PRACTICAL CONSIDERATIONS FOR LONG-TERM MAINTENANCE OF OAK WOODLANDS

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Extended abstract—Managing oak (*Quercus* spp.) woodlands has become an increasing common objective across many areas within the Eastern United States. Oak woodlands have been variously defined, primarily by characteristics of structure (e.g., relatively open canopies, low abundance of midstory trees, and abundant herbaceous ground flora), composition (e.g., fire-tolerant species and woodland indicator ground flora), and disturbance (e.g., fire regime) (Hanberry and others 2014a, Kabrick and others 2014, Nelson 2005). Mounting evidence of the historical prevalence and contemporary reduction in oak woodlands has contributed to interest in restoration efforts (Hanberry and others 2014b, Nuzzo 1986). Given the legacies of land use (e.g., historical logging and more recent fire suppression/exclusion) that have led to contemporary conditions, woodland management is often described in terms of 'restoration' and 'maintenance' phases (Dey and others 2016). The restoration phase uses silvicultural thinning and prescribed burning to reach structural targets and enhance the ground flora community (Kinkead and others 2013, Laatsch and Anderson 2000, Vander Yacht and others 2017). The maintenance phase usually requires repeated prescribed burning in order to reduce encroachment by woody vegetation and favor herbaceous ground flora (Dey and others 2016). Recently, there have been experimental and operational examples of successful woodland restoration and maintenance over relatively short time periods. Over the long-term, woodland management is resource-intensive because repeated management action (e.g., prescribed burning) is required for continued maintenance.

We discuss several considerations for long-term oak woodland management, presenting expected effects of repeated prescribed burning and suggesting recommendations to reduce undesirable outcomes. In some cases, challenges for woodland maintenance derive from interest in retaining relatively static conditions through time (e.g., an open stand structure/habitat) by suppressing dynamic processes (e.g., forest succession or stand dynamics).

Forest dynamics—Several long-term considerations relate to the effects of repeated prescribed burning on processes of forest stand dynamics. The woodland restoration phase commonly uses thinning to initially reduce stand density to meet structural criteria for woodlands (Dey and others 2016, Kabrick and others 2014), which often corresponds to stocking near or below the B-line of the Gingrich stocking chart (Gingrich 1967). At this level of stocking, growing space is available for new trees to establish and grow; thus, maintaining oak woodland structure includes sustained effort to suppress tree regeneration from dominating the midstory layer. The rate at which regenerating trees develop is related to stand density but also site productivity, suggesting that greater effort may be required to maintain woodland structure on higher quality sites. Although individual fires of low intensity may have limited effects on canopy tree mortality, repeated burning over long time periods was found to favor fire-tolerant post oak (*Quercus stellata*) almost exclusively due to canopy attrition of other hardwood species in oak woodlands of the Missouri Ozarks (Huddle and Pallardy 1996, Knapp and others 2015). Maintaining woodland structure through repeated prescribed burning may accelerate hardwood canopy mortality of fire-sensitive species and prohibit regeneration and recruitment of new trees, effectively suspending succession from occurring (Knapp and others 2016).

Plant diversity and conservation value—Increasing light to the forest floor and reducing the thickness of the litter layer allow the development of dense, species-rich ground flora (Hiers and others 2007, Veldman and others 2014). Repeated prescribed burning maintains these conditions, with long-term studies demonstrating the importance of frequent fire for ground flora diversity in woodland ecosystems (Brockway and Lewis 1997, Knapp and others 2015). In the Missouri Ozarks, frequent burning for 16 years at the landscape scale increased the abundance and conservation value of the ground flora (Maginel 2015). However, strength of the effect varied by site characteristics, with greater response observed on exposed sites than on protected sites. These results highlight the importance of considering appropriateness of the edaphic conditions for the potential for woodland

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restoration. Moreover, ground flora species vary in their resource requirements (Peterson and others 2007) and response to specific aspects of fire regime, such as fire season. Thus, evidence suggests that long-term woodland maintenance supports diverse ground flora communities, although nuances of woodland management practice likely modify community responses.

Wildlife habitat—Wildlife species often respond to structural and compositional characteristics of ecosystems, and oak woodlands provide unique and important habitats. The habitats maintained by woodland management commonly meet the needs of some but not all species within taxonomic groups, such as early successional bird species (Vander Yacht and others 2016) or bat species that favor open forests (Starbuck and others 2014). Maintaining woodlands across a landscape of diverse habitats, including closed canopy forests and other early successional conditions, offers variability to satisfy a wider range of habitat needs.

Timber value—The value of standing timber in woodland ecosystems may be reduced by repeated burning. Wounds from fire can lead to rot and value loss of wood products, although the rate and magnitude of value loss varies by species; individual tree characteristics such as size, age, or vigor; and fire behavior. Time since fire and scar size are important because wound tissue that is located on external portions of the bole may be removed during slabbing (Marschall and others 2011). However, maintaining frequent burning when hardwoods are small would likely result in wounds and internal defects that last throughout the rotation. Repeated burning over the long term also affects stumpage value through stand composition and structure. Long-term burning of Missouri Ozark woodlands shifted composition to post oak, a low value species, and reduced the abundance of red oak species of higher value (Knapp and others 2017). Unexpected changes in market value may create uncertainty in long-term economic projections, however, and extending rotation ages of canopy trees may allow individuals to gain value through continued growth.

Tree regeneration—Long-term woodland maintenance will eventually require replacement of canopy trees (Dey and others 2016). Repeated burning at frequent intervals can allow oak sprouts to persist but prohibits recruitment from occurring (Knapp and others 2016). Oak recruitment may require fire-free periods ranging from 10 to 30 years, depending on site productivity and species (Arthur and others 2012). The development of a recruiting midstory cohort and accumulation of forest floor would alter the character of the ecosystem, reducing ground flora density and appearance of the structure. However, once the regenerating cohort reaches around 5 inches dbh, many stems would likely survive reintroduction of frequent fire. Kabrick and others (2014) suggest an area-regulation approach for woodland regeneration, in which fire is removed from woodland stands during a prescribed regeneration period. For objectives of regenerating and recruiting oaks while retaining open woodland structure with frequent fire, more intensive efforts may be needed to protect individuals or small groups of stems from top-kill by fire.

Ecosystem resistance/resilience—Plant species associated with oak woodlands are commonly well-adapted to dry conditions, indicating potential for adaptability for possible future climate extremes. In Missouri, mixing shortleaf pine (*Pinus echinata*) with oak was found to increase estimated compatibility to future climate scenarios (Kabrick and others 2017). Diversifying fire-tolerant tree species within woodlands may provide buffers against future disturbance. In addition, woodland restoration treatments commonly favor retaining large canopy trees, found to increase stand vigor and resistance to drought impacts in a woodland restoration study in Kentucky (Clark and Schweitzer 2016).

The decision to initiate oak woodland management requires consideration of short-term restoration treatment needs but also commitment to long-term management outcomes. On most sites, repeated prescribed burning is necessary to maintain open conditions, diverse ground flora communities, and associated wildlife habitats. Repeated prescribed burning costs time and money, however, and may reduce future timber value. Specific consideration should be given to canopy tree replacement, especially if canopy trees are not highly fire-tolerant. Targeting appropriate ecological sites and canopy species for frequent fire woodland management can reduce required management inputs and likely result in more favorable outcomes.

LITERATURE CITED

Arthur, M.A.; Alexander, H.D.; Dey, D.C. [and others]. 2012. Refining the oak-fire hypothesis for management of oak-dominated forests of the Eastern United States. Journal of Forestry. 110(5): 257-266.

Brockway, D.G.; Lewis, C.E. 1997. Long-term effects of dormant season prescribed fire on plant community diversity, structure and productivity in a longleaf pine wiregrass ecosystem. Forest Ecology and Management. 96(1,2): 167-183.

Clark, S.L.; Schweitzer, C.J. 2016. Stand dynamics of an oak woodland forest and effects of a restoration treatment on forest health. Forest Ecology and Management. 381: 258-267.

Dey, D.C.; Schweitzer, C.J.; Kabrick, J.M. 2016. Silviculture to restore oak woodlands. In: Schweitzer, C.J.; Clatterbuck, W.K.; Oswalt, C.M., eds. Proceedings of the 18th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-212. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 160-169.

Gingrich, S.F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the Central States. Forest Science. 13(1): 38-53.

Hanberry, B.B.; Jones-Farrand, D.T.; Kabrick, J.M. 2014a. Historical open forest ecosystems in the Missouri Ozarks: reconstruction and restoration targets. Ecological Restoration. 32(4): 407-416.

Hanberry, B.B.; Kabrick, J.M.; He, H.S. 2014b. Densification and state transition across the Missouri Ozark landscape. Ecosystems. 17(1): 66-81.

Hiers, J.K.; O'Brien, J.J.; Will, R.E.; Mitchell, R.J. 2007. Forest floor depth mediates understory vigor in xeric *Pinus palustris* ecosystems. Ecological Applications. 17(3): 806-814.

Huddle, J.A.; Pallardy, S.G. 1996. Effects of long-term annual and periodic burning on tree survival and growth in a Missouri Ozark oak-hickory forest. Forest Ecology and Management. 82(1-3): 1-9.

Kabrick, J.M.; Dey, D.C.; Kinkead, C.O. [and others]. 2014. Silvicultural considerations for managing fire-dependent oak woodland ecosystems. In: Groninger, J.W.; Holzmueller, E.J.; Nielsen, C.K.; Dey, D.C., eds. Proceedings, 19th central hardwood forest conference. Gen. Tech. Rep. NRS-P-142. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station: 2-15.

Kabrick, J.M.; Clark, K.L.; D'Amato, A.W. [and others]. 2017. Managing hardwood-softwood mixtures for future forests in eastern North America: assessing suitability to projected climate change. Journal of Forestry. 115(3): 190-201.

Kinkead, C.O.; Kabrick, J.M.; Stambaugh, M.C.; Grabner, K.W. 2013. Changes to oak woodland stand structure and ground flora composition caused by thinning and burning. In: Miller, G.W.; Schuler, T.M.; Gottschalk, K.W. [and others], eds. Proceedings, 18th central hardwood forest conference. Gen. Tech. Rep. NRS-P-117. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station: 373-383.

Knapp, B.O.; Stephan, K.; Hubbart, J.A. 2015. Structure and composition of an oak-hickory forest after over 60 years of repeated prescribed burning in Missouri, U.S.A. Forest Ecology and Management. 344: 95-109.

Knapp, B.O.; Hullinger, M.A.; Kabrick J.M. 2016. Effects of fire frequency on long-term development of an oak-hickory forest in Missouri, U.S.A. Forest Ecology and Management. 387: 19-29.

Knapp, B.O.; Marschall, J.M.; Stambaugh, M.C. 2017. Effects of long-term prescribed burning on timber value in hardwood forests of the Missouri Ozarks. In: Kabrick, J.M.; Dey, D.C.; Knapp, B.O. [and others], eds. Proceedings, 20th central hardwood forest conference. Gen. Tech. Rep. NRS-P-167. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 304-313.

Laatsch, J.R.; Anderson, R.C. 2000 An evaluation of oak woodland management in northeastern Illinois, USA. Natural Areas Journal. 20: 211-220.

Maginel, C.J. 2015. Ozark ground flora response to landscape-scale prescribed fire. Columbia, MO: University of Missouri. M.S. thesis. 129 p.

Marschall, J.M.; Guyette, R.P.; Stambaugh, M.C.; Stevenson, A.P. 2014. Fire damage effects on red oak timber product value. Forest Ecology and Management. 320: 182-189.

Nelson, P.W. 2005. The terrestrial natural communities of Missouri. Jefferson City, MO: Missouri Natural Areas Committee. 550 p.

Nuzzo, V.A. 1986. Extent and status of Midwest oak savanna: presettlement and 1985. Natural Areas Journal. 6: 6-36.

Peterson, D.W.; Reich, P.B.; Wrage, K.J. 2007. Plant functional group responses to fire frequency and tree canopy cover gradients in oak savannas and woodlands. Journal of Vegetation Science. 18(1): 3-12.

Starbuck, C.A.; Amelon, S.K.; Thompson, F.R. 2014. Relationships between bat occupancy and habitat and landscape structure along a savanna, woodland, forest gradient in the Missouri Ozarks. Wildlife Society Bulletin. 39(1): 20-30.

Vander Yacht, A.L.; Keyser, P.D.; Buehler, D.A. [and others]. 2016. Avian occupancy response to oak woodland and savanna restoration. The Journal of Wildlife Management. 80(6): 1091-1105.

Vander Yacht, A.L.; Barrioz, S.A.; Keyser, P.D. [and others]. 2017. Vegetation response to canopy disturbance and season of burn during oak woodland and savanna restoration in Tennessee. Forest Ecology and Management. 390: 187-202.

Veldman, J.W.; Brudvig, L.A.; Damschen, E.I. [and others]. 2014. Fire frequency, agricultural history, and the multivariate control of pine savanna understory plant diversity. Journal of Vegetation Science. 25(6): 1438-1449.