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Forest Ecology and Management 204 (2005) 315–327
Forest Ecology and Management
www.elsevier.com/locate/foreco

Soil properties and growth of swamp white oak and pin oak on bedded soils in the lower Missouri River floodplain

John M. Kabrick[a,*], Daniel C. Dey[a], J.W. Van Sambeek[a], Michael Wallendorf[b], Michael A. Gold[c]

[a]USDA Forest Service North Central Research Station, 202 Natural Resources Building, Columbia, MO 65211, USA
[b]Missouri Department of Conservation, 1110 S. College Avenue, Columbia, MO 65201, USA
[c]Center for Agroforestry, University of Missouri, 203 Natural Resources Building, Columbia, MO 65211, USA

Received 25 May 2004; received in revised form 21 September 2004; accepted 28 September 2004

Abstract

Restoring bottomland hardwood ecosystems is of great interest along the lower Missouri River and within the Mississippi Alluvial Valley. However, bottomland hardwood plantings commonly have a high failure rate. Among reasons cited for failures are frequent flooding and poorly drained site conditions. Soil bedding is a commonly used site preparation method shown to increase the survival and growth of both conifer and hardwood seedlings. However, soil bedding has not always proven beneficial to seedling survival or growth and there are few published evaluations of the effects of bedding on bottomland hardwood seedlings. Objectives of this study were to evaluate the effects of bedding on soil properties and on the early survival and growth of different stock types of pin oak and swamp white oak seedlings in the lower Missouri River floodplain. Soil bedding had a minor effect on soil texture, organic carbon, cation exchange capacity, base cations, and pH. Bedding reduced soil bulk density by 7–16%, reduced gravimetric soil water content by 2–5%, and increased soil temperature by 1–2 °C. When grown with a cover crop of redtop grass, foliar N of trees in bedded soil was about 10% greater than that of trees in soil that was not bedded. There were no differences in survival, diameter growth, or height growth between seedlings grown on bedded and non-bedded soils. Despite beneficial changes to soils caused by bedding, it does not appear to enhance the survival or early growth of planted pin oak and swamp white oak seedlings on our study areas in the Missouri River floodplain.

Keywords: Soil bedding; Seedling survival; Seedling growth; Bottomlands; *Quercus palustris*; *Quercus bicolor*

1. Introduction

Restoring bottomland hardwood ecosystems is of great interest throughout the central and southern U.S.A., particularly along the lower Missouri River

* Corresponding author. Tel.: +1 573 875 5341x229; fax: +1 573 882 1977.
E-mail address: jkabrick@fs.fed.us (J.M. Kabrick).

0378-1127/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.foreco.2004.09.014

(Dey et al., 2003; Shaw et al., 2003) and within the Mississippi Alluvial Valley (Stanturf et al., 2000, 2001). Most of the millions of hectares of bottomland forests that once covered these regions were cleared for agriculture (Patterson and Adams, 2003). Considerable effort has been made to reforest land marginally productive for row crops (Stanturf et al., 2001), however, bottomland hardwood plantings commonly have high mortality (Schweitzer and Stanturf, 1997), resulting in reforestation failures (Patterson and Adams, 2003). Reasons for these reforestation failures include frequent flooding and wet site conditions (Stanturf et al., 1998). Soil bedding (or mounding) is a commonly used site preparation method for establishing tree seedlings in poorly drained soils (Derr and Mann, 1977; Londo and Mroz, 2001). Surprisingly, there is little published information about the use of soil bedding to establish bottomland hardwoods.

Soil beds typically are constructed by mounding soil with a moldboard plow, offset disc, rice levee plow, or similar tillage implements and also with backhoe-type excavators (Londo and Mroz, 2001). Once constructed, beds are 1–2 m wide and 15–60 cm tall. In addition to improving soil aeration and drainage (Page-Dumroese et al., 1997; Lakel et al., 1999; Fisher and Binkley, 2000; Smolander et al., 2000), other noted benefits of bedding include concentrating organic matter and nutrients (Fisher and Binkley, 2000) and mechanically removing competing vegetation (Schultz and Wilhite, 1974). Variation in microtopography is inherent to many natural forest systems (Hodges, 1997; Kabrick et al., 1997; Lyford and MacLean, 1966) and bedding can restore microtopography in agricultural fields.

Bedding increases height growth of slash pine (*Pinus elliottii* var. *elliottii* Engelm.) and loblolly pine (*P. taeda* L.) in poorly drained soils in the Coastal Plain of the southeastern U.S. (Derr and Mann, 1977; Cain, 1978), the survival and growth of jack pine (*P. banksiana* Lamb.) in glacial soils of northern Ontario (Sutton and Weldon, 1993), and the growth of Douglas-fir (*Pseudotsuga menzeisii* var. *glauca* (Beissn.) Franco) and western white pine (*P. monticola* Dougl. ex D. Don) in the mountains of northern Idaho (Page-Dumroese et al., 1997). Bedding improves the growth of hardwood seedlings including beech (*Fagus sylvatica* L.) on loamy soils in southern Sweden (Gemmel et al., 1996) and increases the height growth of yellow poplar (*Liriodendron tulipifera* L.) on soils with fragipans in Tennessee (Francis, 1979). Bedding can be beneficial when establishing bottomland oaks (*Quercus* spp. L.) and other hard-mast-producing tree species because they generally are less tolerant of poorly drained soils than other bottomland tree species. Bedding increases the height of Nuttall oak (*Q. nuttallii* Palmer) seedlings by as much as 35% on poorly drained and frequently flooded soils in the Coastal Plain of Louisiana, U.S.A. (Patterson and Adams, 2003).

However, soil bedding has not always proven beneficial to seedling survival or growth. Derr and Mann (1977) summarized findings from six different bedding studies in the Louisiana Coastal Plain and found only minor increases in the survival and growth of loblolly pine and slash pine. They concluded that bedding is beneficial to these species on only very poorly drained soils of this region. Haywood et al. (1990) found bedding improved soil drainage but not enough to increase the early growth of loblolly pine on silt loams in Louisiana. Gemmel et al. (1996) found that bedding had no effect on the growth of English oak (*Q. robur* L.) seedlings 3 years after planting in southern Sweden.

The great floods of 1993 and 1995 that occurred throughout the central U.S.A. destroyed levees and altered bottomland farms by scouring and depositing sediment. In Missouri, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the Missouri Department of Conservation, and other agencies have acquired thousands of acres of bottomland rendered unsuitable for farming by flooding. These agencies are now seeking methods for restoring a variety of native floodplain habitats, including bottomland hardwood forests, in these abandoned crop fields. Poor survival and growth in many bottomland tree plantings have increased interest in bedding soils for improving the survival and growth rates of oak seedlings in the Missouri River floodplain.

We evaluated the effects of bedding on soil properties and on the early survival and growth of different stock types of pin oak (*Q. palustris* L.) and swamp white oak (*Q. bicolor* Willd.). These two species are commonly planted in bottomlands throughout the Central Hardwood Region. Our study locations were representative of the broad range of soil