Effects of Flooding on Vegetation at Salamonie Reservoir

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Introduction

In estuaries, intertidal zones and freshwater marshes an early successional stage is maintained by fluctuations in water level. These fluctuations provide for rapid nutrient cycling due to aerobic decomposition during drawdown and subsequent release upon reflooding (12). Species with high rates of reproduction and growth are more likely to survive in these uncrowded early successional stages. In contrast, the selection pressure found in later stages of succession favors species with lower growth potential but better capabilities for survival in competitive circumstances (10). Some plant species, however, are capable of surviving periodic flooding due to physiological adaptations such as anaerobiosis (11), and morphological adaptations such as adventitious root systems and oxygen-channeling secondary root structures (9). Flood tolerant woody species, unlike most annuals invading a recently flooded site, usually require adaptations to inundation in order to survive (5,6,7,8).

The objective of this study was to evaluate variations in plant species in relation to flooding frequency. Salamonie Reservoir, the location of this study, appeared to be an opportune site because the impoundment had experienced very high water levels in the past two years. This study was done in conjunction with a small mammal reinvasion study (3).

Site Description

Salamonie Dam, completed in 1966, was built primarily for flood control purposes on the Salamonie River in the upper Wabash basin. The U. S. Army Corps of Engineers controls the working operations of the dam, including regulating water levels and flow rates. The Indiana Department of Natural Resources provides and regulates habitat maintenance, recreation facilities, and hunting and fishing. With minimum (winter) pool at 730 feet above sea level and summer pool at 755 feet, the normal annual variation in water level is 25 feet. The greatest possible variation between minimum and maximum (capacity) water levels is 63 feet, although no water level has come closer than 10 feet to this upper level. Because the water levels vary, a relatively large land area is periodically flooded and drained; and some higher land is flooded occasionally during periods of exceptionally high water.

Four sites on the north shore and one site on the south shore of the reservoir, approximately 1 to 1 1/2 miles apart from each other, were selected for study. Site #1, located 145 yds west of Huntington Co. Rd. 880W, is primarily a forested area with a 30 yd strip of abandoned farmland at the water's edge of the north shore. Site #2, located 125 yds east of Wabash Co. Rd. 750E, is composed of meadow at the water's edge, followed by an abandoned orchard and an old pasture located on the north shore. Site #3, located 95 yds east of Huntington Co. Rd. 700W, is composed of meadow at the water's edge, followed by an abandoned orchard and more meadowland. Site #4 located 210 yds west of State Rd. 105, is abandoned farmland (containing small *Acer negundo* seedlings at the highest elevations) located on the north shore. Site #5, located 160 yds southeast of the Dora boat ramp access road (an extension of

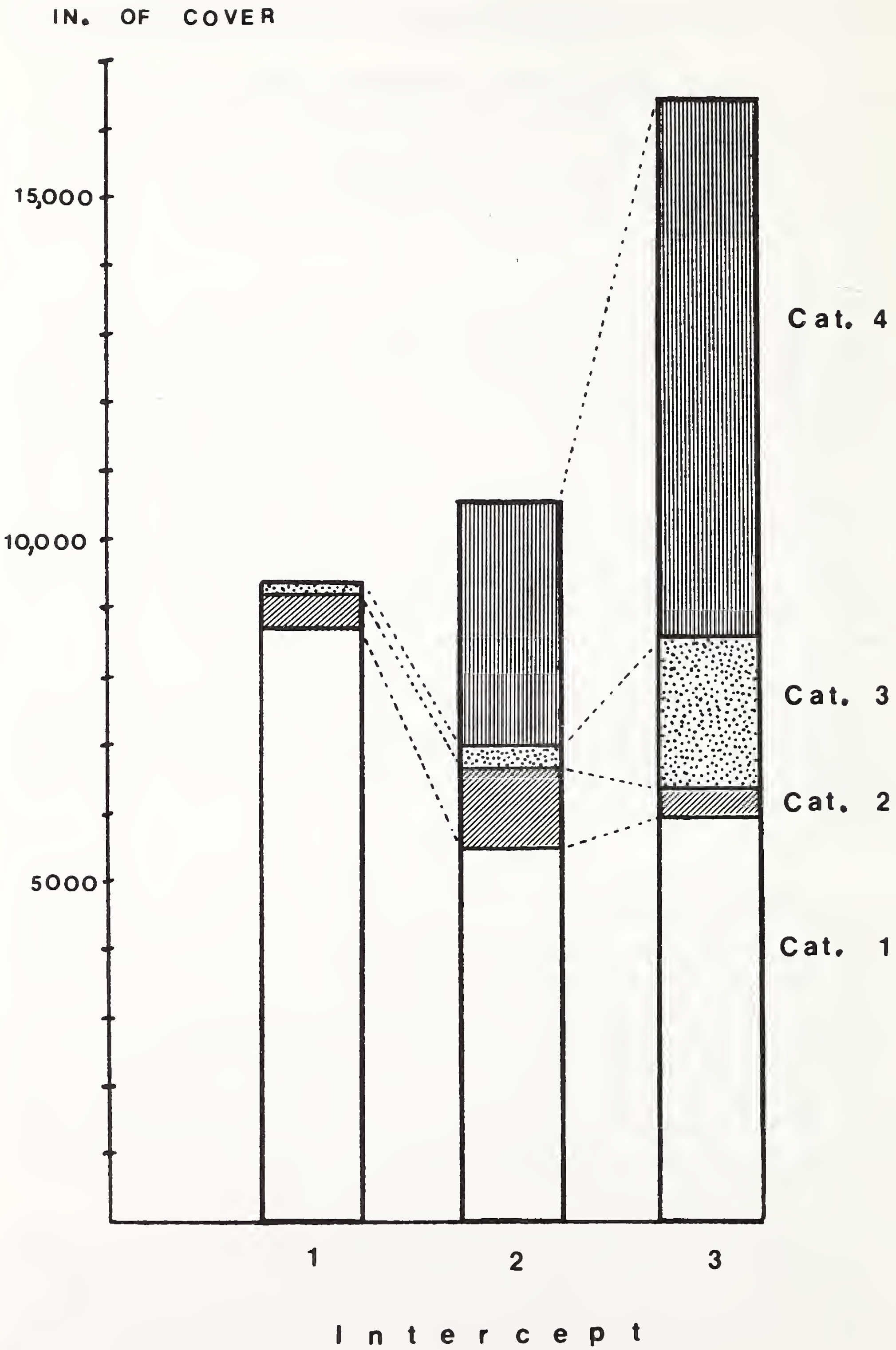

FIGURE 1. *Total cover of vegetation by category in combined transects #1, #2 and #3 at Salamonie Reservoir.*

Wabash Co. Rd. 250S), is a mature hardwood forest found on the south shore.

Materials and Methods

Using the line-intercept method of vegetation analysis, as described by Bauer (1943) and Eberhart (1978), three transects were laid out parallel to the shoreline at each site. These transects were located at intervals of 0 - 10 feet, 10 - 20 feet and over 20 feet above summer pool. Within each interval, random numbers were utilized for the placement of the transects. Total cover was determined for category I (forbs), II (woody shrubs and vines), III (trees under 12 feet tall) and IV (mature trees) species between May 25 (Site #1) and June 30 (Site #5) 1982. Sites were revisited to identify late blooming species.

Using a surveyor's level transit (Burger Model 504) and rod, the elevation of each transect above summer pool was determined. Using the records of daily water levels obtained from the Salamonie Reservoir Army Corps of Engineers, we determined the number of days each transect had been inundated during the last three growing seasons (April 15 - September 15).

Results

From the Army Corps of Engineers data on daily water levels it was found that the 0 - 10 ft level transects (transects #1) were inundated from 103 to 167 ($\bar{x} = 126$) days during the growing seasons of 1980 - 82. Transects at the 10 - 20 ft level (transects #2) were inundated from 51 to 97 ($\bar{x} = 64$) days, while transects at the 20 ft and above level (transects #3) were inundated from 0 to 48 ($\bar{x} = 18$) days.

The total cover of the categories of plant species at each transect is shown in Figure 1. Category III and IV vegetation showed a marked decrease in total cover with increasing inundation frequency and were nearly absent in transect #1. Category II vegetation was twice as abundant in median transect #2 and in either the lowest and highest flooding frequencies. Category I vegetation exhibited the highest amount of total cover in the most heavily flooded transects.

Some of the category I vegetation showed significant trends in response to inundation (Figure 2). The greatest amount of cover in transect #1 was exhibited by *Ambrosia artemisiifolia*, while transect #2 was mostly composed of *Toxicodendron radicans* and transect #3 was mostly composed of *Bromus secalinus*. *T. radicans*, *Setaria viridis* and *Bidens vulgata* provided more cover in transects #1 and #2 and were much reduced in transect #3. *A. artemisiifolia* and *Polygonum pennsylvanicum* were abundant in transect #1 and greatly reduced in transects #2 and #3. *Daucus carota*, however, exhibited an inverse relationship in that its cover was extensive in transect #3, greatly reduced in transect #2, and nonexistent in transect #1. Plants present uniformly in all three transects, included *Erigeron philadelphicus* and *Dicanthelium lanuginosum*. *B. secalinus* and *Poa palustris*, though abundant in transect #3 were found exclusively in a meadow at Site #2.

Category II vegetation (Figure 3), particularly *Rosa multiflora* and *Vitis vulpina*, provided much more cover in transect #2 than in either of the other transects. *V. vulpina* was absent from transect #3.

Category III and IV vegetation trends are indicated in Figure 4. *Ulmus rubra* was the most dominant cover species in all of the transects. Total cover was greatest for category IV *U. rubra* at transect #2, while total cover for category II *U. rubra* was greatest in transect #3. Transect #1, though extremely low in tree cover, contained category III and IV *U. rubra*, with the execption of a small amount of category III *Salix interior*. In the much drier transect #3, category IV *U. rubra* shared cover dominance with several other tree species, namely *Acer saccharum*, *Crataegus* spp.,

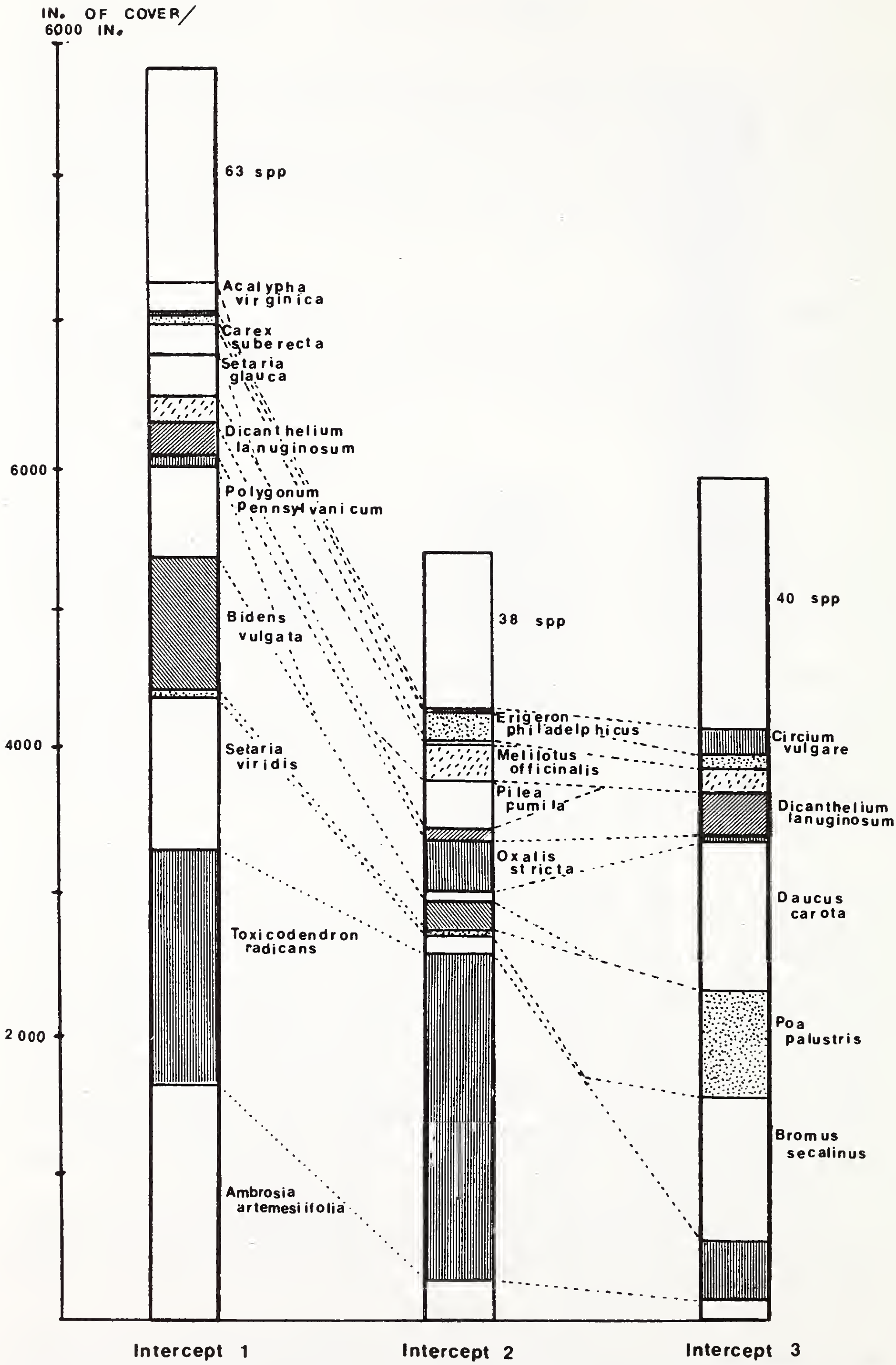

FIGURE 2. *Total cover of category I vegation species in combined transects #1, #2 and #3 at Salamonie Reservoir.*

Fraxinus americana, Quercus rubra and *Prunus serotina.* All of these species carry over into category III cover with the exception of *F. americana.* This can be con-

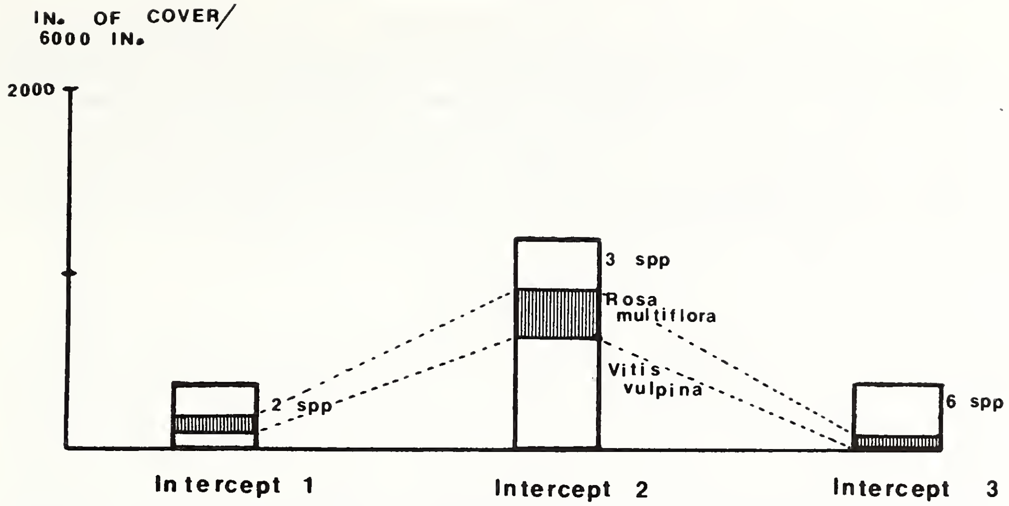

FIGURE 3. *Total cover of category II vegetation species in combined transects #1, #2 and #3* at *Salamonie Reservoir.*

trasted with transects #1 and #2, in which both the number and evenness of tree species is reduced, as well as the amount of young category III trees.

Numerous category III and IV willow trees of the species *S. interior, S. cordata*

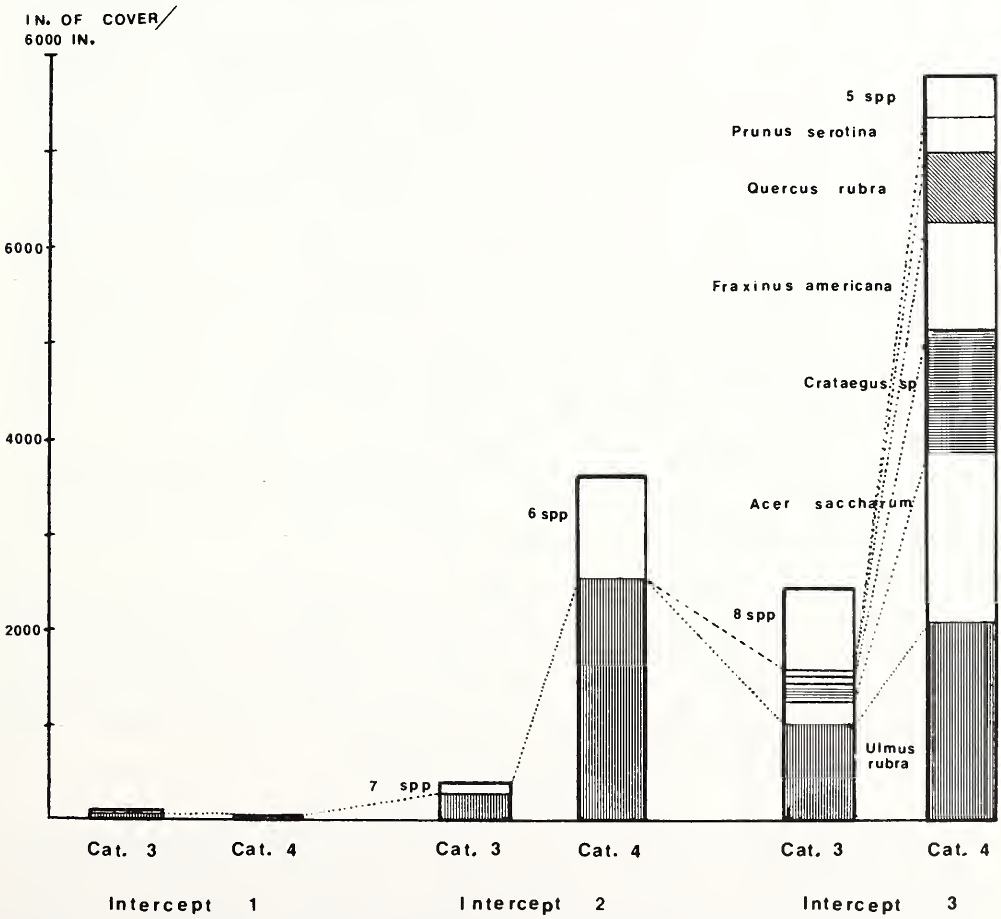

FIGURE 4. *Total cover of category III and IV vegetation species in combined transects #1, #2 and #3 at Salamonie Reservoir.*

and *S. amygdaloides*, as well as cottonwood (*Populus deltoides*) were growing on the study sites, but were not quantified due to their closeness to the edge of the summer pool. None of the transects passed through these species due to occasional short term flooding of the lowest elevations during sampling. Also present at the study sites was a band of standing dead trees including *A. saccharum, Robinia pseudoacacia, F. americana*, and *Crataegus* spp.. This band extended to approximately 15 ft above summer pool. The standing dead trees were not quantified.

Discussion

As indicated by the data, transect #1 was dominated by category I cover. *A. artemisiifolia, T. radicans, B. vulgata, S. viridis* and *P. pennsylvanicum* appeared to favor the early successional environment maintained by the highest flooding frequencies found in transect #1. Their reduced cover at the lower flooding frequencies may suggest an inability to compete with later successional species, or an inability to adapt to drier, less disturbed habitat typical of the later successional stages of a periodically flooded area. The constancy of *E. philadelphicus* and *D. lanuginosum* in all flooding frequencies may be a function of their adaptability or nonspecificity toward these environments.

Due to the widely varying habitats found at Salamonie Reservoir, transects #2 and #3 often had large differences in species composition between the study sites. These differences were much less pronounced and often absent in transect #1. At Salamonie Reservoir, the impact of high flooding frequencies appears to overshadow most of the other parameters that determine the species composition of an ecosystem. Caution must be exercized in applying this concept to all "wetland" ecosystems because changes in the floristic compositions also occur in response to destruction by predators and pathogens, to changes in physical or chemical conditions, to competition and allelopathy, and to species invasions (15). A long-term study at Salamonie could shed light on the interactive effects of flooding with other physical and biological parameters.

The tolerance of trees and shrubs to flooding at Salamonie is similar to studies in several other localities (5). *Salix* spp. and *Populus* spp., commonly referred to as "resistant" in previous studies, experience very little mortality in the Salamonie floods. Due to their adaptations toward inundation, they have been recommended often for the protection of periodically flooded banks (13,14). Brink (1954) observed that *Robinia pseudoacacia* suffered some damage from flooding in the Lower Fraser River Valley in British Columbia, but not a substantial mortality. Our observations, however, showed a widespread mortality of *Robinia* in the highest inundation levels. Since *Robinia* is commonly planted at Salamonie for wildlife forage purposes, it may be appropriate to avoid planting it in frequently flooded areas.

Ulmus rubra was more resistant to flooding than the other upland tree species found at Salamonie. This was not observed in previous studies, though flood resistance has been noted in *Ulmus americana* (5,6,7). Gill (1970) noted that *U. americana* had the ability to form adventitious roots in response to flooding. The authors suggest, in light of this data, that future studies should be performed regarding the morphological and physiological adaptations of *U. rubra* to flooding.

Acknowledgments

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