ABSTRACT OF THE THESIS OF

Joseph A. Pepi for the degree of Master of Science in Soil Science presented on May 2, 1989.
Title: Development of a Land Evaluation and Site Assessment (LESA) Model for Forestry in Lane County, Oregon

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A Land Evaluation and Site Assessment (LESA) Model was developed for the forested soils of Lane County, in western Oregon, based on soil potential ratings and indexes of parcel size and adjacent and surrounding land use conflict. Lane County's economy is heavily dependent on resource production uses of land for forestry. At the same time, population growth around metropolitan areas creates pressure to convert rural land from large resource-use parcels to smaller rural residential parcels.

Planning for future allocation of land among competing uses promted the county to develop an objective method for determining the relative quality of any parcel of land for forestry. Parcels of lower quality could then be considered for conversion to rural residential uses.

LESA was developed by the SCS for use by state and local governments as an objective method of evaluating the resource production quality of land for planning purposes. Land evaluation (LE) measures the relative suitability of the soils of a given parcel for forestry. Site Assessment (SA) measures the relative suitability of the setting in which the parcel occurs.

The soil potential ratings (SPR's) were developed from soil map unit characteristics defined in the Soil Survey of the Lane County Area. SPR's are indexes of the net return to soil management for forestry. Each soil is assigned an expected output, or yield, to soil management for forestry using a computer model called DFSIM. Management practices required to achieve that yield also are specified. Monetary values are determined for both yields and management practices, and the difference between price received and total costs is a measure of soil potential. The soil having the highest net return to soil management is assigned an arbitrary value of 100 points. All other soils are rated by expressing their net return as a percent of the maximum.

Management practices in each of four categories - site preparation and stand establishment, thinning, harvest, and road construction and maintenance - were prescribed, and their costs determined, based on their interactions with soil slope, erodibility, depth, bedrock hardness, and coarse fragment content.

Land evaluation was completed by overlaying a soil map of the land parcel of interest, determining the fractional amount of each soil present, and multiplying that amount by the corresponding soil potential rating. The sum of all the products is a weighted average soil potential rating for a parcel.

Development of the Site Assessment (SA) portion of the model was guided by a technical committee of forest management professionals and land use specialists. The committee chose the factors that were considered important in site assessment and how much weight to give to each factor. For this LESA model, two factors were identified: compatibility with other land uses, and parcel size.

The concept of compatibility implies that large scale forestry uses are compatible with each other but are not compatible with small scale residential uses. Generally, the more non-resource related dwellings in forestry areas, the greater the potential conflict due to noise, chemical spraying, dust, smoke, and vandalism.

Two empirical formulas were developed to measure compatibility effects. One accounts for the number and density of non-compatible parcels adjacent to the parcel of interest. The other measures the density of non-compatible parcels within a specified distance of the target parcel, which was 1/2 mile.

Parcel size implies that large parcels are more suitable for resource uses than small ones, and that parcels surrounded by a few large parcels are more favorable than parcels surrounded by many small parcels. An empirical formula was derived to measure these effects. Optimum parcel sizes depended on slope, parcel shape, and the number of streams running through the parcel.

The final step in the LESA model development was to specify a total point value, and to decide on the proportion of that total that would go to each of the factors, soils, compatibility, and parcel size. In previous LESA models the point total has been 300. This total was allocated to each of the factors as follows: soils 105, adjacent use 75, surrounding use 45, and parcel size 75.

Validation is a critical part of the development of a LESA model, and it is done by applying the LESA criteria to several parcels that represent a range of soil resource quality, sizes, and land use settings. Each parcel must then be examined in the field by the LESA development committee. Field examination is essential in order to make needed adjustments in empirical formulas. Through the repeating of this validation process, the model is fine tuned and its accuracy for planning purposes is validated.

LESA scores can be used to distinguish between primary and secondary land resources. Primary resource lands are sufficiently valuable for forest uses that land use controls are justified to prevent the introduction of non-resource development. Secondary resource land is of lesser quality and is a more appropriate site for smaller scale resource uses and certain non-resource uses. Information from the test parcels was used to set primary/secondary thresholds for each factor and to develop empirical criteria for classifying each parcel.

DEVELOPMENT OF A LAND EVALUATION AND SITE ASSESSMENT (LESA) MODEL FOR FORESTRY IN LANE COUNTY, OREGON

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I. Introduction

The land base for commercial forest production in Oregon is highly productive and makes a substantial contribution to the state's economy. Forestlands account for more than 100,000 manufacturing jobs (Leonard, 1983). Oregon is the nations leading lumber producing state, producing 7.2 billion board feet of lumber worth an estimated $1.76 billion. This represents 23 percent of the nation's softwood production (Goldschmidt, 1987).

Over the last several decades however, this land base has been decreasing. More than 1.25 million acres of forest land in Oregon were diverted to non-timber uses between 1952 and 1977 (Schroeder, 1979). This land was converted to other uses such as homesites, powerline corridors, roadways, and wilderness areas.

On privately owned forestlands, the establishment of residential development in areas formerly dominated by forest production activities has introduced conflicts between these uses. This conflict is perceived by both rural residents and the forest industry as constraining their ability to use the land for the purposes they intended.

Oregon's desire to protect resource lands for resource uses led to legislation in 1974 that initiated a statewide land use program.

Since then 19 goals and guidelines have been adopted to govern the development and implementation of the statewide program. The statewide goal dealing with forestlands, Goal 4, requires that land suited for commercial forest production be identified and set aside for that purpose.

Concern about Goal 4 issues has increased since the late 1970's. Growth outside the metropolitan areas has spread land-use conflicts beyond the floor of the Willamette Valley, into the foothills around the valley's margin. This is the area where many of the nonindustrial private forest (NIPF) lands are located. Subdivision of these lands has created conflict between forest production activities and rural residents. These lands cover about 2.2 million acres, and with intensified management could serve as a source of timber to replace some of that which will not be available from public and corporate forests (Wilson, 1979; Schroeder, 1979).

Lane County (Figure 1) is one of the major timber production and wood products industry counties in the state. In 1988 Lane County was the largest timber producing county in Oregon (Kent Howe, 1989, personal communication). In addition, because it has the second largest metropolitan area in the state (pop. 275,226, PSU, 1988), major conflicts exist in this county between forest and residential land uses.

The forest products industry in Lane County is of major economic importance. During peak operation the forest industry provides direct employment for 13,000 to 14,000 persons in the lumber and wood products sector (Lane County, 1982). The service jobs that are

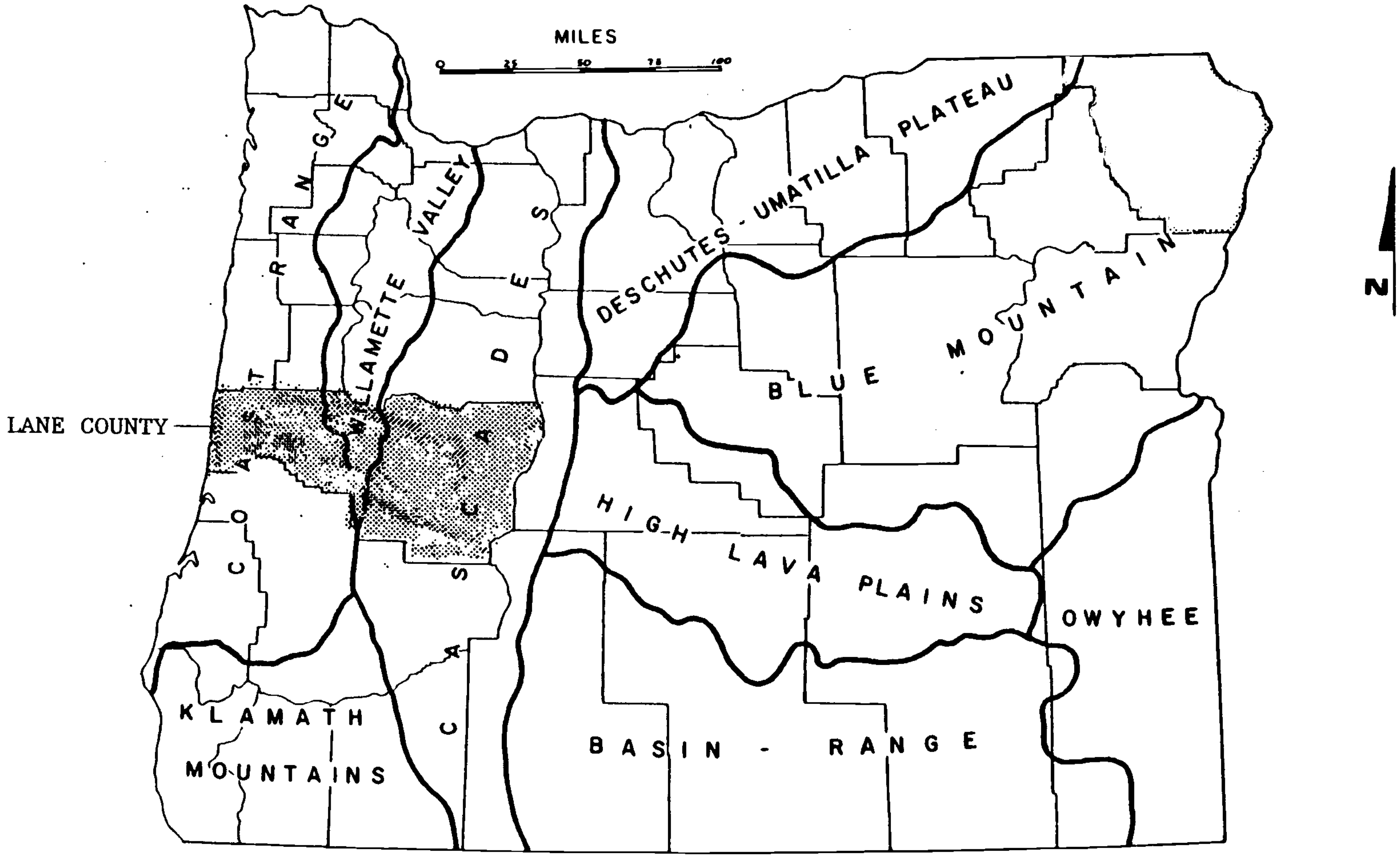


Figure 1. Physiographic regions of Oregon
source: (Dicken, 1973)

created as a result of the basic industrial jobs in wood products amount to an additional 26,000 to 28,000. These jobs include self-employed loggers and truckers and federal government employees. Twenty percent of Lane County payrolls are directly obtained from the lumber and wood products industry. This industry provides 14% of the County's jobs, and two-thirds of all the County's manufacturing jobs. In total the lumber and forest products industry represents 50 to 66% of the economy in Lane County.

The vast majority of the timber harvested in Lane County is processed right within its borders. Lane County is designated as a timbershed, because 85% of the timber harvested in the County is then also processed there. The land that provides the harvested timber is broken up into five main ownership groups (Table 1).

Table 1. Acres of commercial forest land by ownership in Lane County, 1981.

(1,000 acres)

	National Forest	BLM	Other Public	Forest Industry	Non-Industrial Private	Total Owners
Acres	851.6	243.6	24.2	541.1	152.74	1,813.22
(%)	47	13.5	1.00	30	8.5	100

Source: Working Paper: Forest Lands (Draft) Lane County, 1982

Of the total amount of timber harvested in 1980, 72% came from Public lands (National Forest, Bureau of Land Management, and other public, 21% from Industrial forest lands, and 8% from Non-Industrial private lands. The timber harvested from public lands is produced on only 70% of the total public land holdings, because the other 30 % is managed for uses other than timber production.

Douglas-fir is the most prevalent commercial tree species in Lane County, with about 1,270,900 acres. There are only about 150,100 acres of other conifer species (Lane County, 1982). The public agencies manage 60% of the more productive cubic foot site class 2 and 3 lands; the forest industry and non-industrial private ownerships manage 32% and 8%, respectively.

Statewide, focus has intensified on nonindustrial private forest (NIPF) lands due to indications that the supply of timber from the traditional sources, - U.S. Forest Service and industrial forest lands will be declining over the next twenty years. Supplies from the National Forests provide nearly one half of the of the timber for mills in Oregon. In the future, these harvest levels will be reduced by about 20 percent (Johnson and Greber, 1986). Harvest levels on industrially owned forestlands are predicted to decline by 33 percent by the year 2000 (Bueter et al. 1976).

Of the 11.8 million acres of commercial forest land in Western Oregon, industrial and NIPF owners have over 80 percent of the most productive land, some 9.4 million (Richmond, 1987). One-third of this 9.4 million acres are NIPF lands, of which 97 percent are receiving no management intensification (Bueter et al. 1976). This NIPF land is held by about 19,000 owners in parcels of 5 to 5,000 acres. Harvest from these lands could be increased from 378 million board feet annually to 1.0 to 1.5 billion board feet with only modest increases in management intensity (Bueter et al. 1976).

Given the importance of forestlands to the State of Oregon and the potential conflict that exists between forest management and residential land uses on many private forestlands, a coordinated land use planning effort is required. This must be done so that an adequate land base for timber production is maintained and the opportunity for smaller scale resource uses and certain non-resource uses is available. Toward this end the Oregon Land Use Planning Program created the statewide planning goal dealing with forestlands.

A. Oregon's Statewide Forestland Planning Goals

Oregon's land use planning program is the result of the growth of public awareness and concern about land use and environmental issues beginning in the 1960's. Prior to this period the states role in land use planning was limited mainly to providing the enabling legislation under which local governments carried out their planning and regulatory activities. But rapid population growth in the 1960's and 1970's created development problems that were perceived by many segments of the state's political leadership, the media, and the public as threats to the livability and economic viability of the state (BGRS, 1984).

In response to these concerns a number of legislative proposals were put forth in the early 1970's, culminating in the introduction of Senate Bill 100 in 1973, which, after extensive revision, became the Oregon Land Use Act of 1973. This Act had among its major provisions the creation of the Land Conservation and Development Commission and the Department of Land Conservation and Development, the identification of "areas" and "activities" of "critical statewide concern", and the provision for an appeals process for local governments (BGRS, 1984). The Act effected several significant departures from the previously existing land use system in Oregon. Not only did it clarify the mandate for cities and counties to prepare comprehensive plans, but also it created a new system of administrative supervision to ensure that the local governments would comply with the mandate (BGRS, 1984).

In 1974 the Land Conservation and Development Commission (LCDC), adopted a set of 14 goals and guidelines for statewide land use planning. The two major objectives of the goals were (1) to protect natural resources on which Oregon's economy depends (forests, farms, and an environment attractive to tourists) and (2) to concentrate urban development within areas inside or adjacent to cities in order to achieve efficient land use and economy in the provision of urban infrastructure (BGRS, 1984). Since 1974, 5 more goals have been added to the original 14.

The land use planning program in Oregon attempts to guide the process of development in the state in a way that addresses the need for non-resource development as well as the need for conservation of natural resources. This planning program is regulated by the Statewide Planning Goals and guidelines of the Oregon Land Conservation and Development Commission (LCDC, 1985). The purpose of the land use planning process is to identify and apply a justifiable land use plan to achieve the Statewide Planning Goals (Lane County, 1983).

Goal 4 applies specifically to forest lands, and it directs that counties "conserve forest land for forest uses". Forest lands are identified as "lands composed of existing and potential forest lands which are suitable for commercial forest uses". Forest uses are defined as, among other uses, " the production of trees and the processing of forest products". To accomplish conservation of forest land for forest uses, Goal 4 requires that: (1) "Lands suitable for forest uses shall be inventoried and designated as forest lands"; (2) "existing forest uses shall be protected"; and (3) Land designated as forest lands must be identified as such on the comprehensive plan map.

This goal, however does not specify how these lands are to be protected. Unlike Goal 3, which deals with agricultural lands and requires the establishment of exclusive farm use zones, Goal 4 does not require the establishment of exclusive forest use zones.

One reason that Goal 4 lacks the precision of its agricultural counterpart is that the exclusive farm use (EFU) zone provisions contained in Goal 3 were referenced from the tax deferral law, which is very specific as to uses (Jim Pease, 1989, personal communication). Additionally, during the period of the 1970's the conversion of timberlands to other uses was not so dramatically visible as farmland conversion (Leonard, 1983). About 80 percent of Oregon's forest acreage is "locked up" either in public ownership or in large timber plantations owned by large corporations. As a result there seemed to be little likelihood of a significant conversion of forest lands to nonforest uses, and not as great a need to protect remaining forestlands as there did for agricultural lands. Recent reductions in forecasts for timber harvests on public and industrial forest lands have changed this perception and raised questions about the adequacy of the size of the timber growing land base.

Another reason is the lack of major involvement in, or even opposition to, the state land-use program by the timber industry (Leonard, 1983). In contrast, there was substantial involvement from the agricultural community.

Lane County attempted to meet the requirements of Goal 4 with planning efforts in the late 1970's and early 1980's. The approach used involved dividing all forest lands in the county into site classes based on site index values associated with soil survey mapping units (Lane County, 1982). This work was done by the Lane County soil scientist working in conjunction with the Soil Conservation Services Lane County soil survey party. The forest land identification methods used by the county did not recognize important factors other than soils that contribute to the quality of a site for forestry use.

This and other limitations of the Goal 4 definitions for forest land became evident as the county continued to work with Goal 4. The definitions were written broadly by the LCDC and as a result they reserved for forest use all of those lands with commercial forest production potential. Also included were lands that because of low soil quality or existing land use conflict were not as productive or important to the long term viability of the timber growing land base of the state. Release of these lands for other kinds of land use, such as part-time small woodland production or rural residences would not significantly affect this base.

Recognizing this problem, Lane County sought to develop a technique or set of criteria that would distinguish between the best forest lands and those of lesser quality and importance. Other counties in the state came to a similar conclusion as they attempted to meet the requirements of the statewide planning goals and present their comprehensive plans to the LCDC. At this point the problems began to receive attention at the state level in LCDC and at the state legislature.

B. Primary and Secondary Lands Issues

Throughout the 1980's, as counties began to complete their comprehensive plans and present them for acknowledgement by LCDC, it became clear that the existing definitions of both agricultural and forest lands under State Goals 3 and 4 included lands with limited resource value (LCDC, 1987). Consequently, the best (primary) resource lands were not receiving adequate protection, while at the same time less valuable (secondary) lands were being over protected.

In order to deal with these problems, the Oregon Legislature, in its 1985 session directed LCDC to "Consider the adoption of rules, amendments of the goals, and recommendations for legislation that will provide a practical means of identifying secondary resource lands and allow specified uses on those lands" (LCDC, 1987).

This new category of secondary lands was designed to identify rural areas in which neither commercial agriculture nor commercial forestry was the predominant use at the present time and was not anticipated to be in the future because of limitations due to soil productivity, parcel size, and land-use conflicts.

LCDC created a Rural Lands Advisory Committee to discuss the issues associated with secondary lands identification and to develop (1) an objective measure of the relative suitability of soils for farm and forest uses; (2) an objective means for identifying and designating land as either Primary or Secondary; (3) ways to reduce conflicts between resource and nonresource uses of Primary lands by invoking limitations on nonresource uses of Primary lands that are even stricter than those currently in effect within current exclusive farm and forest zones; and (4) ways to reduce restrictions on nonresource uses of Secondary lands that now exist in the current exclusive farm and forest zones (LCDC, 1987).

The Rural Lands Advisory Committee succeeded in developing a proposal that created a more restrictive primary forest zone and a less restrictive secondary forest zone. Major outright uses permitted on primary forestland would include: (1) commercial growing and harvesting of forest tree species, (2) farm use pursuant to ORS 215, 3) uses accessory to commercial forest uses, and 4) portable facilities for the processing of forest products. Restrictions in the primary zone would preclude the introduction of conflicting land use activities into commercial forest areas (LCDC, 1987).

On secondary lands restrictions would be significantly less. Such lands were to be composed of either a high percentage of soils that have low productive capacity for forests, or of areas that have high quality forest soils, but due to land use conflicts or parcel sizes, commercial forest management is no longer feasible. One single-family dwelling on a lot or parcel as defined in ORS 215.010, would be allowed on these lands.

The advisory committee also focused on identifying ways to rate soil suitability for cropland, woodland and range uses. A soil suitability rating system was developed for cropland, woodland, and range use (Huddleston and Latshaw, 1987). Each soil's suitability for these uses was rated as either "high", "medium", or "low". Based on these individual ratings a combined soil rating was adopted for each soil map unit.

Lane County saw the primary and secondary lands issue as an opportunity to take a leadership role in developing a quantitative and objective method of evaluating the quality of forest lands. Certain characteristics of Lane County make it a good location to develop and test land use models. Lane County has the combination of productive forest lands and residential land use patterns that are fairly representative of the rest of Western Oregon. It is also unique in the state in being the only county to which all the 19 statewide planning goals apply (Kent Howe, 1989, personal communication).

Drawing on work that was done in adjacent Linn County on a model developed for agricultural lands (Huddleston et al. 1987), the County thought that a Land Evaluation and Site Assessment (LESA) model (SCS, 1983), developed specifically for forestry could be utilized to identify grades of forest resource land. They considered the detailed nature of a LESA model to be useful for more complex areas where the separation of primary and secondary resource lands was difficult.

In the last decade the need for such a comprehensive land use model was recognized, and efforts at the national level produced the LESA system. This system which is designed to be used for any type of land use, incorporates a measure of soil quality, using soil potential ratings and other methods, and can include any number of site characteristics that are deemed by the local developers of the model to have important effects on resource production activities.

Since no complete forestry LESA model existed, Lane County had to go through the process of developing all of the components of the model. The purpose of this research was to develop a model that would provide an objective and quantitative method of evaluating soil and site quality for forest production on a parcel by parcel basis. An additional task would be to develop criteria for using the LESA model to distinguish between primary and secondary resource land.

The Lane County Land Management Division, in cooperation with the Oregon State University (OSU) Soil Science Department, initiated a project to develop a LESA model that could be used for these purposes.

The County assisted in the formation of the committee that would be responsible for developing the site assessment portion of the model, and maintained ongoing participation in designing, testing, and modification of the site assessment portion and of the final forestry LESA model.

II. Development of the Land Evaluation and Site Assessment Concept

On a national level, the U.S. Soil Conservation Service (SCS) developed the Land Evaluation and Site Assessment (LESA) system (SCS, 1983) in order to evaluate the impacts of U.S. Government programs on the conversion of farmlands to nonfarm uses. This was mandated by the Farmland Protection Policy Act (FPPA) of 1981 (Steiner, 1987). Federal agencies were required by the SCS to use the LESA system in evaluating the impacts of their programs on the conversion of farmland. LESA was also developed in order to assist state and local planners in determining which agricultural land, and under what conditions, should be protected (Wright et al., 1983).

During its development LESA was tested in 12 counties in six different states. After completing this testing, the SCS released a handbook that explained the LESA system to federal, state, and local officials (SCS, 1983).

A. Land Evaluation

The LESA process consists of two parts: Land evaluation (LE) and Site Assessment (SA). LE rates the quality of soil by incorporating four existing U.S. Department of Agriculture (USDA) rating systems: land capability classification, important farmlands classification, soil productivity and soil potential rating.

The land capability classification system set up by the U.S. Soil Conservation Service in the early 1960's has eight land capability classes numbered I to VIII. Land is classified according to the most adequate protection from erosion or other means of deterioration. Soils having greatest capabilities for response to management and least limitations in the ways they can be used are in class I. Those with least capabilities and greatest limitations are found in class VIII.

Important farmlands classification stems from federal legislation passed in 1978 which charged the Soil Conservation Service with identifying and locating prime and unique farmlands and farmlands of statewide and local importance. The prime farmland was that which had the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. Unique farmland is land other than prime farmland that is used for the production of specific high value food and fiber crops. Farmlands of statewide and local importance are not prime or unique, but they are important to supporting the state or local agricultural economy.

Soil productivity rating systems provide a measure of the suitability of a soil for a certain crop such as, good, fair, or poor, or the grouping of soils into classes or grades of suitability based on their characteristics and response to management (Huddleston, 1984). Soil potential ratings on the other hand, provide a measure of not only the suitability but also the inputs that are required to produce a given output. Soil potential ratings provide a numerical index of the relative quality of different soil types for a specific type of land use.

B. Site Assessment

Site assessment (SA) is designed to identify factors other than soils that contribute to the suitability of an area for retention in agricultural use (Wright et al., 1983). Factors that may be considered in site assessment include adjacent land use, parcel size, presence of agricultural infrastructure, existing zoning on the parcel and around it, distance to urban services, surrounding land use, access to transportation, and availability of markets for farm production. Decisions on which of these SA factors to include are made by local officials working with a local LESA committee.

Numerical ratings for both the LE and SA parts of LESA are calculated and added together to give a score that rates the relative, overall agricultural value of a parcel. This can be used to compare different parcels. LESA provides a relatively straightforward process for evaluating the agricultural suitability of a range of potential sites being considered for conversion to nonfarm uses (Steiner, 1987).

C. Existing LESA Models

States and local governments in Illinois, Delaware, and Hawaii have adopted and used LESA most extensively (Steiner, 1987). In Illinois, LESA has been used to implement its Farmland Protection Policy Act of 1982. In Delaware a LESA system was developed as a result of the Agricultural Lands Preservation Act of 1981. State officials in Delaware developed an LE system to be used statewide;

county commissioners were responsible for the SA part. The completed LESA system will be used to evaluate the impact of state and federal programs on conversion of agricultural lands. Hawaiian officials have created a 17-member statewide LESA commission to recommend a system to the state legislature.

A significant amount of work has occurred on the development of LESA models in the Pacific Northwest states of Idaho, Oregon, and Washington. These states have a great deal of ecological diversity and vary in the statutes that govern land use planning. LESA systems have been developed for 3 counties, one in each of these states.

The LESA system developed in Idaho was in Latah county, in the Palouse wheat growing region of the Pacific Northwest (Stamm et al., 1987). The impetus for the creation of a LESA system was a change in the county comprehensive plan to add policies that required the preservation and protection of agricultural lands. The Board of County Commissioners adopted complementary zoning and subdivision ordinances that limited the number of nonfarm residences on each parcel of rural land. Strong plan policies also mandate that urban-density development shall be in or adjacent to existing cities or towns.

Instead of developing a single rating for agricultural suitability, the commission wanted four indices rating suitability for agriculture, forestry, range, and rural residential development. This approach made it possible to identify which rating was primarily responsible for the overall score, and allowed the comparison of scores for existing and proposed land uses for a particular site.

Counties in Oregon are required by state law to identify agricultural land within their jurisdiction and to enact policies and regulations to protect agricultural land use. State guidelines seek to preserve agricultural land in large parcels and to discourage its partitioning and the construction of nonfarm dwellings in agricultural areas. In order to provide assistance to county decision makers in meeting these guidelines, a LESA system was developed for Linn County (Huddleston et al., 1987).

Whitman County in southeastern Washington produces the most wheat and the highest wheat yields of any county in the U.S. Rapid growth in the 1960's and 1970's created conflicts between nonfarm rural residents and agricultural operations. An exclusive agricultural district was adopted for the whole county, which prohibited residential subdivisions except in incorporated and a few unincorporated communities. Concerns remained about the siting of heavy commercial uses in places that would not conflict with agriculture. The county commission decided that a LESA system should be developed that could allow the weighing of the suitability of a site for heavy commercial development against its value as agricultural land (Tyler et al., 1987).

III. Framework for the Lane County LESA Model

A LESA system is designed to take into account local values and objectives that are relevant to a land use problem. A twelve member technical committee was appointed to provide this input and assist in the development, testing, and evaluation of the model. Local input is considered a vital part of a LESA model for a number of reasons (Stamm et al. 1987, Huddleston et al. 1987). The continuing involvement of the local committee helps to insure that the model will be useful in their planning efforts. The committee also can continually evaluate the model for inconsistencies and flaws so it can be adjusted to accurately reflect the environment in which local resource production activities are conducted. All of this input helps to build local credibility for the model.

The Lane County forestry LESA committee had representatives from small woodland operators, industrial forest companies, the U.S. Forest Service, the Bureau of Land Management, the OSU Extension Service, both Lane County Lane Management Division and Lane Council of Governments (LCOG) Planning Department, and the OSU Departments of Soil Science and Geography. This committee brought together a broad spectrum of forest management expertise from diverse operating situations.

The inclusion of small woodland operators was essential because their perspectives were those of the owners and managers of the NIPF land that was the major focus of forest land planning in Oregon. These small woodland operators along with the foresters from the industrial forest companies and the OSU Extension Agents provided information on management and commercial viability of small forest parcels and the types of conflict that can occur between forest management activities on private lands and rural residents.

The two federal agencies manage large acreages of forest land for a variety of land uses, including timber production, within a highly structured planning process. Some of their holdings are in the vicinity of, or exist as isolated parcels adjacent to, rural residential areas. Representatives from these agencies brought knowledge of the types of conflicts that occur on such parcels, as well ideas about how to plan and implement forest management on them.

Lane County Land Management Division and Lane Council of Governments staff provided perspectives on the planning context of this and previous work on forest land issues in Lane County. They also were instrumental in getting the committee together, providing the facilities to hold the meetings, getting out information, and providing transportation throughout all phases of the development and testing of this model.

The technical committee had the task of developing specific criteria for evaluating both soil resource quality and non-resource factors that affect the use of land for commercial forestry uses. The committee operated using group discussions to develop a consensus on the most important elements a forestry LESA model should contain and the specific criteria that would be used to quantify them. The ideas and information developed by the committee were recorded and compiled by the members of the OSU Soil Science Department to produce the various site assessment factor criteria that were part of the final model.

The final criteria were a product of a process where initial proposals from the committee were tested, the results brought back to them for review and then further adjustments were made until they were satisfied with the result.

The consensus process by which this committee operated utilized a modified form of the Delphi method in the course of developing several of the LESA criteria. Delphi was used in two counties in Oregon and Washington to gather data on the spatial, financial, and marketing characteristics of agriculture in the state (Pease, 1984). In general, Delphi is a systematic process for reaching consensus among experts on a set of questions. Although it is mainly a tool for developing policy and forecasting change, Delphi is also an efficient method for gathering information on specific topics, including land use.

Delphi has several characteristics: 1) response anonymity, 2) controlled feedback, and 3) statistical summary of group responses. Central to the method is the advantage that a group of individuals has over a single individual in making accurate estimations. Delphi overcomes the problems common to the face-to-face discussion method of obtaining group opinions (Pease, 1984).

The Delphi process consists of two or more rounds. The first round elicits confidential responses from the experts. Responses are statistically summarized for the group by median and interquartile range. In subsequent rounds, each participant is provided with a statistical summary of the previous round and another response is elicited. The expert then may reconsider his or her answer in ligh of the group response. Over successive iterations, individual responses tend to converge toward a group consensus as defined by the final median and interquartile spread. Maximum consensus is usually achieved after two or three rounds (Pease, 1984).

The LESA committee consisted of a group of forest management experts, and so was well suited for the use of a Delphi process. The modified Delphi process that was utilized in the committee involved soliciting a written response from the members on a specific question, tabulating the results and determining a median, and reporting this back to the committee. This was done for several rounds until a consensus was achieved. The interquartile range of the responses was not calculated.

In the process of developing this model a combination of methods were used in the meetings with the goal of producing a complete and usable LESA model. In order to achieve this, meetings were held over a period of six months from the first discussions to the final presentation and approval of the finished product.

Rogers (1980) and Wiederhold (1985) both list several specific characteristics that are applicable to the development of a forestry LESA model for Lane County. Most of the features identified below are adapted from this work. The first centers on potential uses of the model.

A LESA model should be both comprehensive in its evaluation of soil suitability for forest uses and simple enough to be applied in a repeatable fashion by people who have limited technical knowledge about all aspects of soils. Wiederhold (1985) stresses the fact that the model should be designed for use by nontechnical users.

A second desirable feature is that the model should incorporate as much input as possible from people in the local area. Local input ensures the usefulness of the model, because it reflects conditions that will affect resource management and practices in the local area. Local input helps to build credibility and enhances local acceptance of the model. Local input is an integral part of LESA models (SCS, 1983).

The third desirable feature of the model is that it recognizes other important factors besides soils that have an effect on the quality of a site for forestry uses.

A fourth characteristic is that it is exact and quantitative in specifying the points to assign to each of the factors. Many productivity models (Moss, 1972; Storie, 1933 and 1976) assign a range of values to each soil or site factor, leaving it up to the user to decide exactly which value to assign. When the assignment of points is specified in such an arbitrary manner, the rating of a given soil may vary from user to user. Further ambiguity could be avoided by precisely defining each of the factors to be rated. Building this specificity into the model helps ensure repeatable results, no matter who the user might be (Le Vee and Dregne, 1951; SRTC, 1974).

The fifth desirable feature is the validation of the productivity ratings and other measures generated by the model by comparing them to other measures of soil resource quality and site characteristics that were derived independently from this model. Extensive work has been done by other researchers (Huddleston and Latshaw, 1987; Pease, 1988) to define soil quality, parcelization, and land use conflict criteria, as part of a system to identify secondary resource lands in Oregon. This work will be described later in the thesis.

A final assumption must be made in developing this model. Models are an abstraction and are merely an attempt to approximate the conditions in a natural system (Wiederhold, 1985). Due to the complexity of nature and to limitations in the type and amount of data available, even the most detailed model cannot fully accommodate all of the many interactions that occur in nature. It is necessary to assume, therefore, that it would not be possible to account for all the interactions between soil and site factors in the design of the soil productivity part of this model.

The general form of the Lane County forestry LESA model follows that of the agricultural LESA model developed for Linn County. This form includes separate land evaluation and site assessment components, with the individual factors rated on a numerical scale. In addition, each of the LESA factors would initially be developed on a 100 point scale, and then the weight for each in the final LESA model would be decided on later by the committee. Throughout it's development the model would be field tested, adjusted, and then retested in order check it's validity.

As the different parts of this model are discussed in this thesis, one of the test parcels, number 1, from the Spencer Creek area will be used to illustrate all of the land evaluation and site assessment calculations.

IV. Land Evaluation for Forestry - Soil Potential Ratings

A. Background

The committee chose to base the LE part of the system on soil potential ratings, which they considered the best measure of relative soil quality. This was the approach followed in Linn County, Oregon (Huddleston et al., 1987) and in Whitman County, Washington (Tyler et al., 1987). Soil potential ratings (SPR's) provide a numerical index of the relative quality of different soil types for a specific type of land use. The process for calculating the SPR's was adapted from an earlier effort to calculate soil potential ratings in Linn County.

SPR's for forestry are based on the difference between the value of the merchantable timber that can be produced on a site and the costs of managing that site over several rotations. The volume of merchantable timber produced was calculated using the Douglas-Fir Simulation Model (DFSIM) (Johnson and Sleavin, 1984). DFSIM is a computer program that was developed by the College of Forestry at OSU to provide an estimate of the growth of timber and the volume that could be harvested from each acre of land over an entire rotation under a user specified management system.

Before DFSIM can be run, important assumptions about the management system must be made. These include: origin of the stand, the minimum basal area and diameter to be removed in commercial thinning, the number and spacing of trees that will planted on reforested sites, site preparation methods, slope limitations for thinning and harvesting operations, and the rotation age of the stands.

The management assumptions and costs used in developing the Linn County forestry soil potential ratings were used as the starting point for the Lane County LESA model. The management operation cost figures used in Linn County were compared to those used in Oregon State University Extension publications on woodland business management (OSU, 1983). These figures were reviewed with OSU Forest Management Professor Douglas Brodie, who concluded that they were reasonable.

SPR's were then calculated for each the soil map units in the Lane County Soil Survey Area (Patching, 1987) that had potential for commercial forest production.

B. Prescribing a Management Model

A complete forest management model must consider the natural factors that affect timber production. Also required is a method for measuring the level of productivity of the environment in which this production occurs. Given the inherent potential of the natural environment, a specific set of management steps is required to obtain a given level of forest production. The components of this management system are discussed in the following section.

1. Forest Soils of Lane County

Soils are one of the major factors that determine the appropriate forest management system. The soils in the part of Lane County for which this model was developed are very diverse, reflecting the effects of different parent material, climate, landscape position and topography.

Soils in the Coast Range are deep and moderately deep and mostly well drained. On the broader more stable ridge and side slopes the major soils are Peavine, Blachly and Honeygrove. They formed in material from sandstone or mixed sedimentary and igneous bedrock. Associated with these soils but of minor extent are the McCully, the moderately well drained Cumley, and the somewhat poorly to very poorly drained Minneice soils. Formader, Klickitat and Hembre soils formed in material derived from basic igneous rock, occur on broad to narrow ridges and steep canyon sideslopes.

The other major soils that occur in the Coast Range are Bohannon, Preacher, and Digger. They are all derived from interbedded sandstone and siltstone parent material. Both Bohannon and Digger are moderately deep, and Preacher soils are deep. All are well drained.

Foothills on both sides of the Willamette Valley border the Coast and Cascade Ranges. Parent materials in the foothills include sandstone and basic igneous rocks of Eocene-Miocene age, and old alluvium deposited during the Pleistocene. Common soils in the foothills include Bellpine, Hazelair, and Philomath. All of these soils are derived from the weathering of sandstone or a mixture of igneous and sedimentary rock. Bellpine and Hazelair soils are moderately deep. Bellpine soils are well drained and Hazelair soils are moderately well drained. Philomath soils are shallow and well drained. Two other common soils in the foothills are Nekia and Ritner, both of which are moderately deep and well drained. Veneta and Salkum soils formed in old alluvium. Veneta is deep and moderately well drained and Salkum is deep and well drained.

On major alluvial terraces paralleling the Willamette and McKenzie rivers are several deep soils formed in old alluvial deposits. Malabon and Salem are both well drained, Coburg is moderately well drained and Awbrig is poorly drained. Along the tributaries of the Willamette River are several soils that occupy bottom lands and alluvial fans. These recently deposited soils are all deep but vary in drainage condition and landscape position. Abiqua is well drained, McAlpin is moderately well drained, and Waldo is poorly drained. Two deep poorly drained soils, Natroy and Bashaw, occupy broad terraces, fans, and bottom lands. As streams coming from the Coast Range reach the edges of the valley, they form a series of narrow flood plains, terraces, and fans. Soils on these landscapes include Nehalem, Meda and Nestucca.

In the part of the Cascade Range included in this study, three major soils occur on basic igneous or interbedded sedimentary, basic igneous and pyroclastic rock. All of these soils are well drained but occur on different parent materials and vary in depth. Klickitat soils are deep and underlain by hard basalt. Kinney soils are also deep, but are underlain by interbedded pyroclastic material and lava flows. The moderately deep Bohannon soil is on very narrow ridges and steep south facing side slopes. Keel and Hummington soils are both moderately deep and well drained. They are on the mountain plateaus and rugged uplands of the higher elevation areas in the western part of the Cascade Range and formed in material weathered from mixed igneous rock and volcanic ash. Also included are Cruiser, Mulkey, somewhat excessively drained Yellowstone soils, and well drained Holderman and Winberry soils on high ridges and steep slopes in areas of light colored rhyolite.

2. Soil Properties Affecting Site Productivity and Management

In the land evaluation model developed as part of the Linn County Forestry LESA model (Langridge et al., 1987), the main factors used to evaluate forest site quality were various soil map unit properties. Included were site index, depth to bedrock, coarse fragment content, erosion hazard, slope, and bedrock hardness. Soil potential ratings provide a comprehensive view of the total volume of wood a given soil is capable of producing as well as the limitations that soil map unit properties place on reforestation, thinning and harvesting operations, and road building and maintenance. This view is more complete then a measure of just the rate of growth or the amount of timber volume that a site can produce.

Geographic position and its associated soil and other environmental components make up the site in which trees grow. Site quality is defined as the sum total of all factors influencing the capacity of the forest to produce trees or other vegetation. Most forest classification systems, therefore, attempt to integrate the various site factors so as to yield an estimate of site quality and capacity to produce wood (Pritchett and Fisher, 1987).

Soil properties are one of the major abiotic factors that influence site productivity. The most important soil characteristics that determine site productivity are those that affect the soil's ability to supply water, nutrients, and air in the proper amounts needed for optimum growth. These include effective rooting depth, depth to water table, soil moisture availability, subsoil texture, rock fragment content, and soil fertility (Pritchett and Fisher, 1987).

Methods for measuring site productivity can be put into two groups, indirect and direct. This division is made on whether the estimate is based on some stand measure or on some other feature of the local environment. But productivity can be reasonably estimated on a stand volume or weight or on annual rate of growth, such as cubic feet per acre. It has generally been accepted by foresters that the height of the dominant stand at a specified age is a good index of site productivity (Pritchett and Fisher, 1987).

Site index is used to express the height of dominant and codominant trees projected to some particular stand age. The index or base age is 25, 50, 100 or any age appropriate to the growth rate and longevity of the species being considered (Pritchett and Fisher, 1987). Used along with yield tables, site index is the standard by which relative productivity is measured. If the stands being measured are older or younger than index age, height/age curves are required to project measured height to a height at index age (Beck, 1971).

The site index system of classification is empirical and it provides limited information except that concerning the present stand. It is not useful for sites that have no trees, for those lacking suitable trees, or for the conversion of a site from one species to another. Site index provides little information about the biological limitations of a site. As a result it is not a good predictor of the potential productivity of a site subject to intensive management techniques. However, site index is a convenient and useful guide to measure tree growth for a particular species under a given set of conditions, and it is widely used for this purpose (Beck, 1971; Carmean, 1975; Trousdell, Beck, and Lloyd, 1974).

Soil survey reports are the main source of information used to identify both the site index for a given soil and other properties used in the development of SPR's. In a study done in the Northwestern Cascades of Oregon Stephens (1965), found that the soil taxonomic unit, at the series level, provided an accurate prediction of Douglas-fir site index on the soils studied. He further concluded that any detailed soil survey on forest lands should be accurate in relating site index to the soil map units.

Steinbrenner (1979) studied forest soil productivity relationships in the Douglas-fir region of the Pacific Northwest for the purpose of developing soil-site estimating equations to determine site index for untimbered sites. His data show that soil-site estimating equations can be produced for Douglas-fir, and these data were verified by extensive testing on Douglas-fir stands in the Pacific Coast Forest Region of North America.

Steinbrenner (1975), also found that productivity interpretations based on the soil survey can be the basis for determining the allowable cut, predicting yield, and to provide an economic rationale for intensive forest management, such as regeneration methods, stocking control, and thinning. In addition, he concluded that soil mapping units provide a logical management unit for designing harvest and other management operations.

3. Forest Management System

Production of timber requires a series of management steps; site preparation and stand establishment, precommercial and commercial thinning, roadbuilding, and final harvest operations. The costs associated with these steps are related to the soil properties of the site being managed.

Dollar values assigned to management costs were developed for the Linn County forestry LE committee. They represent a typical system of management for the Douglas-fir region of Oregon. Details of these cost estimates are shown in Tables 2, 4, 5, and 6. The management practices will be discussed in the order they would be carried out after a site was harvested.

The first practice is reestablishing a stand of trees after harvest (Table 2). These costs are determined by the soil and slope characteristics of the site being reforested. For each of the major slope groups, less than 30 %, 30 to 60 %, and 60 to 90 %, a set of basic practices is listed that would be used on the site if no other soil depth, coarse fragment content, or erodibility constraints

Table 2. Stand establishment costs.

ESTABLISHMENT

SLOPE <30%

Assumptions: -Tractor pile and burn or machine scarify to control slash and plant competition ($175/Ac.)

-Plant trees at 10x10 spacing (435 trees/Ac.). When more trees planted, 12x12 spacing or 680 trees/Ac. used.

-2/0 trees cost 12c and 13c/tree labor. 2/1 trees cost 20c and 20c/tree labor. Containerized trees cost 17c and 18c/tree labor.

-Tree survival is 90%.

Soil Depth x Coarse Fragments

Soil Depth (inches)	COARSE FRAGMENT CONTENT >2mm IN PROFILE (%) < 15	15 - 35	35 - 60
< 20	Plant larger stock or more trees $349	Plant larger stock or more trees $349	Plant more containerized trees $413
> 20	No problem $283.75	Plant larger stock or more trees $349	Plant containerized trees $327.25.

K-factor

< .37	No Problem
> .37	Broadcast burn and spray to control slash and plant competition. $240/Ac.

SLOPE 30-60%

Assumptions: -Broadcast burn and spray to control slash and plant competition. (Burn $200/Ac., Spray $40/Ac.)

-Plant trees 10x10 spacing (435 trees/Ac.) w/higher labor costs due to slope.

-2/0 trees cost 12c and 15c/tree labor. 2/1 trees cost 20c and 22c/tree labor. Containerized trees cost 17c and 20c/tree labor.

-Tree survival is 90%.

Soil Depth x Coarse Fragments

Soil Depth (inches)	COARSE FRAGMENT CONTENT >2mm IN PROFILE (%) < 15	15 - 35	35 - 60
< 20	Plant larger stock or more trees $422.70	Plant larger stock or more trees $422.70	Plant more containerized trees $491.60
> 20	No Problem $357.45	Plant larger stock or more trees $422.70	Plant containerized trees $400.95

SLOPE 60-90%

Assumptions: -Broadcast burn and spray to control slash and plant competition. (Burn $225/Ac., Spray $40/Ac.)

-Plant trees 1-x1- spacing (435 trees/Ac.) w/higher labor costs due to slope.

-2/0 trees cost 12c and 18c/tree labor. 2/1 trees cost 20c and 25c/tree labor. Containerized trees cost 17c and 23c/tree labor.

-Tree survival is 90%.

Soil Depth x Coarse Fragments

Soil Depth (inches)	COARSE FRAGMENT CONTENT >2mm IN PROFILE (%) < 15	15 - 35	35 - 60
< 20	Plant larger stock or more trees $460.75	Plant containerized stock $439.00	Plant more containerized trees w/more spraying (2) $577.00
> 20	No Problem $395.00	Plant larger stock or more trees $460.75	Plant more containerized trees $537.00

existed on the site. They apply on a soil which is deeper than 20 inches, has less than 15 percent coarse fragments, and an erodibility (K) factor of less than .37. If any of the factors exceeds these limits however, establishment costs are increased accordingly. A 90 percent survival rate is assumed for the trees planted.

Basic costs for stand reestablishment after harvest for a site with slopes of less than 30 % and without any soil limitations is $283.75 per acre. Tractors can be used to pile before burning or to scarify the site to control slash and plant competition, because the relatively flat slopes don't limit equipment use or present a serious erosion hazard. But for soils with K factors greater than .37, tractor preparation cannot be used, and sites must be broadcast burned and sprayed for slash and brush control, raising the cost of site preparation from $175 to $240 per acre.

For sites with shallow soils (< 20 inches) or with 15 to 35 percent rock fragments in the profile, more trees must be planted in order to get an adequate stand, raising the cost per acre to $349. Containerized trees must be used on sites with more than 35 percent rock fragments in the soil, raising the cost to $327.25 for moderately deep and deep soils and $413 per acre for shallow soils.

This, along with higher labor costs for planting due to increased slope, raises the cost on a site with no other soil limitations to $357.45 per acre. As with the flatter sites, the cost increases even more for shallow soils and for soils with greater than 35 percent rock fragments. Costs increase even further as slopes increase above 60%, up to a maximum of $577 per acre on steep, shallow, very gravelly soils.

Site preparation and stand establishment costs are illustrated for soil map unit 124F, Slickrock gr 1, 25 to 50 % slopes. The Slickrock soil is greater than 20 inches in depth, has 15 to 35 % coarse fragments, and an erodibility factor of .17. Referring to Table 2, for soils with these properties and slopes of 30 to 60 %, the cost is $423 per acre.

Thinning of established stands, the second step, is an integral part of this management system. The costs for these operations are given in Table 4. The length of rotation from the time of stand establishment to final harvest is assumed to be 60 years.

Precommercial thinning is done on all sites regardless of site class and steepness of slope. No merchantable trees are removed from the site during this operation. The age at which a stand is precommercially thinned, however, is based on its site class. Site classes are based on 50 year site index values, and are shown in Table 3.

Table 3. 50 year Douglas - fir site index, site classes and age at precommercial thin.

Site Index	Site Class	Precommercial Thin Age
140 - 160	1	10
130 - 140	2	12
100 - 130	3	15
80 - 100	4	18
60 - 80	5	20

Table 4. Thinning costs over a rotation.

THINNING

Assumptions: -50 year site index data used.

-Precommercial thinning will be done on all sites regardless of site class and steepness of slope. The time at which this is done will be based on site class. Refer to the DF-SIM data sheet for detailed criteria.

-Stocking rate is 435 trees/acre with 90% survival or 400 trees.

-Precommercial thinning on slopes <30% will thin to 300 trees/acre or 12x12 spacing; Precommercial thinning on slopes >30% will thin to 200 trees/acre or 15x15 spacing.

-Rotation age will be 60 years.

-On soils <30% slopes, both precommercial and commercial thinning will be done.

-Commercial thinning using designated skid trails is recommended on soils with slopes less than 30%. Site class determines how many thins and at what age. Refer to DF-SIM data sheet for detailed criteria.

	PRECOMMERCIAL THINNING COSTS (PER ACRE)		
	<30% SLOPE W/COMM. THIN	30-60% SLOPE	>60% SLOPE
No. trees left after P.C.T.	300	200	200
Cost of P.C.T.	$ 75	$125	$150

COMMERCIAL THINNING COSTS W/DESIGNATED SKID TRAILS

SITE CLASS	1st THINNING	2nd THINNING
I, II, III	105 $/mbf	90 $/mbf
IV, V	125 $/mbf	-

Based on the original stocking rate of 435 trees per acre and a 90 percent survival rate, there should be 400 trees per acre at the time of precommercial thinning. On sites with slopes of less than 30 percent the number of trees are thinned to 300 per acre or a spacing of 12 by 12 feet from the original 10 by 10. On sites with slopes of greater than 30%, trees are thinned to 200 per acre. The cost of this thinning is based on the number of trees that must be removed and the difficulty of doing the work on the steeper slopes. The costs shown in the table range from $75 per acre on the flattest sites to $150 on the steepest.

The management plan calls for commercial thinning, where merchantable logs are taken off the site, only on sites with slopes of less than 30 percent where tractor equipment can operate on designated skid trails. Fifty year site index information is used to determine the number and age at which commercial thinning operations are done. The costs of these thinning operations are also based on the site class and the number of board feet of timber removed.

Using map unit 124F once again to illustrate the cost involved in this timber management operation, and referring to Table 4, we find that because this map unit has slopes of 30 to 60 %, it is only suited to precommercial thinning,and the cost is $125 per acre.

The last step in the of management system is the harvest operation. Relationships between soil and site properties and the methods and cost of logging are shown in Table 5. All methods assume a 20 acre clearcut with a ground based yarding system.

There is a significant difference in harvesting costs based on

Table 5. Timber harvest costs.

HARVEST

Assumptions:
- Harvest is by 20 acre clearcut units with a ground based yarding system.
- All soils are assumed to be subject to compaction, requiring a designated skid trail tractor logging system on slopes <30 percent.
- Std. cable logging system will be used on >30% slopes where the hazard of erosion is not high (K-factor <.37) and soil depth is >20 inches.
- Full suspension logging system will be used on >30% slopes where the hazard of erosion is high (K-factor >.37) and/or soil depth is < 20 inches.

LOGGING METHOD COSTS

PERCENT SLOPE	Soil Depth (in.)	EROSION HAZARD K= <.37	EROSION HAZARD K= >.37
<30%		Designated skid trails 65 $/mbf	Designated skid trails 65 $/mbf
30-60%	>20	Standard cable system 120 $/mbf	Full suspension system 160 $/mbf
	<20	Full suspension system 160 $/mbf	Full suspension system 160 $/mbf
>60%	>20	Standard cable system 110 $/mbf	Full suspension system 140 $/mbf
	<20	Full suspension system 140 $/mbf	Full suspension system 140 $/mbf

the depth to bedrock, erosion hazard, and the slope of the site. Soil depth and slope dictates the harvesting methods that can be used and the associated harvest costs. For all harvest operations on sites less than 30 percent slope a tractor logging system using designated skid trails is used. Sites on slopes over 30 % require cable logging systems, which increases harvest costs by 84 % over tractor logging methods, from $65 per thousand board feet (mmb) to $120. Harvest costs are increased by 33 % more, to $160 / mmb on soils that are less than 20 inches to bedrock. This greater cost is due to the need to use a full suspension logging system, which keeps the logs off the ground, decreasing the soil disturbance and resulting erosion. Full suspension logging systems are also employed on highly erodible soils, as indicated by a K value greater than .37.

Map unit 124F, Slickrock soil, has slopes of 30 to 60 %, is greater than 20 inches in depth and has an erodibility factor of .17. Entering these properties in Table 5 shows that harvest costs are $120 per thousand board feet (mbf) of timber harvested. The total harvestable yield per acre for this map unit as calculated by DFSIM is 89,300 board feet, bringing the cost of harvest to $10,713 per acre.

In order to conduct forest management activities there must be access to the site, and the cost of providing this access must be added to the final harvest costs. This management system, shown in Table 6, assumes that one quarter mile of road is needed per 20 acre harvest unit. Road construction and maintenance costs are also affected by the slope, bedrock type, and erodibility of soils located on the site. Costs increase as slope increases because deeper cuts

Table 6. Harvest road construction and maintenance costs.

HARVEST (ROAD CONSTRUCTION AND MAINTENANCE)

Assumptions:
- Road construction and maintainence is included in the harvest final costs.
- One quarter mile of road is needed per 30 acre harvest unit with minimum resource impact road design.
- Percent slope, type of bedrock, and hazard of erosion are soil characteristics which influence road construction and maintainence.
- Road construction is the building of new road which could include use of special equipment needs such as ripping, blasting, and need for deep cuts.
- Road maintainence is done twice/year and based on U.S.F.S. data.
- Increased use of culverts, bank stabilization and end hauling are used as erosion hazard and slope increases.

ROAD CONSTRUCTION AND MAINTAINENCE COSTS

% SLOPE	TYPE OF BEDROCK	EROSION HAZARD K-factor < .37		K-factor > .37	
< 30%	SOFT	Construction	156 $/Ac.	Construction	$171.60 1/
		Maintainence	2.17 $/Ac.	Maintainence	$2.39
	HARD	Construction	200 $/Ac.	Construction	$220.00 1/
		Maintainence	2.17 $/Ac.	Maintainence	$2.39
30–60%	SOFT	Construction	200 $/Ac.	Construction	$240.00 2/
		Maintainence	1.67 $/Ac.	Maintainence	$2.00
	HARD	Construction	250 $/Ac.	Construction	$300.00 2/
		Maintainence	1.67 $/Ac.	Maintainence	$2.00
> 60%	SOFT	Construction	250 $/Ac.	Construction	$312.50 3/
		Maintainence	1.33 $/Ac.	Maintainence	$1.66
	HARD	Construction	312 $/Ac.	Construction	$390.00 3/
		Maintainence	1.33 $/Ac.	Maintainence	$1.66

1/ Additional costs for more culverts (10% over std. costs).

2/ Additional costs for more culverts and bank stabilization (20% over std. costs).

3/ Additional costs for more culverts and end hauling (25% over std. costs).

are required for road construction on steeper sites.

Soft bedrock is not limiting for road construction because regular roadbuilding equipment can be used to construct roads. If a hard bedrock type is found on the site, road construction costs are increased to pay for special equipment needed for ripping and blasting through this material. Increased slope and erodibility combine to create additional costs for culverts, bank stabilization, and end hauling. These increased costs range from 10 to 25 percent above standard costs for highly erodible soils as slope increases from less than 30 to greater than 60 percent.

Based on the 30 to 60 % slope and the soft bedrock type of the Slickrock map unit 124F, the road construction and maintenance costs from Table 6 are $202 per acre.

C. Calculating Timber Output Values Using DFSIM

Timber output values for each soil map unit in Lane County that was considered important for forest uses, were calculated using the Douglas Fir Simulation Model (DFSIM). The program calculates the volume of merchantable timber produced by commercial thinning and final harvest cuts done on each soil type over a 60 year rotation. Much of the information required to run this model comes from the assumptions included in the management cost Tables, 2, 4, 5, and 6.

The information shown in Table 7 is entered in order into the computer before the program is run and the volume numbers are calculated. The stand age at the beginning of the simulation is assumed to be 9 years. The number of trees per acre is based on a 90 percent survival of the original 435 trees planted. The site index for the stand is from the 50 year site index value assigned to the soil map unit. A 60 year rotation length is considered to be an acceptable one for this region.

Most of the thinning operations are based on the site class into which the soil map unit falls. Precommercial thinning ages go from 10 to 20 years as the site class increases from 1 to 5. The residual number of trees after this thinning has been set by the management plan at 300 per acre for map units with less than 30 percent slope and at 200 for those over 30 percent. Only stands with slopes of less than 30 percent are commercially thinned, and the number of such thins is 2 for site classes 1 through 3, and 1 for site classes 4 and 5. The stand age at which the thinning is done is also determined by site class, and is set at 30 and 45 years for the first and second thinning for site classes 1 and 2, and 35 and 50 years for site 3 soils. Only one thin, at 40 years, is done for site class 4 and 5 soils.

The next set of numbers that must be entered into the program are independent of site and soil conditions. These include: 1) that the minimum basal area (in square feet per acre) of all trees greater than 5.6 inches in diameter must be at least 100 before the first commercial thin; 2) that the minimum average stand diameter to be removed is set at 9 inches; and 3) that the minimum basal area per acre to be removed in each commercial thinning, be at least 30. The commercial thin cut parameters are entered as specified on the DFSIM input form.

Table 7. DFSIM data input requirement list.

DFSIM INPUT DATA LIST 1/

1. Simulation of EXISTING stand
2. Stand age at the beginning of the simulation 9
3. Number of trees per acre 400
6. Site index of stand (based on soil site)
7. Stand origin is PLANTED
8. Height/age observations were not used
12. Rotation length is controlled by age
13. Rotation age in years 60
15. The stand is precommercially thinned
16. Stand age at the precommercial thin

SITE CLASS	I	II	III	IV	V
AGE	10	12	15	18	20

17. Residual number of trees per acre after precommercial thin (see Table 6, Thinning)
18. Stand is commercially thinned on slopes ≤ 30 percent
19. Maximum number of thins

SITE CLASS	I	II	III	IV	V
# THINS	2	2	2	1	1

20. Stand age at first commercial thin

SITE CLASS	I	II	III	IV	V
AGE	30/45	30/45	35/50	40	40

21. Minimum basal area of trees greater than 5.6 inches dbh before first commercial thin can be done 100
22. Minimum average stand diameter to be removed in each commercial thin 9
23. Minimum basal area per acre to be removed in each commercial thin 30
24. Timing of commercial thins is at user specified stand ages
29. Stand age for each commercial thin (see 20)
31. Commercial thin cut parameters are:

    d/D ratios are within the range .8-1.25
    residual basal areas not supplied
    user supplied residual # of trees for each commercial thin

32. d/D ratio desired for each commercial thin .90, 1.0
34. Residual # of trees for each commercial thin

SITE CLASS	I	II	III	IV	V
# TREES (1st/2nd)	210/160	210/160	210/160	180	180

35. Stand not fertilized
39. Yield table is printed for trees greater than 1.6 inch dbh
40. Stand statistics printed at time of cutting

1/ This list corresponds to DFSIM INPUT FORM.

The residual number of trees that remain after each commercial thin is determined by site class. For site class soils 1 through 3, the numbers are 210 per acre for the first and 160 for the second. For site classes 4 and 5 the residual is 180 trees per acre.

Three final assumptions are made in running the program: 1) the stand is not fertilized; 2) the yield table is printed for trees greater than 1.6 inches in diameter; and 3) stand statistics are printed at the time of cutting.

The program calculates the volume of merchantable timber produced on each soil type over a 60 year rotation. Table 8 gives a sample of the printout produced by DFSIM for soil map unit 124F, Slickrock gr l, 30 to 60 % slopes. At the top of page 1, all of the stand information that was entered into the program is listed. Because this soil has a site index of 137, it is in site class 2, so the stand is precommercially thinned at 12 years. It also has slopes of 30 to 60 % so it is not commercially thinned.

The information of interest for determining the SPR for commercial timber production is the total volume of output from the soil summed over all of the cuts. This is on page 3 of the printout at the bottom of the page on the far right side, under sum cuts SV6 (Scribner Volume 6). For the Slickrock map unit 124F, this total volume is 89,276 board feet.

This total output volume is multiplied by a price per thousand board feet for saw logs, to provide a dollar value for the gross production from each soil map unit. The value per thousand board feet used in this model was $336. For map unit 124F the total value for

Table 8. DFSIM program output tables..

```
1
                         D F S I M   VERSION 1.0                  PAGE  1
slickro2

                              MANAGED YIELD TABLE
                                FOR DOUGLAS-FIR
                                1.6 INCHES PLUS

                         SITE INDEX =  137. (50 YEARS BH)

                STAND ORIGIN --- PLANTED TO  400. TREES PER ACRE.
                STAND WILL BE PRECOMMERCIALLY THINNED AT AGE  10. TO  200. TREES
                PER ACRE.
                THE SCHEDULED AGE AT THE HARVEST CUT IS  60.
                EXISTING STAND STATISTICS SPECIFIED ARE
                    TOTAL AGE=   9.
                    TREES PER ACRE=   400.
                    BASAL AREA PER ACRE=     .0
                    QUADRATIC MEAN DIAMETER=    .00
                NO COMMERCIAL THINNING TO BE DONE.


TOT  BH          LOREY          BASAL  TREES   CVTS   CAI  *MAI CVTS*  **MAI CV4**
AGE AGE   HT40    HT      DBH AREA/A    PER    PER*   NET  GROSS  NET  ****NET****
YRS YRS   FEET   FEET    INCH  SQ FT   ACRE   ACRE  CVTS   1.6+  1.6+  5.6+  7.6+

*****************************************************************************
WARNING -- STANDS PLANTED OR PRECOMMERCIALLY THINNED TO LESS THAN 300 STEMS
PER ACRE ARE QUESTIONABLE EXTRAPOLATIONS OF MODEL.
*****************************************************************************


PRECOMMERCIAL THINNING DONE AT AGE 10. RESIDUAL NUMBER OF TREES IS  200.


 60  54

HARVEST  143.7 135.2  20.58  311.2   135. 15583.  298.  286.  260.  249.  249.

SUM CUTS                     311.2   135. 15583.
SUM MORTALITY                 36.0    65.  1555.
```

```
1                        D F S I M   VERSION 1.0                  PAGE  2
slickro2

                              MANAGED YIELD TABLE
                                FOR DOUGLAS-FIR
                                5.6 INCHES PLUS

                         SITE INDEX = 137. (50 YEARS BH)

                           BASAL AREA  TREES    TOTAL     CUBIC FEET
                    DBH     PER ACRE    PER   CUBIC FEET   PER ACRE
                   INCHES   SQ. FT.    ACRE    PER ACRE   4-INCH TOP
TOTAL AGE  60.

HARVEST             20.6    311.2      135.     15583.       14960.

SUM CUTS                    311.2      135.     15583.       14960.
SUM MORTALITY                                    1524.
```

Table 8. DFSIM program output tables (Continued).

```
1                          D F S I M   VERSION 1.0                    PAGE  3
 slickro2

                               MANAGED YIELD TABLE
                                FOR DOUGLAS-FIR
                                7.6 INCHES PLUS

                         SITE INDEX = 137. (50 YEARS BH)
```

	DBH INCHES	BASAL AREA PER ACRE SQ. FT.	TREES PER ACRE	CVTS	CV4	CV6	IV6	SV6
TOTAL AGE 60.								
HARVEST	20.6	311.2	135.	15583.	14960.	14736.	99375.	89276.
SUM CUTS		311.2	135.	15583.	14960.	14736.	99375.	89276.
SUM MORTALITY				1189.				

output was 89.276 multiplied by $336 which equals $29,997.

D. Calculating Final SPR's from DFSIM Data and Management Information

Subtracting the total of all management costs from the dollar value of the output yields a number that can be used to calculate the SPR. An example of this calculation is shown in Figure 2. The soil having the greatest difference between output value and input costs is assigned an SPR of 100; for the Lane County SPR's this was map unit 66D. All other soils are assigned SPR's on a scale from 0 to 100 according to the percentage of the maximum difference between inputs and outputs that can be achieved. The result is a numerical expression of the relative value of each soil within a soil survey area for commercial forestry, as shown in Figure 3. The SPR's for each of the soil map units in the Lane County study area were calculated in this way.

The table in Appendix 1 lists all the soil map unit information required to calculate a soil potential rating including, soil properties that effect soil management costs, a yield estimate produced by DFSIM, gross return value, dollar values for management costs, net return per acre, and the SPR's for each map unit. A listing of all of the soil map units in rank order of their SPR's is in Appendix 2. A portion of Appendix 1 showing the information for 5 soil map units is shown in Table 9 .

Example: 124F - Slickrock, 25 to 50 % slopes

Depth - > 20 inches
Coarse Fragment Content - 15 to 35 %
K Factor (erodibility) - .17
Bedrock type - soft
Site index - 137

Volume Of Merchantable Timber From DFSIM

124F - Slickrock 25 to 50 % - 89,276 Bd. Ft. / Acre

Value of Timber Produced On Slickrock

89,276 x $336 / mmb = $29,997 / Acre

Management Costs Based On These Soil Properties

Stand Establishment	- $423 / Acre
Thinning Costs	- $125 / Acre
Logging Costs	- $10,713 / Acre
Road Maintenance	- $202 / Acre
Total Costs	- $11,463 / Acre

Net. Value = Timber Value - Management Costs
= $29,997 / Acre - $11,463 / Acre = $18,534

Figure 2. Calculating the net output value for a map unit.

Calculating the Soil Potential Rating

66D - Kinney cobbly loam, 3 to 20 % slopes
Value of Timber - $30,954
Management Costs - $ 6,846
Net. Value = $24,108 SPR = 100

$$\frac{\text{124F - Slickrock Net. Value}}{\text{66D - Kinney Net. Value}} \times 100 = \text{SPR}$$

$$\text{SPR} = \frac{\$18{,}534 \text{ / Acre}}{\$24{,}108 \text{ /Acre}} \times 100 = 77$$

Figure 3. Calculating the soil potential rating.

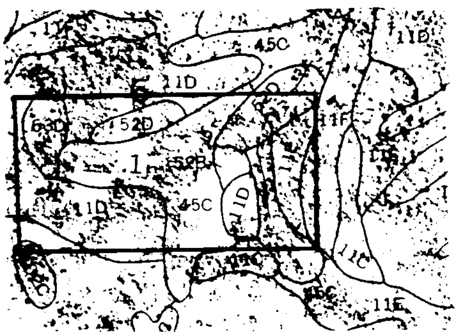
Table 9. Selected Lane County soil potential ratings.

Map unit Symbol	Map Unit	Soil Depth	Coarse Frag	Erosion K-Factor	Bedrock Type	Site Index 50 YR	Yield Est. Bd./Ft./Ac.	Gross Ret. ($/Ac.)
124D	Slickrock gr l, 3 to 25 %	>20	15-35	.17	Soft	137	88068	29591
124F	Slickrock gr l, 25 to 50 %	>20	15-35	.17	Soft	137	89276	29997
135C	Willakenzie cl, 2 to 12 %	>20	<15	.24	Soft	110	50308	16903
135D	Willakenzie cl, 12 to 20 %	>20	<15	.24	Soft	110	50308	16903
135E	Willakenzie cl, 20 to 30 %	>20	<15	.24	Soft	110	50308	16903

Map unit Symbol	Map Unit	Establis ($/Ac.)	Thinnin ($/Ac.)	Logging ($/Ac.)	Road Maint.	Total Cost	Net. ($/Ac.)	Soil Potential
124D	Slickrock gr l, 3 to 25 %	349	1144	4985	158	6636	22954	95
124F	Slickrock gr l, 25 to 50 %	423	125	10713	202	11463	18534	77
135C	Willakenzie cl, 2 to 12 %	284	914	2693	158	5479	11424	47
135D	Willakenzie cl, 12 to 20 %	284	914	2693	158	5479	11424	47
135E	Willakenzie cl, 20 to 30 %	284	914	2693	158	5479	11424	47

In this LESA model, soil resource quality for forestry must be determined on a parcel basis. This is done by calculating a weighted average SPR for the parcel. The weighting factors are the percentages of land area occupied by each different soil map unit within the parcel boundary. The number derived from this calculation is the LE score for that parcel in the overall LESA rating. This calculation is illustrated using parcel 1 from the Spencer Creek study area, as shown in Table 10.

Table 10. Determining parcel weighted soil potential rating.



Soil Map Unit	% of Area	SPR (Table 6).	Weighted SPR
11D, 11E	47	68	32
45C	32	40	13
52B, 52C	12	32	3
63D	5	68	3
108F	4	20	1
		Total	52

The soil potential ratings produced for Lane County were presented to the committee at the beginning of the model development process and were accepted by them as a reasonable measure of soil resource quality.

V. Defining Site Assessment Criteria

A. Background

After deciding on a system for land evaluation, the advisory committee discussed at length what non-resource factors should be incorporated into the LESA model. All of the possible factors from these deliberations were written down initially, and then the committee eliminated all but the ones they considered to be the most important. Ultimately three categories of factors were identified: 1) Forest Economics; 2) Adjacent and Surrounding Land Use; and 3) Other Forest Uses. Most of the factors in the first category were related to parcel size. Most of the factors in the second category were related to compatibility with commercial forestry. Most of the factors in the third category were related to other resource uses, such as wilderness or wildlife habitat that compete for the same land.

The third category was subsequently dropped from further consideration in the LESA model because these uses would tend to preserve the resource status of land, rather than force a choice between resource and non-resource uses of land. Thus the evaluation of site assessment was reduced to an evaluation of effects associated with parcel size and of effects associated with compatibility with non-resource land uses.

B. Parcel Size Criteria

The LESA committee spent a significant amount of time discussing the issue of parcel size. They dealt with this issue from the viewpoint of informed "experts", the majority of them being experienced foresters with many years work in managing and harvesting forest parcels.

The first issue that the committee dealt with was the minimum-size parcel on which forestry could be practiced. In the end a size of 5 acres was accepted as a practical minimum. Between 5 and 40 acres, parcel characteristics may restrict management and reduce the value for forestry. Above 40 acres there is little effect due to size, although larger parcels were still considered more desirable than smaller ones.

The committee identified two other size-related effects. The first was that a 20-acre size was the threshold between land owners who were more likely to be involved in resource type uses and those who were not. The second was that parcels smaller than 10 acres were generally viewed as conflicting with commercial forestry uses. From the discussion of the committee, it can be concluded that parcels larger than 10 acres can be successfully managed for commercial forest production.

While development of the parcel size factor for this LESA model comes solely from the consensus produced by the discussions of the technical advisory committee, their decisions are supported by studies done elsewhere.

Available information (Healy and Short, 1981) dealing with the question of parcel size indicates that size is important because of its effect on economies of scale in forest commodity production. For example, small tract sizes raise the cost of harvesting timber, because of the cost of moving harvesting equipment several times in order to get to several tracts. The economics of applying productivity-raising management techniques is also affected by parcel size because it has substantial impacts on the financial returns to intensive forest management. Scale economies are found as parcel size increases up to at least 160 acres (Row, 1978). Data from this study show that once a parcel size of 50 acres was reached, there wasn't much decrease in the average cost of treatments.

A recent study in Oklahoma demonstrated that size had a measurable influence on the intensity of forest management (Thompson and Jones, 1981). Dr. Douglas Brodie, professor of Forest Management at OSU College of Forestry, indicated that a parcel should be at least 20 acres in size in order to be manageable for commercial forestry (1988, personal communication).

As the committee began work to set up a point scale to rate parcel size effects, it became obvious that the effect(s) of size depended heavily on interactions with other factors such as parcel shape, the slope of the land, and whether or not any class I streams passed through the parcel. To resolve this problem a matrix table was developed that took into account all of these interactions.
Initially, the most favorable combination of size and related factors was identified as a parcel larger than 160 acres having a more or less

square shape on a slope less than 30% and for which there were no class I streams. This combination was assigned a value of 100 points. Lesser point values were assigned to size groups of 80-160, 45-80, 25-45, 5-25 slope, or streams.

Several different versions of this parcel size point distribution matrix were produced. Initially, there was a category for three class 1 streams on a parcel. The committee decided after looking at maps showing the distribution of class 1 streams in the county that having 3 on one parcel was not a likely situation and so the category was dropped.

Points assigned to various parcel sizes changed significantly as the members considered the entire range of sizes. After several attempts, the final distribution of points shown in Table 11 was accepted.

Table 11. LESA committees final point distribution for parcel size.

Parcel Size (AC)	Slope	Presence of Class 1 Streams: 0	1	2 or more
4 - 8	<= 30	25	5	0
	> 30	5	0	0
8 - 16	<= 30	50	30	5
	> 30	35	20	5
16 - 32	<= 30	70	55	35
	> 30	60	45	25
32 - 64	<= 30	85	75	60
	> 30	80	75	55
64 - 128	<= 30	95	85	75
	> 30	92	90	75
128 - 256	<= 30	100	95	90
	> 30	98	97	95

These point values were plotted on graph paper using the midpoints of each size class to plot against. French curves were used to draw smooth curved lines connecting all points. The data from the hand drawn plots were later entered into a computer and drawn out by a plotter. These plots are shown in figure 4. Point values for parcel sizes in 1 acre increments were taken directly from the graph. This process was repeated to develop similar but lower point scales for each combination of size, slope, and streams that represented increasing severity of limitation for forestry use. The results are shown in Appendix 3. A portion of the results from this appendix are shown in Table 12.

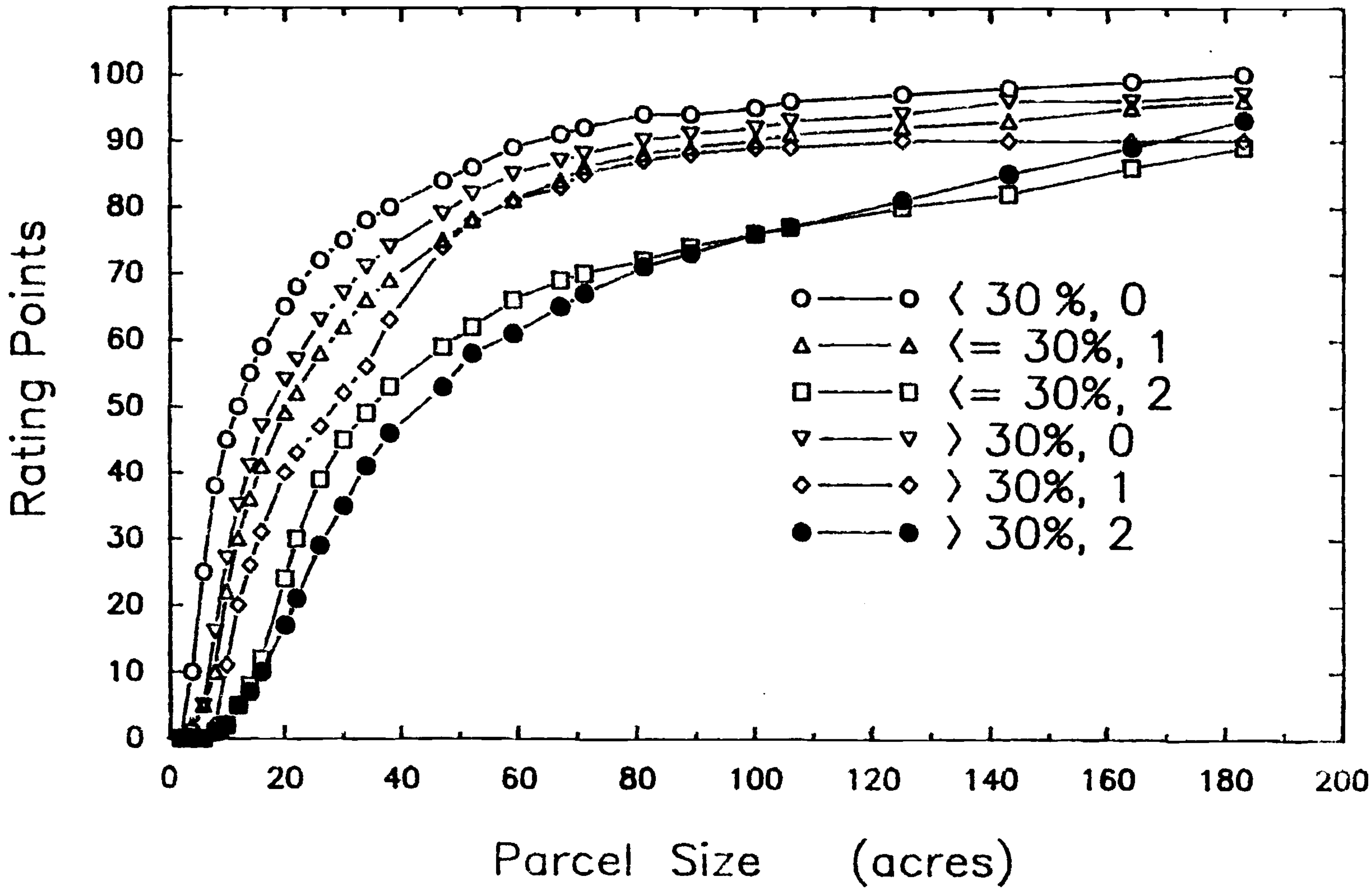


Figure 4. Plot of rating point values for parcel sizes.

Table 12. Rating point values for selected parcel sizes.

SIZE	PERIM	-----SLOPE <= 30%-----			------SLOPE > 30%-----		
		NO. OF CLASS 1 STREAMS			NO. OF CLASS 1 STREAMS		
(Acres)	RATIO	0	1	2	0	1	2
60	<=2.55	89	82	66	85	80	63
	>2.55	59	55	44	57	53	42
61	<=2.57	89	82	66	85	80	63
	>2.57	59	55	44	57	53	42
62	<=2.59	90	83	67	86	80	64
	>2.59	60	55	45	57	53	43
63	<=2.61	90	83	67	86	80	64
	>2.61	60	55	45	57	53	43
64	<=2.63	90	84	68	86	81	65
	>2.63	60	56	45	57	54	43
65		90	84	68	87	81	65
66		90	84	68	87	81	66
67		91	84	69	87	81	66
68		91	85	69	88	82	66

The issue of parcel shape generated a lot of discussion and an interesting resolution. It was agreed that very narrow or irregularly shaped parcels may have limited value for forestry because of the difficulty in felling trees within the property boundary. Thus parcels less than 330 feet wide were considered to be severely limiting. In order to get a measure of parcel narrowness or irregularity, a method for calculating a parcel shape index was developed. The parcel shape index is calculated as the ratio of the perimeter of a parcel to the perimeter of a square having the same area. The index value representing shape limitation was calculated as the ratio of the perimeter of a rectangular parcel 330 feet wide to the perimeter of a square of the same size. The 330 foot figure represents the length of the short side of a 2:1, 5 acre rectangle If the calculated index for an actual parcel exceeds this limiting value, the parcel size rating was reduced accordingly. The values for perimeter ratio for each of the parcel sizes are shown on the left side of Table 12.

Spencer Creek test parcel 1 is 65 acres in size, dominantly less than 30 % in slope and does not contain a class 1 stream. It's perimeter is 7,122 feet. A 65 acre parcel with a square shape would have sides 1,682 feet long and a total perimeter of 6,730 feet. Dividing 7,122 by 6,730 gives a perimeter ratio of 1.06. A 65 acre parcel with a width of 330 feet would have to be 8580 feet long and have a total perimeter of 17,820 feet. Dividing 17,820 by 6,730 gives a limiting perimeter index of 2.65. Because the actual perimeter ratio is well below the limiting shape threshold of 2.65, no further penalty for shape is involved. In fact, the actual ratio is so close to 1.0 that the parcel can be assumed to have a very regular shape. Given these data, the parcel size rating for the test parcel is 90 points.

C . Compatibility Criteria

Factors initially considered by the LESA committee in evaluating compatibility with commercial forestry included the number of nearby residences, the degree of parcelization of surrounding land, the visual impacts of forest operations, the existence of commercial, industrial, and recreational uses nearby, and the presence of utility corridors. The committee ultimately decided that compatibility issues could be adequately evaluated using just two factors: 1) the effects of adjacent land use; and 2) the effects of the degree of parcelization and development in the surrounding area.

The issue of compatibility between commercial forest uses and rural residences comes about due to the growth in demand for such dwellings in the rural areas. There has not been a great deal of study on the types and degrees of conflict between these two uses. However, work has been done to identify the conflicts that exist between farm and nonfarm rural residences in Linn and Lane Counties, respectively (McDonough, 1982; Daughton, 1985).

Farming and nonfarm residences are incompatible uses because the farming activities produce by-products or nuisances that spill over onto adjacent nonfarm properties. These by-products include noise, odors, smoke, dust, and chemical sprays. Farmers are also subject to vandalism, trespassing, stray domestic pets, and liability suits from nonfarm residences within and adjacent to the farm zones (McDonough, 1982).

It is not possible to use the results of studies of conflict between agricultural parcels and rural residences as a basis for evaluating those between commercial forest uses and rural residences. This is mainly due to the fact that the type and frequency of the practices used in commercial forest operations are quite different than those used on commercial farms.

Farm practices are conducted on a yearly basis so the potential for complaints by nonfarm residents is present annually. Forest practices on the other hand occur sporadically, often with 5 to 10 year intervals between them. When they do occur, however, they tend to create significant impacts that can spill over onto nearby or adjacent parcels. These impacts include noise, smoke from slash burning, herbicide spraying, logging truck traffic, and visual impacts due to partial or total removal of the trees.

The distance over which these impacts can be felt varies. The impact of noise from logging equipment and vehicles and herbicide spraying may be fairly localized. However, the impacts from smoke and visual effects may extend for several miles. This makes it difficult to identify a distance over which residential parcels would be affected by forestry practices conducted on a parcel.

Incidents that occur on forest parcels and originate from residences located in the forest zone are also different from those on agricultural parcels. Because there are no buildings or equipment permanently located on most forest parcels, the potential for theft is low. However, theft and vandalism of equipment could occur while they are located on the site during forest management operations. With no livestock on this land there is not a problem due to damage or loss from domestic animals. The major incident that concerns forest managers is the potential for fires, which is greater where there is more human activity in the vicinity.

Overall, it seems that the potential for conflict between commercial forestry practices and rural residences is less than that between commercial agriculture and residences. This would indicate that the distance over which conflict should be considered as important should be less on forest parcels than on agricultural land. However, commercial forestry has some effects which extend over greater distances than do those for agriculture.

1. Effects of Adjacent Land Use

Recognizing that conflict does exist between commercial forestry and other land uses, the next task the committee faced was to classify various types of land use in terms of degrees of compatibility with commercial forestry. At first, classes of compatible, somewhat compatible, and noncompatible uses were identified. At one point a fourth class, moderately compatible, was added, but it was later dropped. The final model uses the following classes of compatibility:

1. Compatible Uses
   - Commercial forestry (F1 zones)
   - Impacted forestry (F2 zones)
   - Federally designated wilderness (NR zones)
   - Agriculture (EFU zones)
   - Gravel/Quarry operations (QM zones)
   - Gas/Oil/Geothermal operations
2. Somewhat Compatible Uses
   - Rural industrial/commercial uses (M/C zones)
   - Recreation uses -- parks, campgrounds, golf courses
   - Airports (A/O zones)
   - Schools

3. Incompatible Uses

   Rural residential uses

   Urban residential uses

   All areas within an Urban Growth Boundary

In order to classify any given parcel into one of the above categories the following definitions were used:

1. Incompatible parcel:
   a. Any parcel zoned rural residential;
   b. Any parcel in EFU, F1, or F2 zones that is <u>both</u>
      1) Smaller than 20 acres, <u>and</u>
      2) Has a dwelling on it.
2. Somewhat compatible parcel:
   a. Any parcel used for commercial, industrial, educational, or recreational uses;
   b. Any parcel in EFU, F1, or F2 zones that is <u>both</u>
   1) Between 20 and 40 acres in size, <u>and</u>
   2) Has a dwelling on it.

The general concept of the adjacent land use rating criterion is that parcels surrounded by fully compatible uses receive 100 points, and that compatibility is reduced in proportion to the percentage of a parcel's boundary that adjoins incompatible and somewhat compatible uses. In its simplest form, this criterion would assign 75 points to a parcel whose perimeter was 75% compatible and 25% incompatible.

Somewhat compatible parcels are viewed as having less serious impacts on commercial forestry than incompatible parcels. By consensus, the committee agreed that these kinds of uses should receive only half as much weight as incompatible uses. In practice, this means that one determines the percentage of a parcel's perimeter that adjoins somewhat compatible uses, divides that percentage by two, then subtracts from 100.

There was some discussion in the committee about assigning more points to parcels that act as a buffer between residential areas and large highly productive forest parcels. It was decided that this was impractical because a uniform scale for assigning points to such parcels would be difficult to maintain.

The first formula used to calculate the adjacent land use score involved measuring the length of the perimeter of the parcel that fell into each of two conflicting categories, dividing that length by the appropriate factor (1 for incompatible parcels and 2 for somewhat compatible), dividing this numerator by the total length of the parcel perimeter, and subtracting that from 1.0. This number was then multiplied by 100 to get the rating for adjacent land use.

After initial testing of the LESA model criteria on several parcels, the adjacent land use criterion was modified to its present form, which includes a parcel density adjustment factor.

This adjustment was made to account for the density of residential development along that portion of the perimeter classified as incompatible. Previous experience with the Linn County LESA model for agriculture (Huddleston et al., 1987), has shown that the magnitude of conflict from adjoining, incompatible parcels depends on the shape and orientation of the conflicting parcels. In Lane County, the standard level of conflict was defined as that arising from 5-acre parcels, rectangular in shape, with a 2:1 length:width ratio, and oriented with the short side adjacent to the parcel in question. Any density less than this would reduce the penalty for incompatible perimeter; density higher than the standard level would increase the penalty.

The density adjustment is calculated as the ratio of the actual number of incompatible parcels to the potential number of incompatible parcels. The potential number is calculated by dividing the total length of incompatible perimeter by the length of the short side of a 2:1, 5-acre rectangle. In on-the-ground terms, that length is 330 feet. This distance would have to be calculated based on the scale of the map being used. On a map with a scale of 1" = 400', that length is 0.825", or 21mm.

The compatibility rating for adjacent land uses can be summarized mathematically in terms of the formulas shown in Figure 5.

100 - {(length incompatible per. * density adj.) + (length swc per/2)} * 100/total perim.

or, for measurements in inches on a 1" = 400' map,

100 --{(.825 * # of incompatible parcels) + (length swc per/2)} * 100/total perim.

Figure 5. Formula for calculating adjacent land use compatibility.

This latter expression simplifies the calculation of the adjacent land use score because it avoids the necessity of measuring the lengths of incompatible perimeter and merely requires counting the number of adjoining parcels that are classified as incompatible.

Parcel 1 in Spencer Creek again serves to illustrate the computation of the adjacent land use score. The land use setting for this parcel is shown in Figure 6. The 6 small parcels to the east and south are all zoned rural residential, hence are classified as conflicting. All the other adjacent parcels are fully compatible. The perimeter of the parcel as measured on a 1" = 400' map, is 21 inches. Using the formula in Figure 5 with these actual values yields an adjacent land use score of 76, as shown in Figure 7.

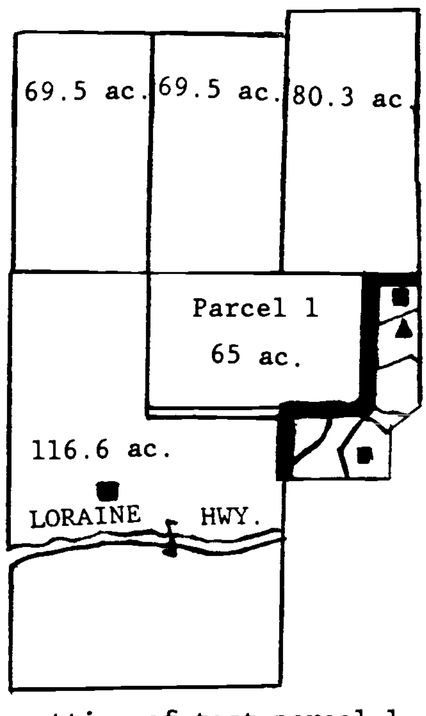


Figure 6. Land use setting of test parcel 1.

Symbols

■ - house

▲ - trailer house

▬ - rural residential exclusion bdy.

═ - road

Adjacent land use compatibility formula.

100 - {(.825 * # of incompatible parcels) + (length swc per/2)} * 100/total perim.

Adjacent score = 100 - (.825" x 6 + 0/2) 100/21 = 76

Figure 7. Calculation of adjacent land use score.

2. Effects of Surrounding Land Use

The committee's first task in developing a method of measuring surrounding conflict was to determine the size of the surrounding area to be considered in evaluating impacts on a given parcel. The committee used a modified Delphi process to develop a consensus that the "radius of influence" should be set at 1/2 mile. This is considerably larger than the equivalent area for existing agricultural LESA models (1/4 mile), but the committee reaffirmed on several occasions their belief that the 1/2 mile radius was the appropriate one to use for forestry models. Daughton's (1985) work on conflicts in agricultural areas adjacent to residential development supports this decision.

The next task was to develop a technique to characterize and rate the patterns of parcelization and development within the 1/2 mile zone. Several alternatives were explored. One was to measure the proportion of the area already in rural residential zones, subtract this number from 100, and use the difference as an index of relative suitability. This procedure was rejected because the index numbers obtained were all quite high and did not seem to represent the degree of land use conflict present.

Another suggestion was to establish sampling quadrants, or radial transects, within or along which measurements of parcelization could be taken. This approach was rejected because the committee could not see how to consistently define starting points, directions, spacing, or sizes of transects or quadrants.

The method that was adopted is to calculate an index based on the parcel size distribution within the 1/2 mile "radius of influence". In order to avoid double counting parcels for conflict, adjacent parcels are excluded from this 1/2 mile radius.

In the procedure for calculating the surrounding land use score the committee decided that parcels less than 40 acres in size had increasing impact on a forest production activities as their size decreased. This was mainly because the chances for and degree of conflict would increase as the size of surrounding parcels decreased and the number of rural residences increased. To account for this effect, all parcels were assigned a weighting factor, such that large, fully compatible parcels received a weight of 1.0 and successively smaller and more conflicting parcels received smaller and smaller weights. This weighting system is shown in Table 13.

Parcels larger than 40 acres that are outside a rural residential zone are multiplied by a weighting factor of 1. All parcels 20 to 40 acres in size and without a dwelling are multiplied by a weighting factor of .9. All those 10 to 20 acres and without a dwelling are multiplied by a weighting factor of .75. Those less than 10 are multiplied by a factor of .5. The effect of this weighting is to lower the surrounding land use score as the number of parcels increased and their size decreased, reflecting a greater degree of conflict.

The procedure shown in Table 13, is designed so that a parcel completely surrounded by parcels of 40 acres or more receives the maximum score of 100 points. As an example, a parcel surrounded by 8 parcels greater than 40 acres in size, would receive a score based on 8 times a weighting factor of 1, divided by 8 (number of parcels). In this case the calculated sum would be the same as the number of parcels, and the score would be 1 multiplied by 100 or 100.

$$\text{Rating score} = \{(\text{Sum } n1..n8)/\text{Total \# parcels}\} * 100$$
$$= \{(8 * 1) / 8 \} * 100 = 100$$

Further, parcels smaller than 40 acres are penalized more heavily if there is a dwelling on them, and the dwelling penalty increases as the parcel size decreases. Those 20 to 40 acres in size were given a multiplied by a weighting factor of .75. At a size of 10 to 20 acres, the factor is .5. Parcels less than 10 acres in size are multiplied by a .1 factor. Parcels within rural residential zones are given the maximum penalty without considering the dwelling question because they have the potential to be developed even if there is no existing dwelling.

All parcels within the 1/2 mile radius are counted even if only a portion of it falls within this area.

Table 13. Rating of surrounding parcelization and conflict effect.

Number of Parcels		Compatibility Weighting		Product
Inside RR Zones	x	0.1	=	n1
Outside RR Zones				
>= 40 acres	x	1.0	=	n2
20-40 acres				
w/o dwelling	x	0.9	=	n3
w/dwelling	x	0.75	=	n4
10-20 acres				
w/o dwelling	x	0.75	=	n5
w/ dwelling	x	0.5	=	n6
< 10 acres				
w/o dwelling	x	0.5	=	n7
w/ dwelling	x	0.1	=	n8

Rating score = {(Sum n1..n8)/Total # parcels} * 100

Parcel 1 in Spencer Creek is surrounded by 20 parcels zoned rural residential and 9 that are outside of rural residential zones (Figure 8). Of these 9, 6 are larger than 40 acres, one is 20 to 40 acres and is without a dwelling, and two are 10 to 20 acres and are without dwellings. From this information the surrounding land use score is calculated as 36 out of a possible 100, as shown in Table 14.

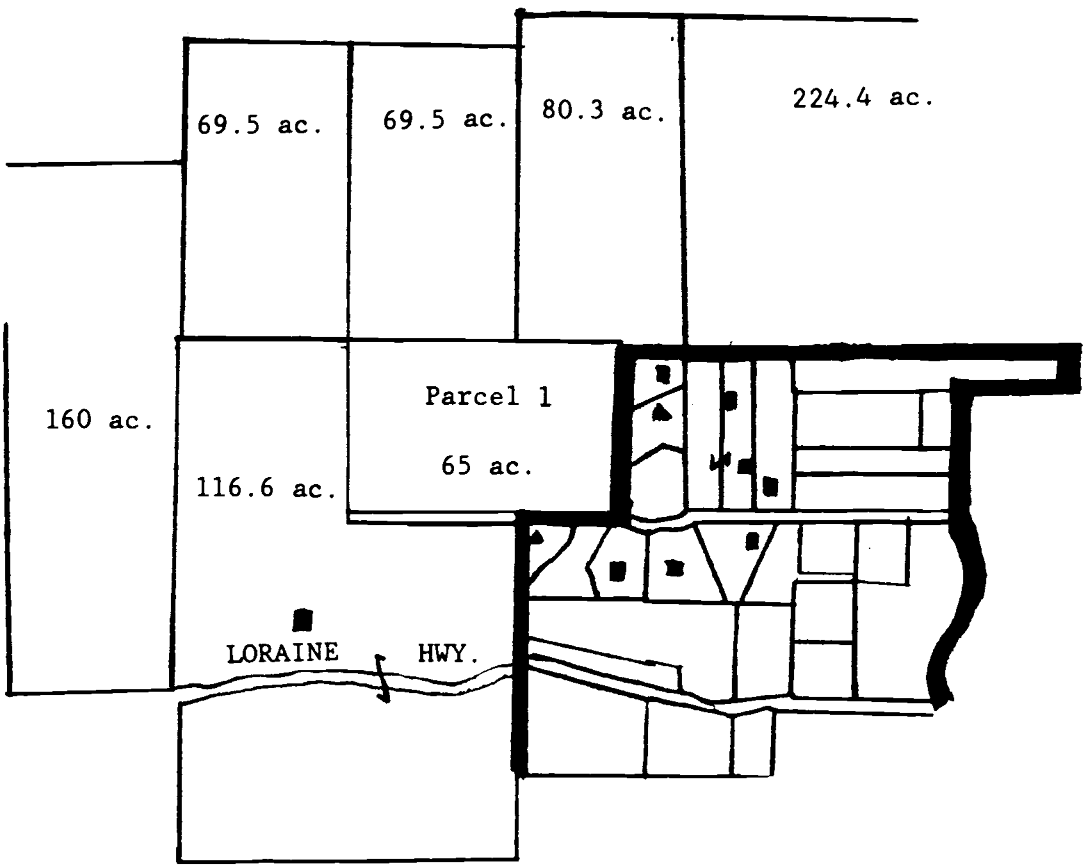


Figure 8. Surrounding land use setting for parcel 1.

Symbols

■ - house

▲ - trailer house

▬ - rural residential exclusion bdy.

= - road

Table 14. Calculation of surrounding land use conflict score for parcel 1.

Number of Parcels			Weighting Factor	Product
Inside RR Zones	20	x	0.1	= 2
Outside RR Zones				
>= 40 acres	6	x	1.0	= 6
20-40 acres				
w/o dwelling	1	x	0.9	= 0.9
w/dwelling	0	x	0.75	= 0
10-20 acres				
w/o dwelling	2	x	0.75	= 1.5
w/ dwelling	0	x	0.5	= 0
< 10 acres				
w/o dwelling	0	x	0.5	= 0
w/ dwelling	0	x	0.1	= 0
Total # Parcels	29		Score	10.4

Rating score = {(10.4)/ 29} * 100 = 36

VI. The Complete LESA Model

One of the unique features of the Lane County LESA process was that each factor - soils, size, adjacent use, surrounding use - was rated independently on its own 100-point scale. This proved to be a very beneficial process, for it made it much easier for the committee to envision proper values for any given situation relative to the maximum value of 100 points for the best level of each factor. The numbers obtained from this process are referred to as the raw scores.

Most LESA models to date have been based on a total of 300 points, and the various factors that make up the total have carried different weights. A 300-point standard was adopted to be consistent with existing LESA procedures. Using the modified Delphi process discussed earlier, each member of the committee made a secret estimate of how much weight each factor should carry. This was continued for several rounds until a consensus was reached by the committee. By this process the group decided on the following weights: Soils, 40%; Size, 25%; Adjacent land use, 25%; Surrounding land use, 10%. Subsequent testing and evaluation using the case study parcels led to a slight revision, decreasing soils to 35% and increasing surrounding land use to 15%.

Once the weights for each of factors were chosen, the raw scores could be converted to the weighted LESA scores. This conversion is done by multiplying the raw score by the weighting factor and multiplying this number by 3 to put the score on the 300 total point basis. The conversion for each factor is shown in Figure 9.

LESA score = (Raw score * weighting factor) * 3

Soils score = (100 * .35) * 3 = 105

Size score = (100 * .25) * 3 = 75

Adjacent score = (100 * .25) * 3 = 75

Surrounding score = (100 * .15) * 3 = 45

Figure 9. Conversion of raw scores to weighted LESA scores.

The final LESA model with the total possible scores is summarized in Table 15.

Table 15. Weighted LESA scores.

Factor	Max. Raw Score	Max. LESA Score 35/25/25/15
Soils	100	105
Size	100	75
Adj. Land Use	100	75
Surr. Land Use	100	45
	Total	300

Test parcel 1 from Spencer Creek has been used to illustrate the calculation of raw scores throughout the discussion of the different components of the LESA model. From this process, the raw scores for each of the components are as follows: soils 52, size 90, adjacent land use conflict 76 and adjacent land use score 36.

Using the formula in Figure 9, these raw scores are converted to weighted LESA scores as follows:

		Weighted LESA Score
soils score	= (52 * .35) * 3 =	55
size score	= (90 * .25) * 3 =	68
adjacent score	= (76 * .25) * 3 =	57
surrounding score	= (36 * .15) * 3 =	16
	Total =	196

From the very beginning the committee recognized the importance of testing criteria developed using actual parcels of land and existing land use patterns. Two areas were chosen outside of the urban area surrounding Eugene that had the mix of forest production and rural residential land uses that would provide a good setting in which to test the model. The Spencer Creek area is about 8 miles southwest of the city of Eugene, and the Marcola-Mohawk area lies 15 miles to the northeast. For this initial testing, 9 parcels from the Spencer Creek area and 5 parcels from the Marcola-Mohawk area were selected. Parcels were chosen to represent a wide range of sizes and land use patterns. Locations of all of these test parcels and their soil types are shown in Figures 10 through 15.

In the Spencer Creek area parcels 1, 2a, and 4b represent a situation where a parcel 40 acres in size or larger is adjacent to a moderate degree of parcelization. Both parcels 2NE and 3 are over 40 acres in size and have a high degree of adjacent and surrounding parcelization. The last four parcels in this area have little residential development of any kind in their immediate area. Numbers 2d and 4a are greater than 40 acres in size, and 2b and 2c are about 20 acres.

The situation in the Marcola-Mohawk area is also diverse. Parcels 7 and 8b are 62 and 38 acres in size respectively, but 7 has a moderate level of surrounding rural residential development, whereas the area surrounding number 8a is highly parcelized. There is a minor amount of development around the last three parcels used for this testing. Two of them, 5 and 8a are about 40 acres, while one, number 6, is just 3 acres.

The first round of testing was done before all of the criteria had been finalized. There was no system for evaluating surrounding land use conflict at this time. Each test parcel was evaluated using the model criteria for the first 3 factors: soils, parcel size and adjacent land use conflict, to determine how well it could differentiate between grades of parcel suitability for forest production under widely varying conditions.

The committee then made a site visit to each test parcel to see the lay of the land, evaluate timber stand quality, observe the surrounding land use patterns, and discuss the accuracy of the ratings scores. These site visits led to modifications in one or more of the criteria until the model evolved to its present status. Included among these modifications was the addition of a density adjustment factor to the adjacent land use formula, an initial approach for quantifying surrounding land use conflict, and verification of the 1/2 mile influence radius for surrounding land use conflict. As in the earlier Linn County LESA model, this process of testing using actual case studies was absolutely essential in order to validate the criteria developed. The consensus of the committee after these field visits was that the three model factors accurately represented each component of the LESA score.

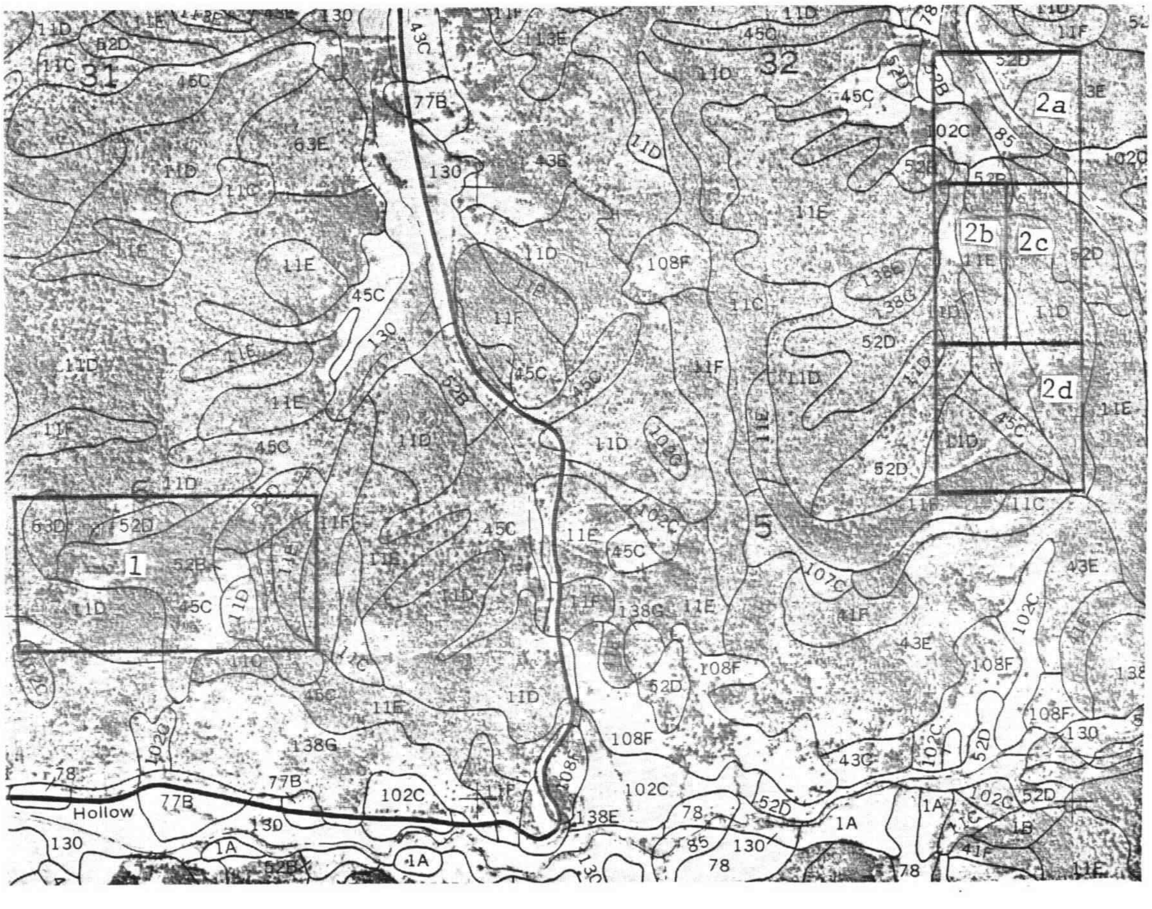


Figure 10. Soils map for parcels 1, 2a, 2b, 2c, and 2d. Map scale is 1: 20,000. Reproduced from map sheet 114 of the Lane County Soil Survey Report (Patching, 1987).

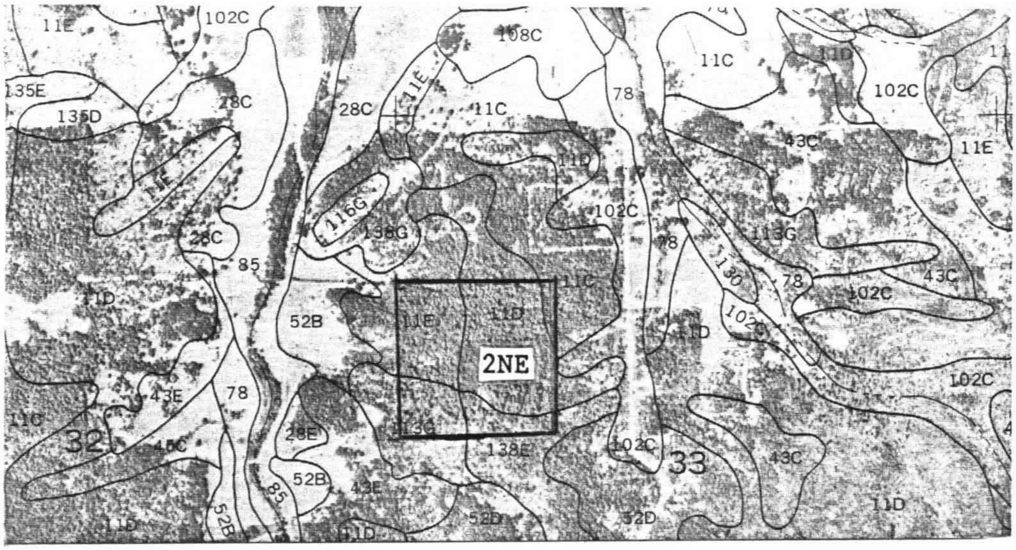


Figure 11. Soils map for parcel 2NE. Map scale is 1: 20,000. Reproduced from map sheet 102 of the Lane County Area Soil Survey Report (Patching, 1987).

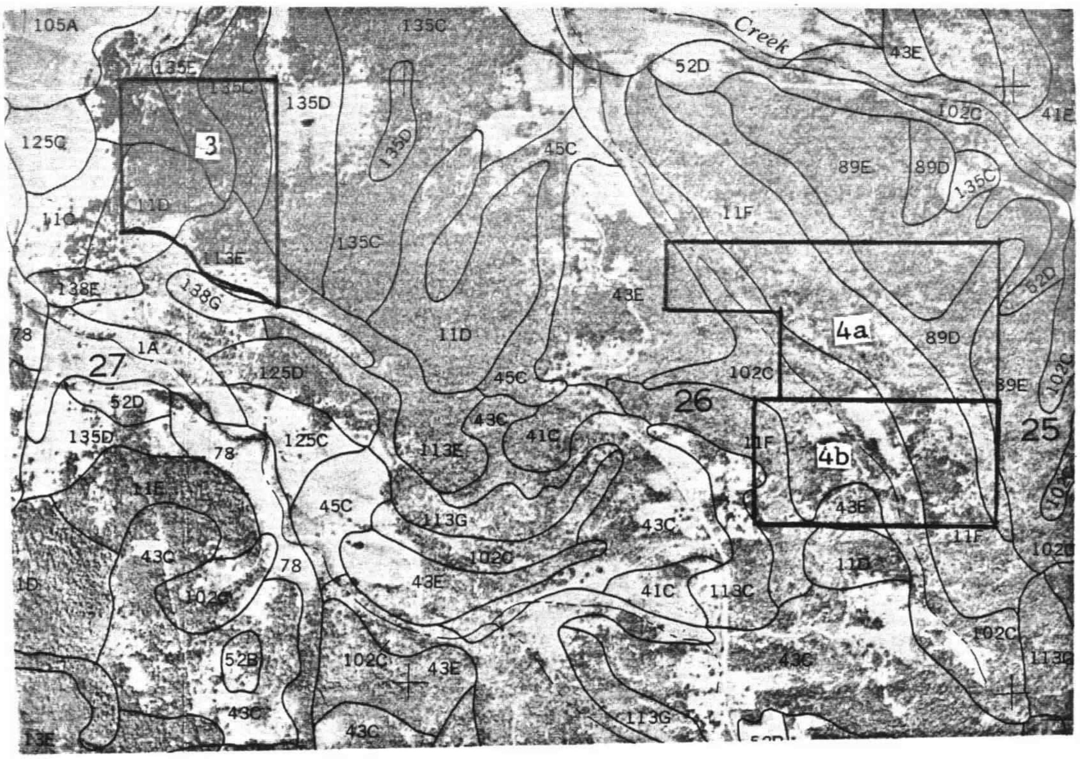


Figure 12. Soils map for parcels 3, 4a, and 4b. Map scale is 1: 20,000. Reproduced from map sheet 102 of the Lane County Area Soil Survey Report (Patching, 1987).

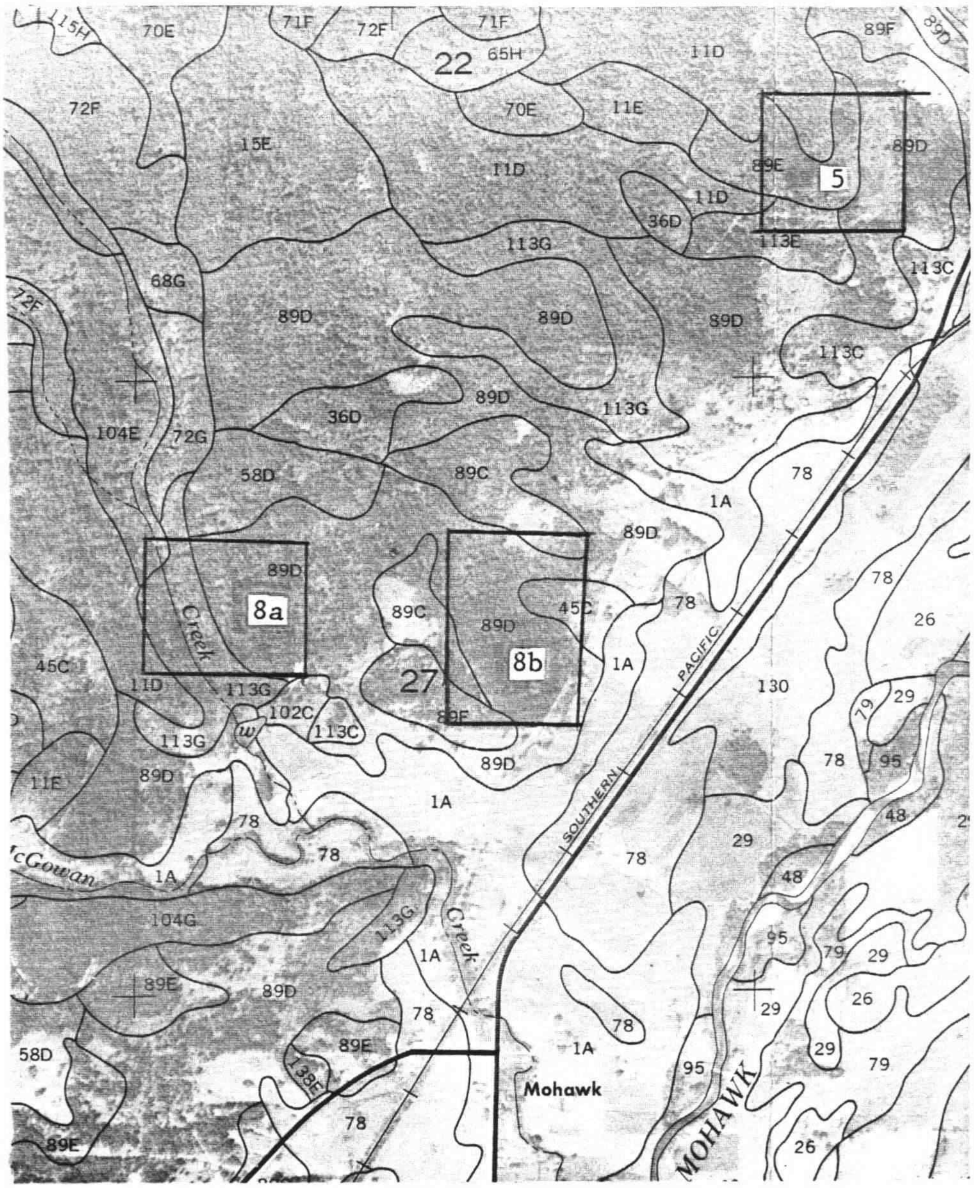


Figure 13. Soils map for parcels 5, 8a, and 8b. Map scale is 1: 20,000. Reproduced from map sheet 46 of the Lane County Area Soil Survey Report (Patching, 1987).

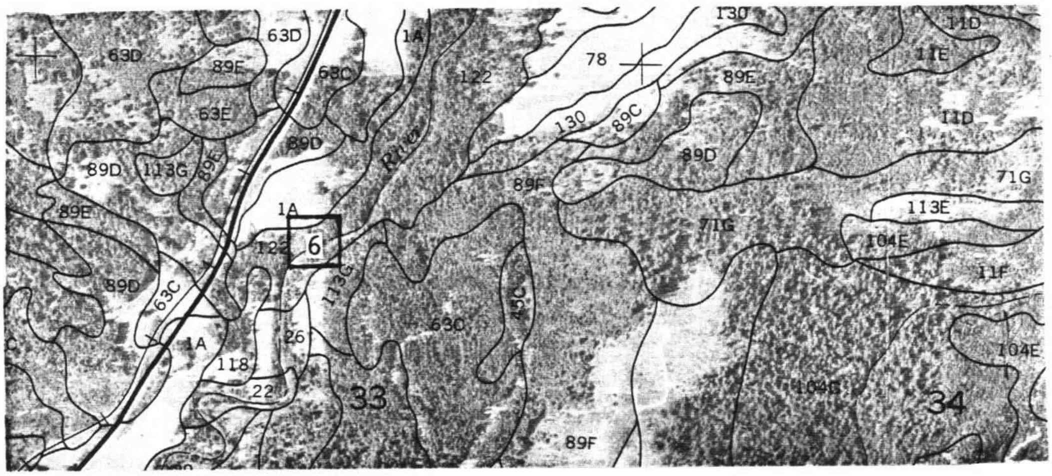


Figure 14. Soils map for parcel 6. Map scale is 1: 20,000. Reproduced from map sheet 17 of the Lane County Area Soil Survey Report (Patching, 1987).

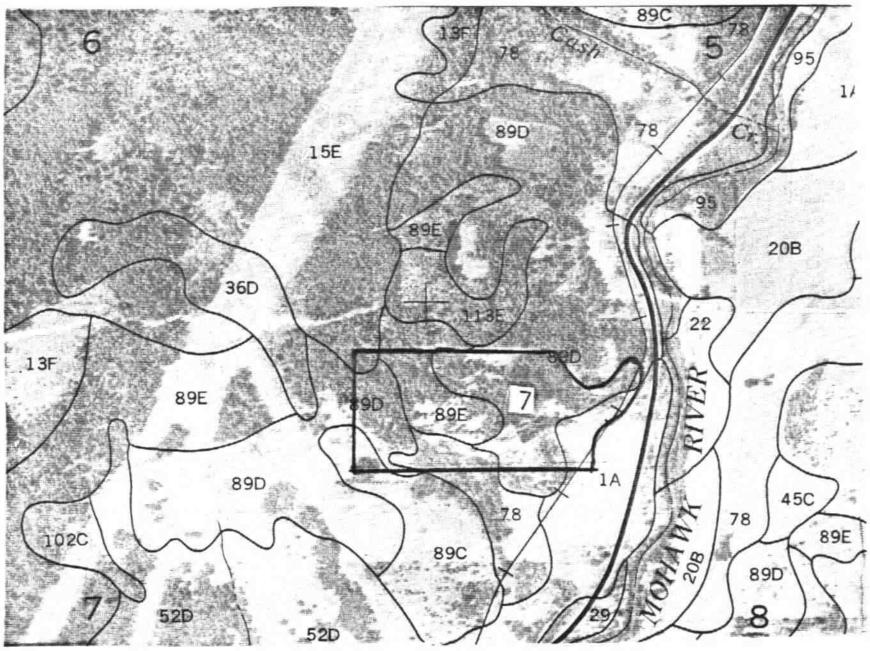


Figure 15. Soils map for parcel 7. Map scale is 1: 20,000. Reproduced from map sheet 30 of the Lane County Area Soil Survey Report (Patching, 1987).

All of the test parcels were again evaluated using all four components of the final LESA model. Soil potential ratings for each parcel were calculated by overlaying the appropriate soil survey field sheet on each parcel, determining the percentage of each map unit with a dot grid, multiplying the fractional proportion of each map unit by its corresponding SPR, and summing the products. Parcel size scores were determined using the table for point values for parcel size in Appendix 3.

Adjacent land use scores were calculated by classifying each of the adjacent parcels in terms of their compatibility with forest uses and then entering the number of incompatible and the length of somewhat compatible perimeter into the adjacent land use compatibility formula in Figure 5. The score for the last component, surrounding land use parcelization and conflict, was determined by measuring out one-half mile from the boundary of the test parcel and counting the number of parcels that fell into each of the parcel categories shown in Table 13. After multiplying by the appropriate weighting factor, the products for each category were summed and this sum was divided by the total number of surrounding parcels and multiplied by 100 to get the final score.

The raw scores from this testing are shown in Table 16. Final LESA scores obtained by converting raw scores to their weighted form are shown in Table 17.

Table 16. Summary of raw scores for test parcels.

Parcel	Soils	Size	Adj. Use	Surr. Use
Spencer 1	52	90	76	36
Spencer 2a	21	71	62	26
Spencer 2b	47	65	100	34
Spencer 2c	59	62	100	29
Spencer 2d	56	80	87	34
Spencer 2NE	62	81	5	15
Spencer 3	57	87	22	25
Spencer 4a	55	92	84	23
Spencer 4b	32	93	71	23
Marcola 5	53	81	68	43
Marcola 6a	41	1	79	69
Marcola 7	60	90	92	30
Marcola 8a	54	81	87	66
Marcola 8b	57	80	63	19

Table 17. Summary of converted raw scores for test parcels using weighted LESA scores.

Parcel	Soils	Size	Adj. Use	Surr. Use	Total
Spencer 1	55	68	57	16	196
Spencer 2a	22	53	47	12	134
Spencer 2b	49	49	75	15	188
Spencer 2c	62	47	75	13	197
Spencer 2d	59	60	65	15	199
Spencer 2NE	65	61	4	7	137
Spencer 3	60	65	17	11	153
Spencer 4a	58	69	63	10	200
Spencer 4b	34	70	53	10	167
Marcola 5	56	61	51	18	186
Marcola 6a	43	1	59	28	131
Marcola 7	63	68	69	14	214
Marcola 8a	57	61	65	28	211
Marcola 8b	60	60	47	9	176

VII. Model Applications

A. Comparing the Suitability of Parcels for Forest Management

The soil potential ratings developed for the LESA Model contain important information about the relative value of soils of each parcel for forest production and the cost of inputs required to produce this output, which can be used in making forest management decisions. As is shown earlier in this thesis (see page 43), both the level of timber output and the input costs are affected by soil and map unit characteristics. These impacts are reflected in the SPR values produced for each of the soil map units.

When the acquisition of, or potential for investment in forest management on several alternative parcels is being considered, the weighted soil potential ratings could be used to help determine which of the alternatives would provide the greatest forest production for the expenditures made.

Because forest management activities are affected by land use conflict with residential parcels, a measure of the relative level of conflict of various parcels could be useful in evaluating management alternatives to acquire, make expenditures on, or even to dispose of a tract of forestland. The land use conflict part of the LESA Model could be used to produce the information required to make these types of decisions.

In addition this model incorporates information about important parcel characteristics such as parcel shape, slope, and the presence of class 1 streams, in the score for parcel size (see Appendix 3), that can have a large impact on forest management.

B. Measuring the Effect of Land Use Changes on Surrounding Parcels

The LESA model is not only capable of measuring the existing level of land use conflict, but can also evaluate the impact that the conversion of a given parcel from forest to residential uses would have on the degree of conflict on adjacent parcels. An example from the test parcels used earlier for validating the model illustrates this ability.

Parcel 2b is 20 acres in size and has a present weighted adjacent land use conflict score of 75, the maximum possible, and a total score of 188. If the 18 acre parcel adjacent to it (2c), which does not have a residence on it at present, was allowed a residence, the adjacent land use and total score for parcel 2b would be reduced by 6 points to 69 and 182, respectively.

This 3 % reduction in the overall LESA score is not that substantial. The user of the model, however, would have to decide what level of change would be acceptable and then set the thresholds appropriately. For example, a 29 point reduction in the adjacent land use score, a 15 % reduction, would result from the development of residences on six parcels adjacent to 2b. Given the pattern of six 20 to 40 acre parcels surrounding parcel 2b, there is the potential for up to seven 20 acre parcels with residences adjacent to it.

The reduction of the LESA score would reflect the increase in potential conflict between forest uses on parcel 2b and adjacent residences to a point where this parcel was essentially unusable for commercial forestry. In this way the LESA Model could be used to evaluate the acceptability of proposals for land use changes by measuring their effect on parcels that are presently used for resource production.

The LESA thresholds for both adjacent and surrounding conflict and total score for each parcel could serve as the limits for the level of conflicting land uses that could be introduced to the vicinity around it. The number of these uses could then be controlled to stay within these limits.

C. Primary/Secondary Resource Land Determination

Since 1985 land use planning efforts in Oregon have been focused on the issue of distinguishing between primary and secondary resource lands. The objective has been to refine the resource land determination process so that the best lands for agriculture and forestry can be protected for these uses, while making it possible to consider using resource lands of lower quality for other uses. Having developed a LESA model to evaluate resource quality on a parcel-by-parcel basis, the next logical step is to test the use of results obtained from the model as a basis for distinguishing between primary and secondary lands.

Two steps are required to use LESA data for this purpose. First, thresholds must be established for each separate factor below which land will be considered as secondary. Second, criteria must be developed that show which combinations of factors having point values above or below factor thresholds mandate classification as secondary, and which combinations remain as primary. This latter issue was particularly important to the advisory committee, as they stressed repeatedly that parcel size alone, in the absence of any other limitations, should never allow a parcel to be classified as secondary resource land. Their main concern was that isolated small parcels surrounded by large ones used for forest production should not be classified as secondary because that would introduce incompatible activities into an area that was previously dominated by commercial forest activities.

1. Setting Primary / Secondary Thresholds

All thresholds are expressed in terms of the weighted LESA numbers. These thresholds are shown in Table 18, and the interactions between factors that lead to the final classification of a parcel, are shown in Table 19.

This method of classification allows factors to compensate for each other. Rather than specifying an absolute limit for conflict, or any other factor, using the total in combination with soils and size allows the value for conflict to float. More conflict can be tolerated on large parcels with very good soils than on very small parcels or on parcels of poor soil quality.

Table 18. LESA score thresholds for Primary/Secondary resource land determinations.

Factor	Maximum LESA Score	Primary/Secondary Threshold
Soils	105	53
Size	75	34
Adj. Use	75	37
Surr. Use	45	16
Total Score	300	160

Table 19. Primary/Secondary land classification.

If size < 34 then if Total > 237 = Primary

If size > 34 and soils < 53, then if Total > 180 = Primary

If size > 34 and soils > 53, then if Total > 160 = Primary

A 6 by 6 matrix that combined all of the LESA factors was originally used to place parcels into the primary and secondary resource land categories. After reviewing this method it was found that there was complete overlap in the classification of parcels in three of the categories and that a clearer and more simple method would be to use just three categories, which showed the relationship between size, soil and total score.

The soils threshold in this method is set at 50% of the maximum possible. This corresponds very closely to the break between high and medium quality forest soils established earlier by an independent process developed jointly by OSU Extension and SCS in cooperation with the State Dept. of Forestry and the Department of Land Conservation and Development (DLCD) (Huddleston and Latshaw, 1987). The soils map units below this threshold are the ones that are of lower productivity and harder to manage because of steep slope, shallow depth, droughtiness, high rock fragment content, short frost free season or high water table.

The size threshold is set to correspond with a size of 10 acres when there are no other limitations due to shape, slope, or class I streams. This is a little above the committee's practical minimum of 5 acres but represents a size below which the economics of commercial forestry would certainly be affected.

The adjacent land use threshold is set at a value equivalent to a situation in which 50% of a parcel's boundary lies adjacent to 5-acre, 2:1 rectangular parcels, all aligned with their short side next to the parcel in question. In practice, this allows for an even greater proportion of the perimeter to be counted as incompatible, inasmuch as most adjacent parcels are either larger than 5 acres or are aligned in a way that lowers the density of adjacent parcelization.

The surrounding land use threshold is set at 35% of the maximum possible score. This threshold is deliberately low partly because the committee felt that surrounding land use compatibility is the least important in determining the overall value for forestry and partly because test parcel data indicated a logical break at this point.

The total score thresholds are set at 237, 180, and 160 to provide some buffer above minimum values. A total score of 237 assumes a score of 34 for size, which corresponds to a 5 acre parcel, and is the size the committee thought was the practical minimum for commercial forestry. Because the size is at the absolute minimum, the other LESA factors would have to be at the maximum in order to place such a parcel into the primary category.

The second category has a total of 180, with the size score above the minimum of 34, but soils below 53. In this situation the combination of the adjacent and surrounding land use scores must add up to at least 93 points, or higher as the soil score decreases.

With both of the size and soil scores over the thresholds a total of 160 is required to qualify for primary classification. This requires a minimum score for the combination of adjacent and surrounding land use of 73.

2. Classifying Test Parcels

After the primary/secondary resource land thresholds and the classification system were set up, it was possible to classify the initial test parcels. Table 20 shows the summary of the ratings for the test parcels.

Table 20. Summary of classification of test parcels using weighted LESA scores and thresholds.

Parcel	Size	Soils	Total	Prim/ Sec Class
Spencer 1	68	55	196	P
Spencer 2a	53	22	134	S
Spencer 2b	49	49	188	P
Spencer 2c	47	62	197	P
Spencer 2d	60	59	199	P
Spencer 2NE	61	65	137	S
Spencer 3	65	60	153	S
Spencer 4a	69	58	200	P
Spencer 4b	70	34	167	S
Marcola 5	61	56	186	P
Marcola 6a	1	43	131	S
Marcola 7	68	63	214	P
Marcola 8a	61	57	211	P
Marcola 8b	60	60	176	P

Five of the 9 Spencer Creek sites were classified as primary. All of the parcels have sizes well above the threshold for that characteristic. All of these except parcel 2b had a soil score above the threshold that qualify them as primary. The data show that soil quality is fairly high. This is also the case with their scores for adjacent land use. In terms of the surrounding land use score, all of the sites have scores at or below the threshold. However, because of their high scores in the other components which make up the LESA rating, they all have totals well above the point total required to be classified as primary resource land.

The other 4 Spencer Creek sites were classified as secondary forest resource land. One of these parcels, 2a, has scores for size and adjacent land use conflict well above those thresholds, but its combination of very poor soils and some conflict put the total score puts it below the threshold required to be classified as primary resource land.

Parcels 2NE and 3 also come out as secondary despite having high scores for both size and soil. Their adjacent and surrounding land use conflict scores are low, so that their total score falls below the threshold.

Several factors put parcel 4b into the secondary land category. Although its scores for size and adjacent land use were significantly above their threshold values, the combination of low scores for soil quality and surrounding land use conflict puts it below the point total required for primary resource land designation. The primary/secondary classification puts all parcels with this combination of scores into the secondary land class.

Four of the five parcels evaluated in the Marcola area classified as primary resource land. Parcels 5, 7, and 8a had size, soil, and total scores which put few limits on their use for resource production. Number 8b was limited only by a low surrounding land use score, however all the others put its total score above the threshold.

The only parcel in the Marcola area which classified as secondary, number 6, did so because of a size score below the 34 threshold, and its total below 237.

D. Large scale testing of the LESA Model in Lane County

After the testing of the LESA model on individual parcels, it was applied to a larger block of land in the Spencer Creek area, so that its ability to identify primary and secondary forest resource lands on a larger scale could be determined. A major percentage of the soils in this area consist of map units of the Bellpine and Willakenzie series. These series have SPR's of 68 on the 100 point scale (71 in the 300 point LESA model) developed for the forestry LESA model, and fall within site class 3. Over 100 parcels were tested in a 9 section part of the study area. Each of the parcels in this study was rated for the four factors used in the LESA model, and the scores were multiplied by their weighting factor and put on a 300 point basis. The weighted LESA scores for each parcel were put through the Primary/Secondary Classification criteria, and the parcels were given a primary/secondary rating.

In this process, 54 % of the parcels in the study area but outside of rural residential zones were rated as primary, and 46 % came out as secondary. In terms of the amount of land outside of parcels zoned as rural residential, 70 % of the land was designated as primary and 30 % as secondary. The smallest parcel of land that was designated as primary was 10.7 acres in size. The mean size for parcels classified as primary was 62 acres. The median size for primary parcels was 40 acres.

On the lands designated as secondary resource land the mean parcel size was 32 acres and the median was 20 acres. The largest parcel designated as secondary was 160 acres and the smallest was 4 acres. The majority of parcels designated as secondary were put into this category because of LESA scores below the thresholds for both soils and surrounding land use conflict.

The largest blocks of land that were classified as secondary were a 340 acre one in the northeast corner of this test area and a 300 acre block in the southwest. Smaller blocks of 123 and 93 acres were located in the southeast corner of this area.

E. Other Methods of Determining Primary/Secondary Lands

Under Oregon's land use Goals, the definitions of farm and forest lands are broad enough to encompass virtually all lands outside of urban growth boundaries (UGBs), which are the legal limits of growth established for each incorporated city (Pease, 1988). The result of this process is that about 16 million acres of privately held lands are zoned for exclusive farm use and 8 million acres for forest use. Since parcelization and development options are severely limited in these zones, criticism has mounted that marginal, or secondary, resource lands are over protected, while primary lands are underprotected.

In response to the criticism, the 1985 legislature directed LCDC to study and report on a practical, objective means to separate primary resource lands from lands of secondary resource importance. The first approach that was considered was one based solely on the Land Evaluation (LE) part of LESA. In order to save the time and expense involved in the development of an LE system or for those counties for which the benefits of LE didn't justify the investment, a simplified process was sought. The LE process could still be used along with this system, but this was the county's option.

This simplified process was to be used by LCDC to review county proposals for secondary lands designation in accordance with standards based on soils quality, parcelization, and potential conflict with existing uses (Pease, 1988). The measure of soil resource quality was based on standards developed jointly by OSU and SCS to determine the soil suitability for cropland, woodland and range use for all soils in Oregon. Based on the soil suitability rankings an overall soil rating is established. This approach avoids the need to develop the soil potential ratings for each use as would be required for LE.

This model also included standards based on parcelization and potential conflict with existing uses. In this model a parcel is defined as contiguous ownership tax lots, i.e. those having the same name on assessor records.

Pease developed several models for different parts of the state based on soils quality and common types of farm and forestry operations. For the purposes of the comparison here, the model developed for the Willamette Valley will be used.

The most recent version of this model (May, 1988) uses a parcel soil quality test based on the high, medium, and low soil quality rating system developed by Huddleston and Latshaw (1987). Based on the soils rating criteria a parcel may be classified as secondary if it meets one of the two following criteria: 1) It is greater than 20 acres but contains only medium or low quality soils, or 2) It is >= 20 acres but the amount of contiguous high soils is less than 20 acres in area and all high soils make up less than 60% of the parcel's area.

The parcelization test measures the density of dwelling units and the percentage of parcels less than 20 acres within a certain distance from the subject parcel. For agriculture this distance is one-quarter mile and for forestry this distance is one-half mile. If there are greater than 10 dwelling units and greater than 60 % of the parcels within this distance are smaller than 20 acres, the parcel would be designated as secondary.

There are two additional tests in this model that a parcel must meet in order to be designated as secondary. These are the block test and the past use test. The block test requires that in order for a parcel to qualify for secondary lands designation, it must be part of a contiguous block of 640 acres or more. The block cannot include acknowledged exception areas. In special cases where the block contains no soils rated as high, it can be combined with an acknowledged exception area in calculating the block size.

The past use test evaluates a parcel to see if it has been used anytime between 1980 and 1988 as part of a ranch, farm, or forestry operation that is capable of grossing more than $40,000 per year. The past use determination is made by a review team consisting of Extension Service, Soil Conservation Service (SCS), Agricultural Stabilization and Conservation Service (ASCS), and the local soil and water conservation district (S&WCD), and 4 to 6 farmers, ranchers, or foresters, who will decide if a proposed secondary resource land block should be retained as primary resource land, because of past use.

The past use test for forestry applies only to parcels designated as potential secondary because of soils. Parcels shall be designated as primary if they are larger than 80 acres, whether they contain a dwelling or not, or if they are between 20 and 80 acres without any dwelling. They shall also be designated as primary if they are part of a forestry block of 500 acres, and that is currently stocked to qualify for tax deferral.

When compared to the Lane County forestry LESA model, the Pease model is less detailed in the rating of soil quality, parcel size, and adjacent and surrounding land use conflict. The soil quality rating used in this model does not provide the information about the management limitations and the basis for putting the soil into one of the three soil quality categories, either high, medium, or low. Such information is readily apparent from the soil potential ratings. Because of this it isn't possible to identify the highest quality soils within the group that is designated as high.

However, when the list of soil map units for Lane County that have been rated as high, medium, and low is compared with the soil potential ratings (SPR's) for the same soils, 94% of the soils rated as high in the soil quality system are above the SPR threshold of 53, which was established for the LESA model. The agreement on the soils rated as medium is not as good. Only 55% of the soils rated as medium had SPR's below 50. The correlation between soils rated as low and with SPR's below 35 was high, at 82%. For the most part these two measures of soil quality gave similar ratings.

Both the Pease and the LESA model used information from the Lane County soil survey for their respective soil quality tests. However, the soils information for each parcel was gathered in a different way. In the Pease model, a soils map was produced that classified each soil map unit into the high, medium, and low categories. This map was used as an overlay on the parcel maps to determine the extent of each of the soil quality groupings on the parcel being tested in order to apply the soil test criteria.

In the LESA model, a transparency of the soil survey map sheets was produced and then overlaid on the parcel being tested to determine the percentage of each soil map unit. These percentages were then multiplied by their respective SPR's to get the overall SPR for the parcel.

There is no relative ranking of parcel sizes, or direct measure of adjacent land use conflict in the Pease model, so it doesn't give as much detail about these parcel characteristics as does the LESA model. Both of the models give a measure of surrounding land use conflict by measuring the degree of parcelization around the subject parcel. The criteria used in the LESA model are more detailed because they weight the value of surrounding parcels both in terms of their size and whether or not there is a dwelling unit present on them.

The LESA model did not include any block size or past use test. These could be added however, to make it a more complete model for determining secondary resource lands.

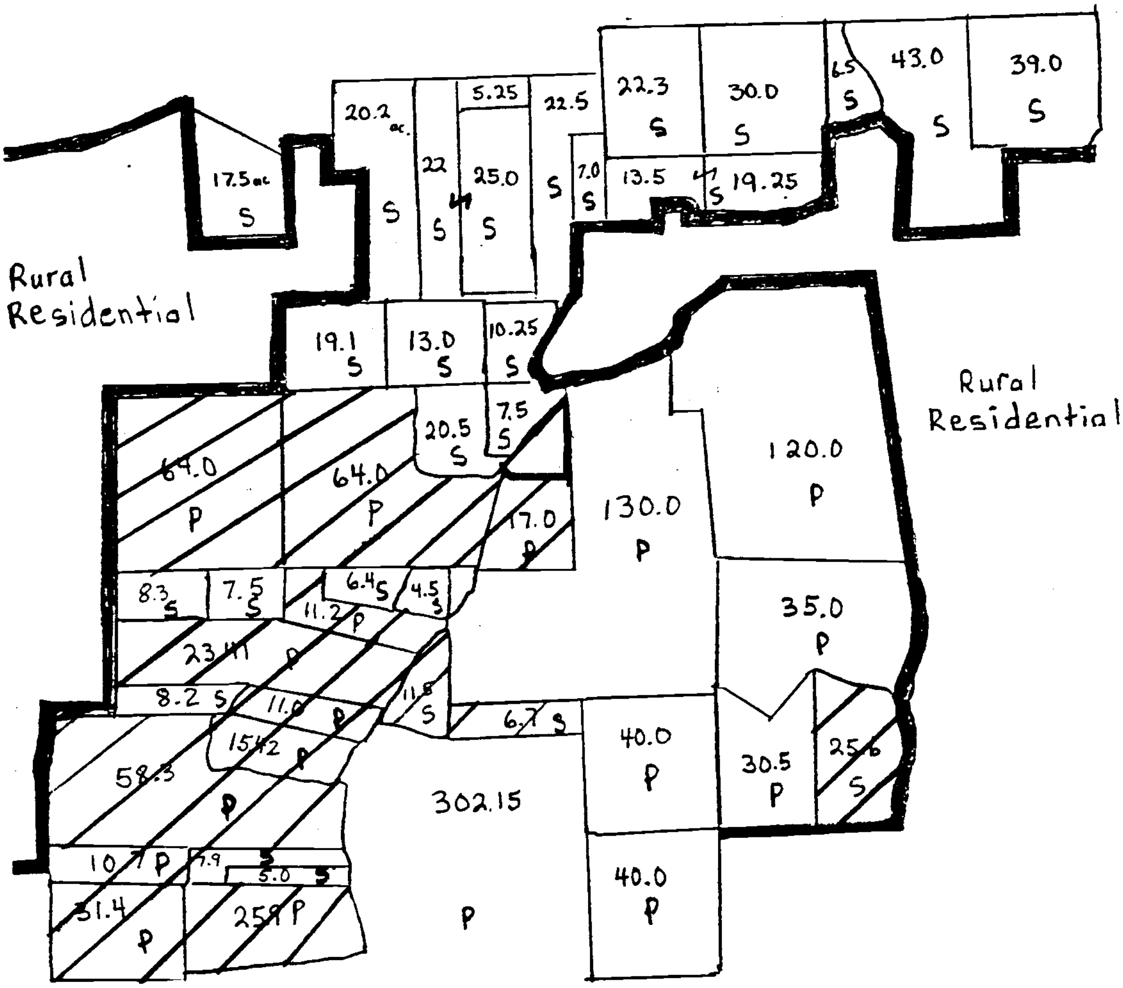
The best comparison of the two models can be made by examining the way in which they classify parcels located in the same area. To do this, a part of the Spencer Creek area was rated using the two systems, and maps were produced to show the results. The map produced using the LESA model is shown in Figure 16, and the map using the Pease model is shown in Figure 17. When the classification of 46 parcels by each of these models is compared, 74 % of the parcels are put in the same resource land category, and 26 % are put into a different one.

Most of the discrepancies in classification between these two models involve parcels that are classified as primary resource land in the LESA model, but are put into the secondary resource land category by the Pease model. These parcels range in size from 11 to 64 acres.

Eleven of these parcels classified as primary in the LESA model because their scores for size and soils put them over the thresholds for both of these categories, and so required a total score of 160. Three of these were 11 acres in size and so received scores just above the LESA size threshold. These would probably have to be considered as marginal parcels for consideration as primary resource land, even though they met the thresholds. They are also very close to the practical minimum size that the site assessment committee considered usable to commercial forestry.

Most of these parcels had fairly high adjacent land use scores, but have scores less than half of the surrounding land use conflict threshold. This is due to the large number of small rural residential parcels within the exceptions areas bounded on the map by the heavy black line.

One of the parcels in this area was classified as secondary by



24 - parcel size (acres)

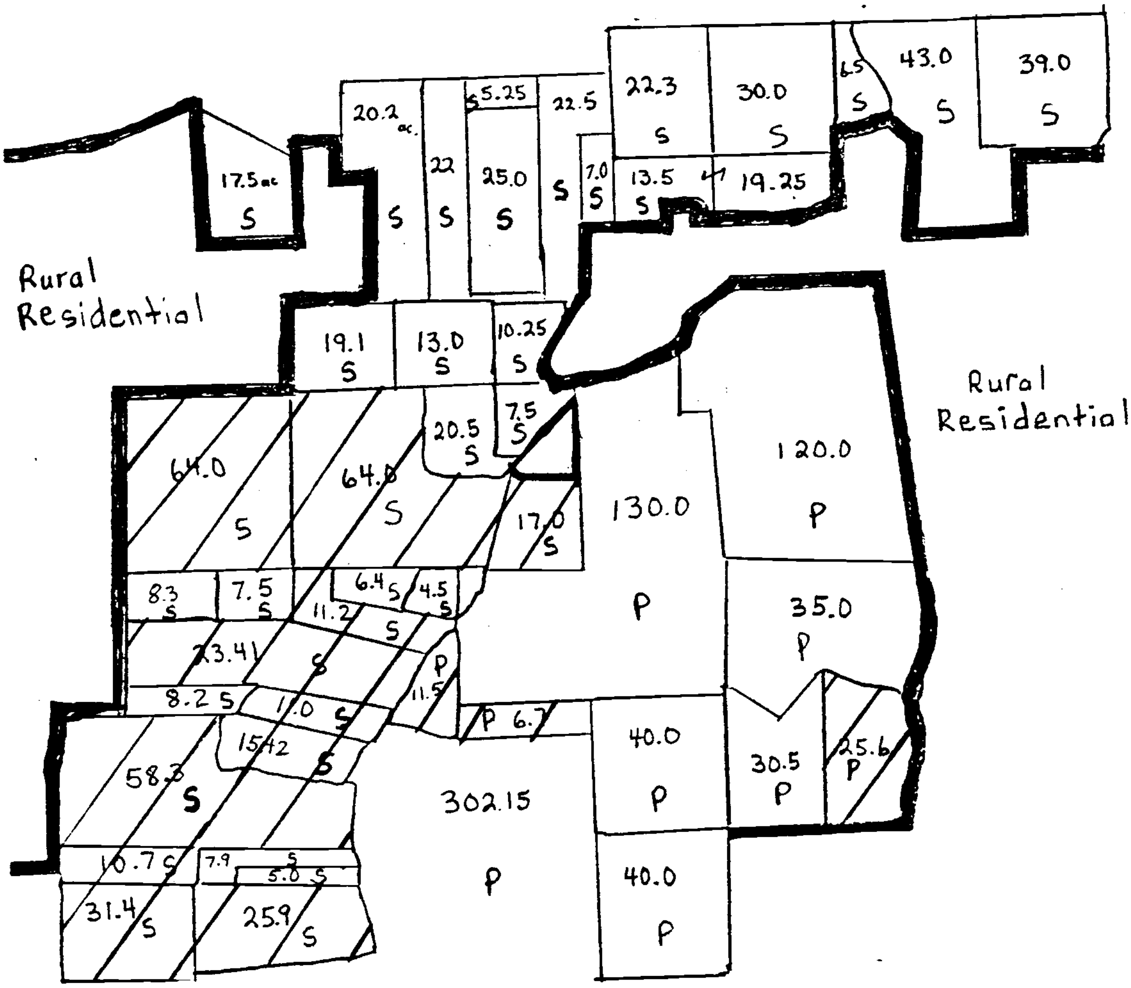
P - primary land

▬ - rural residential bdy.

S - secondary land

▨ - parcel that differs in classification between 2 systems

Figure 16. Primary / Secondary classification of the Spencer Creek area using the LESA model.



24 - parcel size (acres)

P - primary land

▬ - rural residential bdy.

S - secondary land

▨ - parcels that differ in classification between 2 systems

Figure 17. Primary / Secondary classification of the Spencer Creek area using the Pease Model.

the LESA model, but was put into a primary classification by the Pease model. Although its size score was well above the LESA threshold, low scores for soils and surrounding land use conflict kept its total below the required 180. It also had a significant degree of adjacent land use conflict on one of its boundaries. The reason this parcel was put into the primary category using Pease model was its size (26 acres, > 20 acre test), and the fact that 42% of the parcel area consisted of soils rated as high.

A significant portion of the parcels that were classified differently by these two models were close to the threshold levels set for the parcel characteristics, so a case could be made for them to go in either direction.

VIII. Critique of the LESA Model

A. Advantages of the LESA Model Approach

A number of important advantages of using the LESA system have been identified during the course of developing and testing this model, and by those who have worked on other LESA models.

The local control and the ability of local officials to fit the LESA model to local conditions and planning goals was identified as a major strength of this model, as well as the one done for Latah County, Idaho. This avoided problems associated with national definitions of prime farmlands or statewide soil quality standards such as the model developed by Huddleston and Latshaw. Problems with these more widely applied soil quality measures include, inability to differentiate between levels of productivity within the highest quality soils, and failure to recognize soils which may not be prime in a national or regional context, but which are a very important resource base for the local economy.

Local input is meant to be an integral part of the LESA process, as described in the SCS LESA Handbook (SCS, 1983), and was found to be an essential part of the development of both parts of LESA in the model developed for Linn, County Oregon (Huddleston et al., 1987). Since the committees that are formed to develop the land evaluation and site assessment parts of LESA are made up of local experts, the information they gather will have credibility with the public and county officials.

Another advantage of a LESA model is its adaptability for several different applications. It can be used to determine the value of a parcel of land for a specific use, and also to evaluate whether partition or conversion to residential use will be a significant loss to the resource base. LESA can also be useful in classifying grades of resource land quality.

Additionally, LESA can be used to analyze the impact of land use changes on the subject parcel, on adjacent parcels, and on nonadjacent parcels within a specified distance (Huddleston et al., 1987). This can be done by performing an analysis of all potentially affected parcels twice, once in the existing land-use setting, and again under the presumption that the target parcel would be converted to a nonresource use. Comparison of scores before and after the proposed change allow expression of both the absolute value of the effect and the percentage decline in the parcel resource value.

The detailed information on management costs, rating parcel sizes, and defining land use conflict that is developed for the LESA model can be utilized for other purposes such as defining how many acres are required to generate a certain gross income level or rate of return, or defining threshold values for the various LESA criteria. From this information a definition of a commercially viable resource production operation can be derived. This type of information is not as readily attainable from the other methods of determining soil resource quality or primary and secondary resource land determination.

Land use decisions in Oregon must be documented by written findings linking the facts of the case to established policies and standards. The LESA process is suited to becoming part of the information base for land use decisions.

Because the criteria are all clearly quantified and the components of the final LESA score are evident from the individual parcel scores, any criticisms of the results of the LESA model scoring can be specifically focused and the validity of the specific criteria can be tested. The reasons for a rating are not obscured and are clearly evident to the nontechnical user.

LESA provides a way to quantify values of parcel characteristics that people know are intuitively correct. Once this quantification is made, LESA allows objective comparisons of resource quality among variety of parcels. It is not designed to make a specific land-use decision, but it does provide information that can be used by a local jurisdiction in making such a decision.

The method used in calculating the different parts of LESA allow the soil potential ratings to be updated periodically to reflect changes in production technology,interest rates, and market prices. The scaling of points within the site assessment factors can be improved as further research clarifies the relationships between land use conflict and resource value, and between parcel size and resource value. This dynamic aspect of land evaluation and site assessment is one of its greatest strengths, and will improve the model's usefulness as an aid in making land-use planning policy and decisions. (Huddleston et al., 1987).

B. Disadvantages of the LESA Model Approach

There are a number of disadvantages inherent in a LESA model approach. As with any numeric rating system for evaluating land use suitability, the need to clearly define each factor and assign a value to it limits options for judgment and discretion (Stamm et al., 1987). The level of sophisticated statistical analysis required to design and defend a LESA system may be beyond the capability of small rural planning departments. This type of system is not well suited to an area with a wide variety of crops or many isolated areas of small and unique-but locally important farmlands (Stamm et al., 1987).

Because of the numerical form of the LESA ratings, it is possible that planners or local officials may attach too much weight to these numbers, and ignore what their good judgment tells them about the value of a given parcel for resource use.

LESA models may be limited in their ability to measure the cumulative effects of individual land-use changes, which by themselves may have relatively little impact, but when combined with other changes could destroy the integrity of an area for resource production use. The goal of land-use planning is to prevent this from happening, yet LESA may promote this effect by giving ratings that would justify the approval for nonresource use on one or more parcels in an area, which reduces the resource value of another parcel to the point of making it marginal. At that point, its LESA scores would indicate that it too should be approved for nonresource use. To prevent this, some criteria are needed to keep track of and evaluate the cumulative effects of all land-use changes approved after some point of reference. Otherwise, the LESA processes could be misused to promote development in resource areas, rather than controlling it (Huddleston et al., 1987).

When LCDC was reviewing different methods for identifying secondary lands, it looked closely at the possibility of using a LESA model in each county. After review of this idea by the LCDC Rural Lands Advisory Committee, it was decided that developing a LESA type model for both agriculture and forestry for each county would take too much time. The process of creating a local committee for each use, reviewing and creating criteria for both parts of the LESA model, and then testing it, was considered to be too time consuming a process to be useful for the secondary lands identification process (LCDC, 1987).

A major problem with using the LESA model to identify primary and secondary resource lands is the time required to collect the soil quality, parcel size, and land use conflict data on each of the parcels. This process is time consuming no matter what method is used to do this analysis. However, there is significant potential for the use a of geographic information system (GIS) to increase the speed and accuracy with which this analysis can be done. If a GIS is used, a significant amount of information on soils and parcels would have to be entered into a database using a digitizing process. However, once these data were entered for the area to be classified, there are GIS programs with the capability to calculate the values for all of the criteria; soils, parcel size, adjacent and surrounding land use, that make up the overall LESA parcel score.

IX . Summary

The objective of this study was to develop a land evaluation and site assessment (LESA) model for the forested soils in Lane County based on soil potential ratings and indexes of parcel size and land use conflict. The main purpose for developing the LESA model was to classify forest lands into primary and secondary resource categories to meet the new mandate from the State Legislature to revise the definitions of resource lands in the Oregon Statewide Land Use Planning Goals.

Lane County is one of the major timber growing and producing counties in the state. It is also the site of significant population growth, which has created demand for homesites in the rural part of the county. These homesites may be located on important productive forest lands or on small tracts that create conflicts with adjacent or surrounding forest land parcels, making their management difficult or impossible.

Soils in the area for which the LESA model was produced developed from a variety of parent materials including those of sedimentary, alluvial, and volcanic origin. There are 46 series in this area; 34 with mesic temperature regimes and 12 with cryic. Most soils are deep and well drained. The climate is generally cool and moist.

Development of the model involved reviewing information from other LESA models, deriving the soil potential ratings, assembling a forestry technical committee to identify site assessment factors and criteria, grouping these factors into categories, and assigning numerical values to each of the factors in the criteria.

The framework for model development was set forth in five model guidelines based on information from previous LESA models and the requirements of the secondary lands identification process. These guidelines were to: 1) design a model that is both comprehensive and yet simple enough to be used by people with limited technical knowledge; 2) incorporate local input; 3) be exact and quantitative in specifying the points to be assigned to factors; 4) validate the model by comparing it to another independently derived model; and 5) assume that the model is not able to reflect all the complexity of nature.

Soil potential ratings were developed by the author using information from a forestry LESA model developed for Linn County, Oregon. Timber yields for each forest soil map were produced using the DFSIM program, and all of the management practices required to produce that yield given the map unit characteristics were listed. Dollar values for the yield and for management costs were taken from those derived for the Linn County forestry LESA model, and the data were used to calculate a net return to soil management. This process was repeated for all of the forest map units in the soil survey for the Lane County area. The highest net return for forestry was set equal to 100, and all other net returns were expressed as a percentage of the highest one. These relative numbers, on a scale from 0 to 100, were the final soil potential ratings.

Soil potential ratings provide an integrated measure of forest productivity by combining several factors. The factors identified as being most important in producing the SPR's were: soil depth, slope, soil coarse fragment content, bedrock type, site index, and erosion potential. The SPR's were used to produce the land evaluation (LE) score for the LESA model.

In their discussion of the site assessment (SA) part of the LESA model the advisory committee identified 3 main factors which should be included in the model: (1) parcel size, (2) adjacent land use, and (3) surrounding land use. The committee assigned points for parcel size based on size and also the effects of slope, the presence of class 1 streams on the parcel, and a measure a parcel shape regularity. From these point assignments a matrix was produced which gave ratings for different parcel sizes.

Compatibility criteria were identified for adjacent and surrounding land use on the basis of compatibility with commercial forest uses. Three land use compatibility classes were identified; compatible, somewhat compatible, and incompatible. Two formulas were developed for use in calculating the level of land use conflict for both of these SA factors based on the compatibility criteria. These formulas included a weighting factor based on the degree of land use conflict

The LESA model was tested on 14 parcels to evaluate its performance on actual parcels and with existing land use patterns. Each of these parcels was rated using the model criteria, and an overall LESA parcel score was calculated. The committee visited these test parcels to evaluate the accuracy of the rating scores in representing the relative value of the parcel for commercial forestry. Information from these site visits was used to make refinements in the criteria and the relative weighting of each of the factors.

Originally, each of the factors was developed on its own 100-point scale. Factors were combined in the final model by weighting each one and adjusting the overall point total to 300 points. After some testing, the committee agreed by consensus on each of the following weights: Soils, 35%; Size, 25%; Adjacent land use, 25%; Surrounding land use, 15%. These weighted scores were multiplied by 3 to produce the maximum value for each factor: Soils, 105; Size, 75; Adjacent land use, 75; Surrounding land use, 45.

The purpose of developing this model was to use it to identify primary and secondary forest land as part of the Oregon Statewide Land Use Planning program. To use LESA data for this purpose, thresholds were established for each factor below which land would be considered as secondary. Criteria were also developed that show which combinations of factors having point values above or below factor thresholds mandate classification as secondary, and which combinations remain as primary. These thresholds were expressed in terms of weighted LESA numbers. A classification system was developed which showed how different factor combinations would put parcels into the primary and secondary groups.

The LESA model was tested in an area of Spencer Creek in Lane County covering about 6,000 acres, to determine its usefulness for identifying prime and secondary resource lands. The results were compared with another secondary lands classification model developed by the OSU Geography Department, which was used in the same area. A comparison of the results using the two different models showed good agreement.

This model represents a useful empirical land use planning method that is comprehensive, quantified and flexible, and can be tested and modified as a result of observations. It is a useful method for differentiating between primary and secondary forest resource lands.

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Appendices

Appendix 1 - Lane County soil potential ratings

Map unit Symbol	Map Unit	Soil Depth (In)	Coarse Freq %	Erosion K-Factor	Bedrock Type	Site Index 50 YR	Yield Est. Bd./Ft./Ac.	Gross Ret. ($/Ac.)
11C	Bellpine sicl, 3 to 12 %	>20	<15	.28	Soft	120	63083	21196
11D	Bellpine sicl, 12 to 20 %	>20	<15	.28	Soft	120	63083	21196
11E	Bellpine cob sicl, 20 to 30 %	>20	<15	.28	Soft	120	63083	21196
11F	Bellpine sicl, 30 to 50 %	>20	<15	.28	Soft	120	65856	22128
12E	Bellpine cob sicl, 2 to 30 %	>20	<15	.28	Soft	120	63083	21196
13F	Blachly cl, 30 to 50 %	>20	<15	.17	Soft	130	75185	25262
13G	Blachly cl, 30 to 50 %	>20	<15	.17	Soft	130	77607	26075
14E	Blachly sicl, 3 to 30 %	>20	<15	.17	Soft	130	77607	26075
14F	Blachly sicl, 30 to 50 %	>20	<15	.17	Soft	130	77607	26075
15E	Blachly-Mc Cully, 3 to 30 %	>20	<15	.17	Soft	130	71646	24073
16D	Bohannon, 3 to 25 %	>20	15-30	.10	Soft	118	60818	22259
16F	Bohannon, 25 to 30 %	>20	15-30	.10	Soft	118	63080	21195
16H	Bohannon, 50 to 90 %	>20	15-30	.10	Soft	118	63080	21195
035D	Cruiser gr cl, 3 to 25 %	>20	15-35	.17	Hard	110	50308	16903
035F	Cruiser gr cl, 25 to 50 %	>20	15-35	.17	Hard	110	52108	17508
035G	Cruiser gr cl, 35 to 70 %	>20	15-35	.17	Hard	110	52108	17508
036D	Cumley sicl, 2 to 20 %	>20	<15	.24	Soft	120	63083	21196
037C	Cupola cob l, 3 to 12 %	>20	35-65	.15	Soft	109	49299	16564
037E	Cupola cob l, 12 to 30 %	>20	35-65	.15	Soft	109	49299	16564
039E	Digger gr l, 10 to 30 %	>20	15-35	.15	Soft	116	58647	19705
039F	Digger gr l, 30 to 50 %	>20	15-35	.15	Soft	116	60869	20452
040H	Digger - RO, 30 to 85 %	>20	15-35	.15	Soft	116	60689	20452
041C	Dixonville sicl, 3 to 12 %	>20	15-35	.32	Soft	100	39619	13312
041E	Dixonville sicl, 12 to 30 %	>20	15-35	.32	Soft	100	39619	13312
041F	Dixonville sicl, 30 to 50 %	>20	15-35	.32	Soft	100	42185	14174
043C	Dixonville-Philomath-Hazelair, 3 to 12 %	>20	15-35	.32	Soft	70	17828	5990
043E	Dixonville-Philomath-Hazelair, 12 to 35 %	>20	15-35	.32	Soft	70	17828	5990
046	Eilertsen sil	>20	<15	.37	Soft	100	40277	13516
047E	Fendall sil, 3 to 30 %	>20	<15	.20	Soft	127	71767	24114
049E	Formader, 3 to 30 %	>20	<15	.28	Soft	119	61948	20815
049G	Formader 30 to 60 %	>20	<15	.28	Soft	119	64173	21562
050G	Formader-Hembre-Klickitat, 50 to 80%	>20	<15	.35	Soft	119	66948	22495
051B	Haflinger-Jimbo complex, 0 to 5 %	>20	35-60	.10	Soft	112	56635	19029
054D	Hembre sil, 5 to 25 %	>20	35-60	.32	Hard	127	71767	24114
054G	Hembre sil, 25 to 60 %	>20	<15	.32	Hard	127	74051	24881
055E	Hembre-Klickitat complex, 3 to 30 %	>20	35-60	.10	Hard	125	71767	24114
055G	Hembre-Klickitat complex, 30 to 60 %	>20	35-60	.10	Hard	125	71767	24114
057D	Holderman ext. cob l, 5 to 25 %	>20	35-60	.17	Hard	119	61948	20815
057F	Holderman ext. cob l, 25 to 50 %	>20	35-60	.17	Hard	119	64173	21562
057G	Holderman ext cob l, 50 to 75 %	>20	35-60	.17	Hard	119	64173	21562
058D	Honeygrove sicl, 3 to 25 %	>20	<15	.17	Soft	135	82387	27682
058F	Honeygrove sicl, 25 to 50 %	>20	<15	.17	Soft	135	82387	27682
059E	Hullt l, 2 to 30 %	>20	<15	.24	Soft	121	64243	21586
060D	Hummington gr l, 5 to 25 %	>20	35-60	.10	Hard	115	55604	18683
060F	Hummington gr l, 25 to 50 %	>20	35-60	.10	Hard	115	57733	19398
060G	Hummington gr l, 50 to 75 %	>20	35-60	.10	Hard	115	57733	19398
061	Jimbo sil	>20	35-60	.10	Soft	121	64243	21586
062B	Jimbo-Haflinger complex, 0 to 5 %	>20	35-60	.10	Soft	121	59374	19950
063C	Jory sicl, 2 to 12 %	>20	<15	.17	Soft	120	63083	21196
063D	Jory sicl, 12 to 20 %	>20	<15	.17	Soft	120	63083	21196

Lane County soil potential ratings (Continued)

Map unit Symbol	Map Unit	Establish ($/Ac.)	Thinning ($/Ac.)	Logging ($/Ac.)	Road Maint. ($/Ac.)	Total Cost ($/Ac)	Net. ($/Ac.)	Soil Potential Rating
11C	Bellpine sicl, 3 to 12 %	284	942	3502	158	4886	16310	68
11D	Bellpine sicl, 12 to 20 %	284	942	3502	158	4886	16310	68
11E	Bellpine cob sicl, 20 to 30 %	284	942	3502	158	4886	16310	68
11F	Bellpine sicl, 30 to 50 %	357	125	7902	202	8587	13541	56
12E	Bellpine cob sicl, 2 to 30 %	284	942	3502	158	4886	16310	68
13F	Blachly cl, 30 to 50 %	284	1068	4199	158	5709	19553	81
13G	Blachly cl, 30 to 50 %	358	125	9313	202	9998	16077	67
14E	Blachly sicl, 3 to 30 %	358	125	9313	202	9998	16077	67
14F	Blachly sicl, 30 to 50 %	358	150	8536	252	9297	16778	70
15E	Blachly-Mc Cully, 3 to 30 %	284	1021	3989	158	5452	18621	77
16D	Bohannon, 3 to 25 %	349	914	3374	158	4795	17464	72
16F	Bohannon, 25 to 30 %	423	125	7570	202	8320	12875	53
16H	Bohannon, 50 to 90 %	461	150	6339	252	7202	13993	58
035D	Cruiser gr cl, 3 to 25 %	349	913	2693	202	3955	12948	54
035F	Cruiser gr cl, 25 to 50 %	423	125	6253	252	7035	10455	43
035G	Cruiser gr cl, 35 to 70 %	461	125	6253	313	7152	10356	43
036D	Cumley sicl, 2 to 20 %	284	941	4282	158	5665	15531	64
037C	Cupola cob l, 3 to 12 %	327	899	2637	158	4021	12542	52
037E	Cupola cob l, 12 to 30 %	327	899	2637	158	4021	12542	52
039E	Digger gr l, 10 to 30 %	349	910	4147	158	5564	14141	59
039F	Digger gr l, 30 to 50 %	423	125	7304	202	8054	12398	51
040H	Digger - RO, 30 to 85 %	423	150	7304	251	8128	12324	51
041C	Dixonville sicl, 3 to 12 %	349	524	2069	158	3100	10211	42
041E	Dixonville sicl, 12 to 30 %	349	524	2069	158	3100	10211	42
041F	Dixonville sicl, 30 to 50 %	349	125	5062	202	5738	8436	35
043C	Dixonville-Philomath-Hazelair, 3 to 12 %	349	210	1159	158	1876	4114	17
043E	Dixonville-Philomath-Hazelair, 12 to 35 %	349	210	1159	158	1876	4114	17
046	Eilertsen sil	284	825	2134	172	3415	10101	42
047E	Fendall sil, 3 to 30 %	284	994	4028	158	5464	18650	77
049E	Formader, 3 to 30 %	284	928	3438	158	4808	16007	66
049G	Formader 30 to 60 %	357	125	7701	202	8385	13177	55
050G	Formader-Hembre-Klickitat, 50 to 80%	395	125	7364	251	8135	14359	60
051B	Haflinger-Jimbo complex, 0 to 5 %	327	1025	3681	158	5191	13838	57
054D	Hembre sil, 5 to 25 %	284	1022	5050	202	6558	17556	73
054G	Hembre sil, 25 to 60 %	357	125	8886	252	9620	15261	63
055E	Hembre-Klickitat complex, 3 to 30 %	327	995	4028	202	5552	18562	77
055G	Hembre-Klickitat complex, 30 to 60 %	401	125	8612	252	9390	14724	61
057D	Holderman ext. cob l, 5 to 25 %	327	928	3438	202	4895	15920	66
057F	Holderman ext. cob l, 25 to 50 %	401	125	8604	252	9382	12180	51
057G	Holderman ext cob l, 50 to 75 %	537	150	8604	313	9604	11958	50
058D	Honeygrove sicl, 3 to 25 %	284	1118	4631	158	6191	21490	89
058F	Honeygrove sicl, 25 to 50 %	357	125	10152	202	10836	16846	70
059E	Hullt l, 2 to 30 %	284	964	3568	158	4974	16612	69
060D	Hummington gr l, 5 to 25 %	327	975	2992	202	4496	14186	59
060F	Hummington gr l, 25 to 50 %	401	125	6928	202	7656	11742	49
060G	Hummington gr l, 50 to 75 %	537	150	6928	313	7928	11470	48
061	Jimbo sil	327	956	3568	158	5009	16577	69
062B	Jimbo-Haflinger complex, 0 to 5 %	327	886	3225	158	4596	15354	64
063C	Jory sicl, 2 to 12 %	284	943	3502	158	4887	16309	68
063D	Jory sicl, 12 to 20 %	284	943	3502	158	4887	16309	68

Lane County soil potential ratings (Continued)

Map unit Symbol	Map Unit	Soil Depth (In)	Coarse Frag %	Erosion K-Factor	Bedrock Type	Site Index 50 YR	Yield Est. Bd./Ft./Ac.	Gross Ret. ($/Ac.)
063E	Jory sicl,20 to 30 %	>20	<15	.17	Soft	120	63083	21196
064D	Keel cob cl, 3 to 25 %	>20	<15	.20	Soft	105	45370	15244
064F	Keel cob cl, 25 to 45 %	>20	<15	.20	Soft	105	47217	15865
064G	Keel cob cl, 45 to 75 %	>20	<15	.20	Soft	105	47217	15865
065G	Kilchis st l, 30 to 60 %	>20	35-60	.15	Hard	100	42185	14174
065H	Kilchis st l, 60 to (0 %	>20	35-60	.15	Hard	100	42185	14174
066D	Kinney cob l, 3 to 20 %	>20	<15	.10	Soft	140	92125	30954
067F	Kinney cob l (N), 20 to 50 %	>20	<15	.10	Soft	140	93072	31272
067G	Kinney cob l (N), 50 to 70 %	>20	<15	.10	Soft	140	93072	31272
068F	Kinney cob l (S), 20 to 50 %	>20	<15	.10	Soft	135	84600	28426
068G	Kinney cob l (S), 50 to 70 %	>20	<15	.10	Soft	135	84600	28426
069E	Kinney cob l, slump, 3 to 30 %	>20	<15	.10	Soft	135	82387	27682
070E	Klickitat st l, 3 to 30 %	>20	35-60	.10	Hard	115	55604	18683
071F	Klickitat st l (N), 30 to 50 %	>20	35-60	.10	Hard	125	71700	24091
071G	Klickitat st l (N), 50 to 70 %	>20	35-60	.10	Hard	125	71700	24091
072F	Klickitat st l (S), 30 to 50 %	>20	35-60	.10	Hard	115	57733	19398
072G	Klickitat st l (S), 50 to 75 %	>20	35-60	.10	Hard	115	57733	19398
080F	McCully cl, 30 to 50 %	>20	<15	.17	Soft	118	63080	21195
080G	McCully cl, 50 to 70 %	>20	<15	.17	Soft	118	63080	21195
081D	McDuff cl, 3 to 25 %	>20	<15	.24	Soft	121	64243	21586
081F	McDuff cl, 25 to 50 %	>20	<15	.24	Soft	121	66974	22503
081G	McDuff cl, 50 to 70 %	>20	<15	.24	Soft	121	66974	22503
083B	Minniece sicl, 0 to 8 %	>20	<15	.32	Soft	100	40277	13533
089C	Nekia sicl, 2 to 12 %	>20	<15	.24	Hard	115	55604	18683
089D	Nekia sicl, 12 to 20 %	>20	<15	.24	Hard	115	55604	18683
089E	Nekia sicl, 20 to 30 %	>20	<15	.24	Hard	115	55604	18683
089F	Nekia sicl, 50 to 70 %	>20	<15	.24	Hard	112	54636	18358
104E	Peavine sicl, 3 to 30 %	>20	<15	.28	Soft	125	69471	23342
104G	Peavine sicl, 30 to 60 %	>20	<15	.28	Soft	125	71700	24091
111D	Preacher l, 0 to 25 %	>20	<15	.17	Soft	128	72989	24524
111F	Preacher l, 25 to 50 %	>20	<15	.17	Soft	128	75226	25276
112G	Preacher-Bohannon-Slickrock, 50 to 75 %	>20	<15	.17	Soft	128	66774	22436
113C	Ritner cob sicl, 2 to 12 %	>20	35-60	.24	Hard	105	45370	15244
113E	Ritner cob sicl, 12 to 30 %	>20	35-60	.24	Hard	105	45370	15244
113G	Ritner cob sicl, 30 to 60 %	>20	35-60	.24	Hard	100	42185	14174
122	Saturn cl	>20	35-60	.17	Soft	110	43087	14477
124D	Slickrock gr l, 3 to 25 %	>20	15-35	.17	Soft	137	88068	29591
124F	Slickrock gr l, 25 to 50 %	>20	15-35	.17	Soft	137	89276	29997
135C	Willakenzie cl, 2 to 12 %	>20	<15	.24	Soft	110	63083	21196
135D	Willakenzie cl, 12 to 20 %	>20	<15	.24	Soft	110	63083	21196
135E	Willakenzie cl, 20 to 30 %	>20	<15	.24	Soft	110	63083	21196
135F	Willakenzie cl, 30 to 50 %	>20	<15	.24	Soft	110	65856	22128
137F	Winberry v. gr l, 10 to 45 %	<20	35-65	.17	Hard	75	18753	6301
138E	Witzel v cob l, 3 to 30 %	<20	35-65	.15	Hard	90	28886	9706
138G	Witzel, v. cob l, 30 to 75 %	<20	35-60	.15	Hard	90	31704	10429
142G	Yellowstone-RO, 10 to 60 %	<20	35-60	.10	Hard	60	9084	3052

Lane County soil potential ratings (Continued)

Map unit Symbol	Map Unit	Establish ($/Ac.)	Thinning ($/Ac.)	Logging ($/Ac.)	Road Maint. ($/Ac.)	Total Cost ($/Ac)	Net. ($/Ac.)	Soil Potential Rating
063E	Jory sicl,20 to 30 %	284	943	3502	158	4887	16309	68
064D	Keel cob cl, 3 to 25 %	284	864	2407	158	3713	11531	48
064F	Keel cob cl, 25 to 45 %	357	125	5666	202	6350	9515	40
064G	Keel cob cl, 45 to 75 %	395	150	5194	252	5991	9874	41
065G	Kilchis st 1, 30 to 60 %	327	125	5062	252	5766	8408	35
065H	Kilchis st 1, 60 to (0 %	537	150	4640	313	5640	8534	35
066D	Kinney cob 1, 3 to 20 %	284	1177	5227	158	6846	24108	100
067F	Kinney cob 1 (N), 20 to 50 %	357	125	11169	158	11809	19463	81
067G	Kinney cob 1 (N), 50 to 70 %	395	150	10238	252	11034	20238	84
068F	Kinney cob 1 (S), 20 to 50 %	357	125	10152	202	10836	17590	73
068G	Kinney cob 1 (S), 50 to 70 %	395	150	9306	251	10102	18324	76
069E	Kinney cob 1, slump, 3 to 30 %	284	1118	5749	158	7309	20373	85
070E	Klickitat st 1, 3 to 30 %	327	975	2992	202	4453	14230	59
071F	Klickitat st 1 (N), 30 to 50 %	401	125	8604	252	9382	14709	61
071G	Klickitat st 1 (N), 50 to 70 %	537	150	7887	313	8887	15204	63
072F	Klickitat st 1 (S), 30 to 50 %	401	125	6928	252	7706	11692	49
072G	Klickitat st 1 (S), 50 to 75 %	537	150	6351	313	7351	12047	50
080F	McCully cl, 30 to 50 %	357	125	7570	202	8254	12941	54
080G	McCully cl, 50 to 70 %	395	150	6939	251	7735	13460	56
081D	McDuff cl, 3 to 25 %	284	955	4524	158	5921	15665	65
081F	McDuff cl, 25 to 50 %	357	125	8037	202	8721	13782	57
081G	McDuff cl, 50 to 70 %	395	150	7367	251	8163	14339	60
083B	Minniece sicl, 0 to 8 %	284	825	2929	158	4197	9336	39
089C	Nekia sicl, 2 to 12 %	284	975	2992	202	4453	14230	59
089D	Nekia sicl, 12 to 20 %	284	975	2992	202	4453	14230	59
089E	Nekia sicl, 20 to 30 %	284	975	2992	202	4453	14230	59
089F	Nekia sicl, 50 to 70 %	357	125	6556	252	7290	11068	46
104E	Peavine sicl, 3 to 30 %	284	982	3879	158	5303	18039	75
104G	Peavine sicl, 30 to 60 %	357	125	8604	202	9288	14803	61
111D	Preacher 1, 0 to 25 %	284	1007	4099	158	5548	18976	79
111F	Preacher 1, 25 to 50 %	357	125	9027	202	9711	15656	65
112G	Preacher-Bohannon-Slickrock, 50 to 75 %	395	150	7345	252	8141	14295	59
113C	Ritner cob sicl, 2 to 12 %	327	864	2407	202	3800	11444	48
113E	Ritner cob sicl, 12 to 30 %	327	864	2407	202	3800	11444	48
113G	Ritner cob sicl, 30 to 60 %	401	125	5062	252	5840	8334	35
122	Saturn cl	327	848	2270	158	3603	10874	45
124D	Slickrock gr 1, 3 to 25 %	349	1144	4985	158	6636	22954	95
124F	Slickrock gr 1, 25 to 50 %	423	125	10713	202	11463	18534	77
135C	Willakenzie cl, 2 to 12 %	284	942	3502	158	4886	16310	68
135D	Willakenzie cl, 12 to 20 %	284	942	3502	158	4886	16310	68
135E	Willakenzie cl, 20 to 30 %	284	942	3502	158	4886	16310	68
135F	Willakenzie cl, 30 to 50 %	357	125	7902	202	6937	10571	56
137F	Winberry v. gr 1, 10 to 45 %	492	125	3000	252	3870	2432	10
138E	Witzel v cob 1, 3 to 30 %	413	524	1644	202	2783	6923	29
138G	Witzel, v. cob 1, 30 to 75 %	492	150	4439	252	5332	5097	21
142G	Yellowstone-RO, 10 to 60 %	461	150	1453	313	2377	675	3

Appendix 2 - Rank Order of Lane County Soil Potential Ratings

Symbol	Map Unit	SPR
066D	Kinney cobbly loam, 3-20%	100
124D	Slickrock gravelly loam, 3-25%	95
058D	Honeygrove silty clay loam, 3-25%	89
069E	Kinney cobbly loam, slump, 3-30%	85
067G	Kinney cobbly loam, north, 50-70%	84
013F	Blachly clay loam, 30-50%	81
067F	Kinney cobbly loam, north, 20-50%	81
111D	Preacher loam, 0-25%	79
047E	Fendall silt loam, 3-30%	77
055E	Hembre-Klickitat complex, 3-30%	77
015E	Blachly-McCully complex, 3-30%	77
124F	Slickrock gravelly loam, 25-50%	77
068G	Kinney cobbly loam, south, 50-70%	76
104E	Peavine silty clay loam, 3-30%	75
054D	Hembre silt loam, 5-25%	73
068F	Kinney cobbly loam, south, 20-50%	73
016D	Bohannon gravelly loam, 3-25%	72
001A	Abiqua silty clay loam, 0-3%	70 (1)
001B	Abiqua silty clay loam, 3-5%	70 (1)
058F	Honeygrove silty clay loam, 25-50%	70
014F	Blachly silty clay loam, 30-50%	70
078	McAlpin silty clay loam	70 (1)
059E	Hullt loam, 2-30%	69
061	Jimbo silt loam	69
011C	Bellpine silty clay loam, 3-12%	68
011D	Bellpine silty clay loam, 12-20%	68
011E	Bellpine silty clay loam, 20-30%	68
012E	Bellpine cobbly silty clay loam, 2-30%	68
063C	Jory silty clay loam, 2-12%	68
063D	Jory silty clay loam, 12-20%	68
063E	Jory silty clay loam, 20-30%	68
135C	Willakenzie clay loam, 2-12%	68 (1)
135D	Willakenzie clay loam, 12-20%	68 (1)
135E	Willakenzie clay loam, 20-30%	68 (1)
013G	Blachly clay loam, 30-50%	67
014E	Blachly silty clay loam, 3-30%	67
049E	Formader loam, 3-30%	66
057D	Holderman extremely cobbly loam, 5-25%	66
135F	Willakenzie clay loam, 30-50%	65 (1)
081D	McDuff clay loam, 3-25%	65
111F	Preacher loam, 25-50%	65
036D	Cumley silty clay loam, 2-20%	64
062B	Jimbo-Haflinger complex, 0-5%	64
054G	Hembre silt loam, 25-60*5	63
071G	Klickitat stony loam, north, 50-70%	63
104G	Peavine silty clay loam, 30-60%	61
055G	Hembre-Klickitat complex, 30-60%	61
071F	Klickitat stony loam, north, 30-50%	61

Rank Order of Lane County Soil Potential Ratings (Continued)

Symbol	Map Unit	SPR	
050G	Formader-Hembre-Klickitat complex, 50-80%	60	
081G	McDuff clay loam, 50-70%	60	
112G	Preacher-Bohannon-Slickrock complex, 50-75%	59	
060D	Hummington gravelly loam, 5-25%	59	
070E	Klickitat stony loam, 3-30%	59	
089C	Nekia silty clay loam, 2-12%	59	
089D	Nekia silty clay loam, 12-20%	59	
089E	Nekia silty clay loam, 20-30%	59	
039E	Digger gravelly loam, 10-30%	59	
016H	Bohannon gravelly loam, 50-90%	58	
128B	Veneta loam, 0-7%	58	
129B	Veneta Variant silt loam, 0-7%	58	
051B	Haflinger-Jimbo complex, 0-5%	57	
081F	McDuff clay loam, 25-50%	57	
080G	McCully clay loam, 50-70%	56	
011F	Bellpine silty clay loam, 30-50%	56	
049G	Formader loam, 30-60%	55	
035D	Cruiser gravelly clay loam, 3-25%	54	
080F	McCully clay loam, 30-50%	54	
016F	Bohannon gravelly loam, 25-50%	53	
037C	Cupola cobbly loam, 3-12%	52	
037E	Cupola cobbly loam, 12-30%	52	
039F	Digger gravelly loam, 30-50%	51	
057F	Holderman extremely cobbly loam, 25-50%	51	
057G	Holderman extremely cobbly loam, 50-75%	50	
072G	Klickitat stony loam, south, 50-75%	50	
060F	Hummington gravelly loam, 25-50%	49	
072F	Klickitat stony loam, south, 30-50%	49	
064D	Keel cobbly clay loam, 3-25%	48	
060G	Hummington gravelly loam, 50-75%	48	
113C	Ritner covvly silty clay loam, 2-12%	48	
113E	Ritner covvly silty clay loam, 12-20%	48	
089F	Nekia silty clay loam, 50-70%	46	
122	Saturn clay loam	45	
035F	Cruiser gravelly clay loam, 25-50%	43	
035G	Cruiser gravelly clay loam, 50-70%	43	
041C	Dixonville silty clay loam, 3-12%	42	
041E	Dixonville silty clay loam, 12-30%	42	
046	Eilertsen silt loam	42	
064G	Keel cobbly clay loam, 45-75%	41	
045C	Dupee silt loam, 3-20%	40	(1)
064F	Keel cobbly clay loam, 25-45%	40	
083B	Minniece silty clay loam, 0-8%	39	
065G	Kilchis stony loam, 30-60%	35	
065H	Kilchis stony loam, 60-90%	35	
041F	Dixonville silty clay loam, 30-50%	35	
113G	Ritner cobbly silty clay loam, 30-60%	35	
040H	Digger-Rock outcrop complex, 30-85%	33	
043C	Dixonville-Philomath-Hazelair complex, 3-12%	32	
043E	Dixonville-Philomath-Hazelair complex, 12-35%	32	
138E	Witzel very cobbly loam, 3-30%	29	

Rank Order of Lane County Soil Potential Ratings (Continued)

Symbol	Map Unit	SPR
052B	Hazelair silty clay loam, 2-7%	25
052D	Hazelair silty clay loam, 7-20%	25
138G	Witzel very cobbly loam, 30-75%	21
108F	Philomath cobbly silty clay, 3-12%	20 (1)
102C	Panther silty clay loam, 2-12%	10 (1)
137F	Winberry very gravelly loam, 10-45%	10
085	Natroy silty clay loam	5 (1)
142G	Yellowstone-Rock outcrop complex, 10-60%	3

(1) Estimated SPR based on soil properties

Appendix 3 - Rating Points for Parcel Size

		-----SLOPE <= 30%-----			------SLOPE > 30%-----		
		NO. OF CLASS 1 STREAMS			NO. OF CLASS 1 STREAMS		
SIZE (Acres)	PERIM RATIO	0	1	2	0	1	2
2	<=1	0	0	0	0	0	0
	>1	0	0	0	0	0	0
3	<=1	4	1	0	0	0	0
	>1	0	0	0	0	0	0
4	<=1.03	10	2	0	1	0	0
	>1.03	5	0	0	0	0	0
5	<=1.06	16	3	0	2	0	0
	>1.06	11	0	0	0	0	0
6	<=1.10	25	5	0	5	0	0
	>1.10	17	0	0	0	0	0
7	<=1.14	33	7	0	9	1	0
	>1.14	22	2	0	4	0	0
8	<=1.17	38	10	1	16	2	1
	>1.17	25	5	0	11	0	0
9	<=1.21	42	16	1	22	6	1
	>1.21	28	11	0	15	1	0
10	<=1.25	45	22	2	27	11	2
	>1.25	30	15	0	18	6	0
11	<=1.29	48	27	4	31	16	4
	>1.29	32	18	0	21	11	0
12	<=1.32	50	30	5	35	20	5
	>1.32	33	20	0	23	13	0
13	<=1.36	53	33	6	38	23	6
	>1.36	35	22	1	25	15	1
14	<=1.39	55	36	8	41	26	7
	>1.39	37	24	3	27	17	2
15	<=1.43	57	39	10	44	29	9
	>1.43	38	26	5	29	19	4
16	<=1.46	59	41	12	47	31	10
	>1.46	39	27	7	31	21	5
17	<=1.50	61	43	15	49	34	12
	>1.50	41	29	10	33	23	7
18	<=1.53	62	45	18	51	36	13
	>1.53	41	30	12	34	24	8
19	<=1.56	64	46	20	53	38	15
	>1,56	43	31	13	35	25	10
20	<=1.59	65	49	24	52	40	17
	>1.59	43	33	16	36	27	11
21	<=1.62	67	50	27	56	41	19
	>1.62	45	33	18	37	27	13
22	<=1.65	68	52	30	57	43	21
	>1.65	45	35	20	38	29	14
23	<=1.68	69	53	33	59	44	23
	>1.68	46	35	22	39	29	15
24	<=1.71	70	55	35	60	45	25
	>1.71	47	37	23	40	30	17
25	<=1.74	71	56	37	61	46	27

Rating Points for Parcel Size (Continued)

SIZE	PERIM	-----SLOPE <= 30%-----			------SLOPE > 30%-----		
		NO. OF CLASS 1 STREAMS			NO. OF CLASS 1 STREAMS		
(Acres)	RATIO	0	1	2	0	1	2
25	>1.74	47	37	23	40	30	17
26	<=1.77	72	58	39	63	47	29
	>1.77	48	39	26	42	31	19
27	<=1.80	73	59	40	64	48	30
	>1.80	49	39	27	43	32	20
28	<=1.82	74	60	42	65	50	32
	>1.82	49	40	28	43	33	21
29	<=1.85	75	61	43	66	51	34
	>1.85	50	41	29	44	34	23
30	<=1.88	75	62	45	67	52	35
	>1.88	50	41	30	45	35	23
31	>=1.90	76	63	46	68	53	37
	>1.90	51	42	31	45	35	25
32	<=1.93	77	64	47	69	54	38
	>1.93	51	43	31	46	36	25
33	<=1.95	77	65	48	70	55	40
	>1.95	51	43	32	47	37	27
34	<=1.98	78	66	49	71	56	41
	>1.98	52	44	33	47	37	27
35	>=2.00	78	67	50	71	58	42
	>2.00	52	45	33	47	39	28
36	<=2.03	79	68	51	72	60	43
	>2.03	53	45	34	48	40	29
37	<=2.05	79	68	52	73	62	44
	>2.05	53	45	35	49	41	29
38	<=2.08	80	69	53	74	63	46
	>2.08	53	46	36	49	42	31
39	<=2.10	80	70	54	75	65	47
	>2.10	53	47	36	50	43	31
40	<=2.13	81	71	55	75	66	48
	>2.13	54	47	37	50	44	32
41	<=2.15	81	71	55	76	67	49
	>2.15	54	47	37	51	45	33
42	<=2.17	82	72	56	77	69	50
	>2.17	55	48	37	51	46	33
43	<=2.19	82	72	57	77	70	51
	>2.19	55	48	38	51	47	34
44	<=2.22	83	73	58	78	71	52
	>2.22	55	49	39	52	48	35
45	<=2.24	83	73	58	78	72	53
	>2.24	55	49	39	52	48	35
46	<=2.26	84	74	59	79	73	53
	>2.26	56	49	39	53	49	35
47	<=2.28	84	75	59	79	74	54
	>2.28	56	50	39	53	49	36
48	<=2.30	85	75	60	80	75	55
	>2.30	57	50	40	53	50	37
49	<=2.33	85	75	61	80	75	55
	>2.33	57	50	41	53	50	37
50	<=2.35	86	76	61	81	76	56

Rating Points for Parcel size (Continued)

SIZE (Acres)	PERIM RATIO	-----SLOPE <= 30%----- NO. OF CLASS 1 STREAMS			------SLOPE > 30%----- NO. OF CLASS 1 STREAMS		
		0	1	2	0	1	2
50	>2.35	57	51	41	54	51	37
51	<=2.37	86	77	62	81	76	57
	>2.37	57	51	41	54	51	38
52	<=2.39	86	78	62	82	77	58
	>2.39	57	52	41	55	51	39
53	<=2.41	87	78	63	82	77	58
	>2.41	58	52	42	55	51	39
54	<=2.43	87	79	63	83	78	59
	>2.43	58	53	42	55	52	39
55	<=2.45	87	79	64	83	78	60
	>2.45	58	53	43	55	52	40
56	<=2.47	88	80	64	83	78	60
	>2.47	59	53	43	55	52	40
57	<=2.49	88	80	65	84	78	61
	>2.49	59	53	43	56	52	41
58	<=2.51	88	81	65	84	79	61
	>2.51	59	54	43	56	53	41
59	<=2.53	89	81	66	85	79	62
	>2.53	59	54	44	57	53	41
60	<=2.55	89	82	66	85	80	63
	>2.55	59	55	44	57	53	42
61	<=2.57	89	82	66	85	80	63
	>2.57	59	55	44	57	53	42
62	<=2.59	90	83	67	86	80	64
	>2.59	60	55	45	57	53	43
63	<=2.61	90	83	67	86	80	64
	>2.61	60	55	45	57	53	43
64	<=2.63	90	84	68	86	81	65
	>2.63	60	56	45	57	54	43
65		90	84	68	87	81	65
66		90	84	68	87	81	66
67		91	84	69	87	81	66
68		91	85	69	88	82	66
69		91	85	69	88	82	67
70		91	86	70	88	82	67
71		92	86	70	88	82	68
72		92	86	70	88	82	68
73		92	86	70	89	83	68
74		92	87	71	89	83	69
75		92	87	71	89	83	69
76		93	87	71	89	83	70
77		93	87	71	89	83	70
78		93	88	72	90	83	70
79		93	88	72	90	83	70
80		93	88	72	90	83	71
81		94	88	72	90	84	71
82		94	88	72	90	84	71
83		94	88	73	91	84	72
84		94	88	73	91	84	72
85		94	89	73	91	84	72

Rating Points for Parcel Size (Continued)

SIZE (Acres)	PERIM RATIO	SLOPE <= 30% NO. OF CLASS 1 STREAMS 0	1	2	SLOPE > 30% NO. OF CLASS 1 STREAMS 0	1	2
86		94	89	73	91	84	72
87		94	89	73	91	84	73
88		94	89	74	91	84	73
89		94	89	74	91	84	73
90		95	89	74	91	84	73
91		95	89	74	92	84	74
92		95	90	74	92	84	74
93		95	90	75	92	84	74
94		95	90	75	92	85	74
95		95	90	75	92	85	75
96		95	90	75	92	85	75
97		95	90	75	92	85	75
98		95	90	75	92	85	75
99		95	90	75	92	85	76
100		95	90	76	92	85	76
101		95	90	76	92	86	76
102		95	90	76	92	86	76
103		95	91	76	92	86	76
104		95	91	76	93	86	77
105		95	91	76	93	86	77
106		96	91	77	93	86	77
107		96	91	77	93	86	77
108		96	91	77	93	86	78
109		96	91	77	93	86	78
110		96	91	77	93	86	78
111		96	91	77	93	87	78
112		96	91	78	93	87	78
113		96	91	78	93	87	79
114		96	91	78	93	87	79
115		96	91	78	93	87	79
116		96	91	78	93	87	79
117		96	92	78	93	87	79
118		96	92	78	93	87	80
119		96	92	79	93	87	80
120		96	92	79	94	88	80
121		96	92	79	94	88	80
122		96	92	79	94	88	80
123		96	92	79	94	88	81
124		96	92	79	94	88	81
125		97	92	80	94	88	81
126		97	92	80	94	88	81
127		97	92	80	94	88	81
128		97	92	80	94	88	82
129		97	92	80	94	88	82
130		97	92	80	94	89	82
131		97	93	80	94	89	82
132		97	93	81	94	89	83
133		97	93	81	94	89	83
134		97	93	81	94	89	83
135		97	93	81	94	89	83

Rating Points for Parcel Size (Continued)

SIZE	PERIM	-----SLOPE <= 30%-----			------SLOPE > 30%-----		
		NO. OF CLASS 1 STREAMS			NO. OF CLASS 1 STREAMS		
(Acres)	RATIO	0	1	2	0	1	2
136		97	93	81	95	89	83
137		97	93	81	95	89	84
138		97	93	82	95	89	84
139		97	93	82	95	89	84
140		97	93	82	95	90	84
141		97	93	82	95	90	84
142		97	93	82	95	90	85
143		97	93	82	95	90	85
144		98	94	83	95	90	85
145		98	94	83	95	90	85
146		98	94	83	95	90	85
147		98	94	83	95	90	86
148		98	94	83	95	90	86
149		98	94	83	95	91	86
150		98	94	83	95	91	86
151		98	94	84	95	91	86
152		98	94	84	96	91	87
153		98	94	84	96	91	87
154		98	94	84	96	91	87
155		98	94	84	96	91	87
156		98	94	84	96	91	88
157		98	94	85	96	91	88
158		98	95	85	96	91	88
159		98	95	85	96	92	88
160		98	95	85	96	92	88
161		98	95	85	96	92	89
162		98	95	85	96	92	89
163		98	95	85	96	92	89
164		99	95	86	96	92	89
165		99	95	86	96	92	89
166		99	95	86	96	92	90
167		99	95	86	96	92	90
168		99	95	86	97	93	90
169		99	95	86	97	93	90
170		99	95	87	97	93	90
171		99	95	87	97	93	91
172		99	96	87	97	93	91
173		99	96	87	97	93	91
174		99	96	87	97	93	91
175		99	96	87	97	93	91
176		99	96	88	97	93	92
177		99	96	88	97	93	92
178		99	96	88	97	94	92
179		99	96	88	97	94	92
180		99	96	88	97	94	93
181		99	96	88	97	94	93
182		99	96	88	97	94	93
183		100	96	89	97	94	93
184		100	96	89	98	94	93
185		100	96	89	98	94	94

Rating Points for Parcel Size (Continued)

SIZE (Acres)	PERIM RATIO	-----SLOPE <= 30%----- NO. OF CLASS 1 STREAMS			------SLOPE > 30%----- NO. OF CLASS 1 STREAMS		
		0	1	2	0	1	2
186		100	97	89	98	94	94
187		100	97	89	98	94	94
188		100	97	89	98	95	94
189		100	97	90	98	95	94
190		100	97	90	98	95	95
191		100	97	90	98	95	95
192		100	97	90	98	95	95
>192		100	98	90	98	95	95