Forest Water Resources

A position of the Society of American Foresters

Originally adopted on October 7, 2020. This position statement will expire in 2025, unless, after subsequent review, it is further extended by the SAF Board of Directors.

Purpose

To acknowledge and support the importance of watershed services provided by forests in the United States.

Scope

Sustainable urban, community, and rural forest management in the United States that enhances watershed function and resilience.

Position

The Society of American Foresters (SAF) supports policies, programs, and actions that enhance the health, sustainability, management, and restoration of forested watersheds. Healthy, resilient forests are essential to providing a clean and continuous supply of fresh water for humans and the environment. Forests also recharge aquifers, stabilize soils, filter pollutants, mitigate stormwater runoff, regulate stream flows, and moderate stream temperatures. SAF agrees that trees and forests are a critical component to solving the water-related challenges facing communities, utilities, businesses, and the environment, and that sustainable management is critical to improve the health and resilience of the nation's watersheds.

Issue

Increasing population, water use, and the frequency of extreme disturbances and persistent drought events have resulted in water scarcity concerns in many regions of the country. Degraded, polluted, and impaired waterbodies stress already vulnerable water supplies, impacting not only water for human consumption, but also for wildlife and the environment. Additionally, natural disasters, including high-severity wildfires, can further compromise watersheds, waterbodies, water treatment systems, and community infrastructure, resulting in significant and costly repairs and upgrades for utilities and local governments. Forests play a critical role in maintaining watershed stability, resilience, and providing fresh water for millions of Americans. As forests become degraded, fragmented, and converted to other land uses, water resources can be adversely affected.

Background

Forest and Water Relationship

Forests capture, filter, store, and release water over time, making them a fundamental component of the hydrologic cycle in many areas. Precipitation is partially intercepted by tree canopies, reducing the speed and energy of raindrops that fall to the forest floor, protecting the soil surface from erosion, and shading accumulated snowpack. Forest soils function like a sponge, absorbing large amounts of water that reach the ground. Water that infiltrates the soil is either absorbed by the roots of trees and other forest vegetation, stored in underground aquifers, or is slowly released over time into nearby creeks, streams, lakes, and rivers.

In fully functioning forested watersheds, only a small portion of water leaves as surface runoff, which is often slowed and filtered by trees and underlying vegetation, further enhancing water quality. The cumulative effects of these hydrologic functions result in more consistent and higher quality flows in streams, rivers, and lakes.

This fundamental ecosystem service has been recognized and well understood for over a century. Among the primary purposes of the U.S. Forest Service Organic Administration Act of 1897, which directed the management of forest reserves and led to the establishment of many of the National Forests, was "securing favorable conditions of water flows" (Vose, 2019). Many states also established public forests for this purpose.

Economists have estimated values of ecosystem services to help governments, corporations, and individuals make more informed decisions about the conservation of natural resources (Daily et al., 2011). The regulation of water quantity and quality is among the most important forest ecosystem services in many regions of the world (Holmes et al., 2017). Several states have conducted forest-based ecosystem service assessments, with total annual ecosystem service values ranging from 151 to 1,709 thousand dollars per acre of forest land. Water, a key component of these assessments, comprised an estimated 14 to 66 percent of the total value (Sills et al., 2017).

Water Supply and Availability

It is well known that forests provide the most stable and cleanest water of any land use (Liu et al., 2020). Forty-six percent of the nation's water supply is provided by forests that cover only 26 percent of the land area in the United States (Brown et. al, 2016). Relatively high evapotranspiration rates in forests relative to other land uses imply that reductions in forest cover increase water yield, while gains in forest cover may decrease water yield (Elliott et al., 2017; Martin et al., 2017; Filiso et al., 2017). Despite the potential for increased streamflow following forest removal and conversion to other land uses, surface water that is available for drinking water may decline due to unstable flow regimes (Lockaby et al., 2013). While forests use more water than some other land uses, they may increase base stream flows during dry periods, regulating streamflow due to greater soil water storage capacity and increased groundwater recharge (Krishnaswamy et al., 2013).

Climate, extreme and persistent weather events, land use, and population growth are all factors that affect water availability. While precipitation patterns are the primary driver, watersheds can have varying rates of infiltration, storage, and discharge due to differences in soil, vegetation, topography, land use, and geology. Researchers use hydrologic models accounting for these variables to identify areas where future water supplies may be vulnerable and could become scarce.

Water stress, or the ratio of water demand to water supply (Averyt et al., 2013; Duan et al., 2019; Lockaby et al., 2013), is generally of greater concern in the arid and semi-arid climates of the western United States. Although water supply is usually high in the eastern United States due to abundant, regular precipitation throughout the year, high water demand from large population centers has resulted in water stress in some urban areas, such as Atlanta, Georgia (Jeong et al., 2015) and Raleigh, North Carolina (Hester and Larson, 2016). Available water is also expected to continue to decrease across the country due to projected increasing surface temperatures and frequency and severity of droughts (Liu et al., 2020).

The *National Forests to Faucets 2.0 Assessment* identified the relative importance of subwatersheds for surface drinking water supplies across the country. This assessment factored in the vital role that forests play in protecting source water and the extent to which these forestlands are threatened by forest conversion or stand dieback. The resulting “priority watersheds” are areas resource managers should focus forest conservation and stewardship efforts. A key challenge will be to incentivize private landowners through financial assistance or policies to retain forests (Vose, 2019).

Water Quality and Best Management Practices

Research shows that watersheds with greater forest coverage produce better water quality than watersheds with lesser forest coverage (Sun et al., 2004; Tu, 2013). This principle remains true even when forests are actively managed, as long as effective forestry-Best Management Practices (BMPs) are implemented properly. BMPs are defined as “a practice, or usually a combination of practices, that are determined by a state or a designated planning agency to be the most effective and practicable means (including technological, economic, and institutional considerations) of controlling point- and nonpoint- source pollution at levels compatible with environmental quality goals” (Helms, 1998). Sediment is generally considered to be the most significant water pollutant associated with forest management operations (US EPA, 2005); however, temperature, nutrients, silvicultural chemicals, and other water quality constituents can be regionally or locally important.

Forestry BMP guidelines were developed in response to the Federal Water Pollution Control Act of 1972, or Clean Water Act (Cristan et al., 2016) and by 2000, had been established in all 50 states (Shepard, 2006). These practices have undergone numerous scientific research studies to determine their effectiveness at minimizing impacts to water chemistry, physical properties, aquatic communities, and overall stream health. A recent literature review (Cristan et. al, 2016) summarized the conclusions of 81 different studies conducted across the country, primarily within the last 30 years. While BMP effectiveness studies are often site or region specific, they clearly demonstrate a common outcome: forestry BMPs minimize water quality effects of forest operations when implemented as recommended by state forestry agencies (Cristan et al., 2016).

Despite this clear understanding, BMPs have been the subject of legal and regulatory scrutiny for years. In 2012, a case involving the management of stormwater runoff from logging roads made it all the way to the United States Supreme Court. After hearing this case, the Supreme Court reversed an earlier ruling by the U.S. Court of Appeals for the Ninth Circuit that forest roads are subject to a mandatory permit requirement under EPA's point source rules. The Court issued a decision giving deference to EPA's interpretation of the industrial stormwater rule, enabling the agency to maintain its longstanding practice of not requiring stormwater permits for logging roads (Supreme Court, 2013).

BMP programs and guidelines are designed to evolve over time based on new research, technology, operations, and monitoring results. A 2013 survey of state forestry agencies indicated that within the previous five years, half of the states had either written new BMP guidelines or revised existing ones (Cristan et al., 2017). Revisions are generally conducted through multi-disciplinary planning teams consisting of state and federal government, academia, industry, private landowners, and environmental groups (Loehle et al., 2014).

Nonpoint-source pollution contributions associated with forestry tend to be widespread and diffuse, and pollutants are often naturally occurring and difficult to distinguish from background sources (Ice et. al, 2010). Since potential impacts are difficult to measure and monitor, most programs track progress by monitoring BMP implementation, using this as a surrogate for water quality protection (Ice et al., 2010; Cristan et al., 2017). While there is no established national monitoring approach, regional state forestry organizations have developed protocols to ensure consistency and enable comparisons across the states in their respective region. Data summarized from these organizations indicate that as state forestry BMP programs mature, implementation shows a clear upward trend (Ice et al., 2010).

Fish and Aquatic Communities

Riparian forests provide numerous important benefits to fish and aquatic communities. Tree canopies shade streams, moderating water temperatures that are especially important for salmonids, trout, and other cold-water species. These forests also deliver large wood and organic matter inputs to streams, providing critical fish refuge, over-wintering habitat, and food sources for organisms at the base of the aquatic food web (Fausch et al., 2002). Lastly, forests are very effective at filtering runoff water, removing sediment and nutrients that can impact water quality and aquatic communities.

Water-based Recreation

In 2018, 49 million people went fishing and 23 million people participated in at least one paddle sport, such as kayaking, canoeing, or rafting (Outdoor Industry Association 2019b; 2019a). Access to water suitable for fishing was a key factor in participants' decisions to try fishing for the first time or to stop engaging in the activity (Outdoor Industry Association 2019b). Those participating in these water-based activities, as well as those recreating near water, have been found to have above-average concerns about, and recognition of, water quality (Barnett et al. 2018). Improved water quality has been shown to increase the economic benefits of outdoor recreationists engaging in a variety of activities (e.g., Sutherland 1982) and the quantity of water in rivers and reservoirs has been shown to influence demand for water-based recreation (Cordell and Bergstrom 1993; Roach et al., 1999).

Hydrologic Impacts of Forest Conversion

Deforestation, the conversion of forests to other land uses regardless of the type, results in substantial hydrologic and biological changes to adjacent and downstream waters. Storm events following these landscape changes typically result in more rapid runoff, higher peak flows, increased soil erosion, reduced groundwater infiltration, stream channel instability, and increased sedimentation (*SAF Parcelization, Fragmentation, and the Loss of Private Forestlands in the United States Position Statement* 2020). Although total water yield may be higher in urban watersheds, forested watersheds generally have a greater percentage of water available for use, suggesting that increasing urbanization contributes to greater water stress (Lockaby et al., 2013).

Water quality declines are also evident following forest removal. Higher concentrations of suspended sediments, nutrients, and pesticides are commonly detected in water samples (Jackson et al., 2017; Webster et al., 2018). Degraded water quality, coupled with extreme flow regimes that creates unstable habitat, can have dramatic impacts on aquatic populations. Species richness and abundance generally decline, with some species being eliminated from particular locations altogether (Lockaby et al., 2013).

Additionally, health risks are emerging from increased levels of bacteria, pathogens, metals, and even personal care products in urban waterbodies (Lockaby et al., 2013). While effective drinking water treatment may mitigate some of this risk, there remains significant potential for direct contact with polluted water as people recreate in waterbodies that flow through urban residential areas (Lockaby et al., 2013). These adverse changes in watershed hydrologic conditions degrade water quality for human uses, pose threats to human health, and diminish aquatic species diversity (Mapulanga and Naito, 2019).

Natural Infrastructure

Devastating floods and water scarcity concerns across the country highlight the need for comprehensive planning and coordinated mitigation to address these growing problems. Nature-based solutions, working in conjunction with traditional engineering approaches, can often enhance water resource management (Browder et al., 2019). Forested watersheds not only provide safe, reliable drinking water supplies, but also buffer against contamination, offer resiliency against catastrophic impacts, and provide numerous other co-benefits. Given the many water-related benefits of forest lands, many water supply authorities seek to maintain forest lands in their contributing watersheds to protect water quality and minimize water treatment costs (Warziniack et al., 2017).

Increasing the amount of tree cover in urban and community areas can help reduce or slow runoff entering stormwater drainage systems (*SAF Strengthening Community Forestry and Urban Tree Management for Multiple Benefits Position Statement* 2018). Municipalities are beginning to investigate green infrastructure approaches to manage stormwater in developed landscapes. The EPA defines green infrastructure as, "the range of measures that use plant or soil systems, permeable surfaces, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters." Trees and forests are integral parts of these systems. However, in many regions of the country, green infrastructure is often bypassed for more traditional approaches (e.g. dams, detention facilities, levees, and channel improvements), since engineers, planners, and city officials may lack the technical knowledge and understanding of the benefits of implementing these innovative approaches.

Forest Restoration

Over the last two decades, the average annual area burned by wildfire in the United States has increased by 2.5 million acres (*SAF Wildland Fire Management Position Statement* 2019). More recently, most years now exceed 10 million acres burned annually (NIFC 2018). This problem is consistently projected to get worse; with up to 300 million acres of western forests alone over-stocked with fuels, wildfires will continue to burn across larger areas with more severe effects than ever before (ERI, 2011). This includes approximately 59 million acres of forests already ravaged by insects and disease, creating highly flammable conditions.

Severe wildfires result in significant changes to the natural hydrology within watersheds, such as increased surface erosion, seasonal runoff, and sediment loading in waterways (Rengers et al, 2016). Damaging flash floods and landslides occurring on wildfire-stricken landscapes can result in significant erosion, road washouts, and other infrastructure damage. Restoration becomes even more expensive for utilities and local governments when the sediment makes its way to water supply reservoirs. Denver Water spent over 27 million dollars to repair infrastructure, remove sediment, and restore land around key drainages that flow into their reservoirs following two major wildfires (Denver Water, 2018). These catastrophic events can have lasting impacts on watershed function. As a result, water utilities are starting to seek partnerships with land managers to invest in fuel reduction treatments and tree planting efforts to promote healthy forests.

Role of Professional Foresters in Meeting Water Resource Goals

Professional foresters are uniquely qualified to partner with other resource professionals, institutions, organizations, and communities in meeting water resource goals. Foresters are trained to manage forests to achieve desired conditions. Due to the strong connection between forest conditions and water resources, forest management provides an important tool for achieving water resource goals. Water resource management is part of college forestry curriculums certified by SAF. The use of BMPs to protect water quality is part of the culture of professional foresters and the forest community at large.

References

Averyt, K., Meldrum, J., Caldwell, P. *et al*. 2013. “Sectoral contributions to surface water stress in the coterminous United States.” *Environmental Research Letters*, no 8:035046. https://doi.org/10.1088/1748- 9326/8/3/035046.

Barnett, M.J., Jackson-Smith, D., Haeffner, M. 2018. “Influence of recreational activity on water quality perceptions and concerns in Utah: A replicated analysis” *Journal of Outdoor Recreation and Tourism*no. 22. https://doi.org/10.1016/j.jort.2017.12.003

Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T., Lange, G.-M. 2019. “Integrating Green and Gray: Creating Next Generation Infrastructure” Washington, DC: World Bank and World Resources Institute. https://openknowledge.worldbank.org/handle/10986/31430 License: CC BY 4.0.

Brown, T.C., Froemke, P.M., Mahat, V., Ramirez, J. 2016. “Mean annual renewable water supply of the contiguous United States.” Briefing paper. Fort Collins, CO: US Department of Agriculture Forest Service, Rocky Mountain Research Station. 55 p.

Cordell, H.K., J.C. Bergstrom. 1993. “Comparison of recreation use values among alternative reservoir water level management scenarios” *Water Resources Research* no. 29(2):247–258.

Cristan, R., W.M. Aust, M.C. Bolding, S.M. Barrett, J.F. Munsell, E. Schilling. 2016. “Effectiveness of forestry best management practices in the United States*:* Literature review.” *Forest Ecology and Management* no. 360:133–151

Cristan, R., W.M. Aust, M.C. Bolding, S.M. Barrett, J.F. Munsell. 2017. “National status of state developed and implemented forestry best management practices for protecting water quality in the United States” *Forest Ecology and Management*. http://dx.doi.org/10.1016/j.foreco.2017.07.002

Daily, G.C., Kareiva, P.M., Polasky, S. *et al.* 2011. “Mainstreaming natural capital into decisions” In: Kareiva, P., Tallis, H., Ricketts, T.H. et al., eds. *Natural capital: theory and practice of mapping ecosystem services* New York: Oxford University Press:3–14.

Denver Water. “Protecting forests and water year-round” June 8, 2020. www.denverwater.org/education/blog/protecting-forests-and-watersheds-year-round

Duan, K., Caldwell, P.V., Sun, G. *et al* 2019. “Understanding the role of regional water connectivity in mitigating climate change impacts on surface water supply stress in the United States” *Journal of Hydrology* no. 570:80–95. https://doi.org/10.1016/j.jhydrol.2019.01.011.

Ecological Restoration Institute at Northern Arizona University (ERI). 2011. “Millions of excess trees fuel catastrophic wildfires.” https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306254.pdf, last accessed April 31, 2014.

Elliott, K.J., Caldwell, P.V., Brantley, S.T. *et al.* 2017. “Water yield following forest–grass–forest transitions.” *Hydrology and Earth System Sciences*. 21(2):981–997. https://doi.org/10.5194/hess-21-981-2017.

Fausch K.D., Torgersen C.E., Baxter C.V., Li H.W. 2002. “Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes” *BioScience*, 52:483–498.

Filiso, S., Bezerra, M.O., Weiss, K.C.B., Palmer, M.A. 2017. “Impacts of forest restoration on water yield: A systematic review,” PloS One 12(8):doi.org/10.1371/journal.pone.0183210

Helms, J.A. (ED.). 1998. *Dictionary of forestry.* Society of American Foresters, 210 p.

Hester, C.M., Larson, K.L. 2016. “Time-series analysis of water demands in three North Carolina cities.” *Journal of Water Resources Planning and Management*. no. 142(8):1–9.

Holmes, T. P., Vose, J., Warziniack, T., Holman, B. 2017. “Forest Ecosystem services: Water resources. In: Trees at work: economic accounting for forest ecosystem services in the U.S. South.” *General Technical Report SRS-226* Department of Agriculture Forest Service, Southern Research Station.

Ice, G.G., Schilling, E., Vowell, J., 2010. “Trends for forestry best management practices implementation.” *J. For*. no. 108(6):267–273.

Jackson, C.R., Bahn, R.A., Webster, J.R. 2017. “Water quality signals from rural land use and exurbanization in a mountain landscape: what’s clear and what’s confounded?” *Journal of the American Water Resources Association* no. 53(5):1212–1228. https://doi.org/10.1111/1752-1688.12567.

Jeong, H., Minne, E., Crittenden, J.C. 2015. “Life cycle assessment of the City of Atlanta, Georgia’s centralized water system.” *The International Journal of Life Cycle Assessment*, no. 20(6): 880–891. https://doi.org/10.1007/ s11367-015-0874-y.

Krishnaswamy, J., Bonell, M., Venkatesh, B. *et al.* 2013. “The groundwater recharge response and hydrologic services of tropical humid forest ecosystems to use and reforestation: support for the ’infiltration-evapotranspiration trade-off hypothesis.’” *Journal of Hydrology*, no. 498: 191–209. https://doi.org/10.1016/j. jhydrol.2013.06.034.

Liu, N., Dobbs, G. R., Caldwell, P.V., Miniat, C. F., Bolstad, P. V., Nelson, S., Sun, G. 2020. “Quantifying the role of State and private forest lands in providing surface drinking water supply for the Southern United States.” *General Technical Report SRS–248*. US Department of Agriculture Forest Service, Southern Research Station. 405 p. https://doi.org/10.2737/ SRS-GTR-248.

Lockaby, G., Nagy, C., Vose, J.M. *et al*. 2013. “Forests and water. In: Wear, D.N., Greis, J.G., eds. The Southern Forest Futures Project: technical report.” *General Technical Report SRS–178*. US Department of Agriculture Forest Service, Southern Research Station: 309–339.

Loehle, C., Wigley Jr., T.B., Lucier Jr., A., Schilling, E., Danehy, R.J., Ice, G., 2014. “Toward improved water quality in forestry opportunities and challenges in a changing regulatory environment.” *J. For,* no. 112 (1), 41–47.

Mapulanga, A.M., and Naito, H. 2019. “Effect of deforestation on access to clean drinking water.” *Proceedings of the National Academy of Sciences,* no.116(7):8249–8254.

Martin, K.L., Hwang, T., Vose, J.,M, Coulston, J.W, Wear, D.N., Miles, B., and Band, L.E. 2017. “Watershed impacts of climate and land use changes depend on magnitude and land use context.” *Ecohydrology*, no.10(7): doi.org/10.1002/eco1870

National Interagency Fire Center (NIFC). 2018. “Total wildland fires and acres.” www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html, last accessed October 29, 2018.

Outdoor Industry Association. 2019a. 2019 Special report on paddlesports and safety. Available: https://outdoorindustry.org/resource/2019-special-report-paddlesports-safety/.

Outdoor Industry Association. 2019b. 2019 Special report on fishing. Available: https://outdoorindustry.org/resource/2019-special-report-fishing/

Rengers, F.K., McGuire, L.A., Kean, J.W., Staley, D.M., Hobley, D.E.J., 2016. “Model simulations of flood and debris flow timing in steep catchments after wildfire.” *Water Resource Res,* no.52, 6041–6061. https://doi.org/10.1002/2015WR018176.

Roach, B., K. Boyle, J. Bergstrom and S. Reiling. 1999. “The effect of instream flows on whitewater visitation and consumer surplus: A contingent valuation application to the Dead River, Maine.” *Rivers*,no. 7(1):11–20.

Shepard, J.P., 2006. “Water quality protection in bioenergy production: the US system of forestry best management practices.” *Biomass Bioenergy*, no.30 (4):378–384.

Sills, E. O., Moore, S. E., Cubbage, F. W., McCarter, K. D., Holmes, T. P., Mercer, D. E., editors. 2017. “Trees at work: economic accounting for forest ecosystem services in the U.S. South.” *General Technical Report SRS-226.* US Department of Agriculture Forest Service, Southern Research Station. 103 p.

Sun, G., Riedel, M., Jackson, R. [and others]. 2004. “Influences of management of southern forests on water quantity and quality. In: Rauscher, H.M, Johnsen, K., eds. Southern forest science: past, present, and future.” *General Technical Report SRS–75.* US Department of Agriculture Forest Service, Southern Research Station: 195–234.

Sutherland, R.J. 1982. “A regional approach to estimating recreation benefits of improved water quality".” *Journal of Environmental Economics and Management*, no.9:229–247.

Tu, J. 2013. “Spatial variations in the relationships between land use and water quality across an urbanization gradient in the watersheds of northern Georgia, USA.” *Environmental Management,* no.51:1–17. https://doi. org/10.1007/s00267-011-9738-9.

US EPA, 2005. “National Management Measures to Control Nonpoint Source Pollution from Forestry.” *United States Environmental Protection Agency*, 276p.

US Supreme Court, 2013. *Decker* v. *Northwest Environmental Defense Center,* 568 U S 597(2013). www.supremecourt.gov/opinions/12pdf/11-338_kifl.pdf

Vose, J. 2019. “Forests and Water in the 21st Century. A Global Perspective.” *Journal of Forestry*, no.117(1),80–85.

Warziniack, T., Sham, C.H., Morgan, R., Feferholtz, Y. 2017. “Effect of forest cover on water treatment costs.” *Water Economics and Policy*,"no.3(4):1750006. https://doi. org/10.1142/S2382624X17500060.

Webster, J.R., Stewart, R.M., Knoepp, J.D., Jackson, C.R. 2018. “Effects of instream processes, discharge, and land cover on nitrogen export from Southern Appalachian Mountain catchments.” *Hydrological Processes*, no.33:283–304.