Forest Carbon and Climate Program
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State-Level Forest Best Management Practices

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Introduction

Nearly 60% of forests in the U.S. are privately owned, either in corporate ownership (40%) or family ownership (60%) (Oswalt et al., 2019). Likewise, the management decisions of these landowners have profound ecological, economic, and social implications. This dynamic results in federal and state policies that seek to influence silvicultural management activities, such as regulations governing private forest land management and associated impacts to water quality.

With the passage of the Clean Water Act (CWA) in 1972, states were required to develop nonpoint pollution source (NPS) controls (Ice et al., 2004). This process gave states latitude on policy design, allowing them to choose between regulatory and nonregulatory frameworks as long as the program met required water quality metrics (Ice et al., 2004). As such, several different types of NPS control programs were adopted by states, with those requiring or recommending the implementation of specific management practices becoming known as best management practices (BMPs) (Ice et al., 2004).

The central goal of BMPs is to promote water and soil quality during the harvest of timber and other forestry activities (e.g., the development of transportation infrastructure). This is especially significant given that an estimated 50% of U.S. drinking water originates from forested landscapes (NASF, 2018). As a policy type, BMPs play an important role in requiring or incenting sustainable management, which has implications for forest carbon and storage on private forest land.

This paper examines the management activities associated with BMPs. Then, the various regulatory approaches are discussed in conjunction with monitoring requirements and implementation rates. Finally, the forest and climate change implications for land management and forest carbon are introduced. The paper concludes with a summary of key takeaways.

Management Activities

There are eight key management activities typically prescribed in forestry BMPs (Amberg, n.d.). Table 1 illustrates and describes these operating categories.

Table 1. BMP Management Activities

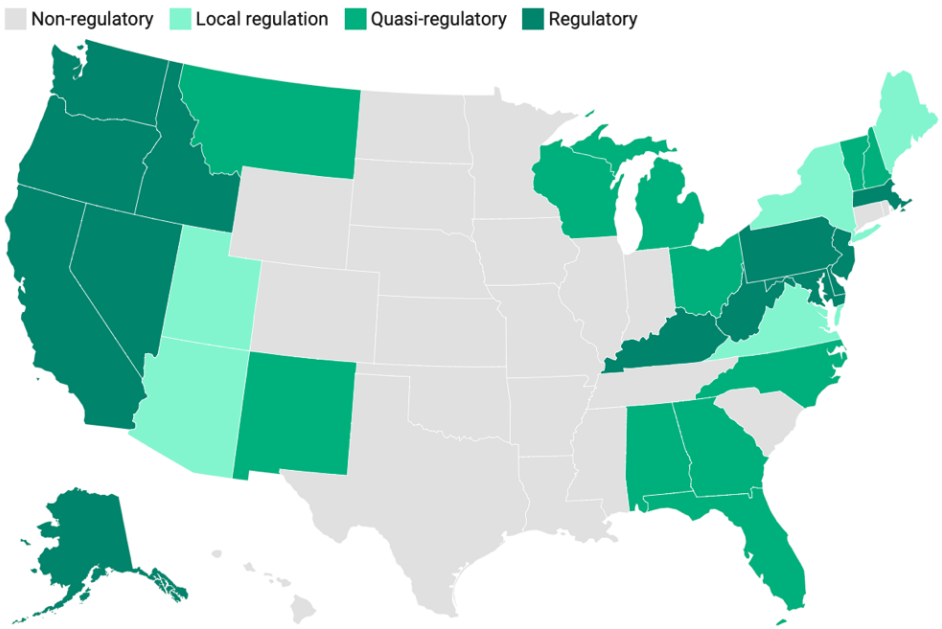
Category	Description
Pre-harvest planning	Pre-planning the location of roads, loading areas, skid trails, stream crossings and streamside management zones to protect water quality.
Streamside management zones (SMZs or RMZs)	Areas near bodies of open water where management activities are modified to protect water quality. Common practices include avoiding timber harvest and chemical fertilizers.
Forest wetlands protection	Avoiding construction and establishing buffer zones to protect wetlands against nearby silvicultural activities.

Road construction and maintenance	Avoiding building new roads near bodies of water, capturing water runoff, minimizing crossings, limiting road grades, and obtaining necessary permitting (e.g., storm water permits). Minimizing damage of skid trails and landings.
Timber harvesting	Planning harvests to avoid water contamination by ensuring uncut stands absorb runoff, avoiding clear-cutting, and maintaining larger, longer-lived trees in RMZs.
Revegetation	Using native plants to stabilize soil and slow water movement.
Fire management	Considering the location and impact of prescribed burns on soil stabilization and water quality.
Forest chemical management	Avoiding chemical fire retardants and other substances, especially near water surfaces or RMZs.

Approaches and Implementation

There are four approaches to the implementation of BMPs, including regulatory, quasi-regulatory, local regulatory, and voluntary programs (NASF, 2019). In regulatory states, BMPs are required by statute. Quasi-regulatory regimes have established standards, but do not indicate how landowners must meet water quality metrics. Meanwhile, local regulation refers to states with counties and/or municipalities with local BMP ordinances. Finally, voluntary programs rely on non-regulated participation from landowners. Figure 1 shows the diffusion of these approaches across the U.S. (NASF, 2019).

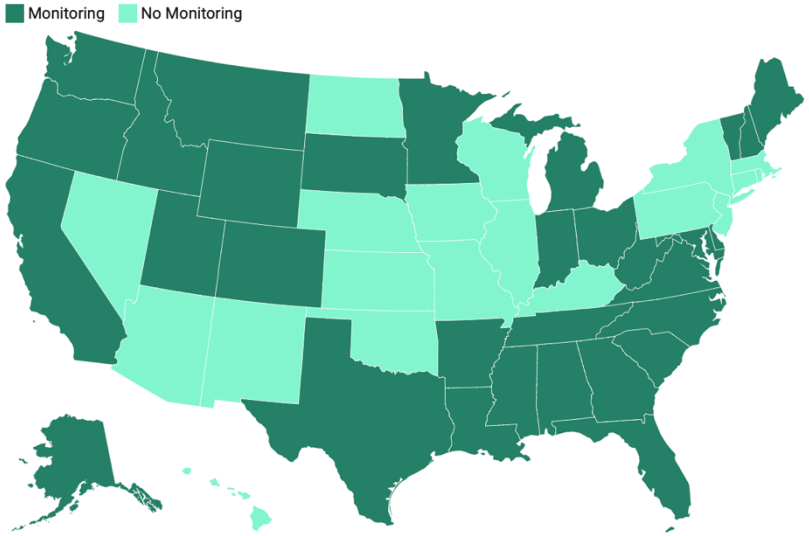
Figure 1. BMP Regulatory Approaches



In addition to differing regulatory regimes, some states monitor compliance with BMPs while others do not. This can be attributed to multiple factors, including a dedicated resources, administrative capacity, and legal authority. It may also be that forestry is not a major land use, meaning that silvicultural activities have a relatively insignificant effect on water quality. Figure 2 illustrates the states that do and do not monitor BMPs (NASF, 2019).

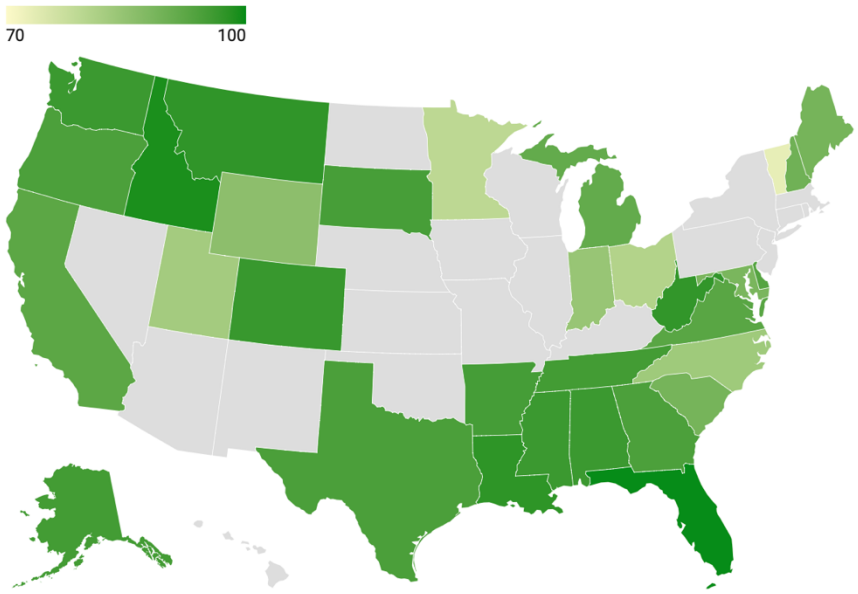
Almost half (47.6%) of voluntary states do not monitor BMPs, compared to 38.5% of regulatory states (38.5%) and states with local BMP governance (40%). Quasi-regulatory states have the most monitoring, with a smaller 18.2% that do not monitor compliance.

Figure 2. BMP Monitoring



Of the majority (62%) of states that do monitor BMPs, the implementation of BMPs do not vary heavily between the different regulatory regimes. The implementation rate is 94.95% for regulatory states, 93.82% for voluntary states, 90.58% for quasi-regulatory states and 89.39% for states with local governance. Figure 3 outlines each states average BMP implementation rate.

Figure 3. BMP Implementation Rate



Forest and Climate Change Implications

Water Quality and Soil Contamination

Overall, BMPs are largely effective at preventing water quality and soil contamination risks when measured against the intended outcomes of management activities. In a literature review by Cristan et al. (2016), BMP operational categories (timber harvesting, skid trails, streamside management zones, site preparation, etc.) were evaluated across the southern, western, and northern regions of the U.S. (Cristan et al., 2016). The authors concluded that:

1. BMPs can minimize erosion and sedimentation
2. Implementation rates and quality are critical to BMP effectiveness
3. BMP implementation can be enhanced with pre-operation planning and with the involvement of a registered professional forester.
4. Increased logger training and landowner knowledge of forestry BMPs can help improve implementation
5. Stream macroinvertebrates are typically not significantly affected by forest operations when BMPs are correctly applied

Notably, this review highlights several cases where the application of BMPs were crucial to success. Without proper implementation, BMPs are less effective, and in some cases ineffective at preventing contamination or damage to biological habitats (Cristan et al., 2016).

Forest Carbon

Soil organic carbon (SOC) is a key carbon stock, accounting for 1,500-2,400 PgC as reflected in Figure 4 (Janowiak et al., 2017). In research conducted by Nave et al. (2022), findings indicate that BMPs have a positive influence on SOC (Nave et al., 2022). However, more research is necessary to determine the magnitude of these results. Shown in Table 2, the authors also identify current BMP management practices with SOC co-benefits (Nave et al., 2022).

Figure 4. Carbon Stocks and Fluxes

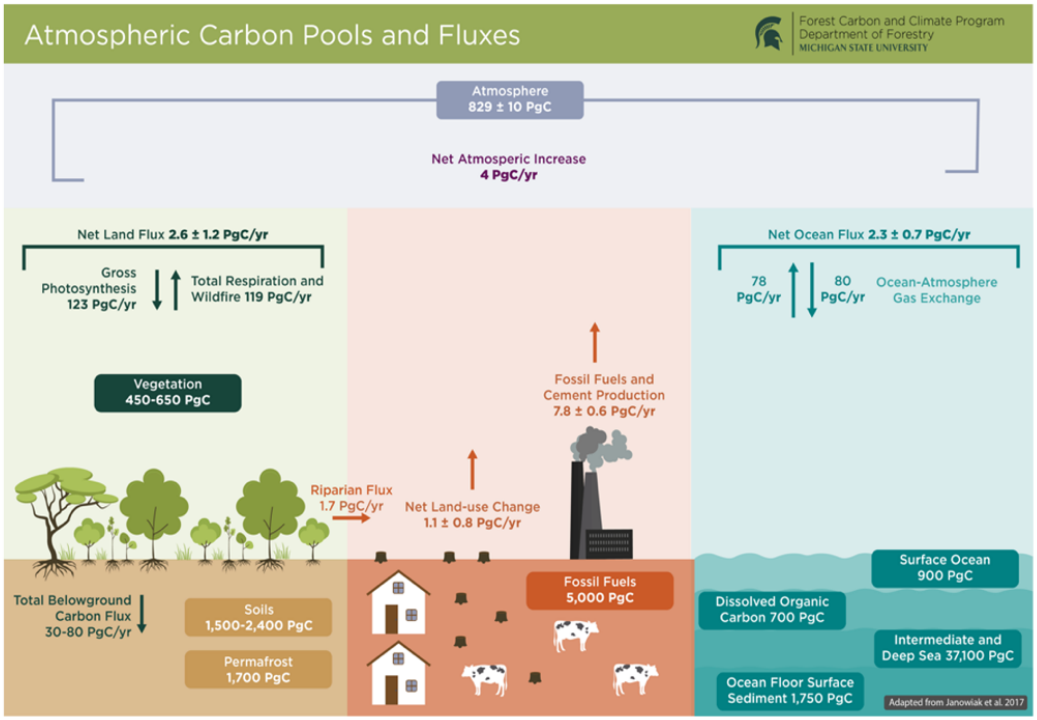


Table 2. Management Practices with SOC Co-benefits

Management Regime	Practice	Intent	Additional Considerations
Mountain hardwoods	Restrict harvesting to slopes < 16%	Minimize risk of detrimental soil disturbance	SOC benefit is assumed, risk still exists on level grounds
Mountain hardwoods	Extend rotation length	Increase woody biomass carbon stocks	Increases rotation length only delays eventual SOC loss
Coastal pine plantations	Restrict litter raking	Accumulate organic horizon carbon, mix into soil during site preparation	Litter straw demand displacement; cost-benefit of site preparation
Coastal pine plantations	Decrease herbicide use	Allow competing vegetation to grow and input carbon to soil	Competing vegetation may diminish wood yield; SOC gains may be transient

Adapted from Nave et al., 2022

Carbon Sequestration

Additionally, carbon sequestration has been shown to improve as a result of improved forest health through BMP activities like prescribed burns and reforestation. Bradstock et al. (2012) show that prescribed fire can possibly mitigate carbon emissions as a result of decreasing unplanned fires (Bradstock et al., 2012). However, this potential differs based on the forest ecosystem (Bradstock et al., 2012). Wiedinmyer and Hurteau (2010) indicate that the wide application of prescribed fires could reduce CO_2 emissions in the western U.S. by 18-25%, and as much as 60% in other forest systems (Wiedinmyer and Hurteau, 2010).

Reforestation and Avoided Degradation

The principles of reforestation and the avoidance of forest degradation play an important role in BMP management activities. In a paper on the role of reforestation in carbon sequestration, Nave et al. (2019) write that an "immediate, but phased and spatially targeted approach" to reforestation can enhance carbon sequestration in the U.S (Nave et al., 2019). As such, BMP programs offer an opportunity to focus on forest regrowth in the face of the climate emergency. Positive benefits of these activities include improving air and water quality, climate adaptation and resiliency, and increased biodiversity.

Conclusion

Since the passage of the CWA in 1972, BMPs have been implemented in all fifty states, ranging from regulatory provisions to voluntary, education-focused programs. Despite these different approaches, implementation remains high across the spectrum. While BMPs are being executed in many states, they are only monitored in 60% of states due to legal, financial, and other resource constraints.

BMPs have been shown to be largely effective at preventing water quality risks and soil contamination, as evidenced by literature reviews of multiple forested regions. There is also growing evidence that the policies promoted by BMPs (e.g., harvest planning, reforestation, damage avoidance) have positive impacts on forest and soil organic carbon. As such, some states have begun updating BMPs to address broader climate concerns by promoting practices like avoided conversion, reforestation, afforestation, and forest carbon management (Volk, 2021).

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