A Field Study to Characterize Riparian Ecosystems in the Northwest Algonquin Region of Ontario

Research Report #35

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> "Riparian networks link terrestrial (upland and lowland) and aquatic ecosystems (wetlands, lakes, streams, rivers, and floodplains), forming integrated landscapes that extend from mountains to coasts and across continents... Plant assemblages in riparian ecosystems have distinct compositions relative to upland communities... [and they provide] valuable ecosystem services including water purification... [and] water availability... Anthropogenic influences have greatly altered riparian ecosystems, so that they are now widely recognized as systems of conservation concern".
>
> (Kominoski et al., ***Frontiers in Ecology and the Environment***, Oct. 2013, pg. 423)

Introduction

In order to formulate accurate and robust restoration targets for riparian zones in disturbed areas (e.g., grazing fields), it is necessary to sample regional reference sites to determine the vegetation composition of natural or undisturbed riparian ecosystems. The data from field samples can then be used to identify a set of vegetation restoration targets. As a first step towards achieving this objective, a literature review was recently completed (Quinby 2015), which addressed riparian ecology and restoration in eastern Canada with a focus on vegetation and an emphasis on Ontario. The results of this literature review were used to help design a riparian baseline field study near Trout Creek, Ontario that was conducted during August 2015 and that is the subject of this report.

Literature Review

Although many field studies have addressed riparian ecology in eastern Canada (see Quinby 2015), only one group has documented the change in plant species composition along a continuous riparian gradient starting at stream banks and ending within upland habitats. These studies were conducted in central Ontario from 1990 through 2001 by Ancient Forest Exploration & Research - four in the Temagami region and one in the Lower Spanish Forest.

The first of these studies was conducted by Giroux (1994); his main findings for the riparian zone in Temagami old-growth Red and Eastern White Pine forests included the following.

- From most to least abundant, the following overstory tree species were found in the riparian zone: Eastern White Pine, Red Pine, Northern White Cedar, Black Spruce, White Spruce, Balsam Fir, Yellow Birch, Jack Pine, Poplar, Red Maple, and Cherry spp.

- From most to least abundant, the following understory plant species were found in the riparian zone: Balsam Fir, Red Maple, Alder spp., Yellow Birch, Black Spruce, Cherry spp., Black Ash, White Spruce, Blueberry spp., White Birch, Honeysuckle, White Pine, Red Pine, Beaked Hazelnut, and Jack Pine.

- Although understory plant biomass in the riparian zone was lowest in the old-growth condition compared with three younger forest stand categories, plant species richness in the riparian zone was highest in the old-growth condition compared with the other age categories.

- Understory plant biomass in the riparian zone was highest around stream riffles compared with stream pools, however, understory plant species richness in the riparian zone was highest around stream pools compared with stream riffles.

At the east end of Blueberry Lake in Temagami, Quinby et al. 1999, found that:

- 63 plant species were found within 32 m of the stream bank and the abundance of 25 of these species (40%) was significantly correlated with distance from the stream bank;

- Of these significant correlations, 18 species (29%) showed an decrease in abundance with increasing distance from the stream bank;

- Of these 18 species, the presence of 14 species terminated prior to the 32 m point;

- The woody plant species associated with the riparian zone included Black Ash, Fly Honeysuckle, and Wild Red Raspberry; and

- Understory plant biomass (total abundance) was not significantly correlated with distance from the stream bank, however, species richness decreased significantly as distance from the stream increased.

For 16 first- and second-order streams draining into Cassells and Rabbit Lakes, Quinby et al. (2000) found a total of 122 understory (<0.5 m height) plant taxa (species and species groups) within 30 m of the stream banks and the following woody plant species were found to be associated (statistically significant) with the riparian zone: Black Ash, Black Swamp Currant, Canada Yew, Choke Cherry, Dwarf Trailing Raspberry, Meadow-sweet, Mountain Maple, Northern Bush Honeysuckle, Speckled Alder, White Birch, Wild Red Raspberry, and Yellow Birch.

In 2001, Saddock identified six plant species in the shrub/sapling layer that explained the greatest amount of variation in distance from the streambank including Black Ash, Canada Fly Honeysuckle, Fancy Wood Fern, Mountain Maple, Sweet Gale, and Yellow Birch. Using these indicator species in the shrub/sapling layer, he found a mean riparian zone width of 37 m.

The primary findings of a field study in the Lower Spanish Forest region of Ontario (Quinby 1997) included the following.

- Both species richness and biomass were significantly higher in the riparian zone compared to the upland zone.

- Logging significantly reduced lichen biomass by 76% and moss/liverwort biomass by 38%.

- The number of understory plant taxa was 16% less in the logged riparian forest compared with the ancient riparian forest.

- The number of unique understory plant taxa was 47% less in the logged riparian forest compared with the ancient riparian forest.

- The number of tree species was 40% less in the logged riparian forest compared with the ancient riparian forest.

- The number of unique tree species was 80% less in the logged riparian forest compared with the ancient riparian forest.

Study Area

Eight pristine riparian sites were sampled between the Village of Trout Creek and the Round (Kawawaymog) Lake area, which are both situated in the northwest portion of the Algonquin Region of Ontario (Figure 1). Sample sites 8 (RZ-8) and 2 (RZ-2) are located roughly 6 and 8 km east of Trout Creek, respectively, along Forestry Road. Sample sites 1 (RZ-1), 3 (RZ-3) and 4 (RZ-4) are located in the southern Round Lake area. Sample sites 6 (RZ-6) and 7 (RZ-7) are located at the east end of Craig Lake, and sample site 5 (RZ-5) is located close to the east end of Maryjane Lake. Sites 1, 3, 5 and 8 are located in riparian zones adjacent to small streams (1.4 to 3.2 m bank full width). Sites 2 and 4 are located adjacent to medium-sized streams (4.2 to 8.4 m bank full width). And finally, sites 6 and 7 are adjacent to large streams (13 to 16 m bank full width).

Methods

Potential undisturbed reference sites for field sampling were identified using Forest Resources Inventory mapping and the Ontario Crown Land Use Policy Atlas (2015). Following identification of these potential sampling sites, the integrity of each site was field checked for potential sampling. Eight riparian areas were identified and sampled. Four riparian areas were adjacent to small streams, two were adjacent to medium-sized streams and two were adjacent to large streams.

Vegetation was stratified into three vertical layers for sampling including the overstory, mid-story and understory along at least three 30 m transects placed perpendicular to the stream and at least 10 m apart at each riparian zone. When multi-sloped riparian areas were available for transect sampling, the lowest sloped areas were chosen for sampling.

The overstory included trees greater than and including 10 cm dbh (diameter at breast height) and was sampled within a 10 x 10 m plot placed at the edge of each stream at the beginning of each transect and within a 10 x 10 m plot at the end of each transect between 30 and 40 m from the stream edge. Overstory trees were identified to species, measured for dbh and their location was mapped.

The mid-story included all vascular plants between .5 m in height and 10 cm dbh assessed within a 2 x 2 m quadrat placed every 2 m along the 30 m transect starting at the edge of the stream for a total of 8 quadrats. The percent cover for each species in each quadrat was determined and recorded. The understory included all vascular plants below .5 m assessed within a 1 x 1 m quadrat placed every other meter along the 30 m transect starting at the edge of the stream for a total of 15 quadrats. The percent cover for each species in each quadrat was determined and recorded.

A plant species inventory was also conducted at each of the eight riparian areas consisting of identifying all vascular plants within two 3 m wide transects running parallel to each stream. One transect (called riparian) included the width between the stream edge and 3 m from the stream edge and the other transect (called upland) included the width between 30 m and 33 m from the edge of the stream. For riparian areas with three perpendicular plot/quadrat transects, 40 m of parallel inventory transects were assessed for both riparian (0 - 3 m) and upland (30 - 33 m) locations. For riparian areas with four perpendicular plot/quadrat transects, 50 m of parallel inventory transects were assessed and for riparian areas with five perpendicular plot/quadrat transects, 60 m of parallel inventory transects were assessed.

In each riparian zone sampled, the following site features were also assessed and recorded: stream bank full width, width of stream water, azimuth of the perpendicular plot/quadrat transect, percent bank slope, elevation, percent exposed bedrock, topography along the perpendicular transect (e.g., even slope, undulating, etc.), evidence of fire, evidence of animal use/presence (e.g., tracks, scat, bones, etc.), presence and location of gaps, presence and location of wetlands, and other important observations.

Following field sampling, data were entered and summarized using Microsoft Exel. Statistical analyses including the T-test and Pearson Product-Moment (PPM) Correlations were carried out using Minitab 17 (www.minitab.com). Comparisons of mean tree species densities for riparian locations versus upland locations were carried out using the T-test and identification of understory plant species associated with riparian zones was accomplished using PPM Correlations. A minimum quadrat frequency of 20 was used for running a correlation on the relationship between understory species abundance and distance from the stream bank. Since only 8 locations along each transect were sampled for the mid-story, no correlations were calculated. When calculating the relative abundance of species within the first 10 m from stream banks, a minimum quadrat frequency of 3 was used for understory whereas a minimum plot/quadrat frequency of 2 was used for the overstory and mid-story.

Forest Plants of Central Ontario (Chambers et al. 1996) and *Wetland Plants of Ontario* (Newmaster et al. 1997) were used in the field to identify unknown plants and *VASCAN, the Database of Vascular Plants of Canada* (Brouillet et al. 2010+) was consulted for determining currently accepted species names.

Results

A total of eight riparian areas were assessed by sampling 62 overstory plots, 248 mid-story quadrats and 465 understory quadrats along 31 perpendicular 30 m transects. In addition, 390 m of parallel riparian plant inventory transects and 390 m of parallel upland plant inventory transects were assessed for the presence of plant species. Three work days were spent doing map work and field reconnaissance in preparation for field sampling and eight work days were spent sampling the eight riparian areas. All site and habitat data for the eight riparian sample locations are provided in Appendix 1. Raw overstory plot data, raw mid-story quadrat data and raw understory quadrat data are provided in Appendices 2, 3 and 4, respectively.

Botanical inventory

Plant species were identified during plot and quadrat assessment along transects running perpendicular to the stream as well as during the separate inventories of plant species within riparian and upland transects running parallel to the streams. Thus, the plant species identified during this study were found somewhere between the stream edge and 33 m from the stream. Table 1 provides a list of plant species (common and scientific names) found during field assessment and indicates if species were found during the plot/quadrat assessments or during

the parallel transect surveys or during both. The table also groups species into four categories including trees, shrubs, flowering herbs and non-flowering plants.

A total of 19 tree species, 46 shrub species, 49 flowering herb species, and 21 non-flowering plant species were found during this study for a total of 135 plant species. More species of shrubs (43), flowering herbs (43), and non-flowering plants (20) were found during the parallel transect surveys since more area was inventoried during these surveys compared with the quadrat assessments for shrubs (39 species), flowering herbs (35), and non-flowering plants (16).

Significant species abundance gradients

As plant species composition in an area is an indicator of habitat conditions, it was possible to assess for the presence of a riparian zone along the eight streams in this study by comparing vegetation composition adjacent to each stream to vegetation composition further upslope from the stream bank. These comparisons were made using pooled data for the overstory, mid-story and understory.

Overstory

Table 2 compares mean tree species density in stream bank locations (0 - 10 m from the stream edge) to mean tree species density in upland areas (30 - 40 m from the stream edge) for 11 species. Although most species show a density difference between riparian and upland areas, only Black Ash, Yellow Birch and Sugar Maple differences were statistically significant.

Black Ash density was 995% higher in stream bank locations (Figure 2) and Yellow Birch was 378% higher (Figure 3). Other species with higher densities in stream bank locations were Black Spruce (267% higher) and Eastern Hemlock (223% higher), however, these differences were not statistically significant.

Sugar Maple density was 214% higher in upland areas compared with stream bank locations (Figure 4), which was highest among species with higher densities in upland areas. White Birch density was also much higher in upland areas (175%), although not statistically significant.

Tree species with small or no density differences between stream bank locations and upland areas included Balsam Fir, White Spruce, Black Cherry, Red Maple and White Cedar (Table 2).

Mid-Story

Only two mid-story species showed a clear trend of decreasing abundance (%cover) from the stream edges (0 m) to the uplands (30 m from stream edges), which were Speckled Alder (Figure 5) and Leatherleaf (Figure 6). These positive associations with the riparian zone were not evaluated statistically, however, due to having only 8 sample points along the 30 m transect from the stream to the uplands for correlation analysis.

Understory

A total of six understory species showed a statistically significant negative relationship between their abundance and distance from the stream edges (abundance decreased with distance away from the stream). These species included Common St. John's Wort (Figure 7), Moss spp. (Figure 8), Sensitive Fern (Figure 9), Sweet Gale (Figure 10), Tall Meadow Rue (Figure 11) and Speckled Alder (Figure 12). Understory species that showed a clear trend of decreasing abundance from the stream edges to the uplands that were not evaluated statistically (due to

low quadrat frequency) included Northern Beech Fern (Figure 13), Jewelweed (Figure 14) and Foamflower (Figure 15).

Habitat

These differences in overstory, mid-story and understory species composition and abundance at the stream edge compared with nearby uplands indicate that habitat conditions in riparian areas differ from habitat conditions in upland areas. However, further field work is required to determine what these habitat differences are and how they influence corresponding vegetation responses.

Stream size and most common riparian plant species

Three stream sizes (previously defined) including small (four streams), medium (two streams) and large (two streams) were assessed during this study. Table 3 categorizes the eight riparian areas sampled in this study by size and provides a list of the dominant plant species (>1% relative abundance) found within 10 m of the stream edge and their abundance in the overstory, mid-story and understory.

Small streams

Seven dominant overstory species (>1%) were found within 10 m of the margins of small streams. Those that represented more than 30% of the relative abundance, from most to least abundant, included Black Spruce, Black Ash and Yellow Birch (Table 3). The remaining species, from most to least abundant, included Sugar Maple, Balsam Fir, White Spruce and White Cedar.

Eight dominant mid-story species (>1%) were found within 10 m of the margins of small streams. Those that represented more than 30% of the relative abundance, from most to least abundant, included Sugar Maple, White Cedar, Mountain Maple and Balsam Fir (Table 3). The remaining species, from most to least abundant, included Beaked Hazelnut, Black Ash, Red Elderberry and Alternate-leaved Dogwood.

Seventeen dominant understory species (>1%) were found within 10 m of the margins of small streams. Those that represented more than 10% of the relative abundance, from most to least abundant, included Moss spp., Wood Fern spp., Sugar Maple, Sedge spp., Grass spp., Creeping Snowberry and Lady Fern (Table 3). The remaining species, from most to least abundant, included Bunchberry, Goldthread, Jewelweed, Mountain Maple, Sensitive Fern, Foamflower, Velvet-leaved Blueberry, Labrador Tea, Canada Mayflower and Trillium spp.

Medium streams

Six dominant overstory species (>1%) were found within 10 m of the margins of medium streams. Those that represented more than 30% of the relative abundance included only Red Maple (Table 3). The remaining species, from most to least abundant, included Balsam Fir, Eastern Hemlock, Yellow Birch, Black Cherry and White Cedar.

Six dominant mid-story species (>1%) were found within 10 m of the margins of medium streams. Those that represented more than 30% of the relative abundance, from most to least abundant, included Eastern Hemlock and Balsam Fir (Table 3). The remaining species, from most to least abundant, included Nannyberry, Red Maple, Speckled Alder and Mountain Maple.

Eleven dominant understory species (>1%) were found within 10 m of the margins of medium streams. Those that represented more than 10% of the relative abundance, from most to least abundant, included Wood Fern spp., Moss spp., Royal Fern and Interrupted Club Moss (Table 3). The remaining species, from most to least abundant, included Bracken Fern, Canada Mayflower, Nannyberry, Tall Meadow Rue, Common Wood-sorrel, Eastern Hemlock and Mountain Maple.

Large streams

Of the two large streams, only the riparian area located along Upper Craig Creek (RZ7) had trees in the overstory within 10 m of the stream margin. Four dominant overstory species (>1%) were found within 10 m of the margins this stream. The only overstory species with a relative abundance greater than 30% in this riparian zone was Balsam Fir (Table 3). The remaining species, from most to least abundant, included White Spruce, Red Maple and White Birch.

Seven dominant mid-story species (>1%) were found within 10 m of the margins of the large streams. Those that represented more than 30% of the relative abundance, from most to least abundant, included only Speckled Alder (Table 3). The remaining species, from most to least abundant, included Meadowsweet, Sweet Gale, Leatherleaf, Choke Cherry, Balsam Fir and Black Spruce.

Eleven dominant understory species (>1%) were found within 10 m of the margins of the large streams. Those that represented more than 10% of the relative abundance, from most to least abundant, included Sweet Gale, Grass spp., Moss spp., Tall Meadow Rue, Wood Fern spp., Sedge spp. and Meadowsweet (Table 3). The remaining species, from most to least abundant, included Black Raspberry, Sensitive Fern, Speckled Alder and Dwarf Raspberry.

Frequency of riparian and upland plant species

In addition to assessing plant species within quadrats and plots at each of the eight riparian sample sites, they were surveyed within two 3 m wide transects running parallel to each stream, one running along the stream bank (0-3 m) and another parallel transect including the area between 30 and 33 m from the stream bank. The main purpose for conducting these surveys was to supplement the identification of plant species during the quadrat/plot assessments. In fact, 16 additional species were identified as a result of the parallel surveys.

In addition to improving the species presence assessment, these data can be used to compare species occurrence within the 3 m zone along the stream bank to the adjacent upland areas (30-33 m). The frequency of occurrence (maximum of 8) for each species found during these surveys organized by plant growth form is presented in Table 4. It must be emphasized, however, that a sample size of eight riparian sites and a sampling intensity of up to 60 m of survey length at each riparian site is much too low to identify trends or draw conclusions. Rather, this table is provided as an example of a technique that can be used to better understand riparian vegetation ecology when sufficient sampling is undertaken.

The species within each plant growth form group are ordered first with those that are most frequent in the riparian stream bank area through those that do not show presence favouring either location to those at the end that are most frequent in the upland area. This technique does not allow for estimates of plant density or the use of statistical analysis. Given an appropriate level of sampling, however, results from this technique would provide for the identification of trends which could be further tested in the field. In addition, these data could provide corroboration of differences found by area-based sampling.

Summary

A total of 19 tree species, 46 shrub species, 49 flowering herbs, and 21 non-flowering plants were found during this study for a total of 135 plant species. More species of shrubs (43), flowering herbs (43), and non-flowering plants (20) were found during the parallel transect surveys since more area was inventoried during these surveys compared with the quadrat assessments for shrubs (39 species), flowering herbs (35), and non-flowering plants (16).

In the overstory of stream bank locations, Black Ash density was 995% higher and Yellow Birch density was 378% higher (both statistically significant) compared to upland areas. Other species with higher densities in stream bank locations were Black Spruce (267% higher) and Eastern Hemlock (223% higher), however, these differences were not statistically significant. Sugar Maple density was significantly higher in upland areas by 214% compared with stream bank locations, which was highest among species with higher densities in upland areas. White Birch density was also much higher in upland areas (175%), although not statistically significant. Tree species with small or no density differences between stream bank locations and upland areas included Balsam Fir, White Spruce, Black Cherry, Red Maple and White Cedar.

The only two mid-story species that showed a clear trend of decreasing abundance (% cover) from the stream edges to the uplands were Speckled Alder and Leatherleaf. The six understory species that showed a statistically significant decrease in abundance with distance from the stream margins included Common St. John's Wort, Moss spp., Sensitive Fern, Sweet Gale, Tall Meadow Rue and Speckled Alder. The three understory species that showed a clear trend of decreasing abundance from the stream edges to the uplands that were not evaluated statistically included Northern Beech Fern, Jewelweed and Foamflower.

Three overstory species representing more than 30% relative abundance were found within 10 m of the margins of small streams including Black Spruce, Black Ash and Yellow Birch. Four mid-story species representing more than 30% relative abundance were found within 10 m of the margins of small streams including Sugar Maple, White Cedar, Mountain Maple and Balsam Fir. Finally, seven understory species representing more than 10% of the relative abundance were found within 10 m of the margins of small streams including Moss spp., Wood Fern spp., Sugar Maple, Sedge spp., Grass spp., Creeping Snowberry and Lady Fern.

The one overstory species representing more than 30% of the relative abundance and found within 10 m of the margins of medium streams was Red Maple. Eastern Hemlock and Balsam Fir were the two mid-story species found within 10 m of the margins of medium streams that represented more than 30% of the relative abundance. Four understory species representing more than 10% of the relative abundance found within 10 m of the margins of medium streams included Wood Fern spp., Moss spp., Royal Fern and Interrupted Club Moss.

Of the two large streams, only the riparian area located along Upper Craig Creek had trees in the overstory within 10 m of the stream margin. The only overstory species with a relative abundance greater than 30% found there was Balsam Fir. Speckled Alder was the only mid-story species with more than 30% of the relative abundance that was found within 10 m of the margins of the large streams. Finally, seven understory species with more than 10% of the relative abundance were found within 10 m of the margins of the large streams including Sweet Gale, Grass spp., Moss spp., Tall Meadow Rue, Wood Fern spp., Sedge spp. and Meadowsweet.

In addition to the plant species found during the plot/quadrat sampling, 16 different plant species were identified as a result of the parallel plant surveys. In addition to improving the species presence assessment, these data can be used to compare species occurrence within the 3 m

zone along the stream bank to the adjacent upland areas. However, the sample size and intensity in this study was too low to identify trends or draw conclusions regarding riparian vegetation composition.

Recommendations

1. Further ecological investigations within the eight riparian reference areas sampled in this study should be conducted to document the full range of botanical, vegetation and habitat variability. One important question is, "does stream or lake size affect the composition, structure and function of riparian ecosystems?"

2. The variety of streams, rivers, and lakes in each of Ontario's resource management areas should be identified, characterized, and classified as soon as possible, preferably before they are modified any further by human activity.

3. All remaining undisturbed riparian reference sites (lakeshores as well as stream and river banks) should be identified and mapped.

4. These remaining undisturbed riparian reference sites should be characterized with both remote sensing and field studies.

5. Finally, as many as possible of these riparian reference sites on crown land should be protected as reserves with the minimum objective of protecting a set of sites that are locally, regionally and provincially representative. Efforts should also be made to protect those on private land, although this may prove to be more difficult than protecting riparian areas on crown land.

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Figure 1 – Study Area: Trout Creek-Algonquin Park, Ontario

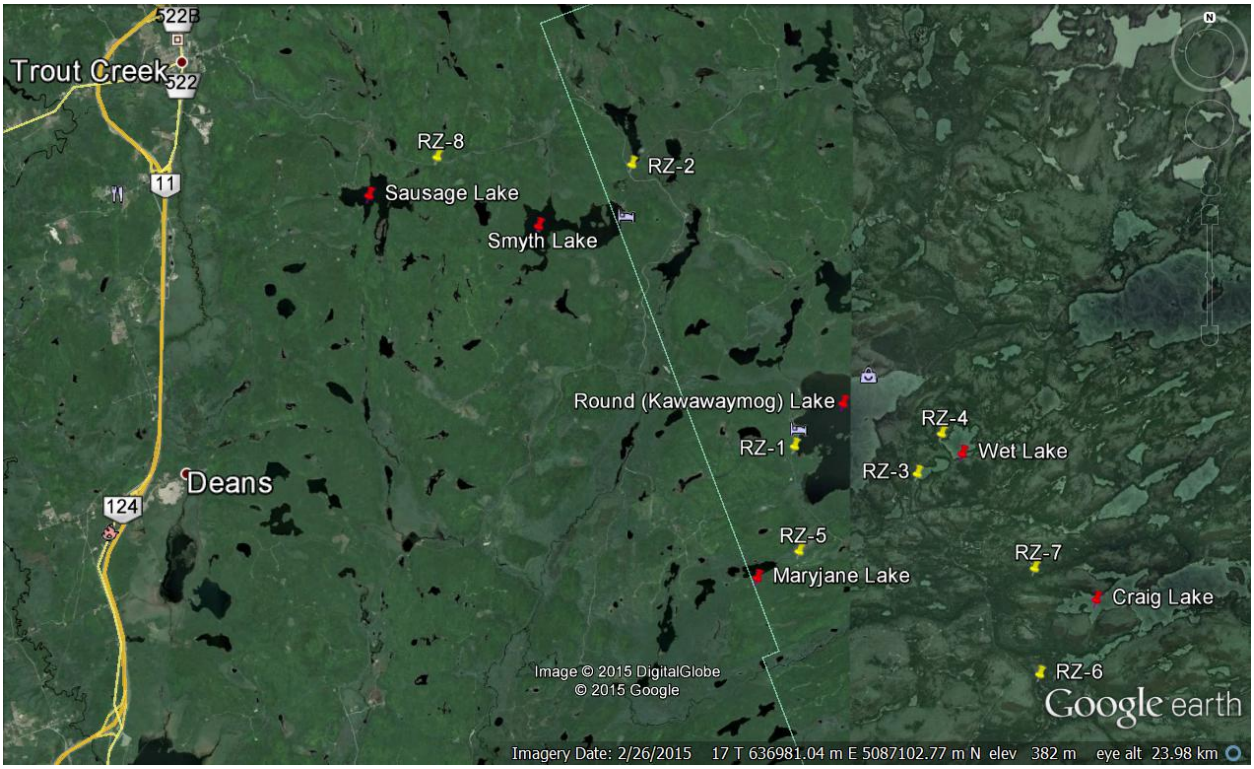

Table 1 - List of Plant Species for the Riparian Areas Surveyed in the Round (Kawawaymog) Lake Area near Trout Creek, Ontario (up to 33 m from streambanks, nomenclature from Brouillet et al. 2010)

Common Name	Scientific Name	Plots/ Quadrats	Survey
Trees (19 species)			
American Beech	*Fagus grandifolia*		x
American Elm	*Elymus americana*	x	x
Balsam Fir	*Abies balsamifera*	x	x
Black Ash	*Fraxinus nigra*	x	x
Black Cherry	*Prunus serotina*	x	x
Black Spruce	*Picea mariana*	x	x
Eastern Hemlock	*Tsuga canadensis*	x	x
Poplar spp.	*Populus* spp.	x	
Red Maple	*Acer rubrum*	x	x
Red Oak	*Quericus rubra*		x
Red Pine	*Pinus resinosa*	x	x

Speckled Alder	*Alnus incana* ssp. *rugosa*	**x**	**x**
Sugar Maple	*Acer sacharrum*	**x**	**x**
Trembling Aspen	*Populus tremuloides*	**x**	**x**
White Birch	*Betula papyrifera*	**x**	**x**
White Cedar	*Thuja occidentalis*	**x**	**x**
White Pine	*Pinus strobus*	**x**	
White Spruce	*Picea glauca*	**x**	**x**
Yellow Birch	*Betula allegheniensis*	**x**	**x**
	total	17	17
	total all	19	
Shrubs (46 species)			
Alternate-leaved Dogwood	*Cornus alternafolia*	**x**	**x**
American Bittersweet	*Celastrus scandens*		**x**
Beaked Hazelnut	*Corya cornuta*	**x**	**x**
Black Raspberry	*Rubus occidentalis*	**x**	**x**
Bog Rosemary	*Andromeda polifolia*	**x**	
Bristly Black Currant	*Ribies occidentalis*		**x**
Bush Honeysuckle	*Diervilla lonicera*	**x**	**x**
Canada Yew	*Taxus canadensis*	**x**	**x**
Choke Cherry	*Prunus virginiana*	**x**	**x**
Common Blackberry	*Rubus allegheniensis*		**x**
Common Juniper	*Juniperus communis*	**x**	
Creeping Snowberry	*Gaultheria hispidula*	**x**	**x**
Dwarf Raspberry	*Rubus pubescens*	**x**	**x**
Fly Honeysuckle	*Lonicera canadensis*	**x**	**x**
High-bush Cranberry	*Viburnum opulus* ssp. *trilobum* var. *americanum*	**x**	**x**
Hobblebush	*Viburnum lantanoides*	**x**	**x**
Juneberry spp.	*Amelanchier* spp.	**x**	**x**
Labrador Tea	*Rododendron groenlandicum*	**x**	**x**
Leatherleaf	*Chamaedaphne calyculata*	**x**	**x**
Low Sweet Blueberry	*Vaccinium angustifolium*	**x**	**x**
Meadow-sweet	*Spiraea alba*	**x**	**x**
Mooseberry	*Viburnum edule*		**x**
Mountain Ash	*Sorbus americana*	**x**	**x**
Mountain Holly	*Nemopanthus mucronatus*	**x**	**x**

Mountain Maple	*Acer spicatum*	**x**	**x**
Nannyberry	*Viburnum lentago*	**x**	**x**
Northern Wild Raisin	*Viburnum nudum* var. *cassinoides*	**x**	**x**
Partridgeberry	*Mitchella repens*	**x**	**x**
Pin Cherry	*Prunus pensylvanica*	**x**	**x**
Red Elderberry	*Sambucus racemosa pubens*	**x**	**x**
Ribes spp.	*Ribes* spp.	**x**	**x**
Sheep Laurel	*Kalmia angustifolia*	**x**	
Smooth Gooseberry	*Ribes glandulosum*		**x**
Steeple-bush	*Spiraea tomentosa*	**x**	**x**
Striped Maple	*Acer pensylvanicum*	**x**	**x**
Sweet Gale	*Myrica gale*	**x**	**x**
Twinflower	*Linnaea borealis*	**x**	**x**
Velvet-leaved Blueberry	*Vaccinium myrtilloides*	**x**	**x**
Viburnum spp.	*Viburnum* spp.		**x**
Virginia Creeper	*Parthenocissus quinquefolia*		**x**
Virgin's Bower	*Clematis virginiana*	**x**	**x**
Wild Red Currant	*Ribes trista*	**x**	**x**
Wild Red Raspberry	*Rubus idaeus*	**x**	**x**
Willow spp.	*Salix* spp.	**x**	**x**
Wintergreen	*Gaultheria procumbens*	**x**	**x**
Woodland Strawberry	*Fragaria vesca*	**x**	**x**
	total	39	43
	total all	46	
Flowering Herbs (49 species)			
American water-horehound	*Lycopus americanus*	**x**	
Arrowhead	*Sagittaria latifolia*		**x**
Aster spp.	*Aster* spp.		**x**
Baneberry spp.	*Actaea* spp.	**x**	**x**
Blue Flag	*Iris versicolor*	**x**	**x**
Bluebead Lily	*Clintonia borealis*	**x**	**x**
Bog Goldenrod	*Solidago uliginosa*	**x**	
Bunchberry	*Cornus canadensis*	**x**	**x**
Canada Mayflower	*Maianthemum canadensis*	**x**	**x**
Common St. John's Wort	*Hypericum perforatum*	**x**	**x**

Common Wood-sorrel	*Oxalis montana*	x	x
False Solomon's Seal	*Maianthemum racemosum*	x	x
Foam Flower	*Tiarella cordifolia*	x	x
Fragrant Bedstraw	*Galium trifolium*	x	x
Fringed Black Bindweed	*Fallopia cilinodis*		x
Goldenrod spp.	*Solidago* spp.	x	x
Goldthread	*Coptis trifolia*	x	x
Grass Spp.	*Poaceae* spp.	x	x
Indian Pipe	*Monotropa uniflora*	x	x
Jewelweed	*Impatiens capensis*	x	x
Joe Pye Weed	*Euphatorium maculatum*		x
Kidney-leaved Violet	*Viola renifolia*	x	
Large-leaved Aster	*Eurybia macrophylla*		x
Large round-leaved Orchid	*Platanthera orbiculata*	x	
Mad Dog Skullcap	*Scutellaria lateriflora*	x	x
Marsh Bellflower	*Campanula aparinoides*		x
Marsh Cinquefoil	*Comarum palustre*	x	x
Naked Mitrewort	*Mitella nuda*	x	
Nodding Trillium	*Trillium cernuum*		x
Northern Bedstraw	*Gallium boreale*		x
Northern Bugleweed	*Lycopus uniflorus*	x	x
Northern White Violet	*Viola renefolia*		x
Painted Trillium	*Trillium undulatum*	x	x
Pink Pyrola	*Pyrola asarifolia*		x
Red Trillium	*Trillium erectum*	x	x
Rose Twisted Stalk	*Streptopus lanceolatus*	x	x
Small White Aster	*Symphyotrichum racemosum*	x	x
Smaller Enchanter's Nightshade	*Circaea alpina*		x
Smooth Solomon's Seal	*Polygonatum biflorum*		x
Solomon's Seal	*Polygonatum pubescens*	x	x
Spatulate-leaved Sundew	*Drosera intermedia*	x	x
Starflower	*Lysimachia borealis*	x	x
Swamp Candles	*Lysimachia terristris*		x
Tall Meadow Rue	*Thalictrum pubescens*	x	x
Trillium spp.	*Trillium* spp.	x	
Violet spp.	*Viola* spp.	x	x

Water Pennywort	*Hydrocotyle umbellata*		**x**
White Lettuce	*Nabalus albus*	**x**	**x**
Wild Sarsaparilla	*Aralia nudicaulis*	**x**	**x**
	total	35	43
	total all	49	
Non-Flowering Plants (21 species)			
Bracken Fern	*Pteridium aquilinum*	**x**	**x**
Cinnamon Fern	*Osmundastrum cinnamomeum*		**x**
Club Moss Spp.	*Lycopodium* spp.	**x**	**x**
Crested Wood Fern	*Dryopteris cristata*	**x**	**x**
Ground Pine	*Lycopodium dendroideum*	**x**	**x**
Hay-Scented Fern	*Dennstaedtia pumctilobula*		**x**
Interupted Club Moss	*Lycopodium annotinum*	**x**	**x**
Interupted Fern	*Osmunda claytoniana*	**x**	**x**
Lady Fern	*Athyrium filix-femina*	**x**	**x**
Marsh Fern	*Thelypteris palustris*		**x**
Moss spp.	*Bryophyta* spp.	**x**	**x**
Northern Beech Fern	*Phegopteris connectilis*	**x**	**x**
Oak Fern	*Gymnocarpium dryopteris*	**x**	**x**
Royal Fern	*Osmunda regalis*	**x**	**x**
Sedge spp.	*Carex* spp.	**x**	**x**
Sensitive Fern	*Onoclea sensibilis*	**x**	**x**
Silvery Spleenwort	*Deparia acrostichoides*	**x**	
Soft-stemmed Bulrush	*Scirpus validus*		**x**
Spinulose Wood Fern	*Dryopteris carthusiana*	**x**	**x**
Toothed Wood Fern	*Dryopteris carthusiana*		**x**
Wood Fern spp.	*Dryopteris* spp.	**x**	**x**
	total	16	20
	total all	21	
	grand total = 135	107	123

Table 2 - Tree Species Density in Riparian Areas versus Upland Areas (significant differences in bold)

Tree Species	Mean Riparian Density (no./ha)	Mean Upland Density (no./ha)	% Difference	Number of Samples	T-Value and Probability
Black Ash[1]	81.0	7.4	994.6	27	**2.20; .037**
Yellow Birch	77.0	16.1	378.3	31	**2.60; .013**
Black Spruce	142.0	38.7	266.9	31	1.47; .150
Eastern Hemlock	52.0	16.1	223.0	31	1.42; .163
Balsam Fir	213.0	184.0	15.8	31	0.43; .670
White Spruce	29.0	25.8	12.4	31	0.20; .843
Black Cherry	25.8	25.8	0.0	31	0.00; 1.000
Red Maple	58.0	65.0	12.1	31	-0.22; .823
White Cedar[2]	28.6	50.0	74.8	28	-0.65; .522
White Birch	12.9	35.5	175.2	31	-1.21; .235
Sugar Maple	45.2	142.0	214.2	31	**-2.20; .033**

NOTES: 1 - Riparian Zone 1 excluded due to location in a Black Ash swamp; 2 - Riparian Zone 6 excluded due to absence of trees in the first 30 m (riparian portion) of the three transects

Figure 2 - **Mean Density (no./ha) Difference for Overstory Black Ash between Riparian (0-10 m) and Upland (30-40 m) Locations (T-value = 2.20; p = 0.037)**

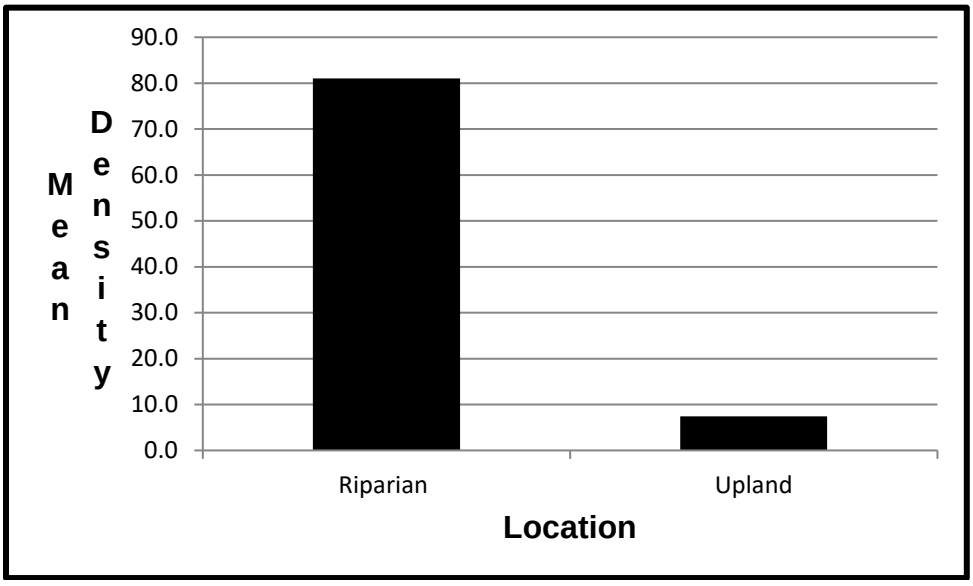

Figure 3 - Mean Density (no./ha) Difference for Overstory Yellow Birch between Riparian (0-10 m) and Upland (30-40 m) Locations (T-value = 2.60; p = 0.013)

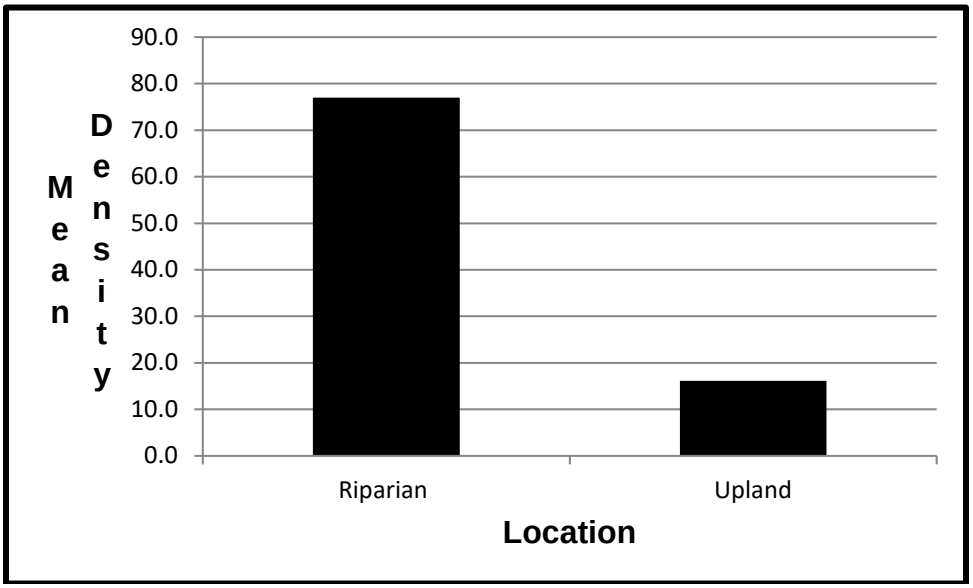

Figure 4 - Mean Density (no./ha) Difference for Overstory Sugar Maple between Riparian (0-10 m) and Upland (30-40 m) Locations (T-value = -2.20; p = 0.033)

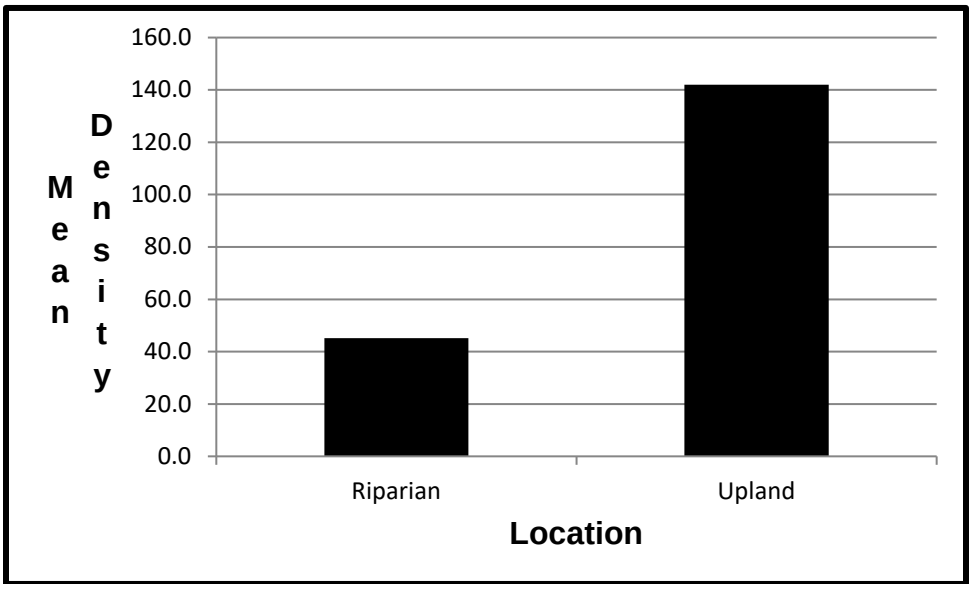

Figure 5 - Change in Abundance for Speckled Alder in the Mid-story from Stream Banks (0 meters) to the Uplands (30 meters) (observed in 36 quadrats)

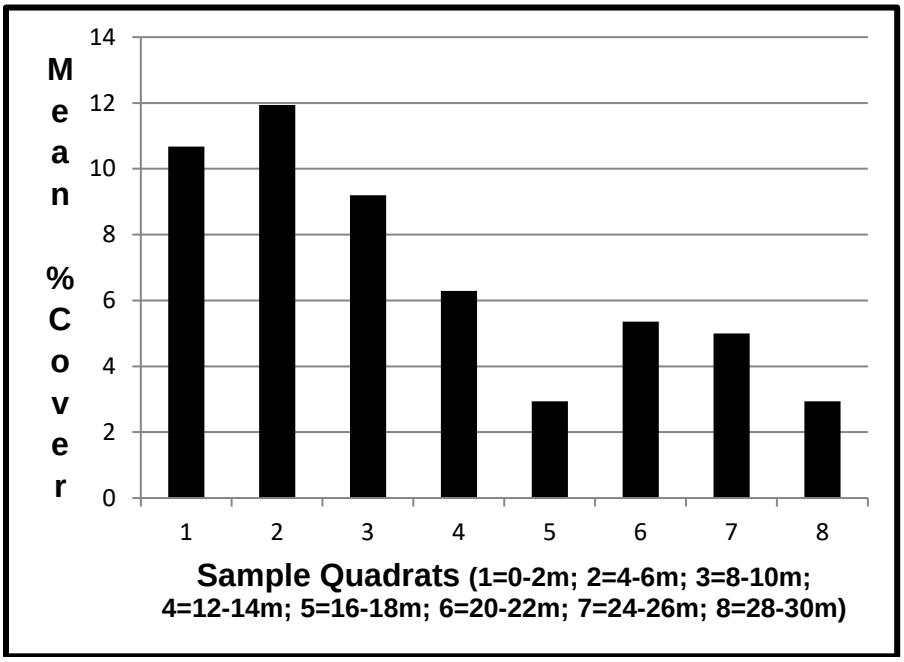

Figure 6 - Change in Abundance for Leatherleaf in the Mid-story from Stream Banks (0 meters) to the Uplands (30 meters) (observed in 8 quadrats)

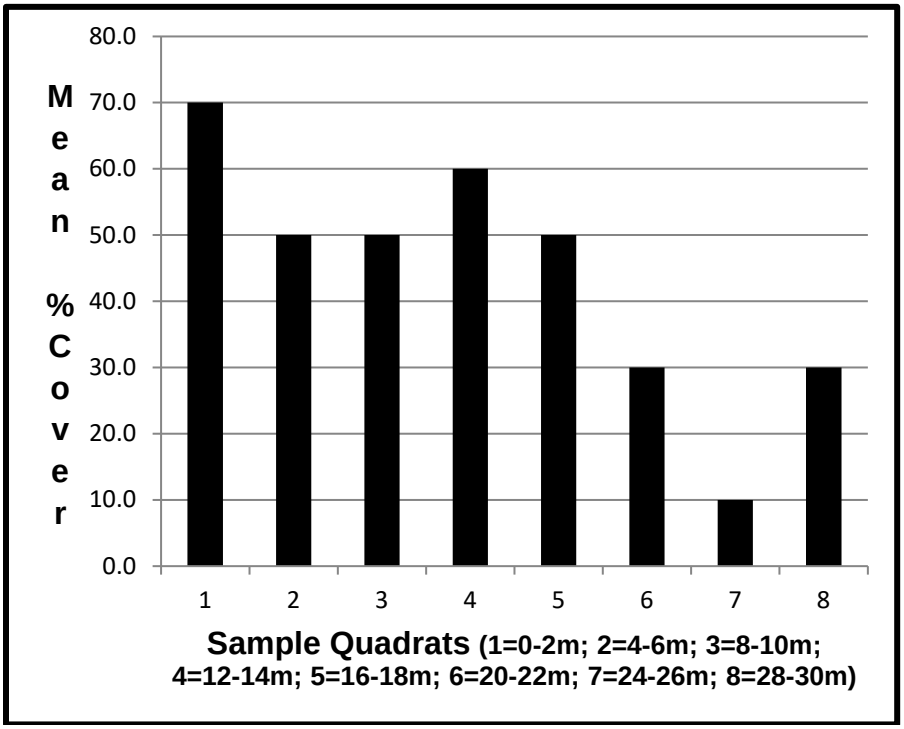

Figure 7 - Change in Abundance for Common St. John's Wort in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 23 quadrats; r= -0.540, p= 0.038)

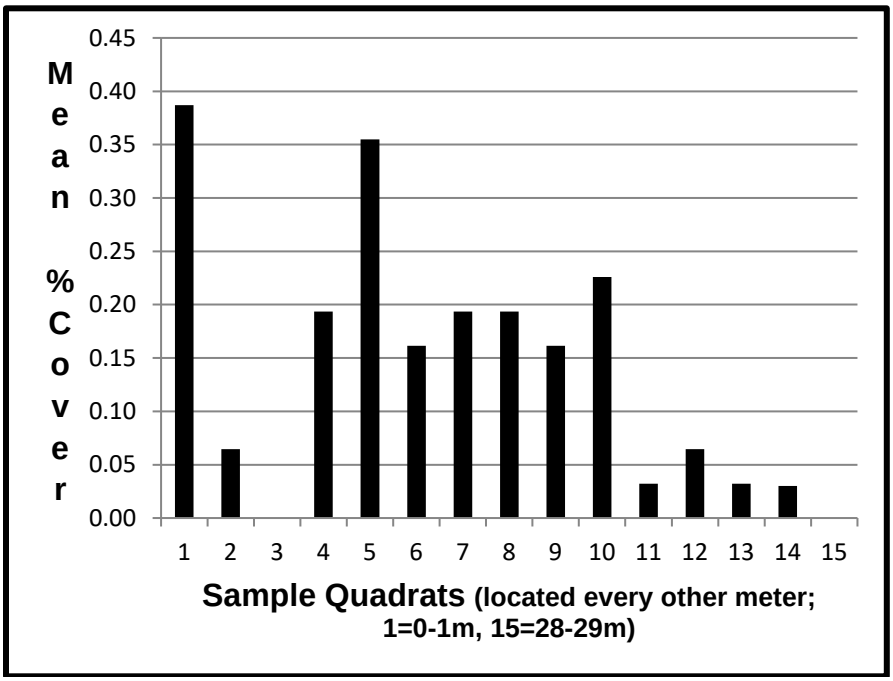

Figure 8 - Change in Abundance for Moss spp. in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 370 quadrats; r= -0.611, p= 0.015)

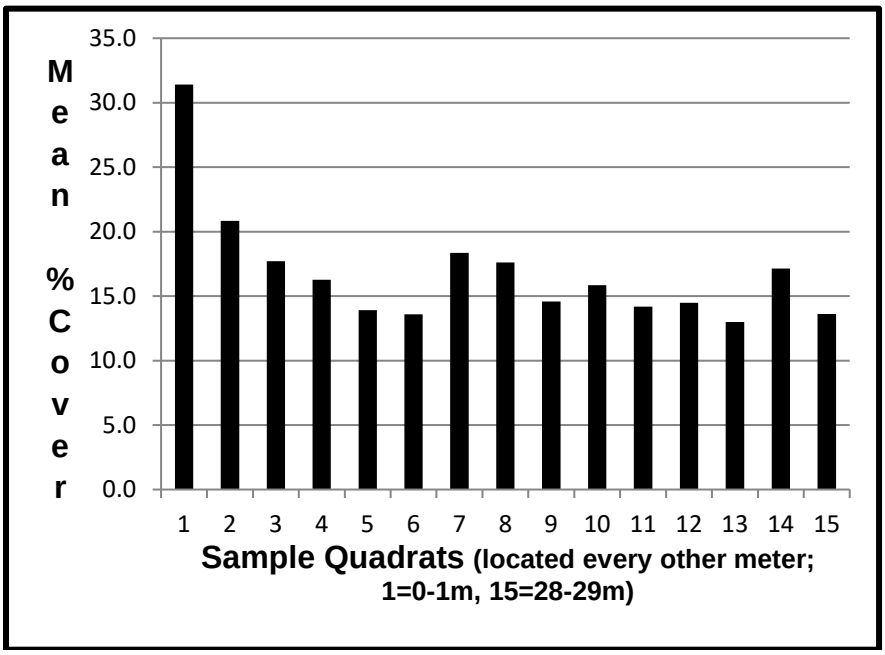

Figure 9 - Change in Abundance for Sensitive Fern in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 59 quadrats; r= -0.661, p= 0.007)

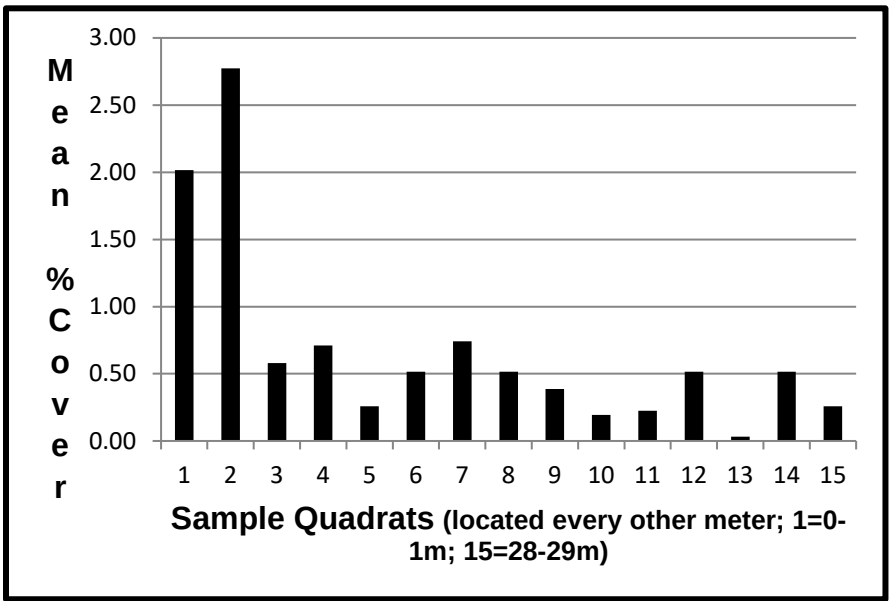

Figure 10 - Change in Abundance for Sweet Gale in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 37 quadrats; r= -0.529, p= 0.043)

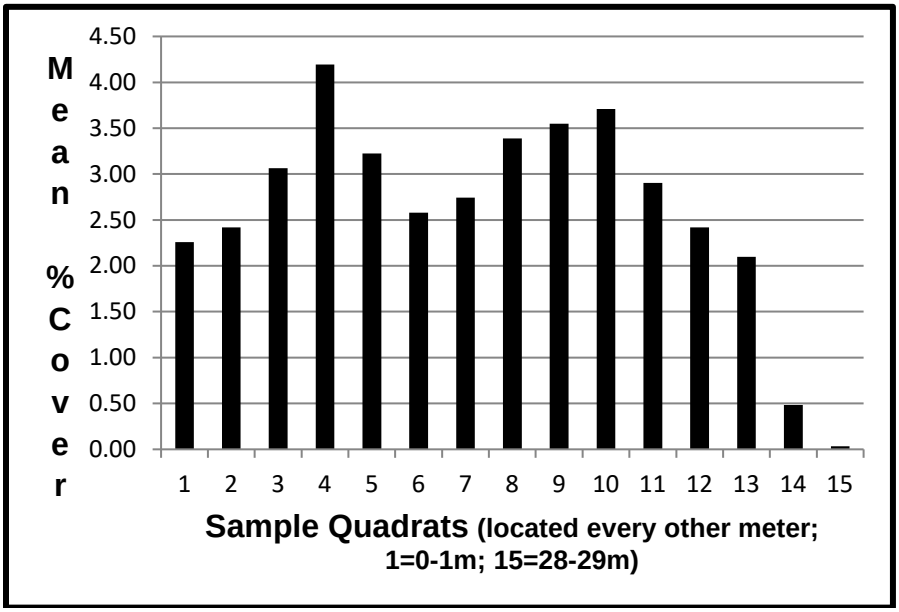

Figure 11 - Change in Abundance for Tall Meadow Rue in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 31 quadrats; r= -0.785, p= 0.001)

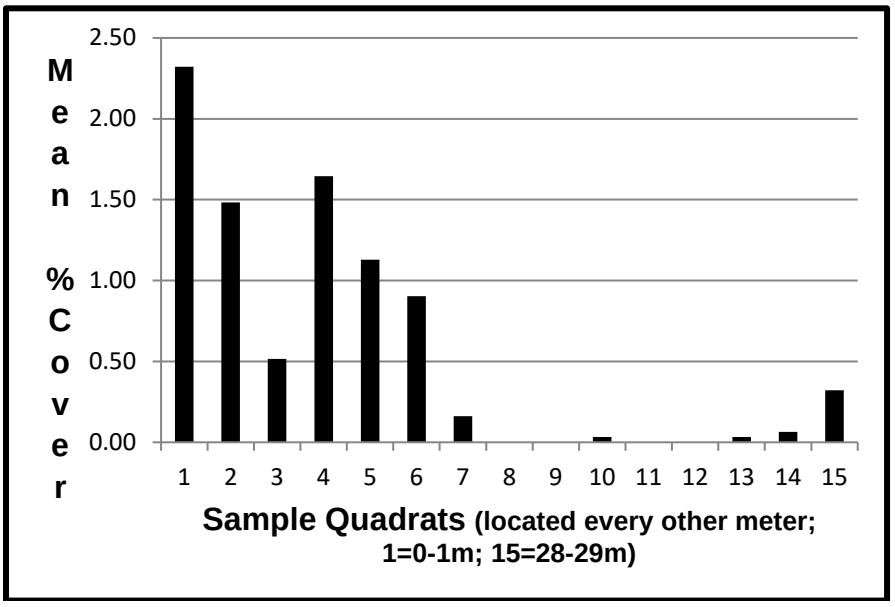

Figure 12 - Change in Abundance for Speckled Alder in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 32 quadrats; r= -0.443, p= 0.098)

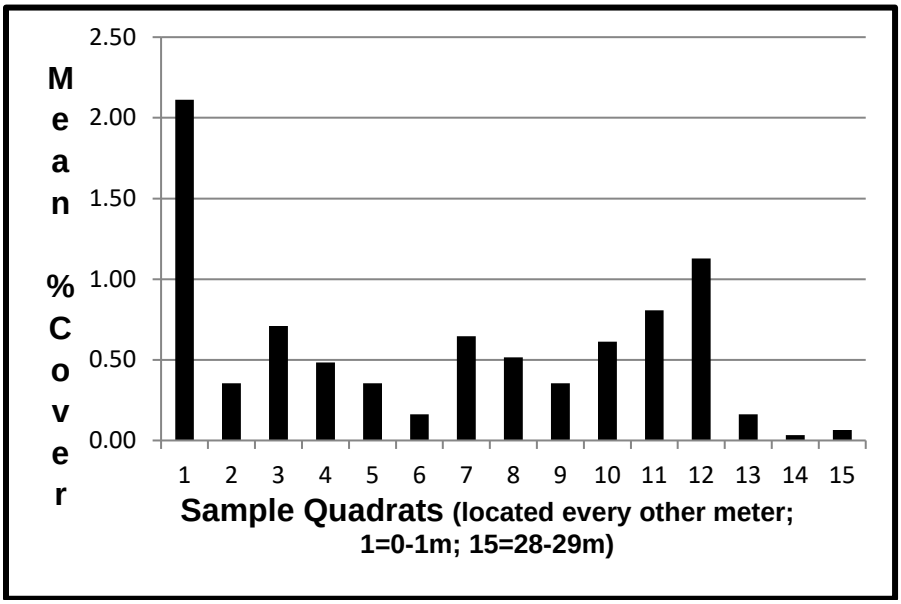

Figure 13 - Change in Abundance for Northern Beech Fern in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 18 quadrats)

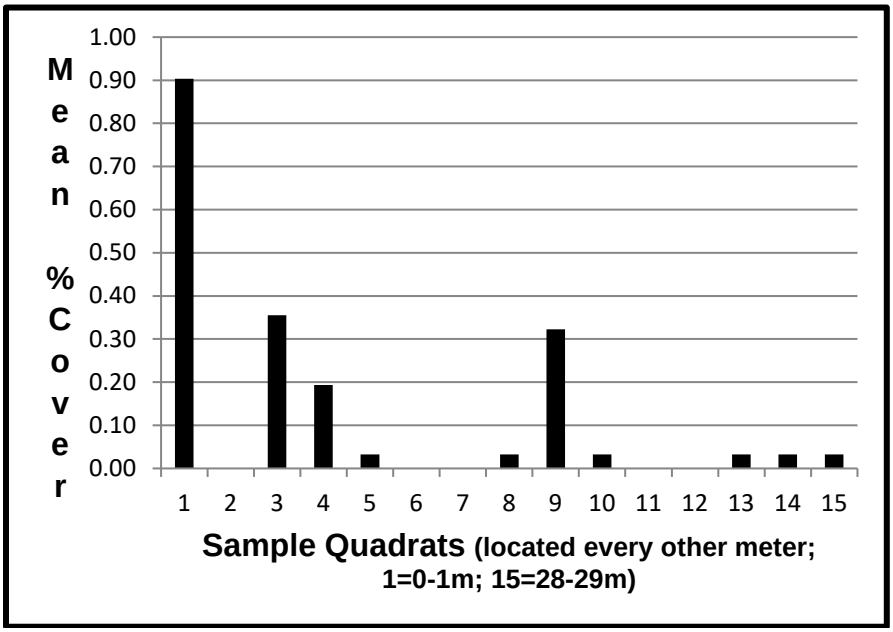

Figure 14 - Change in Abundance for Jewelweed in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 16 quadrats)

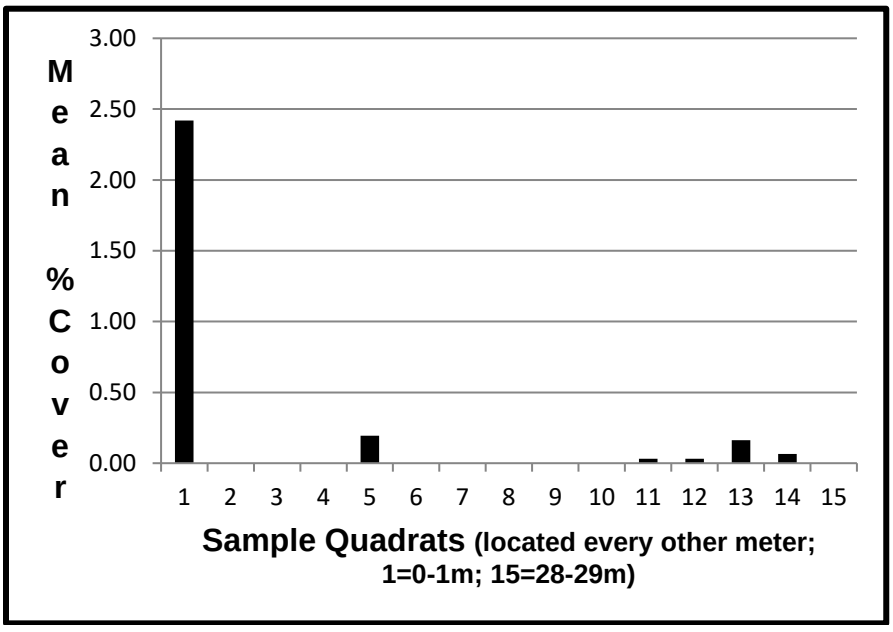

Figure 15 - Change in Abundance for Foamflower in the Understory from Stream Banks (0 meters) to the Uplands (29 meters) (observed in 15 quadrats)

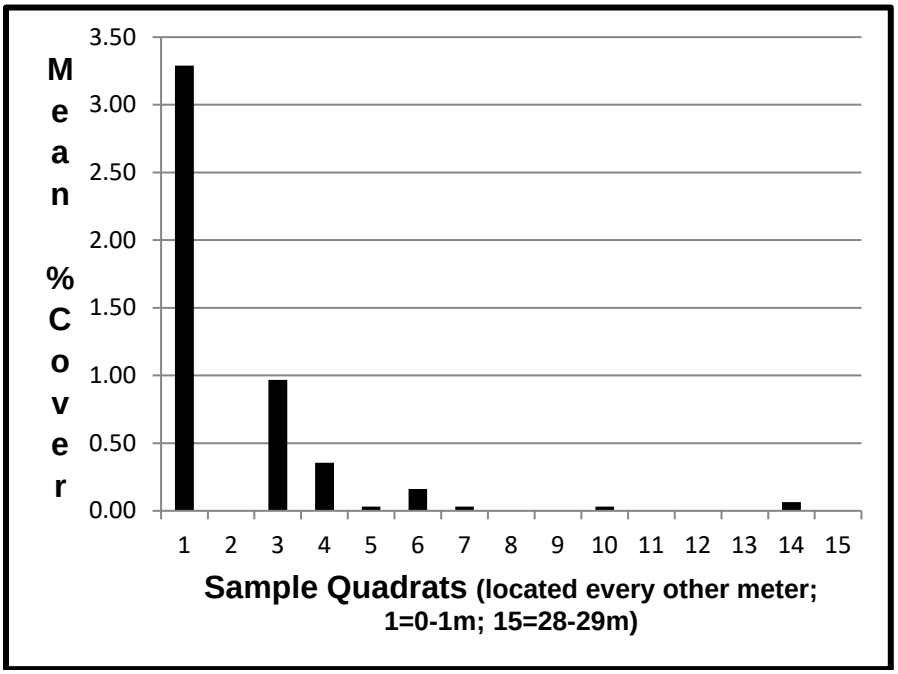

Table 3 - Stream Size, Bank Slope and Dominant Riparian Plant Species within 10 Meters of Stream Banks

Stream Size[1]	Site	Location	Overstory Species Composition (0-10 m)[2]	Mid-Story Species Composition (0-10 m)[2]	Understory Species Composition (0-10 m)[2]
small (1.4-1.9 m)	RZ5	Maryjane Lake	Black Spruce (83%) White Cedar (16%)	White Cedar (50%) Balsam Fir (12%) Sugar Maple (8%)	Moss spp. (59%) Creeping Snowberry (11%) Bunchberry (6%) Goldthread (6%) Velvet-leaved Blueberry (5%) Labrador Tea (3%)
small (2.3 m)	RZ1	West Shore, Round Lake	Black Ash (38%) Yellow Birch (19%) Balsam Fir (17%) White Spruce (17%)	Mountain Maple (36%) Balsam Fir (31%) Sugar Maple (14%) Black Ash (9%)	Moss spp. (50%) Lady Fern (11%) Wood Fern spp. (7%) Jewelweed (6%) Mountain Maple (6%) Sensitive Fern (6%)

small (2.6 m)	RZ3	Blue Lake	Black Ash (55%) Sugar Maple (15%) White Spruce (9%) Balsam Fir (3%)	Sugar Maple (45%) Balsam Fir (30%) Beaked Hazelnut (14%) White Cedar (3%)	Sedge spp. (23%) Moss spp. (21%) Grass (14%) Sugar Maple (12%) Sensitive Fern (4%) Canada Mayflower (2%)
small (1.8-3.2 m)	RZ8	Sausage Lake	Yellow Birch (39%) Black Ash (38%) Sugar Maple (23%)	Sugar Maple (76%) Red Elderberry (5%) Alternate-leaved Dogwood (3%) Beaked Hazelnut (2%)	Wood Fern spp. (36%) Sugar Maple (27%) Moss spp. (11%) Lady Fern (10%) Foamflower (6%) Trillium spp. (2%)
medium (4.7-6.6 m)	RZ2	Smyth Lake	Balsam Fir (27%) Red Maple (17%) Yellow Birch (17%) Black Cherry (15%)	Balsam Fir (46%) Nannyberry (23%) Red Maple (12%) Speckled Alder (5%)	Moss spp. (27%) Interupted Club Moss (17%) Braken Fern (8%) Canada Mayflower (5%) Nannyberry (5%) Tall Meadow Rue (4%)
medium (4.2-8.4 m)	RZ4	Wet Lake West	Red Maple (33%) Eastern Hemlock (19%) Yellow Birch (16%) White Cedar (12%)	Eastern Hemlock (82%) Balsam Fir (16%) Mountain Maple (2%)	Wood Fern spp. (40%) Moss spp. (23%) Royal Fern (20%) Common Wood-sorrel (4%) Eastern Hemlock (2%) Mountain Maple (1%)
large (14 m)	RZ6	Upper South River	*no trees within 30 meters of the stream bank for the three transects sampled*	Speckled Alder (35%) Meadowsweet (25%) Sweet Gale (20%) Leatherleaf (18%)	Sweet Gale (30%) Grass (27%) Sedge spp. (13%) Meadowsweet (12%) Black Raspberry (9%) Speckled Alder (3%)
large (13-16 m)	RZ7	Upper Craig Creek	Balsam Fir (83%) White Spruce (9%) Red Maple (5%) White Birch (3%)	Speckled Alder (76%) Choke Cherry (12%) Balsam Fir (5%) Black Spruce (2%)	Moss spp. (18%) Tall Meadow Rue (18%) Wood Fern spp. (14%) Sensitive Fern (9%) Speckled Alder (7%) Dwarf Raspberry (6%)

NOTES: 1-stream bankfull width range in meters; 2-percentage = relative abundance based on m^2/ha for trees and %cover for mid-story and understory

Table 4 - Riparian and Upland Plant Species Inventory of the Eight Riparian Areas

SPECIES	Frequency (max=8)	
	Riparian	Upland
Trees (17 species)		
American Elm	2	
Eastern Hemlock	1	
Speckled Alder	4	2
Balsam Fir	7	7
Red Maple	6	6
Black Ash	3	3
Red Oak	2	2
Black Spruce	1	1
Trembling Aspen	1	1
Yellow Birch	6	7
White Cedar	3	4
Sugar Maple	5	7
White Spruce	1	3
Black Cherry	2	5
Red Pine		1
American Beech		2
White Birch		3
Shrubs (43 species)		
Alternate-leaved Dogwood	3	
Wild Red Currant	3	
Wild Red Raspberry	3	
Bristly Black Currant	1	
High-bush Cranberry	1	
Mooseberry	1	
Pin Cherry	1	
Steeple-bush	1	
Virginia Creeper	1	
Virgin's Bower	1	
Wintergreen	1	
Meadow-sweet	4	1
Dwarf Raspberry	4	1

Choke Cherry	4	2
Northern Wild Raisin	4	3
Mountain Holly	3	2
Sweet Gale	2	1
Black Raspberry	2	1
Hobblebush	5	5
Striped Maple	3	3
Low Sweet Blueberry	2	2
Mountain Maple	2	2
Red Elderberry	2	2
Velvet-leaved Blueberry	2	2
Twinflower	1	1
Labrador Tea	1	1
Leatherleaf	1	1
Bush Honeysuckle	1	1
Creeping Snowberry	1	1
Canada Yew	2	3
Mountain Ash	2	3
Partridgeberry	1	2
Fly Honeysuckle	5	8
Beaked Hazelnut	1	7
American Bittersweet		1
Common Blackberry		1
Willow spp.		1
Ribes spp.		2
Smooth Gooseberry		2
Woodland Strawberry		2
Viburnum spp.		2
Juneberry spp.		3
Nannyberry		4
Flowering Herbs (43 species)		
Jewelweed	5	
Common St. John's Wort	3	
Goldenrod spp.	3	
Arrowhead	2	
Fragrant Bedstraw	2	
Joe Pye Weed	2	
Marsh Cinquefoil	2	

Smooth Solomon's Seal	2	
Violet spp.	2	
Small White Aster	2	
Fringed Black Bindweed	2	
Marsh Bellflower	1	
Northern White Violet	1	
Painted Trillium	1	
Pink Pyrola	1	
Spatula-leaved Sundew	1	
Swamp Candles	1	
Northern Bugleweed	6	1
Tall Meadow Rue	5	1
Foam Flower	4	1
Northern Bedstraw	3	1
Mad Dog Skullcap	3	1
Blue Flag	2	1
False Solomon's Seal	2	1
Water Pennywort	2	1
Rose Twisted Stalk	4	3
Wild Sarsaparilla	6	5
Bunchberry	2	2
White Lettuce	1	1
Canada Mayflower	5	6
Indian Pipe	2	3
Common Wood-sorrel	2	3
Grass Spp.	4	6
Goldthread	3	5
Bluebead Lily	2	4
Nodding Trillium	1	3
Red Trillium	1	3
Starflower	3	6
Aster spp.		1
Smaller Enchanter's Nightshade		1
Solomon's Seal		1
Baneberry spp.		2
Large-leaved Aster		2
Non-Flowering Plants (20 species)		
Spinulose Wood Fern	4	

Crested Wood Fern	2	
Royal Fern	2	
Club Moss Spp.	1	
Marsh Fern	1	
Soft-stemmed Bulrush	1	
Toothed Wood Fern	1	
Sedge spp.	3	2
Lady Fern	3	2
Moss spp.	8	8
Sensitive Fern	5	5
Bracken Fern	1	1
Interrupted Club Moss	1	2
Ground Pine	2	3
Northern Beech Fern	1	5
Wood Fern spp.	3	8
Cinnamon Fern		1
Hay-Scented Fern		1
Interrupted Fern		2
Oak Fern		2

Appendices (see ancientforest.org for separate document)