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Ecological characteristics of floodplain forest reference sites in the Upper Mississippi River System

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ABSTRACT

Historical and present day disturbances have contributed to long-term changes in the extent, composition, and structure of Upper Mississippi River System (UMRS) floodplain forests. Loss of forest habitat, low tree species diversity, a lack of successful regeneration in many areas, and continued declines in forest health over time are serious threats to this ecosystem. Floodplain forest restoration has therefore gained importance as a management goal throughout the UMRS. A key component of the restoration process is assessing the ecological characteristics of remnant, high quality reference sites to identify appropriate targets for forest restoration efforts. In this study, fourteen reference sites were located and established along a ~1140 km longitudinal stretch of the Upper Mississippi River, lower Illinois River, lower Big Muddy River, and lower Cache River watershed. Biological and abiotic data were sampled from 1000 m^2 permanent plots located at each study site. Overstory floodplain forest communities were generally dominated by silver maple (*Acer saccharinum*) and a variable combination of green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), pin oak (*Quercus palustris*), and hackberry (*Celtis occidentalis*). Common understory trees capable of overstory recruitment included silver maple, green ash, American elm, and hackberry. Overstory species richness and diversity were generally high, but species richness and diversity in the understory layer were much lower, a trend that was most pronounced in the northernmost sites. In addition, the scarcity of mast producing and/or shade intolerant species in the understory was evident throughout the study, even at sites where they were present in the overstory. Herbaceous communities were notably variable between study sites. Despite the latitudinal gradient, ordination of the floodplain forest communities revealed substantial compositional overlap between sites. However, patterns in the ordination were significantly correlated with local variability in canopy cover, elevation, soil texture, and several hydrologic parameters. Species richness and diversity generally increased from north to south. Results suggest that regional differences and local characteristics such as microtopographic features should be considered when selecting target restoration conditions and evaluating the suitability of individual species for specific restoration projects.

1. Introduction

Historical and present day disturbances have contributed to long-term changes in the composition and structure of Upper Mississippi River System (UMRS) floodplain forests (Nelson and Sparks, 1998; Yin, 1998; USGS, 1999). Floodplain forest coverage has been significantly reduced from pre-settlement levels due to timber harvesting, conversion to agricultural cropland, and other land use changes (Nelson et al., 1994; Yin et al., 1997; Knutson and Klaas, 1998; Kruse and Groninger, 2003; Johnson and Hagerty, 2008; De Jager et al., 2013a). Hydrology is recognized as a primary driver of ecological processes in large river ecosystems (Junk et al., 1989; Hodges, 1997; Theiling and Burant, 2012), and contemporary floodplain forests are affected by altered hydrological regimes associated with river impoundment (Yeager, 1949; Yin et al., 2009; Theiling and Nestler, 2010; De Jager et al., 2012; Kenow et al., 2016). A corresponding loss of tree species diversity has been identified as a management concern in the UMRS (Romano, 2010; Sparks, 2010; Guyon et al., 2012). A general lack of successful tree regeneration, particularly the hard mast component, has also been documented in many areas (Battaglia et al., 2002, 2008; Thomsen et al., 2012; De Jager et al., 2013b). Further losses in floodplain forest habitat and diversity over time are likely unless active forest management can reverse this trend (Urich et al., 2002; Guyon et al., 2012). Consequently, floodplain forest restoration is a prominent ecological and

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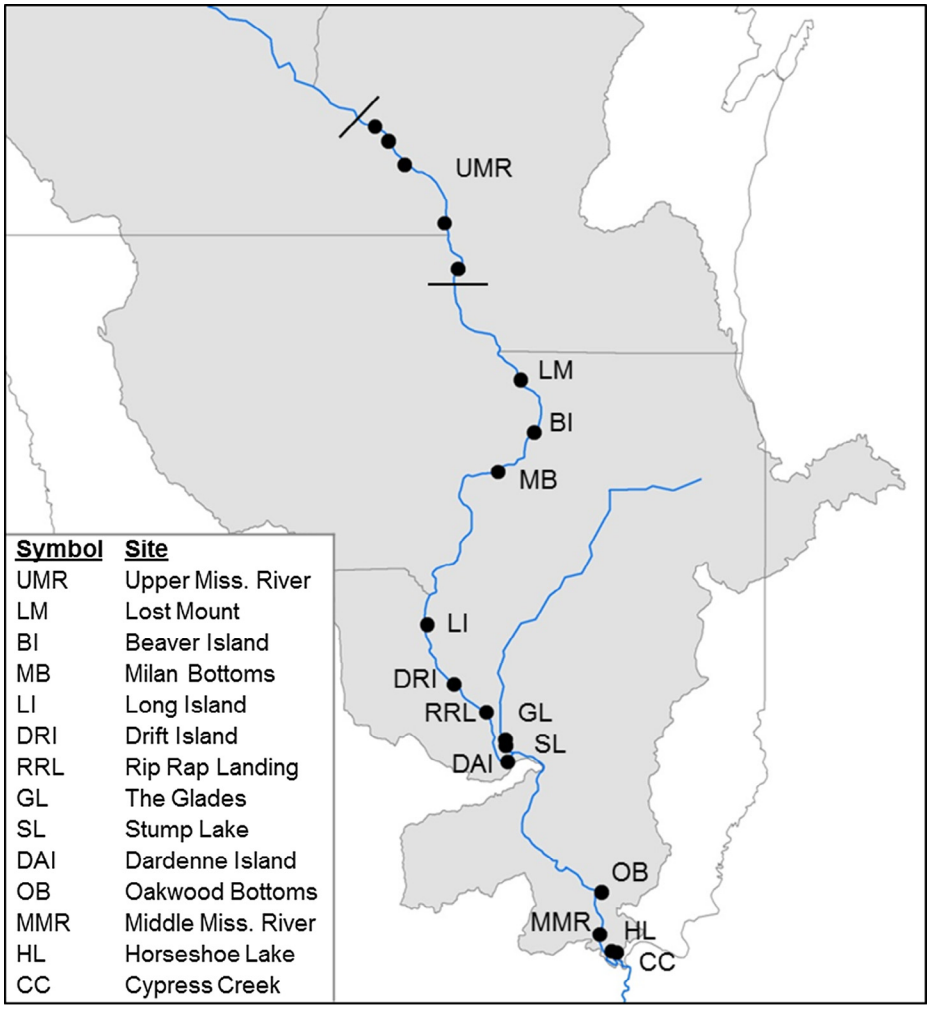

Fig. 1. Study site locations. The five northernmost locations were combined into one Upper Mississippi River reference site due to the limited number of sample plots at several locations.

management goal in Mississippi River floodplain ecosystems (Twedt and Best, 2004; Wilson et al., 2005; Allen, 1997; Heitmeyer, 2008; Yin et al., 2009).

The use of reference sites as targets for ecological restoration efforts is well documented (Allen et al., 2000; SER, 2004; Nestler et al., 2010; Pruitt et al., 2013; Balaguer et al., 2014). Assessing the biological and physical characteristics of remnant high quality UMRS floodplain forests will establish a suite of baseline ecological information for specific reference sites that will in turn inform potential restoration activities. However, the relationship between various environmental factors that affect ecosystem functionality in floodplain forests and the response of vegetation communities to long-term changes in those factors remain unclear (Gergel et al., 2002). In addition, restoration to historical reference conditions may not be feasible in many locations because the conditions under which mature floodplain forest reference sites were established may no longer exist (Stanturf et al., 2001). For example, maintenance of high water levels immediately upriver of locks and dams (Theiling and Burant, 2012) likely inhibits the successful regeneration of less flood tolerant taxa (*e.g.*, *Quercus* spp.) that may have been present in those locations historically or even still inhabit them today as advanced members of the overstory. These hydrologic changes have also been linked to the increasing dominance of the flood-tolerant *Acer saccharinum* (Nelson and Sparks, 1998; Yin et al., 2009; Romano, 2010; De Jager et al., 2012).

Contemporary floodplain forest reforestation efforts may therefore be better guided by a more functional and dynamic assessment and classification of present day UMRS ecosystems that begins to align potential vegetation communities and even individual species with environmental reference conditions that exhibit spatial and temporal variability (Comer et al., 2003; Klimas et al., 2009; Nestler et al., 2010; Hiers et al., 2012; Kirkman et al., 2013). With this approach, the ability of native species to tolerate present conditions would likely be more informative for plantings than whether or not they are known to have inhabited a particular area historically. Furthermore, assessing correlations between contemporary environmental conditions and successful natural regeneration is important in determining requirements for establishment of targeted tree species in the modern floodplain (Kabrick and Dey, 2001; Gardiner et al., 2004). At any rate, tree plantings in floodplains have often met with mixed results (Stanturf et al., 2001; Dey et al., 2003; Grossman et al., 2003), and refining methods to assess site quality and suitability for plantings would benefit restoration efforts in the UMRS.

The objective of this project was to assess the physical and biological characteristics of representative floodplain forest communities in the UMRS, thereby establishing a suite of baseline ecological reference sites that will inform ongoing and future floodplain forest restoration efforts. From a management perspective, identifying a set of environmental variables significantly correlated to the occurrence of particular vegetation types would benefit agencies responsible for restoring bottomland hardwoods and other vegetation communities in the UMRS. We hypothesized that elevation, soil texture, canopy cover, and a set of hydrologic variables would be significant drivers of community