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SILVICULTURE IN FORESTED WETLANDS (BY INVITATION ONLY)

Silviculture and Forested Wetlands of the Southeast United States: an Introduction to the Special Feature

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Abstract

The papers in this Special Feature are the result of an unprecedented collaboration between the wetland and forestry communities, with the goal of fostering open dialogue regarding the interaction between forestry operations and forested wetlands in the Coastal Plain of the southeast U.S. Many misunderstandings exist between these two communities. These misunderstanding are partially caused by a lack of dialogue and the use of varying definitions for commonly-used terms, such as "loss" and "forested," but are magnified by an incomplete understanding of fundamental biophysical processes that occur within intensively managed forests, especially at broader spatial and temporal scales. Our collaborative effort to engage representatives from the forestry industry, state forestry organizations, wetland scientists, and wetland regulators seeks to overcome these misunderstandings through a wide array of information sharing efforts. These have included one-on-one conversations, group meetings, field trips, and scientific symposia, including a session that was held at the 2016 Society of Wetland Scientists Meeting in Corpus Christi, Texas. Following the symposium, the presenters recognized the need to publish their presented papers as one product to facilitate additional dialog. This Special Feature in *Wetlands* is the realization of that vision.

Keywords Forested wetland · Swamp · Silviculture · Forestry · Hydrology · Southeast United States

Background

The southeast U.S. (Virginia, North Carolina, Kentucky, South Carolina, Tennessee, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, and Texas) is an important region in both ecologic and economic terms. It contains about half of the wetlands in the lower 48 states (Hefner and Brown 1984) and an even higher proportion (~64%) of this area's forested wetlands (Wear and Greis 2002). Forested wetlands are integral to the ecological health of the region, providing services such as the regulation of hydrologic flows, water purification, and natural hazards as well as the provision of food, fiber, and fuel. They also provide habitat for fish and wildlife and recreational opportunities such as bird watching, canoeing, and hunting (Hefner et al. 1994).

Forests and forestry have been an important part of the southeast U.S. economy since the late 1600s (Lockaby 2009). In the 1920s, there were 80 million ha of timberland (privately owned forest land) in the south, which increased to 85 million acres by 2012. More recently, the area of intensively managed timberland in the southeast, typically pine plantations, has grown from ~700,000 ha in 1950 to ~16 million ha in 2013 (Fox et al. 2007; Wear and Greis 2013). Approximately 21% of southeast forests are pine plantations (Kittler et al. 2015). Of the total area of pine plantations in the southeast U.S., approximately 11% were classified as wetland (Brown et al. 2001). The southeast is the largest timber producing region in the U.S., accounting for 60% of the timber harvest in the U.S. each year (Oswalt and Smith 2014; Kittler et al. 2015; Kreye et al. 2019). The economic value of timber harvesting in the southeast is substantial, resulting in a gain of

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$230 billion to the economy, generating 1.1 million jobs, and paying $48 billion in wages and salaries in 2013 (Boby et al. 2014).

Human populations in the south have also increased significantly. Between 1970 and 2008, the population of the region increased by 84% compared with the national average of 50% (Hanson et al. 2010). Between 2010 and 2018 alone, the region's population increased from 115 to 125 million (U.S. census data). The region's growing human population has resulted in the loss of forested wetlands to development and other factors (Dahl 2011), and an increasing percentage of forests affected by urbanization (Oswalt and Smith 2014). The southeast is expected to lose 21% of its forests by 2060, and it is likely that a significantly higher percentage of remaining forests will become intensively managed pine (Wear and Greis 2013). This will likely have a significant impact on ecosystem services in this region.

Although the forestry and wetland communities may prioritize different ecosystem services derived from forested wetlands, they share a strong affinity for these ecosystems and their benefits. A shared understanding of terminology, scientific procedures, and data will be key to identifying management actions that could help preserve a mutually valued resource, especially in light of predicted future increases in development pressure.

On June 2, 2016, a special symposium, "Silviculture in Forested Wetlands of the Southeastern and Gulf Coastal Plains: Exploring Wetland Impacts, Communication Hurdles, Best Practices, and Future Directions" was held at the annual meeting of the Society of Wetland Scientists in Corpus Christi, Texas, USA. The symposium's 10 presenters covered a wide range of topics related to forested wetlands and silviculture. They also addressed questions and engaged in dialogue with each other and attendees during multiple panel discussions. After the meeting the presenters recognized the need to publish their contributions as a combined product to facilitate additional dialog. This Special Feature of Wetlands is the realization of that vision.

Overview of the Special Feature

The first paper in this Special Feature provides an introduction to key definitions used by the wetlands and forestry communities, as well as an overview of wetland trends as measured by the U.S. Fish and Wildlife Service (FWS) Wetlands Status and Trends project and current misunderstandings regarding those definitions and findings. It is followed by two background papers that address forest operations and some of the known effects of these operations on wetlands and the interaction of wetland policies (e.g., those associated with the federal Water Pollution Control Act) and silvicultural practices. The last four papers focus on wetland hydrology. Wetlands are defined by their hydrology, and silvicultural practices that alter hydrology have the potential to cause wetland loss.

The article by Lang et al. (this issue) provides important background information regarding the U.S. Fish and Wildlife Service Wetlands Status and Trends dataset and the often disparate understandings within the wetland and forestry communities regarding how these data are produced and what they mean. It is this lack of a common understanding that has partially hampered productive collaboration between the forestry and wetland communities, collaboration that is essential to effectively address the conservation of forested wetlands in the southeast U.S. The article sets the stage by briefly introducing wetlands in coastal watersheds, their importance, and the historic use of forested wetlands for intensive timber production in the southeast U.S. The authors then explain some of the meanings of key terms used in Wetlands Status and Trends data collection and analysis, and clarify definitions for fundamental terms such as "wetland," "upland," and "loss." The article provides a description of the Wetlands Status and Trends project, including an overview of project objectives, methods, and findings. Misconceptions and miscommunications regarding these protocols and findings are described in detail, including the misconception that the Wetlands Status and Trends protocols consider tree harvest to represent the loss of wetland to non-wetland. Approaches for addressing these miscommunications are suggested. Lastly the article highlights opportunities to improve information exchange and collaboration between the forestry and wetland communities, this Special Feature being one such opportunity.

The next paper by Aust et al. (this issue) provides an overview of silvicultural operations in different wetland types including wet mineral flats (which are often managed as pine plantations) and bottomland hardwoods. The authors describe the many types of equipment used in silviculture, both historically and in current operations, as well as non-mechanical aspects of the cultivation process, such as herbicide treatments and prescribed burning. The remainder of the paper summarizes short and long-term studies on the effects of forest operations on a variety of parameters, including soil properties, water quality, hydrology, and post-harvest regeneration and productivity. The importance of Best Management Practices (BMPs) for preventing water quality degradation is also discussed. The authors conclude that under the appropriate silvicultural operation and management systems with the application of BMPs, silvicultural operations are compatible with long-term sustainability of the forested wetlands.

The paper by Schilling et al. (this issue) continues the discussion of BMPs by explaining how the requirements of the U.S. federal Clean Water Act have influenced the development of silvicultural BMPs for forested wetlands, and the establishment of voluntary third-party forest certification programs. The authors review research on BMPs, including their use to protect water quality during stand establishment and harvesting, with a focus on minor drainage, forest roads, and bedding as a site preparation practice. The paper also discusses the role of state forestry agencies and forest certification systems in facilitating the application and monitoring of water quality BMPs. The authors conclude that the widespread use of site preparation BMPs, in part due to the increased numbers of forest landowners and wood procurement entities who participate in voluntary third-party forest certification programs, has led to significant water quality protection on a scale that results in watershed-level benefits.

The next paper by Skaggs et al. (this issue) examines the effect of tree growth on soil hydraulic properties, and discusses how these changes influence the effects of silvicultural drainage on forested wetland hydrology. The authors discuss the history of drainage for agriculture and forestry, the drainage systems currently used for silviculture in forested wetlands, and review past studies that have used modeling to determine whether wetland hydrology, as defined by the U.S. Army Corps of Engineers, would be sustained under a range of ditch depths and spacings typically used in pine plantations in the southeast. The paper then presents two studies, one a long-term field study and the other a simulation, that look at how soil parameters, such as soil lateral hydraulic conductivity (K) and profile transmissivity (T), change as pine plantations mature, and how those changes affect the impact of minor drainage on the forested wetland hydrology. The long-term field study data showed that the soil K of a mature pine plantation was over 20 times greater than that of a young plantation, which results in an increase in T by an order of magnitude over the growth cycle of a pine plantation. The modeling simulation demonstrated that the increase in K and T that occurs as pine plantations mature may result in the loss of wetland hydrology on the entire site by about 8 years after planting. The authors conclude by suggesting measures that could maintain wetland hydrology in silvicultural sites as the trees mature.

In a companion study by Amatya et al. (this issue), the authors review and analyze measured daily water Table (WT) data from four drained pine forests and six undrained pine mixed hardwood wetland forests on the lower Atlantic Coastal Plain. The length of data collection at the individual sites ranged from almost 12 years to 21 years. In addition to characterizing the effects of ditching on the hydrology of the drained sites, the authors compare WT response on the drained and undrained sites to anthropogenic and natural disturbances, such as vegetation removal and extreme storm events and found similar responses for the both, compared to the base line levels. The growing season WT, as influenced by ET demands, at undrained mature forest sites was deeper than the WT at drained sites with young vegetation, but shallower than the WT at drained sites with mature vegetation. The paper also uses the daily WT dynamics, which influence the presence or absence of wetland hydrology, to determine whether conditions for wetland hydrology, as described by the U.S. Army Corps of Engineers, are met at the study sites. The data showed that wetland hydrology did not exist at any of the drained sites, including those with water level control structures, and was also absent at one unditched site with moderately well-drained sandy soil. The authors conclude that the WT dynamics on all soil types and vegetation behaved similarly with WT at or on the surface during extreme storms, and all of these results may have implications in wetland forest restoration and modeling studies related with wetland hydrology assessment.

The final article by Atkinson (this issue) investigates the relationship between hydrologic and climactic factors and the radial growth of Atlantic white cedar (AWC), the dominant tree species in a globally threatened but once common swamp type. The author studied two 60-year-old AWC stands in Virginia and North Carolina, U.S. Hydrologic monitoring revealed that although both sites had ditches, the low topographic position of the North Carolina site resulted in limited drainage, whereas the relatively high topographic position of the Virginia site resulted in effectively drained soils. The two sites showed differences in mean annual growth rate, growth response to precipitation, and growth response to temperature. The author concludes that AWC tree ring growth patterns can provide natural resource managers with insights into historic hydrologic conditions that influence ecosystem services and biodiversity.

Concluding Thoughts

The authors that contributed to this Special Feature hope that by publishing their thoughts and findings within Wetlands, dialogue will be expanded to new communities, regions, or nations. This enhanced dialogue has the potential to positively affect the sustainability and management of wetlands as well as the silvicultural industry with land holdings in and around these ecosystems. Although there are differing views on some critical topics, such as the current effects of some practices associated with intensively managed timberlands (e.g., ditching) on wetland loss within the southeastern U.S., progress towards deriving enhanced wetland benefits for society, both extractive and non-extractive, will be extremely challenging without these conversations.

In addition to continuing dialogue, there is a need for additional research on the identification and assessment of wetland hydrology in intensively cultivated forested wetlands, including the appropriate use of existing criteria for identifying wetland hydrology. Existing studies and long-term experimental forest sites as described in Amatya et al. (this issue) could be used as a foundation for investigating these topics. For example, Chescheir et al. (2003) published an evaluation of seasonal drainage outflow from multiple pine plantation sites in eastern North Carolina. If groundwater well data are also available for these sites, this water table data would also provide information on the wetland hydrology of managed pine forests on varying stand ages and in multiple soil types. For sites with short-term water table data, a method suggested by Zampella et al. (2001) could be used to generate long-term data. If water table data does not exist for some locations, researchers could generate estimated daily water tables using either an established (published) relationship between daily drainage rate and midpoint water table for pine forest sites (Skaggs et al. 2006, 2011; Beltran 2007: Zampella et al. 2001; Skaggs 2017) with the multiple site years of flow data mentioned above, or apply a model like DRAINMOD (Skaggs et al. 1994), rigorously tested for poorly drained soils. There is also a need for new long-term data sets from both drained and undrained wetland forest sites collected explicitly to answer questions raised in this Special Feature, such as identifying management practices that could be used to restore wetland hydrology on disturbed lands. For example, field experiments could be conducted on drained sites to monitor the effects of ditch plugging on hydrology and productivity, and well-validated model simulations could be conducted to quantify drainage design threshold parameters for maintaining wetland hydrology if and when drainage is implemented, while keeping the same productivity. Some scenarios like this have been evaluated for outflow and nutrient losses at a site in North Carolina from the off-site and productivity impacts perspectives (Amatya et al. 1998, 2000, 2003).

The papers in this Special Feature set the stage for further dialogue and collaboration between the forestry and wetlands communities by providing a common frame of reference for the subject of silviculture and forested wetlands in the southeast U.S. A thorough grounding in the terminology, wetland trend monitoring protocols, silvicultural practices in various forest types, hydrologic research, and gaps in research and monitoring discussed in these papers will be a necessary part of moving forward on this topic.

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