

EFFECTS OF ALTERED FLOW REGIMES ON FLOODPLAIN FOREST PROCESSES IN THE SAVANNAH RIVER BASIN

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Abstract. The link between fluvial geomorphic disturbances and dynamics within riparian vegetation and animal populations in the Southern United States has been well documented. Construction of dams on the Savannah River—resulting in altered hydrology, geomorphology, and sediment composition of the floodplain system—has potentially had multiple impacts on species composition and processes within its riparian ecosystem. Productivity and recruitment of floodplain trees in the Savannah River basin have been found to be altered under different hydrologic regimes. Changes in forest community structure and successional processes in areas of the Savannah River floodplain may be linked to changes in hydrology following dam construction. Undisturbed riparian ecosystems normally provide abundant food, cover, and water for wildlife, and often contain some special ecological features or combination of features that are not found in upland areas. Timing, magnitude, and duration of flood inundation in the Savannah River basin must be carefully considered in efforts to restore key processes within its floodplain ecosystem.

INTRODUCTION

The link between fluvial geomorphic disturbances and dynamics within riparian vegetation and animal populations in the Southern United States has been well documented. Because of the close connection between the hydrologic regime of a river and organisms living in its floodplain, alterations in river hydrology can greatly affect processes within riparian ecosystems. The construction of dams and reservoirs has had tremendous impacts on important ecological processes within rivers and associated wetlands, altering the flow of water, sediment, nutrients, energy, and biota in these systems. A number of impoundments in the Savannah River basin constructed in the mid-1900's have altered the

hydrology, geomorphology, and sediment composition of the floodplain system (USACE 1992). These alterations have potentially had multiple impacts on the productivity, recruitment, and species composition of floodplain trees in the basin. We are currently compiling available data on vital ecosystems in the Savannah River basin for a cooperative project involving The Nature Conservancy of Georgia, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and the States of Georgia and South Carolina. With this information, we hope to provide scientific guidance for managing flows below the Thurmond Dam in a manner that protects native species and their habitats. A flow regime meeting the requirements of unique and important floodplain tree species in the Savannah River basin will enhance their persistence in this system.

SEEDLING RECRUITMENT AND SURVIVAL

The timing, duration, and magnitude of floods plays an integral role in the establishment and survival of tree seedlings. A number of studies have demonstrated the importance of floods during the winter months (October through February) for seed dispersal in cypress-tupelo forests (Liu et al. 1990, Schneider & Sharitz 1988). Comparisons of mean monthly flows in the Savannah River prior to (n = 112 years) and following (n = 47 years) construction of Thurmond Dam show a substantial decrease in discharge during the months of December through May (Hale & Jackson, *in press*), suggesting a similar decrease in seed transport during this period.

In contrast, flooding during the growing season limits seedling survival during early phases of recruitment, and summer floods of more than a few days are likely to cause mortality of newly germinated seeds (Sharitz & Lee 1985). Mean monthly flows in the Savannah River have been higher in the months of May through July following dam construction; median monthly flows have

been higher in the months of May through November (Hale & Jackson, *in press*). Artificially elevated water levels during typically low flow periods in late spring and early summer may reduce seed trapping and incorporation into the floodplain substrate, as well as inhibit seed germination and reduce annual recruitment of common floodplain tree species (Schneider et al. 1989). Reduction in seedling germination and survival due to elevated floodplain water levels is a concern for even the most flood tolerant species found on the Savannah River floodplain. Bald cypress (*Taxodium distichum* (L.) Rich) and water tupelo (*Nyssa aquatica*) are canopy dominants in bottomland swamp areas; both species are highly flood tolerant (Hook 1984). Bald cypress seeds do not germinate under flooded conditions, however, and newly-germinated seedlings cannot be sustained after 45 days of submergence (Souther & Shaffer 2000). Floods observed during the growing season of 1994 on the Savannah River floodplain were deep enough to overtop a study population of water tupelo seedlings, with a subsequent 25% reduction in their survival (McLeod et al. 2000).

MATURE TREE PRODUCTIVITY AND SURVIVAL

Hydrologic regime affects the growth and survival of mature floodplain trees in cypress-tupelo and bottomland hardwood forests on the Savannah River floodplain (Keeland et al. 1997, Jones et al. 1994). Significant negative relationships between weekly changes in water level and diameter growth of swamp tupelo (*Nyssa sylvatica* var. *biflora*) trees have been found on Savannah River plots with periodic shallow flooding; bald cypress demonstrates both positive short-term and negative long-term relationships between diameter growth and weekly changes in water level (Keeland & Sharitz 1995, Keeland & Sharitz 1997). Most tree stems in the cypress-tupelo forest of the Savannah River floodplain begin to grow in late spring; the growing season ends in late summer. Diameter growth of mature water tupelo trees on the Savannah River floodplain is inversely related to mean water levels during the growing season, and bald cypress trees subjected to shallow flooding during the growing season achieve greater diameter growth than trees subjected to deep flooding (Keeland et al. 1997). Bottomland hardwood forests on the Savannah River floodplain include less flood tolerant species such as tulip poplar (*Liriodendron tulipifera*), sweetgum

(*Liquidambar styraciflua*), and several species of oak (*Quercus* spp.), in addition to the more flood tolerant bald cypress and swamp tupelo. Megonigal et al. (1997) found aboveground net primary production (NPP) of bottomland hardwood forests on the Savannah River floodplain to be significantly lower on wet (mean growing season flooding depth > 0 cm) plots than on intermediate (groundwater table depth = 0 to -60 cm) and dry (groundwater table depth < -60 cm) plots. For similar tree species on bottomland forest sites in Louisiana, the slope of the mean water depth-NPP relationship was more negative in areas showing evidence of severe hydrologic alteration (i.e. elevated growing season water levels due to a nearby impoundment) (Megonigal et al. 1997). These studies indicate that elevated spring and summer flows resulting from dam regulation in the Savannah River may inhibit growth of mature floodplain trees.

Conversely, floods occurring in winter, before the growing season begins, may improve soil water availability during the growing season in floodplain forests (Megonigal et al. 1997). These floods may also be important in supplying nutrients to areas of the floodplain forest. Several studies of cypress swamps (Mitsch et al. 1979, Brown 1981) report positive correlations between sediment-associated nutrient inputs from floods and aboveground NPP of cypress trees. Mean monthly flow during winter months has been greatly reduced since construction of Thurmond Dam; frequency of overbank flow and extent of floodplain inundation has also decreased (Hale & Jackson, *in press*). These hydrologic alterations could lead to nutrient depletion or desiccation of soils in areas of the Savannah River floodplain. Soil water and nutrient deficits potentially reduce height and diameter growth of woody plants, as well as inhibit all stages of reproductive growth (Brown 1981, Kozlowski 2002).

COMMUNITY STRUCTURE AND SUCCESSION PATTERNS

A particular species composition may persist indefinitely as long as the flooding pattern is consistent from year to year (Conner et al. 2002). Changes in forest community structure and successional processes in areas of the Savannah River floodplain may be related to changes in hydrology following dam construction. One study on the Savannah River floodplain found less than 16% of 474 bald cypress trees are smaller than 10 cm in diameter at breast height at sites on the Savannah; additional analysis at one site revealed individuals in this

< 10 cm size class to be as old as 10 years (Sharitz et al. 1990). These findings imply that very few individuals have been recruited into the population in recent decades. A study by Jones et al. (1994) found decreases in small stem density and increases in large stem density over a ten-year period in forest plots on the Savannah River floodplain (Jones et al. 1994). Decreased regeneration of bald cypress and water tupelo in areas of the Savannah River floodplain is attributed to an increase in desynchronized flood events occurring during the growing season as a result of upstream reservoir management; these floods can potentially inhibit germination and early seedling growth in these species (Sharitz et al. 1990).

The Savannah River has demonstrated decreases in discharge of peak annual flows, as well as reductions in flood recurrence and flood duration (Hale & Jackson, *in press*). These alterations may have an impact on community structure of infrequently flooded bottomland hardwood forests at higher elevations. With a reduction in the periodic perturbation of high discharge floods, flood-intolerant upland species have an opportunity to invade bottomland hardwood forests (Brown 1981, Schneider et al. 1989).

Changes in hydrologic regime may also lead to greater susceptibility of the floodplain ecosystem to exotic invasive species. The Chinese tallow tree (*Sapium sebiferum* (L.) Roxb.) is an invasive species on the Savannah River floodplain. Recruitment and growth of this highly shade and flood tolerant species may be accelerated by changes in floodplain hydrology which adversely affect native species (Jones & Sharitz 1990, Conner et al. 2001, Conner et al. 2002).

CONCLUSIONS

Undisturbed riparian ecosystems normally provide abundant food, cover, and water for wildlife, and often contain some special ecological features or combination of features that are not found in upland areas. In hydrologically altered systems, processes inherent to the survival and growth of unique floodplain species are also altered. Restoration of the tree species native to a floodplain ecosystem requires examination of the specific flow requirements necessary for recruitment, growth, and survival. In the Savannah River basin, timing, magnitude, and duration of flood inundation must be carefully considered in efforts to revitalize key processes within its floodplain ecosystem. Increased peak flows during the winter months are necessary to ensure seed

dispersal and to supply nutrients and water to floodplain soils. Periods of lower flows are needed during late spring and summer to reduce seedling mortality and enhance mature tree growth.

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