Effects of Flooding on Southern Bottomland Hardwoods

Bottomland sites often flood during periods of above-average rainfall. Considering tree mortality, flood waters are rarely problematic in natural systems due to the short duration of flooding events. However, issues arise when flooding is longer in duration in systems where levees, inter-levees, and dredging schedules alter the natural flow of water. A hard-to-quantify yet frequently asked question is, "What did the flooding do to the trees?"

While research can explain what happens to individual trees in floods, there have been no landscape-level studies that consider all combinations of flooding duration, water movement, flood timing, tree species involvement, overall tree health, and similar factors. Unfortunately, in many cases, this deficiency limits our ability to provide definitive answers to the question about trees. In addition, any answer provided is relatively limited because of ongoing environmental stressors, such as additional precipitation, drought, insect infestations, or herbicide drift. However, the likelihood is high that damage extends beyond what is currently visible, especially after multiple years of flooding. This publication attempts to detail the effects of flooding on bottomland hardwoods along with mortality/damage expectations for various classes of trees.

Flooding Variables That Affect Hardwoods

Several variables influence flood damage in bottomland hardwoods: water temperature, site topography, flood timing, flood duration, water movement and stagnation, tree age and health, and flood tolerance of tree species. While generalizations can be made regarding the individual influence of these factors, they are interrelated with multiple factors serving to simultaneously impact tree health, damage, and possibly mortality.

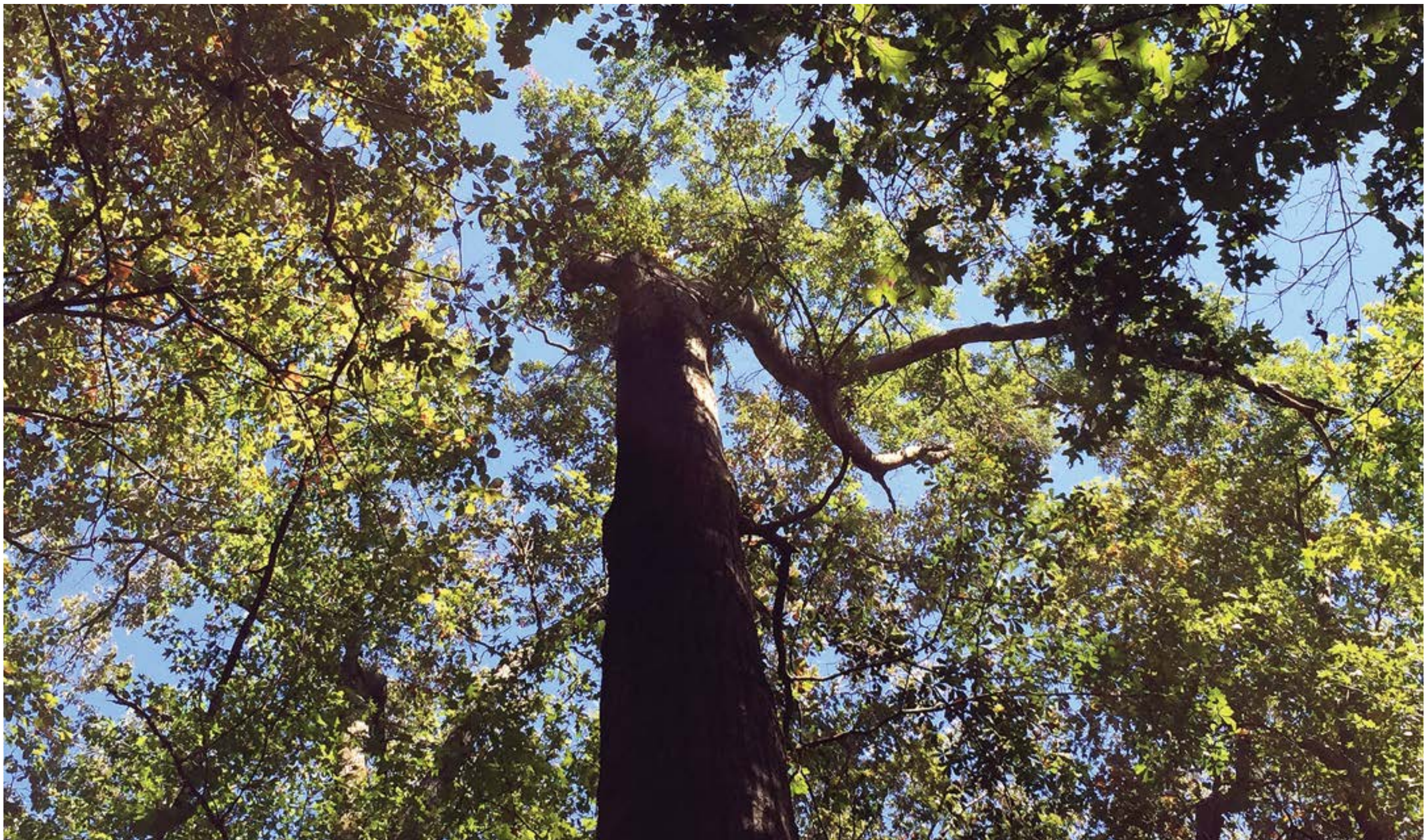

Figure 1. These oaks are growing in green tree reservoir. Note the crown dieback due to root damage resulting from repeated annual flooding.

Flood Timing and Duration

While there is no specific date or time that flood damage begins or intensifies, some generalizations can be made regarding bottomland hardwoods. Typically, flood-induced tree mortality is minimal during the months when trees are physiologically dormant (late November through February for most of Mississippi) (Table 1.). This dormancy occurs when tree physiology slows down, nutrient reserves are pulled into root systems, and the tree stops transpiration. However, even during these months, flooding often impacts trees that have not completely entered dormancy, resulting in some degree of damage to roots (Figure 1). This problem is readily observed in green tree reservoirs (GTRs), or timber stands flooded annually for waterfowl purposes across the region. Damage incurred during this period is often exacerbated by the fact that GTR flooding is typically initiated even earlier in the year, with some managers starting as early as September. Continued regimented “dormant season” flooding in GTRs results in an accumulation of damage that often forces changes in the species composition of these stands over time.

As a rule, damage and mortality increase when flooding occurs (or continues) farther into the year. Again, there are no specific dates when increased tree damage/mortality is assured. However, damage typically increases when floods occur during spring (March through May), and it is greatest when floods occur during summer and fall (late May through October).

Duration of flooding is another important factor in determining the extent of damage and/or mortality in hardwoods. During winter months, a hardwood stand can stay flooded for months without severe damage to trees. However, as the year progresses, longer periods of flooding become more serious. If trees have broken dormancy and are physiologically active, damage and mortality may occur in just a few weeks. Damage/mortality may result in a few days when continued flooding is coupled with other factors, such as when newly planted seedlings are inundated by warmer, slow-moving water.

Water Movement, Stagnation, and Temperature

Water movement is another factor that influences damage severity from flooding. This issue relates to the level of dissolved oxygen present in water. Fast-moving water has a high oxygen concentration, which decreases as the velocity of moving water slows. Stagnant (non-moving) water reaches a point where low oxygen concentrations force root systems into anaerobic respiration, which results in the creation of various alcohols

Table 1. Potential tree damage/mortality due to flooding at different times of the year and water velocity.

Time of year	Speed of water movement	Damage Potential
Dormant season (Late November to February)	Fast	Minimal/Low
Spring (March to May)	Slow	Low/Low to moderate
Summer/Fall (Late May to October)	Stagnant	Moderate to high

Table 2. Potential damage/mortality of various age classes of trees.

Class	Age	Damage Potential
Seedlings	Freshly planted	High
Seedlings	Established less than 1 year	Low to Moderate
Older trees	Saplings to mature	Low
Older trees	Over-mature	Increased

and acids that cause root damage and/or mortality in a short time. Due to dissolved oxygen concentration, variability in water temperature has a similar effect on tree damage and mortality. Cooler water can maintain higher concentrations of oxygen due to greater solubility at lower temperatures. As water warms, dissolved oxygen is decreased to the point that damage occurs. Consequently, trees inundated by warm water that is slow-moving or stagnant are much more likely to sustain damage or mortality than trees flooded by cool, fast-flowing water.

Tree Age and Health

Tree age and health also have serious implications regarding the level of flooding damage sustained. Typically, trees in the sapling to mature age range are the least susceptible to damage from flooding (as long as the species is appropriate for the site) (Figure 2) (Table 2). While these trees do experience some level of root and/or crown damage, they often are able to overcome this setback, and mortality is relatively limited. Conversely, mortality of freshly planted seedlings and over-mature trees is usually higher.

Figure 2. Long-duration flood damage can be seen in the form of chlorotic and necrotic leaves in these sapling-sized Nuttall and water oaks. However, these trees recovered, and overall stand mortality was low.

mortality in longer-lasting floods may be greater than that observed in the 1973 event.

Over-mature trees are also at an increased risk from effects of flooding. Like all biological organisms, older trees typically possess lower vigor (health). These trees are more likely to experience damage due to already compromised root systems and ensuing mortality is more common. In addition, tree vigor can be negatively impacted by issues with other stressors encountered before flooding, such as insect infestations, fungal infections, suppressed crown status, herbicide drift from adjacent agricultural fields, root mortality from soil compaction, or mechanical damage to tree boles or roots. All can result in greater susceptibility of trees to flooding damage.

Figure 3. A suppressed water oak is not able to contend with flood waters.

Flood Tolerance and Topography

If inundated trees are of a species that possesses low flood tolerance, damage and/or mortality is probable. In naturally regenerated, bottomland hardwood stands, the species present typically have a level of flood tolerance appropriate for survival in all but the most severe floods. However, even species with a high level of flood tolerance—black willow, green ash, water hickory, bald cypress, swamp tupelo, and overcup oak—may be damaged in long-duration flooding with warm water that is slow-moving or stagnant (Figure 3). Artificially regenerated hardwood plantations in which species were chosen without proper consideration for species/site relationships can experience significant damage/mortality from even relatively minor flooding.

Mismatching species to a site is one of the more common mistakes in establishing hardwood plantations. Many species do not have a wide range of site suitability. Even within the same species group, different species may have vastly different soil, moisture, and nutritional tolerances. For example, cherry bark oak is unsuitable for growing on wet, clay soils, while Nuttall oak is well-suited for such sites. Managers who ignore these basic traits often meet with plantation failure. When species-site relationships are not considered, stands established on bottomland sites may experience extreme damage and/or high levels of tree

Mortality in freshly planted seedlings is usually high in all but the shortest floods. This greater level of mortality results from a lack of nutrient reserves in root systems and the inability of newly planted seedlings to withstand longer floods. U.S. Forest Service research on the effects of the 1973 Mississippi River flood found that newly planted hardwood plantations were severely impacted with the mortality of various species, reaching levels as high as 100 percent by mid-June. Conversely, plantations of established 1-year-old or older seedlings/saplings/trees did not exhibit high levels of mortality if species were appropriate for the site. However, the 1973 flood reached neither the depth nor the duration of more recent Mississippi floods. Much of the 1973 flooding did not occur until March/April and receded May through late June on many sites. Consequently, tree

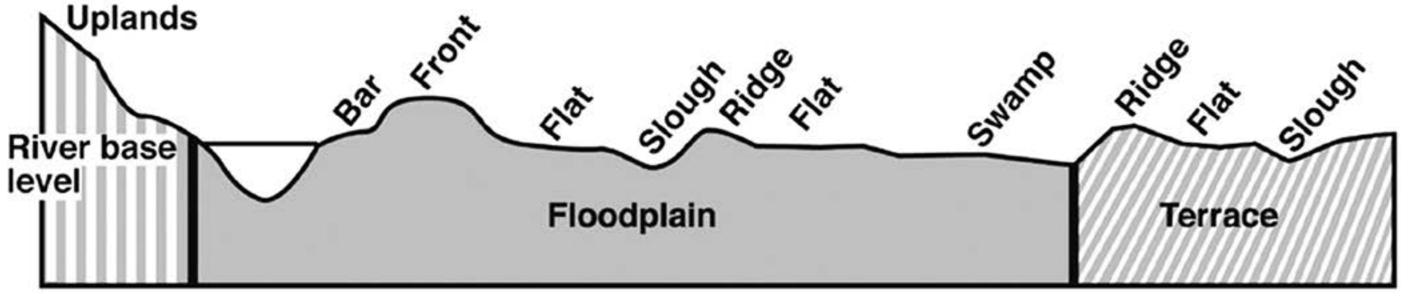

Figure 4. This example diagram of site variation in a floodplain is from MSU Extension Publication 2004, Bottomland Hardwood Management Species/Site Relationships (Illustration by John Hodges).

mortality during floods.

Hardwood stands growing on floodplain sites contend with variable soils that have a wide range of productivity and species suitability. Site changes are driven by topographical changes due to variable soil deposition during floods (Figure 4). Elevational changes of as little as 6 inches may completely change site suitability for a given species due to variations in drainage class, onsite vegetation, soil texture, structure, or pH, among others. All can have major impacts on tree damage and mortality during flooding (Figure 5). For a more thorough explanation of bottomland hardwood species/site relationships, please read Mississippi State University Extension Service ***Publication 2004 Bottomland Hardwood Management Species/Site Relationships***.

What Does Flood Damage Look Like?

Flooding damage to trees is typically the result of injury to root systems. Often, this damage escapes immediate observation and accumulates gradually over time. Physical signs like crown dieback are obvious indicators. It is often impossible to provide a complete long-term prognosis of flood damage using only observable physical indicators. In many cases, root damage will continue to influence overall decline in tree health. This decline may not become apparent for several years. More immediate symptoms (often only manifesting in major flooding events) may occur in the form of leaf chlorosis (yellowing), smaller-than-normal leaves, a complete lack of foliage, death of small branches/twigs, and epicormic sprouting (dormant buds that emerge as branches in stressful events).

Figure 5. This is an example of Shumard and Nuttall oak planted on Mahannah Wildlife Management Area near Redwood, Mississippi. Shumard oak (left side) is not adapted to wet, heavy clay soils, and 100 percent mortality occurred during a flood.

Final Thoughts

The effects of flooding on bottomland hardwoods may be understood and explainable in the case of individual trees, or even smaller stands, but overall impact is difficult to qualify or quantify on a landscape scale. Many variables influence the overall damage/mortality of trees. Only generalizations can be made in the absence of stand-specific details. Generally speaking, short-duration floods of stands ranging from healthy sapling to mature-aged hardwood result in very little tree damage/mortality when waters are cool and flowing. On the other hand, increased damage occurs in trees of low vigor, those that are freshly planted or over-mature, or in long-duration floods later in the year with warm water that is slow-moving or stagnant. In addition, observable symptoms are unlikely to encompass the extent of flood damage sustained, and additional physical damage may become evident over a period of several years, especially with repeated flooding.

Suggested Reading

Kennedy, H. E., and R. M. Krinard. 1974. 1973 Mississippi River flood's impact on natural hardwood forests and plantations. Research Note SO-RN-177. U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 6p.

Self, A.B. 2020. Bottomland Hardwood Management Species/Site Relationships. Mississippi State University Extension, Publication 2004. 7p.

The information given here is for educational purposes only. References to commercial products, trade names, or suppliers are made with the understanding that no endorsement is implied and that no discrimination against other products or suppliers is intended.

Publication 3452 (POD-08-23)

Revised by **Brady Self**, Associate Extension Professor, Forestry.

Produced by Agricultural Communications.