Effects of changes in deposition and erosion, due to climate change, on the seed bank as a function of burial depth

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Abstract

Riparian zones are some of the most diverse, complex, and dynamic habitats on the terrestrial Earth and are particularly sensitive to environmental change. One factor that contributes to high plant species diversity in riparian zones is periodic disturbance caused by floods. However, this same disturbance is thought to facilitate invasive plant species establishment in these habitats, which can threaten biodiversity and impact the ecosystem as a whole. Climate change is predicted to alter dominant patterns of precipitation and runoff, which can change the structure and function of riparian zones. Studies examining how changes in the hydrologic regime due to climate change may impact the deep seed bank within the riparian zone, and consequently the vegetative biodiversity, have not been identified. The overall goal of this research was to project potential impacts that climate change may have on the native and invasive vegetation along meandering rivers. One aspect, presented here, is understanding the relationship between seed viability and burial depth. Along the Little Tennessee River, NC, the floodplain was sampled at three inner and outer positions of meander bends. At each position, a one meter deep core was extracted from each depositional environment moving perpendicular to the channel. Each core was cut lengthwise and one half was used for seed bank analysis as a function of depth, while the other half was used for grain size distribution as a function of depth. Preliminary results from analyzed cores suggest that the seeds are viable at greater depths than most previous studies suggest.

Introduction

Riparian zones, as interfaces between terrestrial and aquatic ecosystems, are some of the most diverse, complex, and dynamic habitats on the terrestrial Earth and are particularly sensitive to environmental change (Gregory et al. 1991, Malanson 1993, Naiman and Decamps 1997, Naiman et al. 1993). One factor that contributes to high plant species diversity in riparian zones is periodic disturbance caused by floods (Gregory et al. 1991, Naiman and Decamps 1997, Pollock et al. 1998, Wissmar and Swanson 1990). However, this same disturbance is thought to facilitate invasive plant species establishment in these habitats (Hood and Naiman 2000, Stohlgren et al. 1998). Invasive plant species can threaten biodiversity (Chapin et al. 2000, Dukes and Mooney 1999), potentially impacting the productivity and stability of the ecosystem (Tilman 2000). Climate change is predicted to alter dominant patterns of precipitation and flooding, which also presents a threat to the structure and function of riparian zones (Meyer et al. 1999, Poff et al. 2002).

Riparian seed bank composition often does not correspond to the aboveground vegetation (Beismann et al. 1996). Furthermore, species richness and abundance of seeds in riparian seed banks has been shown to vary widely after disturbance (Abernethy and Willby 1999, Skoglund 1990). This disconnect could be partly attributed to the life history and reproductive strategies of the plant species present (Berge and Hestmark 1997, Thompson and Grime 1979) but also because the seed bank composition may be influenced by physical processes, such as the hydrologic regime, erosion/deposition of sediment, and a variety of seed dispersal mechanisms (Abernethy and Willby 1999, Bornette et al. 1998, Goodson et al. 2002). In general, it is believed that most deeply buried seeds will not germinate due to lack of viability, regardless of habitat (Harper 1977). On average, most studies sample depths ranging from 10 to 20 cm, with a few ranging from 30 t0 50 cm, but very few any deeper (Chippindale and Milton 1934, Harper 1977, Thompson et al. 1997). However, preliminary germination results of my research suggest that perhaps researchers are not sampling deep enough to fully characterize the seed bank.

Study Location

Fieldwork was conducted along the Little Tennessee River, NC within Needmore Game Lands (19.4 km^2), which includes a 39 km reach between Lake Emory Dam and Fontana Dam (Figure 1). This particular reach of the Little Tennessee River is described as the most intact portion of the river and supports the richest biodiversity in the Little Tennessee River basin (LTLT, 2012).

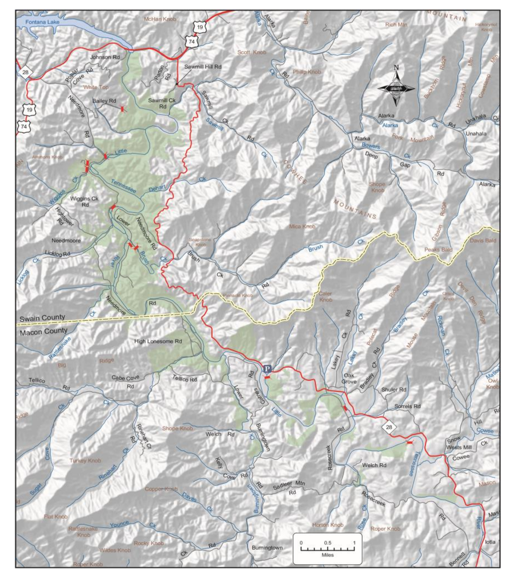

Figure 1: Topographic map in 3-D showing the Needmore Game Land area (in green) and the Little Tennessee River in Swain and Macon County, NC. Map courtesy of NC Wildlife Resources Commission 2013.

Fieldwork

Three inner and outer positions of meandering bends along the Little Tennessee River were sampled (Figure 2).

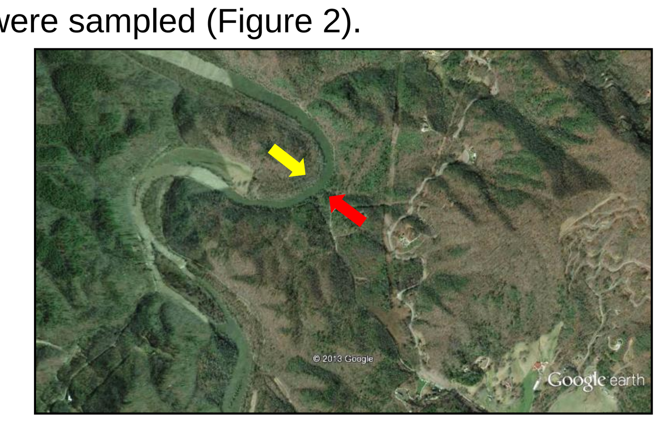

Figure 2: Arial view of an inner (indicated by the yellow arrow) and outer (indicated by the red arrow) position of meandering bends along the Little Tennessee River. Image courtesy of Google Earth 2013.

At each position, starting from the apex of the bend, a surveyor's tape was extended perpendicular to the channel into the floodplain until the hillslope was met. Different depositional environments were identified by changes in slope and the width of each environment was measured. A 1 m x 7.6 cm PVC pipe was hammered into and extracted from the middle of each depositional environment (Figure 3). The soil cores were capped and brought back to UTSA for analysis.

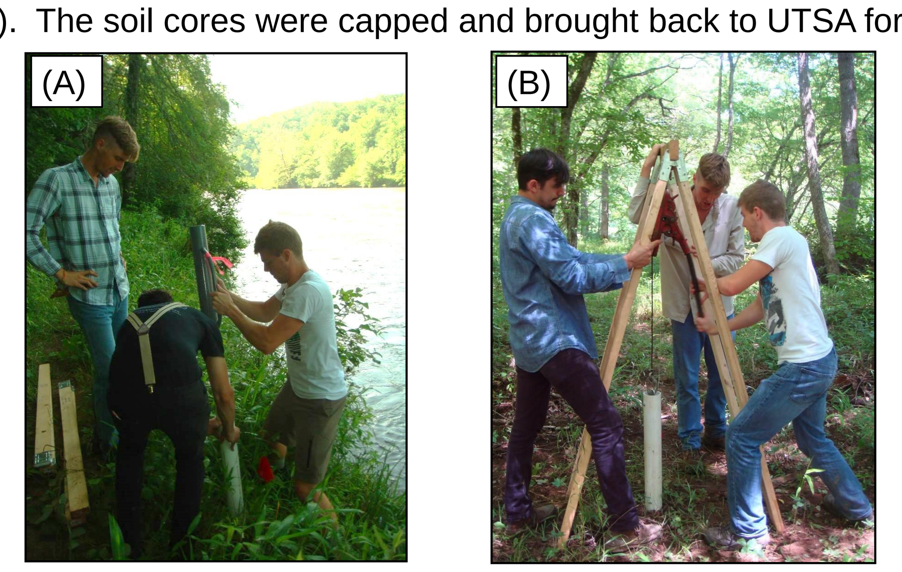

Figure 3: (A) Field crew hammering PVC pipe into ground, using a fence post driver, and (B) field crew extracting PVC pipe, using an A-frame and come-along. The average number of cores extracted per site was 5 ± 1. Photos by Anna K. Boeck 2013.

Lab Work

Pipes will be cut lengthwise with a circular saw and each intact half of the soil core will be sliced into the following depth increments: 3 cm increments from 0 to 30 cm, then 5 cm from 30 to 100 cm. One half of the pipe will be used to examine grain size distribution using the mechanical sieving (Figure 4A) and hydrometer methods (Figure 4B) with the aforementioned increments.

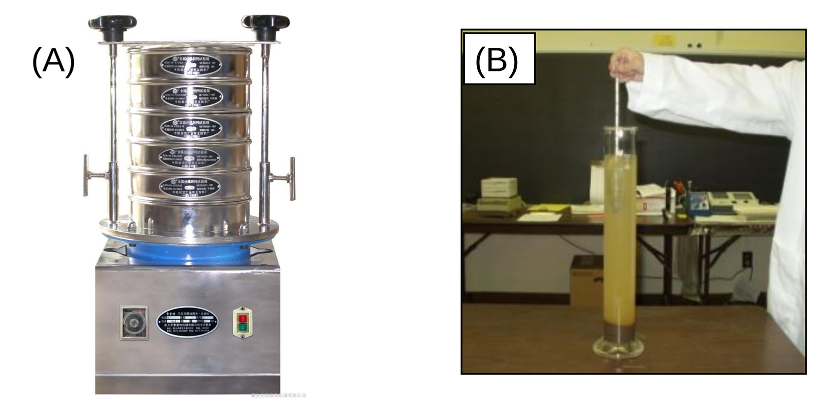

Figure 4: Equipment to be used for grain size distribution analysis; (A) a stack of sieves on a mechanical shaker and (B) a hydrometer immersed in a volumetric cylinder. Image (A) courtesy of www.forevervibrating.com and image (B) courtesy of www.spectrumsoils.com.

The other half of the pipe will be used to characterize the seed bank. The aforementioned increments will be thinly spread on top of potting soil in individual pots in the greenhouse at UTSA. The pots will be kept moist throughout the study and species will be identified upon germination. Once identified, the species will be removed from the pot to reduce competition.

Modeling

A conceptual model framework from Groves *et. al*. will be used as a guide to help understand the connectivity between plant populations and dispersal patterns at the reach scale (2007) (Figure 5).

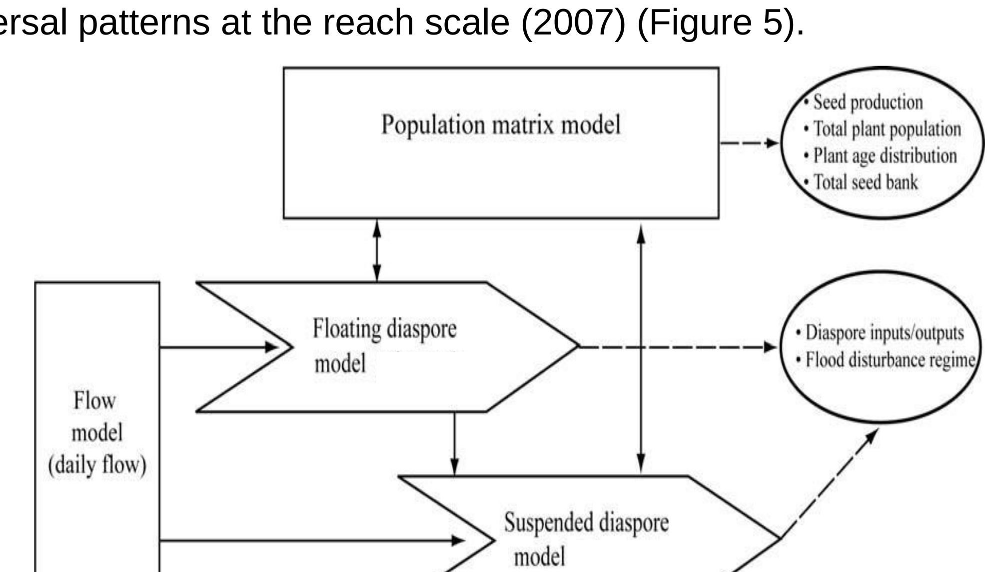

Figure 5: Conceptual model framework for fluvially dispersed seeds (diaspores). Image courtesy of Groves et. al., 2007.

Input data for the flow model will be collected from a USGS gauge (#03203000), which is located on the Little Tennessee River in the Needmore Game Land, and from the Tennessee River Valley Authority, which is the agency responsible for monitoring the dams on the Little Tennessee River.

The population matrix model will be used to predict population growth rate and viability using both within-reach and between-reach inputs. Within-reach inputs require empirical data about the current vegetation composition, seed bank composition, seed production and seed viability. Between-reach inputs will be derived from transport and deposition models (Groves *et.al*., 2007).

Modeling - con't

Hydrochory will be divided into two categories: (1) floating seeds and (2) suspended seeds. Conceptual frameworks from Groves *et. al.* will be used as a basis for understanding the inputs and outputs of seeds by these two pathways (2007) (Figure 6 A and B).

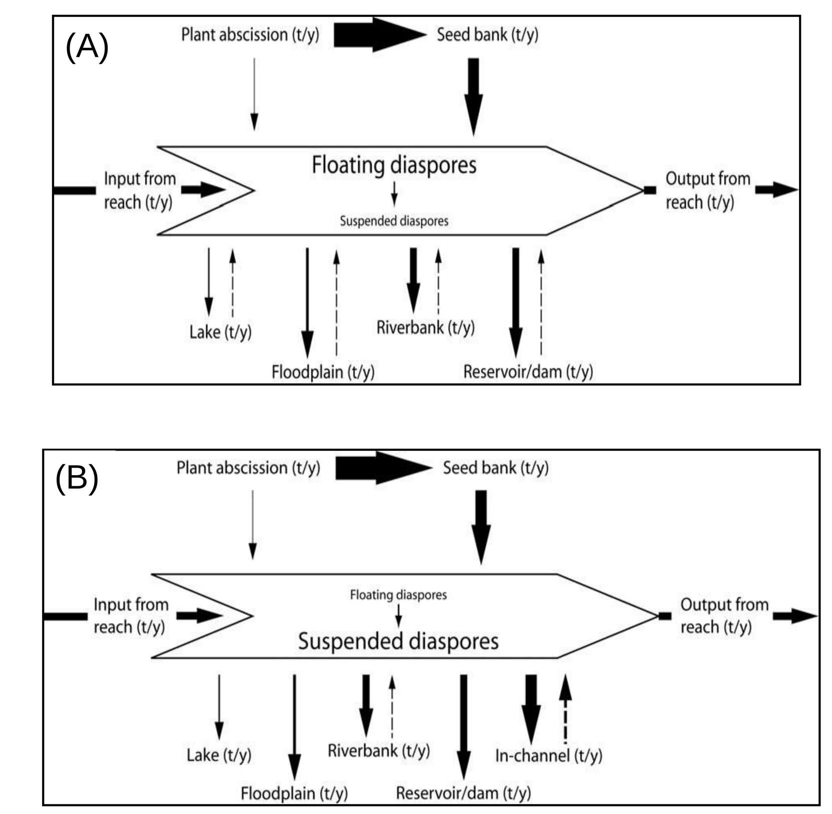

Figure 6: Framework of inputs and outputs of floating seeds (A) and suspended seeds (B), at the reach level. Solid arrows indicate primary movement, dashed arrows indicate potential secondary movement and the size of the arrow indicates the relative proportion of seed movement. Image courtesy of Groves et. al., 2007.

Hydrochory is analogous to sediment transport and deposition, where washload equates to floating seeds and suspended bedload and bedload material equates to suspended seeds. One can use the size and specific density of seeds to describe their rate of transport and deposition in river system (Groves *et. al.* 2007). Therefore, a sediment transport model may be used in combination with a floodplain sedimentation model, where different discharges are input to account for climate change (Asselman *et. al.* 2003). Seed bank composition and seed viability within the seed bank will be useful input variables for floodplain erosion models.

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Acknowledgements

This work was supported by a grant from the US Forest Service Southern Research Station, a grant from the USDA HSI Program, and private donations from Vale/Waller/Alvarez.

Southern Research Station