Investigating Floodplain Forest Communities, Including Soil and Flood Dynamics: Lamprey River, Lee, New Hampshire.


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Abstract

Low variant red maple floodplain natural communities are characterized by having few tree species and a dense herbaceous ground cover that is adapted to periodic flooding and poorly drained soils**.** The purpose of this study was to better understand floodplain forest communities of the Lamprey River in Lee, New Hampshire. Five study plots were established to identify the growing conditions, including: soil, available light and flood dynamics. Herbaceous and arboreal composition was inventoried at each plot by measuring percent of herbaceous cover, tree dominance, tree density and tree relative density. Four of the five plots showed high biological diversity of herbaceous taxa. Red maple (*Acer rubrum*) was the most common tree species but with very low densities at four of the five plots.

Introduction

The riparian complex is a heterogeneous landscape of natural communities found adjacent to river and stream channels. The composition of these natural communities is determined by floodplain characteristics such as cross sectional morphology, soil type, floodplain width, flood frequency and elevation (Nichols, Hoy & Sperduto, 2001). These natural communities include vernal pools, emergent marshes, gravel bars, riverbanks, sparse upper woodlands, floodplain forests, oxbow marshes, riverside meadows and shrub thickets (Sperduto & Nichols, 2004, 2001). A floodplain forest is a biologically diverse community that occurs between the aquatic and terrestrial environments of lowland river valleys and river channels (Sperduto & Nichols, 2004). Typical stream morphology can change from high energy flows upstream where gradients are steep and narrow to low energy, wide, shallower gradients found downstream (Nichols, Hoy & Sperduto, 2001). This community is characterized by low elevations, distance from the river, flood frequency and length of time inundated by floodwaters (Sperduto & Nichols, 2004).

Floodplain forests have poorly drained to moderately drained soils that are rich in nutrients. Nutrient- rich sediment gets deposited during times of flood inundation. Erosion and sediment deposition can build a microtopography within the floodplain forest that includes minor drainages, channels, sloughs, levees and point bars (Harden & Wistendahl, 1983). As water flows around floodplain trees, sediment, litter and debris can build up on the upstream side of the tree while a depression will form on the downstream side. This microtopography can result in gradients of soil nutrients, available moisture, and soil texture (Harden & Wistendahl, 1983). The microtopography, flood frequency, time of flood inundation and elevation gradient characteristics influence the herbaceous growing patterns of this unique forest community (Harden & Wistendahl, 1983). The diverse array of vegetation has been able to thrive by having strong root systems, prolific rhizomes, cespitose growth habits and large quantities of seeds that can be dispersed by wind or water (Sperduto & Nichols, 2004). Biodiversity consists of annual herbs, woody seedlings, emergent perennials, graminoids, perennial forbes, hydrophytes and hardwood tree species (Holland, Burke & McLain, 2000).

Due to a growing demand for water as population increases and a warmer climate from climate change, stream flow could be ten percent lower by 2025 (Mack & Robinson, 2009). Other effects of climate change that may also reduce stream flow include: increased evaporation rates, reduced snowmelt, longer growing seasons and change in precipitation patterns. An increase in severe storms from climate change will likely alter flood frequency patterns and volumes.

Riparian communities serve as important wildlife corridors especially in the highly developed southern part of New Hampshire. These communities provide habitat and important food sources to a variety of amphibians, reptiles and mammals. Floodplain forests have an ecologically important role as a seed source for many rare plants (Holland, Burke & McLain, 2000).

Floodplain forests are part of important river corridors that interconnect many wetlands. Forests and wetlands dissipate and absorb much of the floodwater, controlling damage to downstream municipalities (The NH Heritage Bureau, 2000). More stormwater runoff from increased impervious surface cover and loss of floodplain forests and wetlands has lead to increased intensity and damage from floods (The NH Heritage Bureau, 2000).

Few large floodplain forests still exist in New Hampshire. Relatively flat topography and nutrient- rich soils has led to many floodplain forests being logged and converted to agriculture (Sperduto & Nichols, 2004). The tranquil and scenic qualities, typical of a floodplain forest have also led to many of these forests becoming lost to residential development. Other threats to these rare ecosystems are dams, river channelization, stormwater runoff and invasive species (Sperduto & Nichols, 2004, The NH Heritage Bureau, 2000).

The Northern Forests Land Council stated, " Maintaining the region's biodiversity is important in and of itself, but also as a component of stable forest related economies, forest health, land stewardship and public understanding."(Nichols, Hoy & Sperduto, 2001). Conservation efforts are needed to maintain the ecological requirements that these communities need. It is important to maintain the rich biodiversity of these rare ecosystems because of their role as biotic sinks and wildlife corridors (Hughes& Cass, 1997). Floodplain forests are considered to be the most threatened significant wetland community types in New England (Kearsley, 1999).

There are five objectives of this study: 1. To identify and classify the vegetative composition of a floodplain community. 2. To locate and delineate floodplains along this section of the Lamprey River. 3. To better understand the complex interactions between this community and its unique environment, including: flood frequency, soil characteristics and available light. 4. To provide baseline information for future studies on environmental stressors, change in vegetation composition, nutrient cycling and changes in hydrologic conditions due to climate change. 5. To provide information for land stewards and conservationists about these ecologically rare and critical communities.

Methods

Study plots:

This study was conducted at the UNH Burley/ Demeritt organic farm in the town of Lee, Strafford County, New Hampshire (see fig. 1). Farm property abuts the northeast shore of the Lamprey River. Three floodplain areas were located along the river (fig. 1). All three floodplains were level with a width ranging from eleven to twenty meters. Floodplain area number one has a small tributary stream that flows through its center creating a stream depression. Floodplain area one is mostly a red maple floodplain community with a section that is heavily shaded by eastern hemlock and northern red oak. The “mouth” of area one is narrow with steep banks. Floodplain area one is being used for ongoing research conducted by UNH students. The stream depression in area two only fills up after significant rainfall or during back flooding from the main stem of the Lamprey River. Floodplain area two is a red maple floodplain community with a “mouth” that has steep banks and is heavily shaded by eastern hemlock. Area three is entirely a red maple floodplain community. Five plots were set up in areas one and two (see fig. 1). Plots A and D were located in area one while Plots B, C and E were located in area two. Plots B and C had some microtopography consisting of small raised humps surrounding some trees. Plots A, B C and E are classified as red maple floodplain forests with a low variant (S2S3) (Sperduto & Nichols, 2004). This floodplain community classification has a range of southeastern New Hampshire (Sperduto & Nichols, 2004). The more open tree canopy, lower elevation, wetter character and distance from the main river channel distinguish this community classification (Sperduto & Nichols, 2004). Tree species composition within the five study plots were red maple (*Acer rubrum*), swamp white oak (*Quercus bicolor*), American elm (*Ulmus Americana*), musclewood (*Carpinus caroliniana*), black birch (*Betula lenta*), northern red oak (*Quercus rubra*), and shagbark hickory (*Carya ovata*). Tree species found at adjacent higher elevation terraces were: Eastern hemlock (*Tsuga Canadensis*), White pine (*Pinus strobus*), American basswood (*Tilia americana*), white oak (*Quercus alba*), black cherry (*Prunus serotina*) and northern red oak (*Quercus rubra*). The Lamprey River has a flood frequency of one to three years, has a river slope of 12.1 feet per mile and has eighty nine percent forest cover (USGS Streamstats).

Vegetative Composition:

Five circular study plots were subjectively placed within typical vegetation types of red maple floodplain communities (Kearsley, 1999). All plots had a five meter radius with an area of 78.5m^2. Walking two perpendicular transects, a densiometer was used to determine canopy closure and species were recorded if leaves were present. Data were recorded at every pace along each transect. This method was used to calculate percent canopy cover. Percent of under story cover of herbs and seedlings was visually estimated within each plot (Kearsley, 1999). The

DBH for all trees greater than two centimeters was measured at 1.3 meters above ground level. Dominance was calculated as basal area/ plot area of each tree species. Density was calculated as the number of stems per plot area for each tree species. Relative density was calculated as percentage of the total abundance of all species that a particular species contributes. Species richness (the total number of all vegetative species) was calculated for each plot.

Soils:

A soil probe was used to extract a soil sample from a depth greater than ten centimeters (B horizon) at each plot. The Munsell soil color chart was used to determine the color of each soil sample. Texture was determined by feel, using a texture flow chart. Ten grams of each soil sample were dried, mixed and placed in 20 ml of deionized water for thirty minutes. A digital pH meter was used to determine the pH of this soil slurry. An aliquot of each soil sample was then ground with an electric mortar and pestle and analyzed for percent carbon and nitrogen using a carbon and nitrogen analyzer.

Mapping:

A Trimble GPS backpack unit was used to delineate floodplain areas on the northeast side of the Lamprey River at the UNH Burley/ Demeritt Organic farm. Arcview GIS software was used to plot the three delineated floodplains within an image of the area. GIS software was also used for analysis of floodplain elevation, proximity to wetlands and creating map images.

Results

The percent of herbaceous vegetative composition was made based on a visual assessment at each study plot. Plots A, B, C and E (94%, 98%, 90% and 90% respectively) all showed a dense cover of herbaceous plants compared to Plot D that had only 45% cover. Plots A (10 species), B (11 species), C (8 species) and E (15 species) all showed more biodiversity compared to plot D that had only 6 species present (see table 1). Species richness includes tree species as well as under story species. Plots E and B had the highest species richness (both with 17 species) followed by plot C (13), plot A (9) and plot D with only seven species.

Floodplain soils are classified as Saugatuck loamy sands, Sutton fine sandy loam, Swanton fine sandy loam and Windsor loamy sands (Natural Resource Conservation Service Soil Survey, 2009). These soils types are typical of red maple lowland floodplain forests of the seacoast region. Soils are poorly drained clays and silty clay loams that are dark gray and dark brown in color. Soils were acidic with pH readings ranging from 4.71-6.13 Carbon concentrations of the five soil samples ranged from 0.81% to 3.08%. Nitrogen concentrations of the five soil samples ranged from 0.06% to 0.22% (see table 2).

Red maple was the only tree species recorded at plot A. There were four stems with a total basal area of 274.10cm^2/78.5m^2. Plot A had red maple canopy cover of 83% while the remaining 17% was open. Black birch (1 stem), red maple (3stems) and swamp white oak (1 stem) were found at plot B. The swamp white oak was dominant with a basal area of 2,826.00cm^2/78.5m^2 while red maple and black birch had basal areas of 446.66cm^2/78.5m^2 and 254.34cm^2/78.5m^2, respectively. Canopy cover consisted of mostly red maple (50%) and black birch (25%) while 25% of the canopy was open. At plot C red maple was the most dominant with a basal area of 3,939.13cm^2/78.5m^2 (2 stems) while shagbark hickory (7.065cm^2/78.5m^2, 1 stem), musclewood (102.06cm^2/78.5m^2, 2 stems), American elm (250.62cm^2/78.5m^2, 2 stems) and northern red oak (3.14cm^2/78.5m^2, 1 stem) were also recorded. The canopy of plot C was dense with red maple (58%), musclewood (8%) and American elm (33%). No trees were located in plot D although there was still a dense canopy cover from adjacent eastern hemlock (25%) and northern red oak (67%) trees. Red maple was dominant in plot E with a basal area of 2,195.07cm^2 /78.5m^2 (4 stems) while musclewood (1 stem) and American elm (3 stems) had basal areas of 113.04cm² /78.5m² and 249.83cm² /78.5m², respectively. The canopy was dominated by red maple (75% cover) followed by American elm (16%) and musclewood (8%) (See table 3).

Three low floodplain areas exist along the northeast side of Lamprey River at the UNH Burley /Demeritt Organic farm. Figure two shows the proximity of the floodplain study sites to wetlands with some areas lying within National Wetland Inventory data boundaries. Figure three shows the typical low elevation and flat topography of the floodplains based on contour, slope and Digital Elevation Model data.

Table 1: Percent of Herbaceous Species at Each Plot

Species	**Plot A**	**Plot B**	**Plot C**	**Plot D**	**Plot E**
Cinnamon Fern *(Osmunda cinnamomea)*					2%
Spinulose wood fern **(***Dryopteris carthusiana***)**	2%		1%		1%
Wild Oat *(Uvularia sessilifolia)*					10%
Meadow Rue *(Thalictrum spp.)*	2%				1%
Nettle (*Urtica spp.)*	2%	35%	20%	1%	6%
Jewelweed (*Impatiens capensis)*	50%	20%	10%		2%
Partridgeberry (*Mitchella repens)*			1%		
Bristly dewberry (*Rubus hispidus)*	2%		2%		1%
Wild geranium (*Geranium manculatum)*	2%				1%
Winterberry holly (*Ilex verticillata)*		1%			3%
Poison Ivy (*Toxicodendron radicans)*		2%	2%		
Royal fern *(Osmunda regalis)*		7%		3%	2%
Northern bugleweed *(Lycopus virginicus)*		4%		8%	1%
Jack in the pulpit (*Arisaema triphyllum)*					4%
New York fern (*Thelypteris noveboracensis)*		2%		2%	
Sensitive fern (*Onoclea sensibilis)*	12%	2%	50%	30%	35%
Northern lady fern (*Athyrium filix-femina)*	8%	15%	4%		
Mosses	4%	5%			
Grasses	10%	5%			20%
Unknown				1%	1%

Table 2: Soil PH, Color, Texture, Percent Carbon and Percent Nitrogen					
Plot	**PH**	**Color**	**Texture**	**% Nitrogen**	**% Carbon**
A	5.27	Very dark gray brown	Silty Clay Loam	0.12	1.69
B	6.13	Very dark gray	Clay	0.18	2.14
C	5.81	Olive brown	Clay	0.06	0.81
D	4.71	Dark Gray	Clay	0.07	1.02
E	5.75	Very dark gray	Clay	0.22	3.08

Table 3. Tree Species Dominance, Density, Canopy Densiometer Calculations and Relative Density.					
Dominance	**Plot A**	**Plot B**	**Plot C**	**Plot D**	**Plot E**
Red Maple	274.10cm²/78.5m²	446.66cm²/78.5m²	3,939.13cm²/78.5m²		2,195.07cm² /78.5m²
Black birch		254.34cm²/78.5m²			
Swamp white oak		2,826.00cm²/78.5m²			
Musclewood			102.06cm²/78.5m²		113.04cm² /78.5m²
American elm			250.62cm²/78.5m²		249.83cm² /78.5m²
Shagbark hickory			7.065cm²/78.5m²		
Red oak			3.14cm²/78.5m²		
Density					
Red Maple	4/78.5m²	3/78.5m²	2/78.5m²		4/78.5m²
Black birch		1/78.5m²			
Swamp white oak		1/78.5m²			
Musclewood			2/78.5m²		1/78.5m²
American elm			2/78.5m²		3/78.5m²
Red oak			1/78.5m²		
Shagbark hickory			1/78.5m²		
Relative Density					
Red Maple	100%	60%	25%		50%
Black birch		20%			
Swamp white oak		20%			
Musclewood			25%		12.50%
American elm			25%		37.50%
Red oak			12.50%		
Shagbark hickory			12.50%		
Percent Canopy Cover					
Eastern hemlock				25%	
Red oak				67%	
Red Maple	83%	50%	58%		75%
Black birch		25%			
Musclewood			8%		8%
American elm			33%		16%
No canopy cover	17%	25%	1%	8%	1%

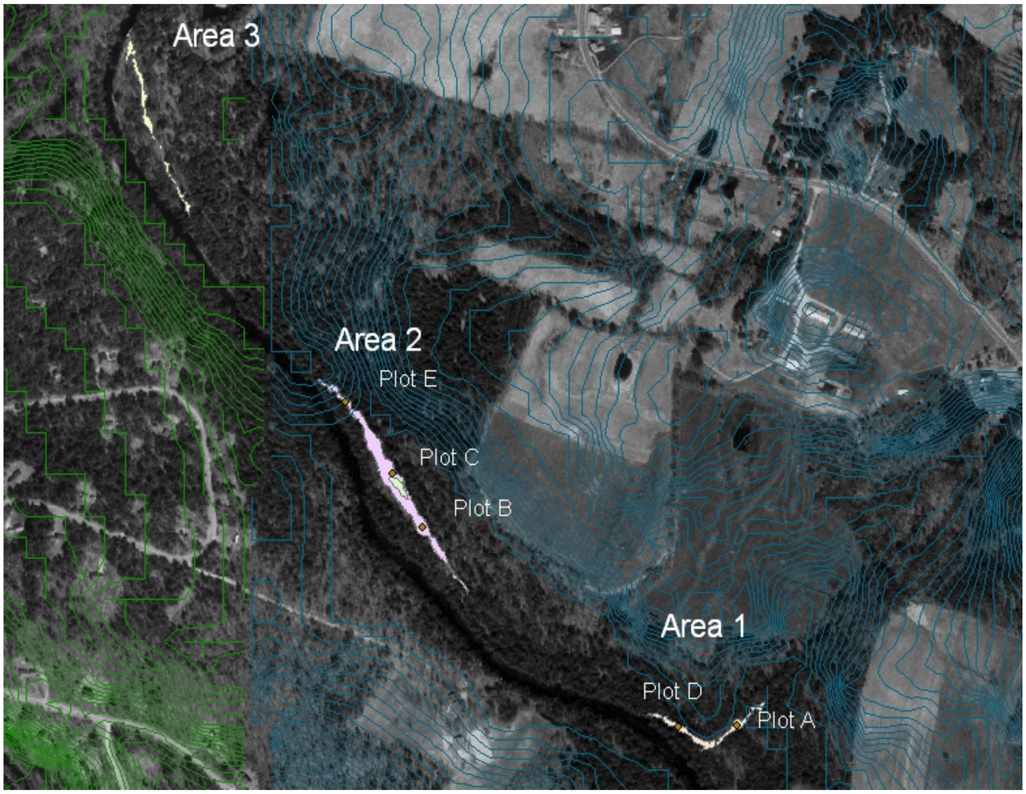

Figure 1. Location of study plots and three low variant red maple floodplain forest communities (areas 1-3) at the UNH Burley/ Demeritt Organic farm, Lee, NH. Image: Digital Orthophoto Quadrangle and Contour data layers.

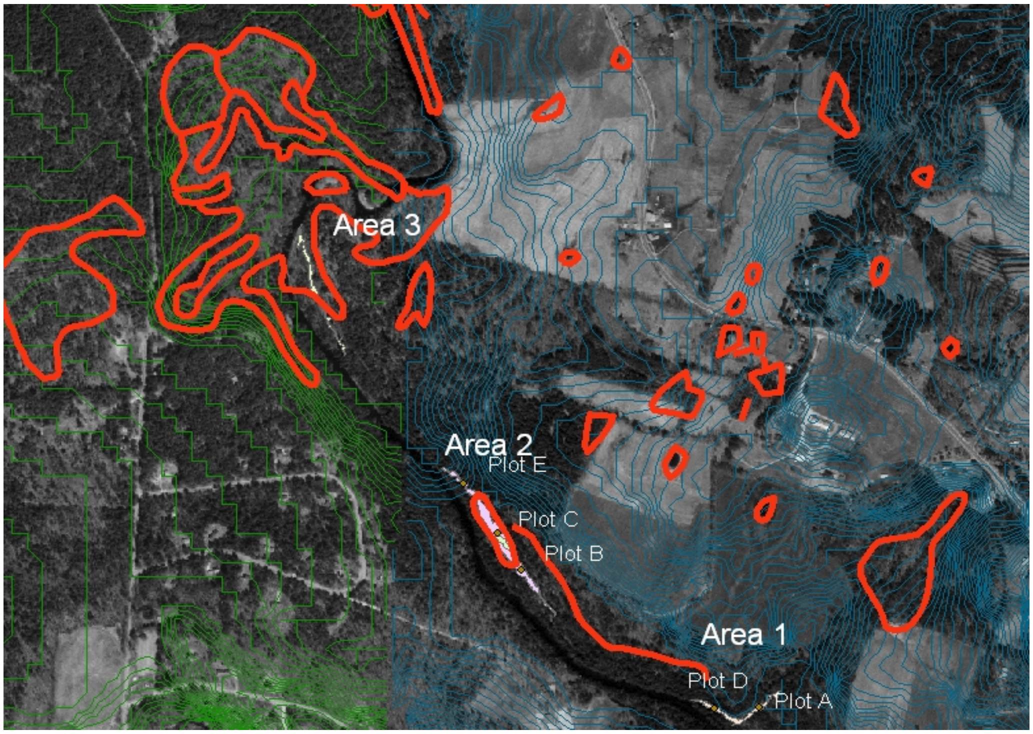

Figure 2. Low variant red maple floodplain communities in relation to the National Wetlands Inventory coverage at the UNH Burley/ Demeritt organic farm, Lee, NH. Image: Digital Orthophoto Quadrangle, Contour and National Wetland Inventory data layers.

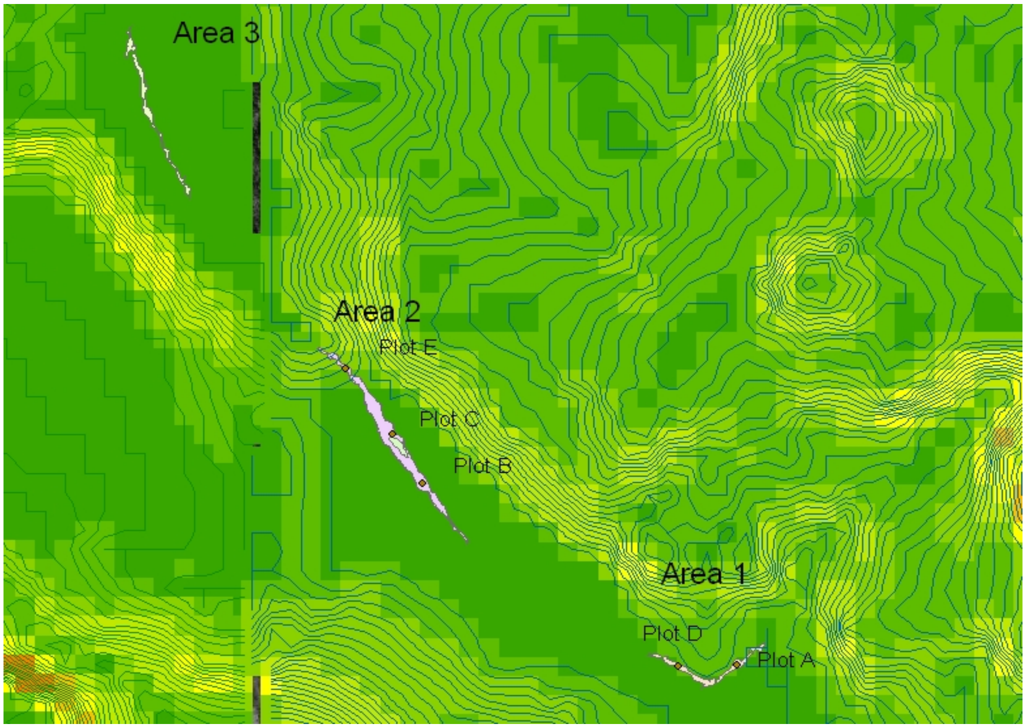

Figure 3. Low variant red maple floodplain communities pictured with the Digital Elevation Model (DEM), Contour and Slope data layers.

Discussion

Red maple floodplain forests have rich plant biodiversity including graminoids, annuals, emergent perennials, perennial forbes, hydrophytes, woody seedlings and hydrophilic tree species. These species are adapted to poorly drained, nutrient rich soils. The hydrological conditions of flood inundation duration and the timing of floods is a complex environmental stress determining what species are able to survive (Holland, Burke & Mclain, 2000). Plots A, B, C and E all had herbaceous vegetation typically found in a low variant red maple forest community (Sperduto & Nichols, 2004). Dominant herbaceous species in these plots were: sensitive fern, northern lady fern, nettle and jewelweed.

Red maple was the dominant tree species and the dominant canopy species at plots A, B, C and E. Compared to upper woodlands, these floodplain communities have few tree species (7) and few tree stems (plot A: 4, plot B: 5, plot C: 8, plot D: 0 and plot E: 8). I can infer that low tree density is a result of many species not being able to survive in areas inundated by flooding for an extended period of time. Red maple has a lower leaf area index (LAI) than coniferous trees, thus letting more light penetrate to the forest floor. The densiometer data show a high amount of canopy cover. Based on visual assessments the floodplain areas (with the exception of plot D) let much more light penetrate to the forest floor than the adjacent upper woodland forests. Plot D was almost completely shaded by adjacent eastern hemlock and northern red oak. The darker forest floor in plot D likely explains the absence of red maple and the presence of only six herbaceous species. Determining percent canopy cover by a means other than using a densiometer may have shown results that more accurately represented the canopy at plots A, B, C and E.

There have been few studies on floodplain vegetative composition in relation to growing condition dynamics. The results from my study differ from a study by Kearsley (1999) in which the authors found non-native species at their study sites in Massachusetts. Another study by Nichols, Hoy and Sperduto (2001) inventoried and classified low floodplain forests of New Hampshire’s minor rivers.

The largely undeveloped shores of the Lamprey River serve as habitat and corridors for many wildlife species. Some of the species observed when conducting field work in autumn, 2009 were black ducks (*Anas rubripes*), a wood frog (*Rana sylvatica*), green frogs (*Rana clamitans melanota*), wood ducks (*Aix sponsa*), a great blue heron (*Ardea herodias*), chipmunks (*Tamias spp.),* squirrels (*Spermophilus spp*.), a skeleton of a white tailed deer (*Odocoileus* *virginianus*) and very recent signs of beaver activity (*Castor Canadensis*). Plants found in floodplain forests provide a seed source for many rare plants. Floodplain forest communities are part of important corridors that connect wetlands. Floodplain and wetland areas provide ecosystem services to municipalities by mitigating flood damage and controlling erosion.

Temperatures will likely continue to increase from anthropogenic climate change. Warmer temperatures will result in reduced spring snowmelt. Climate change may also increase the number of severe storms in the region. Less snowmelt may reduce spring flooding while an increase in severe storms could cause irregular flood patterns throughout the year. Increased flood frequency and shorter flood inundation periods may reduce the productivity of these rare and important natural communities. Red maple floodplain forests clearly rely on the unique growing conditions created by regular flood patterns. These forest communities are under constant threat of being logged or converted to development. Having a better understanding of this rare forest community type may aid in forest management decisions, conservation priorities and community development decisions.

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Photo captions: All photos taken early December 2009.

1. The walk towards the study plots from the farm.
2. Plot D of area one.
3. Area 2.
4. Current beaver use.
5. Beaver dam pool/ pond (what my study plots would look like during flooding).
6. Area 3.
7. Plot E of area 2.
8. Mapping with the GPS backpack.

Photos on cover page:

1. Partial view of area two.
2. The “mouth” of area two.