Article 35

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Wetter Is Not Always Better: Flood Tolerance of Woody Species

There is debate on the contribution of impervious cover to flood frequency and severity and the degree to which natural wetlands and riparian environments are affected. A related and controversial issue is whether natural wetlands should purposely be used to intercept stormwater runoff. Results of studies on the flood tolerance of herbaceous and woody plants would help in resolving this issue. Drawing on the separate literatures of flood tolerance and wastewater loading, Niering (1990) summarizes the multiple effects of submergence and pollutants on woody and herbaceous species of the Northeast US. The information can be used in assessing the impact of increased impervious cover on natural plant communities or in the design of vegetative buffers for intercepting stormwater runoff.

Studies of flood tolerance are also helpful for designers of constructed wetlands (either for water treatment or loss mitigation) in deciding whether and what woody species can be successfully established. Good choices cannot be made based simply on stereotypical examples of flood tolerant species, such as alder. “Obligate” wetland species do not necessarily have superior flood tolerance. To further complicate the decision, different ecotypes of a single species can respond very differently to flooding (Tiner, 1991 in McIninch, 1994). Furthermore, “wet acclimation” of nursery trees and shrubs before planting does not really improve their chance of survival (McIninch, 1994).

Multiple Aspects of Flooding

An increase in paved surfaces and greater channelization of streams increases the rate and volume of runoff delivered to streams, thus altering the hydroperiod of wetlands and riparian environments. Groundwater recharge is affected and, typically, the frequency, duration, and depth of flooding in wetlands is increased to some degree. An excess of water—even unpolluted water—is deleterious to plant health and growth as it results in higher or sustained water levels in wetlands and increased soil saturation in upland zones. The severity of these effects depends on the species of plant and on various aspects of the flood: season, degree of soil saturation, flow, rainfall, water temperature, and most especially *frequency, duration,* and *water depth.*

Flood Sensitivity of Wetland Plants

In riparian environments, flooding can cause the death of trees. The seedlings of trees are more vulnerable than adults and all are more vulnerable in the growing season. In bogs, floating mats of vegetation survive but the surrounding trees may die. Increased frequency of flooding can lower species diversity by eliminating the herbaceous species. An increase in duration of flooding results in leaf drop, chlorosis, and decreased growth—all not necessarily fatal.

An increase in water depth is significant if the root collar of a tree is covered, inhibiting respiration. This is more significant an impact to the tree than is saturation of the soil and is the reason for seedling sensitivity to flooding. Adults, seedlings, and seeds have different requirements. For example, adult cypress trees are very flood-tolerant; however, periodic fluctuations in water level in needed for the fruit to dry and germinate.

In examining these effects, Niering (1990) uses the forested swamps of New England as an example wetland. Different studies have made apparently contradictory observations on the survival of different woody species. The flood tolerance of species such as red maple, black gum, ash, alder, and buttonbush varies greatly depending on, among other factors, the age of

Table 1: Survival of Adult Trees in Flooded Wetlands of New England (Whitlow and Harris, 1979)

Flood-tolerant	Moderately tolerant	Intolerant
Black alder	American elm	American beech
Black willow	Basswood	Black cherry
Red maple	Bigtooth aspen	Chinquapin oak
Silver maple	Hop hornbeam	Eastern hemlock
	Ironwood	Paper birch
	Red oak	Quaking aspen
	White ash	Red spruce
		Sugar maple
		White birch
		White oak
		White pine
		Yellow birch

Flood-Tolerant: Survive season-long deep flooding
Moderately Tolerant: Survive flooding/saturated soil for 30 days in growing season
Intolerant: Hgih mortality if flooded in growing season for more than a few days

Table 2: Seedling Survival of Container-Grown Woody Species in Flooded and Non-Flooded Conditions (McIninch *et al.,* 1994)

Species, Natural range	1st Season: "acclimation"	2nd Season: seasonal or permanent flooding
Red maple All of Eastern US to E. Texas, SE Canada	Good survival in unflooded pots or saturation -5" but few survive (30%) in 10" saturation	Poor survival (50%) when saturated deeper than 2" seasonally; no seedlings survived permanent flooding
Common alder E. Canada, US; S. to FL, W. to TX	Poor survival when saturated 5''; very poor survival when saturated 10''	Moderate to poor survival (around 60%) in seasonal or permanent flooding
Red chokeberry E. Canada, US; S. to FL; W. to KY	Does well in unsaturated or 2"-saturated soil; but 50% survive 5" saturation, none survive 10"	Very poor survival (20-40%) in seasonal flooding. (Permanent flooding not tested)
Buttonbush * E. Canada, US, W. to MN, S. to Mexico	Good survival at all saturation depths	Good survival at all saturation depths, seasonal or permanent
Atlantic white cedar E/ SE US coast	Good survival at 5" saturation or less	Very poor survival (0-20%) in 2nd year
Green ash * All Eastern US, W to Dakotas, SE Canada, SW to Rockies	100% survival at all saturation depths	Excellent survival (80-100%) at all saturation depths.
Winterberry E. Canada, S. to MD, W. to MI	Poor survival at •5" saturation	None survived second season in flooded conditions
Sweet bay magnolia * Mid-SE US	100% survival at all saturation depths	Very good survival (80-100%) in seasonal or perm. flooding
Swamp tupelo * SE US, (N of Florida)	Excellent survival in all saturation depths	Good but somewhat inconsistent survival in 2nd year
Bald cypress * SE lowland US	100% survival in all saturation depths	100% survival of seedlings in all saturation depths (but dry periods are needed for seed germination)

*** = Good planting choice**

the plants and the duration and depth of flooding (Table 1). Seedlings and saplings are most vulnerable; floods of short duration are not as damaging as prolonged saturation of the soil.

McIninch (1993, 1994) tested ten woody species common to wetlands in different hydric regimes and found that all the species survive in mesic or two-inch saturated soils—the big differences in survival occur when the soil saturation is five inches or more (Table 2). This seems to be the dividing line between plants that grow in wet soils and plants that are truly flood tolerant. Tolerant species show changes in their structure (e.g., stem swelling, growth of lateral roots) in response to prolonged saturation (McIninch, 1993).

Changes in Community Composition

In general, an increase in frequency, duration, and depth of floods in forested swamps suppresses herbaceous growth—diminishing species richness of the understory. However, a disturbance such as flooding or pollution often favors certain species over others. Opportunistic, flood- or pollutant-tolerant species such as cattails out compete other herbaceous species. The planting of such pollutant-tolerant species is a good idea if you're a water quality manager but a worry if you're an ecologist charged with monitoring the spread of invasive species. Low-nutrient bogs are especially susceptible to species replacements when exposed to nutrients from stormwater runoff.

Niering concludes that because of the significant ecological impacts of flooding, existing natural wetlands should not be used for treating stormwater runoff —the quality and quantity of which is unpredictable. Other filtering systems can be used to intercept runoff before it reaches wetlands. Natural landscaping and natural buffer zones are also recommended.

McIninch found containerized stocks of bald cypress, buttonbush, green ash, swamp tupelo, and sweet bay magnolia to be good choices for plantings, whereas Atlantic white cedar, red maple and common alder were not. Wet acclimation did not improve the survival of "flood-tolerant" species and killed a good percentage of the "poor" species (Table 2).

There are two main points to draw from these kinds of studies:

- Shrubs and trees common to wetlands cannot automatically be assumed to have good flood tolerance in urban or altered wetlands, and
- The practice of growing seedlings in flooded containers before planting should be discontinued as it does not appear to have any real acclimating value.

—JMC

References

Niering, W. A. 1990 *Effects of Stormwater Runoff on Wetland Vegetation*. Review Paper Presented at New England Institute of Environmental Studies Conference at Southborough MA October 1989.

McIninch, S. M., and D. R. Biggs. 1993. "Mechanisms of Tolerance to Saturation of Selected Woody Plants." *Wetland J.* 5(2): 25-27.

McIninch, S., E. Garbisch, and D. Biggs. 1994. "The Benefits of Wet-Acclimating Woody Wetland Plant Species. *Wetland J.* 6(2): 19-23.

Whitlow, T. H., and R. W. Harris. 1979. *Flood Tolerance in Plants: A State-of-the-Art Review*. US Army Corps of Engineers, Waterways Expt. Stn., Vicksburg, MI. Technical Report E-79-2. 257 pp.