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Sustaining Natural Resources on Private Lands in the Central Hardwood Region

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Current Topics in the Processing and Utilization of Hardwood Lumber

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Sustaining Natural Resources on Private Lands in the Central Hardwood Region

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Current Topics in the Processing and Utilization of Hardwood Lumber

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RESTORING OAKS IN THE MISSOURI RIVER FLOODPLAIN

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Restoration of native vegetation and hydrologic regimes in the Mississippi and Missouri River floodplains is problematic because they are among the most altered ecosystems in North America (Noss et al. 1995), and because of the competing demands placed on these river ecosystems by commercial, private and social interests. Since the 1780s, more than half (53 percent) of the original wetlands have been lost in the conterminous United States, due primarily to drainage and conversion to agriculture (Dahl 1990) (Table 1). Many states in the Midwest and South have lost more than 85 percent of their original wetlands. In the eastern United States, many of these wetlands were originally forested (Bragg and Tatschl 1977, The Nature Conservancy 1992).

Table 1. Percent of wetlands lost between 1780 and 1980 based on estimates of pre-European (circa 1780s) wetlands (Dahl 1990) and acreage determined in the mid 1980s by the National Wetland Inventory for selected states and regions.

STATE	WETLANDS IN 1780s (MILLION ACRES)	WETLANDS IN 1980s (MILLION ACRES)	PERCENT LOSS
Alabama	7.57	3.78	50
Arkansas	9.85	2.76	72
Illinois	8.21	1.26	85
Indiana	5.60	0.75	87
Iowa	4.00	0.42	89
Kentucky	1.57	0.30	81
Louisiana	16.20	8.78	46
Michigan	11.20	5.58	50
Minnesota	15.07	8.70	42
Mississippi	9.87	4.07	59
Missouri	4.84	0.64	87
Ohio	5.00	0.48	90
Tennessee	1.94	0.79	59
Wisconsin	9.80	5.33	
	46		
REGION			
Lower Mississippi Valley	25.00	5.00	80
Conterminous U.S.	221.00	103.00	53

In Midwestern floodplains, oaks (*Quercus sp.*) and other nut (hard mast) species such as hickory and pecan (*Carya sp.*), and black walnut (*Juglans nigra,* L.) were members of diverse bottomland forests containing cottonwood (*Populus deltoides,* Marsh.), silver maple (*Acer saccharinum,* L.), hackberry (*Celtis occidentalis,* L.), sycamore (*Platanus occidentalis,* L.) and black willow (*Salix nigra*, Marsh.). The oaks and other nut species occurred on higher elevations that were flooded less frequently, and that had better drained soils. We know that oak species including swamp white oak (*Quercus bicolor,* Willd.), bur oak (*Q. macrocarpa,* Michx.), and pin oak (*Q. palustris,* Muenchh.) were present in the Lower Missouri and Upper Mississippi River floodplains based on analyses of General Land Office surveys conducted in the early 1800s (Bragg and Tatschl 1977, Nelson 1997, Yin et al. 1997, Nelson et al. 1998), and considering the geographic distribution and silvics of native tree species (Burns and Honkala 1990). In Missouri, oaks were common enough to be recorded on about one third of the survey transects of the Missouri River floodplain in the early 1800s.

Elsewhere, oak-hickory was a recognized floodplain forest type in the Upper Mississippi River basin before European settlement. As well, oaks were also associates in other floodplain forest and savanna types.

Public land managers and private landowners are interested in reforesting former agricultural bottomlands with a component of native oaks and other hard mast producing hardwoods. Restoring bottomland forests is done to improve wildlife habitat, promote native biodiversity, restore ecosystem process and function, provide recreation, enhance waterfowl hunting and produce forest products. Restoration based on natural regeneration alone does not guarantee that the desired native species will be present, that the full complement of native species will colonize the site, that exotic species will not dominate the site, or that the desired character of the forest community will develop in the near future. Silvicultural prescriptions to regenerate bottomland forests will include a mixture of natural and artificial (tree planting and direct seeding) regeneration techniques that meet management objectives for restoration in a timely manner.

Natural regeneration is the preferred method for restoring bottomland forests when it produces the desired forest state because it is the least costly method for establishing a species. The natural regeneration of pioneer species such as cottonwood, sycamore, and willow is common following abandonment of bottomland cropfields because (1) their seed sources are more widely distributed throughout the floodplain, (2) they produce frequent good seed crops, (3) their light seeds are readily dispersed by wind and water, (4) they germinate well on mineral soil seedbeds, and (5) they have rapid initial height growth. In very large bottomland fields, regeneration of these species can be difficult when seed transport to the site is limited by long distances to adjacent forests, and lack of seasonal flooding resulting from management efforts to control flooding. In contrast, the natural development of later successional bottomland species such as swamp white oak, bur oak, pin oak, pecan, shellbark hickory (Carya laciniosa (Michx. F.) Loud.) and black walnut is more problematic due to a lack of seed source and their low regeneration potential on productive sites that are often dominated by lush herbaceous growth, woody vines, and pioneer tree species that exhibit inherently greater shoot growth. Artificial regeneration and vegetation management is required to restore species such as the oaks to floodplain environments.

Unfortunately, attempts to establish oak and other nut species in bottomland fields have often failed despite our best knowledge and efforts. Traditional methods of planting bareroot seedlings or direct seeding of oak, pecan or black walnut in bottomlands has not always been successful, even with annual weed control during the establishment period. These methods have not reliably produced adequately stocked forests. For example, in a survey of 4-year-old Wetland Reserve Program plantings in the Mississippi River floodplain, Schweitzer and Stanturf (1997) found that only 9 percent of the total reforested land in 13 Mississippi counties met the Natural Resources Conservation Service requirement for at least 125 hard mast stems per acre (309 stems per ha) in 3-year-old stands.

High rates of tree mortality and slow growth can result from (1) the use of poor quality seed or seedlings, (2) improperly planted seedlings, or sown seed, (3) damage caused by deer, rabbits and mice, (4) drought, (5) severe competition, and (6) flooding (Stanturf et al. 1998). Loss to flooding is higher when species are planted "off-site" in the floodplain, i.e., their flood tolerance is not matched with the hydrologic regime of the site. Slow growing and damaged seedlings are easily overtopped by competing vegetation on these productive sites. Even when planting has been done properly, regenerating oaks in productive floodplains has proven difficult because of their slow juvenile growth habit and their adaptations to specific soil and micro-topographic environments within floodplains. Further complications in regenerating oaks arise because many natural fluvial processes have been altered, changing soil, micro-topographic and hydrologic patterns.

Throughout the Midwestern and Southern United States, the opportunity to increase the supply of quality hardwood forests on productive bottomlands is great (Stanturf et al. 2000; NRCS 2001a,b). However, this potential to increase the ecologic, social and economic productivity of our bottomland forests will not be achieved if we continue to invest in reforestation strategies and practices that have a low chance of success. In short, both new methods and strategies along with better implementation of existing techniques are necessary to regenerate hardwoods on former floodplain cropfields. Therefore, a study was initiated to develop new approaches for regenerating and thus, restoring oaks to agricultural floodplains along the Lower Missouri River.

We have designed and are testing several silvicultural prescriptions to regenerate oak that include different nursery stock types, species, site preparation methods and non-chemical weed control techniques.

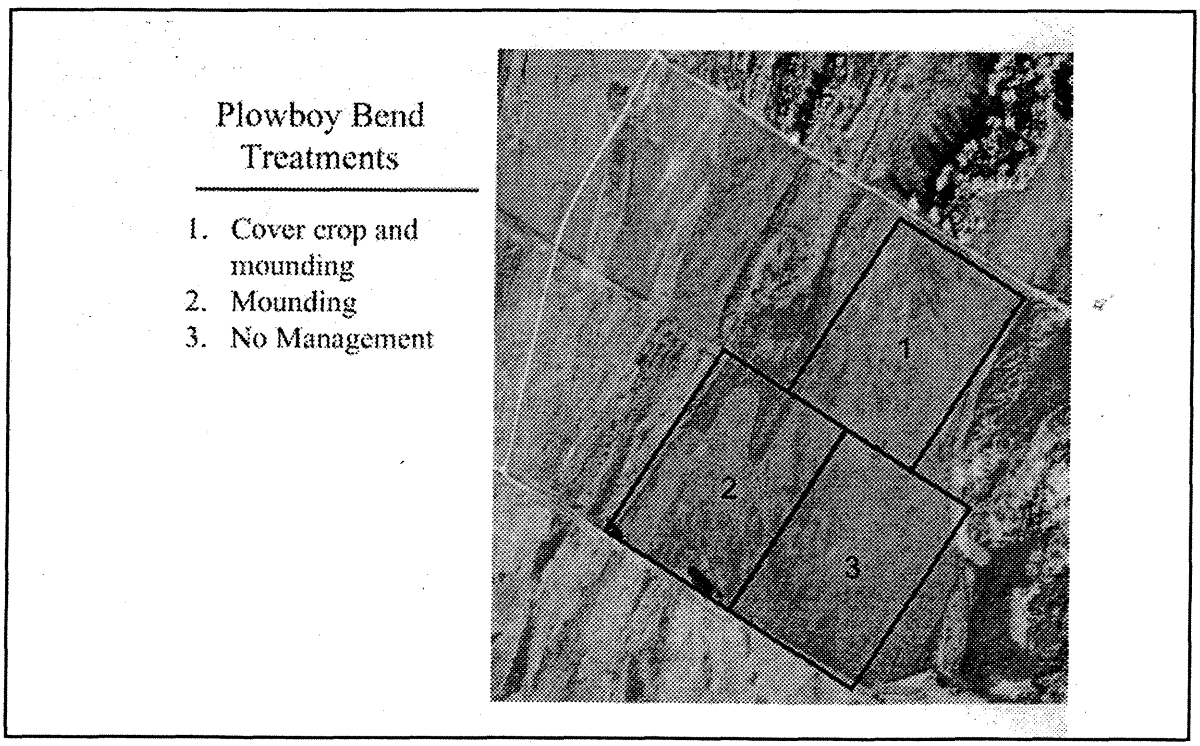
The purpose of this study is to learn how to restore a component of pin oak and swamp white oak to former agricultural bottomlands along the Lower Missouri River. We are evaluating how cultural methods such as planting trees in a soil mound and controlling competition with a cover crop can be used with different nursery seedling types to more successfully regenerate oak by improving its competitiveness in early successional bottomland communities. We are testing the field performance of a new nursery product, the RPM™ seedling, and how oak survival and growth are affected by soil mounding and a cover crop of redtop grass (*Agrostis alba,* L.). RPM™ seedling performance will be compared with that of the more traditional 1-0 bareroot seedlings. Oak regeneration success will be related to vegetation competition, composition and structure under the different silvicultural prescriptions. Our research focuses on solving the common problem of regenerating oaks in bottomlands, and hence will contribute to our ability to restore native bottomland oaks. We recognize that restoring a bottomland forest is a much larger and more complex issue than returning individual species to their native ecosystems.

METHODS

Study Area

The study is located on two conservation areas managed by the Missouri Department of Conservation: Smoky Waters (Sec. 5, T 44 N, R 9 W and Sec. 1, T 44 N, R 10 W; Cole County) and Plowboy Bend (Sections 24, 25, T 47 N, R 14 W; Moniteau County). Soils at the Plowboy Bend site were mapped as Sarpy Fine Sand (mixed, mesic Typic Udipsamments); soils at the Smoky Waters site were mapped as Haynie Silt Loam (coarse-silty, mixed, superactive, calcarious, mesic Mollic Udifluvents) and Leta Silty Clay (clayey over loamy, smectitic, mesic Fluvaquentic Hapludolls). Plowboy Bend is protected from the Missouri River by a levee; Smoky Waters is not. The sites have not experienced flooding since the beginning of the study, although both sites were inundated during the Great Flood of 1993. Crops were previously grown in these fields until the fall of 1998. By the late summer of 1999, all study fields had a cover of herbaceous weeds and native plants.

Figure 1. Design of study treatment blocks at Plowboy Bend Conservation Area. Each block is 40 acres (16.2 ha) in area and contains 44 rows on 30-foot (9.1 m) centers. Rows are either mounded or not. The no management block is the control where no efforts were made to direct succession.



Design

The study is comprised of six 40-acre (16.2 ha) blocks that are equally divided between Smoky Waters and Plowboy Bend Conservation Areas. Each block is laid out as a square with a side being 1,320 feet (402 m) in length. One of the 40-acre (16.2 ha) blocks (Figure 1) at each conservation area has received no treatment after the initial site preparation, which is described below. This field represents the "do nothing" or no management scenario and will be monitored to document "natural" succession that follows abandonment of bottomland cropfields. The other two blocks at each area were randomly assigned a cover crop treatment: redtop grass (*Agrostis alba,* L.) cover crop, or no cover crop. The no cover crop block allows competing vegetation to develop naturally with the planted oak seedlings. Within each of the management blocks, soil mounding treatments (mounded or not) were randomly assigned across each block in groups of 5 rows each (Figure 2).

Figure 2. Soil mounding treatments were randomly assigned across each 40-acre (16.2 ha) management block. Each line represents 5 rows on 30-foot (9.1 m) centers.

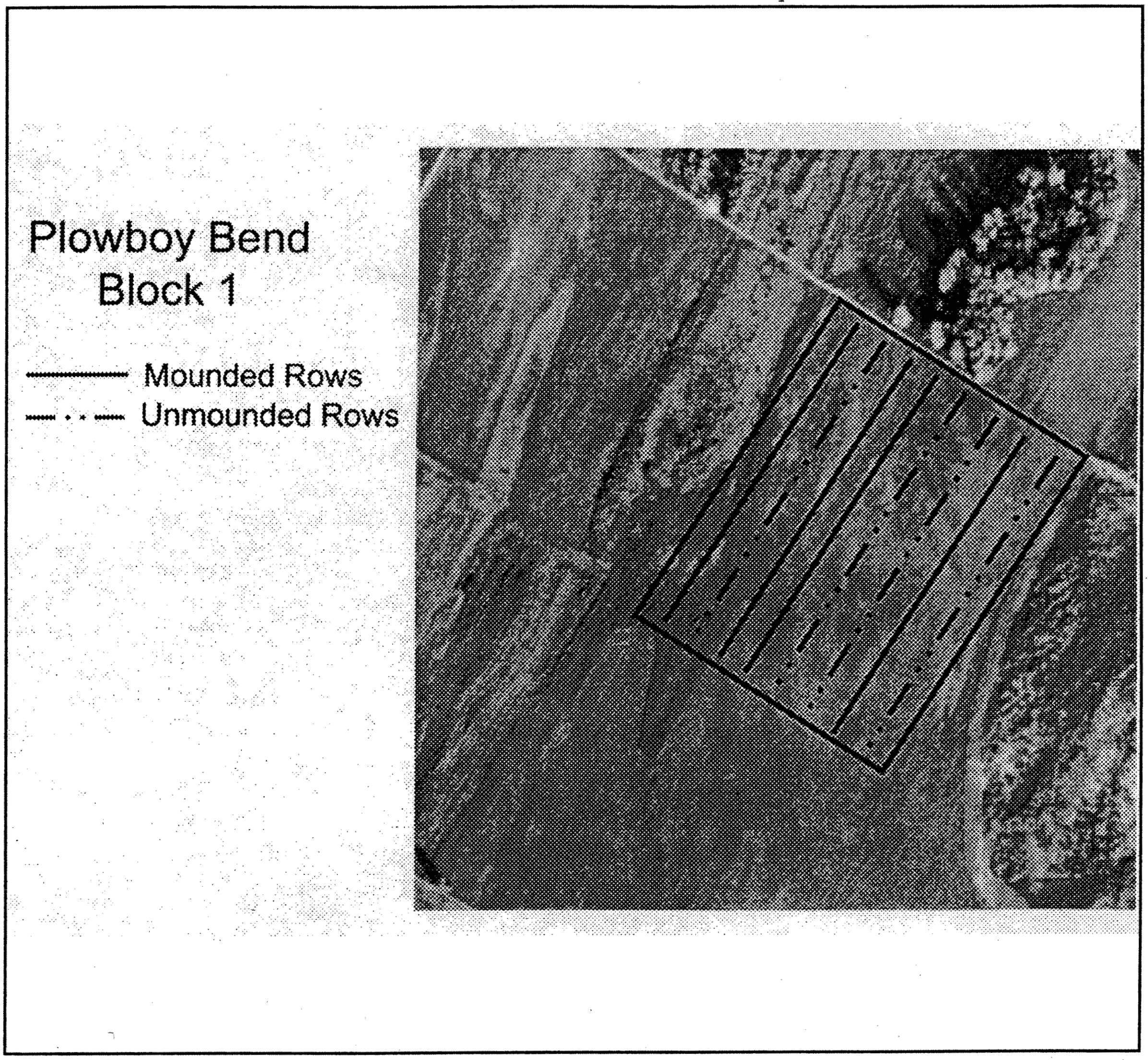
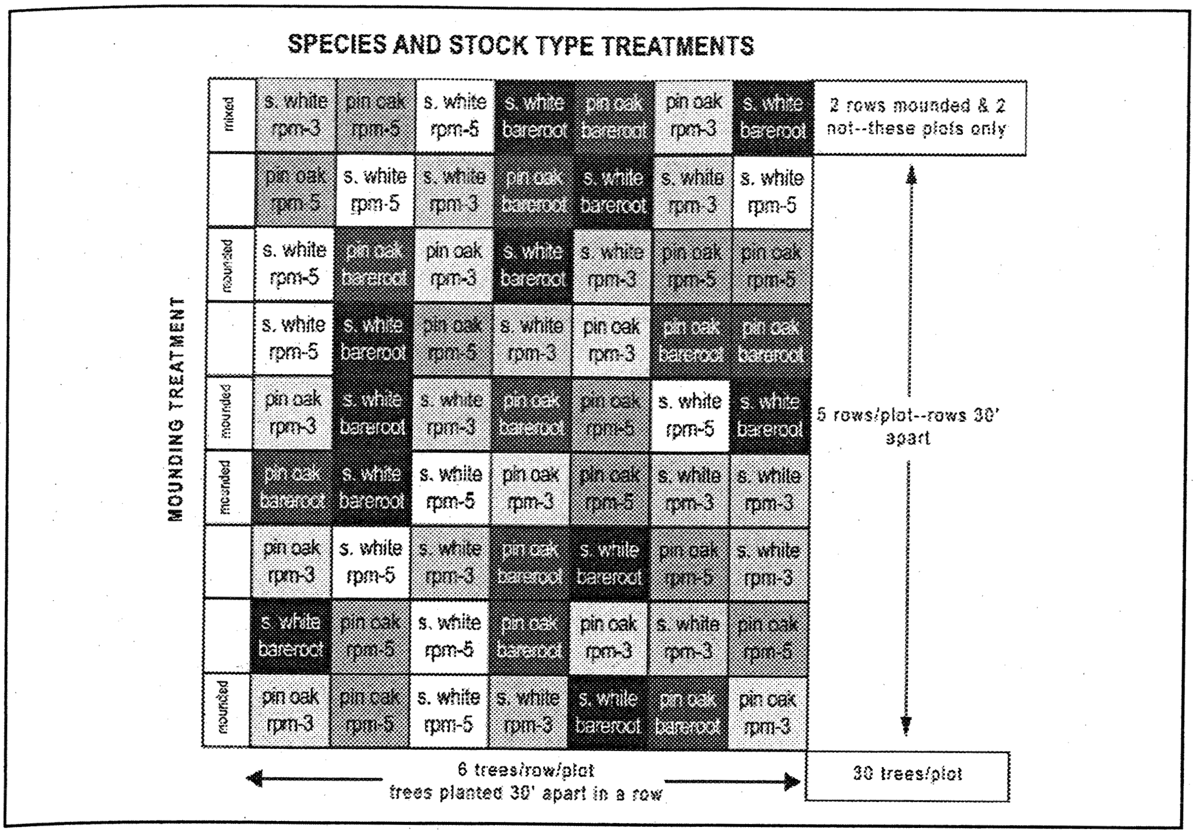


Figure 3. Layout of Smoky Waters no redtop treatment block. The various combinations of species and stock types were randomly located along the soil mounding treatment rows and were replicated 4 times within each 40-acre (16.2 ha) management block. Additional plantings were made to fill out the 40 acres (16.2 ha). rpm-3 = RPM™ seedling in a 3-gallon (11.4 l) container. rpm-5 = RPM™ seedling in a 5-gallon (18.9 l) container.



Rows were spaced 30 feet (9.1 m) apart and oriented parallel to the Missouri River to ensure that soil mounds would not impound surface waters. The combinations of three stock types and two oak species were randomly assigned down each of the 5-row soil mounding treatments. Stock types included 1-0 bareroot, and two classes of RPM™ seedlings. RPM™ is a trademark for the Root Production Method, an air root pruning process developed by Forrest Keeling Nursery in Elsberry, MO. This nursery culture technique produces a large container-grown seedling that has a dense, fibrous root system. Trees are grown into 3- or 5-gallon (11.4 l or 18.9 l) containers and attain heights of 5 feet (1.5 m) in one to two years in the nursery. In our study, RPM™ seedlings were either 1.5-year-old trees in 3-gallon (11.4 l) pots, or 2-year-old trees in 5-gallon (18.9 l) pots. Species included pin oak and swamp white oak. Seedlings were planted on a spacing of 30 feet (9.1 m) within each row (30'x 30' spacing = 48 trees/ac (119 trees/ha)). Within a cover crop block (40-acre (16.2 ha)), mounding, stock type and species treatments were replicated 4 times (Figure 3). Additional trees were planted at field edges to reforest the entire 40 acres (16.2 ha).

Blocks were located after we sampled soils to identify patterns in soil texture, hydrology and other physical properties that may influence plot layout. Soil texture and moisture regime, as evidenced by soil morphology, were determined to a depth of 4 feet (1.2 m) using an auger at both Plowboy Bend and Smoky Waters. We sampled soils systematically across all fields, but also sampled micro-topographic features such as ridges, old side channels and other shallow depressions. Micro-topography, soil texture and drainage did not vary substantially over the study areas and we concluded it would not affect the location or design of treatment plots.

Site Preparation and Establishment

The Plowboy Bend study site was mowed with a tractor and brush-hog in July of 1999, and gone over twice in perpendicular directions with an offset disk in August to prepare it for tree planting and sowing of the redtop grass. Site preparation at the Smoky Waters study site differed somewhat from that at Plowboy Bend because plant biomass was considerably greater. At Smoky Waters, herbicides (2,4-D and Roundup) were applied with an agricultural boom-type sprayer in early August. The herbicide was applied at a rate of 2.0 qt/ac (4.7 l/ha) of Roundup, 1.0 qt/ac (2.3 l/ha) of 2,4-D and 2 pounds/ac (1.2 kg/ha) of water-soluble ammonium sulfate. Within a month, the study site at Smoky Waters was disked the same way as was done at Plowboy Bend. In mid-September of 1999, the redtop blocks were worked with an offset disk, and soil mounds were constructed with a levee plow (AMCO LF6-824) on all but the control blocks. Soil mounds were about 2 foot (0.6 m) in width at the top of the berm and 7 feet (2.1 m) at the base. After the soil settled, mounds were about 12 inches (30 cm) to 15 inches (38 cm) in height above the natural ground elevation. In September, immediately following disking and soil mounding, redtop grass (*Agrostis alba,* L.) was sown at 6 pounds/ac (3.6 kg/ha) with a two-gang roller (Brillion) seeder.

For each oak species, approximately 1,200 seedlings of each stock type were planted in randomly located 30-tree plots (Figure 3), for a total of 7,362 trees over the entire study area. RPM™ trees were planted in November of 1999 and the 1-0 bareroot seedlings were planted in the spring of 2000. Heights and basal diameters were similar between the two RPM™ stock types for each oak species. Height averaged 7.2 feet (2.2 m) and 7.6 feet (2.3 m) for pin oak RPM™ trees grown in 3- and 5-gallon (11.4 l and 18.9 l) containers, respectively (Table 2). Regardless of RPM™ stock type, pin oak seedlings averaged 0.8 inches (20.3 mm) in basal diameter. Swamp white oak RPM™ seedlings were slightly smaller in height and basal diameter than the pin oaks. In contrast, bareroot seedlings averaged about 1.1 feet (0.3 m) in height and 0.2 inches (5 mm) in basal diameter, regardless of species. At the time of planting, a slow release fertilizer (33-3-6) was applied to the ground surface around each seedling at an approximate rate of 2 oz. (30 g) per tree. A 4 x 4 foot (1.2 x 1.2 m) woven plastic weed mat was placed around each seedling in the spring of 2000.

Table 2. Initial seedling size measured after planting by species and stock type.

Species & stock type	Sample size	Mean basal diameter(inches)	Mean total height(feet)
Pin oak BR	1,175	0.23 ± 0.05	1.1 ± 0.2
Pin oak RPM3	1,204	0.75 ± 0.13	7.2 ± 1.2
Pin oak RPM5	1,269	0.79 ± 0.14	7.6 ± 1.2
Swamp white oak BR	1,192	0.25 ± 0.06	1.1 ± 0.2
Swamp white oak RPM3	1,274	0.66 ± 0.13	5.8 ± 1.1
Swamp white oak RPM5	1,248	0.66 ± 0.13	6.1 ± 1.1

(BR = bareroot seedling; RPM3 = RPM™ seedling in a 3-gallon (11.4 l) container; RPM5 = RPM™ seedling in a 5-gallon (18.9 l) container). Basal diameter was measured one inch above the ground surface (mean ± standard deviation).

Table 3. Summary statistics of first-year survival and growth of oaks planted in former agricultural crop fields in the Missouri River floodplain.

Species & stock type	Sample size	Survival (%)	Mean height increment (feet)	Mean basal diameter increment (inches)
Pin oak BR	332	93	-0.4	0.00
Pin oak RPM3	414	100	0.4	0.12
Pin oak RPM5	464	100	0.5	0.15
Swamp white oak BR	358	95.5	-0.3	0.02
Swamp white oak RPM3	423	99.8	0.5	0.07
Swamp white oak RPM5	441	100	0.6	0.11

(BR = bareroot seedling; RPM3 = RPM™ seedling in a 3-gallon (11.4 l) container; RPM5 = RPM™ seedling in a 5-gallon (18.9 l) container).

Measurements

Soil temperature and moisture were monitored at 4-inch (10 cm) and 12-inch (30 cm) depths in both mounded and non-mounded planting rows to determine if and how soil mounding benefits the planted seedlings. Soil temperature was recorded every three hours with HOBO® H8 Outdoor/Industrial data loggers and permanently installed TMCx-HA temperature sensors (both from Onset Computer Corporation, Pocasset MA). Soil moisture was measured weekly with permanently installed Watermark Soil Moisture Sensors (Irrometer Company, Inc., Riverside CA). Soil temperature and moisture sensor installations were paired in adjacent mounded and non-mounded rows. Data included in this paper are from single, randomly-located installation pairs in each planted 40-acre (16.2-ha) block.

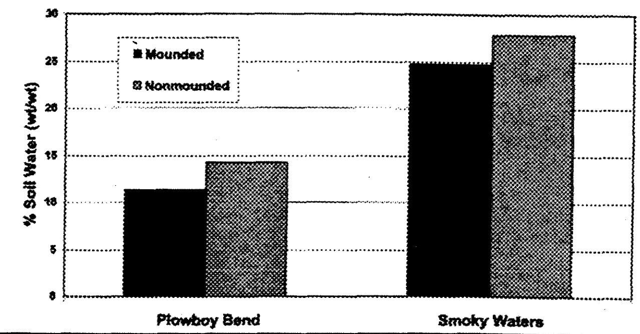
Initial total height and basal stem diameter (one inch (2.54 cm) above the ground) were measured on all seedlings after planting (November 1999) and again at the end of the first growing season (measurements began in September of 2000). Beginning in mid-August 2000, an acorn survey was conducted on all RPM™ swamp white oak trees (N=2,522) because they are capable of producing seed in the first year after outplanting. RPM™ pin oaks also can fruit much earlier than naturally grown pin oaks, but they usually take several years longer than swamp white oak to begin producing acorns.

From June through August of 2000, ground layer vegetation was monitored using randomly located paired 1-m^2 (approx. 11 ft^2) quadrats and 10 m x 20 m (approx. 33 ft x 66 ft) macroplots, which were permanently marked to facilitate remeasurement. Percent ground cover by species was determined on the quadrats and macroplots. Paired quadrats, one between seedlings within a planted row and one located perpendicular to it in between the rows, were used to quantify composition and abundance of competing vegetation within treatment plots. Within each 40-acre (16.2 ha) block, three replications of mounding, stock type and species treatment combinations were sampled with paired quadrats. A total of 72 1-m2 (11 ft^2) quadrats were installed in each block. Additionally, three macroplots per 40-acre (16.2-ha) block were established to more thoroughly document plant species diversity and succession. Vertical structure of the ground flora was quantified at each quadrat location in between the rows using a density board to estimate percent cover of grasses, woody vegetation, forbs and total vegetation by 0.25-m (0.8-foot) height increments up to a height of 2 m (6.6 feet) (Hays et al. 1981).

RESULTS

The results presented here are a preliminary look at the growth and survival of the planted trees based on the measurement of approximately one-third (2,432 trees) of the study trees after one growing season. Observations were evenly distributed among all combinations of species and stock types (Table 3). Summary statistics are presented for soil moisture and temperature, seedling survival and growth, acorn production, and competing vegetation. In general, there were no substantial differences in survival and growth between mounding, or cover crop treatments for a given stock type. Thus, data are summarized by species and stock type, or by study area and cover crop treatment. Statistical analysis of treatment effects will be conducted once all data are collected.

Figure 4. Percent soil water in mounded and nonmounded soils at the 4-inch (10 cm) depth at Plowboy Bend and Smoky Waters Conservation Areas.



Soil Moisture and Temperature

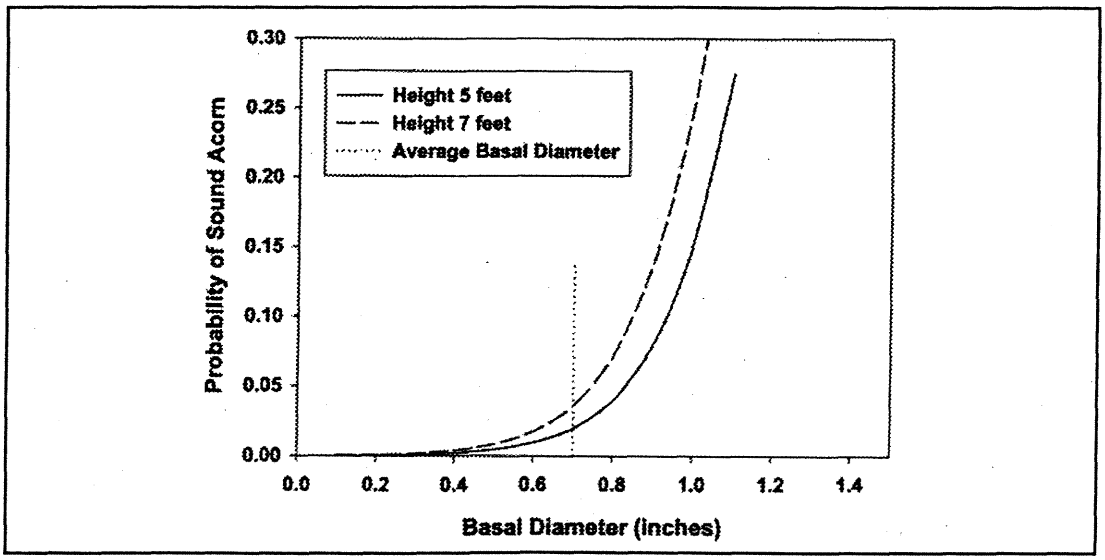
Soil water content at the 4-inch (10 cm) depth was greater at Smoky Waters (averaging 27 percent) than at Plowboy Bend (averaging 13 percent). The finer textured soil at Smoky Waters has greater soil moisture holding capacity than does the soil at Plowboy Bend. Better soil moisture at Smoky Waters is one reason why there was a greater percent of ground cover than at Plowboy Bend (see vegetation section below). At the 4-inch depth (10 cm), soil mounding decreased soil water content by an average of 3 at both Smoky Waters and Plowboy Bend (Figure 4). At Smoky Waters, a similar decrease in mounded soils was found at the 12-inch (30 cm) depth but at Plowboy Bend there were no differences in soil water content between mounded and non-mounded soils at the 12-inch (30 cm) depth. Although soil water content differences between mounded and non-mounded soils were small when averaged for a growing season or an entire year, we observed that mounded soils were 10 percent to 20 percent drier than non-mounded soils shortly after heavy rainfall. Thus, soil mounding enhanced drainage and shortened the duration that soils contained excessive amounts of water. We anticipate that soil mounding will elevate seedlings above flood waters and help to drain soils more quickly after flood waters recede.

We found that mounded soils generally warmed up more quickly in the spring but cooled off more quickly in the fall. Early soil warming in the spring may encourage root growth to begin sooner, but early soil cooling may cause root growth to stop prematurely in the fall. Despite these differences in soil moisture and temperature between mounded and non-mounded soils, we have not observed any differences in survival and growth of seedlings on mounded and non-mounded soils. We will continue to monitor soil moisture and temperature with seedling growth and survival to determine if there are long-term benefits from soil mounding. The benefits of soil mounding may not become apparent until the sites experience flooding.

Oak Seedling Survival and Growth

Survival was high for all species and stock types (Table 3). RPM™ seedlings had little to no mortality, while 5 percent to 7 percent of the bareroot seedlings died in the first year. Bareroot oak seedlings showed negative height increment due to shoot dieback and resprouting, a common problem that is observed during the establishment period for hardwood bareroot seedlings (e.g., Johnson 1984). Average first-year height increment ranged from 0.4 feet (0.1 m) for RPM™ pin oaks from 3-gallon (11.4 l) containers to 0.6 feet (0.2 m) for swamp white oak RPM™ from 5-gallon (18.9 l) containers. RPM™ seedlings grew about 0.1 inch (2.5 mm) in basal diameter, whereas diameter growth was negligible in bareroot seedlings regardless of species.

Figure 5. The probability of producing at least one sound acorn during the first year in relation to basal diameter of swamp white oak RPM™ seedlings.



Acorn Production

Acorn production occurred in a small proportion (3.5 percent) of the 2,522 swamp white oak RPMTM seedlings their first year in the field. Most of the production (60 percent) occurred in oaks from 5-gallon (18.9 l) containers, but larger 3-gallon (11.4 l) container RPM™ trees also produced acorns. Trees that produced seed in the first year averaged 3.5 sound acorns, and production varied from 1 to 18 acorns. For both the 3- and 5-

gallon (11.4 l and 18.9 l) swamp white oak RPM™, the probability of producing at least one sound acorn at the end of year one increased with increasing basal diameter and height (Figure 5). For example, the probability of producing a sound acorn after one year is 2 percent for a 5-foot-tall (1.5 m) RPM™ seedling with a basal diameter of 0.7 inches (17.8 mm), but increases to 15 percent for a 1.0-inch-basal-diameter (25.4 mm) tree of similar height. Early production of acorns is quite remarkable considering that open-grown oaks do not begin producing seed until they are 20 to 30 years old (Burns and Honkala 1990).

Figure 6. Mean percent ground cover by cover crop treatment at Plowboy Bend (PB) and Smoky Waters (SW) Conservation Areas.

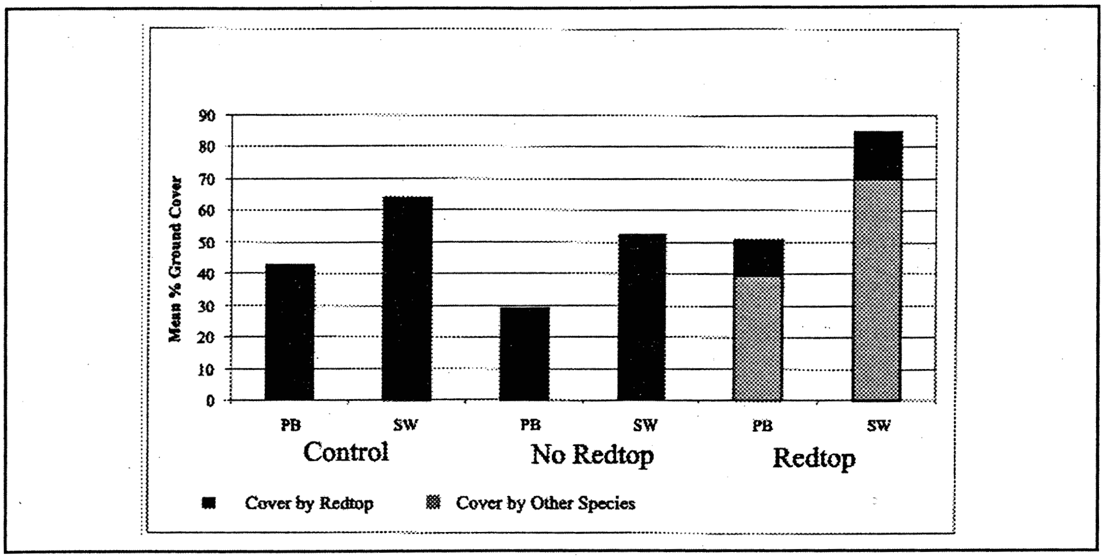
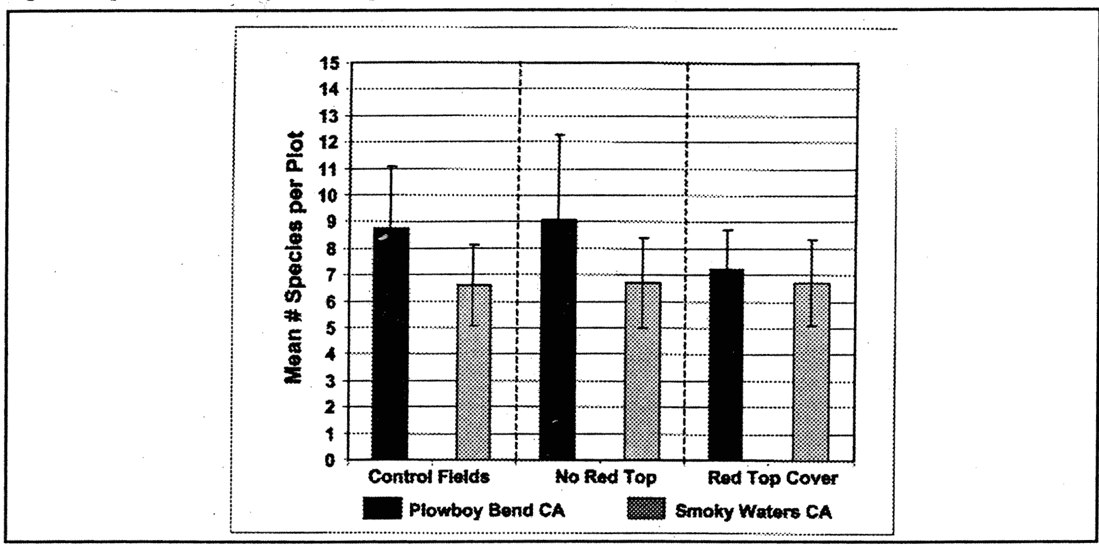


Figure 7. Species richness by cover crop treatment at Plowboy Bend (PB) and Smoky Waters (SW) Conservation Areas.

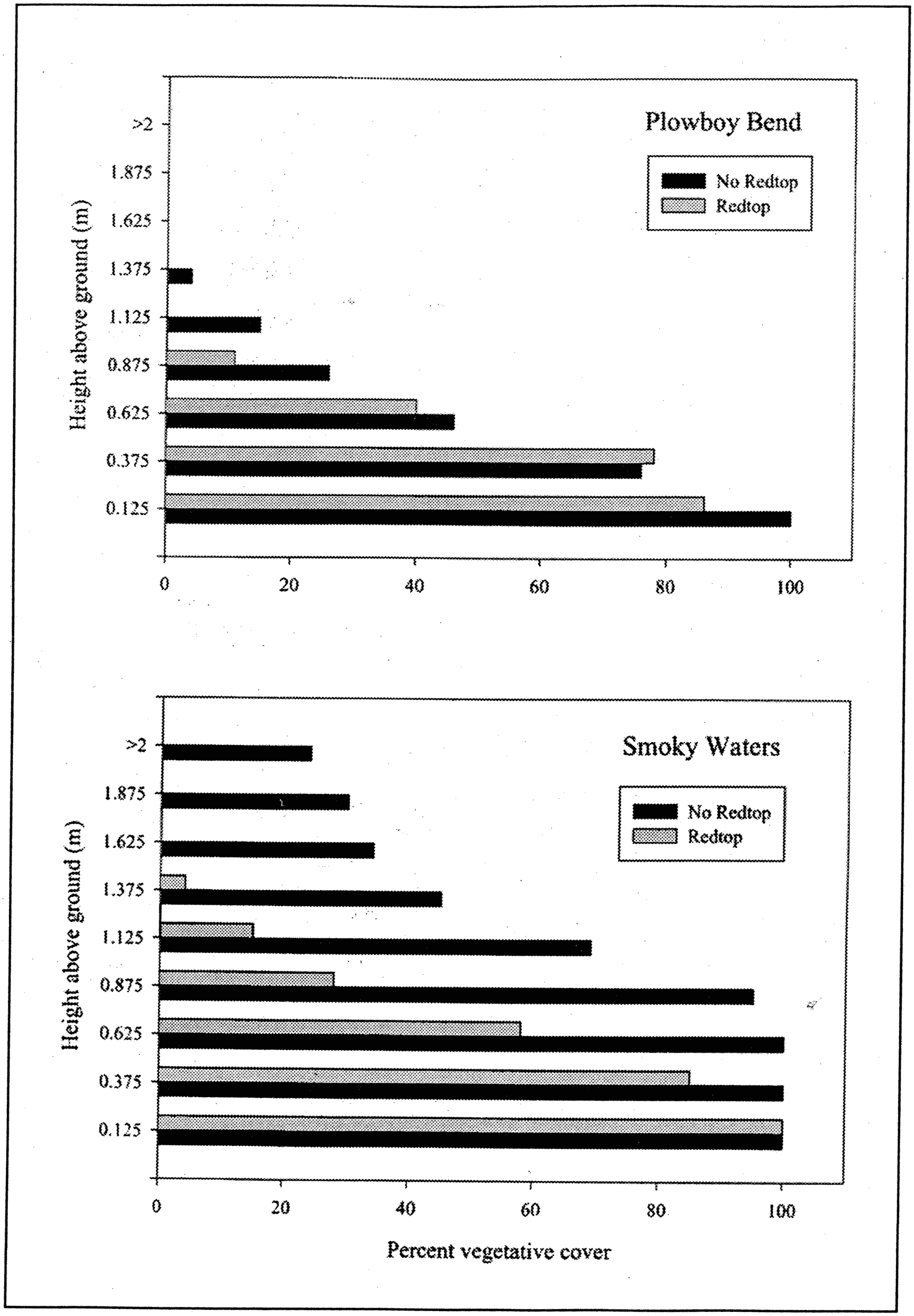


Vegetation Development

During the first summer, we identified 101 plant species across all study blocks at Smoky Waters and Plowboy Bend Conservation Areas. Most plants were annual and biennial forbs and grasses, of which slightly more than half were exotic species. Common native species included purslane speedwell (*Veronica peregrina,* L), cut-leaf primrose (Oenothera laciniata Hill), and horseweed (*Conyza canadensis,* L.). Many species (N=81) were not widely distributed, occurring on less than 10 percent of all the 1 m² (11 ft²) quadrats. Woody species inventoried included boxelder (*Acer negundo,* L.), eastern cottonwood, hackberry and trumpet creeper (*Campsis radicans,* L.). In general, mean percent ground cover was greater at Smoky Waters than that at Plowboy Bend (Figure 6). Sowing redtop grass as a cover crop increased the total percent ground cover at all sites and reduced the percent cover of other herbaceous species. At Smoky Waters, mean percent ground cover of other plants was reduced from about 52 percent on the no redtop block to about 15 percent on the redtop block. Similar reductions were observed at Plowboy Bend. Species richness (mean number of species per 1 m² (11 ft²) plot) was slightly higher at Plowboy Bend than Smoky Waters (Figure 7).

Vertical structure of the vegetation varied by cover crop treatment and between the two study sites (Figure 8). Percent cover decreased more rapidly with increasing height above the ground on the redtop grass blocks than on the no redtop blocks at both Smoky Waters and Plowboy Bend. Vegetation reached greater heights at Smoky Waters than at Plowboy Bend regardless of cover crop treatment. At Plowboy Bend, vegetation grew to 4.9 feet (1.5 m) on the no redtop block and 3.3 feet (1 m) on the redtop block. At Smoky Waters, vegetation grew to heights exceeding 6.6 feet (2 m) on the no redtop block but little vegetation was taller than 3.3 feet (1 m) on the redtop block. On the no redtop blocks at Smoky Waters, total percent cover was substantial above 3.3 feet (1 m), and it averaged 24 percent above 6.6 feet (2 m). Grasses dominated (50 percent to 65 percent of the total percent cover) the vegetation up to 2.5 feet (0.75 m) on the redtop blocks, but they made up little of the vegetation on the no redtop blocks at both study sites.

Figure 8. Vertical structure of ground flora at Plowboy Bend and Smoky Waters by cover crop treatment.



SUMMARY

Soil texture was related to average soil water content with the finer textured soils at Smoky Waters having higher average annual soil water content than that at Plowboy Bend. Vegetation development was greater at Smoky Waters than at Plowboy Bend, in part, because of these differences in soil texture and moisture. Soil mounds had better drainage than non-mounded soil, which resulted in more rapid loss of soil moisture after heavy rains and decreased soil water content in surface (upper 4 inches (10 cm)) soils at both sites. Soil mounding improved drainage and shortened the duration that soils contained excessive amounts of water after heavy rains, even in the finer sand and silt loam soils. It is too early to draw conclusions on the benefits of soil mounding for neither site has experienced a flood since the establishment of this study.

After one year, annual and biennial forbs and grasses dominated the plant community on these former bottomland cropfields. Exotic species comprised more than half of the species present during the first summer. The establishment of a cover crop of redtop grass greatly modified the development of vegetation on former bottomland cropfields after one year. Sowing redtop grass increased the total percent ground cover, effectively reduced the presence and vertical canopy coverage of other competing vegetation, decreased the height of competing vegetation to less than 3.3 feet (1 m), and increased the importance of grasses in the plant community. Grasses had an insignificant presence on the no redtop blocks, where competing vegetation grew to heights of 6.6 feet (2 m) and higher. The vertical structure of the ground flora was more complex and well developed on the blocks without redtop grass. Total percent cover was greater with increasing heights without redtop grass, and maximum development occurred at Smoky Waters where there was still more than 20 percent total canopy cover in the 6.6 feet (2 m) and above height category. Although there was substantial differences in plant community composition and structure between the cover crop treatments and between the two study sites, it is too early to conclude that the redtop grass competes less with planted oaks than does the mixture of herbaceous vegetation that develops in the absence of redtop grass. Differences in oak seedling survival and growth were negligible between the cover crop treatments.

The two RPM™ stock types were similar in their field performance regardless of species. Likewise, soil mounding and the use of a cover crop did not increase seedling survival or growth during the first year after planting. Survival was very high, even for the bareroot seedlings. Height and basal diameter growth of the RPM™ seedlings were greater than that observed in bareroot seedlings, which experienced negligible diameter growth and negative height growth due to shoot dieback and resprouting. A small proportion of the swamp white oak RPM™ seedlings produced sound acorns in the first year. Larger swamp white oak RPM™ seedlings had a significantly greater chance of producing at least one sound acorn in the first year than did smaller seedlings. We will continue to monitor seedling survival and growth to determine if stock type, species, soil mounding or a cover crop improves oak regeneration as the competition intensifies and the sites experience flooding.

The results of this research will lead to recommended methods of oak regeneration that can be used to (1) diversify native forests that develop on abandoned cropfields by supplemental planting of oak and other nut producing trees, (2) incorporate oaks and nut trees in agroforestry operations, and (3) sustain oaks in private land forests, greentree reservoirs, conservation areas and wildlife refuges. Humans always have and will continue to influence floodplain environments. Our hope is that by learning about processes of hard-mast reforestation, these habitats can be managed in more productive and valuable ways.

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