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Hybrid Poplar in the Pacific Northwest

The Effects of Market-Driven Management

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ABSTRACT

Hybrid poplar is a new addition to the Northwest's agricultural economy, with over 50,000 acres currently in production. Originally conceived as feedstock for the energy industry, poplar has been grown primarily as raw material for the paper business. However with falling prices for wood chips, efforts are now under way to manage poplar for the solid wood market. Poplar's utility also extends to its use in the treatment of municipal and industrial wastewater, nutrient removal from agricultural runoff, and phytoremediation of industrial landfills. Future applications are likely to exploit its carbon sequestration ability in the developing markets for tradable pollution credits.

Keywords: forest products; plantation forestry; silviculture

The cultivation of hybrid poplar in the Pacific Northwest has advanced during the past 20 years, from research and development to a commercial enterprise occupying roughly 50,000 acres. Throughout this period, the strategy of poplar management has evolved as landowners have responded to changing commodity prices and advances in environmental amelioration technology. Envisioned originally as an energy crop during the petroleum crisis of the 1970s, hybrid poplar was instead first commercialized by the pulp and paper industry in the mid-1980s. Today, with chip prices at near-record lows, hybrid poplar plantations are being retooled to provide a variety of commodities, including those destined for the solid wood market. In addition, this relatively new crop is tak-

Above: **Hybrid poplar plantations are only cultivated two years out of eight, far less than the annual cropping systems they replace. The less frequent tillage reduces soil erosion.**

ing an innovative role in environmental and pollution-control technologies that ultimately may be of significant societal consequence with far-reaching economic implications.

Plantation Management

West of the Cascade Mountains, the largest concentration of poplar plantations is found on the poorly drained silt-loam alluvial soils of the lower Columbia River floodplain. The climate there is relatively mild, and ample rainfall supports growth rates of 350 to 500 cubic feet per acre per year after eight years. Plantations also have been established east of the Cascades on well-drained, loamy, fine sands in the mid–Columbia River basin. Drip irrigation of up to 40 inches per growing season is required under the extremely arid conditions, as is fertilization with nitrogen, phosphorus, zinc, and iron. Compared with the west side's alluvial plantations, those of the mid–Columbia River basin achieve superior growth rates of 600 cubic feet per acre per year on six- to seven-year rotations due, in part, to warmer temperatures and virtually cloudless days throughout the growing season.

Nearly all of the acreage on which poplar is now being grown previously had been hayed, pastured, or farmed for a variety of agronomic crops (e.g., corn, wheat, and potatoes). Precise tree spacing, vegetative propagation of selected varieties, and the use of intensive farming practices provide for an extraordinary level of crop uniformity that approaches that of the typical grain or row crop. Stocking rates typically vary from 200 to 900 trees per acre, depending on the intended product. The mainstay of the planting stock derives from first-generation crosses involving four species: native black cottonwood *(Populus trichocarpa),* eastern cottonwood *(P. deltoides)* from the Midwest, Japanese poplar *(P. maximowiczii),* and European black poplar *(P. nigra).* Adventitious rooting by hardwood cuttings of the six possible interspecific combinations is a reliable and inexpensive method of stand establishment that affords the selection and commercial propagation of productive individual hybrid varieties. Although hybridization of first-generation parental selections is still used to increase yields and replace those hybrids culled from commercial use because of susceptibility to pests, cold, frost, and windthrow, several breeding programs also focus on parental species improvement to sustain genetic gains in future hybridization programs.


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Hog fuel is ground for use in cogeneration boilers. Multiple markets, including energy feedstock, are important to the future profitability of hybrid poplar plantations.

Energy Feedstock

The use of hybrid poplar for energy feedstock in the Pacific Northwest has been limited to area pulp and paper mills that have periodically used hog fuel residuals from wood-chipping operations to fire their cogeneration boilers. However, electrical generating plants that integrate 50,000 acres of hybrid poplar biomass plantations currently are being sited elsewhere in Minnesota. The configuration of such plantations was at one time designed to follow the woodgrass or silage sycamore model: stands planted at extremely high densities (45,000 stems per acre), harvested annually, and managed by coppice regeneration. Although coppicing greatly reduces the cost of second-rotation site preparation, the need for year-round harvesting (including the summer months when stump sprouting is inconsistent and insubstantial) has mostly precluded its use. More widely spaced stands and longer rotations also have been shown to be much more productive (DeBell et al. 1993, 1997). The yield of biomass from commercial west-side plantations stocked at 900 trees per acre and managed on six-year rotations have averaged 37 dry tons per acre, with selected varieties yielding as much as 55 tons.

Burning ground biomass in place of coal or cofiring with coal to produce electricity is a well-developed technology. Although thermal conversion efficiencies for coal and poplar biomass are nearly equivalent, more poplar is required to produce the same quantity of electricity because of its lower caloric content (9 MBtu per ton at a 45 percent moisture content) when compared with coal (20 MBtu per ton) (Wright et al. 1992; Lamarre 1994). The expense of harvesting and chipping operations further contributes to the higher cost of poplar biomass, although a new scheme based on whole-tree processing may significantly lower production and handling costs while improving boiler efficiency (Lamarre 1994; Perlack et al. 1996). However, existing cost comparisons have not accounted for reductions in carbon dioxide, sulfur dioxide, and nitrogen oxide emissions realized through the quantity of coal offset by sustainable management for renewable biomass, an analysis that could be forthcoming if taxes on greenhouse gas emissions or credits for pollution mitigation are enacted in the near future (Hohenstein and Wright 1994).

Pulp and Paper

Twenty-five years ago, the pulp fiber market in the Northwest—historically dependent on residual chips and sawdust from area lumber mills—was notoriously cyclical, tied as it was to the ebb and flow of the construction industry. Beginning in the late 1970s, some papermakers identified short-rotation plantations located near their mills as providing an opportunity to moderate the fluctuations in fiber pricing. In light of its fast growth and the timely genetic and silvicultural research of R.F. Stettler and P.E. Heilman at the University of Washington and Washington State, hybrid poplar emerged as the prime plantation candidate. The decision to use poplar was reinforced by a concomitant shift toward paper grades that required hardwood fiber at a time when regional forecasts were projecting drastic shortages in red alder *(Alnus rubra)* fiber, the region's only commercial hardwood (Huddy et al. 1983). In 1982, Crown Zellerbach Corporation began planting hybrid poplar on the lower Columbia River floodplain near Clatskanie, Oregon, and in the mid–Columbia River basin near Boardman, Oregon. Ultimately, James River Corporation developed an 11,000-acre plantation near Clatskanie, while Boise Cascade and Potlatch Corporations independently established a combined total of 40,000 irrigated plantation acres in the Boardman, Oregon, and Wallula, Washington, area. By the mid-1990s, MacMillan Bloedel had planted 6,000 acres of hybrid poplar in the Skagit River Valley.

Plantations managed for clean wood chips often are stocked at a rate of 600 trees per acre and harvested after eight years. A major factor in the determination of rotation length was the transition to desirable pulp characteristics (e.g., heightened kraft yields and improved pulp strength and drainage) that occurs in poplar during the fifth through eighth years when periodic stand growth rates also are culminating. Trees are sheared and piled with a feller-buncher, forwarded to a landing with skidders, debarked with a chain flail, chipped, and blown into vans for truck delivery to the pulp mills. Processing in the field is cost-effective and allows for just-in-time delivery that maintains the inherent brightness of poplar wood by lessening the time chips are stored in piles. Commercial yields of clean chips vary between 28 and 45 dry tons per acre depending on site quality, with an additional yield of 10 to 15 tons of hog fuel (i.e., combined dry weight of upper stemwood, limbs, bark, and foliage).

Both refiner mechanical and kraft chemical pulping processes have made use of hybrid poplar. It is well-suited to the mechanical process, where the comparatively low wood density of 18 to 21 pounds per cubic foot conserves refining energy. When pulped via the kraft process, however, the low wood density reduces digesting efficiency, which yields less pulp per unit of digester volume. Lignin chemical reactions somewhat darken kraft pulps, rendering them less suitable for high-value communication papers without a measure of chlorine-based bleaching. Conversely, poplar's bright wood character is preserved in mechanical pulps with minimal hydrogen peroxide bleaching.

An eight-year-old stand of hybrid poplar (variety 20-88-183) growing on the lower Columbia River floodplain for wood chips for papermaking. Established at 622 trees per acre, the stand carries 165 square feet of basal area per acre.

Mechanical pulp has been used to make a wide range of coated and uncoated grades of specialty newsprint. Poplar's short (less then one millimeter) and relatively wide (23–30 micrometers), thin-walled (2.1–2.7 micrometers) fibers of kraft pulp, on the other hand, have proved ideal for the manufacture of bond paper grades. These fibers easily collapse during sheet formation, resulting in a smooth, dense, opaque formation with few surface voids. The same morphologies that lend themselves to collapsible fiber formations also give poplar a low bulk capacity, making it poorly suited to towel and tissue products that place a premium on softness.

Lumber and Engineered Wood Products

Although some shortages have occurred in various years, a sustained shortfall of red alder fiber has not yet taken hold in the region. Today, as Asian papermakers move their hardwood supply toward eucalyptus and acacia plantations from the Southern Hemisphere, thus curtailing the export market for alder chips, prices for hardwood chips are near all-time lows, and many growers are adopting a multiple-product plantation strategy focused primarily on solid wood commodities. One traditional outlet is the plywood market, which uses the native black cottonwood for core veneer stock. A potentially more lucrative market is the use of hybrid poplar as a substitute for species such as red alder, American basswood *(Tilia americana),* and yellow-poplar *(Liriodendron tulipifera)* in the manufacture of decorative molding, window casings, boxes, frame stock, blinds, and several furniture components (Mater Engineering 1998). The acceptance of hybrid poplar in conventional solid wood markets has not been wholly proven, but mill trials have demonstrated that hybrid poplar machines well, accepts a wide range of finishes, glues well, and does not warp when adequately dried (Carlson and Berger 1998). Furthermore, the wood's bright, light color; light weight; and smooth-grain appearance are all quite desirable. For the time being, hybrid poplar is forging its own niche market in specialty wood products such as edge-glued panels used in the construction of cabinetry, paneling, and doors. Broadacres Nursery, an Oregon poplar grower, has constructed a 1,500-square-foot building in which 95 percent of the building materials were derived from poplar and featured engineered joists as framing, structural grade plywood, and finish molding. Poplar's relatively low strength and surface hardness will, however, preclude most structural applications, although the wood of selected varieties may have a commercial potential for some construction uses (e.g., web members of trusses, studs of walls) (Kretschmann et al. 1999).

Sawlogs and peeler logs will be grown at stocking rates of 200 to 300 trees per acre for 12 to 15 years. (Under current Oregon guidelines, poplar rotations are limited to 12 years if they are to be regulated and taxed as an agricultural crop. Fifteen-year rotations are consistent with an agricultural designation in Washington, after which hybrid poplar is considered a timber crop subject to regulations of the Forest Practices Act.) Log yields of 6,800 to 7,500 cubic feet per acre (five-inch small-end diameter) and up to 12 dry tons of residual chips have been estimated for 12-year-old stands. Based on mill trials of small-diameter poplar logs (Carlson and Berger 1998), the total yield of sawn lumber could be as high as 20,000 to 30,000 board feet per acre. Presently, some landowners are thinning five-year-old pulpwood plantations to enable the production of sawlogs on an extended rotation (five-year-old stands will respond to release while yielding a sufficient quantity of wood chips to cover the cost of stand improvement). Pruning to 21–24 feet in four annual lifts beginning in the second year is likely to become routine given the premium placed on high-quality, clear wood.

Hybrid poplar also has been tested in the manufacture of oriented strand board (OSB) and laminated veneer lumber (LVL). Closely related to aspen, which has been the quality standard for OSB manufacture, hybrid poplar has proved a good substitute requiring some modifications in resin and press time specifications. Hybrid poplar is often blended with other species to compensate for its low wood density, which improves the strength characteristics of OSB and LVL products.


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In-field delimbing, debarking, and chipping of trees from an eight-year-old hybrid poplar stand along the lower Columbia River floodplain. The yield of clean wood chips is 40 bone-dry tons per acre.

Environmental Applications

The economic impact of hybrid poplar culture in the Northwest extends well beyond commodity production to its role in pollution abatement projects. Poplar stands have proved highly effective in removing nutrients from effluent when irrigated with municipal and industrial wastewater and in nutrient removal from farm runoff (O'Neill and Gordon 1994; Schultz et al. 1995; US Environmental Protection Agency 1999). Hybrids are well-suited to each of these applications by virtue of an extensive root system that ensures good soil percolation and a free-growth pattern of shoot development that helps in maintaining a large leaf area into the fall, thus prolonging the irrigation season. Moreover, the superior rates of biomass accumulation and elevated leaf area indices maximize rates of transpiration and nutrient uptake.

A large number of environmental plantings are now evident throughout the region. These include the cities of Woodburn and McMinnville, Oregon, and Vernon, British Columbia, each of which has used poplar in treating their municipal effluent or in containing landfill leachate. Riparian buffer plantings also are being used in the Tillamook basin to protect the water quality of anadromous fish–bearing streams from the runoff from adjacent dairy farms. In the industrial sector, a fish processing plant in Shelton, Washington, a vegetable cannery in Brooks, Oregon, and a potato processing plant in Caldwell, Idaho, also have incorporated poplar plantings into their treatment of waste process water, while a pulp mill in Halsey, Oregon, is testing poplar plantings in the treatment of secondary pulp sludge. A related application uses hybrid poplar's ability to metabolize certain toxic chemicals (Burken and Schnoor 1997; Gordon et al. 1997) in removing trichloroethylene from an industrial landfill near Bremerton, Washington, with consid-

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A variety of solid wood products, including furniture, can be made from hybrid poplar as management looks for higher-value markets to increase plantation profitability.

Bill Schuette

When irrigated with municipal and industrial effluent, hybrid poplar stands have proved highly effective in wastewater treatment and water quality improvement. Shown here is a wastewater pumping station and a closeup of an irrigation stake.

erable cost savings compared to alternative methods of soil removal and decontamination.

Hybrid poplar plantations often are mentioned as potential carbon sinks in the discussion of global warming; the annual growth of an acre of poplar requires five to eight tons of atmospheric carbon, approximately double the carbon fixed by agronomic crops (Ranney et al. 1991). However, because of their relatively short harvest cycles, poplar's real impact on climate change will come from their sustainable management as a renewable energy crop that offsets substantial carbon, sulfur, and nitrogen emissions from fossil fuels (Ranney et al. 1991). Nonetheless, poplar plantations could figure prominently in tradable pollution allowances in what may become the world's largest commodity market (Foroohar 2001). The Climate Trust of Oregon now considers funding for carbon dioxide sequestration projects including current and recent proposals to plant 400 acres of abandoned pasture in the Sandy River delta using local black cottonwood selections (Sandy River Delta Gallery Forest Restoration) and 3,100 acres along the lower Columbia River with a diverse mix of hybrid varieties (Jefferson Poplar Carbon Sink). Moreover, the Tree Canada Foundation (on behalf of Shell Oil) has purchased nearly a quarter-million hybrid poplar trees being established by Alberta-Pacific Forest Industries in return for future carbon credits.

Although treating municipal, industrial, and farm effluents and sequestering atmospheric carbon dioxide are beneficial environmental roles for poplar plantations, their large-scale propagation has raised concerns over their long-term effect on wildlife habitat and biodiversity. Poplar plantations do not contain the diversity nor the stability of habitats found in riparian forests west of the Cascade Mountains or in the east side's shrub-steppe biome. However, the abundance and diversity of bird and small mammal populations both appear to be richer in plantations than the agricultural cropping systems they replace (Hanowski et al. 1997; Moser et al. 2002). What remains unknown, however, is the long-term habitat value of poplar plantations, including their effect on wildlife reproduction. Yet this value could be appreciable—plantations extend the size and utility of disconnected native west-side riparian forests (Hanowski et al. 1997) and add habitat diversity to the landscape of the east side's mid–Columbia River basin.

Organizational Approaches

Straddling the division between agronomy and forestry, the cultivation of hybrid poplars has developed several innovative approaches to the organization, management, and marketing of plantation operations.

Industrial approach. The most prominent approach is that of the pulp and paper industry: sizable acreages, contiguous parcels, mostly fee lands with a smaller proportion managed under leases of sufficient length to allow for two or three rotations. The efficiency of plantation operation is the advantage here; the distribution of age classes is configured to allow for well-planned cultivation and harvest operations, and the composition of hybrid varieties is diversified and balanced so as to minimize the risk of unforeseen pest and weather events. The pulp and paper industry has conducted much of the applied cultivation research, equipment testing, and tree improvement work that has fostered hybrid poplar's commercialization.

Partnerships and cooperatives. Farmer-based partnerships and grower's cooperatives have more lately come into their own as alternative approaches. The partnerships are adjuncts of the larger industrial plantations in which individual landowners manage their own stands with planting material and technical advice provided by the larger operation in exchange for a first right-of-refusal to the wood at harvest. Cooperatives, on the other hand, are associations of independent farmers sharing information while working together with greater flexibility to develop new markets that can be met collectively by their constituents. The pooling of resources greatly extends farming experiences, equipment, and marketing expertise. The two main regional cooperatives are the Hybrid Poplar Growers' Association operating west of the Cascades and the Agricultural Wood Producers' Association in the mid–Columbia River basin. The lack of annual cash flow (inherent in all multiyear rotation poplar management scenarios) and unpredictable markets have been the biggest obstacles to wider farmer participation in partnerships and cooperatives. These obstacles are not likely to be overcome in the near future.

Conclusion

The long-term importance of hybrid poplar to the Pacific Northwest's agricultural economy will become proportionally larger if projected shortages in alder sawtimber materialize. Poplar plantations could take on an added imperative if domestic wood supplies come to depend on hardwood plantations of the Southern Hemisphere (Kellison 2000), in the same way that a significant portion of Oregon and Washington's agricultural economy (e.g., apples, pears, grapes, berries, and salmon) now struggles to remain competitive with South American growers. Whether hybrid poplar can maintain an economically competitive position at home and abroad will depend on increasing profitability in five main areas:

- Sustained-yield improvement through ongoing hybridization and varietal selection.
- Reduction in harvesting and processing costs.
- Development of more cost-efficient methods of plantation silviculture.
- Increased consumer acceptance in the all-important solid wood market.
- Value from improvements in water and air quality.

The future profitability of regional plantations also could be secured by recognition of their place in responsible land management, a designation already awarded to Potlatch Corporation's poplar farm by the Forest Stewardship Council. To the degree that hybrid poplar achieves success through commodity production and novel applications in environmental and pollution control services, it will also help to diversify and sustain the region's indispensable rural economies.

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