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POPLAR CHIP PRODUCTION FOR WILLAMETTE VALLEY GRASS SEED SITES

by

Brad Withrow-Robinson
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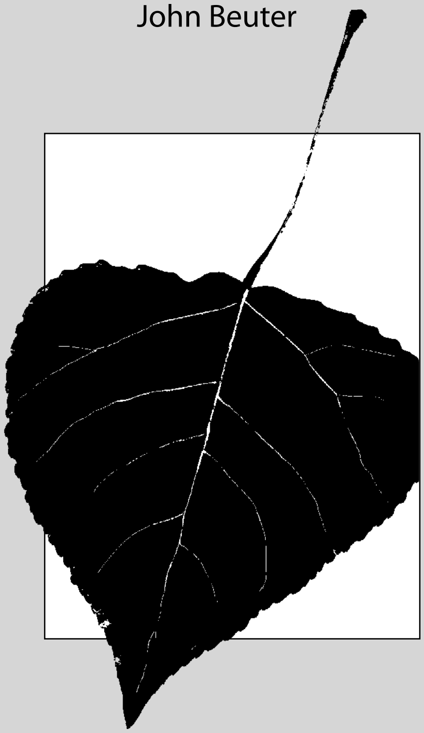

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Executive Summary

Purpose of this Report

This publication is part of a 1-year project funded by the Oregon Department of Agriculture, Alternatives to Field Burning Program. Crop substitution is one strategy for reducing smoke from field burning. The objective of the project was to evaluate the potential for hybrid poplar as an alternative crop for poorly drained agricultural soils in the Willamette Valley.

The evaluation focused on the potential yield of poplar on agricultural soils commonly used for annual ryegrass production, and on an economic analysis of poplar grown for pulp chips in the valley. The pulp chip market was seen as the most immediate and viable market outlet for poplar wood, although it is not the only possibility.

Findings

Our survey showed that, given good management, poplars performed well on a wide variety of soil types with very different levels of agricultural productivity. Although the best growth was generally found on well-drained bottomlands, good growth was found across a wide range of soil conditions: loams and clays, well drained and poorly drained.

A computer model was developed to predict stand volume yields and to generate yield curves that describe the change in stand volume at yearly intervals up to 10 years. These calculations have helped quantify yields that can be expected in the Willamette Valley and serve as the basis of the economic analysis.

The break-even poplar chip price varies with the Productivity Class. Break-even chip prices ranged from $89 to $141 per bone dry ton (BDT), and the cost-effective production cycle ranged from 7 to 10 years. Farmers cannot expect poplar to be profitable under any circumstances if chip prices 7 to 10 years in the future are less than $89 per BDT. On the other hand, if chip prices are more than $141 per BDT, poplar is probably profitable in any of the Productivity Classes.

Projected cost budgets were developed for four establishment alternatives. The budgets reflect operational costs of typical grass seed farms in the Willamette Valley. The budgets were prepared in a modified enterprise budget format to increase accessibility of the information.

Information in this Publication

The results of this study are useful to growers, extension agents, industry, and public agencies. This broad audience has a wide range of interests and information needs regarding poplar cultivation in the Willamette Valley. The chapters are structured to give readers a choice in selecting the information most relevant to their needs and interests. Each chapter presents the procedures and basic results of each part of the project; appendices include detailed data sets that are important in evaluating and interpreting our results.

Introduction

Background

Grass seed is an important agricultural crop in the Willamette Valley, where about 370,000 acres are devoted to grass seed production (Young et al. 1994). About a third of the acres is in annual ryegrass (Lolium multiflorum), a third is in perennial ryegrass (Lolium perenne), and a third is divided among six other grass species.

Grass seed, particularly annual ryegrass, is raised on clay soil that is too wet for production of most agricultural crops. Annual ryegrass soil is typically poorly drained, with a very high clay content and high winter water table. Growers have a limited choice of crops that can tolerate the wet winter conditions and grow well on these soils. Annual ryegrass is often the only economically viable crop.

For many years, burning was the primary means of disposing of straw left after the grass seed harvest each year. Field burning remains the most cost-effective means for controlling seed-borne diseases. However, in response to adverse public reactions, the 1991 Oregon legislature passed a law that will significantly reduce field burning after 1997.

The field burning limitation affects annual ryegrass production particularly strongly because there are limited economic uses for annual ryegrass straw. Its protein content is too low to make it desirable as an animal feed, the main use of straw from other grass species. Also, annual ryegrass seed production generally has the lowest economic margin among grass seed species, so the extra costs of straw disposal, weed control, and field cultivation increase production risks and can make the crop unprofitable.

The legislative limitation on burning has led to a search for alternatives. The 1991 law authorized the use of field burning fees to investigate the potential for alternative crops. Alternatives that are compatible with current grass farming activities could contribute both to the solution of environmental problems as well as to the economic health of farm enterprises. One alternative crop is hybrid poplar.

Potential for Poplar

Hybrid poplar is a promising new crop for the Willamette Valley. It is a fast-growing tree, well-suited to the local climate. Poplar is easy to grow and is raised like most other agricultural crops, with common equipment and familiar activities. Perhaps most importantly, large potential markets already exist for poplar products in the region’s forest products industry.

Poplar wood has a number of industrial uses. Poplar chips are valuable in pulp and paper production. The short fibers of poplar and other hardwoods are suited to making high quality office-grade paper. The particularly light color of poplar wood reduces the need for bleaching the fiber, offering both financial and environmental benefits. Paper mills operating in the area require a supply of hardwood chips in the paper-making process. As the supply of hardwood fiber from forest lands becomes more uncertain, local paper companies are increasingly interested in plantation production of poplar. Poplar may also be grown for other uses, such as solid wood boards, veneer, or oriented strand board. Poplar plantations may be harvested for chips within 5 to 10 years of planting, while production for other uses will likely require longer periods of time.

The future of poplar as a crop in the Willamette Valley is not yet certain. Poplars are now being grown in large industrial plantations in Oregon and Washington in western valleys and along the Columbia River plateau, east of the Cascade Range. The success of these plantations illustrates the potential of poplar in the region, but it does not guarantee the profitability of poplar for individual farmers in the Willamette Valley. The resources and business objectives of individual farmers are very different from those of the pulp and paper industry. However, the search for viable alternative crops for poorly drained lands and the interest from paper and other forest product companies offer an opportunity for profitable poplar farming in the Willamette Valley.

Objectives of this Project

In the fall of 1993, the Oregon Department of Agriculture asked the Department of Forest Science at Oregon State University (OSU) to evaluate the potential for hybrid poplar in the Willamette Valley. In particular, we were asked to focus on growing poplar for pulp-chip production as an alternative crop for poorly drained agricultural lands. We were asked to collect and evaluate information on soil resources, growth and yield, economics of production, and market potential relevant to the success of hybrid poplar production in the Willamette Valley. Several steps were identified for this project:

- Survey existing trials and plantings
- Estimate production potential
- Analyze economics of hybrid poplar
- Develop educational information
- Identify and prioritize information needs for future development of poplar

This publication summarizes the results of this project. Although it includes some cultural descriptions, this is not a grower's guide.[1] It is meant to serve as a tool for growers, extension agents, and agencies in evaluating the role of poplars in Willamette Valley agriculture.

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[1] For more information on cultural practices, see "High yield poplar plantations in the Pacific Northwest," PNW 356 (Heilman et al. 1995). The PNW report is available from Publications Orders, Agricultural Communications, Oregon State University, Administrative Services A422, Corvallis, OR 97331-2119.

Terminology

There are a number of terms that are commonly used by foresters, but may be unfamiliar to agriculturalists or are applied in a new way in this publication. These terms deserve some explanation. **Poplar** is a general term that applies to all members of the genus Populus. There are many different species of poplar trees, which are widely distributed around the temperate regions of the world. Aspens, black poplars (including Lombardy poplars), and cottonwoods [including our local black cottonwood ("Bam")], are all different kinds of poplar trees. Crosses between two or more species of poplar produce a **hybrid poplar**. Crosses between our local black cottonwood (Populus trichocarpa) and the eastern black cottonwood (P. deltoides) are commonly referred to as TxD hybrids and have produced outstanding selections. These are the trees generating the most interest in this region. Although both parents are cottonwoods and the cross may also be called a hybrid cottonwood, we will use the generally accepted term of **hybrid poplar** or simply **poplar** in this publication.

Unlike corn or other agricultural crops, the individual offspring of hybrid crosses between tree species are very different from one another. Some of these individual plants have exceptional characteristics of growth or disease resistance or both. To capture the advantage of hybridization, breeders select individuals with superior characteristics. After selection, these individuals are propagated vegetatively by cuttings and are referred to as **clones**. Cloned plants are all genetically identical offspring of the parent plant.

Early breeding work at the University of Washington and Washington State University produced clones that illustrated the great potential of hybrid poplar as a cash crop. One clone, **H-11**, has been widely planted in western Oregon and Washington. Much of the analysis in this study is based on observations of clone H-11. Continued breeding and selection has led to the later releases of new, more productive clones with improved characteristics, such as greater growth rates, resistance to certain diseases, and desired wood qualities. We were not able to define or characterize the performance of these new clones individually, but refer to them collectively as **improved hybrids**.

In forestry terminology, **rotation** describes the length of the crop cycle. The term rotation is used in this publication to mean the number of years from planting to harvest of the crop, rather than the pattern of crops grown over time.

Productivity of Poplar on Willamette Valley Soils

Activities and Procedures

Since the introduction of clone H-11, local interest in poplars has steadily increased. After hearing reports of poplar's tremendous growth rates, many Willamette Valley landowners decided to grow some trees on their own farms. As a result, many trial plantings were made on small farms, particularly since 1990. These plantings represent a limited but useful resource for evaluating the potential of poplars in the valley. Information gathered from these plantings provides the basis for describing poplar soil Productivity Classes and estimating yields for each class.

Survey of Stands in the Willamette Valley

A field survey was conducted to gather information that would be useful in predicting future yields from poplar plantations in the Willamette Valley. This required finding, screening, and selecting poplar plantings that fit the objectives of the study.

Selection Criteria

Only plantations within the Willamette Valley were considered for this survey. The planting had to be arranged in a block greater than seven rows wide. To meet plot size and buffer criteria, plantings generally were greater than 0.25 acre.

Individual measurement plots varied in size from 10 to 30 trees. Plots were from two to four rows wide, with edge buffers of two or more rows of trees.

Plots were located within an area that was relatively homogeneous with regard to soil type, clone, and management. A plot had to be well-stocked with 90 percent or better survival. In some cases, more than one plot was sampled at a given farm.

During the screening and selection process, 28 stands on 13 different soil series were identified throughout the Willamette Valley. Many other sites were rejected because of the small size of the plantation and high proportion of edge, or inadequate care at establishment which made them unsuitable for our purposes of predicting growth of managed plantations.

Data Collection and Analysis

In contrast to an annual crop, a tree shows information about previous years' growth, which allowed us to gather information on several years' growth. By collecting basic data from each survey stand, we learned about the stands' past development and growth, and developed the basis for predicting future growth. Data were collected during the winter of 1993–1994. Basic stand data included the following:

- *Tree height*: current total tree height and heights 1 to 4 years previously, based on bud scars and branching patterns
- *Diameter at Breast Height* (DBH): current stem diameter (including bark) at 4.5 ft above the ground
- *Spacing*: distance between trees within rows and between rows; used to calculate stand density
- *Management history*: date planted, site preparation, and weed control
- *Clone*: source of cuttings
- *Soil series*: classification according to location on the county soil map

Average tree height, annual height growth increments, stand density, and standing volume were calculated for each plot. These results became the building blocks for estimating future growth and yield.

Poplar Productivity Classes

Four poplar Productivity Classes of soils in the Willamette Valley were established from the stand survey results. Each class was defined by tree height and included a range of tree growth.

Height Index

Site classifications were based on tree height, which is the most common measure of site quality in forestry. Height growth is less affected by tree spacing and other cultural factors than is tree diameter, basal area, or stand volume; thus height is the best measure of potential site productivity.

Because the rate of height growth changes with tree age (time t in years), an age-sensitive Height Index was developed based on a reference stand:

$$\text{Height Index} = \frac{\text{Height of surveyed stand at time } t}{\text{Height of reference stand at time } t} \times 100$$

Reference Stand

The reference stand we chose was a 7-year-old planting of clone H-11 that represented growth under very good soil conditions and good cultural practices (Table 1). It did not represent a regional mean; rather, it had site and cultural conditions that were considered to be very close to ideal for clone H-11.

Table 1. Reference stand heights.

Age (years)	Height (ft)
1	7
2	17
3	30
4	42
5	54
6	63
7	69

Soil Groupings

Survey stands were ranked by their Height Index. Differences in stand establishment histories were taken into account by considering recent annual height growth increments as well as total height. Four Productivity Classes (Low, Medium-Low, Medium-High, and High) were defined based on this ranking (Table 2). This gave us a productivity ranking for all surveyed soils. Each Productivity Class contained a range of productivity. Our models show the maximum and minimum values for these classes as well as a line called the central value, a production rate roughly centered within the range of production values found in each class.

Other important agricultural soils of the valley that were not represented in the survey were then ranked into the poplar Productivity Classes. We looked at which soil properties in the initial survey stands might most affect poplar growth. We considered soil texture, soil structure, and fertility as well as soil drainage, depth to the water table, when and how long water was likely to stand in the field, and position of that soil in the landscape (Boersma et al. 1970; Huddleston 1982). We also consulted soil scientists and local farmers about which factors were most important. The picture we developed of how poplar trees and soils interact was then used to assign the unsurveyed soil series to a Productivity Class.

Table 2. Productivity Classes by range of Height Index.

Productivity Class	Height Index	Central value
	------------------(%)-------------------	
High	>100	110
Medium-High	85–100	92.5
Medium-Low	70–84	77.5
Low	<70	60

Results and Discussion

Soil Classification

Each of the four Productivity Classes shown in Table 3 is composed of a group of valley-floor soils. Each class represents a range of poplar growth that we feel is likely to be found on these soils.

This classification can be used to determine what sites on a farm might yield the best poplar growth. Also, the Productivity Classes can be used by growers in conjunction with the economic analysis (discussed below) to decide if poplar represents a viable crop for their farm.

Table 3. Soil series ranked by poplar Productivity Class. (**Bold** names were included among survey stands.)

High	Medium-High	Medium-Low	Low
Camas	Aloha	Bashaw*	Courtney*
Chehalis	**Amity**	**Cove***	**Dayton***
Clackamas	Awbrig*	Holcomb*	Natroy*
Cloquato	**Chapman**	**Santiam**	
McBee	Coburg	Verboot	
Newberg	**Concord***		
Salem	Conser*		
Sifton	Malabon		
	Waldo*		
	Wapato*		
	Willamette		
	Woodburn		

*hydric soil

Poplar Growth on Willamette Valley Soils

Our survey showed that, given good management, poplars performed well on a wide variety of soil types with very different levels of agricultural productivity. Although the best growth was generally found on well-drained bottomlands, good growth was found across a wide range of soil conditions: loams and clays, well drained and poorly drained. It was clear, too, that poor growth can be induced on any class of soil if cultural requirements are neglected. Management practices, particularly weed control, affect tree growth on any soil type.

Some of the survey results were expected. It was not surprising that the highest productivity soils were generally the coarse, well-drained soils near major rivers that are often used for row crops. This is the kind of site in which native cottonwood is common. Also, the lowest productivity soils were all poorly drained, prairie soils, which are all hydric soils commonly used for grass seed production.

Distinctions were less clear in the Medium-High and Medium-Low Productivity Classes. Poplar productivity on a particular soil did not always match its ranking for agricultural productivity described by Huddleston (1982). The Medium-High class is made up of two fairly distinct groups. One includes many deep, well-drained, and very versatile soils, such as Willamette and Woodburn, that are generally regarded as among the best agronomic soils in the valley. The other group includes deep, but clayey, poorly drained, and difficult-to-manage hydric soils, such as Wapato and Cove, that lie in low places in the landscape; this soil type is also found in the Medium-Low Productivity Class.

Some of the poor agricultural soils, such as Awbrig, Cove, or Wapato, are promising for poplar. On such soils, the field crop production that would be forfeited may be low while the potential yields of poplar are relatively high. These soils should be among the first considered for conversion to poplar plantations.

The ranking of soils into Productivity Classes should help individual farmers evaluate the suitability of poplars on their farms. It is important to remember that this list is based on limited local information. Also, most poplar plantations in the valley are rather uneven in their growth; poplar may be sensitive to either small changes in soil condition or cultural practices, which limits our ability to predict future behavior and yield of the crop as well as we would like. The true measure of each soil's productivity will only be developed over time, with many plantings of different clones on each soil type and the development of new cultural practices for these soils.

Growth and Yield

Height is a useful measure for comparing the growth potential of trees on different soil types. However, as with other crops, poplar chips are commonly bought and sold on a dry-weight basis. Tree stands are usually measured by dimension (e.g., DBH, height, number of trees per acre), and yield is usually estimated on a volume basis (e.g., in ft^3). We need to be able to estimate plantation yields for each Productivity Class. Estimates of stand volume must first be adjusted to reflect wood loss during harvest and then converted to weight.

Activities and Procedures

Two steps were involved in estimating future poplar yields in the Willamette Valley: 1) stand volume yields were predicted for each Productivity Class and stand age; 2) harvest yields were converted from stand volume to weight to determine how many tons of chips are expected to be harvested and sold.

Poplar Yield Predictions

Development of Growth Models

A computer model was developed to predict stand volume yields from the tree Height Index [Appendix 1, Equation (2)]. The model is based on the data collected from 24 stands of clone H-11, age 2 to 7 years, and incorporates stand age, stand density, stand volume, and mean tree height (see Appendix 1 for details). The model estimates total stand volume (without bark) from the base to the very top of the tree.

The model was used to develop yield curves that describe the annual change (up to 10 years) in stand volume of clone H-11 planted at a spacing of 600 trees per acre in each of the four Productivity Classes.

Genetic Gains in Yield

Recent breeding programs have produced new clones (improved hybrids) that are estimated to be 20 to 30 percent more productive than the clone H-11 available for this study. To reflect these improvements in yields, we increased the estimated volumes of clone H-11 by 20 percent to produce yield curves for the currently available improved hybrids grown with good management for each Productivity Class.

The improved hybrids are not all equal; some yield more than others, and some are also likely to be more productive on one soil over another. We felt that a 20 percent increase over established plantings of clone H-11 was a reasonable adjustment to make for new plantings of improved hybrids.

Estimating Harvest Yield

Some yield will inevitably be lost during harvest and the volume of chips sold will be less than the volume standing in the field. Calculating the harvest yield from stand volume requires adjustments for harvest loss and conversion to dry weight (Husch et al. 1972), which is the basis of sale. The adjustments are described below.

Harvest Volume

At harvest, some wood is lost at the bottom and top of the tree (where diameter drops below 3 in.) and in the process of removing the branches and bark. The merchantable utilization value is used to adjust for volume lost during harvest, and it reflects the percent of the stand volume that can be captured in the harvested yield. Actual utilization is not fixed; it will be lower if the trees are debarked and delimbed to produce clean chips, and it will be higher as the size of the harvested trees increases. We selected a merchantable utilization value of 89 percent to reflect harvest of clean chips from trees up to about 7 in. DBH grown at a stand density of approximately 600 trees per acre (as in our model) (from waste/yield relationships given in Browne 1962). We applied this value across all ages of the stand, but utilization will vary if density or rotation length is altered.

Conversion from Volume to Weight

The procedure for converting harvest volume estimates to dry weight in bone dry tons (BDT) per acre is described in Appendix 1 [Equations (3) to (7)].

Waste

During the production of clean chips, harvest waste (bark, stem tops, and branches) will also be produced. This waste may be returned to the field or sold as hog fuel, and therefore has some economic value. We calculated the waste yield indirectly by assuming that hog fuel equals 33 percent of the clean chip yield (dry weight); this amount is added to the chip harvest to estimate total yield.

Yield

Adjusted yield curves for the improved hybrids show the estimated harvest in BDT per acre (Figure 1). Productivity Class includes a range of yields, but are represented in the economic analysis by the central value (Figure 1; see also Table 2). These yield curves have helped quantify yields that can be expected in the Willamette Valley and serve as the basis of the economic analysis.

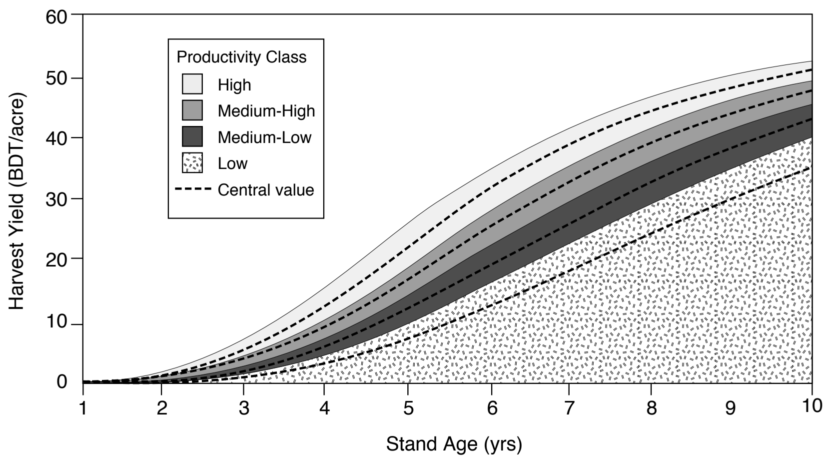

Figure 1. Estimated harvest yields by Productivity Class of clean chips harvested from improved hybrids planted at 600 trees per acre. The central value was used in the economic analysis.

Economics of Poplar

Activities and Procedures

An economic analysis was developed to determine the potential profitability of poplars. The costs of activities relating to poplar production were considered, and net returns were estimated for poplars grown in the Willamette Valley.

Assumptions

The following conditions and assumptions pertain to the economic analysis:

- Poplar yield projections were based on a yield model derived from measurements of clone H-11 that were planted across a range of soils in the Willamette Valley. Improved hybrids were assumed to be 20 percent more productive than clone H-11. The projected yields presume good management practices, which include careful site preparation and planting as well as diligent weed control during the first few years until the trees shade them out. Planting density is assumed to be approximately 600 trees per acre (7 by 10 ft spacing), which is the current industry standard.

- Poplar plantations are assumed to be at least 30 acres within an average-sized (1500 acres) grass seed farm.[2] The fixed costs per acre for land, machinery, and services for the poplar plantation are assumed to be the same as those for the grass seed operation. The land lease rate is assumed to start at $65 per acre and increase at 2 percent per year throughout the production cycle.

- Poplar is assumed to be grown for wood chips over a production cycle of 5 to 10 years. The analysis does not consider the alternative of short-cycle, high-intensity regimes with successive crops originating from stump sprouts, nor does it consider longer cycles for the production of sawlogs or veneer logs. Both are technically feasible alternatives. Veneer and solid wood products have a higher value than pulp chips, and they may be more profitable if future markets and land use regulations develop favorably. However, because the chip market was seen as the most immediately viable outlet, it was chosen as the target of this study.

- Preharvest costs per acre are accounted for annually, from site preparation through harvest, 5 to 10 years after planting. The analysis is based on one poplar production cycle only. Four alternative establishment practices are discussed below. Variable costs used in the economic analysis were based on estimates from full tillage site preparation following annual ryegrass.

- Harvesting, processing, and transportation costs vary with harvest yield.

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[2] The 1500-acre average size for a grass seed operation comes from grass seed enterprise budgets prepared by the OSU Extension Service (Taylor et al. 1990; Cross et al. 1992). By assuming the same size operation here, the fixed costs per acre for the grass seed operation can be used to approximate those for a poplar plantation.

As yield increases, costs increase on a per acre basis, but decrease on a per ton basis. Harvesting is accomplished with the same equipment used in local logging operations on flat ground: a mechanical harvester and a grapple skidder. Future harvesting systems may be more cost effective. Delimbing and chipping occur at the plantation, with chips blown into a chip truck as they are processed. Bark and other waste are processed and loaded in the field and sold as hog fuel. Transportation costs are based on a 60-mile haul (the average distance from Albany, Oregon, to likely chip destinations at Halsey or Toledo, Oregon, or Camas, Washington).

- The analysis stops at the harvest stage. Post-harvest costs are not included in this analysis because site-preparation costs vary, depending on what crop is planted next. The costs are usually assigned to the next crop, except when land is leased with a prior agreement to return it to a specified condition following harvest. In this case, the post-harvest costs should be deducted from the net returns shown in this analysis.
- Risk was not explicitly considered in the analysis; however, an element of risk is implied in the 12 percent interest charge that is carried throughout the poplar production cycle on all preharvest variable costs. Also, fixed costs per acre are increased at 2 percent per year throughout the poplar production cycle.
- The net returns from poplar production are determined for clone H-11 and improved hybrids in each of the four Productivity Classes. Returns depend on the age of poplar at harvest (ranging from age 5 to 10 years) and the market price of delivered wood chips (ranging from $50 to $150 per BDT). The price for hog fuel generated from bark and other waste is fixed at $20 per BDT throughout the analysis. A break-even chip price is determined for each harvest age; the lowest break-even price represents the harvest age with the most cost-effective relationship between costs and yields.
- Net returns are determined as of harvest time. Costs are compounded at 5 percent from the month and year they are incurred to the year of harvest. Chip and hog fuel prices are nominal at the time of harvest.

Poplar Budget

Currently, poplars are not widely planted in the Willamette Valley and represent a new crop alternative. With so little acreage in production, it is hard to describe typical farming practices. Four alternative establishment practices (discussed below) and their associated variable costs were examined. Preharvest costs, including the variable costs associated with full tillage site preparation following annual ryegrass, were used to develop a limited budget that estimates the costs of producing hybrid poplar on plantations in the central and southern Willamette Valley. The budget is designed to be useful to growers who currently have grass seed crops growing on poorly drained agricultural soils in the valley. The operations described in this budget reflect the opinions of growers who have already planted poplar; therefore they represent practices likely to be employed. In creating these poplar budgets, we adopted many of the assumptions used in ryegrass budgets developed by the OSU Extension Service (Cross et al. 1992; Taylor et al. 1990; Young et al. 1994).

Operations

Four alternative establishment practices were chosen to reflect two site preparation options (minimum and full tillage) following each of two grass crops (annual and perennial ryegrass). For the minimum site preparation, the field is ripped with a single row subsoiler to mark the planting row and to aid in planting poplar cuttings. For the full tillage option, the field is plowed, harrowed, and ripped to mark the planting row.

The annual versus perennial ryegrass crops have different weed control demands. Preparation for the normal midwinter planting can be done anytime after harvest, but before significant rain. No assumptions are made concerning straw removal; most practices apply similarly to either bare ground or soil with a straw load.

A full-cover spray is applied 1 week before planting to kill existing weeds and provide pre-emergent control of summer weeds. Cuttings are planted by hand in February or March. In May or June of the first growing season, the plantation is spot-sprayed to control perennial weeds and then cultivated between rows. In the winter between the first and second growing season, a directed spray is applied to kill established weeds and control spring-emerging weeds. Another spot spray is recommended for the second growing season. If strict weed control is maintained during the first two growing seasons, no weed control will be needed during the third growing season.

Expenses associated with practices other than the basic operations described above were difficult to reflect accurately in the poplar budget. Additional costs may be incurred with practices such as pest or disease control and fertilization or irrigation designed to increase yields and profits. Outbreaks of certain insect pests and diseases have occurred in plantations along the lower Columbia River. It is not clear at this time whether it is economical to control them, and such controls have not been included in the budget. It is not clear whether the application of lime, fertilizers, or irrigation will be beneficial to poplar production in the Willamette Valley. Because neither the need for nor the response to these practices is known, they have not been included in the budget.

Animal damage, particularly by deer, voles, and beaver, has been a problem in the Willamette Valley. Deer often browse poplar in the first couple years of establishment, but the probability of damage or need for control varies with location. Repellents or fencing may offer effective control, if needed. The cost of repellents has been included in this budget, but it is discounted by 30 percent to reflect an overall expense on only some acreage. Vole damage during early establishment is generally prevented by effective weed control. Voles may become a problem later as the trees themselves provide cover. No additional costs for this control were estimated. Although beaver can cause significant damage, no costs for beaver control have been included in this general budget because this problem tends to be very localized.

Results and Discussion

Production Costs

Estimated variable costs for four establishment alternatives are presented in a modified enterprise budget format in Appendix 2 (Tables A1 to A4). Variable and fixed costs for one of the alternatives (full tillage following annual ryegrass) from establishment up to harvest are summarized in Table A5 (Appendix 2). Harvesting, processing, and transportation costs are summarized in Table A6 (Appendix 2).

Net Returns

In this analysis, net returns from poplar production vary depending on site productivity, harvest age, and market price for wood chips. Other variables that might affect net returns, such as costs of different management techniques, alternative technology, and the discount rate, were not varied, either because there was no good basis for doing so or because it made the analysis and presentation simpler. With the structure of the analysis in place, it would not be hard to adjust the variables that were included or to include other variables as warranted.

Clone H-11 was included in this economic analysis only because it is the hybrid used as a reference for determining the relative productivity of Willamette Valley soils for poplar, not because it should be considered in future plantings. It would be unwise to continue to plant clone H-11 when newer hybrids are available.

Poplar Profitability

A grower can easily determine if annual crops, such as ryegrass, are profitable by simply comparing the expected costs for the year with the expected yields. Determining potential profitability for poplar is not so easy, because costs vary from year to year and there are no returns until harvest, 5 to 10 years after planting. Interest charges for carrying the costs incurred in the early years need to be included through the entire production cycle. Also, poplar yields change from year to year as the trees grow. As long as the yields are increasing at a faster rate than the costs of production, it pays to delay harvest, assuming prices are steady or increasing.

One way to estimate the most cost-effective production cycle is to determine the year in which the break-even chip price (price required to recover all production costs to date) is minimized. In this analysis, the break-even chip price varies with both the Productivity Class and hybrid (Table 4). In general, higher Productivity

Table 4. Break-even chip prices and optimum production cycles by Productivity Class and poplar hybrid.

	Minimum break-even chip price ($/BDT)		Optimum production cycle (years)	
Productivity Class	Improved hybrid	Clone H-11	Improved hybrid	Clone H-11
High	89	99	7	7
Medium-High	97	109	8	8
Medium-Low	106	120	9	9
Low	124	141	10	10

Classes have lower break-even chip prices. This is true for both hybrids (improved hybrid and clone H-11); however, within a given Productivity Class, the break-even chip price is always lower for the improved hybrid, which reflects its higher inherent productivity (Table 4). Higher Productivity Classes in this analysis also have shorter cost-effective production cycles; these vary from 7 years for high productivity sites to 10 years for low productivity sites (Table 4). The production cycle is the same length for both hybrids within each Productivity Class (Table 4).[3]

Within the range of chip prices considered in this analysis, the chances of poplar being profitable on low productivity soils are maximized over a 10-year production cycle—the time when the break-even chip price will be the lowest. If chip prices in 10 years are expected to exceed $141 per BDT, either hybrid is probably profitable on low productivity soils. If chip prices are expected to be between $124 and $140, only the improved hybrid is likely to be profitable. If chip prices are below $124 per BDT, neither hybrid is likely to be profitable on low productivity soils (Table 4).

Farmers who have higher productivity soil available for planting poplar can increase their chances of making a profit sooner and at lower chip prices, as low as $89 per BDT in 7 years for improved hybrid on high productivity sites (Table 4). Farmers cannot expect to make a profit under any circumstances if chip prices in 7 to 10 years are less than $89 per BDT. On the other hand, if chip prices are more than $141 per BDT, they can probably make a profit with either hybrid in any of the Productivity Classes (Table 4) (See Appendix 2, Table A7, for more detail; also see Table 5, below).

The lowest chip price that will yield a profit (i.e., positive net return) is $89 per BDT (Table 4). If the chip price at harvest is $90 per BDT, the net return for improved hybrid poplar grown on high productivity soils for 7 years is expected to be $55 per acre; if harvest is delayed until the eighth year, the net return would fall to $23 per acre (Table 5).

Over the range of chip prices and production cycles studied, the highest net return is $2804 per acre for improved hybrid poplar grown for 9 years on high productivity soil when the chip price at harvest is $150 per BDT; the same production cycle and chip price for clone H-11 also produce its highest net return, $1887 per acre (Table 5).

The net returns for both hybrids drop dramatically as soil productivity diminishes. Clone H-11 would not be profitable on low productivity soils unless the chip price was at least $150 per BDT; the improved hybrid on low productivity soil becomes profitable at a chip price of $130 per BDT (Table 5).

The chip price can affect the optimum production cycle. For example, when only costs and physical yields were considered, the most cost-effective production cycle for both hybrids on medium-low soils was 9 years (Table 4). However, if the price of chips is $120 per BDT, the optimum production cycle for the improved hybrid is 10 years; for both hybrids,

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[3] Although the most cost-effective production cycle was the same for both hybrids in this study, this should not be accepted as a general rule. In this analysis, the yield differences between hybrids was smoothed as a percentage difference across all age classes. Thus, both hybrids have the same marginal growth rate at a given point in time. Because the marginal costs and marginal growth over time were the same, the best production cycle for the two hybrids was also the same. If yield trajectories or costs (or both) differ over time, the most cost-effective production cycles may vary.

10 years becomes optimum on medium-low productivity soils when the chip price is $140 or more (Table 5).

Poplar can be profitable if the chip price is high enough, particularly if an improved hybrid is planted. Farmers must compare these estimates of returns for hybrid poplar with returns for other crops when choosing which crops to grow.

Cautions and Considerations

The results show that hybrid poplar could be profitable under some circumstances with future chip prices as low as $90 per BDT. However, the economic analysis should be regarded with caution. The results are sensitive to the assumptions made about costs; these are based on limited experience, best estimates, and crude adjustments to account for the variation in tree size associated with production cycles of different lengths. There has not been enough experience to date to be more precise.

The economic analysis assumes that the primary market for poplar will be clean pulp chips (those free from bark and other debris); however, there may be other markets, such as fiberboard or biofuel, that would pay for chips. The next chapter addresses the market analysis.

The green-tree/dry-chip relationship would change with assumptions about the moisture content of the trees, the costs of harvesting, processing, and transportation, and the amount and value of bark and other waste. Within the range of profitability for poplar, the relationship does not change significantly with changes in the production cycle. Estimated yields in green tons per acre for improved hybrids in each hybrid, Productivity Class, and production cycle appear in Appendix 2 (Table A6).

Market Analysis

Because of the past regional harvest patterns and the recent dramatic reduction in federal timber harvest in the Pacific Northwest, a pulp fiber shortage has been predicted in the region over the next several years. Less timber is being harvested, and fewer residues are being generated from the generally younger timber that is harvested.

Market Outlook

This market analysis focuses primarily on the potential for growing poplar for pulp chips in the south-central Willamette Valley, centering on Albany, Oregon. Three pulp mills that use hardwood chips are the primary markets for this analysis: Pope & Talbot, Inc., at Halsey, Oregon; Georgia-Pacific Corp. at Toledo, Oregon; and James River Corp. at Camas, Washington. Other mills that use hardwood and are potential markets include James River Corp. at Wauna (near Clatskanie), Oregon, and Weyerhaeuser Co. at Longview, Washington; however, they are farther than the 2-hour travel limit used by the industry as a rough estimate of an economical haul distance. The transportation cost used in this analysis was based on

Table 5. Net returns from poplar production by chip price and length of production cycle, hybrid, and Productivity Class. The establishment alternative is full tillage following annual ryegrass. Maximum net returns are in **bold**.

		Net returns ($/acre)							
	Production	Improved hybrid				Clone H-11			
Chip price ($/BDT)	cycle[1] (years)	High	Medium-High	Medium-Low	Low	High	Medium-High	Medium-Low	Low
≤80	all	<0[2]	<0	<0	<0	<0	<0	<0	<0
90	7	**55**	<0	<0	<0	<0	<0	<0	<0
	8	23	<0	<0	<0	<0	<0	<0	<0
100	6	263	<0	<0	<0	<0	<0	<0	<0
	7	443	55	<0	<0	**43**	<0	<0	<0
	8	**466**	**128**	<0	<0	2	<0	<0	<0
	9	389	98	<0	<0	<0	<0	<0	<0
	10	200	<0	<0	<0	<0	<0	<0	<0
110	5	193	<0	<0	<0	<0	<0	<0	<0
	6	579	105	<0	<0	199	<0	<0	<0
	7	831	381	<0	<0	367	<0	<0	<0
	8	**909**	517	66	<0	**371**	**44**	<0	<0
	9	872	**535**	**140**	<0	279	9	<0	<0
	10	710	445	107	<0	85	<0	<0	<0
120	5	420	<0	<0	<0	112	<0	<0	<0
	6	895	355	<0	<0	462	11	<0	<0
	7	1219	707	178	<0	691	252	<0	<0
	8	1352	906	393	<0	**740**	368	<0	<0
	9	**1355**	**972**	523	<0	681	**374**	<0	<0
	10	1220	919	**535**	<0	510	259	<0	<0
130	5	647	101	<0	<0	301	<0	<0	<0
	6	1211	605	45	<0	725	219	<0	<0
	7	1607	1033	440	<0	1015	523	33	<0
	8	1795	1295	720	<0	**1109**	692	220	<0
	9	**1838**	**1409**	906	114	1083	**739**	**310**	<0
	10	1730	1393	**963**	**223**	935	654	289	<0
140	5	874	268	<0	<0	490	<0	<0	<0
	6	1527	855	234	<0	988	427	<0	<0
	7	1995	1359	702	<0	1339	794	251	<0
	8	2238	1684	1047	154	1478	1016	493	<0
	9	**2321**	1846	1289	412	**1485**	**1104**	629	<0
	10	2240	**1867**	**1391**	**572**	1360	1049	**645**	<0
150	5	1101	435	<0	<0	679	124	<0	<0
	6	1843	1105	423	<0	1251	635	76	<0
	7	2383	1685	964	29	1663	1065	469	<0
	8	2681	2073	1374	394	1847	1340	766	<0
	9	**2804**	2283	1672	710	**1887**	**1469**	948	145
	10	2750	**2341**	**1819**	**921**	1785	1444	**1001**	**263**

[1] Age of stand at harvest.

[2] Costs exceed returns.

a one-way trip of 60 miles, the average distance from the three primary markets to Albany, Oregon.

Pulp chips are not the only useful product from poplar trees; alternative uses include biofuels or wood products such as sawlogs or veneer logs. There is some renewed interest in using biofuels for power generation. Production of biofuels requires a high intensity plantation over a very short rotation, which is technically feasible. Profitability depends on very large increases in power costs (from a current cost of about $0.03 per kilowatt-hour for hydropower to at least $0.10 per kilowatt-hour). Based on the costs used in this study, it is unlikely that biofuels could be a profitable market for Willamette Valley poplar in the near future.

Native cottonwood has been used in the region for plywood and solid wood products, and some small local market outlets do exist. Growing poplar for longer rotation periods (20 years or more) to produce larger trees for these or other uses may have economic potential. However, because a large market for poplar fiber has not been established, price trends have not been well-documented. Also, without a critical mass of available poplar, it would be highly speculative to assume a significant market other than pulp for paper at this time.

Prices

Our economic analysis showed that it could be profitable to grow poplar at chip prices between $90 and $150 per BDT, depending on factors such as site productivity and harvest age. How does that compare with current prices? What are the prospects for the future?

Current Prices

There is no open market for poplar chips to reliably determine past and current prices. Only about 8 percent of the chips consumed by Oregon pulp mills is hardwood of any kind. Most of it is red alder (Alnus rubra), and it is used by only a few mills. Poplar that is harvested from mature plantations on company land is transferred within the same company, and its market value is not revealed.

The highest reported prices for red alder chips in the Pacific Northwest export market were $97.50 per BDT in July 1993 (Wood Fiber Northwest 1993) and $100 per BDT in July 1994 (Wood Resources International, Ltd. 1994).[4] Domestic market prices for alder chips in the Willamette Valley in June 1994 were reported at $72 per BDT, compared to a Pacific Northwest regional average of $80 per BDT (Wood Resources International, Ltd. 1994).

Alder chip prices rose dramatically in the late 1980s, but fell back in the early 1990s. They are rising again and nearly reached the 1980s level in June 1994 (Associated Forest Products Consultants, Inc. 1990; B. Atkinson, Department of Forest Engineering, OSU, personal communication). The upward trend is likely to continue because of a projected wood fiber shortage over the next few years.

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[4] Chip prices must be researched carefully because they are usually reported in dollars per bone dry unit (BDU). A BDU is 2400 pounds and a BDT is 2000 pounds; thus there are 1.2 BDT per BDU. To convert from $/BDU to $/BDT, divide by 1.2.

Future Prices

There is no strong basis for forecasting future hardwood chip prices. Once a mill develops a pulp mix that uses hardwood, a secure, steady supply of it must be maintained. Prices can rise and fall rapidly if supplies fluctuate. On the other hand, without a forecast of steady supplies of hardwoods at predictable prices, the use of hardwood chips is unlikely to increase greatly.

A severe fiber shortage (a shortfall of 20 percent) has been predicted for pulp mills in the Pacific Northwest for 1995 to 1998 because of the dramatic reduction in federal timber harvest in the Pacific Northwest. Pulp mill capacity in the region was geared to the large supply of softwood residues from old-growth timber that was processed into lumber and plywood. The loss of federal timber supply represents an absolute decrease in fiber availability; as the regional harvest shifts to smaller timber from nonfederal lands, there is also a relative decrease in fiber availability because fewer residues are left after processing the smaller, sounder timber.

It is not certain what the fiber shortage means for poplar chip prices in the future. Shorter fibered hardwood is not a direct substitute for the long-fibered softwood that is being lost; however, hardwood can be blended into the pulp mix over time. It is not clear that the demand for pulp fiber will remain constant. Several pulp mills in the region are rumored to face impending closure (Marples Business Letter 1993), although none of them are mills identified in this study as potential markets for Willamette Valley poplar.

For certain paper products, some hardwood fiber is required to be competitive in national markets. Alder has traditionally filled this need. The impending shortage of alder (Hibbs et al. 1994) may increase the demand on other hardwood fiber sources, including hybrid poplar.

The increase in hardwood chip prices in the Pacific Northwest since the mid-1980s was partly fueled by an increase in export demand for wood fiber. With the impending hardwood and softwood fiber shortage in the Pacific Northwest, prices can be expected to continue to increase, even without help from the export market. Some hardwood chips will be substituted for the dwindling softwood supplies, which should keep prices at least in line with inflation. Table 6 shows the predicted increase in red alder chip prices over a 7- to 15-year period, starting with 1994 prices of either $80 or $100 per BDT and assuming three different inflation rates.

Table 6. Future chip prices per BDT at three different inflation rates, assuming 1994 chip prices of $80 or $100 per BDT.

	Inflation rate					
	2 percent		3 percent		4 percent	
Year	($/BDT)					
1994	80	100	80	100	80	100
2001	92	115	98	123	105	132
2002	94	117	101	127	109	137
2003	96	120	104	130	114	142
2004	98	122	108	134	118	148
2005	99	124	111	138	123	154
2006	101	127	114	143	128	160
2007	103	129	117	147	133	167
2008	106	132	121	151	139	173
2009	108	135	125	156	144	180

Chip Marketing Prospects

The best indicator of future market potential for poplar chips is that James River Corp. and Georgia-Pacific Corp. are recruiting Willamette Valley farmers to grow poplar. These companies are providing incentives in the form of technical advice, discount prices for planting stock, and agreements to purchase poplar stumpage or chips at market or negotiated prices.

Georgia-Pacific Corp. recently announced a goal of contracting 2000 acres per year for poplar production (Hahn 1994). James River Corp. has established 11,000 acres of poplar plantations in the lower Columbia River region of Oregon and Washington. Boise Cascade Corp. and Potlach Corp. have over 20,000 acres in eastern Oregon and Washington that are planted in poplar; these companies are planning to more than double that acreage. However, these large-scale operations are an integral part of the fiber supply strategies for existing company pulp mills and are not dependent on open market speculation.

The farmer who plants a small tract of poplars every few years is not likely to be much different from small woodlot owners who often rely on consultants for marketing advice. However, economic risk can be diminished by a prior formal agreement with a company that uses poplar chips or with a fiber marketing cooperative. Risk can also be diminished by a competitive market in which high chip demand and prices occur at about the time a plantation matures.

A hybrid poplar marketing cooperative in southwest Washington (Columbia Consulting Group, Inc. 1993) has sponsored marketing studies for that region, which overlaps with the marketing area for the Willamette Valley (Associated Forest Products Consultants, Inc. 1990). If the cooperative can encourage a critical mass of growers to participate, marketing options would likely increase to include more distant pulp mills and perhaps foreign export.

Regional Land Base Resources

The regional land base suited to poplar production was estimated to evaluate the regional productivity potential. This estimate incorporates information from individual Soil Conservation Service (SCS) county soil surveys and from the SCS's 1982 National Resource Inventory (NRI) (Soil Conservation Service 1982) to reflect both soil classification and land use.

The acreage of each soils series within each county is estimated in the individual county soil surveys; this information is considered to accurately reflect how these soils are distributed on the Willamette Valley landscape. The distribution in eight Willamette Valley counties is summarized in Table 7. However, the SCS soil survey estimates do not reflect land use or the availability of this land for agricultural activities. Rural and urban development each reduce the amount of available cropland. The NRI categorizes the total acreage of each soil series by land use, although only on a watershed scale.

We used the NRI estimates of cropland to adjust the SCS soil survey estimates to reflect land use patterns within an individual soil series in each county. The adjusted county estimate for each soil series was calculated as follows:

$$\text{Adjusted county estimate} = \frac{\text{NRI Total (cropland)}}{\text{SCS Total (8 counties)}} \times \text{SCS county estimate}$$

The adjusted distribution of Willamette Valley soil series by county and Productivity Class is summarized in Table 8.

Economic and Market Analysis Summary

Based on the results of the economic analysis and the discussion of market prospects, the viability of a poplar crop in the Willamette Valley might be summed up with words such as feasible, risky, tantalizing. There is clearly a huge acreage that could be planted to poplar. There is no apparent reason to reject poplar as an alternative crop and also no apparent reason to convert an entire farm operation to poplar. For farmers who are looking to diversify their crop base, it may be worth trying. Poplar may be least risky and most profitable if grown on soil on which annual ryegrass yields are low but poplar yields are moderate.

The 1994 chip price of $80 per BDT is close to the break-even price of $97 for improved hybrid on medium-high productivity soils (Table 4). Except for low productivity soils, the improved hybrid would reach its break-even price within 15 years for any of the inflation rates shown. For the low productivity soils, the break-even price would be reached within 15 years if the inflation rate is 3 percent or more. (Note: in September 1995, the price was already $135 per BDT.)

This analysis should be qualified regarding the risk of poplar production. The risk may be overstated somewhat because poplar chips may be more valuable than red alder chips are in comparable use. Poplar is relatively more white than alder, and the pulp requires less bleaching than does alder pulp. Reduced bleaching can help mitigate a pressing environmental problem for some Pacific Northwest pulp mills and may lead to higher chip prices for poplar than for alder.

Another factor that may reduce the risk of poplar production is the flexible timing in marketing poplar. The production cycle may be shortened or lengthened to take advantage of or avoid price fluctuations. Also, if the chip market slumps, poplar may be grown out until it is large enough to produce veneer logs. Some analysts have shown that net returns can be enhanced by varying the production cycle in a plantation to produce both pulp chips and veneer logs (Columbia Consulting Group, Inc. 1993; Heilman et al. 1995). However, a longer production cycle (beyond 10 years) crosses a state regulatory boundary between agriculture and forestry and may also subject a plantation to Federal wetland regulations. Regulatory issues can affect taxes, crop subsidy eligibility, riparian management, and wetland status.

The break-even prices (and net returns) are sensitive to the assumptions about poplar yields and the costs of production. On average, 62 percent of the accumulated costs from site preparation through delivery of chips to a mill occurs during the preharvest stage; the other 38 percent occurs at the end of the production cycle. Changes in preharvest costs will result in disproportionate changes in the break-even price at harvest time because costs are carried over from the preharvest stage; changes in harvesting, processing, and transportation costs will produce a proportionate change in the break-even price.

Table 7. Soil Conservation Service (SCS) estimates of the distribution of selected soils in eight Willamette Valley counties.

Productivity Class	Benton	Clackamas	Lane	Linn	Marion	Polk	Washington	Yamhill	SCS Total
Soil series	(acres)								
High									
Camas (gravelly sandy loam)	1,934	1,781	6,370	2,185	5,815	533			**18,618**
Chehalis (silty clay loam, silt loam)	10,365	2,274	9,300	10,895	5,730	4,672	7,901	5,710	**56,847**
Clackamas (gravelly silt loam)		3,127		12,375	10,430				**25,932**
Cloquato (silt loam)	4,806	5,373	5,170	8,350	20,165	3,063		5,410	**52,337**
McBee (silty clay loam)	2,050	3,366	5,200	7,930	3,750	1,696	9,494	450	**33,936**
Newberg (loam, fine sandy loam)	5,771	5,111	18,460	14,185	11,563	2,726		3,350	**61,166**
Salem (gravelly silt loam, silt loam 0-12%)	587	10,586	7,550	5,010	5,640	3,094			**32,467**
Sifton (gravelly loam, variant)			650	1,480	6,450				**8,580**
Total	**25,513**	**31,618**	**52,700**	**62,410**	**69,543**	**15,784**	**17,395**	**14,920**	**289,883**
Medium-High									
Aloha (silt loam 0-6%)		28,578					28,801	5,830	**63,209**
Amity (silt loam)	6,100	5,943		26,700	45,109	9,721	6,092	13,360	**113,025**
Awbrig (silty clay loam)			9,890	9,985					**19,875**
Chapman (loam)			3,800	7,000					**10,800**
Coburg (silty clay loam)	7,233	3,729	13,480	16,165		3,465			**44,072**
Concord (silt loam)	1,198	2,293		10,835	14,980	5,755			**35,061**
Conser (silty clay loam)	2,704	1,727	4,200	9,955					**18,586**
Malabon (silty clay loam)	8,265	405	15,350	13,445		4,810			**42,275**
Waldo (silty clay loam)	8,406		7,550	6,800	3,380	12,480			**38,616**
Wapato (silt loam silty clay loam)	1,217	5,381	2,320	4,920	11,008	3,053	11,548	9,670	**49,117**
Willamette (silt loam 0-20%)	7,025	6,281		7,125	11,000	4,374	7,325	5,910	**49,040**
Woodburn (silt loam 0-20%)	10,148	21,945	215	31,530	65,297	23,021	34,027	36,810	**222,993**
Total	**52,296**	**76,282**	**56,805**	**144,460**	**150,774**	**66,679**	**87,793**	**71,580**	**706,669**
Medium-Low									
Bashaw (clay, silty clay, silty clay loam)	6,095		9,650	25,635	4,830	2,861			**49,071**
Cove (clay silty clay loam (all))		3,534				6,577	5,010	8,040	**23,161**
Holcomb (silt loam)			1,560	17,530	2,430	1,359			**22,879**
Santiam (silt loam 3-6%)				3,240	1,430	5,605			**10,275**
Verboot (silty clay loam)							6,756		**6,756**
Total	**6,095**	**3,534**	**11,210**	**46,405**	**8,690**	**16,402**	**11,766**	**8,040**	**112,142**

Table 7. continued.

Productivity Class Soil series	Benton	Clackamas	Lane	Linn	Marion	Polk	Washington	Yamhill	SCS Total
	----------	----------	----------	----------	(acres)	----------	----------	----------	----------
Low									
Courtney (gravelly silty clay loam)			2,820	8,500	4,850				**16,170**
Dayton (silt loam (all))	15,362	5,772	4,280	59,075	10,440	9,767	2,672	4,420	**111,788**
Natroy (silty clay, silty clay loam)			17,170						**17,170**
Total	**15,362**	**5,772**	**24,270**	**67,575**	**15,290**	**9,767**	**2,672**	**4,420**	**145,128**
Grand total	**183,170**	**228,640**	**265,700**	**574,125**	**473,304**	**207,497**	**236,580**	**193,500**	**2,362,516**

Table 8. Adjusted estimates[1] of the distribution of selected soils in eight Willamette Valley counties.

Productivity Class Soil series	Benton	Clackamas	Lane	Linn	Marion	Polk	Washington	Yamhill	Adjusted Total	Percent of SCS Total[2]
	----------	----------	----------	----------	(acres)	----------	----------	----------	----------	----------
High										
Camas (gravelly sandy loam)	177	163	582	200	531	49			**1,700**	9.13
Chehalis (silty clay loam, silt loam)	7,275	1,596	6,528	7,647	4,022	3,279	5,546	4,008	**39,900**	70.19
Clackamas (gravelly silt loam)		1,990		7,874	6,636				**16,500**	63.63
Cloquato (silt loam)	3,489	3,901	3,754	6,063	14,641	2,224		3,928	**38,000**	72.61
McBee (silty clay loam)	459	754	1,165	1,776	840	380	2,126	101	**7,600**	22.40
Newberg (loam, fine sandy loam)	4,312	3,819	13,792	10,598	8,639	2,037		2,503	**45,700**	74.71
Salem (gravelly silt loam, silt loam 0-12%)	128	2,315	1,651	1,096	1,233	677			**7,100**	21.87
Sifton (gravelly loam, variant)			871	1,984	8,645				**11,500**	134.03
Total	**15,840**	**14,537**	**28,342**	**37,237**	**45,188**	**8,645**	**7,672**	**10,539**	**168,000**	

Table 8. continued.

Productivity Class Soil series	Benton	Clackamas	Lane	Linn	Marion	Polk	Washington	Yamhill	Adjusted Total	Percent of SCS Total[2]
	-------	-------	-------	-------	(acres)	-------	-------	-------	-------	-------
Medium-High										
Aloha (silt loam 0-6%)		15,779					15,902	3,219	**34,900**	55.21
Amity (silt loam)	4,690	4,569		20,528	34,682	7,474	4,684	10,272	**86,900**	76.89
Awbrig (silty clay loam)			10,748	10,852					**21,600**	108.68
Chapman (loam)			1,337	2,463					**3,800**	35.19
Coburg (silty clay loam)	4,924	2,538	9,176	11,004		2,359			**30,000**	68.07
Concord (silt loam)	851	1,628		7,695	10,639	4,087			**24,900**	71.02
Conser (silty clay loam)	1,484	948	2,305	5,463					**10,200**	54.88
Malabon (silty clay loam)	4,242	208	7,879	6,901		2,469			**21,700**	51.33
Waldo (silty clay loam)	1,807		1,623	1,462	726	2,682			**8,300**	21.49
Wapato (silt loam, silty clay loam)	488	2,158	931	1,973	4,415	1,225	4,632	3,878	**19,700**	40.11
Willamette (silt loam 0-20%)	5,329	4,765		5,405	8,344	3,318	5,556	4,483	**37,200**	75.86
Woodburn (silt loam,0-20%)	7,104	15,362	151	22,072	45,709	16,115	23,820	25,768	**156,100**	70.00
Total	**30,918**	**47,956**	**34,149**	**95,818**	**104,516**	**39,729**	**54,594**	**47,620**	**455,300**	
Medium-Low										
Bashaw (clay, silty clay, silty clay loam)	2,844		4,503	11,963	2,254	1,335			**22,900**	46.67
Cove (clay, silty clay loam (all))		1,938				3,606	2,747	4,409	**12,700**	54.83
Holcomb (silt loam)			505	5,670	786	440			**7,400**	32.34
Santiam (silt loam 3-6%)				1,987	877	3,437			**6,300**	61.31
Verboot (silty clay loam)							1,700		**1,700**	25.16
Total	**2,844**	**1,938**	**5,008**	**19,620**	**3,917**	**8,818**	**4,447**	**4,409**	**51,000**	
Low										
Courtney (gravelly silty clay loam)			645	1,945	1,110				**3,700**	22.88
Dayton (silt loam (all))	9,798	3,681	2,730	37,679	6,659	6,230	1,704	2,819	**71,300**	63.78
Natroy (silty clay, silty clay loam)			8,400						**8,400**	48.92
Total	**9,798**	**3,681**	**11,775**	**39,624**	**7,769**	**6,230**	**1,704**	**2,819**	**83,400**	
Grand total	**109,004**	**132,542**	**146,774**	**344,972**	**315,010**	**120,613**	**135,130**	**127,956**	**1,432,000**	

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[1] National Resource Inventory estimates of acreage by land use (Soil Conservation Service 1982) were used to adjust Soil Conservation Service (SCS) estimates.

[2] (Adjusted total)/(SCS total) x 100. SCS totals are listed in Table 7.

A 12-percent interest rate was used in this analysis to carry preplanting, planting, and other variable costs (except general overhead) through the production cycle. This analysis was therefore comparable to annual ryegrass enterprise budgets, which use the same rate to carry the annual working capital. Break-even prices are also affected disproportionately by changes in this interest rate.

Poplar yields vary with all the usual factors that affect farming: management practices, weather, diseases, insects, and animal damage. The yields used in this study reflect plantations that have grown over a number of years with varying management practices and environmental conditions. We believe that the yields are within the expected range for the two hybrids included in this analysis.

Future Information Needs

The future of poplar in the Willamette Valley was not defined by this project. A poplar crop appears technically feasible, although the economic benefits remain unclear. Much will hinge on future market changes that are beyond local control. The farming practices that are developed and used locally will also influence profitability.

Clearly, poplar is potentially profitable under a wide range of scenarios. One local grower suggested that there is enough promise to justify growing poplar if a farmer likes growing it. Many growers are looking for more concrete justifications. Some want more facts on productivity levels; others want to wait for the development of cultural practices specific to valley conditions. Most want to see where prices head. In short, most potential growers still want more information.

Some thought, planning, and commitment are needed to develop better information to answer current and future questions. One objective of this project was to describe some approaches to filling future information needs. The decisions on whether and how to incorporate poplar as a crop alternative in the Willamette Valley must come largely from the agricultural community.

Different kinds and intensities of activities are justified by different objectives in the agricultural community. If the primary objective is to continue to evaluate poplar’s potential, a limited agenda of research activities is justified, focusing on refining the growth responses of poplar on different soils. In this case, monitoring new farm plantations may be sufficient. This activity would improve our understanding of poplar’s response to current field conditions, but it would not improve management ability.

If the primary objective is to develop regionally specific farming practices and perhaps support future development and expansion of poplar, much more intensive research and extension work are needed. This objective requires work that specifically evaluates the effects and usefulness of different cultural practices, as well as the interaction of soils, clones, and management. Some potential research activities are described below.

Potential Research and Educational Activities

Soil and Clone Productivity

Through the field survey, this project compiled valuable information on poplar growth on different soils. But the data on which to predict future yields are limited. The data base has no data on the differences among clone performances on different soils, and it only allows educated guesses of performance on soils not sampled. Any future work should include efforts to improve this understanding.

An elaborate experimental design could place a variety of clones on all of the Willamette Valley soil series and follow them through a rotation, but the same ends could be achieved by monitoring new stands that farmers establish over the next few years. Such monitoring might involve collecting establishment information (soil, clones, weed control, site preparation) and then annually measuring clone sizes, beginning at year 3. This approach would yield less information than a systematic approach since some soils may not be included, but the costs would be much lower.

Growers frequently ask which of the many poplar clones are most suited to the Willamette Valley. While tracking the development of new commercial stands may help answer this question, more structured screening must be considered. Local screening can evaluate disease responses and help rank the large pool of public hybrid material worthy of more extensive trial plantings.

Plantation Establishment

Current cultural practices were developed under soil and climate conditions quite different from those in the Willamette Valley. It is unclear how much can be gained from modifying these practices. Plantation establishment involves many separate farming practices, including straw management, tillage, planting methods, and weed control. The effectiveness of each practice may vary with soil, season, or past cropping history, as well as with interactions between practices, such as between tillage and herbicide use.

Cultural practices include different degrees of soil preparation, from no-tillage to completely working a field prior to planting, as well as the effects of hilling or deep soil ripping. Moisture-conserving practices such as straw retention or shallow summer tillage may influence establishment success, as might the size and placement of cuttings. And while herbicides are central to effective weed control, the combination of particular field preparation practices and herbicides may interfere with tree establishment.

Questions about what establishment practices are most effective can only be addressed systematically through planned experiments. But like the productivity questions, establishment practices may best be evaluated by selecting treatments and establishing trial plots in operational plantations in cooperation with farmers and private industry. The efficiency of this approach could be improved by developing a standard treatment protocol for establishing the trial plots. The protocol would include combinations of site preparation and weed control treatments.

Fertilization and Irrigation

Both fertilization and irrigation are likely to increase poplar growth. Growth in first-year plantations has responded well to irrigation; the benefits may occur either during or following plantation establishment. No systematic work has been done with fertilization.

As with plantation establishment, these questions can only be addressed systematically through planned experiments, but fertilization, at least, could be evaluated in cooperation with farmers in operational plantations. A standard treatment protocol for farmers to follow for establishing trial plots would include combinations of fertilizer types and rates of application.

Regulations

An assortment of state and federal regulations in agriculture and forestry may apply to poplar production. These regulations can be confusing; they sometimes appear contradictory. Some regulations discourage the longer rotations needed for sawlog or veneer log production, and thus restrict marketing options.

Two activities are needed regarding regulations. First, a descriptive summary of these regulations should be prepared in nontechnical language to clarify the existing situation. Second, regulatory change should be promoted to increase clarity and consistency among regulations and thereby remove impediments to management. This would best be pursued by activities at the private citizen, farm organizational, corporate, and agency levels.

Education

Educational opportunities for farmers about poplar cultural practices, harvesting, marketing, and economics are needed. Also, as poplar acreage increases in the valley, so will the need for the management assistance farmers receive from agricultural and forestry professionals. Thus, professionals in the Oregon Departments of Agriculture and Forestry, county Extension Service, Natural Resources Conservation Service, and the farm industry need to be targeted by educational programs.

Conclusion

If poplar is to become an established crop in the Willamette Valley, more work in research and extension is needed. A cooperative effort between private landowners, industry, and public entities would be most beneficial. This project has contributed some basic information about poplar growth in the valley, but it has also exposed needs for future development of poplar as a crop. We recognize that the agricultural community must first determine the scope of these activities in order that OSU and the Department of Forest Science may effectively continue their role in either research or extension.

Literature Cited

ASSOCIATED FOREST PRODUCTS CONSULTANTS, INC. 1990. A study of marketing prospects for hybrid cottonwood grown in southwest Washington by private landowners. Report prepared for the Columbia-Pacific Resource Conservation and Development Corp., Aberdeen, Washington. 82 p.

BOERSMA, L., G.H. SIMONSON, and D.G. WATTS. 1970. Characterization of water tables in Oregon soils with reference to trafficability. Volume II: Analysis. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Contract Report M-70-l. 71 p.

BROWNE, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. British Columbia Forest Service, Forest Surveys and Inventory Division, Victoria, B.C. 9 p.

COLUMBIA CONSULTING GROUP, INC. 1993. Business plan: hybrid poplar cooperative, southwest Washington. Report prepared for the Columbia-Pacific Resource Conservation and Development Corp., Aberdeen, Washington. 30 p.+ Appends.

CROSS, T., M. MELLBYE, B. YOUNG, and M. TAYLOR. 1992. Enterprise budget: perennial ryegrass seed establishment, Willamette Valley Region. Oregon State University Extension Service, Corvallis, Oregon. Miscellaneous Publication EM8496. 3 p.

HAHN, P.F. 1994. Short-rotation hybrid poplar bio-mass production. Georgia-Pacific Forestry Research Center, Cottage Grove, Oregon. 10 p.

HEILMAN, P.E., R.F. STETTLER, D.P. HANLEY, and R.W. CARKNER. 1995. High yield hybrid poplar plantations in the Pacific Northwest. Revised edition. Washington State University Cooperative Extension (Pullman, Washington); Oregon State University Extension Service (Corvallis, Oregon); University of Idaho Cooperative Extension System (Moscow, Idaho); USDA (Washington, D.C.). Pacific Northwest Bulletin PNW 356. 41 p.

HIBBS, D.E., D.S. DeBELL, and R.F. TARRANT. 1994. The Biology and Management of Red Alder. Oregon State University Press, Corvallis. 256 p.

HUDDLESTON, H.J. 1982. Agricultural productivity ratings for soils of the Willamette Valley. Oregon State University Extension Service, Corvallis, Oregon. Extension Circular EC 1105.

HUSCH, B., C.I. MILLER, and T.W. BEERS. 1972. Forest Mensuration. Second edition. Ronald Press Co., New York. 410 p.

MARPLES BUSINESS LETTER. 1993. Regional outlook, pulp and paper. November 24, 1993. Marples, Seattle, Washington.

SOIL CONSERVATION SERVICE. 1982. National Resource Inventory. Washington, D.C.

TAYLOR, M., T. CROSS, and M. MELLBYE. 1990. Enterprise budget: annual ryegrass seed (no-till), Willamette Valley Region. Oregon State University Extension Service, Corvallis, Oregon. Miscellaneous Publication EM8423. 4 p.

WOOD FIBRE NORTHWEST, INC. 1993. Market report - June 1993. Wood Fibre Northwest, Inc., Albany, Oregon.

WOOD RESOURCES INTERNATIONAL, LTD. 1994. Market report - June 1994. Wood Resources International, Ltd., Reston, Virginia.

YOUNG, W.C., III, M.E. MELLBYE, and T.L. CROSS. 1994. Annual ryegrass seed production in the southern Willamette Valley: implications for availability of straw. Department of Crop and Soil Science, Oregon State University, Corvallis, Oregon. Special Report Ext/CrS 100. 11 p.

Interviews/Consultation

Atkinson, Bill, Professor, Department of Forest Engineering, Oregon State University, Corvallis, Oregon. 1994.

Badger, Phil, SE Regional Biomass Program, U.S. Department of Energy, Muscle Shoals, Alabama. 1994.

Baham, John, Associate Professor, Department of Soils and Crop Science, Oregon State University, Corvallis, Oregon. 1994.

Breuner, R.E., Manager, Fiber Supply, Smufit Newsprint Corp., Oregon City, Oregon. 1994.

Dutrow, George, Forest Economist, Duke University, Durham, North Carolina. 1994 (telephone).

Hahn, Philip F., Manager, Forestry Research, Georgia-Pacific Corp., Cottage Grove, Oregon. 1994.

Heilman, Paul E., Forest Scientist, Washington State University, Puyallup, Washington. 1994 (telephone).

Kellison, Bob, Geneticist, Hardwood Genetics Program, North Carolina State University, Raleigh, North Carolina. 9/2/94 (telephone).

Lewis, Charles S., Forestry Consultant, Albany, Oregon. 1994.

Mellbye, Mark, District Extension Agronomist, Oregon State University Extension Service, Albany, Oregon. 1994.

Moulton, Richard E., Projects Director, Columbia-Pacific Resource Conservation and Development, Aberdeen, Washington.

Olson, John., Project Manager, Hybrid Poplar Program, Potlatch Corp., Boardman, Oregon. 1994.

Rice, Donald E., Supervisor, Lower Columbia Fiber Farm, James River Corp., Clatskanie, Oregon. 1994.

Storm, Rex, Forester, American Pulpwood Association, Inc., Eugene, Oregon. 1994.

Strauss, Charles, Forest Economist, School of Forest Resources, The Pennsylvania State University, State College, Pennsylvania. 1994 (telephone).

Toliver, John R., Forest Management Research, USDA Forest Service, Washington, D.C. 1994 (telephone).

Turnbull, Jane, Biofuels Specialist, Electric Power Research Institute, Palo Alto, California. 1994 (telephone).

Wearstler, Kenneth A., Jr., President, Poplar Intensive Culture Technologies, Pasco, Washington. 1994.

Young, William C., III, Extension Seed Production Specialist, Department of Crop and Soil Sciences, Oregon State University, Corvallis,

APPENDIX 1
Equations for Estimating Growth and Yield

Stand Volume

An important step in modeling stand growth was to calculate stand volume; we applied a volume equation developed for native cottonwood by Browne (1962). The equation uses survey values of mean tree height and DBH (including bark) to calculate stem volume (without bark), from base to terminal bud, for an average tree:

$$\text{Log base}_{10}\ \text{TVol} = -2.95 + 1.80 \log \text{DBH} + 1.24 \log \text{Ht} \qquad (1)$$

where TVol = average stem volume (ft^3); DBH = diameter at breast height (in.); and Ht = height (ft). To calculate stand volumes (ft^3 per acre), average stem volume was multiplied by stand density (trees per acre).

Yield Function

A Chapman-Richards nonlinear regression model was developed to describe the relationship between stand volume and height, density, and age of surveyed stands of clone H-11. Data from 24 stands of clone H-11, age 2 to 7 years, were used to develop this regression model:

$$\begin{aligned} \text{SVol} = {} & [-2612.58 + 13.46(\text{Dens})]\{1\text{-}\exp[-\text{Age}(0.0031(\text{HI}) \\ & + 0.00015(\text{Dens}))]\}^{[0.012(\text{Dens})]} \qquad (2) \\ R^2 = {} & 0.997 \end{aligned}$$

where SVol = stand volume (ft^3); Dens = stand density (trees/acre); HI = Height Index (percent); and Age = stand age (years).

The model was then used to estimate yield (stand volume) over 10 years for clone H-11 planted at a spacing of 600 trees per acre. Yield was estimated for each Productivity Class. A single representative value was needed to describe potential yields in the economic analysis. A simple mean was taken for the Medium-High and Medium-Low classes. For the High class, the representative value was 10 percent above the lowest value for the class; for the Low class, the representative value was 10 percent below the highest value for the class. (Note: maximum growth rates are limited by the biology of the tree. No natural restriction besides death limits the range of growth on the low end of the scale.)

Conversion From Green Volume to Dry Weight

A specific gravity value of 0.31 was used to convert green volume estimates to dry weight. The value represents a mean of 16 hybrid clones, age 3 and 4 years. This value was based on oven-dry weight and green volume of clean wood (no bark) at breast height (P.E. Heilman, Washington State University, personal communication). The following series of equations was used to convert from green volume to dry weight:

Dry density = (specific gravity) X (density of water) (3)

Green density = dry density + (dry density X percent moisture content based on dry weight) (4)

Green wood volume = (2000 lb./ton)/(green density) (5)

Green tons per acre = (harvest volume)/(green wood volume) (6)

BDT per acre = (green tons/acre) X (dry matter content) (7)
where dry matter content = (dry weight)/(total weight)

Appendix 2

Economic Analysis Results

Table A1. Estimated variable costs for hybrid poplar: minimum site preparation following annual ryegrass.

	Variable costs ($/acre)			
Cost categories	Labor	Machinery	Materials	Total
Preplanting and planting				
Tillage (single rip)	1.75	4.97	0	6.72
Spray[1] (February)	0	0	20.25	20.25
Planting stock[2]	30.00	0	125.00	155.00
General overhead[3]	0	0	10.42	10.42
Pickup[4]	1.44	1.06	0	2.50
Capital interest[5]	0	0	1.35	1.35
Total	**33.19**	**6.03**	**157.02**	**196.24**
First growing season				
Spot spray (May-June)	0	0	7.00	7.00
Cultivation[6] (May-June)	3.04	6.34	0	9.38
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	25.50	25.50
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	23.81	23.81
Total	**7.99**	**8.89**	**59.31**	**76.19**
Second growing season				
Spray[1] (winter)	0	0	18.25	18.25
Spot spray (May-June)	7.00	0	0	7.00
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	26.01	26.01
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	31.08	31.08
Total	**11.95**	**2.55**	**78.34**	**92.84**
Third growing season				
General overhead[8]	0	0	26.53	26.53
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	36.10	36.10
Total	**3.45**	**2.55**	**62.63**	**68.63**
Fourth growing season				
General overhead[8]	0	0	27.06	27.06
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	41.15	41.15
Total	**3.45**	**2.55**	**68.21**	**74.21**
Fifth growing season				
General overhead[8]	0	0	27.60	27.60
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	46.81	46.81
Total	**3.45**	**2.55**	**74.41**	**80.41**

Table A1. continued.

Cost categories	Variable costs ($/acre) Labor	Machinery	Materials	Total
Sixth growing season				
General overhead[8]	0	0	28.15	28.15
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	53.15	53.15
Total	**3.45**	**2.55**	**81.30**	**87.30**
Seventh growing season				
General overhead[8]	0	0	28.72	28.72
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	60.25	60.25
Total	**3.45**	**2.55**	**88.96**	**94.96**
Eighth growing season				
General overhead[8]	0	0	29.29	29.29
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	68.19	68.19
Total	**3.45**	**2.55**	**97.49**	**103.49**
Ninth growing season				
General overhead[8]	0	0	29.88	29.88
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	77.10	77.10
Total	**3.45**	**2.55**	**106.98**	**112.98**
Tenth growing season				
General overhead[8]	0	0	30.47	30.47
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	87.07	87.07
Total	**3.45**	**2.55**	**117.54**	**123.54**

[1] Spray costs include: Herbicides (0.5 qt X $10/qt = $5.00; 0.75 oz X $11/oz = $8.25); Adjuvant ($2.00); Custom application ($5.00). No adjuvant applied during the second growing season.

[2] Stock costs: 622 cuttings X $0.20/cutting = $125.

[3] Overhead costs prorated for 5 months @ $25/year.

[4] Pickup costs prorated for 5 months.

[5] Interest at 12 percent on establishment costs.

[6] Cultivation performed twice.

[7] Repellent discounted to 30 percent of full cost.

[8] Overhead costs represent 2 percent annual increase.

[9] Interest at 12 percent on all operations to date.

Table A2. Estimated variable costs for hybrid poplar: minimum site preparation following perennial ryegrass.

Cost categories	Variable costs ($/acre) Labor	Machinery	Materials	Total
Preplanting and planting				
Tillage (single rip)	1.75	4.97	0	6.72
Spray[1] (February)	0	0	39.00	39.00
Planting stock[2]	30.00	0	125.00	155.00
General overhead[3]	0	0	10.42	10.42
Pickup[4]	1.44	1.06	0	2.50
Capital interest[5]	0	0	2.29	2.29
Total	**33.19**	**6.03**	**176.70**	**215.92**
First growing season				
Spot spray (May-June)	0	0	7.00	7.00
Cultivation[6] (May-June)	3.04	6.34	0	9.38
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	25.50	25.50
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	26.17	26.17
Total	**7.99**	**8.89**	**61.67**	**78.55**
Second growing season				
Spray[10] (winter)	0	0	23.50	23.50
Spot spray (May-June)	7.00	0	0	7.00
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	26.01	26.01
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	34.35	34.35
Total	**11.95**	**2.55**	**86.86**	**101.36**
Third growing season				
General overhead[8]	0	0	26.53	26.53
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	39.77	39.77
Total	**3.45**	**2.55**	**66.30**	**72.30**
Fourth growing season				
General overhead[8]	0	0	27.06	27.06
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	45.26	45.26
Total	**3.45**	**2.55**	**72.32**	**78.32**
Fifth growing season				
General overhead[8]	0	0	27.60	27.60
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	51.41	51.41
Total	**3.45**	**2.55**	**79.01**	**85.01**
Sixth growing season				
General overhead[8]	0	0	28.15	28.15
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	58.30	58.30
Total	**3.45**	**2.55**	**86.46**	**92.46**

Table A2. continued.

Cost categories	Variable costs ($/acre) Labor	Machinery	Materials	Total
Seventh growing season				
General overhead[8]	0	0	28.72	28.72
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	66.02	66.02
Total	**3.45**	**2.55**	**94.74**	**100.74**
Eighth growing season				
General overhead[8]	0	0	29.29	29.29
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	74.66	74.66
Total	**3.45**	**2.55**	**103.95**	**109.95**
Ninth growing season				
General overhead[8]	0	0	29.88	29.88
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	84.34	84.34
Total	**3.45**	**2.55**	**114.22**	**120.22**
Tenth growing season				
General overhead[8]	0	0	30.47	30.47
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	95.18	95.18
Total	**3.45**	**2.55**	**125.66**	**131.66**

[1] Spray costs include: Herbicides (1.0 qt X $10/qt = $10.00; 2.0 oz X $11/oz = $22.00); Adjuvant ($2.00); Custom application ($5.00).

[2] Stock costs: 622 cuttings X $0.20/cutting = $125.

[3] Overhead costs prorated for 5 months @ $25/year.

[4] Pickup costs prorated for 5 months.

[5] Interest at 12 percent on establishment costs.

[6] Cultivation performed twice.

[7] Repellent discounted to 30 percent of full cost.

[8] Overhead costs represent 2 percent annual increase.

[9] Interest at 12 percent on all operations to date.

[10] Spray costs include: Herbicides (0.75 qt X $10/qt = $7.50; 1.0 oz X $11.00/oz = $11.00); Custom application ($5.00).

Table A3. Estimated variable costs for hybrid poplar: full tillage site preparation following annual ryegrass.

Cost categories	Variable costs ($/acre)			
	Labor	Machinery	Materials	Total
Preplanting and planting				
Tillage				
Plow	2.12	5.71	0	7.83
Harrow	0.85	1.33	0	2.18
Harrow and roll[1]	1.69	3.51	0	5.20
Single rip	1.75	4.97	0	6.72
Spray[2] (February)	0	0	20.25	20.25
Planting stock[3]	30.00	0	125.00	155.00
General overhead[4]	0	0	10.42	10.42
Pickup[5]	1.44	1.06	0	2.50
Capital interest[6]	0	0	2.11	2.11
Total	**37.85**	**16.58**	**157.78**	**212.21**
First growing season				
Spot spray (May-June)	0	0	7.00	7.00
Cultivation[1] (May-June)	3.04	6.34	0	9.38
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	25.50	25.50
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	25.73	25.73
Total	**7.99**	**8.89**	**61.23**	**78.11**
Second growing season				
Spray[2] (winter)	0	0	18.25	18.25
Spot spray (May-June)	7.00	0	0	7.00
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	26.01	26.01
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	33.22	33.22
Total	**11.95**	**2.55**	**80.48**	**94.98**
Third growing season				
General overhead[8]	0	0	26.53	26.53
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	38.50	38.50
Total	**3.45**	**2.55**	**65.03**	**71.03**
Fourth growing season				
General overhead[8]	0	0	27.06	27.06
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	43.84	43.84
Total	**3.45**	**2.55**	**70.91**	**76.91**
Fifth growing season				
General overhead[8]	0	0	27.60	27.60
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	49.83	49.83
Total	**3.45**	**2.55**	**77.43**	**83.43**

Table A3. continued.

Cost categories	Variable costs ($/acre) Labor	Machinery	Materials	Total
Sixth growing season				
General overhead[8]	0	0	28.15	28.15
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	56.53	56.53
Total	**3.45**	**2.55**	**84.68**	**90.68**
Seventh growing season				
General overhead[8]	0	0	28.72	28.72
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	64.03	64.03
Total	**3.45**	**2.55**	**92.75**	**98.75**
Eighth growing season				
General overhead[8]	0	0	29.29	29.29
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	72.43	72.43
Total	**3.45**	**2.55**	**101.72**	**107.72**
Ninth growing season				
General overhead[8]	0	0	29.88	29.88
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	81.84	81.84
Total	**3.45**	**2.55**	**111.72**	**117.72**
Tenth growing season				
General overhead[8]	0	0	30.47	30.47
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	92.38	92.38
Total	**3.45**	**2.55**	**122.86**	**128.86**

[1] Performed twice.
[2] Spray costs include: Herbicides (0.5 qt X $10/qt = $5.00; 0.75 oz X $11/oz = $8.25); Adjuvant ($2.00); Custom application ($5.00). No adjuvant applied during the second growing season.
[3] Stock costs: 622 cuttings X $0.20/cutting = $125.
[4] Overhead costs prorated for 5 months @ $25/year.
[5] Pickup costs prorated for 5 months.
[6] Interest at 12 percent on establishment costs.
[7] Repellent discounted to 30 percent of full cost.
[8] Overhead costs represent 2 percent annual increase.
[9] Interest at 12 percent on all operations to date.

Table A4. Estimated variable costs for hybrid poplar: full tillage site preparation following perennial ryegrass.

	Variable costs ($/acre)			
Cost categories	Labor	Machinery	Materials	Total
Preplanting and planting				
Tillage				
Plow	2.12	5.71	0	7.83
Harrow	0.85	1.33	0	2.18
Harrow and roll[1]	1.69	3.51	0	5.20
Single rip	1.75	4.97	0	6.72
Spray[2] (February)	0	0	39.00	39.00
Planting stock[3]	30.00	0	125.00	155.00
General overhead[4]	0	0	10.42	10.42
Pickup[5]	1.44	1.06	0	2.50
Capital interest[6]	0	0	3.05	3.05
Total	**37.85**	**16.58**	**177.46**	**231.89**
First growing season				
Spot spray (May-June)	0	0	7.00	7.00
Cultivation[1] (May-June)	3.04	6.34	0	9.38
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	25.50	25.50
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	28.09	28.09
Total	**7.99**	**8.89**	**63.59**	**80.47**
Second growing season				
Spray[10] (winter)	0	0	23.50	23.50
Spot spray (May-June)	7.00	0	0	7.00
Animal control[7]	1.50	0	3.00	4.50
General overhead[8]	0	0	26.01	26.01
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	36.50	36.50
Total	**11.95**	**2.55**	**89.01**	**103.51**
Third growing season				
General overhead[8]	0	0	26.53	26.53
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	42.17	42.17
Total	**3.45**	**2.55**	**68.70**	**74.70**
Fourth growing season				
General overhead[8]	0	0	27.06	27.06
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	47.95	47.95
Total	**3.45**	**2.55**	**75.01**	**81.01**
Fifth growing season				
General overhead[8]	0	0	27.60	27.60
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	54.43	54.43
Total	**3.45**	**2.55**	**82.03**	**88.03**

Table A4. continued.

Cost categories	Variable costs ($/acre) Labor	Machinery	Materials	Total
Sixth growing season				
General overhead[8]	0	0	28.15	28.15
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	61.68	61.68
Total	**3.45**	**2.55**	**89.83**	**95.83**
Seventh growing season				
General overhead[8]	0	0	28.72	28.72
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	69.80	69.80
Total	**3.45**	**2.55**	**98.52**	**104.52**
Eighth growing season				
General overhead[8]	0	0	29.29	29.29
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	78.90	78.90
Total	**3.45**	**2.55**	**108.19**	**114.19**
Ninth growing season				
General overhead[8]	0	0	29.88	29.88
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	89.09	89.09
Total	**3.45**	**2.55**	**118.96**	**124.96**
Tenth growing season				
General overhead[8]	0	0	30.47	30.47
Pickup	3.45	2.55	0	6.00
Capital interest[9]	0	0	100.50	100.50
Total	**3.45**	**2.55**	**130.97**	**136.97**

[1] Performed twice.

[2] Spray costs include: Herbicides (1.0 qt X $10/qt = $10.00; 2.0 oz X $11/oz = $22.00); Adjuvant ($2.00); Custom application ($5.00).

[3] Stock costs: 622 cuttings X $0.20/cutting = $125.

[4] Overhead costs prorated for 5 months @ $25/year.

[5] Pickup costs prorated for 5 months.

[6] Interest at 12 percent on establishment costs.

[7] Repellent discounted to 30 percent of full cost.

[8] Overhead costs represent 2 percent annual increase.

[9] Interest at 12 percent on all operations to date.

[10] Spray costs include: Herbicides (0.75 qt X $10/qt = $7.50; 1.0 oz X $11/oz = $11.00); Custom application ($5.00).

Table A5. Summary of preharvest variable and fixed costs for hybrid poplar under the full tillage following annual ryegrass alternative: nominal, present, and future values.

				Cumulative	
Stand age (time t in years)	Cost category[1]	Nominal cost	PNW[2] at 5 percent	PNW	Future value at t
		---------------------------($/acre)---------------------------			
0	Variable	212.21			
	Fixed	98.30			
	Total	**310.51**	310.51	310.51	310.51
1	Variable	78.11			
	Fixed	100.27			
	Total	**178.37**	169.88	480.38	504.40
2	Variable	94.98			
	Fixed	102.27			
	Total	**197.25**	178.91	659.30	726.88
3	Variable	71.03			
	Fixed	104.32			
	Total	**175.35**	151.47	810.77	938.57
4	Variable	76.91			
	Fixed	106.40			
	Total	**183.31**	150.81	961.58	1168.81
5	Variable	83.43			
	Fixed	108.53			
	Total	**191.96**	150.41	1111.99	1419.21
6	Variable	90.68			
	Fixed	110.70			
	Total	**201.38**	150.27	1262.26	1691.55
7	Variable	98.75			
	Fixed	112.92			
	Total	**211.66**	150.42	1412.68	1987.79
8	Variable	107.72			
	Fixed	115.17			
	Total	**222.90**	150.87	1563.55	2310.08
9	Variable	117.72			
	Fixed	117.48			
	Total	**235.20**	151.61	1715.16	2660.78
10	Variable	128.86			
	Fixed	119.83			
	Total	**248.69**	152.67	1867.83	3042.50
Grand total		**2356.57**	1867.83		

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[1] Variable costs are listed in Table A3. Fixed costs include cash costs ($67.50 total: machinery and equipment insurance costs = $2.50; land lease costs = $65.00) and noncash costs ($30.80 for machinery and equipment depreciation and interest) (Young et al. 1994). Fixed costs are increased at 2 percent per year.

[2] Present net worth.

Table A6. Yields and harvesting, processing, and transportation (HPT) costs for improved hybrids.[1]

Productivity Class	Stand age (Time t in years)	Green yield (tons/acre)	Chip yield	Hog fuel yield	HPT costs ($/acre)
			-----------(BDT/acre)-----------		
High	5	56.6	22.7	7.6	1036
	6	78.9	31.6	10.5	1415
	7	97.1	38.8	12.9	1707
	8	110.8	44.3	14.8	1950
	9	120.7	48.3	16.1	2103
	10	127.5	51.0	17.0	2197
Medium-High	5	41.8	16.7	5.6	763
	6	62.5	25.0	8.3	1120
	7	81.4	32.6	10.9	1435
	8	97.1	38.9	13.0	1712
	9	109.4	43.7	14.6	1903
	10	118.5	47.4	15.8	2042
Medium-Low	5	29.5	11.8	3.9	538
	6	47.4	18.9	6.3	847
	7	65.4	26.2	8.7	1152
	8	81.8	32.7	10.9	1439
	9	95.7	38.3	12.8	1668
	10	106.9	42.8	14.3	1844
Low	5	16.9	6.8	2.3	311
	6	29.9	12.0	4.0	538
	7	44.8	17.9	6.0	788
	8	60.1	24.0	8.0	1056
	9	74.5	29.8	9.9	1297
	10	87.4	34.9	11.6	1503

[1] Yields assume 150 percent moisture content (dry basis); equivalent to 60 percent moisture content (green basis). Costs assume chips are processed on-site. Logging cost @ $16/BDT (D.E. Rice, James River Corp., personal communication); increase by 5 percent per year if < 7 years; decrease by 3 percent per year if > 8 years. Delimbing, barking, and chipping @ $19/BDT (D.E. Rice, James River Corp., personal communication). Hog fuel grinding and loading in field @ $7/BDT (D.E. Rice, personal communication). Transportation cost based on average one-way trip of 60 miles; $5/BDT for chips and hog fuel (Columbia Consulting Group, Inc. 1993; D.E. Rice, James River Corp., personal communication).

Table A7. Net returns for poplar production alternatives for improved hybrids under the full tillage following annual ryegrass alternative.[1]

Productivity Class	Chip price ($/BDT)	Stand age (time t in years)					
		5	6	7	8	9	10
		($/acre)					
High	50	-1169	-1317	-1497	-1749	-2026	-2350
	60	-942	-1001	-1109	-1306	-1543	-1840
	70	-715	-685	-721	-863	-1060	-1330
	80	-488	-369	-333	-420	-577	-820
	90	-261	-53	**55**	23	-94	-310
	100	-34	263	443	**466**	389	200
	110	193	579	831	**909**	872	710
	120	420	895	1219	1352	**1355**	1220
	130	647	1211	1607	1795	**1838**	1730
	140	874	1527	1995	2238	**2321**	2240
	150	1101	1843	2383	2681	**2804**	2750
	Break-even price[2]	101	92	**89**	89	92	96
Medium-High	50	-1235	-1395	-1575	-1817	-2087	-2399
	60	-1068	-1145	-1249	-1428	-1650	-1925
	70	-901	-895	-923	-1039	-1213	-1451
	80	-734	-645	-597	-650	-776	-977
	90	-567	-395	-271	-261	-339	-503
	100	-400	-145	55	**128**	98	-29
	110	-233	105	381	517	**535**	445
	120	-66	355	707	906	**972**	919
	130	101	605	1033	1295	**1409**	1393
	140	268	855	1359	1684	1846	**1867**
	150	435	1105	1685	2073	2283	**2341**
	Break-even price	124	106	98	**97**	98	101
Medium-Low	50	-1289	-1467	-1656	-1896	-2158	-2461
	60	-1171	-1278	-1394	-1569	-1775	-2033
	70	-1053	-1089	-1132	-1242	-1392	-1605
	80	-935	-900	-870	-915	-1009	-1177
	90	-817	-711	-608	-588	-626	-749
	100	-699	-522	-346	-261	-243	-321
	110	-581	-333	-84	-66	**140**	107
	120	-463	-144	178	393	523	**535**
	130	-345	45	440	720	906	**963**
	140	-227	234	702	1047	1289	**1391**
	150	-109	423	964	1374	1672	**1819**
	Break-even price	159	128	113	108	**106**	107
Low	50	-1344	-1549	-1761	-2006	-2270	-2569
	60	-1276	-1429	-1582	-1766	-1972	-2220
	70	-1208	-1309	-1403	-1526	-1674	-1871
	80	-1140	-1189	-1224	-1286	-1376	-1522

Table A7. continued.

Productivity Class	Chip price ($/BDT)	Stand age (time t in years) 5	6	7	8	9	10
		($/acre)					
Low	90	-1072	-1069	-1045	-1046	-1078	-1173
	100	-1004	-949	-866	-806	-780	-824
	110	-936	-829	-687	-566	-482	-475
	120	-868	-709	-508	-326	-184	-126
	130	-800	-589	-329	-86	114	**223**
	140	-732	-469	-150	154	412	**572**
	150	-664	-349	29	394	710	**921**
	Break-even price	248	179	148	134	126	**124**

[1] Net revenues are derived from BDT yields and chip prices shown; assume hog fuel @ $20/BDT (delivered) for all alternatives. **Bold** figures are maximum net revenues (minimum net losses) at a given chip price or the minimum break-even price.

[2] Break-even chip price ($/BDT) = [Costs - ($20*hog fuel yield)]/chip yield. Costs are as of the end of the growing season at time t. Costs are the sum of preharvest future value at time t from Table A5 and HPT costs at time t from Table A6. Yields are from Table A6.

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