APPENDIX E – SILVICULTURAL SYSTEMS

Introduction

This appendix describes the silvicultural systems available and some of the silvical characteristics of the tree species found on the Chugach National Forest.

No single silvicultural system can produce all desired combinations of products and amenities from a particular stand, or from a national forest. A good silvicultural system is a solution to a specific set of circumstances and it should fit logically into the overall management plan for the forest. The system must provide for the control of damaging agents and provide adequate resistance to the same. A silvicultural system is developed from stand-specific analyses. The prescription is designed to meet desired conditions and considers such issues as worker safety, logging systems layout, pathogen and insect effects, animal populations, costs, stand development and yield, fuels management, and so forth.

Each of the described systems has a sound scientific basis when applied appropriately and matched to the management objectives and site conditions. Factors other than the silvical or ecological limitations of the species weigh heavily in the choice between even-aged, two-aged and uneven-aged management, and the various regeneration methods or variations within each system. These may include:

- other resource values;
- management objectives.
- terrain considerations with its limitations on logging systems;
- susceptibility to windthrow;
- susceptibility to logging damage;
- policy constraints; or,
- socio-economic considerations.

All silvicultural systems are available for site-specific project level design and analysis. Certified silviculturists usually make the site-specific project level selection of silvicultural systems, which are evaluated through the NEPA process.

The choices are dependent on matching the attributes of the silvicultural systems with specific management objectives, the ecological characteristics for specific stands and species, and policy direction.

The Revised Forest Plan provides direction on the appropriateness of some of the silvicultural systems for specific management area prescriptions or provides standards or guidelines modifying size, location and so forth of harvest units. The selection of an appropriate method depends on a number of factors, which may include: 1) the physical limitations of the sites, 2) the species involved, and 3) other resource considerations.

Legal and Administrative Framework

- **36 CFR 219.27(b)** and Forest Planning Regulations – Criteria for the selection of regeneration methods (silvicultural system) for vegetative manipulation that may be used on national forests in Alaska are in 36 CFR 219.27(b).

  The selected method must meet all the criteria, which are:

  (a) be capable of meeting special management and multiple-use objectives (36 CFR 219.27(b): Criteria 1 and 6);

  (b) permit control of vegetation to establish desired species composition, density, and rates of growth (36 CFR 219.27(b): Criteria 4 and 6);

  (c) promote a stand structure and species composition that minimize risks from solar radiation, disease, and windthrow (36 CFR 219.27(b): Criterion 4);

  (d) use available and acceptable logging methods (36 CFR 219.27(b): Criterion 4);

  (e) assure that lands can be adequately restocked within 5 years (36 CFR 219.27(b): Criterion 2);

  (f) be practical and economical in terms of transportation, harvesting, preparation, and administration of timber sales (36 CFR 219.27(b): Criterion 7); and,

  (g) not be selected solely on the basis of greatest dollar return or highest output of timber, and not permanently reduce site productivity or impair conservation of water and soil resources (36 CFR 219.27(b): Criteria 3 and 5).

Silvicultural Systems

This section describes the major silvicultural systems considered in land management planning for the Chugach National Forest. The discussion includes the biological and managerial factors and the advantages and disadvantages of various systems. Much of the information also applies to selecting an appropriate silvicultural system for a particular stand.

Silviculture is the art and science of manipulating forest vegetation to meet various resource management objectives and desired future conditions. Silviculture is applied forest ecology. Manipulating forest vegetation may consist of controlling its establishment, composition, and growth. Objectives may include aesthetics, water, timber, wildlife, fish and recreation. Wood production may or may not be a primary objective. For example, the vegetative manipulation methods used to improve wildlife habitats in the forest are silvicultural.

Silvicultural systems refer to a complete set of treatments used to manage forest stands and forest landscapes over long periods of time (Harris and Johnson 1983). The systems used will strongly influence forest conditions and the ability to provide the outputs society desires. A silvicultural system is the process of growing a stand for a specific purpose and it is the means of reaching a desired future condition. This process includes the harvest or regeneration of the stand, intermediate cuttings, and other cultural treatments necessary for the development and replacement of the forest stand.

Silvicultural systems are applied through prescriptions, which are written records of the examination, diagnosis, and treatment regimes prescribed for the stand. The Forest Service, as documented in the Forest Service Manual, requires that all silvicultural prescriptions be approved by a certified silviculturist.

Silvicultural systems are adaptations of natural occurrences. Nature makes "regeneration cuttings" through fire, insects, disease, wind, and other phenomena by removing a single tree, a small group of trees, a stand, or sometimes a whole forest. Diversity in landscapes is usually the result of disturbance. Disturbance descriptors are frequency, intensity, size, and type of action. Through the imitation of natural disturbance regimes, land managers can achieve many ecosystem objectives, since many organisms and processes are adapted to such regimes.

The regeneration methods or stand replacement methods defines the name of the silvicultural system. There are five broad classes of regeneration cuttings, and they are: selection (single-tree and group), seed tree, shelterwood, clearcut, and coppice. These classes include a number of variations within each class.

The Forest Service currently groups regeneration methods into even-aged, two-aged, and uneven-aged systems. Clearcutting, shelterwood, seed tree and coppice regeneration methods create even-aged stands; selection and group-selection create uneven-aged stands; and clearcutting with reserves, seedtree with reserves, and shelterwoods with reserves will create two-aged stands. A comparison of some of the advantages and disadvantages of each method is found in Table E-1.

Even-Aged Systems

Even-aged systems produce stands that consist of trees of the same or nearly the same age. A stand is even-aged if the range in tree ages normally does not exceed 20 percent of the rotation age--the age at which the stand is harvested. Even-aged stands have a beginning and an end in time. Seed-tree cutting, shelterwood cutting, clearcutting, and coppice cutting will all produce even-aged stands.

Some features of even-aged systems are: simplicity of harvesting, favorable economics, the removal of great volumes per entry, the control of disease, and the creation of conditions favorable for regeneration of Sitka spruce, white spruce, and early successional hardwoods.

Stands regenerated by even-aged systems develop through distinct succession stages. There are even-aged stands of various ages and sizes distributed throughout the managed forest. The system produces a stand-developmental sequence much like that which follows stand replacement events such as catastrophic wildland fire, windthrow, landslides or avalanches. The sequence may include dense seedlings and saplings, thinned saplings, poles, small diameter trees, medium diameter trees, and large diameter trees. Consequently, even-aged forests have relatively low vertical diversity (variety within a site), but they have a high degree of horizontal diversity (variety across the landscape) and edge effect diversity. The forest is a mosaic of patches of trees and openings. The low vertical diversity is a result of the comparatively simple structure of the even-aged stand.

Vertical diversity can be developed with time-lengthened rotations or modifications of standard even-aged harvest practices. Ecosystem management does not mean that even-aged systems are not appropriate methods. The traditional use of the practice may require some modification to incorporate some of the ecosystem concepts.

Clearcutting method. The clearcut method is the removal of all or most of the stand in one cutting. Clearcuts may be in the form of patches, strips, or stands. Natural seeding from adjacent stands or planting provides the necessary forest reproduction. With careful harvest techniques, much of the advanced regeneration can survive the logging operation. The clearcut method mimics large-scale disturbances such as windstorms or other stand replacement events.

A variation of the method is the retention of reserve trees, which are left to meet specified management objectives. Much like the natural disturbance of windthrow, clearcutting re-initiates the process of plant succession. Invasions of forage plants and browse plants occur, followed by the establishment of trees. Usually, the prime objective of this method is to re-establish an even-aged stand by removing the mature or overmature one. Where timber production is the primary management objective, the clearcut method with natural regeneration and follow-up precommercial thinning has been the primary regeneration method on the Chugach National Forest. The system usually provides abundant regeneration, effective disease tree control, viable harvest economics, and compatibility with the use of standard logging systems. The regeneration comes from wind-dispersed seed and from advanced regeneration that has survived the logging operation.

The controversy over the size of clearcut openings led to the National Forest Management Act of 1976. The act established maximum size limits and for the hemlock-Sitka spruce type on both the Tongass and Chugach National Forests the limit is 100 acres (36 CFR 219.27(d)(2)).

Size limits exceeding 150 acres require 60 days' public notice and review by the Regional Forester. Congress expressed that: 1) even-aged systems are appropriate only to meet the objectives and requirements of the Forest Plan; and 2) clearcutting is appropriate when it is the optimum method (Public Law 94-588).

On June 4, 1992, the Chief of the Forest Service issued a policy memo on ecosystem management. In conjunction with the proposed ecosystem policy announcement, the Chief stated that the Forest Service must accelerate the reduction in clearcutting as a standard forest management practice on the national forests. The reductions called for are national estimates of implementing the policy, not goals or objectives, and are not to be interpreted as applying to each region or forest.

The Chief stated in his policy letter that clearcutting is appropriate only where it is essential to meet specific forest plan objectives and within the circumstances outlined below:

1. to establish, enhance, or maintain habitat for threatened, endangered, or sensitive species;
2. to enhance wildlife habitat or water yield values, or to provide for recreation, scenic vistas, utility lines, road corridors, facility sites, reservoirs, or similar development;
3. to rehabilitate lands adversely impacted by events such as fires, windstorms, or insect or disease infestations;
4. to preclude or minimize the occurrence of potentially adverse impacts of insect or disease infestations, windthrow, logging damage, or other factors affecting forest health;
5. to provide for the establishment and growth of desired trees or other vegetative species that are shade intolerant;
6. to rehabilitate poorly stocked stands due to past management practices or natural events; or,
7. to meet research needs.

The rationale for reduced clearcutting and the expected impacts are:

1. Public Attitudes. There is a continuing and escalating public criticism of clearcutting because of the public's perception of the impacts of clearcutting and its visual appearance.
2. Current scientific knowledge suggests that in many--but not all--instances, substitute timber regeneration methods such as shelterwood, seed tree, and individual tree selection are preferable to clearcutting in:
   - maintaining vertical structure of vegetation;
   - lessening degree of change in wildlife habitat conditions
   - minimizing fragmentation;
   - retaining some attributes associated with old-growth forests;

- minimizing risk of loss of soil productivity; and,
- improving health and resilience of ecosystems and their basic processes.

However, there are costs associated with reduced clearcutting that could result in:

- more frequent entries into stands with attendant environmental impacts;
- reduction in optimum habitat for some wildlife species;
- increased road construction and maintenance with associated environmental impacts and increased costs;
- reduction in the level of the timber sale program and reduced revenues;
- increased unit costs in timber sale preparation and administration, which may exacerbate the below-cost timber sale issue; or,
- increased investments for some timber companies for logging equipment compatible with substitute harvest methods.

As they relate to the previously discussed criteria, the reasons for continued clearcutting on the Chugach National Forest are:

1. Forest Health Reasons (Chief's criteria No. 3 and 4);

    On the Kenai Peninsula, clearcutting would favor restoration of spruce beetle impacted lands in the white spruce type.

    It eliminates the risk of blowdown as compared to methods that leave standing trees. However, the potential for windthrow increases along cutting boundaries but can be reduced through proper design of cutting units. (36 CFR 219.27(b): Criterion 4)

    It eliminates the risk of stand damage. Spruce-hemlock stands consist of large trees that require large-sized logging equipment. Large logs and large equipment can cause significant damage to a residual stand. Spruce and hemlock tend to be shallow-rooted and have thin bark and, therefore, are susceptible to damage (soil compaction and tree bole damage) from ground-based systems. Damage will increase the incidence of wood decay and can lead to subsequent losses due to windthrow and decay. Clearcutting reduces these risks. (36 CFR 219.27(b): Criterion 4)

    It can improve productivity. Alaskan soils in old growth usually have low soil temperatures, poor soil aeration, excess water, and deep humus mats. Decomposition is a limiting factor in autotrophic productivity and soil disturbances from logging may improve productivity (Spies et al. 1991). The cold air temperatures and cold soil temperatures do not favor decomposition of the organic forest floor. Exposing the site by clearcutting raises temperatures, which subsequently speeds the decomposition of raw humus. (36 CFR 219.27(b): Criterion 5)

2. It favors spruce;

   Spruce is more competitive in an open environment. The logging operation will destroy some of the advance hemlock regeneration and thus take away its initial advantage. The increased sunlight also favors the spruce. Spruce is desirable from a diversity standpoint; and mixed stands of spruce and hemlock have higher yields than pure stands of either species (Taylor 1935). (36 CFR 219.27(b): Criteria 4 and 6)

3. It requires less road development to remove a given amount of timber;

   On cable yarding ground, clearcuts favor longer cable spans that also allow for increased spacing between roads. Stream sedimentation from timber harvesting is largely a function of disturbance from logging rather than the silvicultural system. A major disturbance of timber harvesting is road construction. However, proper forestry practices addressing drainage, location, construction, and maintenance can minimize this risk.

   Silvicultural systems that require increased roading can increase the erosion hazard. As roads are pushed into steep terrain, the construction difficulty and hazard increase as the roads cut into erosive soils or unstable slopes or encroach on stream channels. (36 CFR 219.27(b): Criterion 5)

4. It provides viable harvest economics;

   Roading costs are high in Alaska. The high fixed costs involved are chargeable to the acre that is logged and are difficult to meet without spreading the cost over the largest volume of timber that can be cut from a single road or yarding point, often a minimum of 2 million board feet is needed per mile of new road construction in coastal types. (36 CFR 219.27(b): Criterion 3 and 5)

5. It provides excellent natural regeneration; and,

   Attaining natural regeneration in coastal forest types does not appear to be a problem on the Chugach National Forest. Natural regeneration is generally is abundant and stocking control is usually necessary between the ages of 15 and 20. Stocking control (controlling the number of trees per acre) should increase the rate of diameter growth of remaining trees (tree size has a significant impact on log values and harvest costs), improve crown ratios, favor spruce, favor species (forage) or age classes that are most valuable for wildlife. Early thinning may increase windfirmness, or achieve other multiple-use objectives. (36 CFR 219.27(b): Criterion 2)

6. It is compatible with the use of standard logging systems.

Tractor logging is the predominant system used by industry on most of the Kenai Peninsula, while tractor or highlead has primarily been used in Prince William Sound and Copper River. (36 CFR 219.27(b): Criterion 4)

Seed-tree method. The seed-tree method is the removal of the old stand in one harvest entry, except for a small number of trees left singly, in small groups, or narrow strips, as a source of seed for natural regeneration. This method mimics a large-scale disturbance, in which a few mature trees are left per acre. The seed-tree method is most appropriate to species that are shade intolerant, good seed producers, resistant to windthrow and breakage, and have comparatively light seeds easily carried by the wind. A variation of the method is a seed-tree cut with reserves. This method is same as above except there is no intent to remove residual trees.

Shelterwood method. The shelterwood method involves the gradual removal of the entire stand in a series of partial cuttings that extend over a fraction of the rotation. The establishment of a new stand occurs under the canopy of the old stand. The residual large trees may provide seed and shelter the natural regeneration from extreme heat and cold. Hemlock and spruce lend themselves to shelterwood cutting because both species can become established under a forest canopy. Heavy shade would favor hemlock, moderate to light shade would permit more and light and favor establishment of spruce. A variation of this method is a shelterwood cut with reserve. This method is the same as above except there is no intent to remove residual trees.

Coppice Method. The coppice method is the removal of all trees in the previous stand and the majority of regeneration is from sprouts or root suckers. This method is only applicable to the aspen, paper birch, black cottonwood, or mixed hardwood stands on the Chugach National Forest.

Two-aged Systems

Two-aged systems produce stands that contain two age classes for most of the rotation. The resulting stand may be two-aged or trend towards an uneven-aged condition as a consequence of both an extended period of regeneration establishment and the retention of reserve trees that may represent one or more age classes. The residual overstory trees provide structural diversity and a biological legacy.

Clearcutting with reserves - a clearcutting method in which varying numbers of reserve trees are not harvested to attain goals other than regeneration.

<u>Seed tree with reserves</u> - a seed tree method in which some or all of the seed trees are retained after regeneration has become established to attain goals other than regeneration.

<u>Shelterwood with reserves</u> - a variant of the shelterwood method in which some or all of the shelter trees are retained, well beyond the normal period of retention, to attain goals other than regeneration.

Uneven-aged Systems

Uneven-aged systems are methods of regenerating a forest stand and maintaining a multi-aged and multi-layered stand structure by removing some trees in all age groups either singly, in small groups, or in strips. Overstory density is regulated to avoid the suppression of understory trees and to maintain understory vigor. Uneven-aged stands have no beginning or end in time. Selection cutting will produce uneven-aged stands. The features of uneven-aged systems are: 1) complexity of harvesting, 2) the removal of relatively small volumes per entry, and 3) the creation of conditions generally more favorable to shade tolerant species such as hemlock (USDA Forest Service 1987).

Uneven-aged management regimes produce stands of high structural diversity because of the intermingling of the different age classes. The basis for the regulation of the forest is the development and maintenance of a range of tree diameters, with many trees in the smaller diameter classes and progressively fewer in the larger diameter classes. These forests have a high degree of vertical diversity (within site diversity), but horizontal diversity (across site diversity) and landscape diversity will be low (Emmingham et al. 1992). The system produces large blocks of continuous forest cover dominated by relatively mature trees; there is a gradual reduction of shade intolerant trees and understory plants.

<u>Single-tree method</u>. Trees are removed individually, here and there, from a large area. Regeneration and intermediate cuttings usually occur in one operation; each tree is evaluated for its contribution to the desired characteristics or structure of the uneven-aged stand. This method simulates natural disturbances caused by the death of scattered trees. Regeneration occurs under the partial shade of larger trees, and seedlings must be able to grow in a shaded environment. Sitka spruce and western hemlock are adapted to grow in a shaded environment. However, heavily shaded environments will favor hemlock over spruce. Under the selection method, the stand always has some relatively old trees. Stands managed under a single-tree system are not closed canopy stands. Stocking levels can vary from 50 to 75 percent of full stocking. The reduced stocking levels promote individual tree growth.

<u>Group Selection Method</u>. Trees are harvested in small groups, usually less than about two acres. The small holes simulate small natural disturbances and the uneven-aged stand is a mosaic of even-aged groups.

Table E-1: Silvicultural systems, methods, and features.

SYSTEM	METHOD	ADVANTAGES	DISADVANTAGES
Even-Aged Systems			
	Clearcutting Method	Exposure to the sun raises soil temperatures, which speeds decomposition of the organic forest floor, thereby improving the productivity of the forest site. Alaskan soils in old-growth stands generally have low soil temperatures, poor aeration, excess water, and deep humus mats. Decomposition is relatively slow and can be a limiting factor in soil productivity.	Seedling distribution may be uneven and parts of an area may become understocked or overstocked.
		Favors regeneration of Sitka spruce or white spruce because it reduces the competitive advantage of hemlock. Spruce is more competitive in an open environment, where increased sunlight favors spruce. In addition, the logging operation will destroy some of the advance hemlock regeneration and thus take away its initial advantage.	Control of species composition is poor but can be improved through planting.
		Eliminates the risk of blowdown in residual trees because there is no residual overstory.	The chance of blowdown along cutting boundaries is increased, but can be reduced through proper design of cutting units.
		No logging damage to standing timber.	Clearcutting is aesthetically undesirable to some people, because of the appearance of recently harvested areas.
		Logging costs are lower than other systems.	Poor seed years may delay regeneration and growth conditions may deteriorate rapidly from brush re-establishment.
		On cable ground, permits longer cable yarding distances than would be practical in partial cutting--permitting wider road spacing, reduced road costs, and less soil disturbance caused by road construction. However, road construction on the Chugach National Forest is terrain limited. Roads can only be put in certain locations and the location is generally indifferent to the regeneration method.	Clearcutting tends to reduce protection from landslides. Extreme hazard slopes greater than 70 percent have been deleted from the timber base in the land suitability process.
			The method has generated considerable public controversy.
			It could lead to a high degree of old-growth habitat fragmentation for wildlife.
	Seed-tree method	When compared with clearcutting, there is a better distribution of seed.	It is limited to windfirm trees, and it is not feasible where seed trees will be blown over by wind.
		When compared to clearcutting, there is better control over species composition.	Control of spacing and the timing in relation to the seed crop is difficult.
		Logging costs are low.	If seed trees are left, they may reduce the growth of the newly developing stand.
		Species Diversity.	

Table E-1 (continued): Silvicultural systems, methods, and features.			
SYSTEM	**METHOD**	**ADVANTAGES**	**DISADVANTAGES**
		Even-Aged Systems (continued)	
	Seed-tree method	As with clearcutting, raises soil temperature and speeds decomposition of the organic forest floor	Spruce and hemlock produced lightweight seed that is capable of being blown long distances. Winds in Alaska tend to be strong and occur often.
		Decomposition is relatively slow and can be a limiting factor in soil productivity.	Final removal of the seed trees is costly and regeneration damage may occur.
		Seed-tree cutting has slightly better aesthetics than clearcutting.	The seed-tree system is commonly limited to lightweight-seeded species.
		Seed trees add vertical diversity.	Soil protection is not much different than clearcutting.
	Shelterwood Method	Allows ultimate control of site conditions for the regeneration of even-aged stands. Through control of the number of trees left, the relative degree of shelter and exposure can be adjusted both in space and time to best meet the ecological requirements of the species being regenerated.	Logging costs are increased because of the returns to the same area for smaller volumes and the care that must be exercised to prevent excessive damage to the residual trees. Spruce and hemlock are highly susceptible to damage and subsequent rot due to their thin bark.
		Natural regeneration is usually more certain than from the seed-tree or clearcut methods, because there is usually a more abundant source of seed. However, seed is generally abundant most years in Alaska, and adequate or an overabundance of stocking is usually obtained from clearcutting (except in white spruce type).	It requires a fairly windfirm species, and it is not feasible where wind can blow down the sheltering trees.
		Provides better protection of the site from landslides through retention of a living root system.	Unavoidable damage to residual stand and reproduction occurs during logging, particularly on cable ground.
		Superior to all methods, except selection, with respect to aesthetic considerations.	Overstocking of regeneration may be expected. Overstocking from clearcutting is common in Southeast Alaska; this method could compound the problem.
		Provides the best control over species composition, amount, and distribution by controlling the seed source.	Difficult to maintain spruce in the understory because hemlock can tolerate more shade than spruce.
		Shelter trees add vertical diversity.	Growth rate of seedlings is slower under shade.
			Is inappropriate in overmature old-growth stands where trees are large. Yarding large logs can damage the residual stand; trees may suffer from exposure or wind damage; and the removal of the overstory can easily damage the regeneration.
	Coppice Method	Very similar to clearcutting.	Is limited to early successional hardwood species.

Table E-1 (continued): Silvicultural systems, methods, and features.

SYSTEM	METHOD	ADVANTAGES	DISADVANTAGES
		Two-Aged Systems	
	Clearcutting with Reserves	Two-aged management regimes can produce stands of greater structural diversity. The structural diversity comes from the retention of green trees and or snags.	Because of the increased complexity, there is a greater degree of risk in logging (i.e., safety issues).
		This method retains some of the advantages of even-aged systems while attaining some of the features of uneven-aged systems.	
	Seed tree with Reserves	Green tree retention provides carryover structural components, which could allow old-growth characteristics and structural attributes to redevelop in a shorter time. The method would be suitable where windthrow is not a major problem and the terrain is suitable to logging.	Can result in an immediate reduction in yield (trees left on site), and there may be a long-term reduction in growth and yield. Work on green tree retention techniques by Long and Roberts (1992) in mixed-conifer stands in Northern Idaho indicates that there may be a 20 percent reduction in yield (one rotation) and an increase in harvest costs due to the smaller average tree sizes. Smaller tree sizes reduce value and increase handling costs. Work done by Birch and Johnson (1992) in coastal Douglas-fir found a 6 percent-25 percent (multiple rotations) decline in growth in future stands depending on the number of trees left, their size, and rotation age of future stands. They also found an increase in harvest costs of 5 percent to 10 percent and a decline in present net value in existing and future stands.
	Shelterwood with Reserves	This method could provide much of the structural complexity of classic uneven-aged systems while reducing the associated operational difficulties (Long and Roberts 1992).	The susceptibility of Southcentral Alaska forests to wind disturbance is not well understood and it may limit the opportunity to use some of the green tree retention techniques or regeneration methods with reserves. On the Tongass, National Forest in Southeast Alaska, wind is a major disturbance factor in 7 of 10 old-growth types on the Tongass National Forest.
		Uneven-Aged Systems	
	Single-tree Method	It is capable of maintaining an uneven-aged stand;	Highly skilled people are needed to implement it.
		Reproduction of tolerant species is easily obtained	Crop trees are scattered throughout the stand
		This method usually has the highest aesthetic rating.	A more extensive road system is usually necessary to obtain the same volume of timber obtained by use of other systems; increased roading could lead to increased erosion rates. Erosion rates are usually a function of the harvest method and roading density or location rather than the choice of regeneration methods.

Table E-1 (continued): Silvicultural systems, methods, and features.

SYSTEM	METHOD	ADVANTAGES	DISADVANTAGES
		Uneven-Aged Systems (continued)	
	Single-tree Method	Site protection is excellent with little or no exposure to insolation (exposure to sunlight) and wind.	Logging costs are much higher because of the small volume per acre, the frequent entries required for each stand, the complexity of the logging systems, and the care necessary to hold damage to an acceptable limit.
		Stands can be readily adapted to changing market conditions.	Considering the limitations of terrain, the old-growth stand structure, and the necessity for cable logging on steeper slopes in coastal Southcentral Alaska, it may not be possible to achieve minimal damage objectives.
			Because of the frequent entries, the boles and roots of residual trees may be damaged from felling and yarding tall, large diameter trees with much defect. Damage done to root systems and trunks of the residual stand can result in accelerated mortality of trees and overall deterioration of old-growth stand. This system has probably the greatest potential for causing stand damage from harvest operations than any other method. Hemlock and spruce are thin barked, shallow-rooted species highly susceptible to logging damage.
			This method would favor hemlock over spruce regeneration.
	Group Selection Method	Group selection tends to increase diversity of plants and animals because of a temporary increase in shade-intolerant plants in the small openings.	Same as the single-tree method but to a lesser degree.
		The small openings may be more favorable for spruce regeneration.	
		The small groups may be aesthetically more acceptable to some people.	
		The regeneration in the small groups grows up under even-aged conditions with better bole form.	
		Harvesting is more concentrated so logging costs are lower than single-tree selection. Tractor or helicopter yarding may be the most appropriate harvest system for this method.	
		Harvesting in groups lowers damage to the residual stand, especially if yarding is done by tractor or helicopters.	

Genetic Implications of Silvicultural Systems and Timber Harvesting

There is a large amount of variability in the gene pool in the unmanaged forest. Treatments that selectively remove trees could adversely affect genetic variability. Harvest methods that remove the largest and highest quality trees--often called high grading--could result in the regeneration being the product of remaining lower quality trees, and possibly, slower-growing trees. If regeneration is from a small number of parents or isolated trees, there is an increased risk of reducing genetic quality or increasing inbreeding. Natural regeneration from a large number of parents exhibiting desirable growth and form characteristics can maintain a broad genetic base and move the genetic composition toward a higher frequency of desirable traits.

Some possible consequences in the use of various natural reproduction methods are:

- clearcutting with natural regeneration. This method generally maintains the status quo; there is little effect on the genetic composition of the stand. The genetic composition will be similar to the adjacent stands (the parents).
- seed-tree cutting. Through the selection of the best trees, this method allows for the greatest opportunity for change in the genetic composition of the future stand. There is a low probability of the offspring being inbred because the widely spaced trees are not likely related. The danger of this method is that the genetic base could be less if an insufficient number of seed trees remains.
- shelterwood cutting. When compared to the seed-tree method, there is less opportunity for changes in the genetic composition of the stand. Selection pressure is less because more trees remain. This method presents the greatest danger of substantial increases in inbreeding levels because neighboring trees are more likely to be related to each other.
- selection cutting. When compared to seed-tree and shelterwood cutting, selection cutting has the least opportunity to change seed quality. This is due to the uneven-aged stand structure and the intermittent waves of seed production and regeneration. Proper application of selection cutting may lead to an upgraded gene pool in terms of bole form and tree health, but there may be difficulty in selecting for small differences in growth. If improperly applied, such as "high grading" the better trees and selecting poorly among the lower age classes, selection cutting is likely to lead to a lowering of genetic quality.

Silvicultural Systems and Forest Characteristics

The regeneration method must be compatible with available logging methods. Acceptable harvest methods allow the harvest of the stand without excessive damage to the desired remaining trees or to other resources. The wide variation of topography and vegetation on the Chugach National Forest, combined with various land uses, dictates that both logging systems and transportation plans meet the silvicultural constraints of stand tending or management, the physical spacing of roads, unit shape, topography, and other resource needs. The choice of silvicultural system influences five important aspects of timber harvesting:

1. variability in sizes of harvested trees;
2. area to be harvested;
3. complexity of the harvesting treatments;
4. the probability of causing significant damage to trees left in the stand; and,
5. the probability of causing long-term disease problems.

The first three influence harvesting efficiencies, and the other two affect the vigor, tree stocking, and value of the remaining stand.

There is wide size variation in trees harvested in each operation under the selection system. This results in a reduction in harvesting efficiency, because logging equipment is dependent upon tree size. Logging equipment must be sized to handle the largest pieces in the stand. Equipment that is sized for big trees is not working efficiently when it has to handle small pieces.

Harvesting with the selection system is much less cost-efficient than for the other systems. More land is required in each operation to harvest the same desired yield from the forest.

Harvest treatment complexity is also greatest with the selection system. The identification of trees or groups of trees to cut, determining felling patterns, felling the trees in the designated areas, and removing the trees or logs out of the stand without damaging the residual trees can be very difficult and costly.

Generally, only tractor or helicopter yarding systems are suited for selection cutting. In the selection method, cuttings occur as frequently as every five to ten years. In other systems, only the intermediate cuttings are as complex. The regeneration cuttings in the other systems are more straightforward operations. Clearcutting is the most efficient.

Logging damage to trees left to grow in the stand is typically greatest for the single-tree selection system. Selective harvesting of trees in dense stands without damaging many remaining trees is very difficult, if not impossible, in most situations on the Forest, particularly on steep slopes. Damaged trees are often the entry sites for wood-decaying fungi that may persist in the soil for long periods, thus retaining their capacity to infect new trees. These fungi reduce the windfirmness, vigor, commercial value, and stocking of the remaining trees.

There is a significant difference in the record keeping, inventory, and project administration required for uneven-aged systems versus even-aged systems. The detailed information needed to plan and carry out treatments, as well as the frequency of treatments, make the uneven-aged systems more costly to manage.

Inventory information must be more accurate to prescribe harvest from several tree classes. To achieve this resolution in data collection, stands must be stratified to a finer detail; many more stands must be inventoried, have records kept on them, and be administered.

Key factors in the determination of appropriate systems on the Chugach National Forest are: existing stand conditions, silvical characteristics--that is the reproductive habits and growth requirements--of the tree species, the operational environment (physical and biological setting), economics, policy, social and political setting, available harvest systems, and the management objectives that the Region wants to achieve.

The forests of the Chugach National Forest in Prince William Sound and Copper River are predominantly old-growth forests generally undisturbed by humans. The forests on the Kenai Peninsula on the other hand, have been heavily influenced by human disturbance since the early 1900s and the spruce beetle since the late 1950s.

The Forest is largely roadless. Most old-growth stands are a mosaic of small groups of more-or-less even-aged trees arranged in complex patterns. Most stands usually consist of trees of advanced age, declining vigor, and large amounts of defect.

Silvical Characteristics

On the Kenai Peninsula, characteristic needleleaf forest trees include white spruce, Lutz spruce, Sitka spruce, mountain hemlock, and occasional black spruce. Broadleaf forests include paper birch, aspen and black cottonwood and willow. Human-caused fires are common and significantly affect forest vegetation succession in this area.

In the uplands of Prince William Sound, characteristic needleleaf forest species include Sitka spruce, mountain hemlock, and western hemlock while in the Copper River Delta area, needleleaf forest communities feature western hemlock and Sitka spruce.

White spruce (*Picea glauca* (Moench) Voss) – is characterized as shallow rooted and intermediate in tolerance to shade. In mixed stands, it is more shade tolerant than its associated early successional species (aspen, birch, cottonwood) and eventually replaces them, frequently at stand ages of 80-100 years if spruce was established at the time of stand formation. Seedling and juvenile growth are slower than its early successional associates. Mean annual increment of unmanaged stands on moderate to good sites varies from 30 to 50 cubic feet per acre. Hybrids between Sitka and white (Lutz) occur on the Kenai Peninsula.

Natural spruce regeneration occurs when an adequate supply of viable seed encounters an appropriate seedbed. Occurrence of cone and seed crops is erratic, good to excellent crops can occur at 2-year intervals or they can be separated by 10 –12 years (Nienstadt and Zasada 1990). These seed crops are often infested with seed-feeding insects. Smaller seed crops are produced more often.

Primary cone production occurs on dominant and co-dominant trees. Seed production in quantity begins at about age 30 in natural stands. Good seed years may be related to hot, dry weather during the time of bud formation, usually in July the year prior to pollination, especially when the current and preceding cone crops have been poor. Cones can be collected from 2-4 weeks before ripening. Observations of fireweed blooming can predict when ripening occurs: spruce seed mature at the same time that the lowest seed capsule on local fireweed flower spikes are bursting. Seeds can be held in storage at a nursery for up to 17 years.

White spruce seed dispersal distances are related to wind speed and direction at the time of seed release (September, during dry weather), cone height, and seed wing structure. In Alaska, seed dispersal range is generally no more than 300-400 feet from windward side of the seed source.

White spruce seeds may not germinate the first spring after they are dispersed if conditions are not right, but can germinate the next year (16 months after seed ripening). Spruce seeds are subject to predation by small animals.

The best seedbed for spruce establishment is a mineral soil or mixed mineral/organic soil. This type of seedbed is also ideal for the establishment of many other species, including birch, aspen, alder, fireweed, and blue-joint reedgrass. In mature stands, natural regeneration occurs on a variety of seedbeds, including rotted logs, feather moss, and associated organics, but the best seedbeds in mature stands are exposed mineral soil after wind throw, flooding, or fire. Stocking is low and highly variable, but is best on exposed mineral soil microsites.

Seedlings in the understory grow slowly, but may be important as a "seedling bank" to regenerate sites after overstory removal.

Growth is best at full light intensity. White spruce is capable of responding to release from a very young age to 200 or more years. Sapling and pole size structural stages can respond immediately to cultural practices such as thinning and fertilization.

Spruce/paper birch forest types regenerate optimally following site disturbances, which create a seedbed consisting of a mixture of bare mineral soil with some organic material. Optimal establishment of white spruce depends on the presence of exposed mineral soil, viable seed, and adequate shade.

Field observations, literature review, as well as permanent plot data indicate reductions in spruce biomass in heavily beetle-impacted stands. Spruce is capable of regenerating under an overstory of spruce and other early successional tree species such as birch; response, however, is highly variable and density and percent stocking are low. Unless particular attention is given to proximity of seed sources, site and seedbed conditions, white spruce abundance in heavily beetle impacted areas is expected to decrease.

Paper Birch (*Betula papyrifera* Marsh) - Paper birch is a dominant broadleaf forest species on the Kenai Peninsula and a major component of the mixed hardwood forests. It is an early successional species with rapid juvenile growth, relatively high light requirement, short life span, and eventual replacement by more tolerant species like spruce. Birch frequently occupies cooler, moister sites than quaking aspen. Mean annual increment on good sites may average 48 cubic feet per acre.

Good seed crops every other year, on average. Seed ripens from early August until mid-September. Dispersal begins soon after ripening. A large number of male catkins the fall before the seed year are an indicator of a good seed crop.

Seeds are winged and light; they can be carried great distances by the wind, especially when blown across the surface of the snow. However, most seeds fall within the stand they were produced. A range of 100 feet is dependable for natural regeneration for full stocking levels. Some seeds may lie dormant on the forest floor for a year or more. Buried seed viability in the field may be as long as 6 years.

Seed germination begins in the spring as soon as conditions are suitable and continues until all viable seeds are germinated or the seedbed dries out. Best germination on mineral soil, but will also germinate on rotting logs, stumps, and tree boles. Shaded sites produce about twice the number of germinants as full sun. In Alaska, sites that had been scarified following clear cutting were fully stocked after 3 years. Similar sites that were left unscarified were only 30 percent stocked.

Following disturbance, the bulk of birch regeneration becomes established during the first growing season from seeds that fell the previous fall and winter. Paper birch can also regenerate by vegetative means from sprouts following cutting or fire. Younger trees produce more sprouts than older trees. Sprouts tend to mature and decline sooner than trees originating from seeds.

In natural stands, birch usually last for only one generation before being replaced by a more shade tolerant species. However, when growing in mixed stands with spruce, birch often retain a position in the stand, and the stands do not go toward a pure spruce climax.

Birch can invade declining old-growth spruce in openings created by the death and uprooting of the spruce. Mineral soil exposed by uprooting and decaying fallen trees provide suitable seedbeds.

Stands approaching maturity seldom respond to thinning.

In Alaska, pure birch stands have little fuel available, so fires are uncommon.

Young regenerating stands provide browse and cover for moose. Moose may over-browse, resulting in short, brushy growth. Peak browse production occurs 10-16 years after disturbance.

Quaking aspen (*Populus tremuloides* Michx.) is a very shade intolerant species and a very aggressive pioneer, especially after fire. Like birch, it is an early successional species with rapid juvenile growth, short life span, and eventual replacement by more tolerant species like spruce. On the Kenai Peninsula, quaking aspen forests occur sporadically on drier sideslopes. Mean annual increment on good sites may be as high as 80 cubic feet per acre.

Aspen produce good crops of highly viable seed every 4 or 5 years. The fresh seeds are not dormant and will germinate within a few days if they reach a good seedbed of moist exposed mineral soil (Perala 1990). However, few aspen seedlings survive; the main method of reproduction is by vegetative means in the form of root-sprouting.

Most aspen stands are clones of one or several sexually produced individuals. Sprouting is encouraged by cutting and/or fire.

Dormant season cutting produces the most vigorous sprouting. Summer cutting produces few sprouts initially, but after two years the number of sprouts is the same regardless of the cutting season (Perala 1990).

Soil temperature is the most critical environmental factor affecting sprouting. High temperatures promote the growth hormones that encourage sprouting while degrading those that repress it.

In general, the amount of sprouting is proportional to the degree of cutting, and so light burning following heavy cutting will produce the most new sprouts.

Aspen provides habitat and browse to a wide variety of wildlife, and is also highly valued for its esthetic qualities (Perala 1990). According to Collins (1996), when stands dominated by birch or spruce are logged, felling of all associated aspen will do more to enhance wildlife habitat via browse production than any other single practice in those stand types.

Black Cottonwood (*Populus trichocarpa* Torr. & Gray) is an early successional species with rapid juvenile growth, relatively high light requirement, short life span, and eventual replacement by more tolerant species like spruce. It is commonly adjacent to rivers on the Kenai Peninsula and the Copper River Delta and is generally of minor importance on upland sites. Mean annual increment on good sites may be as high as 100 cubic feet per acre.

Black cottonwood can reproduce by seed, stump sprouting, root suckering, or by rooting and growth of broken, buried stem or branch segments. It is considered a floodplain species and is quite tolerant to flooding.

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) is the largest and one of the most valuable trees on the Chugach -- both biologically and economically. This species is shade tolerant to intermediate in shade tolerance and demands more light than western hemlock (Harris and Farr 1974). Spruce tends to be tolerant to shade in Alaska (Ruth and Harris 1979). Western hemlock has a competitive advantage over spruce in shaded environments. Spruce can become established beneath light shade, consequently it can come in beneath partially cut stands, but growth is slow (Harris and Farr 1974). However, few stands continue to 100 percent hemlock.

Spruce is able to maintain a stand presence because:

1. Sitka spruce lives longer than western hemlock (it may live to 700 to 800 years and hemlock may live to 500 years) and tends to achieve a greater size than hemlock; and,
2. stand disturbance caused by blowdown creates gaps or small openings in the overstory, which allows the spruce to become established and to better, compete with hemlock (Harris 1990a).

Sitka spruce is a prolific seeder and produces small wind-disseminated seed. The strong Alaskan winds can carry the seed long distances. If moisture is abundant, Sitka spruce seed will germinate on almost any kind of seedbed; consequently, natural regeneration can be obtained through various reproduction methods.

Establishment is best on mineral soil (such as that created by the upturned roots of windthrow trees) with organic matter and with side shade and overhead light (Harris 1990a). Spruce has an advantage over hemlock on bare soil. Clearcutting and exposing mineral soil during the logging operation can increase the percentage of spruce reproduction.

The rooting characteristics of Sitka spruce show great variability, but in Southeast Alaska this species tends to be shallow-rooted; consequently, it is vulnerable to compaction and blowdown. The bark is relatively thin, which makes it susceptible to logging injury and subsequent decay. Blowdown is the most serious damaging agent.

Western Hemlock (*Tsuga heterophylla* (Raf.) Sarg.) is also a major component of the Chugach National Forest. Western hemlock is very shade tolerant and dominates the reproduction of the old-growth forests (Harris and Johnson 1983), which makes it an ideal species for management that includes partial cutting. Other associated conifers include Alaska cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) and mountain hemlock (*Tsuga mertensiana* (Bong.).

Hemlock is a prolific seeder and produces wind-disseminated seed almost every year, with heavy crops every five to eight years. The strong Alaskan winds can carry the small seed great distances. The species can thrive on a wide variety of seedbeds; consequently, various reproduction methods from single-tree to clearcutting can provide the necessary natural reproduction. Most stands contain advanced regeneration and through careful logging are often stocked or overstocked.

Hemlock does not develop a taproot and is also a shallow-rooted species; it is susceptible to windthrow. Most of the roots, particularly the fine roots, are near the surface, and are susceptible to damage from compaction. Like spruce, this species has thin bark and is susceptible to logging injury and subsequent decay.

Mountain Hemlock (*Tsuga mertensiana* (Bong.) Carr.) is shallow rooted and tolerant of shade and other forms of competition. Growth in both height and diameter are slow. Associates include both Sitka and white spruce on the Kenai Peninsula, and Sitka spruce on the Copper River Delta.

Wind, snow avalanching, and mass movement, are primary disturbance processes. Snow avalanching appears to be the dominant disturbance process in the open "park land" like forests nearest tree line. Tree growth is much slower than on warmer well-drained sites at low elevations. Cold temperatures are a primary ecological factor in this type. Regeneration is common in disturbed areas, but slow to respond due to heavy snow damage. While closed canopy forest conditions can occur (usually in bands less than 500 feet wide) stands are predominantly open grown. Therefore, stand size considerations as compared to maintaining interior forest old-growth conditions are not significant in this type.

Alaska cedar is a slow-growing and long-lived species that occurs in a few locations in Prince William Sound. The species occurs in scattered groups or individually in mixture with hemlock and spruce. Alaska cedar is intolerant of shade in Alaska, and it has difficulty competing with hemlock and spruce on the better sites (Harris and Farr 1974). As a result, Alaska cedar usually occurs on the poorer sites.

Planting is the surest means of establishing Alaska cedar. The natural regeneration capabilities are not well understood, and deer browsing may be a factor in removing cedar seedlings from a site. A recent study (Hennon 1991) demonstrated that planted seedlings could successfully establish in Alaska. Excellent growth occurred on sites with good light exposure and soil moisture drainage. Survival and growth were best on burned clearcut sites and diminished by heavy shade and poor soil drainage. The results from the study suggest that seedlings cannot tolerate heavy shade. Compared to hemlock and spruce, this species is a poor producer of seed. Cones are small and fewer, and the proportion of filled seeds from mature cones is generally low and extremely variable (Harris 1990b). Seeds are much heavier than spruce and hemlock, but there is no information on the distance seed is disseminated by wind. Evidence suggests that leaving seed trees on site may be one approach in maintaining the species by natural regeneration.

Cedar in Southeast Alaska suffers from a condition called cedar decline, but is most prevalent on poorly drained sites (bog, semi-bog sites). The reason for this decline is unknown at this time. However, it is suspected to be a physiological reaction relating to soil drainage.

Operational Environment

The Operational Environment is the physical and biological setting of the Chugach National Forest or the environmental variables that may affect possible management objectives or treatments. These environmental variables may include the climate (light, air temperature, wind, evaporative capacity), soils, competing vegetation, insects and disease, and animals. Those variables that may control growth and mortality are known as the regulating variables.

This section describes some of the environmental variables that may affect possible management objectives or treatments on the Chugach National Forest.

Climate

The Forest has a maritime climate with abundant moisture throughout the year and has relatively mild winter temperatures and cool summers. Lack of pronounced drought (one exception is a brief period during June on the Kenai Peninsula) is probably the most important factor in affecting vegetation.

The management implications of climate are:

- moisture is not a limiting factor in tree regeneration; and,
- wildland fire is not a major problem except during the June drought period in interior portions of the Kenai Peninsula.

Soils. The most productive soils are moderately well drained to well drained with a moderate texture. They are found on older less active, alluvial fans and floodplains (Landtype Association 80), and on lower sideslopes, footslopes, and terraces (Landtype Association 40). Soils on these landforms in Prince William Sound are more productive that those on the Kenai Peninsula because of more moderate temperatures and higher amounts of precipitation.

Competing Vegetation. On the Kenai Peninsula**,** blue-joint reedgrass (*Calamagrostis canadensis* (Michx.) Beauv.) is a significant competitor with young seedlings. Blue-joint can delay tree establishment and retard forest succession (Lieffers et al. 1993). Root competition dominates as blue-joint produces a dense, continuous sod. It also shades and smothers seedlings. Conifer seeds fall on grass above soil and sprouting seeds dry and wither as the grass dries out. The period of blue-joint dominance may extend for decades but, in general, it's cover declines with time particularly when it becomes shaded by taller vegetation. In permanent plots along Resurrection Creek spruce seedlings are establishing and blue-joint, after significantly increasing in cover following beetle-induced tree loss and fire (Holsten et al. 1994), is becoming less dominant after 20 years of canopy opening (Schulz 2000).

Blue-joint is well adapted to harsh northern climates. It tolerates exposed conditions and is very winter hardy. Blue-joint grows best in full sunlight and is found on moist, nutrient-rich forest sites and along stream banks where it may dominate the understory vegetation. Based on data from sample plots, blue-joint is present with 1 percent or greater canopy cover on about half of spruce-dominated forest sites on the Kenai Peninsula portion of the Forest (DeVelice 1998). It commonly invades clearcuts and a wide variety of disturbed soils, but is most aggressive in wet soils, or deep, fine soils capable of holding moisture. It is rare to absent under a closed forest canopy, but clones that are present and that survive a disturbance that removes the overstory will rapidly expand by rhizome growth. As vigor increases, so does seed production.

Preferred seedbed is a wet mineral-organic mix. Recruitment via seeds is not heavy in burned areas.

Blue-joint spreads by wind-dispersed seeds and by rhizome growth from "mother" plants. Wetlands may serve as seed sources in areas of predominantly old forests. Blue-joint seeds maintain viability for long periods in seed banks.

Rhizomes are segmented, and clones can be spread by activities that cut rhizomes and move them to new areas. If it is desirable to mix organic layers with mineral soil during site preparation, double disking twice may be required.

Rhizome growth can be limited by increasing bulk density of scarified areas. If fire is used to control grass, it must be intense enough to kill rhizomes. Low intensity fires tend to stimulate blue-joint grass.

Canopy closure of 40 percent has a significant effect in reducing blue-joint vigor and biomass. Vigor is also reduced as litter and thatch layers build up; nutrients are tied up in this organic matter and spring thaw is delayed due to insulation.

Blue-joint is not used as food by moose in Alaska. It is moderately palatable for domestic livestock, and is most nutritious when shoots are first emerging from rootstock.

Insects. Spruce beetle (*Dendroctonus rufipennis* (Kby)) populations in Prince William Sound and Copper River are endemic in nature, while over the last two decades the spruce beetles have been at epidemic levels on the Kenai Peninsula and the rest of Southcentral Alaska killing several million acres of mature spruce forest.

One defoliating insect, the black-headed budworm (*Acleris gloverana* (Wals.)) has been documented on the Chugach in Prince William Sound (Hard 1974). Periodically, they cause widespread defoliation, particularly to western hemlock.

The northern spruce engraver (*Ips perturbatus* Eichhoff) is killing mature as well as pole-sized spruce on the Kenai portion of the Chugach National Forest (Holsten 1998). The combined effects of the spruce beetle and northern spruce engraver may increase with the apparent warming trend occurring throughout Alaska (Berg and DeVolder 2001).

Diseases. In Southcentral and Interior Alaska, heart, butt, and root rot fungi cause considerable volume loss in white spruce forests. Large amounts of potentially recoverable timber volume are lost annually due to sap rot fungi (*Fomitopsis pinicola*, the red belt fungus) on the Kenai Peninsula, where salvage logging has not kept pace with tree mortality from the continuing spruce beetle epidemic. Sap rot decay quickly develops in spruce trees attacked by spruce beetles, and significant volume loss occurs several years after tree death.

Tomentosus root disease (*Inonotus tomentosus* (Fr.) Teng.) is a fungus that causes root and butt-rot of white, Lutz, and Sitka spruce in Southcentral and Interior Alaska. Spruce trees of all ages are susceptible to infection through contact with infected roots. Infected trees exhibit growth reduction or mortality depending on age. In young-growth managed stands, planted spruce seedlings may become infected if planted to close to infected root systems of harvested trees.

In the coastal forests of Southeast Alaska, approximately 1/3 of the old-growth timber volume is defective largely due to heart rot fungi. While no studies have been conducted in the old-growth forests of Prince William Sound or Copper River, one could reasonably expect the same level of volume loss to heart rot fungi in these coastal forests of the Chugach National Forest.

Animals. Several species of animals are present that directly compete with regeneration efforts. These animals are moose, Sitka black-tailed deer (in Prince William Sound), rabbits, porcupines, voles and mice. Land managers have taken sporadic efforts to control damage done to young seedlings; however, the amount of damage attributed to these animals is small.

Management Goals and Objectives

The goals and objectives most affecting the choice of silvicultural systems are those that relate to producing timber, and those that in some way conflict with or modify the way timber is produced. The application of the silvicultural systems may be constrained or altered in the different management area prescriptions in response to various resource needs and societal concerns.

Most alternatives that include timber harvest specify a fairly low level of intensive management. There are also goals for providing habitats to support all native wildlife species, protecting soil and water, and providing recreation opportunities. Throughout all the management programs and activities, the implementation of the Revised Forest Plan should be accomplished in an efficient and cost-effective manner.

Some of the management objectives relating to selection of silvicultural systems vary by the management area prescription defined for alternative land allocations. Silvicultural systems may be applied to meet a variety of resource objectives, but will be applied mostly where the management area prescription has timber management as a specific objective.

Alaska Region's Ecosystem Management Strategy

The Region's ecosystem strategy states that regeneration methods other than clearcutting be objectively considered through a project-level prescription process, and that documentation of this process and results are to be provided in NEPA documents and records of decision.

The final selection of the regeneration method for any site-specific project will be part of the silvicultural prescription. The determination of where clearcutting is the optimum method at the project level will be based on site-specific factors (i.e., esthetic, environmental, biological, engineering, and economic) related to the selection criteria previously mentioned in this Appendix and the objectives and requirements of the Revised Forest Plan. The identification of clearcutting as the optimum method for sites on the Chugach National Forest will often be influenced by the key factors mentioned previously: the difficulty in protecting the residual stand through harvest operations on steep slopes, viable sale economics, the desirability of perpetuating spruce, disease control, and other forest health concerns.

The evaluation of regeneration methods is based on operational experience and research findings in the scientific literature.