## *Malecki, R. A.* et al. *1983. Effects of Long-Term Artificial Flooding on a Northern Bottomland Hardwood Forest Community. Forest Science 29(3): 535-544.*

**Introduction**
Creation of artificial wetland habitats, including both permanently and seasonally flooded areas, is a management practice used to remedy this situation (the serious reduction of suitable waterfowl habitat) (Rudolph and Hunter 1964).

Incentive for the development of impoundments is reinforced by findings that forest growth can be enhanced in some cases by seasonal inundation with shallow water during the winter period (Broadfoot 1967).

Here (specifically the Montezuma National Wildlife Refuge in central New York),management generally favors permanent inundation of lowland areas. While this achieves its intended wildlife function, the desired effect is of limited duration because of the eventual decline of the forest community (Cowardin 1965).

**Results** (of the 12-year monitoring effort)
Flooding was seasonal: mid-March to late June and the authors indicate that the mean water depth during this flooding was 27-30 cm.
Frequency of occurrence estimates indicates that the composition of tree species in the treatment pools ... has remained relatively constant.

Mean densities of the five major tree species in the east, west, and control pools in 1979 revealed no significant differences (*t*-test; $p>0.05$).

Tree seedling survival, as indicated by density estimates in 1979 of individuals less than (1 inch) dbh, favored red maple. Red ash, elm, and blue beech declined significantly. Among shrub species, spicebush (*Lindera benzoin*) and winterberry (*Ilex verticillata*) had significantly lower mean densities...

Of the herbaceous vegetation, mean densities of all fern species decreased significantly in the east and west pools during the period 1965 to 1979...

**Discussion**
(R)educed tree growth and alteration of the understory plant communities (in a northern bottomland hardwood forest), including tree reproduction, in the treated pools is evident (following continuous spring flooding over a 12-year period).

Greater injury and lower survival of most tree species are associated with increasing periods of flooding during the growing season (Gill 1970, Broadfoot and Williston 1973, Teskey and Hinckley 1978). Hall and Smith (1955) found that survival of even the most flood tolerant species required an unflooded condition for at least 50 percent of the growing season.

The major effect of flooding is to create anaerobic conditions in the rhizosphere (Teskey and Hinckley 1977) which promotes immediate dormancy or death of roots developed under aerobic conditions (Hosner and Boyce 1962, Broadfoot and Williston 1973).

Over the long term, reduced stem growth reflects the interrelated effects of decreased total photosynthesis due to crown dieback and reduced water and nutrient uptake due to root death (Teskey and Hinckley 1977).

The impact of continuous seasonal impoundment is most striking with regard to tree regeneration. However, this appears to be due to the impact of flooding on seedling survival rather than on seed germination (Teskey and Hinckley 1977).

The controlled spring flooding of the bottomland forest at Montezuma has greatly enhanced the attractiveness and utility of this habitat to breeding waterfowl, in particular the wood duck (*Aix sponsa*) (Haramis 1975).

Recognition of the need to limit the duration of flooding to no more than 50 percent of the growing season, to provide for periodic or aperiodic nonflooded years, to allow seedling establishment and to maintain the vigor of the existing plant community, appear essential to the successful continuance of such a management scheme.

## *Mitsch, W.J. and Rust W.G. 1984. Tree Growth Responses to Flooding in a Bottomland Forest in Northeastern Illinois. Forest Science 30(2): 499-510.*

**Introduction**
Bell and Johnson (1974) reported that continued flooding during the growing season decreased tree growth and caused increased tree mortality. Tree ring data of three bottomland hardwood species were compared with reconstructed hydrologic conditions of flooding for the period 1917 through 1978 for a riparian forest along the Kankakee River in northeastern Illinois.

**Results and Discussion**
The fact that no substantial linear relationships between tree growth and flooding were found in the above correlations suggests a more complicated interplay of several factors determining the growth of trees in this riparian ecosystem.

**Conclusions**
This study found a general lack of correlation between growth of moderately water-tolerant trees and measures of floodplain flooding duration, whether the flooding was in growing season or during the entire year.

Causes and effects of tree growth vs. flooding are difficult to determine because flooding can have both positive (nutrient and water replenishment) and negative (anaerobic root zone) influences. The overall relationship between growth and flooding has been shown here to be difficult to represent through the use of simple linear regression models.

## *Harris, M.D. 1975. Effects of Initial Flooding on Forest Vegetation at Two Oklahoma Lakes. Journal of Soil and Water Conservation 30(6): 294-295.*

**Discussion**
Trees with a small portion of the crown above water or that were submerged for a few days displayed varying degrees of stress during July.

Following initial flooding in 1973, Keystone Lake crested 28.5 feet above normal pool, while Oologah Lake crested 21.28 feet above. Keystone is normally 26,300 acres (at 723 feet elevation) and increases to 55,4000 acres at flood pool level, whereas Oologah is typically 29,500 acres (at 638 feet elevation) and increases to 57,000 acres. Both lakes were constructed in the mid-1960s by the US Army Corps of Engineers and are meant to store high levels of runoff.

Approximately 80 percent of the trees that were less than 10 inches diameter breast high and 25 feet tall and exhibiting such stress perished. Living trees larger than 10 inches dbh and taller than 25 feet in height showed no visible stress other than a reduced growth rate in late summer.

Mortality was greatest among oak-hickory types and increased as tree size decreased.

On the basis of these surveys, trees and shrubs planted for recreation purposes in such flood zones should be confined to the following species: green ash, sycamore, cottonwood (cottonless), buttonbush, willow, mulberry (fruitless), silver maple, bald-cypress, river birch.

## *Ernst, K.A. and Brooks, J.R. 2003. Prolonged Flooding Decreased Stem Density, Tree Size and Shifted Composition Towards Clonal Species in a Central Florida Hardwood Swamp. Forest Ecology and Management 173(2003): 261-279.*

**Introduction**
Studies have shown that prolonged or chronic flooding causes a compositional shift toward more flood-tolerant tree species through the elimination of less flood-tolerant species (Malecki et al., 1983; King, 1995; Young et al., 1995)

(T)ree size has been reported to influence flood-tolerance, but many results are conflicting. In some studies, large trees have greater survival rates than small trees (Harms et al., 1980; Kozlowski, 1982; Lugo and Brown, 1984). Other studies have contradicted this apparent size advantage, suggesting that larger trees may be more sensitive to flooding (King, 1995; Young et al., 1995). Clearly, more studies are needed that can document the role of tree size on flood-tolerance.

Prolonged flooding may also bring about changes in stand composition and structure by favoring clonal (vegetative) reproduction over seed germination.

Because clonal reproduction is not a characteristic shared by all wetland tree species, conditions that prevent seed germination and seedling establishment can lead to dramatic changes in community composition over time.

**Discussion**
Studies in similar hardwood swamps have shown that depth of flooding impacts growth rates and the length of time it takes for trees to die, even under permanently flooded conditions (Eggler and Moore, 1961; harms et al., 1980). For example, Megonigal et al. (1997) found that aboveground production decreased by approximately (4.89 lb/ft^2) per year with every centimeter increase in mean growing season water depth. Harms et al. (1980) found that stands exposed to more than 4.27 feet of flood depth were entirely dead after 3 years of flooding, whereas those subject to less than 1 m had mortality levels that varied between 2 and 41%.

**Conclusions**
The alteration of water flow into Flatford Swamp has caused tree communities to shift towards shrubby, more flood-tolerant and less diverse assemblages.

Although previous studies have examined the relationship between tree diameter and vigor under varied levels of flood stress, results are highly variable and deserve further research (Lugo and Brown, 1984; King, 1995; Harms et al., 1980).

## ***Virginia Carter* et al*. 1978. Water Resources and Wetlands. Wetland Function and Values: The State of our Understanding. American Water Resources Foundation.***

Species, like red maple, found growing under a wide range of flooding conditions may have ecotypes well adapted to flooding and other ecotypes that are poorly adapted.

Plants of a particular species, established and matured under conditions of infrequent flooding, will prove to be more sensitive to growing season inundation than plants of the same species established and matured under a regular regime of flooding. Therefore, it’s sometimes not sufficient to consider species alone; some insight into natural flooding conditions during the period of establishment is also required.

Trees normally growing in unflooded parts of the natural streamside forests were affected as the flood period increased beyond 30 days.

### *Chambers, J.L.* **et al.** *1992. Flood Timing, Growth and Morphological Responses of Bottomland Oak Species. In: Brissette, John C., ed. Proceedings of the 7th biennial southern silvicultural research conference; 1992 November 17-19; Mobile, AL. Gen. Tech. Sep. S)-93. New Orleans, LA: US Department of Agriculture, Forest Service, Southern Forest Experiment Station: 407.*

**Abstract**
Controlled, somewhat regular flooding, over a period of years as is common in greentree reservoirs, appears to reduce successful regeneration of bottomland oak species.

For flood sensitive Cherrybark oak even the November to February flood treatment heights were 17.8 % less than in the control treatment.

### *Martha R. McKevlin. 1992. Guide to Regeneration of Bottomland Hardwoods. Southeastern Forest Experiment Station. Ashville, NC.*

The following tabular guide (adapted from Kennedy 1990) provides information on species flood tolerance. Those who use this guide must take into account that tolerance to flooding depends not only on duration and season of flooding but also on depth of flooding and number of flooding events each year.

| | Periodic Flooding | |
|---|---|---|
| January - May | January - April | January - March |
| Sweetgum | Sawtooth Oak | Shumard Oak |
| Water Oak | Sycamore | Cherrybark Oak |
| Willow Oak | Cottonwood | Swamp Chestnut Oak |
| Nuttal Oak | Sweet Pecan | Nuttal Oak |
| Green Ash | Nuttal Oak | Green Ash |
| Swamp Tupelo | Green Ash | Swamp Tupelo |
| Red Maple | Swamp Tupelo | Red Maple |
| | Red Maple | |