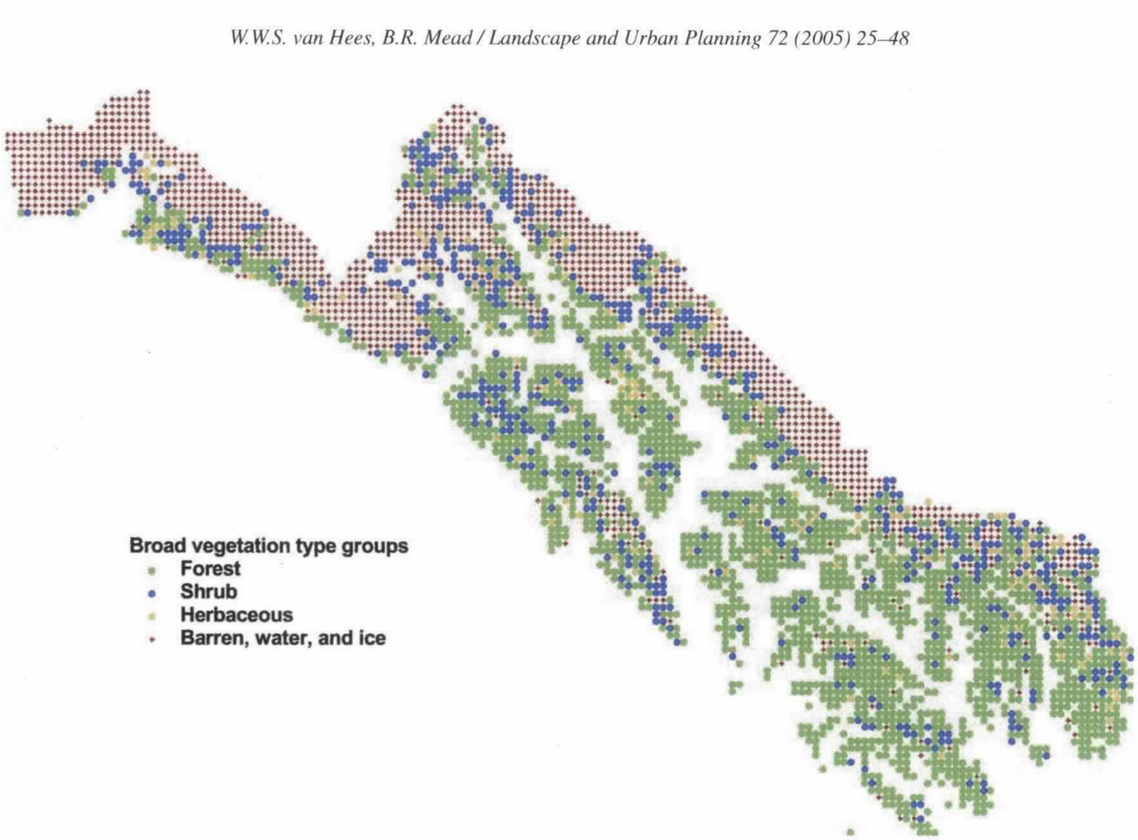

Fig. 6. Forest, scrub, herb, and barren plot distribution, southeast Alaska, 2000.

(27.8). The lowest was the fresh sedge marsh type (15.2).

When moss, lichens, and liverworts were included with vascular plants, diversity values followed similar trends, but made some subtle differences. Although the Sitka spruce type continued to be the lowest in richness in the closed forest category when all plants were considered (26.5), the mixed-conifer type moved to the highest richness (36.3). In the open forest category, the mixed conifer type remained highest (38.5) while the Sitka spruce-western hemlock moved to the lowest (26.0).

4.2.2.3. Modified AVCS group cover estimates. In the tables and charts and discussions that follow, the modified AVCS types were grouped together and identified by the primary cover species. They are not the actual AVCS types used in the inventory, rather a summarization of them.

Table 5 shows land areas by owner and modified AVCS level. Fig. 6 shows plot spatial distribution of the broad types that were sampled. Plots were not located in homogeneous types, so for the purposes of plotting AVCS types, the whole plot is assigned to the same AVCS type as the condition class with the largest area on the plot location.

Readers may notice differences between estimates of forest area presented in this section and those presented above. For timber inventory purposes, forest classification depends on numbers of trees per unit area. In the AVCS, forest classification depends on foliar cover. Differences in estimates can be expected. Fig. 7 shows the spatial distribution of forest plots based on the forested type groupings and includes dwarf-tree nonforest plots.

Examining the range of nonforest types and their perceived importance to wildlife and plant diversity, their occurrence or absence on adjoining lands may assist national forest and state planners and others in management of their own lands.

Knowing the plants that occur on various forest and nonforest conditions has increasing relevance as the marketing of nontimber forest products and nonforest plant products increases. Salal (*Gaultheria shal-*

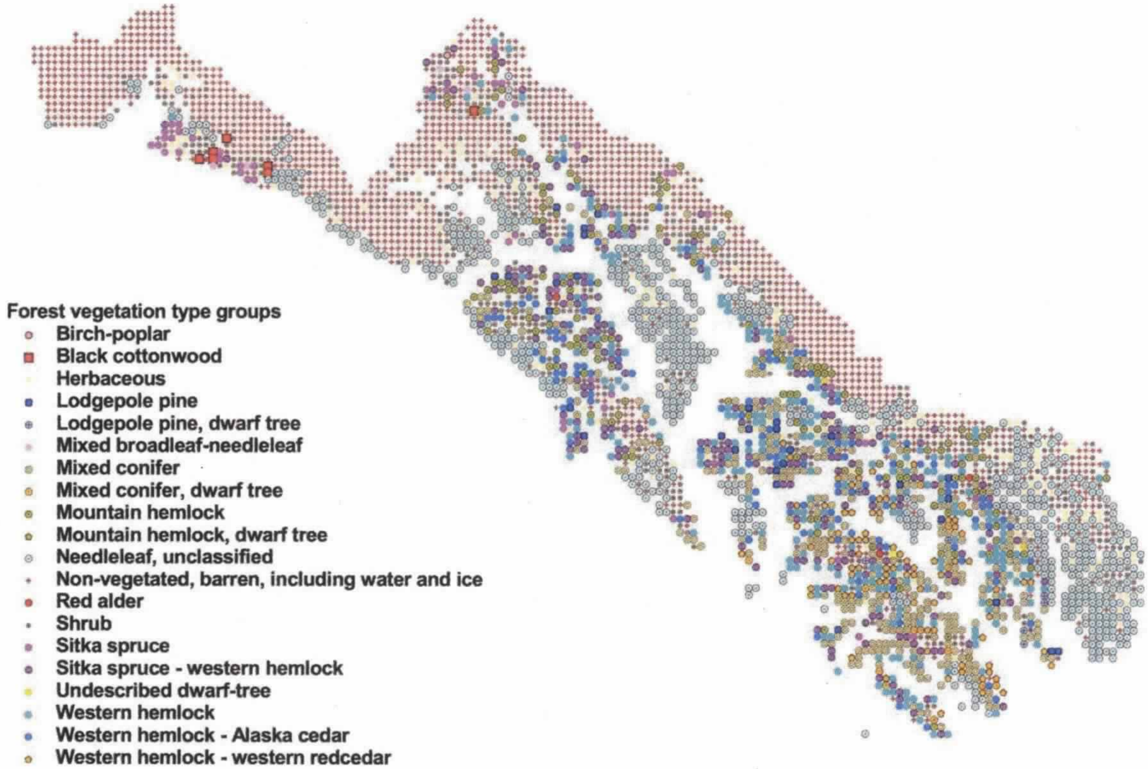

Fig. 7. Plot distribution by Alaska vegetation classification system forested type, including dwarf-tree scrub plots, southeast Alaska, 2000.

lon Pursh) is increasingly sought by the floral industry as a component of commercially sold floral arrangements; devilsclub (*Oplopanax horridus* Miq.) has been sought by the herbal industry for its medicinal properties; and mushrooms are increasingly sought by the food industry (Vance et al., 2001). There is also growing awareness of the impact of introduced plants on native vegetation communities. For example, attempts to stabilize soils along forest roads by using nonnative cover species may cause unexpected community changes (Gucinski et al., 2001). Periodic, regional-scale inventories such as the one we describe here, may identify invasion by, and expansion of exotic plant communities. These data can alert mangers to situations potentially requiring further scientific study.

Soil scientists have long recognized that certain plants prefer well-drained sites whereas others prefer poorly drained sites. These plants can indicate the quality of a site for growing trees in terms of rates of wood production. This inventory included direct measurement of tree growth, making it possible to compare these measurements of tree growth with plant community composition at each site. Old-growth forests represent a unique challenge to direct measures of tree growth, because younger trees, in the more active growing stage of their life cycle, may be difficult to find. In these cases, understory plants may indicate, which sites will be more productive than others when a forest is cut and regenerated.

There have been a number of studies of plant associations and classifications of plant communities within the southeast panhandle and adjacent areas (Shephard, 1995; Pawuk and Kissinger, 1989; DeMeo et al., 1992; Martin et al., 1995). Data used to develop these classifications were derived from subjective sampling as noted in the methods section for the Chatham area classification: "in general, stands were selected only if the overstory and understory vegetation and environmental conditions appeared to be homogeneous. Attempts were made to sample only stands, which had the general characteristics of late seral vegetation. In addition, edge effects, ecotones, windthrow, and sites exhibiting

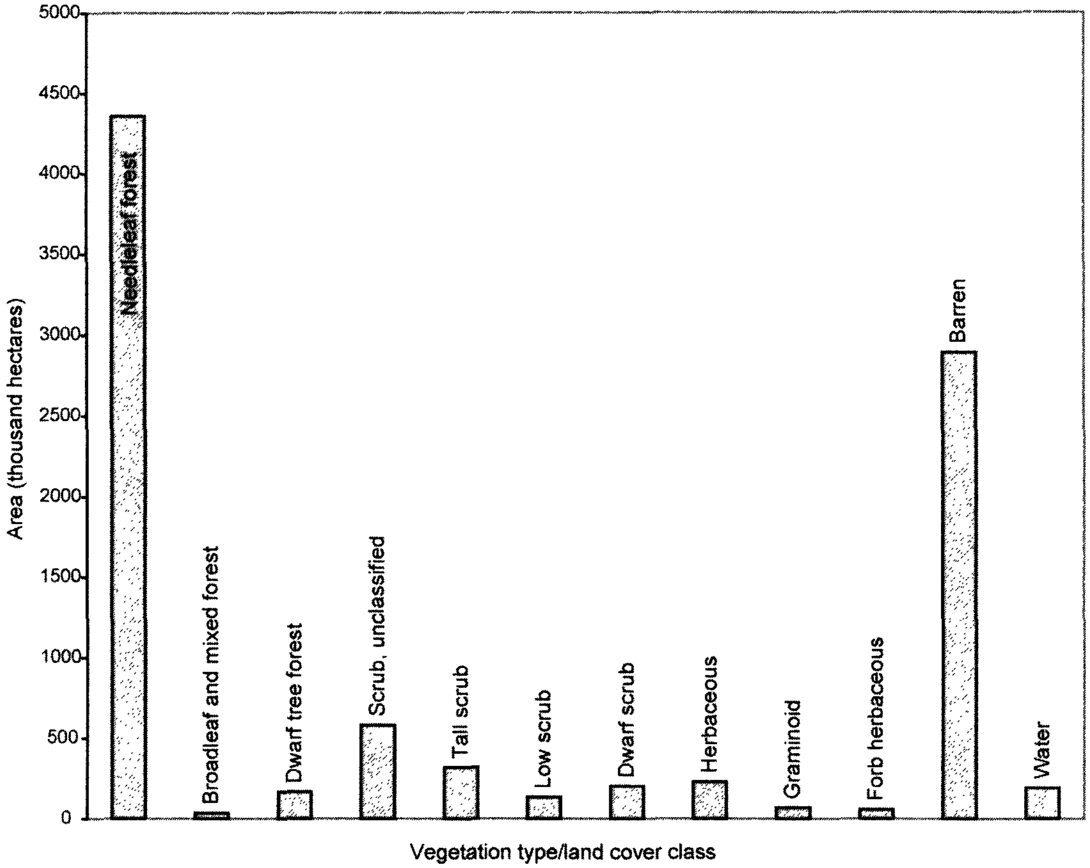

Fig. 8. Area by vegetation type/land cover class, southeast Alaska, 2000.

atypical vegetation patterns were avoided" (Martin et al., 1995).

The data from the FIA inventory differ in that plots were located systematically and were not located to sample specific type conditions or stages of community development. These data offer the opportunity to develop a regional classification based on a systematic survey of existing vegetation that is inclusive of the ranges of natural variability. The FIA is currently in the process of developing such a classification that incorporates the broad AVCS types discussed throughout this section. As noted earlier, systematic sampling has limitations, which include potential undersampling of rare types and bioenvironmental combinations, potential oversampling of common types, and inefficient capture of the range of variation in the study area. Ecological studies that are not aimed at broad-scale inventory often use an alternative approach that potentially overcomes these limitations such as the gradsect method described in Gillison and Brewer (1985) and Austin and Hedges (1989).

Fig. 8 illustrates the relative proportions of the southeast Alaska land area by broad vegetation type groupings. Needleleaf forest covers the highest proportion of land area (47%), barren lands account for 31% of the total, and unclassified scrublands, which occur mainly on reserved land areas, occupy about 6% of the area (Table 5). The area estimate for the unclassified scrubland type was obtained primarily by remote sensing of reserved lands. Other major types, in terms of land area, are tall scrub, herbaceous, dwarf scrub, dwarf-tree nonforest, and dwarf scrub. Total vegetated land area in southeast Alaska is estimated at 6.2 million hectares compared with 3.1 million hectares occurring as barren, ice, or water-covered lands.

Table 6
Area of dwarf tree scrub land by modified Alaska vegetation classification system (AVCS) level 4 and owner, southeast Alaska, 2000

Modified AVCS level 4 type	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Lodgepole pine	15.1		0.6	6.1	21.8
Mixed conifer	32.6			0.8	33.4
Mountain hemlock	106.1			1.2	107.3
Subalpine fir	0.6				0.6
Undescribed	4.7				4.7
All types	159.1		0.6	8.1	167.8

The following discussion will address nonforest vegetation types as they occur by presumed height of the life form, with tree species types considered first, and tall scrub, low scrub, dwarf scrub, and herbaceous types discussed in that order, rather than according to their order of importance based on total area.

Dwarf-tree scrub. Dwarf-tree scrub is the fifth most prevalent nonforest vegetation type in terms of area, covering an estimated 167,800 ha. These types occur either on alpine sites near treeline, as krummholz, or as stunted trees on wet or bog soil conditions at lower elevations. The lodgepole pine types can occur on very poorly drained sites from sea level to the subalpine, but are, according to Pawuk and Kissinger (1989), "most common at low to mid-elevations on the poorest of forested soils". Mountain hemlock can be found on a wide range of sites at mid to high elevations, but "at lower elevations, it is restricted to cold sites and poorly drained sites" (Pawuk and Kissinger, 1989).

These site preferences help explain the differences of the various types by owner (Table 6). Because most private land selections appear to have occurred at lower elevations (as evidenced by the proportion of forest to nonforest shown in Table 1; there is little forest above 760 m elevation) the lodgepole pine type predominates on private lands (75% of the area), whereas the mountain hemlock type, which is found on a greater range of elevations, predominates on national forest lands (67% of the area).

Tall scrub. Tall scrub types occur on 320,400 ha (Table 7) and represent 5.2% of the vegetated area of southeast Alaska. Among the fully classified types, it is second only to forest, which composes 71% of the vegetated land area (6.2 million hectares). The most common tall scrub type on national forest is alder (136,600 ha or 53%). On private lands the most common tall scrub type is blueberry (*Vaccinium* L.)–salmonberry (*Rubus spectabilis* Pursh) (4455 ha or 90%), (Table 7). These types reflect current, existing vegetation, not climax vegetation, and some of these types occur on sites that have been logged and were previously forested. They are now in a transitional type as trees regenerate. The pure salmonberry and willow

Table 7
Area of tall scrub land by modified Alaska vegetation classification system (AVCS) level 4 types (species-level) combined at level 3 (open + closed) and owner, southeast Alaska, 2000

Modified AVCS level 4 types combined at level 3	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Alder (e.g., closed alder + open alder)	136.6	9.4	40.1	0.5	186.2
Alder-salmonberry (new type)	60.8		2.3		63.2
Dwarf birch-willow	17.1	2.0	2.3		21.4
Blueberry-salmonberry (new type)	7.0			4.5	11.6
Salmonberry (new type)	21.3				21.3
Unclassified tall scrub (level 2)	3.5				3.5
Willow	12.9				12.9
All types	259.2	11.4	44.7	5.0	320.4

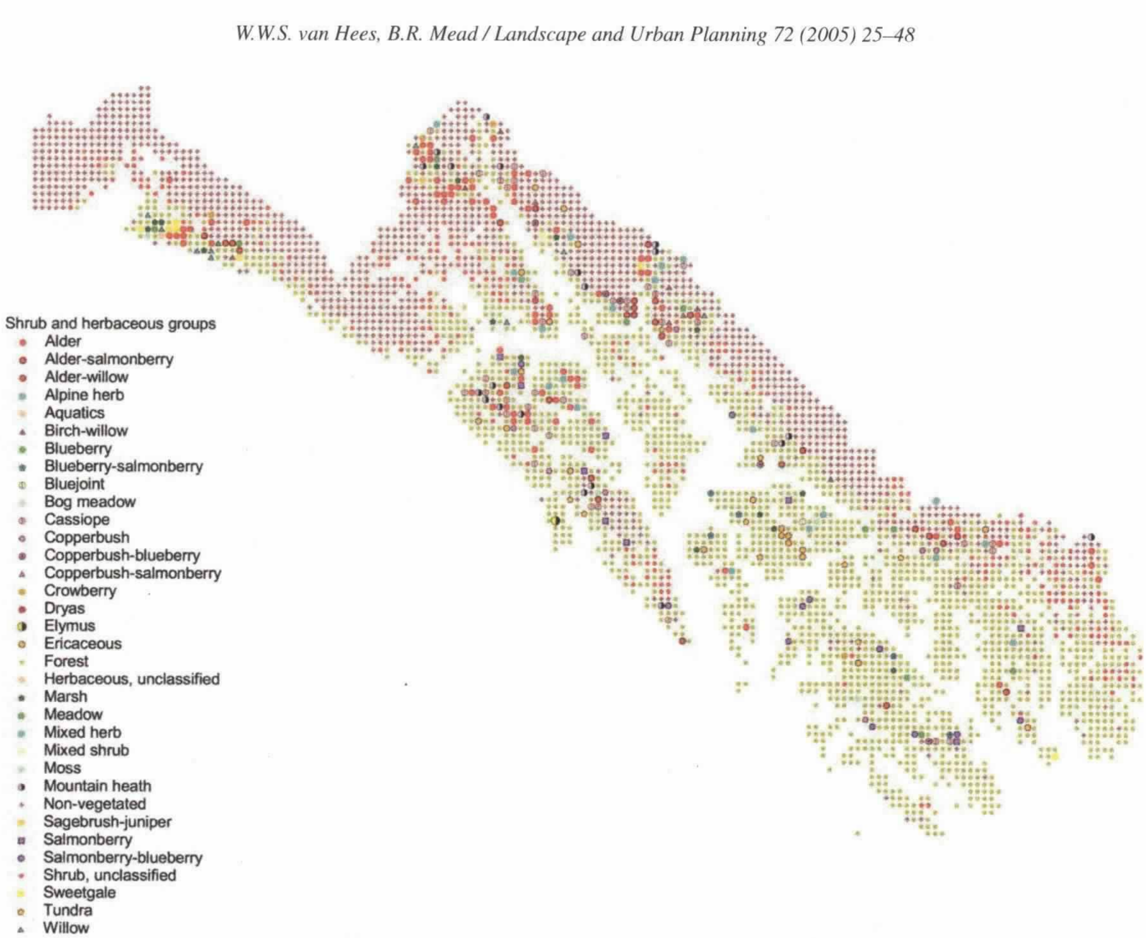

Fig. 9. Plot distribution with scrub and herbaceous type groups highlighted, southeast Alaska, 2000.

(*Salix* L.) types are found almost exclusively on national forest lands. Fig. 9 shows the spatial distribution of sample plots that fell in scrub and herbaceous AVCS types.

Low scrub. There are 136,000 hectares in low scrub vegetation types (Table 8). Some of the types, such as sagebrush (*Artemisia* L.)–juniper (*Juniperus communis* L.) were sampled at a single location, others occurred on plots scattered throughout the region. The sagebrush-juniper estimate is based on a single location in the Skagway quadrangle on an area of cracked bedrock and broken rock where there was little soil and the site was exposed and dry. At 2300 ha, it is probably an overestimate of its occurrence.

The copperbush types were sampled in the central portion of the panhandle, but no plots in the copperbush type were located north of 59° latitude. The sweetgale (*Myrica gale* L.) vegetation type, on the other hand, occurred on some of the most southern and northern plots with sparse representation in the central part of the panhandle.

Some differences were noted by ownership. The most common low scrub type on national forest was the ericaceous type at 28,500 ha (Fig. 10). On private lands, the blueberry–salmonberry type was highest at 12,900 ha. This type generally occurs on cutover lands at lower elevations.

The sweetgale type occurs on an estimated 15,400 ha. Sweetgale is a nitrogen-fixing shrub, and dense stands can fix substantial amounts of nitrogen. This ability allows it to compete in peatland areas where nitrogen is limiting. In the Copper River Delta area, there is some management concern that all-terrain vehicle use can damage these communities by directly killing or damaging the plants and by changing the hydrology of the wetlands where they occur (Shephard,

Table 8
Area of low scrub land by modified Alaska vegetation classification system (AVCS) level 4 types (species-level) combined at level 3 (open + closed) and owner, southeast Alaska, 2000

Modified AVCS level 4 types combined at level 3	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Alder (extended range of type)	1.2				1.2
Alder-willow (extended range of type)	3.8				3.8
Copperbush (new type)	13.8			2.3	16.1
Copperbush-blueberry (new type)	12.3				12.3
Copperbush-salmonberry (new type)	2.9				2.9
Ericaceous	28.5			6.4	34.9
Mixed scrub	2.3				2.3
Sagebrush-juniper (extended range)			2.3		2.3
Salmonberry-blueberry (new)	9.8			12.9	22.7
Sweetgale	15.4				15.4
Unclassified	7.0			6.8	13.9
Willow	4.1		1.8	2.3	8.2
All types	101.1		4.1	30.7	136.0

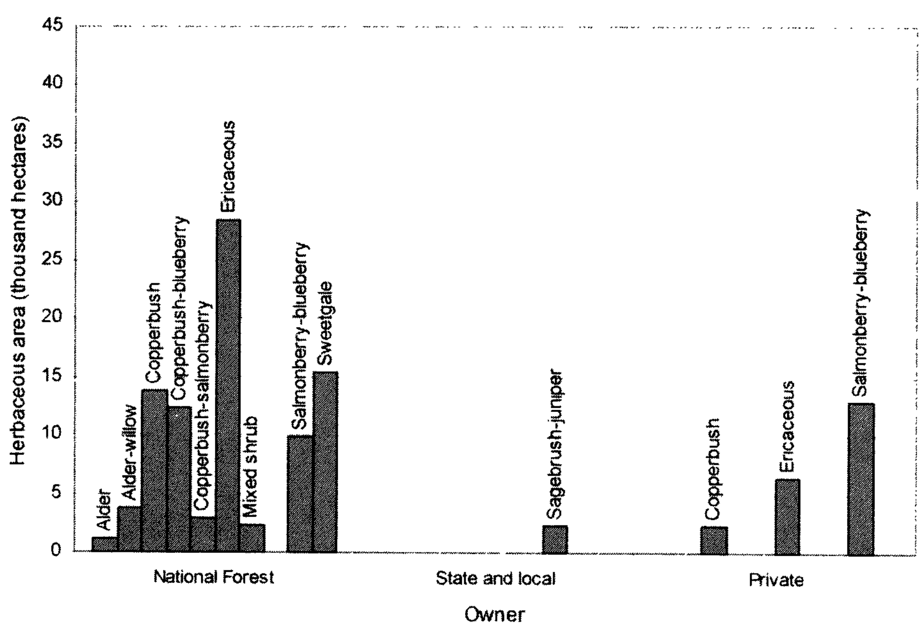

Fig. 10. Area of low scrub land by modified Alaska vegetation classification system level 4 types (species level) combined at level 3 (closed + open) and owner, southeast Alaska, 2000.

Table 9
Area of dwarf scrub land by modified Alaska vegetation classification system (AVCS) level 4 types and owner, southeast Alaska, 2000

Modified AVCS level 4 types (exceptions noted)	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Blueberry	6.3		2.3	2.3	11.0
Cassiope	91.8	2.3	2.3	2.3	98.8
Crowberry	7.6	2.3	4.7		14.7
Dryas (combined to level 3)	2.3				2.3
Ericaceous (classified only to level 3)	11.7				11.7
Phyllodoce	36.9	4.7	4.7		46.3
Unclassified	18.6				18.8
Willow			0.6		0.6
All types	175.4	9.3	14.6	4.6	204.2

Table 10
Area of modified Alaska vegetation classification system (AVCS) level 4 type herbaceous vegetation and groups used for graphing purposes, by owner, southeast Alaska, 2000

Modified AVCS level 4 herbaceous types (exceptions noted)	Group	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)
Alpine herb	Alpine herb	10.3				10.3
Alpine herb-sedge	Alpine herb	2.4				2.3
Bluejoint-herb	Bluejoint	1.2				1.2
Dry bryophyte	Moss	2.6			2.3	4.9
Elymus	Elymus	3.3				3.3
Ferns	Mixed herb	7.0				7.0
Fireweed	Mixed herb				1.2	1.2
Fresh grass marsh	Marsh	1.8				1.8
Fresh herb marsh	Marsh	4.0		2.3	2.3	8.6
Fresh sedge marsh	Marsh	20.0		3.5		23.5
Halophytic grass wet meadow	Meadow			1.2		1.2
Halophytic herb wet meadow	Mixed herb	0.6				0.6
Large umbel	Mixed herb	2.9				2.9
Marine algae	Aquatics	0.2				0.2
Mesic sedge-grass meadow tundra	Tundra	0.6				0.6
Mixed herb	Mixed herb	19.6	2.4		0.3	22.3
Pondlily	Aquatics	1.7				1.7
Seral herbs	Mixed herb	3.2				3.2
Subarctic lowland sedge	Meadow	3.9		1.2		5.2
Subarctic lowland sedge bog	Bog meadow	0.6				0.6
Subarctic lowland sedge-moss bog	Bog meadow	3.3		1.7		5.0
Subarctic lowland sedge-shrub	Meadow	2.5				2.5
Unclassified herbaceous (level 1)	Unclassified	194.7	37.5			232.2
Wet graminoid herbaceous (level 3)	Meadow	2.4				2.3
Wet sedge meadow tundra	Tundra	12.6				12.6
Wet sedge-grass meadow tundra	Tundra	0.7				0.6
Wet sedge-herb meadow tundra	Tundra	8.5				8.5
All types		310.5	39.9	9.9	6.1	366.3

Table 11
Area of herbaceous type groups by owner, excluding 240,600 ha of photo classified herbaceous types estimated on reserved lands, southeast Alaska, 2000

Herbaceous type group	National forest (thousand hectares)	Other federal (thousand hectares)	State and local (thousand hectares)	Private (thousand hectares)	All owners (thousand hectares)	Percent (%)
Alpine herb	12.6				12.6	10
Aquatics	1.9				1.9	2
Bluejoint	1.2				1.2	1
Bog meadow	3.9		1.7		5.6	4
Elymus	3.3				3.3	3
Marsh	20.0		5.8	2.3	28.1	22
Meadow	6.5		2.4		8.9	7
Mixed herb	33.4	2.3		1.5	37.2	29
Moss	2.6			2.3	5.0	4
Tundra	22.3				22.3	18
All groups	107.7	2.3	9.9	6.1	126.1	100

1995). Managers in southeast Alaska may have similar concerns about this type or other wetland types that are subject to high recreational use.

Alder and alder-willow also occurs among the low scrub types, either on exposed scree slopes, or in braided river stream bottoms that are frequently disturbed. Prior to the inventory it was assumed that alder always occurred as a tall scrub type in southeast Alaska; however, there seem to be areas where it persists as a low shrub for a significant period of time until substrate conditions are stabilized.

Our knowledge of southeast Alaska scrub types has increased tremendously since the publication of the AVCS in 1992. At that time, the closed eri-

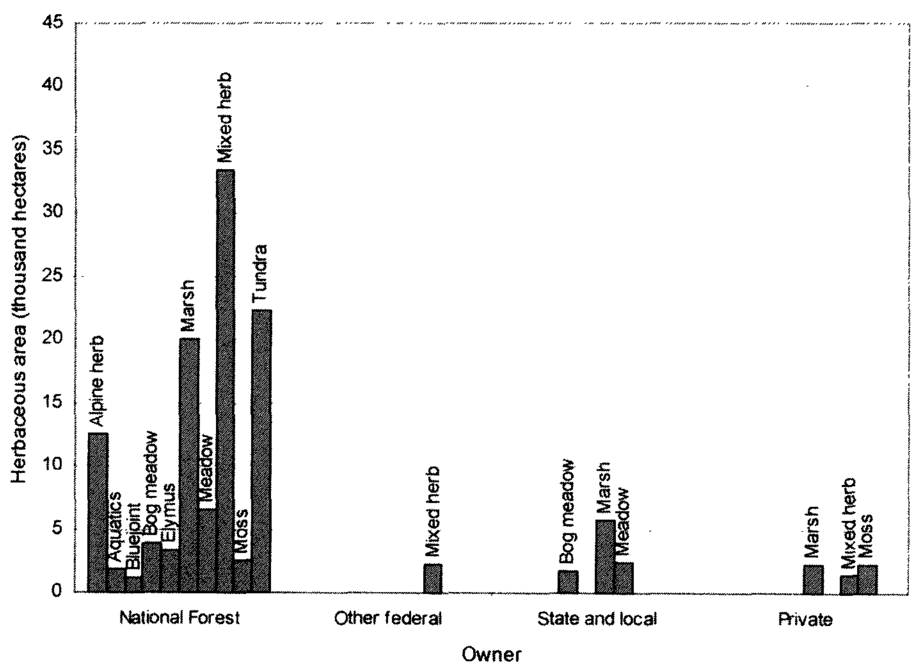

Fig. 11. Area of herbaceous types by owner, excluding 240,600 ha of photoclassified herbaceous types estimated on reserved lands, southeast Alaska, 2000.

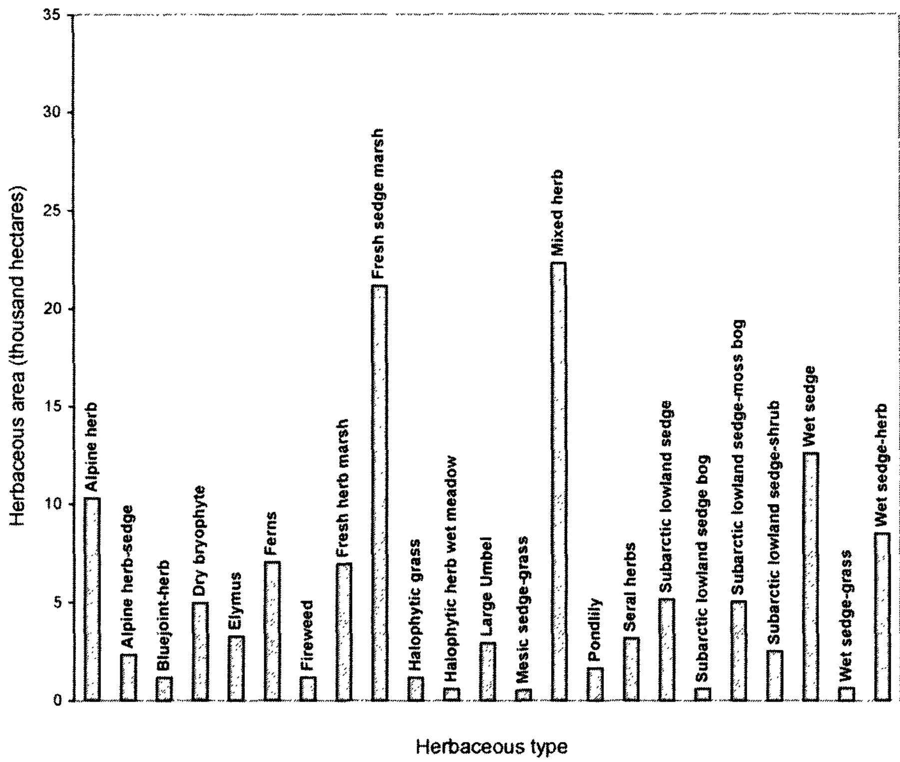

Fig. 12. Area of herbaceous types, all owners, excluding 240,600 ha of photoclassified herbaceous types estimated on reserved lands, southeast Alaska, 2000.

caceous scrub type was estimated to be rare and the only known type listed was copperbush, which forms dense stands. Once the inventory was underway we realized that copperbush (*Elliottia pyroliflorus* (Bong.) S.W. Brim and P.F. Stevens) was much more common than thought, and it was broken out into several other newly identified types such as copperbush–blueberry and copperbush–salmonberry associated types. What remained in the closed ericaceous scrub type was a much more diverse grouping of shrubs such as blueberry, buffaloberry (*Shepherdia canadensis* (L.) Nutt.), bog laurel (*Kalmia polifolia* Wangenh.), salal, and bearberry (*Arctostaphylos* Adans.) The ericaceous types – other than copperbush-composed 26% of the area in low scrub; the closed low ericaceous scrub community is estimated to occur on 9700 ha and composes 7% of all low scrub types.

Dwarf scrub. Most of the dwarf scrub lands occurred on national forest lands with Alaska moss heather (*Cassiope* D. Don) and mountainheath (*Phyllodoce* Salisb.) types composing the largest land areas at 91,800 and 36,900 ha, respectively. Combined, they represent 73% of the dwarf scrub area on national forest ownership (Table 9). Proportionally, blueberry types are more prevalent on state (16%) and private lands (50%) than on federal lands (4%).

Herbaceous. Discussion of the herbaceous types is hampered by the large amount of area that had to be estimated from remote sensing in reserved areas, which were not ground sampled and could not be further classified. The unclassified type composes 63% of the total area estimated as herbaceous cover. Table 10 shows the impact this unclassified area has on our analysis (232,200 out of 366,500 ha in this category). For this reason, we also present Table 11, and Figs. 11 and 12 developed from unreserved lands only. These show a clearer comparison of the types in the areas that were classified.

Table 12
Selected inventory estimates and standard errors, southeast Alaska, 2000

Attribute	Estimate (thousand hectares)	Standard error (%)
All forest land	4449.5	1.62
Other forest land	2791.7	2.38
Timberland	1657.8	3.31
Nonforest land	4805.2	1.5
Net volume	595786.0	4.59
Gross growth	4930.0	3.84
Mortality	3350.7	10.61

Prevalence of herbaceous types across all owners is illustrated in Fig. 12. Predominant among the classified herbaceous land areas were mixed-herb and marsh types, followed by wet sedge-tundra and alpine herb. All of the tundra, alpine herb, aquatic, and bluejoint (*Calamagrostis* Adans.) and beachryegrass (*Elymus L.*) areas occurred on national forest lands (Table 11, Fig. 11). Other federal owners had some mixed herb types; state and local ownership had bog meadow, marsh, and meadow types; and private lands had marsh, mixed herb, and moss types.

5. Reliability of inventory data and cautions on its use

Estimates presented in this report are based on sampling and are subject to two types of error. The first is sampling error. This type of error can be estimated mathematically. The second type of error arises from measurement mistakes or equipment limitations. The second error cannot be estimated mathematically but is minimized through proper training, supervision, emphasis on careful work, and a program of quality assurance and control. The reliability of the inventory is expressed as relative sampling error at the 68% confidence level. Estimates of sampling error are provided in Table 12.

The timberland estimate, for example, is 1.66 million hectares, ±3.31%, with 68% confidence limits of 1.61 and 1.71 million hectares. If repeated samples were taken of this population, the estimate of timberland area would be between 1.61 and 1.71 million hectares 68% of the time.

Some characteristics of the modified AVCS type estimates bear on use of these estimates. Newly identified types are tentative, and complete type descriptions have not yet been published. Vegetation types are based on current vegetation, and abundance levels are subject to impacts of human-caused disturbances as well as natural processes. Some types will be transitory, as forests regenerate on cutover forests, recover from insect and disease impacts, or regenerate after wind damage. Area values for rare vegetation types may be overestimated, underestimated, or not reported owing to small sample sizes. Species richness estimates for types observed on few plots are less reliable than for types observed on many plots. Numbers of locations are provided as an indicator of reliability of the richness estimates.

6. Summary

This inventory of southeast Alaska represents the first systematic and comprehensive survey of all vegetation, across all ownerships, in this area of the state. Knowledge about the character and extent of various forest and nonforest vegetation types on all lands can assist natural resource managers in making land use and management decisions. It provides a unique assessment of existing vegetation that goes beyond traditional timber surveys of the past. It can inform land use planners on the extent of these various types, the overall diversity of plant community types, and the relative abundance of each type. Finally, the systematic placement of sample locations provides capability for regional spatial analysis previously unavailable to resource managers in southeast Alaska.

Future analyses will benefit from the recently published ecological subsection classification of southeast Alaska (Nowacki et al., 2001). This classification describes ecological units in terms of landform, parent material, soils, land cover, productivity, wetlands, stream processes, slope, aspect, and land use and will provide a deeper context and understanding when describing plant community distribution and how various plant communities fit in the underlying landforms. This may help in understanding the implications of alternative actions by land managers of those communities.

Appendix A

Scientific names of species.

Scientific name	Common name
Alnus P. Mill.	Alder
Arctostaphylos Adans.	Bearberry
Artemisia L.	Sagebrush
Betula papyrifera Marsh.	Paper birch
Calamagrostis Adans.	Bluejoint
Carex L.	Sedge
Cassiope D. Don	Alaska moss heather
Chamaecyparis nootkatensis (D. Don) Spach	Alaska yellow-cedar
Chamerion Raf. ex Holub	Fireweed
Dryas L.	Mountain avens
Elliottia pyroliflorus (Bong.) S.W. Brim and P.F. Stevens	Copperbush
Elymus L.	Beachrye grass
Empetrum nigrum L.	Crowberry
Gaultheria shallon Pursh	Salal
Juniperus communis L.	Juniper
Kalmia polifolia Wangenh.	Bog laurel
Myrica gale L.	Sweetgale
Nuphar Sm., *Nymphaea* L.	Pondlily
Phyllodoce Salisb.	Mountainheath
Picea sitchensis (Bong.) Carr.	Sitka spruce
Pinus contorta Dougl. ex Loud.	Lodgepole pine
Populus trichocarpa Torr. and Gray	Black cottonwood
Rubus spectabilis Pursh	Salmonberry
Salix L.	Willow
Shepherdia canadensis (L.) Nutt.	Buffaloberry
Thuja plicata Donn ex D. Don	Western redcedar
Tsuga heterophylla (Raf.) Sarg.	Western hemlock
Tsuga mertensiana (Bong.) Carr	Mountain hemlock
Vaccinium L.	Blueberry

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