Understory Vegetation Development Following Commercial Thinning in Southeast Alaska: Preliminary Results from the Second-Growth Management Area Demonstration Project

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Abstract

Five commercial thinning demonstration sites in southeast Alaska were treated in 1984-85 to evaluate commercial thinning treatments that could enhance the development of understory vegetation. The effects of these treatments upon the availability and quality of Sitka black-tailed deer forage were also evaluated. The five commercial thinning sites were re-assessed in 1998. The strip and strip + individual tree selection (ITS) treatments had the highest total biomass, 2,291 pounds per acre and 2,138 pounds per acre, respectively. Most of the biomass of these two treatments consisted of conifers. The ITS treatment had 1,357 pounds of total biomass per acre, of which 782 pounds per acre were of shrub/fern/forbs, which had more nutritional value for deer. The ITS treatment yielded better forage resources for deer (capacity for "deer days") than did any other treatment or the untreated control. Results from this study show that thinning treatments can improve deer forage availability when compared to no thinning treatment and that individual tree selection thinning can provide summer habitat for deer similar to the values provided by old-growth forest.

Keywords: Thinning, active stand management, individual tree selection, strip thinning, Sitka black-tailed deer, deer forage.

Introduction

Replacement of old-growth forest with even-aged young-growth is a major management issue for wildlife resources in Southeast Alaska. Several economically and socially important species such as the Sitka black-tailed deer are heavily dependent upon old-growth forests for sustenance and cover. Other species such as the Alexander Archipelago wolf, prey upon Sitka black-tailed deer and, thus, are indirectly dependent upon old-growth forests. Forest managers are seeking answers as to how well these species might adapt to younger forests and how could active stand management of young-growth stands bring about the desirable habitat features of mature and old-growth forests.

The natural southeast Alaska forest environment is characterized by a high-frequency, low-magnitude disturbance regime (Brady and Hanley 1984). The process of individual trees or small groups of trees dying or being blown down by wind is more or less a continuous process (Harris 1989). The old-growth forest is a succession of canopy gaps in space and time. With the forest floor light environment continuously shifting, no one species or group of species can gain a competitive advantage over others and shade them out. This equilibrium more or less continues until some extensive canopy disturbance such as windthrow or clearcut harvesting occurs.

New stand development after a major disturbance such as clearcutting follows a general pattern. A new cohort of advance regeneration and newly germinated western hemlock and Sitka spruce (>4000 trees/acre) reoccupy the disturbed site (Oliver 1981; Alaback 1982a; Deal et al. 1991). Following clearcutting, residual shrubs also respond with a rapid growth increase that peaks in cover (Robuck 1975) and biomass (Alaback 1980) between 15 to 25 years. Conifers begin to overtop

shrubs by 8 to 10 years and crown closure may be complete by 25 years (Harris and Farr 1974). During this stage of stem exclusion, the decline of understory vascular plants is rapid, and their elimination occurs in 25-35 years (Alaback 1980). Continued suppression of understory vegetation and tree regeneration may last for up to 100 years with understory vegetation not becoming well developed until stands are 120-150 years old (Alaback 1982b, 1984; Tappeiner and Alaback 1989).

The lack of light is probably the most important factor limiting understory growth (Alaback 1980). Light reaching the forest floor of a closed-canopy conifer forest, even on a clear day, is but a small fraction (1,000 luxes) of levels (50,000 luxes or more) that fall in open areas (Klein 1979). It may require 250 years or more for stands to achieve old-growth overstory characteristics of widely spaced trees and complex multi-layered canopies that allow light of variable intensity to reach the forest floor (Alaback 1984). These characteristics promote the development of an understory shrub and herb layer of oval-leaf blueberry, red huckleberry, bunchberry, fern-leaf goldthread, five-leaf bramble, foamflower, skunk cabbage, and shield fern, all of which are key plant species for deer forage.

Precommercial thinning may delay the onset of the stem exclusion stage and loss of understory for a brief period if the thinning is performed when understory plants are well established. However, aggressive understory conifers will outgrow the other species and shade them out, or the overstory canopy will close and shade out the understory (Deal and Farr 1993).

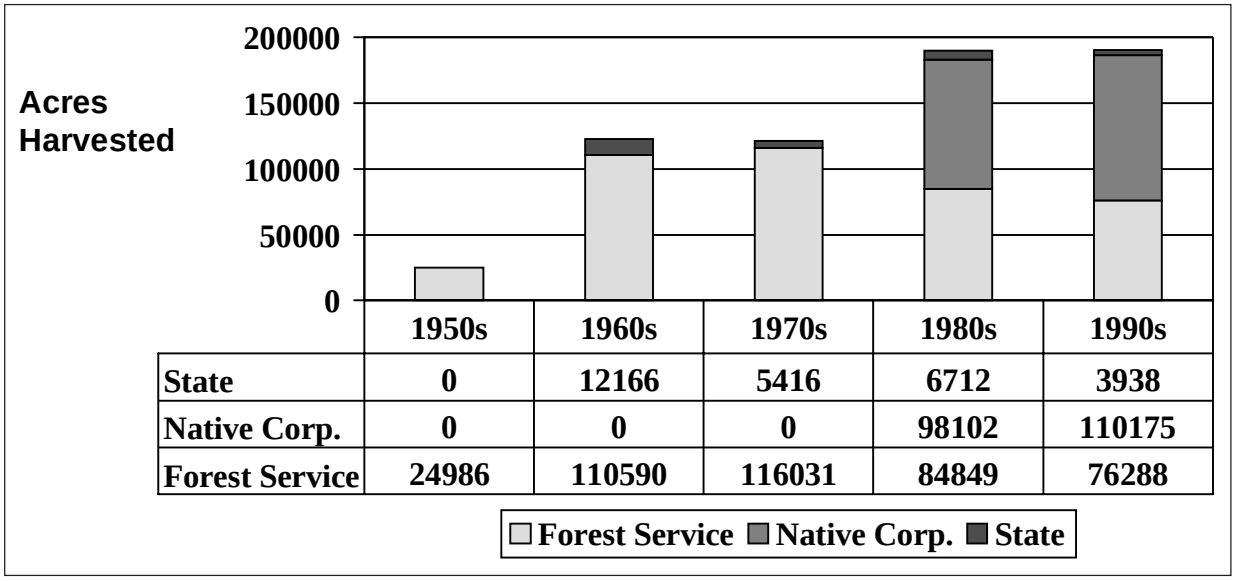
Prior to the 1950s, timber harvest practices in southeast Alaska consisted mostly of selective cutting of individual or small groups of trees to supply wood products for mining, fish canneries, and lumber for local southeast Alaska communities. Logging was mostly confined to easily accessible areas along the shoreline and lower river valleys. Harvested areas were generally less than 124 acres (Deal 1999).

The scale of timber harvest increased significantly in the 1950s with the establishment of long-term timber sale contracts on the Tongass National Forest. These 50-year contracts called for the harvest of over 13 billion board feet (USDA FS 1979) and construction of associated pulp mills in Ketchikan and Sitka. The objectives of these contracts were to provide a sound economic base in southeast Alaska, provide year-round employment, and replace a portion of the highly defective old growth with vigorous young growth to increase the productivity of the forest for wood fiber.

The scale of timber harvest in southeast Alaska was further increased through passage of the Alaska Native Claims Settlement Act in 1971. This Act authorized the transfer of about 44 million acres throughout the State of Alaska from Federal management to private ownership. Native regional and village corporations were given the opportunity to select land holdings from National Forest System lands. Of the total 550,000 acres the Native corporations selected from the Tongass National Forest, 460,000 acres are estimated to be productive forestland. A primary objective of these Native corporations was to provide an economic return to their shareholders. Many Native corporations harvested their forestlands to help meet their objectives.

As of 2000, slightly over 654,000 acres in southeast Alaska have been harvested: 416,400 acres on National Forest lands, 210,000 acres on Native corporation lands, and 28,000 acres on State of Alaska lands; all primarily using the clearcut method (fig. 1). Clearcutting is well suited to the timber species and conditions found in southeast Alaska. Western hemlock and Sitka spruce's thin bark makes them susceptible to logging damage and subsequent wound infection by decay fungi. Their shallow roots (due to shallow soils) make standing residual trees susceptible to windthrow. The risk of windthrow increases when partial cutting opens up stands. Clearcutting disturbs less area for a given amount of timber volume than does partial cutting. Compared to other harvesting methods, clearcutting is the most economical method (Harris and Farr 1974).

To address the question of how could active stand management of young-growth stands bring about the desirable habitat features of mature and old-growth forests, an Alaska Region Silvicultural Development Group was established in 1982. The objective of this group was to "…develop, implement, monitor, and demonstrate a program to monitor second-growth stands of hemlock and spruce forests on the Tongass National Forest to increase



	1950s	1960s	1970s	1980s	1990s
State	0	12166	5416	6712	3938
Native Corp.	0	0	0	98102	110175
Forest Service	24986	110590	116031	84849	76288

Figure 1–Acres harvested by decade and by ownership in southeast Alaska, 1950-2000.

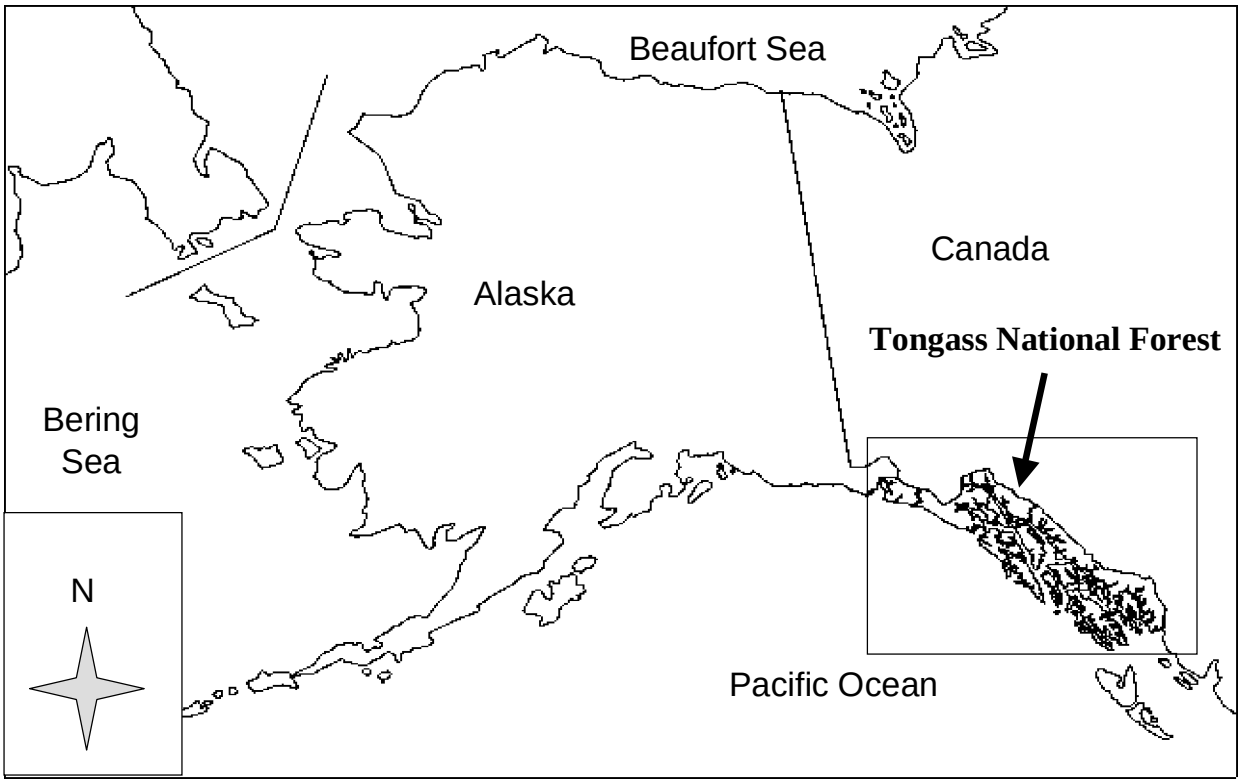


Figure 2–Vicinity map, second-growth management demonstration area .

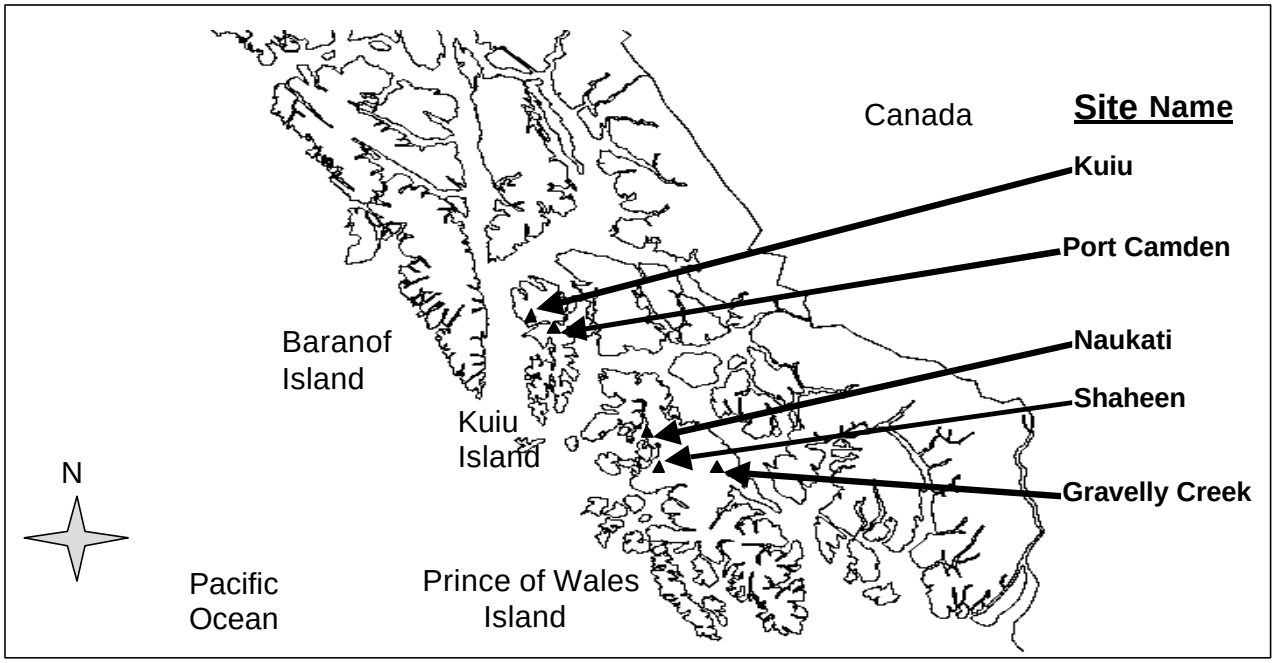


Figure 3–Location map, second-growth management demonstration area.

timber production and improve wildlife habitat capability." Emphasis was placed on implementing commercial and precommercial thinning projects to test their value for wildlife habitat improvement and timber production. The precommercial thinning projects were later abandoned because their remoteness caused logistical problems in monitoring, and the Forestry Science Laboratory was conducting other studies that were intended to address the values of precommercial thinning.

To achieve the above objective, the Second-growth Management Area Demonstration Project was developed. The purpose of the project was two-fold: to determine the effects of various commercial thinning treatments on understory diversity and abundance and to assess the effects of these treatments on deer forage availability. Five commercial thinning sites on the Tongass National Forest were chosen: three on Prince of Wales Island (POW) and two on Kuiu Island (figs. 2 and 3). Because the objectives of the study were to demonstrate the effects of different commercial thinning treatments on understory development for deer habitat, all sites were located in high-value deer winter range. All five sites were clearcut between 1890 and 1942 and commercially thinned in 1984 and 1985. Thinning treatments were: ITS—individual tree selection, trees thinned to 20- to 25-foot spacing (four sites); strip + ITS—combination of 30-foot wide cut strips alternated with 20- to 25-foot wide strips that were thinned to 20- to 25-foot spacing (three sites), and strip—alternating 20-foot cut strips and 20-foot no-cut strips (two sites) (fig. 4). One unthinned control was also established at each of the five sites.

Table 1 displays the site name, year harvested, year thinned, and treatment applied. Because commercial thinning was new to southeast Alaska, all of the falling and yarding was performed through a service contract to maintain better quality control over the logging operation.

Methods

Aboveground measures of biomass for all vascular species were obtained within 1.0-m^2 quadrats along transect lines established within each stand. Spacing of quadrats varied with the size and shape of each stand, but quadrats were spaced to ensure a uniform sampling of the entire stand. Twenty quadrats were used for herbs (forbs, ferns, graminoids), and 30 quadrats were used for shrubs and conifer seedlings. All aboveground biomass was harvested and weighed (fresh weight) by species within each quadrat. For each shrub species within each quadrat, a subsample of three stems (cut at ground level) was separated into leaves

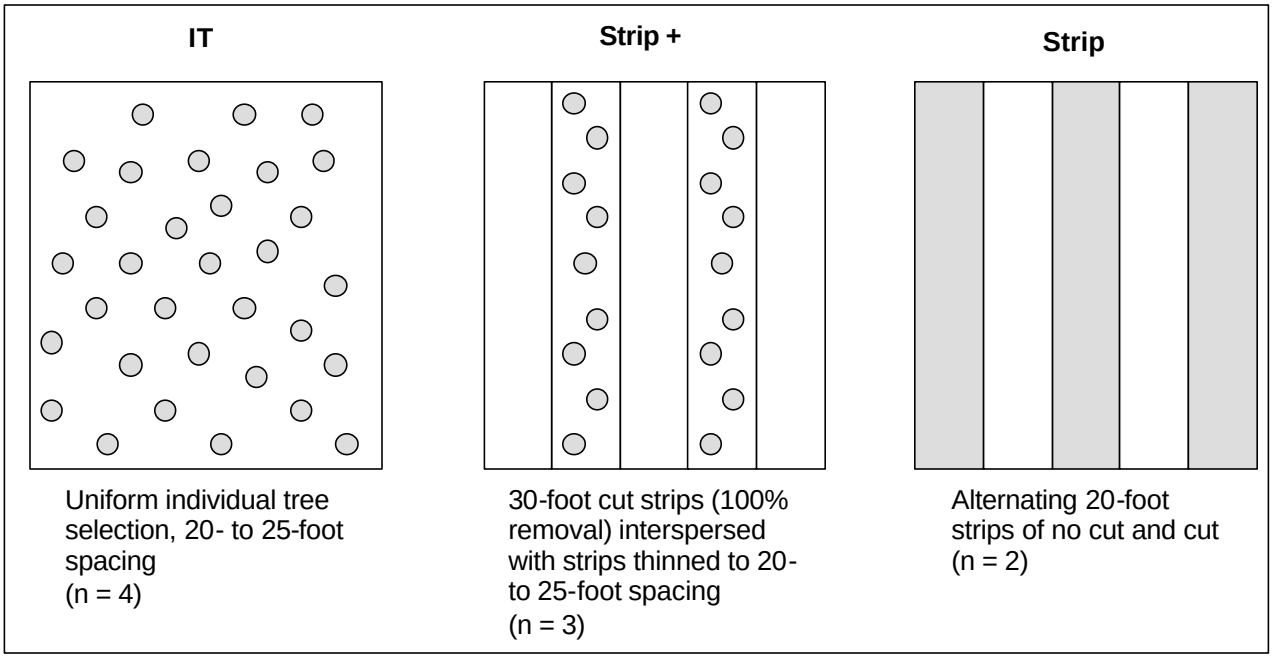


Figure 4–Schematic drawings of treatments.

Table 1—Treatment locations and treatments applied

Treatment Site	Location	Year Harvested	Year Thinned	Treatment Applied
Gravelly Creek 1	POW Island[a]	1920	1985	ITS
Gravelly Creek 2	POW Island	1920	N/A	Control
Naukati 1	POW Island	1925	1985	Strip
Naukati 2	POW Island	1925	1985	Strip + ITS
Naukati 3	POW Island	1925	1985	Strip + ITS
Naukati 4	POW Island	1925	N/A	Control
Shaheen 1	POW Island	1929	1985	Strip
Shaheen 2	POW Island	1929	1985	Strip + ITS
Shaheen 3	POW Island	1942	1985	ITS
Shaheen 4	POW Island	1929	N/A	Control
Kuiu 1	Kuiu Island	1890	1984	ITS
Kuiu 2	Kuiu Island	1890	N/A	Control
Port Camden 1	Kuiu Island	1935	1984	ITS
Port Camden 2	Kuiu Island	1935	N/A	Control

[a] POW (Prince of Wales).

(including flowers), current year's twigs, and stems (prior years' growth) and weighed. A subsample of three conifer seedlings for each species within each quadrat was similarly separated into current year's growth and prior year's growth and weighed. Subsamples of fresh material were oven-dried each day for each species to determine the dry weight per unit fresh weight. All understory biomass measures are expressed in terms of oven-dry weight (105°C).

Samples of the 18 most abundant understory species were collected within each stand in which they occurred, separated into leaves, twigs, and stems (shrubs), and current and prior years' growth (conifers), and oven-dried at 40°C for nutritional analyses. Nutritional analyses were conducted by the Range and Habitat Analysis Laboratory at Washington State University and included sequential detergent analysis (Goering and Van Soest 1970, as modified by Hanley et al. 1992) for fiber constituents and total nitrogen by the Kjeldahl method for all forage samples. Digestible dry matter and digestible protein were estimated with equations from Hanley et al. (1992), without incorporating effects of plant tannins on protein digestion.

The value of understory vegetation as food resources for deer was quantified with a nutritionally based model for calculating the number of deer days that could be supported by the food supply (Hanley and Rogers 1989). One deer day equals the forage needed to maintain one deer for one day at a specified metabolic requirement without losing weight. We calculated deer days for each stand under two different levels of metabolic requirements: one for an adult female at maintenance requirement (no weight gain or reproduction) and one for a lactating adult female with one fawn (i.e., reproduction requirement). Lactation requires higher average dietary standards of both digestible dry matter (i.e., energy) and digestible protein. The model makes no assumption about habitat other than the input data for food resources: the biomass of each forage species, its dry-matter digestibility, and its concentration of digestible protein. Food resources are considered as though they were harvested and fed to captive deer.

Results

Total biomass. Figure 5 shows the mean total biomass for the controls, treated stands, and seven old-growth stands in coastal Alaska (Alaback and Juday 1989). The strip and strip + ITS treatments had the highest total biomass, 2,291 pounds per acre and 2,138 pounds per acre, respectively. The ITS treatment had 1,357 pounds of total biomass per acre, and the control (unthinned) treatment had 111 pounds per acre. When compared to old growth, however, all treatments had less total biomass. The old-growth forest had 2,743 pounds per acre of total biomass.

Biomass by plant groupings. Figure 5 also shows biomass by plant groupings (forbs, ferns, shrubs, and conifers) by treatment and the old-growth forest. The strip + ITS treatment produced the highest amount of conifer biomass (1,894 pounds per acre) followed by the strip treatment (1,947 pounds per acre), the ITS treatment (575 pounds per acre), and the control (21 pounds per acre). The old-growth forest had 667 pounds of conifer biomass. The ITS treatment produced the highest amount of shrub/fern/forb biomass (782 pounds per acre), followed by the strip treatment (345 pounds per acre), the strip + ITS treatment (245 pounds per acre), and the control (90 pounds per acre). All of these treatments produced less shrub/fern/forb biomass than the old-growth forest (2,072 pounds per acre).

Deer forage availability. Table 2 shows the deer forage availability for each of the treatments. The strip and strip + ITS treatments provided almost the same deer forage availability, providing 161 and 160 deer days per acre, respectively. The ITS treatment provided 142 deer days and the control 26 deer days. All of these values however, were lower than the 251 deer days provided by upland old-growth forest (Hanley and Hoel, 1996).

When the nutritional requirements of a fawn are added in, the picture changes dramatically. The ITS treatment provides the highest number of doe + fawn days (34 days), followed by the control and strip (six days each), and the strip + ITS provided the fewest number of doe + fawn days (three days). In comparison, the old-growth forest provides 30 doe + fawn days.

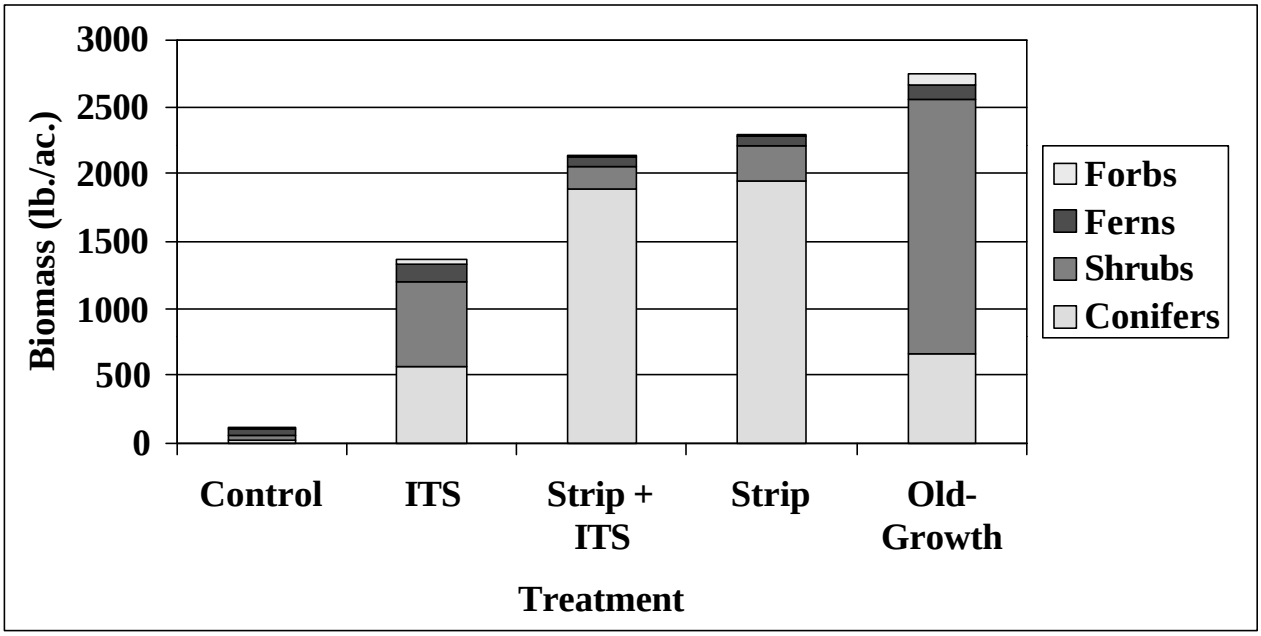


Figure 5–Total biomass and biomass by plant groupings.

Table 2—Deer forage availability by treatment

	Control	ITS	Strip + ITS	Strip	Old-Growth
N=	5	4	3	2	7
Doe only (days/ac)	26	142	160	161	251
Doe+1 fawn (days/ac)	6	34	3	6	30

Discussion

Care must be taken in interpreting the results of this demonstration project given the limited sample. However, some general observations can be made:

- Commercial thinning, regardless of type, appeared to enhance habitat of deer when compared to no commercial thinning.
- Habitat for deer reproduction was best improved by the ITS treatment, when compared to the other treatments and to no commercial thinning. Forbs were the forage class of highest nutritional value for deer–they typically contain less total fiber, fiber that is more digestible, and greater concentrations of digestible protein than all other forage classes (Hanley and McKendrick 1983, Parker et al. 1999). The number of deer days was strongly determined by the biomass of forbs, and this was especially true for the higher nutritional requirements of lactating deer (reproduction). The difference in carrying capacity (deer days) for reproductive versus non-reproductive deer, therefore, was much greater in treatments containing fewer forbs in their understory than in forb-rich understories. Although shrubs in the old-growth stands contributed more toward maintenance requirements of deer than they did in any of the thinning treatments, little of that shrub biomass was sufficient for meeting reproductive requirements. Carrying capacity of the ITS treatment for reproductive deer came very close to that of the old growth. However, our analysis applies only to summer conditions; deciduous leaves and snow-covered plants are not available to deer in winter.
- Opening the stand up too much, as in strip thinning, greatly increases the amount of conifer regeneration produced.
- Total biomass is not a good measure of deer forage resources. Forbs are the major determinant of carrying capacity for deer, and their biomass determines how much use can be made of the additional, lower quality foods such as shrubs, ferns, and conifers.

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References

Alaback, P.B. 1980. Biomass and production of understory vegetation in seral Sitka spruce-western hemlock forests of southeast Alaska. Corvallis, OR: Oregon State University. 79 p. Ph.D. dissertation.

Alaback, P.B.1982a. Dynamics of understory biomass in Sitka-spruce-western hemlock forests of southeast Alaska. Ecology. 63: 1932-1948.

Alaback, P.B. 1982b. Forest community structural change during secondary succession in southeast Alaska. In: Means, J.E., ed. Proceedings of the symposium on forest succession and stand development research in the Northwest. Corvallis, OR: Forestry Research Laboratory, Oregon State University: 70-79.

Alaback, P.A. 1984. A comparison of old-growth forest structure in the western hemlock-Sitka spruce forests of southeast Alaska. In: Meehan, W.R.; Merrell, T.R., Jr.; Hanley, T.A., eds. Fish and wildlife relationships in old-growth forests. Proceedings of a symposium, Juneau, AK: American Institute of Fisheries Research Biologists: 219-226.

Brady, W.W.; Hanley, T.A. 1984. The role of disturbance in old-growth forests: some theoretical implications for southeast Alaska. In: Meehan, W.R.; Merrell, T.R., Jr.; Hanley, T.A., eds. Fish and wildlife relationships in old-growth forests. Proceedings of a symposium, Juneau, AK: American Institute of Fisheries Research Biologists: 213-218.

Deal, R.L. 1999. The effects of partial cutting on stand structure and growth, and forest plant communities of western hemlock-Sitka spruce stands in southeast Alaska. Corvallis, OR: Oregon State University. 191 p. Ph.D. dissertation.

Deal. R.L.; Farr, W.A. 1994. Composition and development of conifer regeneration in thinned and unthinned natural stands of western hemlock and Sitka spruce in southeast Alaska. Canadian Journal of Forest Research. 24(5): 976-984.

Deal, R.L.; Oliver, C.D.; Bormann, B.T. 1991. Reconstruction of mixed hemlock-spruce stands in coastal southeast Alaska. Canadian Journal of Forest Research. 21: 643-654.

Deal, R.L.; Tappener, J.C. 2000. The effects of partial cutting on structure and growth of western hemlock-Sitka spruce stands in southeast Alaska. Forest Ecology and Management. 5486: 1-14.

Goering, H.K.; Van Soest, P.J. 1970. Forage analyses (apparatus, reagents, procedures and some applications). Agricultural Handbook 379. Washington, D.C: U.S. Department of Agriculture, Agricultural Research Service.

Hanley, T.A. 1991. Old-growth forests and biological conservation in temperate rain forests of North America. In: Maruyama, N.; Bobek B.; Ono, Y. [and others], eds. Wildlife conservation: present trends and perspectives for the 21st century. Proceedings, international symposium on wildlife conservation in Tsukuba and Yokohama, Japan: 65-68.

Hanley, T.A.; Hoel, T. 1996. Species composition of old-growth and riparian Sitka spruce-western hemlock forests in southeast Alaska. Canadian Journal of Forest Research. 26: 1703-1708.

Hanley, T.A.; McKendrick, J.D. 1983. Seasonal changes in chemical composition and nutritive value of native forages in a spruce-hemlock forest, southeastern Alaska. Research Paper PNW-312. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 41 p.

Hanley, T.A.; Robbins, C.T.; Hagerman, A.E. [and others]. 1992. Predicting digestible protein and digestible dry matter in tannin-containing forages consumed by ruminants. Ecology. 73: 537-541.

Hanley, T.A; Rogers, J.J. 1989. Estimating carrying capacity with simultaneous nutritional constraints. Res. Note PNW-RN-458. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 29 p.

Harris, A.S. 1989. Wind in the forests of southeast Alaska and guides for reducing damage. Gen. Tech. Rep. PNW-GTR-244. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 40 p.

Harris, A.S.; Farr, W.A. 1974. The forest ecosystem of southeast Alaska, 7: Forest ecology and timber management. Gen. Tech. Rep. PNW-25. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 109 p.

Kessler, W.B. 1982. Wildlife and second-growth forests of southeast Alaska: problems and potential management. In: Wildlife and fisheries habitat management notes. Doc. No. 110. U.S. Department of Agriculture, Forest Service, Alaska Region.

Klein, D.R. 1979. Ecology of deer range in Alaska. In: Wallmo, O.C.; Schoen, J.W., eds. Sitka black-tailed deer. Proceedings of a conference. Juneau: U.S. Department of Agriculture, Forest Service, Alaska Region: 25-32.

Oliver, C.D. 1981. Forest development in North America following major disturbances. Forest Ecology Management. 3: 153-168.

Parker, K.L.; Gillingham, M.P.; Hanley, T.A. [and others]. 1999. Energy and protein balance of free-ranging black-tailed deer in a natural forest environment. Wildlife Monographs. 143: 1-48.

Robbins, C.T.; Hanley, T.A.; Hagerman, A.E. [and others]. 1997. Role of tannins in defending plants against ruminants: reduction in protein availability. Ecology. 68: 98-107.

Robuck, W. 1975. Understory vegetation in thinned and unthinned hemlock-spruce stands in Alaska. Program Representative, Coop. Administration Study FS-PNW-1642. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 5-8.

Tappeiner, J.C.; Alaback, P.B. 1989. Early establishment and vegetative growth of understory species in western hemlock-Sitka spruce forests of southeast Alaska. Canadian Journal of Botany. 67: 318-326.

Appendix

Common and Scientific Names of Plants, Trees, and Animals

Common name	Scientific name
Bunchberry dogwood	*Cornus canadensis* L.
Fernleaf goldthread	*Coptis asplenifolia* Salisb.
Five-leaf bramble	*Rubus pedatus* Sm.
Foamflower	*Tiarella trifoliata* L.
Oval-leaf blueberry	*Vaccinium ovalifolium* Sm.
Red huckleberry	*Vaccinium parvifolium* Sm.
Shield fern	*Dryopteris expansa* (K. Presl) Fraser-Jenkins & Jermy
Skunk cabbage	*Lysichiton americanus* Hultén & St. John
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Alexander Archipelago wolf	*Canis lupis ligoni*
Sitka black-tailed deer	*Odocoileus hemionus sitkensis*