VEGETATION COVER AFFECTS MAMMAL HERBIVORY ON PLANTED OAKS AND SUCCESS OF REFORESTING MISSOURI RIVER BOTTOMLAND FIELDS

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Abstract—We are evaluating oak regeneration methods at Plowboy Bend and Smoky Waters Conservation Areas in the Missouri River floodplain by planting oak seedlings in different cover types (redtop grass vs. natural vegetation) on four 40-acre fields. After 1 year, survival of planted oaks was high; however, herbivory from rabbits was intense depending on cover type. Damage to an individual oak seedling was substantially more severe in the natural vegetation fields than in the redtop grass fields. Most herbivory in the redtop grass fields occurred near the field edges, whereas herbivory occurred throughout the natural vegetation fields. In the winter of 2001-2002, we estimated rabbit densities at one rabbit per acre in the redtop grass field and three rabbits per acre in the natural vegetation field based on a mark-recapture study at Plowboy Bend. We attribute these differences in rabbit density, and severity and extent of damage to oak seedlings, to composition and structure of the ground flora (cover type), which may influence food availability and predation risk to rabbits.

INTRODUCTION

Managers are interested in planting oaks in the Mississippi River and Lower Missouri River floodplains for a variety of reasons including afforesting former agricultural bottomlands, conserving native bottomland tree species, improving wildlife habitat, and establishing agroforestry practices. However, regenerating oaks in bottomland fields can be difficult due to intense competition from other vegetation and to wildlife damage. We initiated a study to evaluate different methods for establishing bottomland oaks in floodplains using different nursery seedling types and planting seedlings with a cover crop of redtop grass (*Agrostis gigantea* Roth) to control competition (Dey and others 2003, Shaw and others 2003). After the first growing season, we observed a substantial amount of rabbit herbivory on the planted oak seedlings. This varied by cover crop within the fields.

The eastern cottontail rabbit (*Sylvilagus floridanus*) is a habitat generalist with an extensive geographic range that covers the eastern two-thirds of the United States (Conway and others 1974, Hanson and others 1969, Lord 1963). Rabbits are herbivores that prefer succulent green vegetation. In Missouri, the most preferred foods are blue grass (*Poa pratensis* L.), wheat (*Triticum aestivum* L.), and white clover (*Trifolium repens* L.) when they are available. In the winter, the rabbit's diet includes more buds, bark, shoots and twigs of vines, shrubs, and trees, especially when the ground is snow covered (Haugen 1942, Schwartz and Schwartz 1995). During the summer, rabbit damage to woody plants is minimal because of the abundance of preferred grasses, legumes, and forbs. But in winter, rabbits can cause severe damage to tree reproduction by pruning, barking, and girdling stems and shoots, which often increases seedling mortality (Geis 1954, Meiners and Martinkovic 2001). Trees with thin bark, young stump sprouts, and seedlings are particularly vulnerable.

The specific objectives of this paper are to estimate the winter population density of rabbits by cover type within the 40 acre fields at Plowboy Bend Conservation Area, MO, and to relate population density to the amount and distribution of rabbit herbivory on planted oak seedlings by cover type. The two cover types in this study are redtop grass and natural vegetation, in which we have planted oak seedlings.

METHODS

The study was 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 (Secs. 24 and 25, T 47 N, R 14 W; Moniteau County). Shaw and others (2003) have reported the experimental design of this study and how the vegetation data were collected. To summarize, we planted swamp white oak (*Quercus bicolor* Willd.) and pin oak (*Quercus palustris* Muenchh.) seedlings grown as 1-0 bareroot, 3 gallon RPM™, or 5 gallon RPM™. Grossman and others (2003) have described the Root Production Method (RPM™) that was developed by Forrest Keeling Nursery in Elsberry, MO, and used to grow the RPM™ seedlings in our study. The RPM™ is a cultural system that uses air root pruning to produce a large container-grown seedling with a dense, fibrous root system. We planted the oak seedlings in 40-acre fields with a cover crop of redtop grass, or with natural vegetation that develops when bottomland crop fields are abandoned. Within each field seedlings were planted at a density of 48 trees per acre (30 foot by 30 foot spacing).

Initial seedling sizes after planting are shown in table 1. Heights and basal diameters were similar between the two RPM™ stock types for each oak species. Height averaged 7.2 feet and 7.6 feet for pin oak 3 gallon RPM™ and 5 gallon RPM™ trees, respectively. Regardless of RPM™

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Citation for proceedings: Connor, Kristina F., ed. 2004. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 594 p.

Table 1—Height and basal diameter (1 inch above groundline) of seedlings planted in this study

Species and stock type	Sample size	Mean basal diameter	Mean total height
	no. trees	*- - inches - -*	*- - feet - -*
Pin oak bareroot	1,175	0.23 ± 0.05	1.1 ± 0.2
Pin oak 3 gallon	1,204	0.75 ± 0.13	7.2 ± 1.2
Pin oak 5 gallon	1,269	0.79 ± 0.14	7.6 ± 1.2
Swamp white oak bareroot	1,192	0.25 ± 0.06	1.1 ± 0.2
Swamp white oak 3 gallon	1,274	0.66 ± 0.13	5.8 ± 1.1
Swamp white oak 5 gallon	1,248	0.66 ± 0.13	6.1 ± 1.1

stock type, pin oak seedlings averaged 0.8 inches in basal diameter (1 inch above the root collar). 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 in height and 0.2 inches in basal diameter, regardless of species. Annually, we monitored survival, diameter and height growth, and animal damage on the planted oaks.

From June through August of 2000, ground layer vegetation was monitored using 432 1-m^2 quadrats that were randomly located across all 40-acre cover type fields. Percent ground cover by species was determined on the quadrats. Vertical structure of the ground flora was quantified at each quadrat location by setting a density board between rows of trees to estimate percent cover of grasses, woody vegetation, forbs, and total vegetation by 0.8 foot height increments up to a height of 6.6 feet (Hays and others 1981).

Beginning in the fall of 2000 and through the winter, we noticed that cottontail rabbits (*Sylvilagus floridanus*) were browsing a substantial number of the planted oaks, especially in the natural vegetation fields. Therefore, in the spring of 2001 we documented the herbivory damage by recording the proportion of each RPM™ seedling stem that was girdled; i.e., where the rabbits had chewed through the bark and eaten the cambium. For bareroot seedlings, we noted if the stem was completely clipped or not.

In December 2001, we set Tomahawk cat/rabbit model 606 live-traps at a rate of one per acre in each of the two 40-acre cover type fields to estimate population density of cottontail rabbits at Plowboy Bend Conservation Area. We set traps on a 210 foot by 150 foot grid in the natural vegetation field for 8 continuous days, then repeated the procedure for another 8 consecutive days in the redtop grass field.

We covered the traps with black roofing paper to minimize stress on the rabbits and to protect them from inclement weather. The roofing paper was tightly wrapped around the trap and held in place by the weight of the trap. We left the ends of the trap uncovered so the food was visible to the rabbits and so they could get into the trap. We baited the traps with equal amounts of cabbage, carrots, celery, and rabbit feed. We checked each trap daily between 7:00 a.m. and 9:00 a.m. for captures and re-baited them as needed.

Initially, each rabbit caught was assigned a unique number and marked with a pair of similarly numbered metal tags that we attached to each ear. We measured the rabbit's weight, determined its sex, and rated its health based on the visual appearance and behavior of the animal. Each day of the 8 day trapping session, we recorded the ear tag number of recaptured marked rabbits and released them from the point of capture. Newly captured rabbits were marked with uniquely numbered ear tags and measured. We treated all injuries sustained by the rabbits during the trapping process with an antiseptic spray.

We determined rabbit abundance using the Schnabel method for mark and recapture data. The Schnabel method is suitable for multiple trapping periods, and accounts for possible deaths and rabbits that are captured more than once. The standard Schnabel equation for determining a population estimate is:

$$N = \frac{\sum_t (C_t M_t)}{\sum_t R_t}$$

where, N is the population estimate, C_t is the total number of individuals caught in sample t, M_t is the number of marked individuals in the population just before sample t is taken, and R_t is the number of individuals already marked when caught in sample t.

RESULTS AND DISCUSSION

During the first summer, we identified 101 plant species in the redtop grass and natural vegetation fields at Plowboy Bend Conservation Area. 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-m^2 quadrats. Woody species inventoried included boxelder (*Acer negundo* L.), eastern cottonwood (*Populus deltoides* Bartr. ex Marsh. var. *deltoides*), hackberry (*Celtis occidentalis* L.), and trumpet creeper (*Campsis radicans* L.). Total ground cover averaged 30 percent on the natural vegetation field, where the presence of grasses was minimal and forbs dominated the plant community. Sowing redtop grass as a cover crop increased the mean total ground cover to 53 percent and reduced the mean total cover of forbs to about 13 percent. Grasses dominated (75 percent of the total cover) the vegetation in the redtop grass field.

Vertical structure of the vegetation varied by cover treatment at Plowboy Bend Conservation Area (fig. 1). Vegetation grew to 4.9 feet on the natural vegetation field and 3.2 feet on the redtop grass field. Percent cover decreased more rapidly with increasing height above the ground on the redtop grass field than on the natural

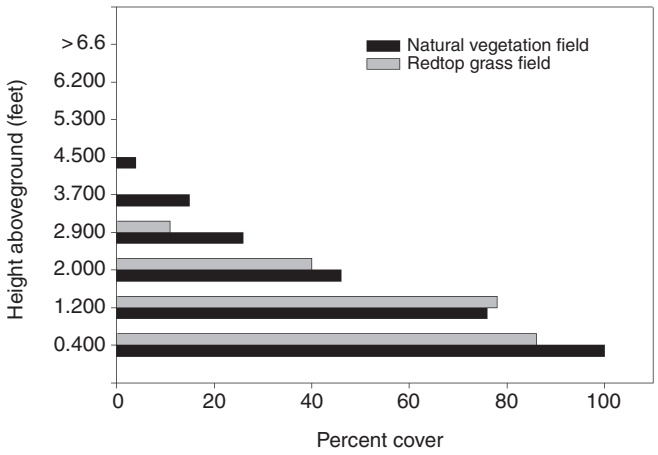

Figure 1—Height of vegetation and percent cover by height class in the redtop grass and natural vegetation fields after 1 year at Plowboy Bend Conservation Area.

vegetation field. At about 3 feet above the ground, total vegetation cover had dropped to 12 percent on the redtop grass field, but there was still 25 percent cover on the natural vegetation field. Total plant cover on the natural vegetation field averaged 4 percent even at 4.5 feet.

First-year (fall 2000) survival of oak reproduction at Plowboy Bend Conservation Area was high for both RPMTM and bareroot seedlings, regardless of species or cover type. Survival of RPM™ was nearly 100 percent, while that of bareroot seedlings averaged 82 percent for pin oak and 92 percent for swamp white oak. Second-year survival (fall 2001; i.e., 1 year after the first rabbit herbivory) for RPM™ seedlings remained high, but it declined for bareroot stock, regardless of species. Swamp white oak bareroot seedling survival was 73 percent in the redtop grass field and 80 percent in the natural vegetation. Survival was lowest for pin oak bareroot seedlings with only 53 percent of the seedlings surviving in the natural vegetation field and 67 percent in the redtop grass field.

Second-year heights of oak seedlings were reduced in the natural vegetation field at Plowboy Bend Conservation Area, where RPM™ trees lost significant amounts of height due to shoot dieback and resprouting after being girdled by rabbits (table 2). In contrast, there was generally a net increase in height after 2 years in the redtop grass field, regardless of species and stock type.

Herbivory to oak seedlings primarily consisted of barking, girdling and shoot clipping by rabbits. Damage to planted oaks was substantially greater in the natural vegetation field than the redtop grass field. In the redtop grass field, 69 percent of the bareroot seedlings had no rabbit herbivory damage and approximately one-third had the main stem clipped. In contrast, 85 percent of bareroot seedlings were clipped in the natural vegetation field. Of the RPM™ seedlings in the natural vegetation field, 97 percent were girdled or had the main stem completely clipped, whereas only 25 percent were damaged in the redtop grass field (fig. 2). Rabbit damage was severe (> 50 percent of the main stem girdled or shoot clipped) on 87 percent of the RPM™ seedlings in the natural vegetation field, but only 14 percent of the damage was severe in the redtop grass field. Most herbivory in the redtop grass field occurred near the field edges, whereas herbivory occurred throughout the natural vegetation field.

We marked a total of 26 rabbits in the redtop grass field and 58 rabbits in the natural vegetation field in 8 days of trapping. When incorporating recapture rates, we estimated rabbit densities at roughly one rabbit per acre and three rabbits per acre in the redtop grass and natural vegetation fields, respectively. Rabbit densities were high in the natural vegetation field compared to densities reported in the literature for the Midwestern United States (Swihart and Yahner 1982). We believe that the higher density of rabbits in the natural vegetation field is because the growth of summer vegetation provides good winter hiding cover for the rabbits, thus reducing their risk to predation. The preponderance of residual vegetative cover offers refugia to rabbits, thus attracting them to these sites. As a result, rabbits may be more likely to feed around these suitable cover sites.

Redtop grass sod is effective in preventing the development of natural vegetation in former bottomland crop fields. In the winter, the low-growing (< 2 feet in summer) redtop grass mats down and provides little cover

Table 2—Average initial and second-year height by species, stock type and cover type at Plowboy Bend Conservation Area

Species and stock type	Natural vegetation field		Redtop grass field	
	Initial height	Second-year height	Initial height	Second-year height
	feet			
Pin oak bareroot	1.1	0.5	1.1	1.0
Pin oak RPM™	7.5	4.8	7.8	8.2
Swamp white oak bareroot	1.1	0.9	1.2	1.4
Swamp white oak RPM™	6.0	2.7	6.1	6.3

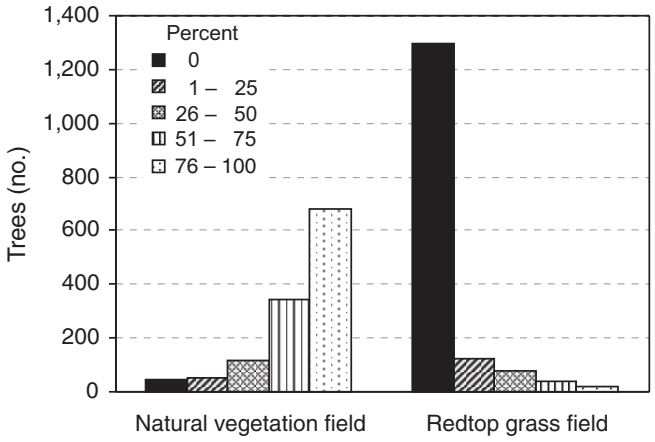

Figure 2—Distribution of RPM™ seedlings by rabbit herbivory damage class after the winter of 2000-2001 in the redtop grass and natural vegetation fields at Plowboy Bend Conservation Area. Damage classes are the percent surface area of each seedling stem girdled or injured by rabbits.

for rabbits. In contrast, vertical cover in the natural vegetation field remains relatively dense with increasing height above the ground because many of the forbs are heavy-stalked, woody-stemmed species such as horseweed, common sunflower (*Helianthus annuus* L.), and common lambs quarter (*Chenopodium album* L.) that do not readily mat down during the winter. In the natural vegetation field, winter cover is present to at least 3 feet high. The higher rabbit densities in the natural vegetation field are associated with more extensive and severe herbivory damage to the planted oak seedlings. In addition, food availability in the winter is limited in either of the redtop grass or natural vegetation fields, making the oak seedlings more vulnerable to rabbit herbivory.

Methods that create favorable understory conditions for rabbits may hamper regeneration efforts. We found that even subtle differences in vegetation structure are important determinants of rabbit density and herbivore damage to tree seedlings. Through manipulation of the habitat, managers can control rabbit damage to oak reproduction. Redtop grass cover is not good rabbit habitat in the winter, and planted seedlings are more likely to survive the winter with little herbivory damage from rabbits. Larger fields of redtop grass will have proportionally less rabbit herbivory because there is less edge to field area than in smaller fields. Fall mowing of natural vegetation in bottomland tree plantings to eliminate winter cover may be an alternative to using redtop grass as a cover, but this needs to be evaluated in future studies. Using radiotelemetry, our future work will evaluate fine scale rabbit use of planted fields, and we will relate this to habitat use and damage to planted oak seedlings.

ACKNOWLEDGMENTS

This work was funded through the University of Missouri Center for Agroforestry under cooperative agreements AG-02100251 with the U.S. Department of Agriculture, Agriculture Research Station (ARS) and C R 826704-01-0 with the U.S. Environmental Protection Agency (EPA). The results presented are the sole responsibility of the authors and may not represent the policies or positions of the ARS or EPA. This research was approved by the University of Missouri Animal Care and Use Committee (Protocol #3820).

LITERATURE CITED

Conway, C.H.; Sadler, K.C.; Hazelwood, D.H. 1974. Geographic variation in litter size and onset of breeding in cottontails. Journal of Wildlife Management. 38(3): 473-481.

Dey, D.C.; Kabrick, J.; Grabner, J.; Gold, M. 2003. Restoring oaks in the Missouri River floodplain. In: Proceedings 29th annual hardwood symposium: ardwood silviculture and sustainability: 2001 and beyond. 2001 May 17-19; French Lick, IN. Memphis, TN: National Hardwood Lumber Association: 8-20.

Geis, A.D. 1954. Rabbit damage to oak reproduction at the Kellogg Bird Sanctuary. Journal of Wildlife Management. 18(3): 423-424.

Grossman, B.C.; Gold, M.A.; Dey, D.C. [In press]. Restoration of hard mast species for wildlife in Missouri using precocious flowering oak in the Missouri River floodplain, USA. Agroforestry Systems.

Hanson, J.C.; Bailey, J.A.; Siglin, R.J. 1969. Activity and use of habitat by radio-tagged cottontails during winter. Transactions of the Illinois State Academy of Science. 62: 294-302.

Haugen, A.O. 1942. Life history studies of the cottontail rabbit in Southwestern Michigan. The American Midland Naturalist. 28(1): 204-244.

Hays, R.L.; Summers, C.; Seitz, W. 1981. Estimating wildlife habitat variables. FWS/OBS-81/47. U.S. Department of the Interior, Fish and Wildlife Service. 111 p.

Lord, R.D., Jr. 1963. The cottontail rabbit in Illinois. Technical Bulletin No. 3. Illinois Department of Conservation. 94 p.

Meiners, S.J.; Martinkovic, M.J. 2001. Survival of and herbivore damage to a cohort of *Quercus rubra* planted across a forest-old field edge. American Midland Naturalist. 147(2): 247-255.

Schwartz, C.W.; Schwartz, E.R. 1995. The wild mammals of Missouri. Columbia and London: University of Missouri Press and Missouri Department of Conservation. 356 p.

Shaw, G.W.; Dey, D.C.; Kabrick, J. [and others]. [In press]. Comparison of site preparation methods and stock types for artificial regeneration of oaks in bottomlands. In: Proceedings 13th central hardwood forest conference; Urbana-Champaign, IL. Gen. Tech. Rep. NC-. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.

Swihart, R.K.; Yahner, R.H. 1982. Eastern cottontail use of fragmented farmland habitat. Acta Theriologica. 27: 257-275.