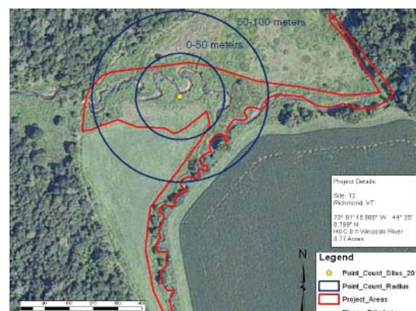
TECHNICAL REPORT NO. 64

Riparian Habitat Restoration Monitoring

Monitoring Tree Health and Bird Use of Riparian Restoration Projects in Vermont



January 2012

Final Report
Prepared by Leah Szafranski
The Intervale Center and the U.S. Fish and Wildlife Service

for
The Lake Champlain Basin Program

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All of the landowners who allowed us to revisit their properties, Vermont, USA

EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (USFWS) and conservation partners (The Intervale Center, U.S. Department of Agriculture, the Vermont Agency of Agriculture, local Conservation Districts, and watershed organizations) plant up to 30,000 stems each year, along approximately 15 miles of rivers and streams, throughout the State of Vermont. In the past, monitoring the success of tree planting restoration efforts has been limited due to funding and programmatic priorities. In 2008 the Intervale Center, in partnership with the USFWS began monitoring the success of tree and shrub plantings at completed restoration projects. The primary focus of the monitoring has been to track the survivorship, growth, and condition of seedlings planted in riparian habitat restoration projects.

To date, 27 sites and over 1500 seedlings have been monitored for survivorship, condition, growth, species, tree protection materials, plant material type, and site. The data and results of our monitoring efforts will help conservation planners better understand what makes a successful project , which in turn will guide the adaptive planning process, and ultimately help to improve the overall success of restoration projects throughout Vermont.

Avian point counts were conducted, during the breeding season in 2011, at three different types of riparian sites: unplanted, planted, and established riparian buffers. In total, avian point counts were conducted at fifteen sites across Vermont. Preliminary results from one year of avian point counts are included in this report; however, no conclusions will be made until further data have been collected.

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INTRODUCTION

Preceding European settlement Vermont's landscape was approximately 95% forested. A period of significant deforestation occurred across much of New England following European settlement; in Vermont by 1850 it is estimated that the forest cover was reduced to 25% (Thompson and Sorenson 2000). The reduction in forest cover has been driven by development, agriculture, timber harvesting and other land uses. Currently, it is estimated that roughly 78% of the Vermont landscape is forested (Wharton et al. 2003) yet the majority of riparian areas remain deforested or fragmented. As a result, intact floodplain forests are now recognized as an uncommon natural community type found in Vermont (Thompson and Sorenson 2000).

Healthy riparian forests provide valuable ecosystem functions such as habitat for terrestrial and aquatic species, maintenance of hydrologic flow regimes, erosion control, and water quality improvement (Manci 1989). Due to the complex and dynamic nature of naturally functioning riparian areas they tend to have high levels of both plant and animal species diversity (Brinson and Verhoeven 1999, Naiman et al. 2002, Ross and Baker 1983, Decamps et al. 1987, Doyal 1990). Forested riparian buffers provide shade, helping to maintain the cool temperatures required by many aquatic species, and provide food and habitat for the macroinvertebrates which form the base of the food chain. Riparian forest buffers also serve as an effective method for reducing non-point source pollutants, such as nitrogen and phosphorus, largely contributed by agricultural runoff (Correll 1997). At the same time, root structure is vital to improving bank stability and reducing erosion and the related sediment inputs into streams. Excessive sediment inputs increase phosphorous loads, reduce the water quality and habitat for many aquatic species, and often lead to further instability downstream.

As we have learned more about the important functions and values of healthy functioning riparian areas, increased emphasis has been placed on riparian restoration projects. Restoration projects, with an emphasis on tree planting, have become a high priority throughout Vermont. Many partners and programs work together to implement projects; in addition to the U.S. Fish and Wildlife Service (USFWS) and the Intervale Center (Intervale), the U.S. Department of Agriculture (USDA), the Vermont Agency of Agriculture Food and Markets (VAAFM), local Conservation Districts, watershed groups, and other non-profit organizations are all necessary partners in planning and implementing effective riparian restoration projects. More than 30,000 stems are planted each year along approximately 15 miles of rivers and streams throughout the

State of Vermont (C. Smith, personal communication, February 15, 2012). In the past, monitoring the success of tree planting restoration efforts has been limited due to funding and programmatic priorities. Long-term monitoring and further experimentation is needed in order to evaluate the success of project goals and objectives (NRC 1992; Henry & Amoros 1995; Kondolf and Micheli 1995).

In 2008, the Intervale in partnership with the USFWS began monitoring the success of tree and shrub plantings at completed riparian restoration sites. A riparian monitoring protocol was developed to assist project planners in assessing local and regional project outcomes. The ultimate goal of the monitoring program is to provide the restoration community with information necessary to improve future riparian restoration projects. Objectives of the project include: distribution of a standardized monitoring protocol to local project partners, data collection and analysis of multi-age riparian restoration projects, development and distribution of a standardized summary report for riparian planting projects.

Additionally, in 2011 avian point count surveys were added to the study. Bird surveys were added to the study in an effort to track species abundance and diversity at restoration sites over time. The USFWS is interested in monitoring migratory bird use of riparian restoration sites and the evaluation of habitat quality as the riparian site matures. Restoring and maintaining riparian corridors is a vital part of sustaining populations of many bird species and aquatic organisms.

This report is the culmination of four field seasons of data collection between 2008 and 2011. Analysis of growth, condition, and survivorship by site, species, plant material type, and plant protection materials was conducted at the conclusion of the 2011 field season. Results from this monitoring project, supported by results from past research projects, provide insight into the successes and failures of riparian habitat restoration projects and practices within Vermont.

METHODS

TREE MONITORING

Study Location

Planted trees and shrubs at riparian restoration sites were monitored between 2008 and 2011. Survival and condition data were collected from twenty-seven riparian restoration sites, along rivers and tributaries throughout Vermont, USA. The twenty-seven sites are located within seven watersheds across the State (Figure 1).

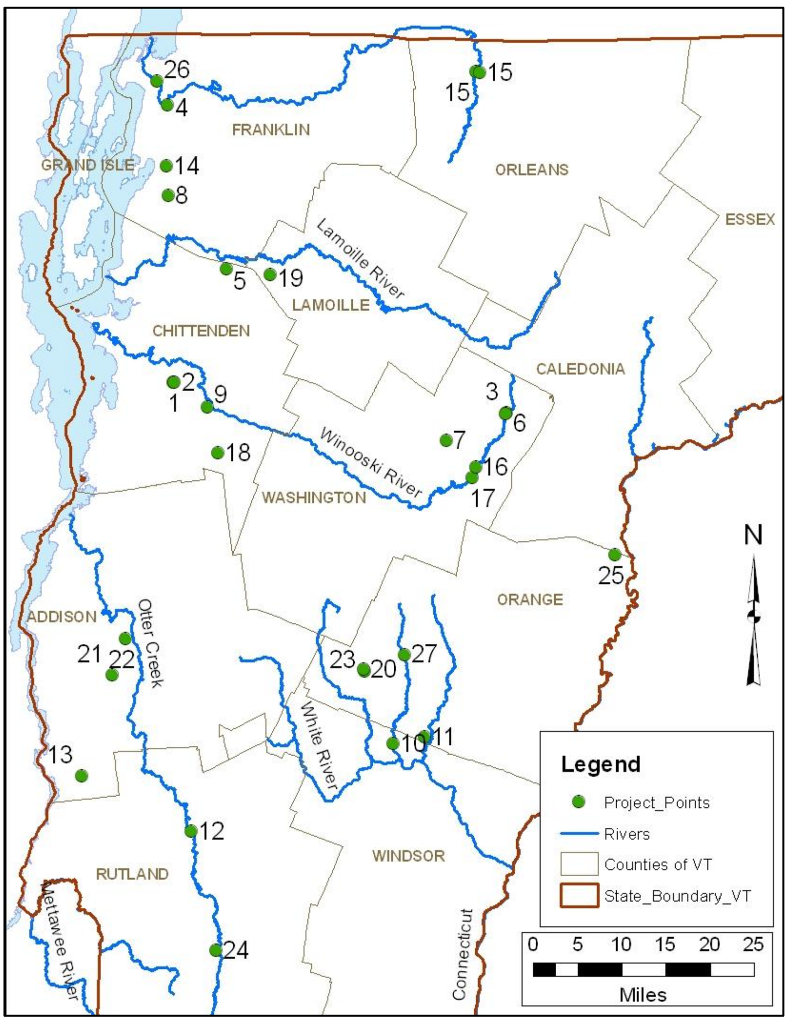

Figure 1. Riparian habitat restoration monitoring sites, 2008-2011, Vermont, USA.

Site Selection

Sites were selected that represent the conservation practices being used in riparian restoration throughout Vermont. Selected sites consist of: riparian areas, with prior land use of agricultural cropland, livestock pasture, or fallow land, which have been planted with trees and shrubs in a delineated buffer. All sites are protected by either a conservation easement or a partnership agreement that protect the delineated buffer for a specified period of time (usually 10-20 years).

New monitoring sites were selected each spring. The selected sites were chosen from projects being conducted by one or more of the following organizations: the Agency of Agriculture, the USFWS, not-for profit watershed organizations, and local municipalities. A total of twenty-seven riparian habitat restoration projects have been selected to be a part of this study.

Study Design

Planted tree survival and condition data were collected at twenty-seven riparian restoration sites within seven watersheds throughout Vermont (Table 1). Monitoring took place between the months of May and October, from 2008 to 2011. Data was collected at ten sites starting in 2008 (tree monitoring sites: 05, 08, 09, 14, 15, 16, 17, 21, 23, and 27), four sites in 2009 (tree monitoring sites: 01, 18, 20, and 24), seven sites in 2010 (tree monitoring sites: 07, 11, 12, 13, 19, 22, and 25), and six sites in 2011 (tree monitoring sites: 02, 03, 04, 06, 10, and 26). Data was collected within the same year (1st year) of tree planting at twenty-three sites; four sites (tree monitoring sites: 05, 09, 14, and 27) were not monitored until the following year (2nd year). In 2011, five sites (tree monitoring sites: 02, 03, 04, 06, 10, and 26) were visited twice; once, immediately after planting (April – May) to collect baseline data and a second time to collect the standard monitoring data. All sites were revisited each year after monitoring was started during the growing season (May – October).

Site #	Monitoring Year	Size	Town	Watershed (HUC 8)
1	2009	10.35	Williston	Winooski River
2	2011	3.82	Williston	Winooski River
3	2011	0.84	Cabot	Winooski River
4	2011	8.7	Swanton	Winooski River
5	2008	0.8	Westford	Lamoille River
6	2011	0.78	Cabot	Winooski River
7	2010	9.92	East Calais	Winooski River
8	2008	3.9	Georgia	Lake Champlain
9	2008	8.77	Richmond	Winooski River
10	2011	1	South	White River
11	2010	8.4	Tunbridge	White River
12	2010	11	Pittsford	Winooski River
13	2010	5.1	Orwell	Lake Champlain
14	2008	16.4	St. Albans	Lake Champlain
15	2008	37.9	North Troy	Missisquoi River
16	2008	7.3	Marshfield	Winooski River
17	2008	6.8	Marshfield	Winooski River
18	2009	0.64	Huntington	Winooski River
19	2010	14.43	Cambridge	Lamoille River
20	2009	14.4	Randolph	White River
21	2008	6.5	Rowe	Otter Creek
22	2010	14.1	Weybridge	Otter Creek
23	2008	10	Randolph	White River
24	2009	10.5	Clarendon	Otter Creek
25	2010	4	Newbury	Connecticut River
26	2011	4.8	Swanton	Missisquoi River
27	2008	13.1	East Randolph	White River

Table 1. Riparian habitat restoration monitoring sites 2008 – 2011, Vermont, USA.

Although all twenty-seven projects were planted with native woody species along a restored riparian buffer, each project differed with regard to planting density, species selection, plant material selection, tree protection measures, buffer width, and total acreage. The diversity of project practices is in part, a result of not all projects being conducted by the same organizations or enrolling in the same programs. However, the goals and implementation plans are often very similar. All projects conducted through the Conservation Reserve Program (CRP) (a program of the USDA) and the Conservation Reserve Enhancement Program (CREP) (a program of VAAFM) follow a set of guidelines or a “Conservation Practice Standard” and use a

“Practice Specification Guide sheet”. In Vermont and specifically for these riparian buffer projects, the implemented practices are most commonly: “Tree/Shrub Establishment (612)” and “Riparian Forest Buffer (391)”.

In 2008 a standardized monitoring protocol was developed for riparian monitoring activities in Vermont. This monitoring protocol was followed at all monitored sites (Appendix 1). A minimum of three transects were completed at each site, spaced approximately 200 feet apart or equally distributed throughout a representative portion of the property; additional transects were added to larger sites to increase the sample size. All transects were perpendicular to the watercourse across the extent of the planted buffer. Variations in transect length were due to varying buffer widths at each site. The first transect would begin approximately 50 feet upstream and downstream of the project boundary (Figure 2).

Figure 2. An example of a riparian restoration site showing project boundaries and transect end points, Site 23, Randolph, Vermont.

Transects were labeled in consecutive order (1, 2, 3, etc) on stakes that were put in the ground at each end of a transect line, and then marked on the Trimble GeoXH datalogger or Garmin GPS. A digital photograph with supporting documentation was taken at each end of a transect to capture the transect location and characteristic vegetation, as well as to serve as a historic reference point. A tape measure was then run along the length of a transect between the stakes and was left on the ground to mark the transect centerline. All trees within 10 feet of the tape (both sides) were counted for the entire length of a transect. If tree density was sparse, it was necessary to go beyond 10 feet of the tape until a count of a minimum of ten trees was acquired. Tree data collection began by counting the trees on the left side of the tape first (Figure 3).

Figure 3. A typical transect view demonstrates the layout of a tape measure and planted trees, Cornwall, Vermont.

In order to return to the same tree over time and to record its relative condition, trees were individually numbered with a corresponding tree tag staked to the base of the trunk. Additionally, a corresponding GPS reference position and a digital photograph were taken, while tree data variables were measured and documented. The photograph was also helpful to identify specific condition/species characteristics that were not always readily identifiable in the field. The process of tree tagging, GPS recording, photographing, and data recording began for all trees on the left side of the tape in consecutive order beginning with the tree farthest away from the water. The same process was then completed on the right side of the tape/transect centerline. Natural regeneration of trees and shrubs found within 10 feet of the tape was also recorded.

The original protocol design was set up with the assumption that the individual collecting data would have access to a GPS. In an effort to expand monitoring efforts within the conservation community it was quickly realized that not all partners had access to a GPS; thus an alternative solution to data collection needed to be established. Following the same protocol stated above, a person can collect tree survivorship and condition data manually, using a specially designed map and data collection sheet (Appendix 2).

Data Collection

Thirteen variables were examined in this study. Independent variables included plant species, plant origin, plant material type (bareroot, tubling, container grown, balled & burlap, livestake, or fascine), tree planter, year monitored, year planted, tree protection (mat, tube, mat & tube, or no protection), percent browse, percent girdling and vegetative competition (species, height, and density). Dependent variables included plant survival (dead/alive), condition (vigorous, healthy, moderate, unhealthy, very unhealthy, dead), and stem height (inches).

Mat types consisted of green polyethylene brush mats, black plastic and recycled burlap coffee bags. Tube or shelter types consisted of Blue-X shelters (a 24” tall plastic film with a clear blue-tinted poly sleeve/liner), Tubex plastic tree shelters, and yellow plastic mesh tree shelters (Figure 4).

Blue-X tree shelter — Tubex tree shelter — Yellow-mesh tree shelter

Figure 4. Three common types of tree protection tubes found during 2008 -2011 monitoring, Vermont, USA.

Six different plant material types were planted at restoration sites including bareroot, tubling, container grown, balled and burlap, livestake, or fascine material. Bareroot stock is defined as woody plant seedlings lifted from the nursery soil and delivered ‘bare-root’ (without soil). Tublings are defined as pre-rooted cuttings of woody plant species grown in plastic "plug" containers with a small amount of soil (only several species are offered as tublings: willows, dogwoods, and elderberries). Although tublings are technically a type of ‘container grown’ plant material, their smaller size makes them sufficiently different enough to be treated separately. Container stock plants are woody plant seedlings and saplings grown and delivered in soil within a plastic container. Balled & burlap plants are generally the largest of all the plant material used in restoration projects. Balled & burlap plants are grown in a nursery, a root ball is dug with the soil intact, wrapped with burlap, and tied with twine. Live stakes are defined as living woody plant cuttings (willow, dogwood, or elderberry) capable of quickly rooting in moist soils; live stakes are generally ½ - 2 inches in diameter and 1-3 feet long and large enough to be tamped-in as stakes. Fascines, or bundles of dormant living plant material, generally willow, are tied together to create long cylinders, which are planted in shallow trenches and backfilled with soil.

Plant materials (bareroot, balled & burlap, tubling, container stock, live stakes, and fascines) were provided by a combination of local, regional, and national plant nurseries. Trees are shipped from as far away as Michigan and Montana, as well as trees provided by local in-state nurseries, or collected at adjacent locations within the same watershed. Tree nursery providers were listed individually by name. Most project sites had trees supplied by at least two or three nurseries, with specific tree species generally coming from one nursery, occasionally two. In the case of multiple nurseries supplying the same species, either two separate plant material types were selected for the job, a single nursery couldn’t supply the whole order, or the two nursery providers were intentionally being compared.

In addition to the source of plant material, the study also attempted to identify who planted the trees at each site. Tree planting was completed by a range of experience levels from paid contractors, to youth work groups and community volunteers. Tree planters were grouped into two skill level categories: volunteer (little to no experience) and professional (past tree planting experience expected).

The type of browsing/girdling was identified by bite characteristics for known species including beaver, deer browse, meadow vole, and insects. For example, insect browse on tree leaves was differentiated from vole or beaver browse along the trunk and stem of trees. Prior to tree planting, land use (past ten years) at the restoration sites included: livestock pasture, agricultural cropland, and fallow land. Following tree planting all agricultural and livestock pasture activities were required to cease within the delineated buffer for the extent of the contract, while fallow land could continue with its current use. Past land use practices were recorded as part of this monitoring.

Data Analysis

Survival, condition, and growth were dependent variables that were analyzed by independent variables. Independent variables include: all trees, site, protection materials, plant materials, species, and years since planting. In order to understand trends in survivorship, growth, and condition it was necessary to look at sites with three years of data. Of the twenty-seven monitored sites, fourteen sites have three years of data. Out of the fourteen sites, four were removed because baseline data was not established until the 2nd year after planting; the remaining ten sites were established in the 1st year after planting was completed. The data collected from the remaining ten sites were used to evaluate survival, condition, and growth.

Data were analyzed in SAS program JMP 8.0.1 and Excel 2007. Contingency tables (chi square statistic) were used to compare the frequency of survivorship for seedlings by: site, plant material type, tree protection material, and species. Contingency tables were also used to compare the frequency of condition variables of seedlings by: age of site, tree protection materials, plant material type, and species. A nonparametric two-way analysis of variance test (Wilcoxon signed rank test) was used to analyze the effects of site, plant material, tree protection material, and species on mean seedling growth. When growth or height was analyzed all dead stems were removed.

Plant material type, plant protection materials, and species were analyzed only if they met sample size requirements. Each species, plant protection material or plant material type needed to occur at a minimum of three sites ($n \geq 3$), and occur a minimum of five times ($n \geq 5$) at each site. These requirements removed a substantial amount of data from the analysis for plant material type and species.

The ten sites used for analysis include site numbers: 01, 08, 15, 16, 17, 18, 20, 21, 23, and 24. Plant protection materials were evaluated based on four variables: no mat & no tube, tube only, mat only, or a mat & a tube. Plant materials were divided into two categories: bareroot and balled & burlap. Six species were evaluated through analysis: green ash (*Fraxinus pennsylvanica*), red osier dogwood (*Cornus stolonifera*), silky dogwood (*Cornus amomum*), red maple (*Acer rubrum*), silver maple (*Acer saccharinum)*, and sugar maple (*Acer saccharum*). Three years of data were divided by years after planting, 1st year, 2nd year, and 3rd year.

Plant material types that had insufficient data include tublings, container stock, and live stakes. Species that had insufficient data and were removed from species analysis included: speckled alder (*Alnus rugosa*), black ash (*Fraxinus nigra*), white ash (*Fraxinus americana*), quaking aspen (*Populus tremuloides*), basswood (*Tilia americana*), yellow birch (*Betula alleghaniensis*), boxelder (*Acer negundo*), black cherry (*Prunus serotina*), highbush cranberry (*Viburnum trilobum*), elderberry (*Sambucus canadensis*), American elm (*Ulmus americana*), balsam fir (*Abies balsamea*), hackberry (*Celtis occidentalis*), hazelnut (*Corylus cornuta*), Eastern hemlock (*Tsuga canadensis*), hophornbeam (*Ostrya virginiana*), northern red oak (*Quercus rubra*), swamp white oak (*Quercus bicolor*), white oak (*Quercus alba)*, white pine (*Pinus strobus*), red spruce (*Picea rubens*), willow spp. (*Salix spp*.), and black willow (*Salix nigra*).

Condition data were labeled by categories of percent damage, 0-5% for vigorous trees, 6-25% for healthy trees, 26-50% for moderate trees, 51-75% for unhealthy trees, and 76-99% for very unhealthy trees. Annual survival data were extrapolated from the condition data and stems were marked alive or dead. When necessary, the above stated condition variables, were grouped into three categories: healthy (vigorous and healthy), moderate (moderate), and unhealthy (unhealthy and very unhealthy). Dead stems were removed for the analysis of condition variables.

In 2011, five new sites were established: sites 02, 03, 06, 10, and 26. Initial data were collected in the spring and annual data was collected a second time later in the summer at those five sites. This data was intended to better understand survival and growth across those five sites within the 1st year after planting. Mean survival was calculated in the same way as for the ten sites evaluated with long term data. Mean growth was calculated as the difference between height at the initial survey and height at the secondary survey; all dead stems were removed.

AVIAN POINT COUNT SURVEYS

Study Location

Avian point count surveys were conducted at fifteen sites throughout northwest and central Vermont, USA in the spring of 2011 between May and June (Figure 5). The point count sites were located within four different watersheds, in riparian zones adjacent to rivers and streams. The sites were located in three different treatment types: unplanted, planted, and established riparian buffers associated with riparian habitat restoration.

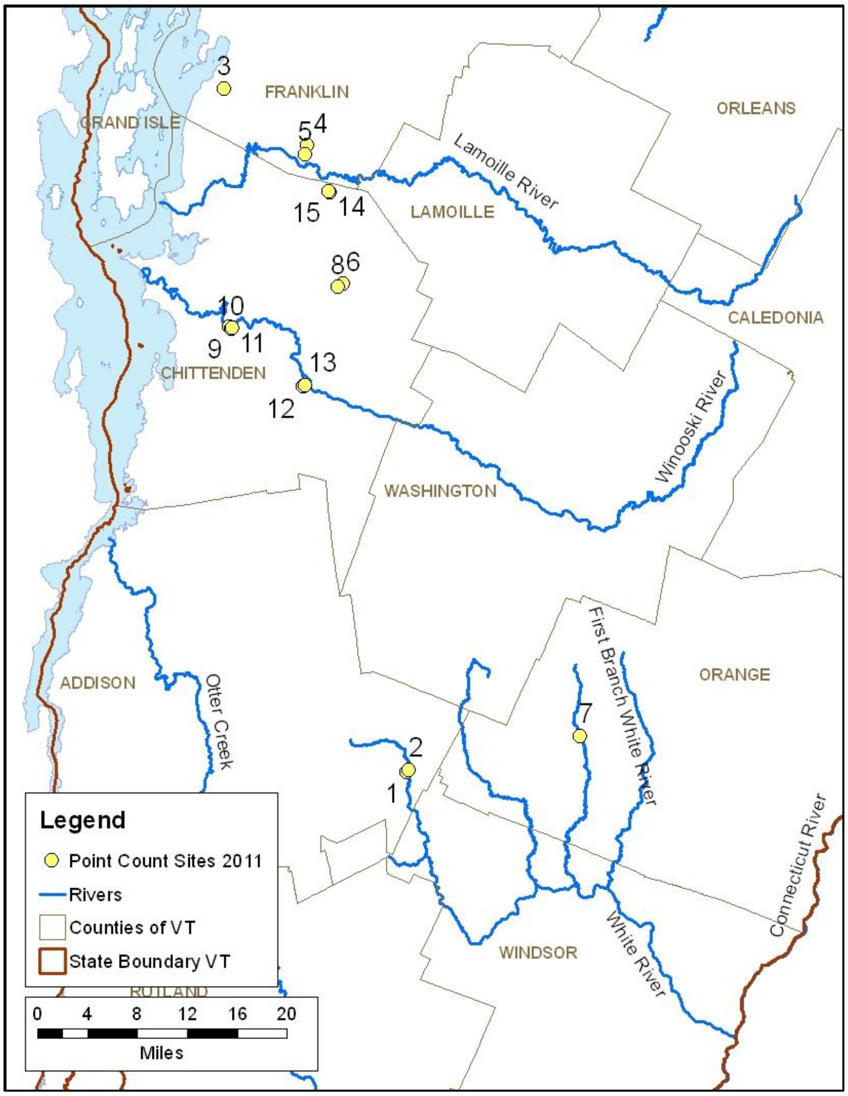

Figure 5. Point Count Survey Sites, Vermont, USA 2011.

Site Selection

Fifteen sites were selected for point count bird surveys. The fifteen sites were selected based on several criteria. Three categories of riparian buffers with different treatment types were defined, identified, and selected: unplanted, planted, or established (Table 2). Five sites were selected to represent each of the three treatment types. Distance from one site to the next was one applied criterion; an attempt was made to group sites in threes, within relatively close proximity to one another. Each site was to be a minimum of 250 meters apart from the point count locations. Within each of the three buffer types, further criteria were applied to the selection process.

Site #	Buffer Type	Town	HUC 8 Name
1	Established	Granville	White River
2	Unplanted	Granville	White River
3	Planted	Georgia	Lake Champlain Direct
4	Unplanted	Fairfax	Lamoille River
5	Unplanted	Fairfax	Lamoille River
6	Unplanted	Jericho	Lamoille River
7	Planted	Randolph	White River
8	Established	Jericho	Lamoille River
9	Unplanted	Williston	Winooski River
10	Planted	Williston	Winooski River
11	Established	Williston	Winooski River
12	Planted	Richmond	Winooski River
13	Established	Richmond	Winooski River
14	Planted	Westford	Lamoille River
15	Established	Westford	Lamoille River

Table 2. Avian point count sites and associated buffer types, Vermont, USA.

Planted sites were the first to be selected. Planted sites were established (planted) 5-10 years prior to the start of the avian point count monitoring surveys. It was preferred these sites also had baseline survivorship and tree monitoring data. Three of the avian point count sites (avian sites: 7, 12, and 14) were sites that had been previously monitored in the tree monitoring surveys (tree monitoring sites: 5, 9, and 27). Avian sites 3 and 10 had no initial tree survivorship and condition baseline data but they met all other criteria.

Unplanted sites are sites which have been determined as in need of riparian habitat restoration by the USFWS or a conservation partner, and they are to be planted in the spring of 2012. These sites were challenging to select because many conservation planners were still implementing 2011 projects and few had established projects for the 2012 season. Five sites (avian sites: 2, 4, 5, 6, and 9) were selected as unplanted avian point count monitoring sites. Established buffers were selected to represent mature, functioning, riparian forests. Established buffers were selected that were within relatively close proximity to either unplanted or planted sites. ARC GIS, Google Earth, and Bing Maps were used to initially select potential sites. After on the ground investigation the sites were further narrowed down and selected (avian sites: 1, 8, 11, 13, and 15).

Study Design

Fifteen point count survey sites were visited between May and June 2011 during the avian breeding season. Data was collected at unplanted, planted, and established riparian buffers in an attempt to track the change in abundance and diversity of bird species associated with riparian habitat restoration sites.

The point count protocol used to conduct this survey was suggested by Professor Noah Perlut PhD, University of New England. The protocol was modified from an existing protocol (Hutto, et al.1986) to better fit the needs of our study. Professor Perlut also recommended a former student, Katherine Dunbar, to conduct the point count surveys. Point counts were conducted at fifteen sites throughout Vermont, May – June, 2011.

Using ARC Map and polygon shape files that were created to denote project boundaries an approximate center point within each polygon (specific to the riparian restoration site) was created, to be used as the point count site within planted and unplanted buffer types. Established buffer types had no preexisting project boundaries; therefore we selected a point count site within the selected established buffer and marked it with the GPS.

Data Collection

Point count data were collected at fifteen sites between May and June 2011. A point count survey was conducted three times at each point count site. Katherine Dunbar conducted all forty-five point count surveys. Each site was visited on a cycle of no less than seven days apart. Point counts were conducted in the morning daylight hours between 5:30am (not before sun-up) and 10:00am. Point counts were not conducted if the wind speed was greater than10 mph and/or if it was raining.

A GPS was used to navigate to the point count sites. All sites were visited prior to the start of the point count survey season to ensure efficiency and minimum disturbance during the actual point counts. Approximately two to four sites were visited in a day during the survey. The person conducting the surveys was equipped with binoculars, a stop watch, and a point count data collection sheet (Appendix 3).

Upon arrival to each site there was a timed 3 minute period of silence. A standard 10 minute point count (three individual point count intervals, each 3 minutes and 20 seconds) was conducted at each site. All birds seen or heard were marked, according to their distance from the point count location, within one of two categories: 0-50 meters or 50-100 meters (Figure 6). A third category – “flyovers” was used to mark birds that flew over the site and were not directly using the site. All individuals were recorded only once during each interval.

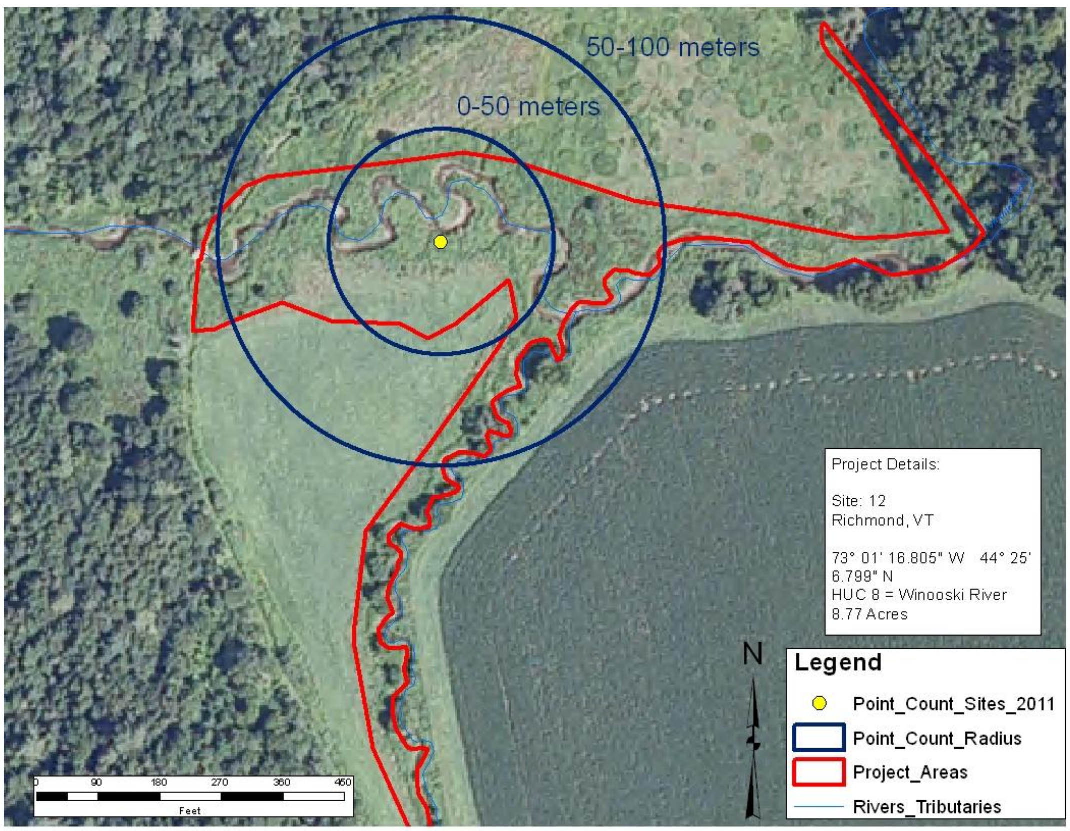

Figure 6. An example of a point count site, showing point count radius and project area boundary.

Data Analysis

Preliminary data analysis was conducted by Noah Perlut, in Microsoft Excel. Analyses included: birds counted (abundance), species richness (diversity), and bird community variation. Data was separated for all three analyses by treatment types: established riparian buffer, no treatment – not yet planted, planted 2006/2007, and planted 1999. Planted sites were separated into two groups because of the seven year gap in time between planting dates. For abundance and diversity, the mean of each treatment type was calculated along with the standard deviation. Bird community variation was associated with six types of landscape communities: shrub, mixed, forest, wetland, foreign, and agriculture. Additional data will be collected for one to two additional years before further analysis will be conducted.

RESULTS AND DISCUSSION

TREE MONITORING

Survivorship

Three years of survivorship data, of all trees and shrubs, indicates that across ten sites the overall mean survivorship within the first year of planting is 96% (n= 595). Mean survivorship continued to decrease to 84% the second year (n= 590), and 72% the third year (n= 574) (Figure 7). The change in survivorship from the 1st year to the 3rd year was found to be significant (p= <0.0001). Mean survivorship changed by 12% between the 1st and 2nd years and the 2nd to 3rd years.

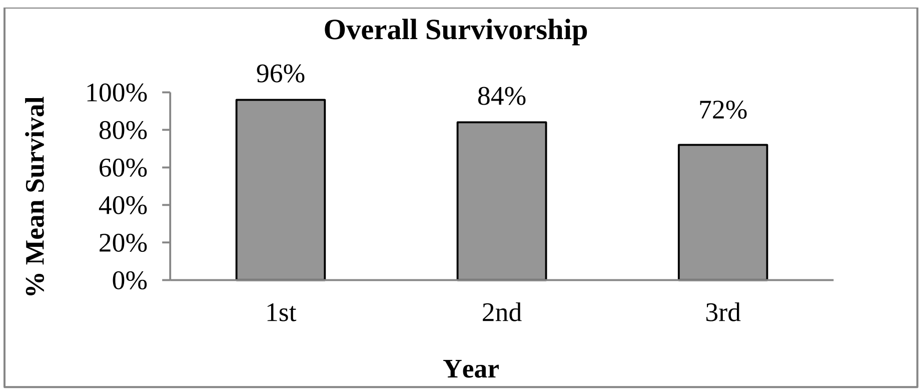

Figure 7. Mean annual seedling survivorship across ten riparian restoration sites, Vermont, USA.

Mean survivorship across ten sites was variable. In the third year of monitoring, individual site survivorship ranged from 97% to 54% (Figure 8). Four sites (01, 16, 21, and 23) had survivorship rates above the mean (74%, 97%, 75%, and 88% respectively); the remaining six sites (08, 15, 17, 18, 20, and 24) had survivorship rates below mean survivorship (67%, 61%, 55%, 65%, 65%, and 67% respectively). Site 16 has the highest 3rd year survivorship at 97% and site 17 has the lowest at 55%.

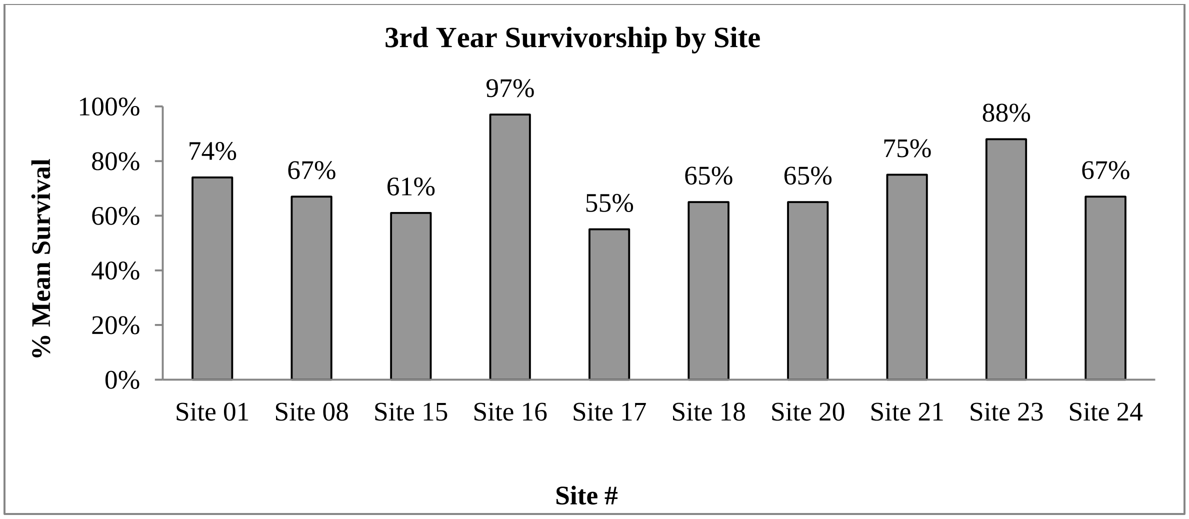

Figure 8. Third year mean survivorship by site across ten riparian restoration sites, Vermont, USA.

Two plant material types, balled & burlap and bareroot stems were analyzed for survivorship. Analysis of mean seedling survivorship by plant material type shows that balled & burlap trees had the greatest 3rd year survivorship (95%) (Table 3). During the 1st year, survivorship varied between plant material types from 100% (balled & burlap) to 95% (bareroot). The difference in 1st year survivorship between balled & burlap and bareroot stems is significant (p= 0.0351).

Plant Material Type	Year, % Mean Survivorship, and Sample Size					
	1st Year % Survivorship	n	2nd Year % Survivorship	n	3rd Year % Survivorship	n
Balled and Burlap	100%	78	99%	78	95%	78
Bareroot	95%	405	81%	403	68%	402

Table 3. Mean annual seedling survivorship by plant material type across ten riparian restoration sites, Vermont, USA.

Survivorship in the 2nd year ranges from 99% for balled & burlap and 81% for bareroot stems. The 18% difference between balled & burlap and bareroot stems was found to be significant (p= <0.0001). Balled and burlap trees have the greatest 3rd year mean survivorship at 95% and bareroot stems have a 3rd year survivorship rate of 68%. The 27% difference between balled & burlap and bareroot 3rd year mean survivorship is significant (p= <0.0001).

Four different combinations of plant protection materials (no mat & no tube, a mat & no tube, a tube & no mat, or a mat & a tube) were compared for survivorship. Analysis of survivorship based on the method of plant protection, including all species and plant material types, indicates that plants with both a mat and a tube have the highest 3rd year mean survivorship at 77% (Table 4). Plants with no protection have a survivorship rate of 69%, suggesting that survivorship increases by 8% with the use of a mat and a tube, however this difference in survivorship is not significant (p = 0.1663). The use of only one protection material either a tube or a mat also leads to increased survivorship (1% and 3% greater survivorship respectively). The increase in survivorship when either a tube or a mat is applied is not significant (p = 0.9503 and p = 0.6070 respectively).

Protection Variables	**Year, % Mean Survivorship and Sample Size (n)**					
	1st Year % Survivorship	n	2nd year % Survivorship	n	3rd Year % Survivorship	n
Mat = No & Tube = No	100%	85	95%	91	69%	120
Mat = No & Tube = Yes	99%	102	96%	97	70%	92
Mat = Yes & Tube = No	94%	238	76%	241	72%	220
Mat = Yes & Tube = Yes	95%	170	84%	161	77%	142

Table 4. Mean annual seedling survivorship by plant protection materials across ten riparian restoration sites, Vermont, USA.

Analysis of 3rd year survivorship was conducted by the method of plant protection for bareroot stems. When both a mat and a tube (n= 120) are applied to a bareroot stem, mean survivorship is 75% (Table 5); when no mat and no tube (n= 38) are applied mean survivorship is 32%. The difference in mean survivorship based on the addition of a mat and a tube is significant (p= <0.0001). When only a mat (n= 152) is applied, mean survivorship is 71%, this 39% increase (as compared to no mat and no tube at 32%) in mean survivorship is significant (p= <0.0001). When only a tube (n= 92) is applied mean survivorship is 70%, this 38% increase (as compared to no mat and no tube at 32%) in survivorship is also significant (p= <0.0001). The highest mean survivorship (75%) for a bareroot stem is achieved when both a mat and a tube are used.

Protection Variables	3rd Year % Survivorship	n
Mat = No & Tube = No	32%	38
Mat = No & Tube = Yes	70%	92
Mat = Yes = & Tube = No	71%	152
Mat = Yes & Tube = Yes	75%	120

Table 5. Mean 3rd year bareroot survivorship by plant protection materials across ten riparian restoration sites, Vermont, USA.

Six species (n= 358) were analyzed individually by 3rd year survivorship: green ash (*Fraxinus pennsylvanica*) (n= 33), red osier dogwood (*Cornus stolonifera*) (n= 41), silky dogwood (*Cornus amomum*) (n= 43), red maple (*Acer rubrum*) (n= 107), silver maple (*Acer saccharinum*) (n= 64), and sugar maple (*Acer saccharum*) (n= 43). Species analysis includes all plant material types in order to achieve the desired sample size; each species does include more than one plant material type (Table 6).

Species and Plant Material Type	Count of Species by Plant Material Type (n=)
Ash, Green	
Bare Root	30
Container Grown	3
Dogwood, Red Osier	
Bare Root	23
Container Grown	5
Tubling	13
Dogwood, Silky	
Bare Root	41
Container Grown	2
Maple, Red	
Balled and	28
Bare Root	67
Container Grown	12
Maple, Silver	
Bare Root	57
Container Grown	7
Maple, Sugar	
Balled and	14
Bare Root	28
Grand Total	**330**

Table 6. Species, plant material type, and distribution of sample size across ten riparian restoration sites, Vermont, USA.

Of the six species analyzed for survivorship, four (green ash, red osier dogwood, silky dogwood, and red maple) had higher mean survivorship than the overall mean survivorship (72%). The remaining two species (silver maple and sugar maple) each had mean survivorship less than the overall mean. Green ash had the highest 3rd year mean survivorship at 94% and sugar maple had the lowest at 50% (Figure 9).

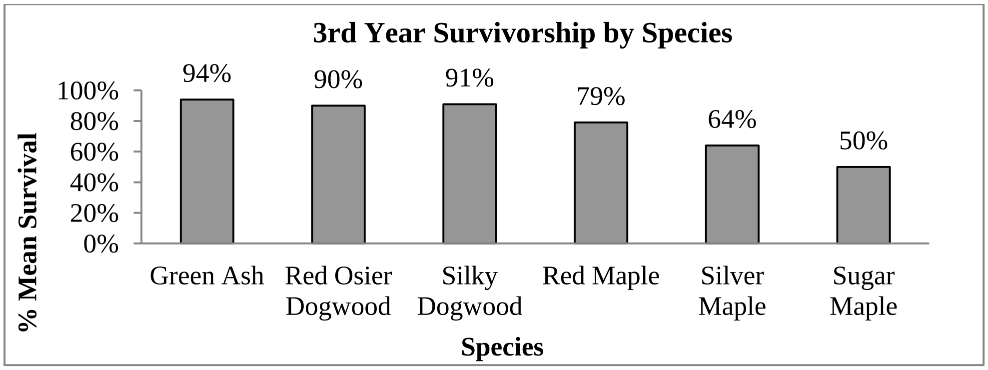

Figure 9. Mean third year seedling survivorship by species across ten riparian restoration sites, Vermont, USA.

Survivorship analysis for the five new sites established in 2011 reveals 99% mean survivorship within the initial survey and 86% mean survivorship within the secondary survey (Figure 10). When survivorship was analyzed by plant material type initial survey results show balled & burlap (n= 26) with 100% survival and bareroot (n= 164) with 99% mean survival. The 1% dead bareroot plants were planted dead; this is known because monitoring was conducted immediately after planting. Secondary survey results show that balled & burlap stems had 96% mean survival and bareroot had 85% mean survival after the 1st year.

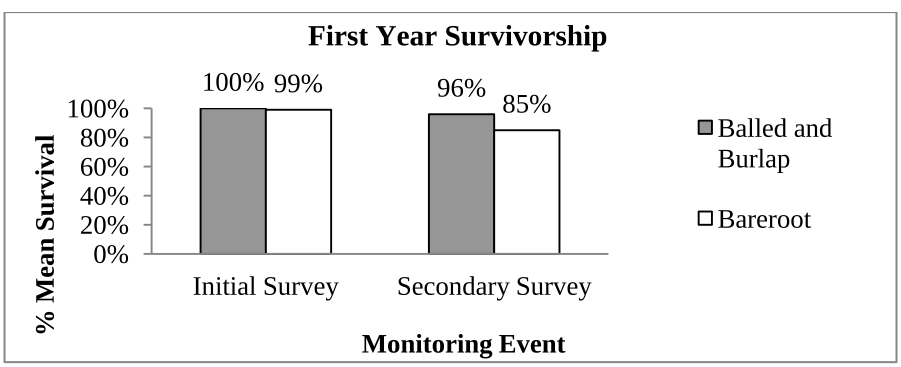

Figure 10. Mean survivorship across 5 riparian restoration sites in the 1st year after planting, Vermont, USA.

Condition

Tree health was measured by five condition variables ranging from vigorous to very unhealthy. Analysis of condition, when all sites were combined and dead stems removed, reveals that the amount of vigorous stems increased between the 1st (5%) and 2nd (9%) growing years and showed no change between the 2nd and 3rd years (9%) (Figure 11). Healthy stems represent the majority of stems in the 1st year (59%). Healthy stems appear to decrease between the 1st and 2nd years (59% - 39%) and then increase slightly in the 3rd year (42%). Moderate stems increase each year over the 3 year period (23%, 29%, and 32% respectively), representing approximately one quarter of the 1st and 2nd years and one third of all trees in the 3rd year. Unhealthy stems increased between the 1st and 2nd years from 7% - 16% and then decreased in the 3rd year to 12%. Very unhealthy stems represented 6% of stems for the 1st year, increased to 7% the 2nd year, and decreased back to 6% in the 3rd year. The figure below demonstrates the initial health of the seedlings in the 1st year, followed by a dramatic decrease and then a slow improvement in health by the 3rd year.

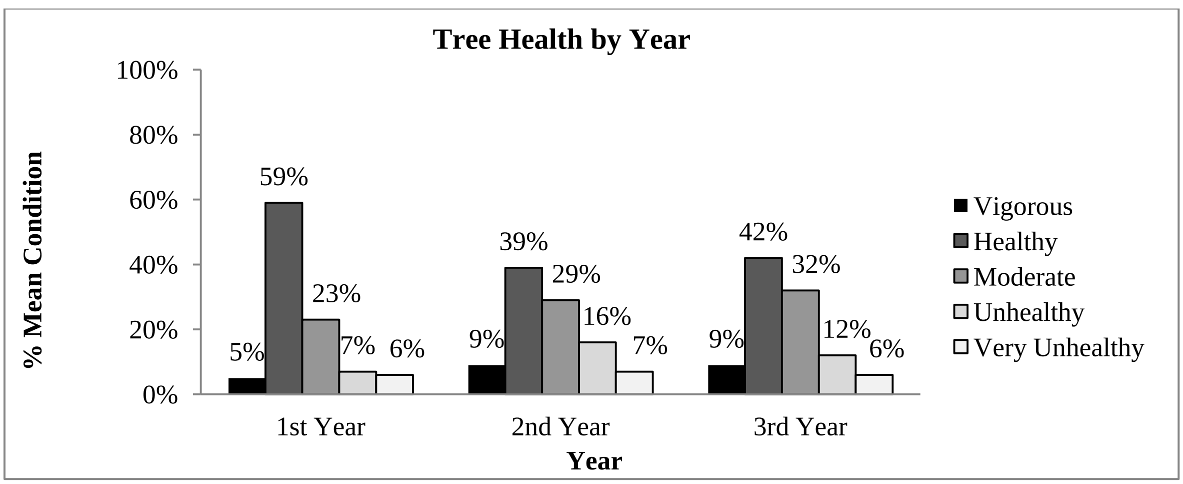

Figure 11. Mean annual tree health based on five condition variables across ten riparian restoration sites, Vermont, USA.

Analysis of condition, based on plant protection materials, reveals that trees with tubes (mat & tube (n= 109) and tube only (n= 64)), in the 3rd year, have the highest combined percentage of unhealthy and very unhealthy stems (25% and 26% respectively). Trees with no tubes (no mat & no tube (n= 82) and mat only (n= 158) in the 3rd year have a much lower combined percentage of unhealthy and very unhealthy stems (13% and 10% respectively). When we compared all four combinations of plant protection materials the difference in 3rd year condition across different protection variables was significant (p= 0.0007).

Five variables of health were challenging to compare. To simplify analysis and comparisons of health, condition variables were grouped into three categories: healthy, moderate, and unhealthy. Healthy and unhealthy stems were compared for all combinations of plant protection materials. Analysis of stems with a mat & tube vs. no mat & no tube shows that stems with no protection were significantly healthier than stems with a mat & a tube (p=0.0059) (Table 7). A comparison of stems with only a tube vs. no mat & no tube shows stems with no protection to be healthier than stems with a tube. This difference in health is significant (p= 0.0227). The difference between no mat & no tube and a mat only showed no significance (p = 0.6194). When stems with a mat & a tube vs. tube only were compared the difference in health was not found to be significant (p = 0.7889). When stems with a mat & a tube vs. a mat only were analyzed stems with only a mat were healthier and the difference in health was found to be significant (p= 0.0002).

Protection Materials	**3rd Year % Mean Condition by Protection Materials**		
	Healthy	Moderate	Unhealthy
Mat and Tube	37%	39%	25%
Mat Only	57%	33%	10%
No Mat No Tube	61%	26%	13%
Tube Only	44%	30%	27%

Table 7. Mean third year seedling health based on three (grouped) condition variables by plant protection material type, Vermont, USA.

Two plant material types were analyzed by condition: balled & burlap (n = 74) and bareroot (n= 273). Analysis of 3rd year condition, across all sites, with dead stems removed, shows balled and burlap and bareroot stems have similar distributions of condition variables (Figure 12).

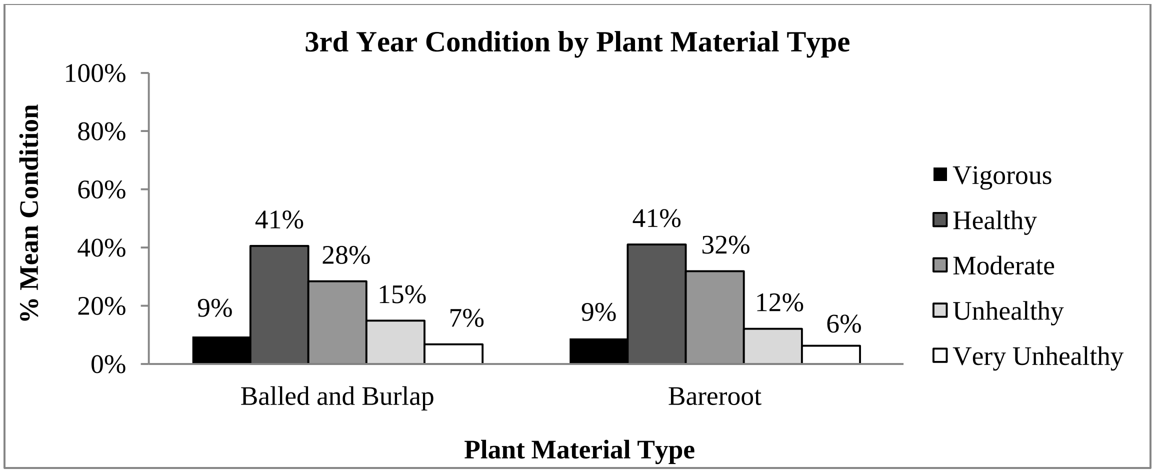

Figure 12. Mean third year seedling health based on five condition variables across ten riparian restoration sites, Vermont, USA.

Both plant material types showed a decrease in healthy stems between the 1st and 2nd years, followed by an increase in the 3rd year (Table 8). The same pattern was true for unhealthy stems; there was an initial increase in unhealthy stems in the 1st and 2nd years followed by a decrease in the 3rd year, with the exception of balled & burlap stems which continued to show an increase of unhealthy stems.

Plant Material Type and Year	Vigorous	Healthy	Moderate	Unhealthy	V. Unhealthy
Balled & Burlap					
1st Year	6%	53%	35%	5%	0%
2nd Year	8%	40%	40%	8%	4%
3rd Year	9%	41%	28%	15%	7%
Bare Root					
1st Year	4%	60%	22%	7%	6%
2nd Year	7%	37%	27%	20%	9%
3rd Year	9%	41%	32%	12%	6%

Table 8. Mean seedling health based on five condition variables by plant material type and year across ten riparian restoration sites, Vermont, USA.

Six species were analyzed by condition for 3rd year data. Most of the species had similar percentages for each of the various condition categories (Figure 13). Several species stood out, having higher percentages of moderate, unhealthy and v. unhealthy stems. Red maple had the largest percentage of moderate stems (53%), silver maple had the largest percentage of unhealthy stems (27%) and sugar maple had the largest percentage of v. unhealthy stems (14%). The species with the most vigorous stems was silky dogwood with 11%. Green ash (58%), red osier dogwood (62%), and silky dogwood (55%) had the highest percentage of healthy stems. In general 3rd year data shows that four of the six species have the majority of their stems in the healthy condition category with the exception of red maple and silver maple.

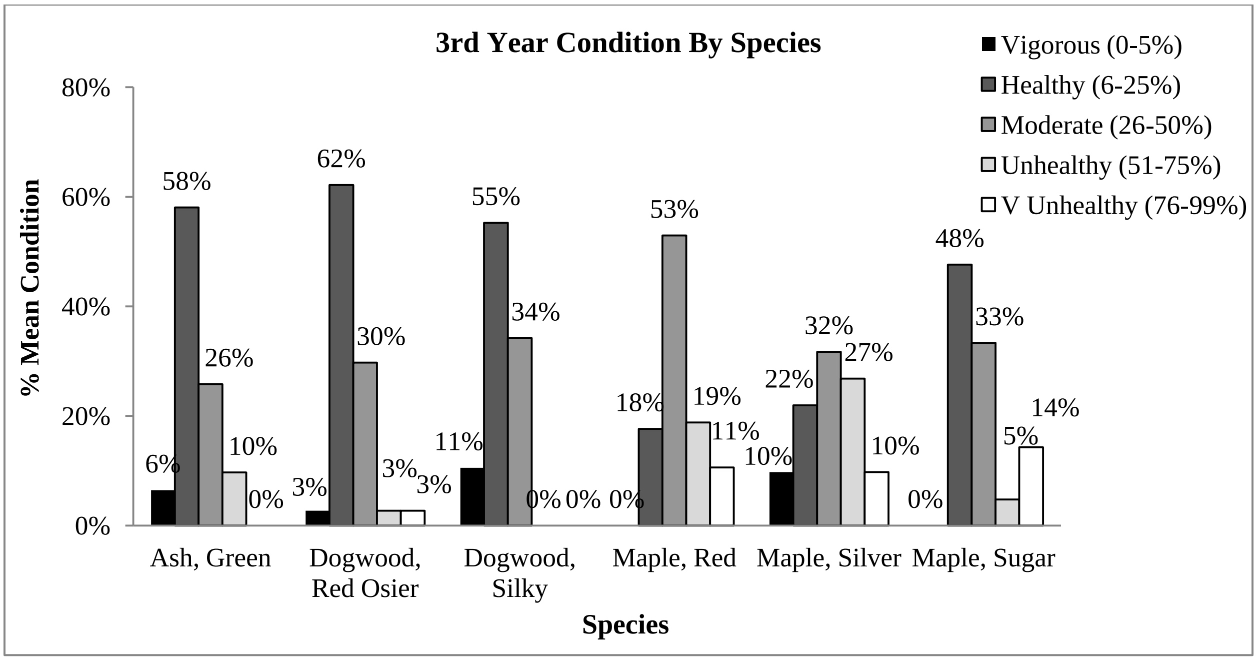

Figure 13. Mean third year seedling health, based on five condition variables, by species across ten riparian restoration sites, Vermont, USA.

<u>Growth</u>

Across all sites, between the 1st and 2nd years of monitoring, mean stem growth was 4 inches (Figure 14). and from the 2ndyear to the 3rd year, mean stem growth was 5 inches, the total mean growth over the three year period was 9 inches ($p=<0.0001$). Growth could not be calculated for the 1st year, because the 1st year we established baseline data, and did not return to the sites until the 2nd year. Growth was found to be steady between 4 and 5 inches each year.

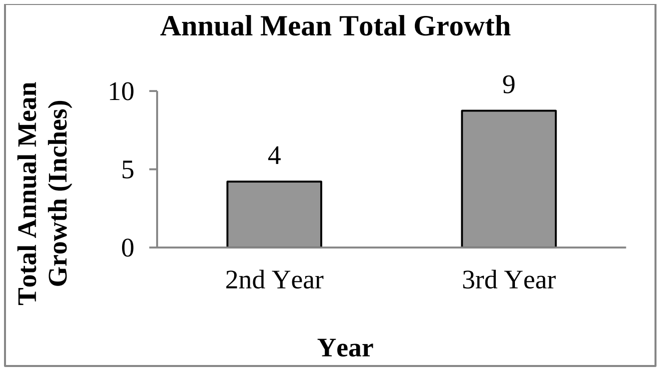

Figure 14. Mean annual seedling growth across ten riparian restoration sites, Vermont, USA.

Growth at each site was compared for the 2nd and 3rd years of monitoring after planting. The sample size of stems across all ten sites varied (n= 28 to n= 92 in the 2nd year and n= 18 to n= 92 in the 3rd year) (Table 9). Of the ten sites that have been monitored for 3 years or more, the mean growth increased at nine sites and decreased at one. Although the majority of sites showed growth, it was variable across all ten sites. Site 18 grew more than any other site between the 1st and 2nd year (18 inches). Site 23 grew more than any other site between the 2nd and 3rd year (9 inches). Site 18 grew the most over all, across all sites, from the 1st year to the 3rd year (23 inches). Site 16 did not show any positive growth between the 1st and 2nd year; in fact, it decreased by 17 inches. Between the 2nd and 3rd years site 16 increased by 8 inches.

Site #	2nd Year Mean Growth	Sample Size (n=)	3rd Year Mean Growth	Sample Size (n=)
Site 01	3	57	5	39
Site 08	15	44	19	33
Site 15	7	66	11	42
Site 16	-17	30	-9	30
Site 17	-1	28	6	18
Site 18	18	28	23	20
Site 20	2	45	10	39
Site 21	-3	44	7	39
Site 23	4	92	13	92
Site 24	7	63	4	62

Table 9. Mean second and third year seedling growth by site across ten riparian restoration sites, Vermont, USA.

The average growth of balled and burlap (2nd year n= 77, 3rd year n= 74) and bareroot seedling (2nd year n= 326, 3rd year n= 274) plant material types was calculated and compared across ten monitoring sites (Figure 15). Balled & burlap stems are the tallest of all the plant material types in this study at the time of planting. Monitoring data shows that balled and burlap stems on average are 105 inches at the time of planting. Mean growth figures show that balled & burlap stems decreased by 4 inches between the 1st and 2nd years of monitoring. Mean growth further decreased between the 2nd and 3rd years by 1 inch, a total mean decrease of 5 inches, by the 3rd year. Bareroot stems have a mean 1st year height of 24 inches. Bareroot stems grew by a mean of 6 inches between the 1st and 2nd years. For bareroot stems the mean growth continued to increase between the 2nd and 3rd years by 6 inches. The total mean growth over three years for bareroot stems is 12 inches. The 17 inch difference in growth, over three years, between balled & burlap and bareroot seedlings is significant (p= 0.0005).

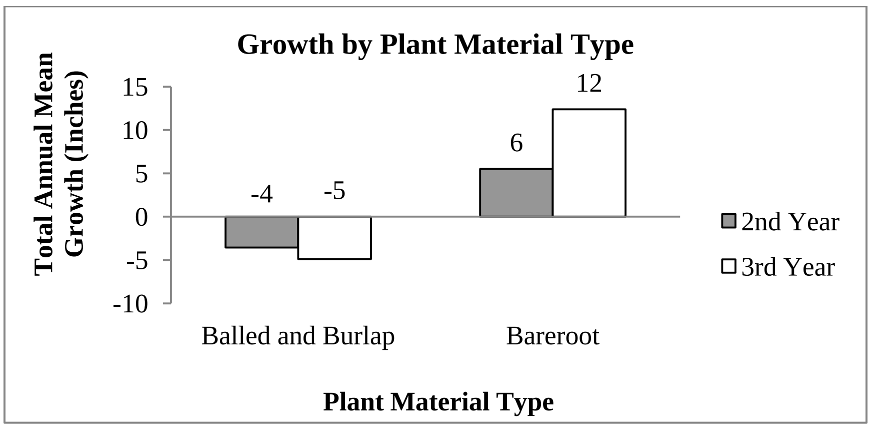

Figure 15. Mean second and third year seedling growth by plant material type across ten riparian restoration sites, Vermont, USA.

Across ten sites and over three years, six species had a large enough representative population to be analyzed for growth: green ash (*Fraxinus pennsylvanica*) (n= 31), red osier dogwood (*Cornus stolonifera*) (n= 37), silky dogwood (*Cornus amomum*) (n= 39), red maple (*Acer rubrum*) (n= 85), silver maple (*Acer saccharinum*) (n= 41), and sugar maple (*Acer saccharum*) (n= 21).

Of the six species analyzed for growth green ash grew the most with an average growth of 21 inches (Figure 16). Sugar maple and red maple grew the least, on average they decreased by (-) 4 inches. Mean growth figures indicate that red osier dogwood increased by 13 inches, silky dogwood increased by 12 inches, and silver maple increased by 9 inches. Growth was found to only be significant for red osier dogwood (p= 0.0009) and silky dogwood (p= 0.0152). When all six species were grouped together overall growth was found to be significant (p= 0.0075).

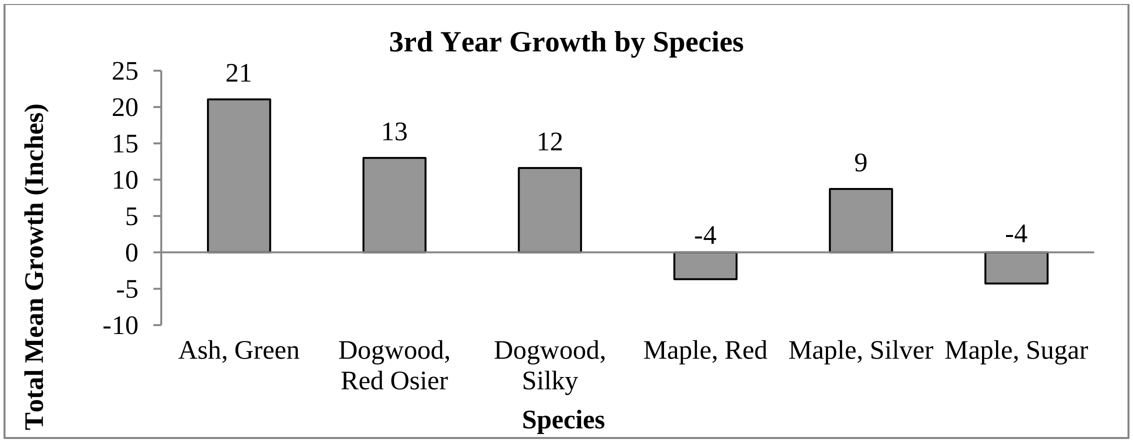

Figure 16. Mean third year growth by species across ten riparian restoration sites, Vermont, USA.

Analysis of plant protection variables and growth shows that stems with protection had a higher mean growth over three years than stems with no protection (Figure 17). Stems with only a tube grew the most by the 3rd year with a mean height of 13 inches, however overall growth was not found to be significant. Stems with no protection grew the least with a mean height of 7 inches, and growth was not found to be significant. Stems with a mat and a tube grew 9 inches and stems with only a mat grew 8 inches. Growth for stems with a mat and a tube was significant (p= 0.0244) as was growth for stems with only a mat (p= 0.0001). When each plant protection material was compared directly against one another for growth, the difference in growth was not found to be significant. However, when stems with only a mat and only a tube were compared the 5 inch difference was notable (p= 0.0599).

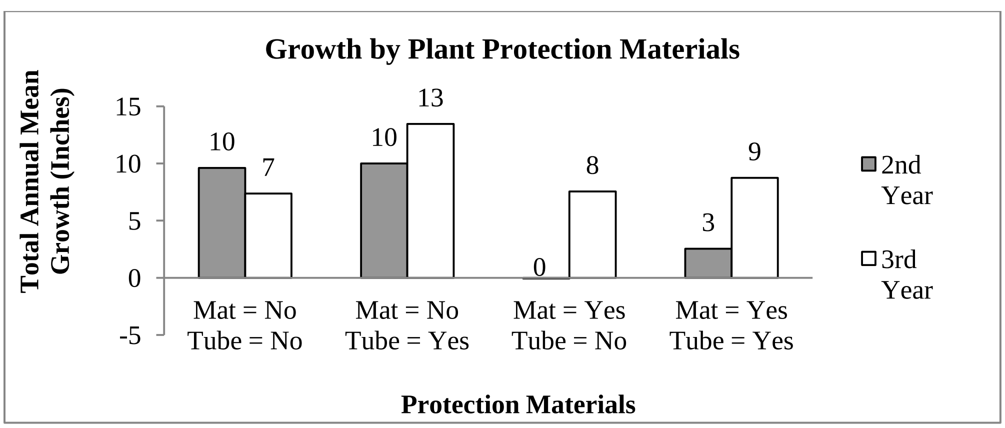

Figure 17. Total mean seedling growth by protection material, for the 2nd and 3rd years, across ten riparian restoration sites, Vermont, USA.

Condition and growth were compared for 2nd year and 3rd year data. Analysis suggests that growth is contingent upon condition because as condition improves, growth increases (Figure 18). Analysis based on mean growth shows that vigorous stems grew 26 inches between the 2nd and 3rd years and very unhealthy stems decreased by 9 inches. Both vigorous and very unhealthy growth rates were found to be significant ($p = <0.0001$ and $p = 0.0188$ respectively). Healthy stems increased 8 inches between the 2nd and 3rd years, this increase in height was significant ($p = <0.0001$). Unhealthy stems decreased by 11 inches between the 2nd and 3rd years, this decrease was also found to be significant ($p = 0.0302$). Moderate stems showed no change.

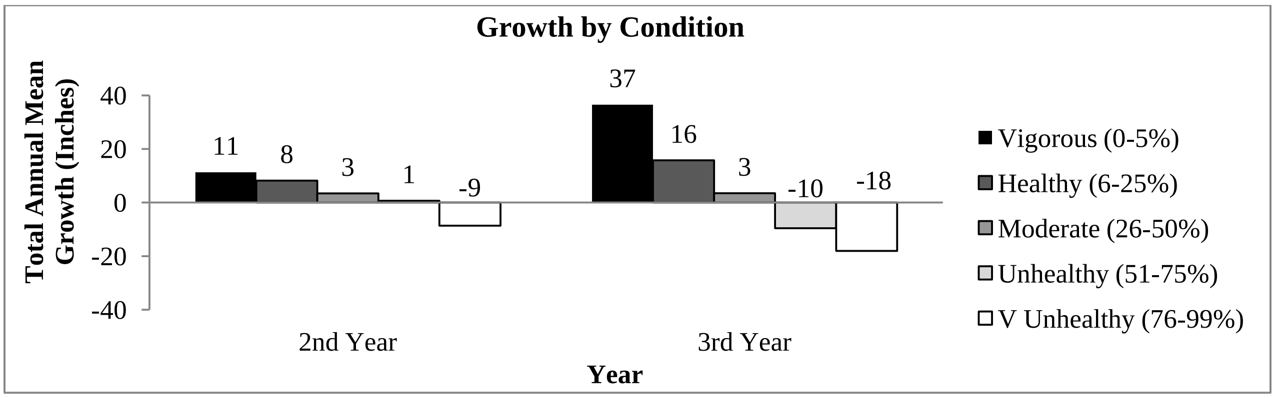

Figure 18. Mean second and third year growth by condition across ten riparian restoration sites, Vermont, USA.

In a separate analysis of growth by condition, condition variables were grouped into three categories: healthy (n=208) (vigorous 0-5% and healthy 6-25%), moderate (n=134) (moderate 26-50%), and unhealthy (n=71) (unhealthy 51-75% and very unhealthy 76%-99%). Third year data shows that healthy stems grew 19 inches and unhealthy stems decreased by (-) 12 inches. The 31 inch difference in mean 3rd year growth between healthy and unhealthy stems is significant ($p = <0.0001$). When healthy and moderate stems are compared there is a significant difference in mean 3rd year growth of 16 inches ($p = <0.0001$). There is also a significant difference between moderate and unhealthy stems for mean 3rd year growth of 16 inches ($p = <0.0001$).

In 2011 we established five new monitoring sites in an effort to better understand the changes that take place within the 1st year after planting; these sites were monitored twice. These five sites were initially monitored, as soon after planting was completed as possible. A second survey was conducted, at each of the five sites, toward the end of the monitoring season in late summer. Based on height measurements taken in these two surveys, mean tree growth was 1 inch within the 1st year (Figure 19). Of the five sites monitored twice, the mean height increased at three sites (02, 03, and 10), decreased at one (26), and one (06) showed no change.

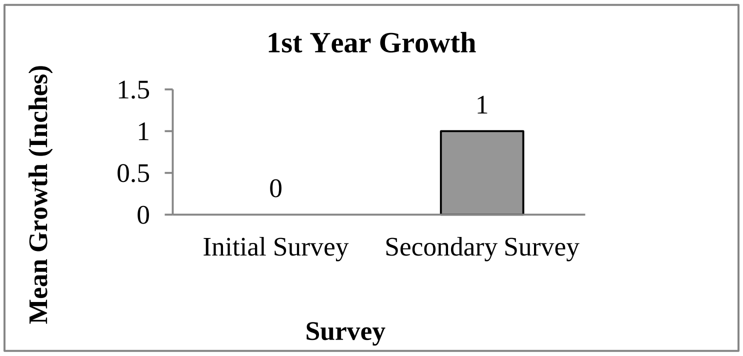

Figure 19. Mean first year mean seedling growth across five riparian restoration sites, Vermont, USA.

Discussion

There are many factors which potentially contribute to the survivorship of planted seedlings, some of which we measured in this study, and others we did not take into account. Site, plant material type, plant protection materials, and species all had significant impacts on survivorship. These four variables with respect to our results should be taken into consideration during the planning and implementation process. Due to the variability of survivorship at individual sites we recognize that there are contributing factors and site specific conditions which are also influencing survivorship which we did not monitor.

In this study mean third year survivorship of planted trees calculated across ten riparian restoration sites reveals 72% survivorship. Third year survivorship when analyzed by site was found to be significantly variable ranging from 97%-55% survival. The variation in survivorship when comparing sites is consistent with findings from other studies. Sweeny and Czapka (2004) reported that site can significantly impact survivorship, further highlighting soil moisture, fertility, light, and temperature regime as major components of site variability. The variability in site conditions and resulting fluctuation in survivorship emphasize the importance of site specific planning; consideration of appropriate species, plant material, and protection materials is necessary in order to increase survival on a site by site basis.

When balled & burlap stems and bareroot stems were compared for 3rd year survivorship, we found balled & burlap had the highest survival (95% and 68% respectively). Balled & burlap stems are often used in specific applications such as “witness trees” to delineate a boundary between a new buffer planting and an agricultural field (with no fence). Despite the significant difference in survivorship, plant material expense and site logistics prevent exclusive use of balled & burlap stems on riparian restoration projects. Further data collection and understanding of site specific variables may help to improve overall survivorship of bareroot seedlings.

When all plant material types were grouped together and protection methods were compared for survivorship, we found no statistically significant difference. However, when only bareroot stems were analyzed for protection and survivorship, we found a significant difference in survivorship between stems planted with a mat & a tube and stems with no protection materials (75% and 32% respectively). These findings are consistent with previous studies of bareroot material, which state a mat and a tube or just a mat or tube, significantly increase survivorship (Keeton 2008; Lai and Wong 2005; Sweeney et al. 2002; West et al. 1999). Sweeney and Czapka reported almost identical findings to our study (43% difference in survival), stating that tree shelters exhibit on average about 39% higher survival. Another study (Sweeney et al. 2002) found that only the combinations of a tube and a mat or a tube and herbicide produced 4th year survivorship rates greater than 50% (57.5% and 88.8% respectively).

Of the six species analyzed, green ash was found to have the highest 3rd year survivorship at 94%, and sugar maple has the lowest at 50%. The variability of survivorship across different species is consistent with other research findings (Keeton 2008; Sweeney et al. 2002; Sweeney and Czapka 2004; West et al. 1999). Based on the monitoring results and results from the literature, species selection is a very important factor in overall survivorship associated with riparian restoration projects.

Overall mean stem growth increased by 9 inches across 10 riparian restoration sites over three years. Growth at each site was variable and decreased by as much as (-) 9 inches and increased by as much as 23 inches. Plant material type also demonstrated variability of growth; bareroot trees had the greatest mean growth of 12 inches over 3 years. Of the six species analyzed for growth, green ash grew the most, at 21 inches and sugar maple decreased by(-) 4 inches. The decrease in height can be explained by several scenarios; some sites were dramatically impacted by beaver browse, other sites were impacted by deer browse, and overall tip die back was a major factor in the decrease of stem growth, specifically for balled and burlap seedlings.

In this study plant protection materials were found to increase growth; the greatest seedling increase was observed for stems with a tree tube and no mat. It has been widely recognized that the addition of a tree tube significantly increases seedling growth (Clatterbuck 1999; Lai and Wong 2005; Lantagne 1995; Potter 1988; Sweeney and Czapka 2004; Sweeney et al. 2002; West et al. 1999). Sweeney and Czapka (2004) discovered 300% greater growth for seedlings with tubes by year five than those without. One study in particular found that while this initial growth advantage is significant it is not maintained once the seedling emerges from the tube (Clatterbuck, 1999).

The condition of trees and shrubs may help to predict future trends in survivorship. Condition, like survivorship can help to determine successful planting and planning practices. It was observed that the condition of seedlings significantly decreases initially after planting and then slowly increases. Condition based on plant material type for balled & burlap and bareroot stems are similarly distributed; both plant material types have a majority of stems recorded as vigorous to healthy. Plant protection materials were found to impact tree health; stems with no protection were found to be the healthiest in the 3rd year. This finding is somewhat contradictory to the finding that protection materials increase survival, which raises the question: when do protection materials need to be removed? In general, the measure of condition, investigated in this study can be used to better understand trends over time. Currently, the seedlings overall are trending towards becoming more healthy as they become established; at the same time, the seedlings with protection materials are potentially showing a trend of becoming less healthy. We will consider these observations in future analysis as our ability to look at trends improves over time.

AVAIAN POINT COUNTS

Abundance, Diversity, and Bird Community Variation

The results of the avian point counts represent one season of data collection. This is strictly preliminary data, no conclusions were made from these analyses. Analysis was conducted on three treatment types: established riparian buffer, no treatment (not yet planted), and planted sites (Table 10). Planted sites were divided into two groups due to the time between planting dates. Preliminary data analysis allowed us to calculate: birds counted (abundance), species richness (diversity), and bird community variation. Additional data collection of 1-2 more years will allow for further analysis.

Treatment Type	Sample Size (n=)	Site Numbers
Established riparian buffer	5	1, 8, 11, 13, 15
No treatment, not yet planted	5	2, 4, 5, 6, 9
Planted 2006/2007	4	3, 7, 12, 14
Planted 1999	1	10

Table 10. Avian point count monitoring sites and associated riparian habitat restoration treatment types, Vermont, USA.

Preliminary analysis indicates that the number of individuals counted varied among treatments, but importantly, showed signficant variation within a given treatment (Figure 20). The Planted 2006/2007 treatment was heavily biased by a single point (Site 3) where 780 Canada Geese (*Branta canadensis)* were counted. Mean abundance suggests that the greatest number of individuals were found at planted sites; the least number of individuals were counted at established sites.

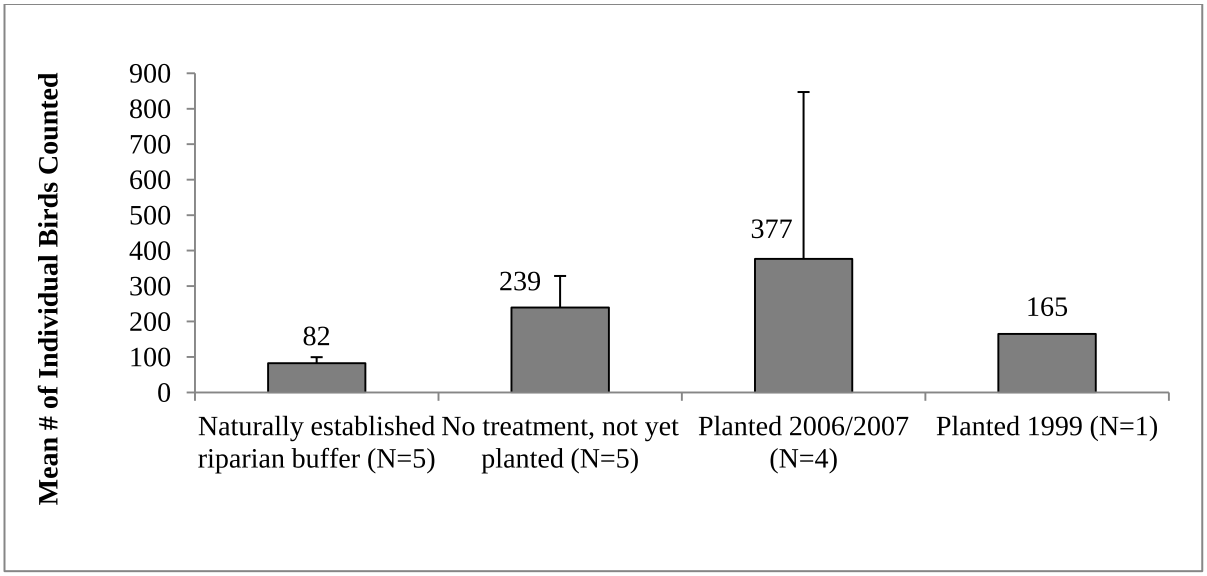

Figure 20. Mean bird abundance by treatment type across 15 sites, Vermont, USA.

Based on preliminary analysis there was little variation in species richness across treatments (Figure 21). Sites with no treatment (not yet planted) had the lowest mean diversity (19) and the single planted 1999 site had the highest mean diversity (25).

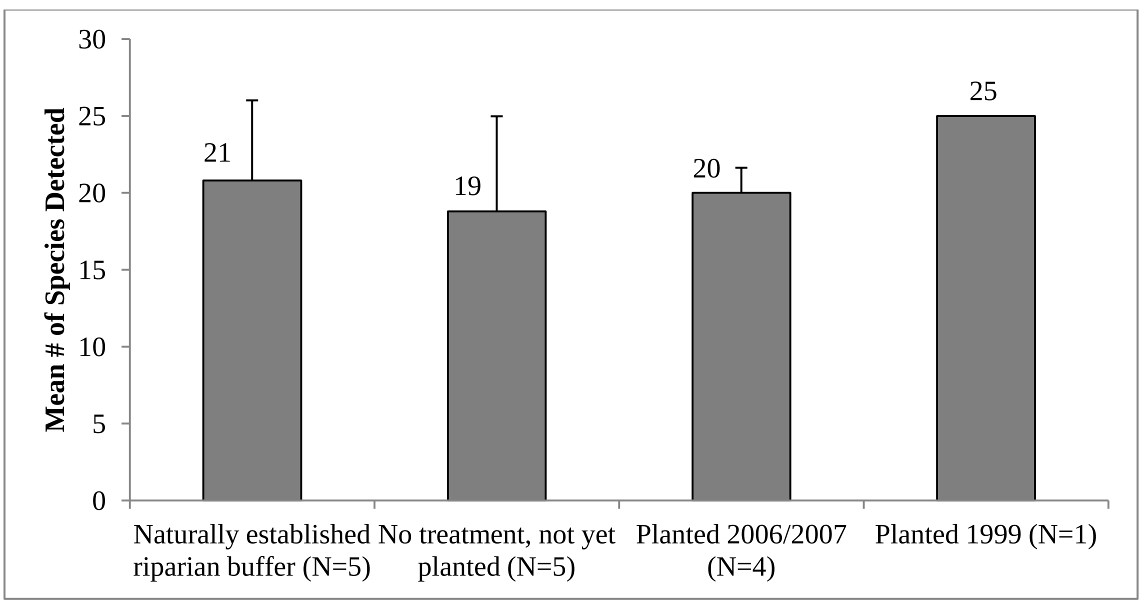

Figure 21. Mean species diversity across treatment types at 15 sites, Vermont, USA.

While species richness did not significantly differ across treatments, the species communities showed some variation, particularly between the wetland and forest species (Figure 22). Established riparian buffers had the greatest percent of species associated with forested landscapes (48%) and planted sites had the least (32% and 24%). Planted sites had the greatest percent of species associated with wetlands (30% and 36%) and established riparian buffers had the least (22%).

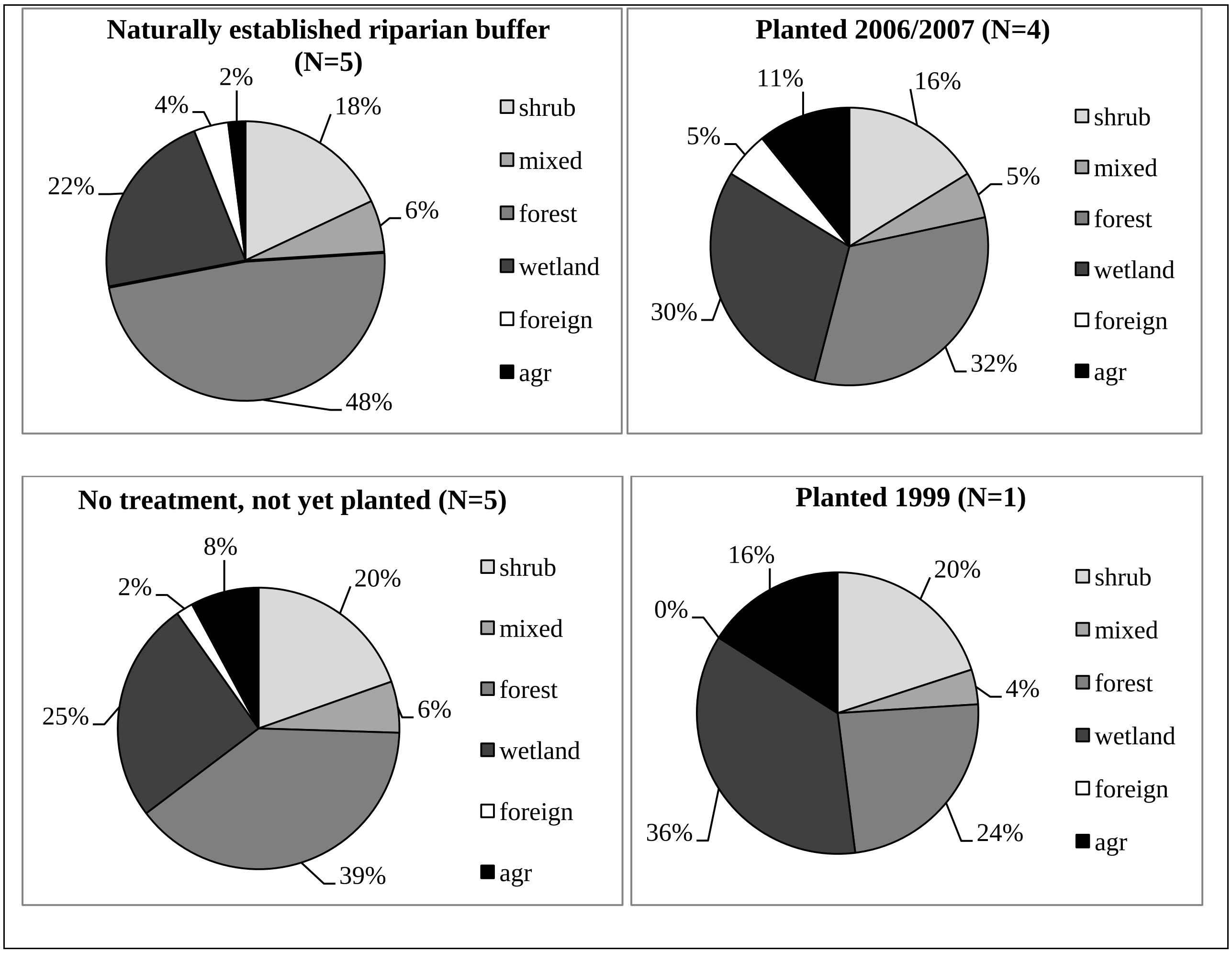

Figure 22. Bird community variation across treatment types at 15 sites, Vermont, USA.

Over the course of point count surveys in 2011 a total of 48 different bird species were counted at established sites, 42 species were counted at planted sites, and 48 species were counted at unplanted sites (Appendix 4). Ten species were unique to established sites, four species were unique to planted sites, and 7 species were unique to unplanted sites. Future data collection will be analyzed to provide insight regaurding species diversity and abundance.

RECOMMENDATIONS FOR FUTURE WORK

In the future we may be able to add other variables such as soil type, soil moisture, topography, and climate/weather data, and so on to our data collection and analysis. Analysis of our existing database was helpful to identify areas where we need to expand our data collection. Many of our analyses were limited due to insufficient sample sizes and/or distribution. Species analysis was limited to 6 tree and shrub species out of 29 monitored species. Based on the data it is clear that species type has a significant impact on survivorship. We will work to increase the sample size of each of the 23 species we could not analyze. Plant material type was another category where we had insufficient data on many of the material types used in these projects and in the future we will focus on expanding our sample sizes specifically for tublings, container stock, and live stakes.

Very little (if any) maintenance is conducted at these restoration sites post implementation. Follow-up maintenance could include tree watering, removal of competing vegetation, inter-planting, invasive removal, and tree tube and brush mat removal. Our monitoring observations indicate that a substantial number of seedlings die due to the competition of herbaceous plants such as reedcanary grass, bindweed, bedstraw, and so on. Annual follow-up could improve survival by removing herbaceous competition that has impacted the structural integrity of the tree and/or shrub. Further work could be done to facilitate logistics necessary to include annual maintenance for a predetermined length of time post project implementation.

On Wednesday December 7th the Intervale hosted a symposium to share the results from this monitoring project with approximately forty project partners including planners, implementers, growers, educators, researchers, and administrators. Sharing the results with practitioners generated discussion and further questions. Most importantly, we shared the monitoring protocol and results with the intention of encouraging the expansion of monitoring efforts. Partners indicated potential resources (labor, finances, and planning) exist to expand monitoring efforts.

During the symposium we discussed the idea of follow-up maintenance; specifically the removal of tree tubes and mats. Symposium participants suggested that the contracts currently signed by landowners and partnering agencies should be updated to acknowledge and include what we have learned, i.e. that tubes and mats are not biodegrading as advertised and inevitably damaging and even killing otherwise healthy trees. In 2012 the USFWS, the Intervale, and local conservation partners will be taking steps to remove tree tubes on projects older than five years. Project partners believe the tube removal efforts will lead to standardized pre-project planning that would account for the future removal of tree tubes and mats.

The Interval and USFWS plan to continue monitoring efforts, with a goal of collecting five years of data per site. Data collected during additional growing seasons will better inform the trends of survivorship, growth, and condition. Our database will continue to expand, as we continue to re-monitor sites which have been added to our list each year. In 2012 our sites with 3 years of data will increase from 10 to 17 sites and in 2013 from 17 to 23 sites, resulting in increased sample sizes each year. Future analysis is planned for variables such as stem browse, girdling, vegetative competition, and nursery source.

Ultimately, we would like to provide the restoration community with a set of guidelines based on the findings of our monitoring efforts and the results from pertinent research projects. To date the information gained from the riparian monitoring project can be used by project partners to better understand how riparian restoration projects are responding across Vermont. Adjustments to current practices, based on the findings in this report, if adopted by practitioners will likely improve overall project success.

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APPENDICIES

APPENDIX A

Riparian Restoration Monitoring Protocol

This protocol is designed for monitoring tree survival at riparian restoration projects. By setting up permanent transects and recording information about specific trees (species, mat, tube, etc.), we can return to the sites in the future to evaluate tree survival.

1) Before going to the field

A) Call FWS to get tree tags. Leah Szafranski (802) 872-0629 ext 28

B) Make or obtain a map of the project site, and decide how many transects you want. Transects run perpendicular to the stream, and should extend a few feet beyond the extent of the planted trees. The first transect should be at least 50 feet from the project boundary (Figure 1). A reasonable number of transects is 3 for a small site (1 acre) and 5 for a larger site. Transects should be at least 200 ft apart and equally distributed throughout the project area.

C) Make sure you have all the things you need on the check list included in the spreadsheet.

D) Determine what nursery the trees are from, and who planted the trees. If a planting plan is available it may have this information. The NRCS contact for the county may know this information or be able to refer you to someone. Be aware that trees ordered from one nursery may have been grown at another. For example, if I order trees from the Intervale and they don't have all the trees I want, they may order them from another nursery.

2) Transect set up

A) Pound a stake at each end of the transect and GPS (if possible) the stake. Number each transect (1, 2, 3, etc) and write the number on the stake. Run a tape measure between the stakes and take a photograph along the length of the transect showing the tape (Figure 1).

B) Collect data on all trees within 10 feet of the tape (both sides) for the entire length of the transect. If planted trees are sparse, you should go beyond the 10 feet and count a minimum of 10 planted trees per transect.

C) To prevent confusion, monitor all the trees on one side of the tape before going to the other side.

2) Data Collection

Data may be collected three ways: First, with a Trimble GPS which allows you to store all data for each tree. Second, use a basic GPS and a datasheet in which you record all of the tree variables and the waypoint for each tree. Third, a datasheet and a transect map in which you measure and mark points on a map.

A) Place a tree tag at the base of each tree and take a GPS point or mark it on your map. Place a measuring stick next to the tree and take a photo (Figure 2). It will help you keep track of photos if you take a photo of each tree tag before you take the photo of that tree.

B) Record the tree data (See Section 3 "Description of Tree Variables")

C) Record any natural regeneration of trees and shrubs within 10 feet of the tape. Do not go beyond 10 feet for natural regeneration. Just record the variables that apply to natural regeneration (GPS Waypoint, Species, Height, Condition, Girdled, Browse, Notes)

3) Descriptions of Tree Variables:

Tree Tag: This is the number on the tree tag. It provides a unique ID for each plant.

Species: Use common names. Be as specific as you can, but just call it Unknown, Maple, Ash etc., if you can't tell exactly which species it is. If you cannot ID it in the field take multiple pictures that will help you ID it later.

GPS Waypoint: If you are using a simple GPS like a Garmin, which does not allow you to collect data for each point, then use a data sheet and record the way point and tree variables for each tree.

Height in inches: Measure to the highest living leaves or buds (do not count dead leaders).

Dead Leader: Measure the height of dead stems (measure from the ground to the top of the dead stem). If the sapling is still living measure the live part and include that measurement in the normal height category.

Inches Below Tube: This field is just for trees that are shorter than the tube they are planted in. Measure from the top of the tube to the highest living part of the sapling.

Condition: There are 6 categories based on the % of live foliage (Figure 2).

-Vigorous (0-5%) of foliage damaged or missing.

-Healthy (6-25%)

-Moderate (26-50%)

-Unhealthy (51-75%)

-Very Unhealthy (76-99%)

-Dead (100%)

Planting Material Type: Bare root, tubling, container, balled and burlap, seed, live stake, fascine, natural regeneration. You may need to talk to the person who ordered or planted the trees to get this information. The NRCS contact for the county may know this information or be able to refer you to someone.

Mat Type: Black, Green, Burlap, Other, or None. If the mat fits into the other category please explain what is in the notes.

Tube: None, Blue-X, Yellow Mesh, Hardware Cloth, Hard Plastic, Other (describe in notes)

Stem Browse: Note any browsing that has occurred. This is to help us get an idea of how much pressure the trees are getting from animals or insects eating their branches. If you can identify the culprit please do. It is also helpful to take pictures of this damage for our records (Figure 3).

Leaf Browse: Note any browsing that has occurred. This is to help us get an idea of how much pressure the trees are getting from animals or insects eating their leaves. If you can identify the culprit please do. It is also helpful to take pictures of this damage for our records (Figure 3).

***** Identify both **stem browse** and **leaf browse** in 10% increments (i.e.: 0, 1-10%, 10-20% etc.) based on the amount of plant material that has been removed from the plant. This can be challenging and subject to interpretation, please do your best.

Girdled: This is most often caused by rodents eating the bark around the base of the tree. If they remove the bark from the entire circumference, the tree will die. This field only covers the percentage of the diameter that has been girdled; make a note if the girdling has affected more than two inches of the sapling's height. As with the browse category please use increments of 10 (i.e.: 0, 1-10%, 11-20% etc.) In the case of beaver damage or any damage that completely cuts down the sapling, please add details in the notes section.

Competing Species: This section identifies the 3 dominant plants that are around the planted sapling. Common plants found have been: reed canary grass, goldenrod, bedstraw, etc. If you cannot ID the plants in the field take pictures following your tree tag and tree photos, you can try again later.

Competing Cover: This is an estimate of the density and ground cover of the competing vegetation. There are three categories to choose from: Sparse (0-33%), Medium (34-66%), and Thick (67-100%).

Competing Height: Simply measure the three dominant species and average the height.

Notes: Put any additional observations on an individual's health or status in the Notes field. For example, if a plant is mostly dead but has a few remaining buds, you might categorize that individual as Very Unhealthy (76-99%) and note that it was, "nearly dead with buds only." Another example may be that morning glory had grown up the tree and was pulling it to the ground.

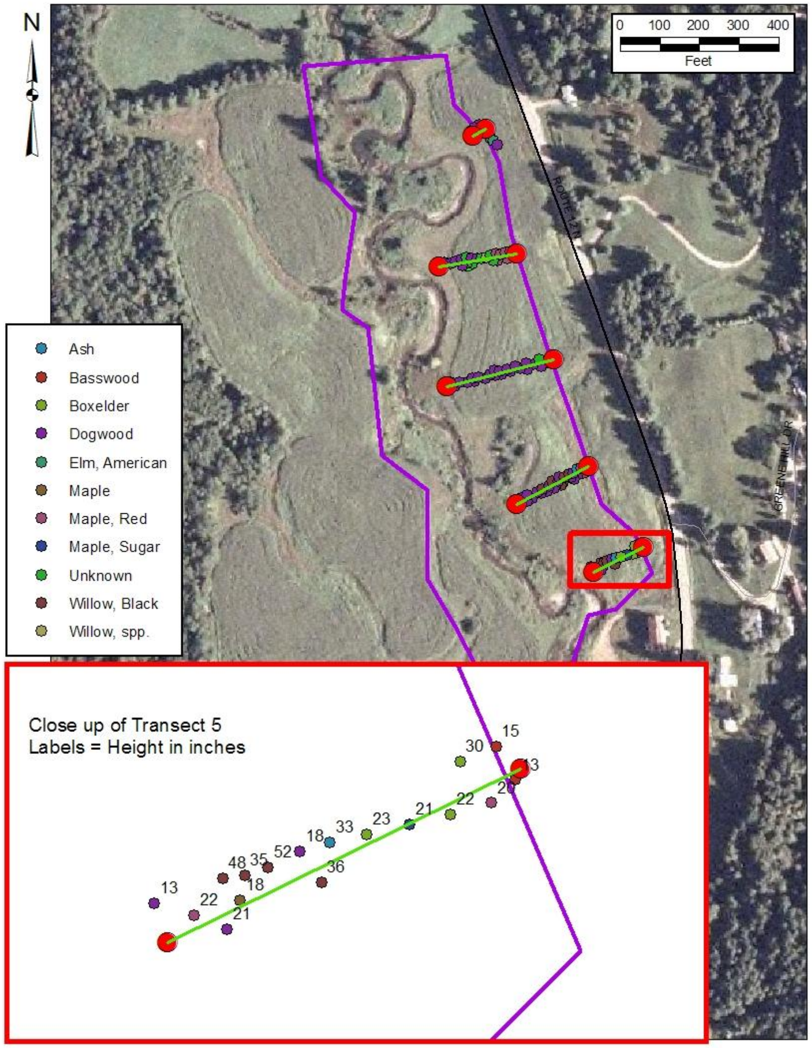

Figure 1: Aerial map showing project boundary, transect locations, transect close-up, and a photo of transect.

Vigorous (0-5%)

Healthy (6-25%)

Moderate (26-50%)

Unhealthy (51-75%)

V. Unhealthy (76-99%)

Dead (100%)

Figure 2: Examples of Plant Condition

Girdled 100%

Girdled 50%

Stem Browse 100%

Stem Browse 50%

Leaf Browse (20%)

Figure 3. Photos of tree girdling and browse.

APPENDIX B

Riparian Restoration Monitoring Data Sheet

Site:	Transect #:	Nurseries for Each Species:	Who Planted It:
Date:	Beginning and Ending Waypoints:		Planting Date:
Observers:	GPS:		

Tree Tag	GPS Way Point	Species	Height (Inches)	Height of Dead Leader	Inches Below Tube	Condition	Plant Material Type	Mat Type	Tube	Stem Browse	Leaf Browse	Girdled	Competing Species	Comp. Cover	Comp. Height	Notes

Condition Choices:
Vigorous (0-5%)
Healthy (6-25%)
Moderate (26-50%)
Unhealty (51-75%)
V. Unhealthy (76-99%)
Dead (100%)

Mat Types:
Black
Green
Burlap
Other
None

Tube Types:
Blue-X
Yellow Mesh
Hardware Cloth
Hard Plastic
Other (Describe)

Browse Options:
None
1-10%
10-20%
20-30%
30-40%
etc. up to 100%

Girdling Options:
None
1-10%
10-20%
20-30%
30-40%
etc. up to 100%

Compteting Species:
ID the three most dominant species around each tree

Comp. Cover
Sparse (0-33%)
Medium (34-66%)
Thick (67-100%)

Comp. Height:
Average the 3 species

Site: ____________________ Observers: ____________________

Date: ____________________ ____________________

River, Brook, or Stream Bank

Transect #:

Transect Length:

Feet from center tape

15 10 5 0 5 10 15

Distance along transect

5 ft

10ft

15 ft

20 ft

25 ft

30 ft

35 ft

40 ft

45 ft

50 ft

15 10 5 0 5 10 15

Outer Edge of the Buffer

1.) Set up transect end points perpendicular to the water cooridor

2.) Run a tape measure, from the transect point closest to the water cooridor, to the other transect point (Record this distance)

3.) Use this grid to map the trees on the transect, draw a point for each tree and lable it with the appropriate tree tag #, at the appropriate distance on the transect

4.) Only go 10 feet from the transect line and collect a minimum of 10 trees/shrubs. If you need to go beyond 10 feet in order to attain 10 trees then do so.

5.) If a tree/shrub is present within your transect, that was not planted, write NR (Natural Regeneration) next to the cooresponding dot, do not use a tree tag.

6.) If your transect is longer than 50 feet simply use another sheet to extend your map

APPENDIX C

Date:	Obs:		Start Time:	Point #:	Point Moved?	Coordinates:
					Y N	
Weather:	Temp:	Wind sp:	Wind dir:	Cloud cover:	Precip:	% of Sky Visable:
Habitat Description: High noise? Y N						
Landscape description (within 100m):						

Draw a line between each interval (3 min. 20 sec.)

Species #	0-50	50-100	Flyover	S/H	Notes

Continue on the back if necessary – only one point -count per sheet!

APPENDIX D

Established Sites – Total Species Count: 48

Alder Flycatcher (*Empidonax alnorum)*

American Crow (*Corvus brachyrhynchos)*

American Redstart (*Setophaga ruticilla)**

American Robin (*Turdus migratorius)*

Belted Kingfisher (*Ceryle alcyon)*

Black-and-white Warbler (*Mniotilta varia)*

Black-capped Chickadee (*Parus atricapillus)*

Black-throated Blue Warbler (*Dendroica caerulescens)*

Black-throated Green Warbler (*Dendroica virens)*

Blue Jay (*Cyanocitta cristata)*

Canada Goose (*Branta canadensis)*

Chestnut-sided Warbler (*Dendroica pensylvanica)*

Chipping Sparrow (*Spizella passerina)*

Common Grackle (*Quiscalus quiscula)*

Common Merganser (*Mergus merganser)*

Common Yellowthroat (*Geothlypis trichas)*

Eastern Phoebe (*Sayornis phoebe)*

Eastern Wood – Pewee (*Contopus virens)**

European Starling (*Sturnus vulgaris)*

Golden-crowned Kinglet (*Regulus satrapa)**

Gray Catbird (*Dumetella carolinensis)*

Great Crested Flycatcher (*Myiarchus crinitus)*

Hermit Thrush (*Catharus guttatus)**

House Sparrow (*Passer domesticus*)*

Killdeer (*Charadrius vociferous)*

Least Flycatcher (*Empidonax minimus)*

Mallard (*Anas platyrhynchos)*

Mourning Dove (*Zenaida macroura)*

Northern Cardinal (*Cardinalus cardinalus)*

Ovenbird (*Seiurus aurocapillus)*

Pileated Woodpecker (*Dryocopus pileatus)*

Red-breasted Nuthatch (*Sitta carolinensis)**

Red-eyed Vireo (*Vireo olivaceus)*

Red-winged Blackbird (*Agelaius phoeniceus)*

Ring-billed Gull (*Larus delawarensis)*

Rose-breasted Grosbeak (*Pheucticus ludovicianus)**

Song Sparrow (*Melospiza melodia)*

Spotted Sandpiper (*Actitis macularia)*

Tree Swallow (*Tachycineta bicolor)*

Tufted Titmouse *(Baeolophus bicolor)*

Veery (*Catharus fuscescens)*

Warbling Vireo (*Vireo gilvus)*

Wild Turkey (*Meleagris gallopavo)*

Wood Duck (*Aix sponsa)**

Woodpecker spp. (*Picus spp.)*

Yellow-bellied Sapsucker (*Sphyrapicus varius)**

Yellow-throated Vireo (*Vireo flavifrons*)*

Yellow Warbler (*Dendroica petechia)*

*** Species found only at this site**

Planted Sites – Total Species Count: 42

Alder Flycatcher (*Empidonax alnorum)*

American Crow (*Corvus brachyrhynchos)*

American Goldfinch (*Carduelis tristis)*

American Robin (*Turdus migratorius)*

Bank Swallow (*Riparia riparia)**

Barn Swallow (*Hirundo rustica)*

Belted Kingfisher (*Ceryle alcyon)*

Black-and-white Warbler (*Mniotilta varia)*

Black-throated Blue Warbler (*Dendroica caerulescens)*

Blue Jay (*Cyanocitta cristata)*

Bobolink (*Dolichonyx oryzivorus)*

Brown-headed Cowbird (*Molothrus ater)*

Canada Goose (*Branta Canadensis)*

Chestnut-sided Warbler (*Dendroica pensylvanica)*

Common Grackle (*Quiscalus quiscula)*

Common Merganser (*Mergus merganser)*

Common Yellowthroat (*Geothlypis trichas)*

Eastern Kingbird (*Tyrannus tyrannus)*

Eastern Phoebe (*Sayornis phoebe)*

European Starling (*Sturnus vulgaris)*

Gray Catbird (*Dumetella carolinensis)*

Great Crested Flycatcher (*Myiarchus crinitus)*

Killdeer (*Charadrius vociferous)*

Mallard (*Anas platyrhynchos)*

Mourning Dove (*Zenaida macroura)*

Northern Cardinal (*Cardinalus cardinalus)*

Northern Flicker (*Colaptes auratus)**

Northern Rough-winged Swallow (*Stelgidopteryx serripennis)**

Pileated Woodpecker (*Dryocopus pileatus)*

Red-winged Blackbird (*Agelaius phoeniceus)*

Ring-billed Gull (*Larus delawarensis)*

Rock Dove (*Columba livia)**

Savannah Sparrow (*Passerculus sandwichensis)*

Song Sparrow (*Melospiza melodia)*

Spotted Sandpiper (*Actitis macularia)*

Swallow spp. (*Hirundo spp.)*

Tree Swallow (*Tachycineta bicolor)*

Tufted Titmouse ((*Baeolophus bicolor)*

Warbling Vireo (*Vireo gilvus)*

Willow Flycatcher (*Empidonax traillii)*

Woodpecker spp. (*Picus spp.)*

Yellow Warbler (*Dendroica petechia)*

*** Species found only at this site**

Unplanted Sites – Total Species Count: 48

Alder Flycatcher (*Empidonax alnorum)*

American Bittern (*Botaurus lentiginosus)**

American Crow (*Corvus brachyrhynchos)*

American Goldfinch (*Carduelis tristis)*

American Kestrel (*Falco sparverius)**

American Robin (*Turdus migratorius)*

Barn Swallow (*Hirundo rustica)*

Belted Kingfisher (*Ceryle alcyon)*

Black-capped Chickadee (*Parus atricapillus)*

Black-throated Blue Warbler (*Dendroica caerulescens)*

Black-throated Green Warbler (*Dendroica virens)*

Blue Jay (*Cyanocitta cristata)*

Bobolink (*Dolichonyx oryzivorus)*

Brown-headed Cowbird (*Molothrus ater)*

Chestnut-sided Warbler (*Dendroica pensylvanica)*

Chipping Sparrow (*Spizella passerina)*

Common Grackle (*Quiscalus quiscula)*

Common Merganser (*Mergus merganser)*

Common Raven (*Corvus corax*)*

Common Yellowthroat (*Geothlypis trichas)*

Eastern Kingbird (*Tyrannus tyrannus)*

Eastern Phoebe (*Sayornis phoebe)*

European Starling (*Sturnus vulgaris)*

Field Sparrow (*Spizella pusilla*) *

Gray Catbird (*Dumetella carolinensis)*

Great Blue Heron (*Ardea Herodias)**

Great Crested Flycatcher (*Myiarchus crinitus)*

House Wren (*Troglodytes aedon)**

Killdeer (*Charadrius vociferous)*

Least Flycatcher (*Empidonax minimus)*

Mourning Dove (*Zenaida macroura)*

Northern Cardinal (*Cardinalus cardinalus)*

Ovenbird (*Seiurus aurocapillus)*

Red-eyed Vireo (*Vireo olivaceus)*

Red-winged Blackbird (*Agelaius phoeniceus)*

Ring-billed Gull (*Larus delawarensis)*

Savannah Sparrow (*Passerculus sandwichensis)*

Song Sparrow (*Melospiza melodia)*

Spotted Sandpiper (*Actitis macularia)*

Swallow spp. (*Hirundo spp.)*

Swamp Sparrow (*Melospiza Georgiana)**

Tree Swallow (*Tachycineta bicolor)*

Tufted Titmouse *(Baeolophus bicolor)*

Veery (*Catharus fuscescens)*

Warbling Vireo (*Vireo gilvus*)

Wild Turkey (*Meleagris gallopavo)*

Willow Flycatcher (*Empidonax traillii)*

Yellow Warbler (*Dendroica petechia)*

*** Species found only at this site**