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SP702-C-Short Rotation Woody Crops for Biofuels

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Short Rotation Woody Crops for Biofuel

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With the correct chemical refinement, essentially any tree species can be used to produce biofuel. However, those species with rapid growth potential and the propensity to re-sprout prolifically once harvested have received more attention. These qualities could allow for both a favorable investment return and quicker renewal of the woody resource (Figure 1).

Hybrid poplar (*Populus* species, including Eastern cottonwood) and willow (Salix species) are two of the most promising trees and have received the most research attention. Others having good potential for biofuel production include American sycamore (*Platanus* species), sweetgum (*Liquidambar* species) and loblolly pine (*Pinus* species). None of these five are overly common in Tennessee. Collectively, these species represent only 7 percent of the total number of live trees in the state. This is attributed mainly to their explicit high-moisture site requirements, conditions that are often poor or limiting throughout much of Tennessee.

Following is a brief overview of the silvics, conditions that affect tree growth with particular reference to the environmental factors, of the five species mentioned above. The discussion of each includes:

1) site requirements,
2) reproduction potential,
3) growth and yield estimates,
4) principal pests and
5) geographic distribution within Tennessee.

Figure 1. A plantation consisting of American sycamore (Platanus occidentalis L.)

Eastern Cottonwood (Populus deltoides M.)

A number of crosses and clones have become available for cottonwood, bringing rise to the generalized title of "Hybrid Poplar." The native Eastern cottonwood is the species described here. This species is very site-specific, has a limited growing niche and is not common throughout much of Tennessee. It requires an abundant and continuous supply of moisture during the growing season. Soils should be moist, but not continually saturated and with good internal drainage. It prefers damp, well-drained, fine sandy-loam soils located near streams, where coarse sand is first deposited as flooding occurs. Normally, cottonwood trees are found at elevations < 20 feet above the average level of adjacent streams. They flourish when the water table depth is 2-6 feet, when top soil is deep (> 4 feet) and without a hardpan. Cottonwood trees do not tolerate continuous flooding, preferring sites with winter and early spring flooding only.

Plantation-grown trees are typically established with cuttings of stems from 1-year-old wood, with cuts made during the dormant season. Cuttings are 18–24 inches long, inserted into the ground with buds pointed up and with only 2–4 inches of the cutting exposed. Once harvested, cottonwood will sprout vigorously from both roots and stumps, allowing for continued production. Propensity for stump sprouting declines as the trees age.

Unmanaged stands of cottonwood on good sites can yield 24 cords of pulpwood per acre (53 tons) at 10 years. Intensively managed plantations of genetically improved cottonwoods on the best sites will produce an average yield of 5 dry tons/acre/year. In just six growing seasons, hybrid poplars can reach 60 feet or more in height. Cottonwood can be attacked by a number of insect pests: the cotton leaf beetle, the night-feeding beetle, the cottonwood twig borer and the cottonwood root and stem borer. Each of these can stress trees and reduce growth. Cottonwood is susceptible to ground fire damage at all ages. Beavers may also damage trees, as they prefer young cottonwood trees for food and for building dams.

Cottonwood is distributed very sparsely across Tennessee, with the highest concentration in the west. It is a principal component of the Mississippi River floodplain and can be found along the Tennessee River. The drier uplands throughout much of the state are not suitable for cottonwood production without intensive irrigation.

Willow Species (Salix)

There are about 150 species of willow in North America. Black willow (*Salix nigra* M.) is the most widespread. The extensive and shallow roots of this species require an abundance and continuous supply of moisture during the growing season. Hence, it more commonly exists on river margins and in lower, moist and less sandy sites. It flourishes at or slightly below water level and is not damaged by flooding and silting. Willow propagates well with seedlings or with cuttings. Sprouting and initial growth can be prolific with the latter. With sufficient weed control or cultivation combined with adequate moisture, survival of first-year plantings can approach 100 percent.

In natural stands, and on preferred sites, trees can average 50 feet tall and 5.6 inches in diameter in just 10 years. On such sites, trees self-prune very well. Unmanaged stands in the South have been estimated to yield 50 cords of wood per acre (110 tons) at age 25. If fertilized and irrigated, yields of 3-year-old rotations have exceeded 10.8 dry tons/acre/year. The principal enemy of willow trees is drought, especially on clay-capped alluvial soils. Hot ground fires can kill entire stands too.

Black willow is not widely distributed throughout Tennessee. It is more common in West Tennessee, between the Mississippi and Tennessee Rivers. It is also present in the south-central region and in pockets at the northern border, particularly along streams.

American Sycamore (Platanus occidentalis L.)

American sycamore prefers alluvial soils along streams and in bottomlands. It is tolerant of wet soil conditions and slow internal drainage, but cannot tolerate flooding of more than a few weeks during the growing season. The water table must be low enough to permit good soil aeration. Sycamore sprouts readily from younger sapling or pole-sized stumps when young (Figure 2). Propagation via cuttings made from young, fast-growing stems will readily develop roots. Such cuttings are normally 20+ inches long and are set ¾ of their length into the ground.

Sycamore growth and yield is less than cottonwood and willow. Unmanaged saplings on average sites will grow 2.4 to 3.2 inches in diameter in 10 years, but can reach in excess of 5 inches on excellent sites. Volume yield on unmanaged, average sites can produce 20 cords (47 tons) in 17 years. Many insects feed on sycamore and can become economically important in plantations, including sycamore lace bug, the flat-headed sycamore heartwood borer and the sycamore tussock moth. Sycamore anthracnose is a disease, often causing complete defoliation in moist spring weather, rarely killing trees, but suppressing spring growth and making trees susceptible to attack by other agents.

American sycamore is fairly evenly distributed throughout Tennessee, with a higher abundance than either cottonwood or willow. It is even present in the Nashville Basin, occupying small niches in the ravines and coves that separate the drier upland regions.

Figure 2. Sprouts from once-harvested American sycamore (Platanus occidentalis L.)

Sweetgum (Liquidambar styraciflua L.)

Sweetgum is a species tolerant of a variety of soils, but grows best on rich, moist, alluvial clay and loam soils of river bottoms. In general, the best sweetgum sites are those suitable for yellow-poplar. It prefers soil absent of a hardpan within the top 2 feet, and with moderate to good internal drainage. It does not grow well above elevations of 2,500 to 3,000 feet. Sweetgum is capable of reproducing via stump sprouts, not declining in vigor until the third generation of sprouts from the same stump. Seedlings reach a height of 4.5 feet in three to five years, while sprouts reach the same height in one growing season. Ten-year-old sprouts frequently have the same size and appearance as 18- to 20-year old seedlings in the same stand.

The average diameter growth for immature trees is estimated at 2.5 to 3.0 inches over a 10-year period, ranging from 1 to 4 inches depending on site productivity. Height growth in unmanaged stands will vary from 1 to 2.5 feet per year. Volume yield data are not readily available, but due to the slower initial growth, sweetgum will likely yield similar to American sycamore. Mice and rabbits are principal pests, causing considerable damage to seedlings. Sweetgum is very resistant to attack from insects and disease, but will succumb to death or injury by ground fires.

Of the five species discussed in this document, sweetgum has the greatest distribution and highest overall abundance in Tennessee. It is more heavily concentrated in West Tennessee, but is found in most counties, except in the Nashville Basin, where it is rare. It tolerates a wide range of sites, occupying bottomlands, rolling hills (if moisture is adequate) and ravines.

Loblolly Pine (Pinus taeda L.)

Loblolly pine is quite adaptable to a variety of sites. It performs well on both poorly drained bottomland flats to modestly arid uplands. The best growth is obtained where the surface drainage is poor, the soil surface layer is deep and the subsoil is firm. It does not tolerate extended flooded conditions, though it can tolerate brief periods. Growth rate gradually decreases from bottomland to upland sites, with highly eroded abandoned fields as least productive. It performs best at elevations < 2,000 feet. Genetically improved seedlings and plugs are available; cuttings are not. Loblolly does not re-sprout from the stump. However, 1- to 3-year-old seedlings will re-sprout from dormant buds. This species has also been successfully grafted.

Depending on site quality, diameter and height will range from 4.6 inches and 32 feet, to 8.5 inches and 65 feet, at age 20. Annual growth in plantations will average 1.5 cords per acre per year (4 tons). With intensive weed control and multiple fertilizations, yields can double this average. The principal pests of Loblolly are the Southern pine and the Ips engraver beetles. These insects are normally more problematic as stands age and become overstocked, or during drought periods. Sleet, snow and ice can cause damage by bending, breaking or uprooting trees.

The natural range of Loblolly pine is limited to 15 counties along the southern border of Tennessee. The commercial range is broader, extending throughout much of the state. Exceptions include higher elevations where the ground freezes, and also in the Nashville Basin.

Summary

Other species can be used for biofuel production. Tennessee has approximately 13.9 million acres of forestland. Perhaps the best trees for many of the forest sites are those that have already proven to endure there. For instance, oak species have adapted to tolerate many of the dry and infertile sites and are by default, the best selection. On such sites, the rotation length would be considerably longer and the yield less than the examples outlined in this factsheet. Still, where the woody resource already exists, biofuel could be an alternative to traditional wood markets.

Short rotation woody crops eventually lose their vigor if repeatedly harvested and then allowed to re-sprout. Normally, after three rotations, productivity is lost and plantations need to be re-established. Depending on the intensity of management, this time frame could be three to six decades.

As the demand for traditional fuels continues to rise, support for alternative sources will likely increase. Approximately 55 percent of Tennessee is covered in forest, and strong consideration should be given toward the use of woody crops to produce biofuel.

References

Baker, J. B. and W. M. Broadfoot. 1979. A Practical field method of site evaluation for commercially important southern hardwoods. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. SO-26. South For. Exp. Stn., New Orleans, La.

Beltz, R. C. and D. F. Bertelson. 1990. Distribution maps for Midsouth tree species. Resour. Bull. SO-151. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station.

Fowells, H. A. 1965. Silvics of forest trees of the United States. U.S. Department of Agriculture, Forest Service. Agric. Handbook 217. Washington, D.C.

Harrar, E. S. and J. G. Harrar. 1962. Guide to southern trees. Second edition. Dover Publications, Inc., New York.

Ruark, G. 2006. Woodys have biomass potential. Inside Agroforestry. Vol. 15, Issue 3. U.S. Department of Agriculture, National Agroforestry Center. Lincoln, NE.

Schultz, R. P. 1997. Loblolly Pine: The ecology and culture of Loblolly pine. U.S. Department of Agriculture, Forest Service. Agric. Handbook 713. Washington, D.C.

Schweitzer, C. J. 2000. Forest statistics for Tennessee, 1999. Resour. Bull. SRS-52. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

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