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ABSTRACT: *Anthropogenic activities have altered streams and rivers throughout Florida. Silvicultural practices, deadhead logging, road and bridge maintenance, de-snagging for navigation and flood control, and the clearing of riparian buffers for development have all impacted Florida's streams and rivers through the loss of ecologically important woody material from stream banks and channels. Repercussions from these impacts include changes to sedimentation patterns and stream morphology, erosion of banks and bars, and the consequent loss of habitat structure and diversity. The loss of large woody material (LWM) presents far-reaching impacts on the hydrology, ecology, and water quality of southeastern coastal plain streams, however federal and state law regulating the removal and/or reintroduction of LWM remains murky. Current decision-making does not adequately account for LWM's importance to Florida streams, and in many cases, the law appears to treat the removal of LWM more favorably than it does its reintroduction. We conclude that use of Best Management Practices associated with current statutory exemptions and categorical permits, as well as stakeholder education, offers the greatest promise of reducing the adverse impacts historic loss of LWM has had on coastal plain streams in Florida. Specific challenges include working with regionally appropriate techniques, balancing safety and accessibility with natural processes, and allowing for uncertainties.*

Key Words: Woody material, woody debris, coastal plain, best management practices, rivers

THE SCIENTIFIC RATIONALE FOR ECOLOGICALLY-BASED MANAGEMENT OF WOODY MATERIAL—In the scientific community large woody material (LWM) in streams is known to play a number of very important ecological and geomorphological roles such as: providing habitat for invertebrates and fishes, bank stabilization, sediment retention, structuring hydrologic regime and in-stream habitat diversity, and increasing overall productivity by providing habitat and nutrient cycling (Diehl, 1994; Downs and Simon, 2001; Gollady et al., 2007; Gurnell and Sweet, 1999; Smock et al., 1985; Shields

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et al., 2004; Shields et al., 2006; Wallerstein and Thorn, 2004). In Florida, where many of the streambeds are composed of sand, this woody material provides some of the only structure and stabilization. In general, both the U.S. and State of Florida laws fall short of protecting or even acknowledging the importance of LWM in streams. Where there are no actual laws concerning conservation, best management practices (BMP's) are often used to inform policy and law by offering voluntary guidelines or conditions of permits. Silviculture BMP's are an excellent of example of this practice. This paper reviews current science and policy regarding LWM specifically for Florida sand bed streams and based on this review, LWM BMP's are suggested.

In order to assess the importance of LWM, first a clear definition of LWM is necessary. In the scientific literature, authors often differ in their definitions of LWM. A common element in these definitions is the reference of wood size. Jackson and Sturm (2002) classify LWM as anything larger than 10 cm in diameter and 1 m in length in channels 4 to 30 m in width. Wallerstein and Thorn (2004) define the size of the LWM as anything larger than 10 cm in diameter and 1 m in length. Zelt and Wohl (2004) define LWM as a piece of wood larger than 10 cm in diameter and 2 m in length, and state that it must extend partially into or above the channel. A qualitative definition by Shields et al. (2004) states that 'key pieces' are LWM that have root wads attached and also span the width of the channel. Finally, Gipple (1995) poses that the importance and effectiveness of LWM depends on the size of the channel compared to the size of wood. For the purposes of this work LWM will be defined as *any piece of wood larger than 10 cm in diameter and 1 m in length. Key pieces will be defined as any piece of wood that is larger than 10 cm in diameter, 2 m in length, and has the rootwad attached.*

The ecological importance of LWM has been well documented (Diehl, 1994; Downs and Simon, 2001; Gollady et al., 2007; Gurnell and Sweet, 1999; Smock et al., 1985; Shields et al., 2004; Shields et al., 2006; Wallerstein and Thorn, 2004). Because of the lack of alternative stable substrate in sand bed streams, LWM is particularly important in structuring food webs. For example, there is greater invertebrate diversity, abundance, biomass, and productivity on submerged woody material compared to other sand bed stream habitats (Benke, 2001; Benke et al., 1985; Ray, 1999).

Ray (1999) sampled submerged deadhead logs (large logs that were submerged during historic timbering operations) for macroinvertebrates and fish in the Blackwater River, Florida, in the Gulf Coast Coastal Plain. He documented the importance of deadhead logs as breeding habitat for fish. The logs created riffles and provided habitat diversity in this sand bed stream, where there are not many other stable substrates such as large rocks and boulders. The logs were also highly productive and diverse in clean water macroinvertebrates. Ray (1999) found higher productivity and diversity on two deadhead logs than in a 100 m span of stream lacking woody material.

Benke (2001) sampled macroinvertebrates in the Ogeechee River which is a low gradient sand bed river in the Coastal Plain of Georgia. He collected

samples from three habitat types: the channel, woody material snags, and the floodplain. He notes that species composition between the habitat types is different which infers that the snags serve a distinct ecological niche. He also demonstrated the importance of snags with respect to overall productivity, as the snags had the highest level of biomass per habitat surface area of any of the habitat types.

Aside from the ecological significance, several studies investigate the purely morphologic function or structural role of LWM in sand bed streams (Diehl, 1994; Downs and Simon, 2001; Gippel, 1995; Shields et al., 2004; Shields et al., 2006; Wallerstein and Thorn, 2004). Shields and co-workers (2004) conducted a stream restoration project in a severely incised sand bed stream using woody debris structures in central Mississippi. Their study showed that the wood structures increased flow resistance, slowed velocity, and increased retention time. Another study by Diehl (1994) stated that channel blockages in Tennessee valleys caused by LWM increased the area and depth of seasonal flooding, decreased flow velocity, increased sedimentation, and increased filtration by vegetation. Similarly, Gippel's (1995) literature review of studies throughout the world found that LWM provided hydraulic roughness, contributed to a diverse flow environment, decreased average velocity, elevated local water-surfaces, and increased the travel time of the flow.

Zelt and Wohl (2004) conducted an investigation of twenty-three sand bed stream reaches to determine the relationship between LWM presence and streambed stability. They concluded that LWM location, volume, and number of jams per length of stream are all related to the morphological processes that occur at different stages of unstable and incised streams. Overall, they found that LWM jams trapped more sediment than they mobilized and accelerated channel stabilization.

The source of LWM to streams has been attributed to various mechanisms along the riverbank, and temporal events such as storms. Wallerstein and Thorne (2004) investigated woody material dams in sand bed streams in Northern Mississippi in an attempt to determine the material's origin. The most important source of woody material was from bank retreat, contributing over 2/3 of the material for debris jams. More specifically, the input mechanisms included 37% from outer bank erosion in meander bends, 36% recruitment from mass failure due to bank instability and widening, 9% from beaver dams, 7% from erosion of palaeodebris, 6% from wind, and 5% transport from upstream. They also noted that windblown trees tended to fall in random directions while inputs from bank instability generally fall perpendicularly across or away from the channel. Storm events and associated flooding have proven to be a temporal input mechanism. Benke and Wallace (1990) found that 17% of the wood in the Ogeechee River, Georgia, moved after 3 large flood events. Similarly, after measuring fallen tree occurrence in a Gulf Coast Plain stream, Golladay and co-workers (2007) concluded that debris recruitment pulsed with large flood events.

Sand bottom streams in Florida, as well as those in other states in the Atlantic Coastal Plain, have undergone changes due to anthropogenic

activities. As it pertains to this discussion, these include, but are not limited to; current and historical logging, deadhead log removal, bridge and structure maintenance, and de-snagging for navigation and flood control. These activities, in addition to local land use change, have increased sedimentation to the stream and changed stream morphology and habitat (Allan, 2004; Poff et al., 1997; Resh et al., 1988).

Woody material that falls into streams from riparian banks is an ever-present and natural occurrence in pristine sand bottom streams. However, historical logging and de-snagging practices have drastically reduced the amount of woody material in these streams. From the late 1800's to the early 1900's loggers in the Atlantic Coastal Plain clear-cut the native longleaf pine forests and harvested the state's giant cypress, as well as other species. This historical logging denuded the riparian areas of trees that were a vital component for bank and soil stabilization as well as sources for LWM. Additional morphological changes occurred to the channel structure as these logs floated down the rivers to mills. Current logging practices have fewer impacts, as logs are no longer floated down the river and logging in riparian buffers is restricted (DOF, 2000). However, the use of modern logging roads, mechanical removal and vehicular transport of logs, are all sources of additional sedimentation into rivers. Under Florida's silvicultural BMP's, logging is limited to 50 percent in the riparian corridor, which ranges anywhere from 35–200 feet from the stream channel (Division of Forestry, 2000). This practice reduces an already limited stock of woody material that is available for input into rivers.

Between the 1800's and the 1900's when logs were floated down river in transit to downstream mills, some of the cut timbers sank and were lost to river bottoms where they were preserved by the cool water and low oxygen. These 'deadhead' logs can be very important for the ecology of sand bed streams, providing stable substrate and habitat for macroinvertebrates and fishes (Ray, 1999). Deadhead logs are highly regarded by craftsmen due to their great strength, durability, and resistance to rot. Wood from deadhead logs, revered for its tight grain and array of colors ranging from blond to caramel to black, is up to ten times more valuable than conventional wood (DEP, 2010). However, removal of these logs can compromise the integrity of sand bed streams through the loss of habitat, stable substrate, and morphological structure.

Another removal method is known as de-snagging, which involves the removal of woody material for navigation or flood control. De-snagging was once a widespread practice (Maser and Sedell, 1994, 1994; Triska, 1984), but is now generally recognized as detrimental for stream ecology and is discouraged (Shields and Smith, 1994). A study by Webb and Erskine (2005) in Australia, notes that some consequences of this practice are increased flow velocity, widespread bed degradation, channel enlargement, and loss of fish habitat.

Construction projects, namely bridges, can also impact LWM movement within and down the stream. Particularly during high flow events, logjams can occur on the upstream side of the bridges and prevent material from moving

downstream. It is common to conduct routine clearing of these materials to ensure bridge safety. As a part of this maintenance, log blockages are removed from the upstream end of a bridge and may or may not be transported to the other side of the bridge, allowing for continued movement or bank implantation downstream.

SCIENTIFIC CONCLUSIONS—The literature demonstrates that LWM provides important environmental services, including habitat for invertebrates and fishes, bank stabilization, sediment retention, hydrologic regime structuring, and nutrient cycling, thereby increasing overall ecological productivity. LWM is especially important in sand bed streams because in many cases it provides the only stable substrate and opportunity for creating diversity in stream morphology. Hydrologically, LWM increases flow resistance, slows velocity, and increases retention time. Degradation associated with LWM in sand bed streams occurs through logging, deadhead log removal, and the removal of LWM for bridge maintenance, navigation, and flood control. In order to maintain and improve the integrity and productivity of streams in Florida it is important to consider LWM in forest management plans, de-snagging operations, and channel and bridge maintenance. This consideration must involve a comprehensive understanding of the laws under which LWM is regulated.

CURRENT MANAGEMENT PRACTICES ASSOCIATED WITH WOODY MATERIAL IN FLORIDA STREAMS—Currently, woody material is removed from water bodies for safety, flood control, navigation and through the commercial practice of "deadhead logging." Woody material is routinely removed from the base of bridges and other in-stream structures because its build up can cause concerns over structural stability. Woody material causing flow blockage is also removed for flood control purposes allowing the water to move downstream more quickly. Removal of LWM for navigation purposes, whether to clear channels for canoe, small motor craft or for larger recreational and commercial vessel passage is another common practice. Often, a combination of these reasons is used to justify de-snagging operations in Florida's sand bed streams. Key entities involved in the removal of woody material include state and local transportation and public works agencies and their contractors. Small-scale removal is often undertaken on an *ad hoc* basis by individual property owners or resource users to improve navigation and address localized flooding.

The special case of deadhead logging—Due to their value and the highly impactful nature of removal, deadhead log removal is regulated under state law. Unless they are marked, sunken logs remain the property of the state and can only be removed pursuant to approval from the State of Florida (Florida Attorney General Op., 1996), a process known as "deadhead logging." The Governor and Cabinet are statutorily authorized to receive the proceeds from the sale or dispossession of the products of state lands (Odom, 1996), including

deadhead logs. Section 253.45(1), Florida Statutes, authorizes the board of trustees to sell or lease timber or similar substances in, on or under any land to which the state has title. However, if the original brand that identifies the owner remains affixed, the original owner of the submerged logs may claim and recover those logs by obtaining a permit from the State's Submerged Lands and Environmental Resource Permitting (SLERP) Program.

A special program has been created for those individuals and entities that wish to collect unbranded deadhead logs (FAC, 2011a). Through this program a permit allows recovery of submerged timber from a contiguous twenty-mile river reach on one named waterway. Once a deadhead logger has the appropriate authorization, there is no limit to the number of logs that may be removed and recovered within a 1-year period (DEP, 2010). There are currently fourteen authorized deadhead loggers in Florida (FAC, 2011a). Since 1999, a total of 20,779 logs have been reported as removed from waters of the state (FAC, 2011a).

Although DEP has the authority to require mitigation practices for LWM removed through the deadhead logging permit program, either through rulemaking or by conditioning permits, it has not done so (FAC, 2011a). Consideration of LWM management through the regulatory process seems to be focused on the short-term ecological impacts of disturbance during removal, rather than its importance to stream health. Currently, there is no overarching management strategy that considers the *in situ* importance of LWM in Florida.

The Legal Framework for In-Stream Anthropogenic Activity in Florida—The current legal framework for in-stream manipulation of LWM remains murky at best. Both federal and state laws presumptively apply to the manipulation of LWM in Florida's navigable water bodies. The management of LWM may implicate regulatory processes in two ways – through its removal and through its reintroduction. In either case, the primary basis for regulation is through both federal and state dredge and fill law, and through state ownership of submerged lands and resources, as discussed above in context of deadhead logging. In most cases, all three of these are treated through a consolidated permitting process administered by the Florida Department of Environmental Protection, and partially delegated to the State's regional water management districts.

Federal Jurisdiction and Regulation—To the extent it is federally regulated, the removal and return of woody material falls within the ambit of the Clean Water Act (CWA) and/or the Rivers and Harbors Act (RHA), two laws that have different purposes but similar effects. For Clean Water Act jurisdiction to attach to woody material, it would have to constitute ''fill'', a seemingly counterintuitive notion in the context of removal activities such as de-snagging. The Rivers and Harbors Act, a statute largely designed to address navigation, regulates the ''creation of any obstruction'' to navigation, or any work that would affect the course, location, condition, or capacity of navigable

waters. Here again, a de-snagging project would ordinarily have the effect of removing rather than creating obstructions, making the assertion of RHA jurisdiction seem anomalous.

The Clean Water Act—Section 404 of the Clean Water Act (CWA) authorizes the United States Army Corps of Engineers (USACE) to issue permits "for the discharge of dredged or fill material into the navigable waters." Section 301(a) of the CWA provides that the "discharge of any pollutant by any person" is unlawful unless in compliance with the Act's permit requirements, including those of §404 (FAC, 2011b). "Discharge," in turn, is defined as "any addition of any pollutant to navigable waters from any point source" (FAC, 2011c). The USACE's statutory jurisdiction under §404 extends only to a "discharge," defined as "the addition of any pollutant to navigable waters" (USC, 2011a).

Dredged material is material that is excavated or dredged from waters of the United States (CFR, 2011a). A "discharge of dredged material" includes any addition, including redeposit other than "incidental fallback," including excavated material, into the waters of the United States which is incidental to any activity, including mechanized land clearing, ditching, channelization, or other excavation (CFR, 2011b).[1] An activity associated with a discharge of dredged material degrades an area of waters of the United States if it has more than a *de minimis* (i.e., inconsequential) effect on the area by causing an identifiable individual or cumulative adverse effect on any aquatic function (CFR, 2011d). Section 404 authorization is not required for any incidental addition, including redeposit of dredged material associated with any activity that does not have the effect of destroying or degrading an area of waters of the U.S. (CFR, 2011c).

Fill material is any material placed in waters of the United States where the material has the effect of replacing any portion of a water of the United States with dry land or changing the bottom elevation of any portion of a water of the United States (CFR, 2011e). A non-exhaustive list of examples of fill materials does not specifically include the re-introduction of large woody material (CFR, 2011f). Additionally, a discharge which elevates the bottom of waters of the United States without converting it to dry land does not thereby reduce the reach of, but may alter the flow or circulation of, waters of the United States and requires a permit (CFR, 2011g). The reintroduction of LWM could conceivably elevate or cause the elevation of a stream bottom and result in the alteration of stream flow and circulation. Indeed, to some extent that is one of the important roles LWM plays in streams.

[1] Deciding what qualifies as a discharge of dredged material is a complicated issue, especially in this instance. EPA regulations also provide that activities that involve only the cutting or removing of vegetation above the ground (e.g. mowing, rotary cutting, and chain-sawing) where the activity neither substantially disturbs the root system nor involves mechanized pushing, dragging, or other similar activities that redeposit excavated soil material is not a discharge of dredged material.

The District of Columbia Court of Appeals held that incidental fallback resulting from a net withdrawal of dredged material could not reasonably be considered an addition (Hollins, 1999) primarily through the Rivers and Harbors Act (USC, 2011b). Furthermore, the USACE issued a public notice, which stated:

> "[A]ctivities that result in the discharge of no more than incidental or *de minimis* fallback of excavated sediments are not regulated under Section 404 of the Clean Water Act. Such activities include the removal of accumulated material or debris from areas otherwise subject to Corps jurisdiction where the discharge is incidental to the primary activity of excavation by use of backhoes, excavators, suction dredges or similar equipment. Bulldozing and stockpiling of material to facilitate eventual excavation is regulated as a discharge of material if conducted within Corps jurisdiction and would require a Section 404 permit. Removal of vegetation by use of hand tools or certain mowers does not typically result in the discharge of fill material and is not regulated under the Clean Water Act, but bulldozing for vegetation removal would likely be regulated as well as disking of the substrate for weed control in certain circumstances" (USACE, 2010a)."

Therefore, it appears the method and scope of an activity involving the removal of LWM ultimately determines whether permitting is required under the CWA. Notwithstanding the absence of clarity, LWM removal has been implicitly treated in the federal permitting process through categorical exemptions and explicitly addressed through categorical permits (nationwide permits).

In terms of categorical exemptions, the CWA specifically exempts certain activities from requiring a permit (CWA, 2011a). Most applicable to the removal of woody material is Section 404(f)(1)(B), which states:

> "[a discharge] for the purpose of maintenance, including emergency reconstruction of recently damaged parts, of currently serviceable structures such as dikes, dams, levees, groins, riprap, breakwaters, causeways, and bridge abutments or approaches, and transportation structures, … is not prohibited by or otherwise subject to regulation under this section" (CWA, 2011b).

Essentially, this subsection allows maintenance of structures like bridges to be conducted without having to apply for either an individual or nationwide permit. The CWA does not directly define what is considered maintenance. Presumably, removing accumulated woody material from around structures could be construed as maintenance.

At the same time, however, categorical "Nationwide Permits" (NWPs) explicitly authorize woody material removal from around bridges and culverts. Nationwide Permits are essentially pre-approved categories of activities with a streamlined approval process because of their minimal impacts to aquatic life (USACE, 2010b). This streamlined process requires a permit applicant to meet

general conditions and provide notice to the USACE. Most germane to LWM are NWP's 3 and 18, which pertain to the maintenance of structures, and are limited to their immediate vicinity.

NWP 3 authorizes the removal of "sediments and debris in the vicinity of, and within, existing structures (e.g., bridges, culverted road crossings) (NWP, 2011b). Thus, when maintenance crews remove accumulated woody material around structures, their actions may be covered under this NWP and a separate approval (individual permit) is not required. However, unlike exemptions, they must still adhere to the General Conditions common to all NWPs, including the requirement that notification must be provided to, and approval granted by, USACE in advance of the work.

When it reauthorized NWP 3 in 2002, the USACE took particular note of the important role woody material plays as in-stream habitat. One public comment suggested that when woody material was removed from the upstream side of a bridge, "a condition of the permit should be that all substrate of spawning size and all wood of any size should be placed at the downstream end" (USACE, 2002b). The USACE responded:

> "[W]e agree that, to the extent that actions to enhance such fish and substrate passage can be incorporated into individual NWP 3 authorizations, they should be included as Best Management Practices. Any redeposit of excavated spawning-size substrate may be authorized under NWP 18, subject to the limitations of that permit" (USACE, 2007b).

This statement provides clear guidance to USACE Districts and endorses the concept of keeping woody material in the river as important fish habitat. Nationwide Permit 18 authorizes the discharge of limited quantities of fill material, such as woody material from the upstream side of a bridge into waters of the United States (NWP, 2011a). Thus, taken together, NWPs 3 and 18 appear to allow for the removal and reintroduction of woody material "in the immediate vicinity of" structures, and in no case more than 200 feet in any direction (NWP, 2011b).

USACE Districts in other parts of the country have expanded on the guidance contained in the NWP 3 Decision Document. The San Francisco District issued a Supplement to the Decision Document for NWP 3 that contained regional conditions to be implemented above and beyond the general conditions required by the NWP. The District added a condition to approvals issued in their jurisdiction under NWP 3 that specifically required any new or additional bank stabilization to "incorporate structures or modifications beneficial to fish and wildlife (e.g. soil bioengineering or biotechnical design, root wads, large woody debris, etc.)." It was also noted that this echoed the recommendations of the U.S. EPA.

The Rivers and Harbors Act of 1899—As with the Clean Water Act, jurisdiction under the Rivers and Harbors Act appears to be clearer in cases

where Large Woody Material is being returned or "discharged" to a water body rather than removed from it. Section 10 of the Rivers and Harbors Act of 1899 prohibits the creation of obstructions to the navigable capacity of navigable waters of the United States (USC, 2011c). Section 10 also prohibits "any work which would affect the course, location, condition, or capacity of navigable waters." It is conceivable that both removal and reintroduction of woody material could have this effect. Section 13 of the Rivers and Harbors Act further prohibits the deposit of refuse matter into navigable waters of the United States without prior approval (USC, 2011d). The Secretary of the Army must give prior approval for any deposits of refuse from floating crafts or the shore or the deposit of material on the banks of any navigable water which might be washed into the water and obstruct navigation (USC, 2011d). Interestingly, Section 13 also provides that it shall not extend to or prohibit operations in connection with the improvement of navigable waters or public works operations, at least when those improvements are being undertaken at the behest of the United States (USC, 2011d). This provision suggests that at least some de-snagging for navigation improvements could be outside of Section 13's approval requirement.

State Jurisdiction and Regulation—*Proprietary authorizations*—Florida's navigable rivers and streams are subject to state ownership as well as regulation. Under the Florida Constitution, all submerged lands and overlying navigable waters are held by the State (Florida Const. Art X, Section 11). As noted above in the discussion of deadhead logging, the State of Florida has title to the land under navigable waters and presumptively owns the resources within them. As a result, any LWM removal and reintroduction activities will likely require the permission of the State of Florida. FDEP administers the state sovereign submerged lands program. Chapter 253, Florida Statutes, authorizes the use of submerged lands through the granting of easements, leases, consent by rule or letters of consent. LWM removal or reintroduction activities are not specifically mentioned as activities to which any of these forms of authorization apply. An activity involving the removal and reintroduction of LWM would likely involve a "letter of consent," either because it is otherwise exempt from regulatory permitting (discussed below), or because it is "the least amount of interest in the sovereignty submerged land necessary for the activity" (FAC, 2011d).

Regulatory authorizations—In addition to proprietary authorizations, Florida also regulates activities within waters and wetlands. Under Chapter 373, Florida Statutes, the Environmental Resource Permit (ERP) program regulates the dredging or filling of tidal or freshwater wetlands and other surface waters. Under the ERP program, entities seeking an applicant for a permit to dredge or fill waters of the state must show that state water quality standards will not be violated and the activity is "not contrary to the public interest" (FS, 2010). For Outstanding Florida Waters, which includes many

navigable rivers and streams within the state, this standard is stricter and an applicant must also show that their activity is ''clearly in the public interest'' (Ankersen et al., 2010). Because it is an activity that may involve dredging or filling ''in, on or over waters of the state'' that may affect water resources, the ERP program presumptively applies to the removal and reintroduction of LWM. Florida also has exemptions and categorical permits which could place certain LWM activities outside the individual ERP process. Chapter 373 includes a ''*de minimus* exemption'' for activities that do not individually or cumulatively have a significant adverse effect on water resources.

Like the federal Nationwide Permit discussed above, Florida Noticed General Permits (NGP's) provide a streamlined approval process for certain categories of activities that FDEP has previously approved. Like NWP's, Florida NGP's are subject to General Conditions that must be satisfied in addition to the specifics of each NGP, including the requirement of notice to FDEP prior to commencing the proposed activity (FAC, 2011d; FAC, 2011e).

Regarding removal of woody material accumulated upstream of bridges and culverts in rivers, two NGP's could possibly apply, albeit in limited circumstances. FDEP granted the Florida Department of Transportation (FDOT) an NGP which allows the agency to 1) place, replace and maintain culverts associated with existing roadways in some streams, and 2) perform limited channel clearing and shaping by dredging and/or filling in waters of the State to ''facilitate maximum hydraulic efficiency of the structures'' (FAC, 2011f-g). The removal of woody material around culverts would appear to accomplish both of these objectives.

There is also an NGP for ''Minor Activities,'' which grants the ability to, among other things dredge or fill less than 100 square feet of wetlands or other surface waters or to conduct maintenance dredging removing less than 50 cubic yards of material (FAC, 2011h-j). It would appear that either of these could be employed in the context of the removal of LWM in appropriate circumstances. Whether the removal of LWM constitutes dredging under Florida law would appear to be contextual, just as it appears to be under federal law.

A Florida LWM regulation case study—In at least one recent Florida case, LWM removal was the subject of a jurisdictional determination by DEP and the USACE. Characterized as a ''de-snagging,'' the project involved a two phase project to remove woody material from Thomas Creek in Nassau County for the ostensible purposes of flood control. The project was determined to be exempt from any regulation by DEP under the ERP Program because of its *de minimus* impact. The Corps simply concluded that the activity ''was not regulated'' and alluded only to the jurisdiction of the Clean Water Act in its determination (and not the Rivers and Harbors Act), finding that no filling was involved. In both phases, it was the low-impact LWM removal methods used that led to the jurisdictional determinations. However, and perhaps most importantly, in granting the exemptions neither DEP nor the USACE appeared to consider the ecological value of the woody

material *in situ*, only the minimal impact that the act of removing the material would have on water resources.

Approaches to LWM in Other Jurisdictions—Some states and communities are explicit in addressing the *in situ* value of LWM. These actions appear to be prompted by studies showing the benefits woody material. Florida has not provided management guidance that addresses the significance of LWM in the ecological health of its watersheds.

For example, the Ohio Stream Management Guide states that, ''Governmental entities at the municipal, county, state, and federal levels have the statutory authority to undertake stream clearing and drainage improvement projects, but no governmental entity at any level has been assigned by statute the responsibility for such logjam removal activities'' (ODNR, 2005).

The Michigan Department of Environmental Quality (MDEQ) and the Michigan Department of Natural Resources (MDNR) developed the ''Clean and Open Method of Woody Debris Management'' to give guidance on how to manage logjams, preserving the benefits they provide while minimizing the problems they can create (Riparian Corridor Management Technical Advisory Committee, 2004). This plan was in response to new studies that show that properly managed logjams help reduce erosion and provide habitat for fish and wildlife. The Clean and Open Method involves 6 steps: (1) Plan for safety, access, public health, and hydrologic characteristics, (2) Clean foreign trash, (3) Open channel to allow a passage of flow, (4) Place excess woody material along the stream banks, (5) Leave woody material that is embedded in the banks or channel, and (6) Minimize the impact to the work site. The plan appears to be implemented at the county level.

The City of Rochester Hills, Michigan developed a Primer for the management of LWM (JFNew, 2007). This document outlines the need for a preliminary assessment of the woody material based on type, anchor point, channel dimensions, and general observations before any action is taken. Only then should management options should be evaluated. These options include: no action, modification without repositioning (clean and open), removal and off-site disposal, and cutting and anchoring.

The Ohio Department of Natural Resources prepared a Stream Management Guide with a focus on Large Woody Debris in Streams (ODNR, 2002). The guide recognized the importance of large woody material in streams, but left considerable discretion in how LWM would be addressed. A separate Stream Management Guide that focused on stream debris and obstruction removal recommended precautions that should be taken before and during an obstruction removal project (ODNR, 2005).

Australia has also witnessed wide scale de-snagging and in response has developed guidelines for the restoration and reintroduction of LWM to streams (Erskine and Webb, 2003). These guidelines address the site selection, LWM placement and distribution, amount of reintroduced material, introduction

techniques, and sources of material. They suggest that reintroduced logs should be oriented within 30° of the flow direction and also placed in low flow areas such as channel edges and inside meander bends. They follow Gippel et al.'s (1996) suggestion that in lowland rivers a loading goal may be 100 m^3ha^{-1}. They discourage the use of invasive heavy equipment but do provide example of anchoring techniques. Their aim is to reintroduce natural levels of LWM into streams until pre-disturbance levels of LWM are available from the riparian zone. In Australia, de-snagging is no longer an approved practice and LWM rehabilitation projects are ongoing (Erskine and Webb, 2003).

Conclusion—A number of scientific studies have shown the importance of LWM in streams. However, historic and ongoing silviculture activities, deadhead logging, and clearing for flood control, navigation, and bridge safety are all practices that decrease the amount of LWM now in streams, and the amount that is available to streams in the future. Florida regulatory programs do not adequately address the *in situ* significance of woody material in streams, and the reach of both federal and Florida law remains uncertain. The current regulatory framework appears to disfavor the assertion of jurisdiction for purposes of *in situ* protection of woody material, at the same time it seems to favor jurisdiction for the reintroduction of LWM (e.g., filling and potential obstructions to navigation). This conclusion appears to be borne out by the Thomas Creek case study described above where a de-snagging project was considered *de minimus* by FDEP, while the ACOE concluded that the activity was "not regulated." This leads to the somewhat odd conclusion that an environmental restoration project may be more likely to invoke regulatory processes than a de-snagging project for flood control and navigation, an irony that has been noted by others (Rizzardi, 2002).

Under current law, Best Management Practices for woody material management have the potential for improving the health of many of Florida's rivers and streams. BMP's could follow the other states' examples by imposing flexible voluntary guidelines or could be attached to the existing regulatory structure through conditions on individual and categorical permits, or in exchange for receiving an exemption from permitting, as is currently provided for in the silviculture exemption to stormwater regulation (Ankersen et al., 2010). Creating a guide similar to those used in Michigan and Ohio would educate those removing the woody material on the ecological benefits it provides. Incorporating LWM BMP training in outreach and extension programs could also improve awareness of the important role of woody material in sand bed streams. Below are suggested BMP's that could be incorporated into the current policy framework for woody material management in Florida.

Proposed BMP's for Florida—The management of LWM in Florida should consider the approaches of other states such as Michigan and Ohio.

However, the state's low gradient sand bed streams may also call for region-specific strategies. Any strategy should first call for an assessment and characterization of the material and the problem. From there the appropriate solution can be implemented. To take no action should always be an option when considering the removal of LWM, because in most instances LWM is more valuable *in situ* than removed. If action is deemed necessary to address human needs, such as flood control and navigation, then BMP's can be used to minimize and mitigate impacts. BMP's are widely used in Florida for other activities that may affect resources and can be tied to permitting through conditions, categorical permits and exemptions. The following is a list of possible LWM BMP's that may be appropriate for the state of Florida. These BMP's are based on the value of LWM in streams identified through the scientific literature while allowing for practical management and maintenance.

1. BRIDGE CLEARING AND POST-STORM MAINTENANCE[2]—Whenever feasible and safe, all woody material that is cleared from bridge blockages should not be transported off site but rather some should be placed in the river downstream from the bridge. The clean and open method should be used where practical (Riparian Corridor Management Technical Advisory Committee, 2004).

2. NAVIGATION[2]—Where logjams inhibit small boat traffic; minimally invasive navigation channels should be cut and maintained based on the beam and draft of the typical vessels using the particular watercourse. Recreational boaters should not be allowed to move woody material for navigational purposes without authorization. Where LWM inhibits larger boat traffic, as much woody material should be left in place as possible and every effort should be made to ensure that key pieces remain securely in the stream. In some cases, navigational signage may be appropriate. The Clean and Open Method should be used where practical (Riparian Corridor Management Technical Advisory Committee, 2004).

If authorization to de-snag a stream reach is sought there are several additional practices that will minimize impacts.

1. A buffer width from the stream bank should be maintained on each side of the navigation channel where disturbance is prohibited. The width of this buffer will vary from project to project and depend on the stream width and the boat traffic particular to that river.

[2] Factors for consideration when mitigation, repositioning, clearing, and anchoring LWM (Shields et al., 2004).

• Trees such as cedar are more resistant to degradation than other species.
• LWM soaked for 10 day has 50–80% higher density than dry material.
• LWM 'key pieces' are usually those that have root wads attached and span the channel.
• Multi-stemmed/wide spreading trees tend to form snags because of their geometry. Single trunks are more mobile and accumulate as racks and form log jams.

2. Where feasible, removal of LWM should be done by hand using chainsaws and other hand operated equipment to minimize impacts to the channel and banks.
3. Embedded materials should not be removed or dislodged. These pieces may be cut or topped if they present a hazard.
4. Submerged material and benthic substrate that is not an immediate navigational hazard should not be removed. Portions of this material that do present a hazard may be cut without disturbing the substrate. The depth of removal will vary and depend on the boat traffic.
5. LWM that is removed may be lodged against the bank in the stream channel if it does not present an additional hazard. This is a favorable solution because it clears a path for navigation and at the same time keeps the LWM available to the stream.
6. LWM that is not lodged against the banks should be placed in the floodplain as terrestrial habitat.
7. If LWM is taken off-site then boats with block and tackle should be used to transport the LWM to an input/output area.
8. Access to the site should be minimized. Consider using temporary docks, mats, and having only one input/output area.
9. Disturbance at the site should be minimized. Fill in all ruts and minimize erosion potential.

3. FLOOD CONTROL[2]—Woody material may form debris jams that can block water and present a flood hazard. Where compelling evidence of these hazards exists and clearing is deemed necessary for safety reasons, documentation of the necessity for the clearing should be required. As much woody material should be left in place as possible and every effort should be made to ensure that key pieces remain securely in the stream. The clean and open method should be used where practical (Riparian Corridor Management Technical Advisory Committee, 2004). Where permits or exemptions for de-snagging a stream reach for flood control are obtained refer to points 1–9 in the navigation BMP section.

4. DEADHEAD LOGGING[2]—Permits for deadhead logging should be minimized or discontinued. If permits are allowed to continue, then mitigating actions should be required when permits are issued. Mitigation may involve introducing alternative stable woody material into the stream so that the function of the deadhead log is not lost. Mitigation may also involve contributing to a fund that would support implementation of a woody material management plan for the stream where the deadhead logging is proposed. Offsite mitigation should be discouraged because it does not contribute to the ecological health of the stream where the removal is proposed.

5. EDUCATION—Education including signage, brochures, and public campaigns should be conducted to inform members of the community of the

benefits of woody material including habitat and food for fish and wildlife. Education programs may include: certification of outfitters in a "green manner" that can be used as a marketing tool for the outfitters; public marketing campaigns focused on the benefits of LWM that are important for stakeholders (e.g., habitat for fish and food web for waterfowl); signage at waysides; or brochures attached to fishing/hunting licenses.

6. SILVICULTURE—One major reason for the loss of LWM may be that is not being replenished at its natural rate because of logging in the riparian corridor. According to the Division of Forestry Silvicuture BMP's selective harvesting can be done in the Primary Zone of perennial streams. The Primary Zone is an area extending away from stream banks with a width that varying between 35–200 feet. Primary Zone BMP's pertain to Outstanding Florida Waters (OFW), Outstanding National Resource Waters (ONRW), Class I Waters, and wetlands. The restrictions that apply to LWM management in the Primary Zone are as follow:

> Within the Primary Zone "selective harvesting may be conducted to the extent that 50% of a fully stocked stand is maintained. The residual stand should conform to the following. Trees should be left to maintain the approximate proportion of diameter classes and species present prior to harvesting, except that oaks (other than water oaks) and den trees may be favored. However, in mixed pine/hardwood forests the residual stand may be composed of up to 90% hardwood and 10% pine, and den trees may be favored. Repeated entry into a harvested Primary Zone in short time intervals for additional harvesting is prohibited. No trees will be harvested in stream channels or on the immediate stream bank. Special emphasis should be given to the following, within the Primary Zone in which added protection is provided for very large trees and/or old trees, snags and cavity trees, and protection of trees where any part of the canopy overhangs the water…." (Division of Forestry, 2000)

Silviculture BMP's should be revisited to explicitly investigate if these practices can be updated to enhance the stock of LWM available for input into streams.

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