# Task 1b: Final report on patch project baseline vegetation data 

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As per the grant agreement between The Nature Conservancy and the Minnesota Department of Natural Resources, please accept this report for Task 1b, submitted December 31, 2009. This report contains data summaries for key forest vegetation variables by treatment class. The file "data_08_09_final.xlsx "contains all of the raw data. The raw data has been checked for errors in values, plot identification, and plant species codes. Soil temperature-moisture data logger output collected in November 2009 will be sent in a separate report.

## Introduction

At total of 139 permanently marked vegetation transects were completed during the 2008 and 2009 field seasons in order to characterize baseline forest conditions on the Manitou Patch project site (Figure 1). Transects will be resampled following treatment in the next two to five years. Transects were randomly distributed within treatment polygons based primarily on proportion of total treatment area within the patch project. This was adjusted because of the area of wetland inclusions in some treatment patches limited transect locations (Table 1). In addition, 45 soil temperature loggers, 13 soil moisture base stations, and 5 soil moisture-temperature base stations were also distributed within the plot network (Figure 2).

Table 1. Transect distribution by treatment class.

| Treatment | Transect | Patches |
| :--- | ---: | ---: |
| Seed tree | 53 | 3 |
| Shelterwood | 62 | 4 |
| Reserve | 16 | 2 |
| Clearcut | 8 | 2 |
| Total | 139 | 11 |

## Methods

The sampling method follows The Nature Conservancy's monitoring protocol for upland forest communities in the Manitou Landscape. This transect based sampling approach utilizes 50 m transects for downed wood along with fixed and variable radius plots for other vegetation elements. See appendix A for detailed methods. The Nature Conservancy has collected 250 transects across a range of age classes in upland forests of the Manitou Landscape.

The data elements were selected to represent key ecological indicators of forest conditions in northern Minnesota upland forests. These indicators were derived from The

Nature Conservancy's Manitou Landscape Conservation Action plan as well as from the Patch Project planning team (Table 2).
Table 2. Data elements key variables and indicators.

| Data Element | Variable | Indicator |
| :---: | :---: | :---: |
| Duff and litter | mean depth (mm) | Non-native earthworms, fuel conditions. |
| ```Herbaceous layer (< 1 m ht)``` | Cover, Frequency | Native plant community, native species diversity, exotic-invasive plant species. |
| Tree and shrub stems $<2.5 \mathrm{~cm} \mathrm{dbh}$ ) | Density per hectare | Tree species regeneration, shrub density |
| Tree and shrub stems $2.5-10 \mathrm{~cm} \mathrm{dbh}$ ) | Density per hectare | Subcanopy composition and structure |
| Live tree and stems > 10 cm dbh, height class | Density and basal area per hectare | Canopy composition and structure |
| Dead tree and stems $>10 \mathrm{~cm} \text { dbh }$ | Volume, $\mathrm{m}^{3} / \mathrm{ha}$ | Standing dead woodstructural complexity |
| Coarse woody debris $>10 \mathrm{~cm}$ diameter | Volume, $\mathrm{m}^{3} / \mathrm{ha}$ | Downed woodstructural complexity |

Table 3. Codes and species names for woody species.

| code | Scientific name | common name |
| :--- | :--- | :--- |
| abibal | Abies balsamea | balsam fir |
| acerub | Acer rubrum | red maple |
| acespp | Acer | maple |
| alninc | Alnus incana | alder |
| betpap | Betula papyrifera | paper birch |
| picgla | Picea glauca | white spruce |
| picmar | Picea mariana | black spruce |
| poptre | Populus tremuloides | quaking aspen |
| thuocc | Thuja occidentalis | white cedar |
| acespi | Acer spicatum | mountain maple |
| amelsp | Amelanchier | Juneberry |
| corcor | Corylus cornuta | beaked hazel |

## Results

## Basal area and density

Stand age ranges approximately 10 years in recently cut patches to over 120 years in one reserve patch. The shelterwood patches are approximately $80-85$ years of age, while the seed trees patches are between 70 and 75 years of age. Overall stand basal area for stems
greater than 10 cm dbh is similar in the seed tree and shelterwood patches ( $22 \mathrm{~m} 2 / \mathrm{ha}$ ) but is higher in the reserve patch ( $32 \mathrm{~m} 2 / \mathrm{ha}$ ) (Figure 3). The higher mean basal area in the reserve patch is due to the high values in one later successional reserve patch. The reserve patches have high basal area for paper birch, white cedar and white spruce. The shelterwood patch is dominated by paper birch with lesser amounts of quaking aspen and balsam fir. The seed tree patch has higher basal area for quaking aspen, but with significant amounts of paper birch, balsam fir and white spruce. Overall stem density is similar in all three treatment classes and species level abundance is similar to basal area values (Figure 4). There were no stems greater than 10 cm dbh recorded in the recent cut patches.

Mature forest patches here are generally similar to the larger Manitou landscape with relatively high abundance of paper birch, balsam fir, white spruce and white cedar.

## Subcanopy density-2.5-10 cm dbh

Overall density varied among treatments with over 6000 stems/ha in the recent cut patches while the reserve class had 250 stems/ha (Figure 5). Density in the seed tree (750 stems $/ \mathrm{ha}$ ) and shelterwood ( $590 \mathrm{stems} / \mathrm{ha}$ ) treatments were more similar. Balsam fir was by far the most abundant species in mature forest patches; values ranged from 218 in the reserve treatment to 570 stems/ha in the seed tree class. White and black spruce both occurred in the seed tree patch, accounting for 140 stems/ha. Moutain maple was the most abundant shrub species in this class with values ranging from 50 stems/ha in the seed tree class to 275 stems/ha in the reserve class (Figure 6).

## Seedling/sapling/shrub density-less than 2.5 cm dbh

Tree species density in this class ranged from 12000 in the recent cuts to over 19000 in the seed tree class (Figure 7). Balsam fir and aspen made up most of the 12000 stems/ha in the recent cut class. Balsam fir accounted for over 15000 stems/ha in the seed tree treatment, while balsam fir and red maple made most of the stems in the reserve and shelterwood classes. White spruce, black spruce, and white cedar had low abundance values in all treatments.

Shrub densities were relatively similar across all treatments. Beaked hazel peaked in abundance in the recent cut was secondary to balsam fir in the reserve and seed tree treatments (Figure 8). Hazel and balsam fir were co-dominant in the shelterwood class.

## Herb layer composition

Herb layer composition here is typical of mesic fire dependent forests in northeastern Minnesota. Appendix A lists species and percent frequency overall and within each treatment class. Two exotic plant species (Taraxacum officinale, Cirsium) were recorded within the 139 samples. However, tansy ragwort (tanacetum vulgare) occurs in
several significant patches along the road before the bridge.

## Standing dead and downed wood

Dead wood volumes peaked in the reserve class due to the one late-successional patch. Volume in the reserve class ( $86 \mathrm{~m} 3 / \mathrm{ha}$ ) was substantially higher than shelterwood ( 48 $\mathrm{m} 3 / \mathrm{ha}$ ) and seed tree ( $50 \mathrm{~m} 3 / \mathrm{ha}$ ) (Figure 9). The volume in the recent cut class was lower ( $38 \mathrm{~m} 3 / \mathrm{ha}$ ) than values typically recorded in even-aged treatments in this area (90-110 $\mathrm{m} 3 / \mathrm{ha}$ ). Volumes for the seed tree and shelterwood treatments were also lower than average values recorded in the surrounding landscape for similar age classes.

## Duff and Litter Depth

Only trace amounts of duff were recorded in the recent cut patches. In the mature forest areas, litter and duff peaked in the reserve class and was lowest in the seed tree treatment area (Figure 10). Recent work on non-native earthworms in mesic fire dependent forests should give a better indication of how litter and duff level correlate with earthworm presence and abundance.


Figure 1. Transect mid-points.


Figure 2. Data logger locations.


Figure 3. Mean basal area for tree species (> 10 cm dbh) by treatment.


Figure 4. Mean stem density for tree species (> 10 cm dbh ) by treatment.


Figure 5. Mean density per hectare for tree species stems $2.5-10 \mathrm{~cm}$ dbh by treatment class.


Figure 6. Mean density per hectare for shrub species stems $2.5-10 \mathrm{~cm}$ dbh by treatment class.


Figure 7. Seedling-sapling ( $<2.5 \mathrm{~cm}$ dbh) stem density for tree species by treatment.


Figure 8. Seedling-sapling ( $<2.5 \mathrm{~cm}$ dbh) stem density for shrub species by treatment.


Figure 9. Mean deadwood volume by size class and treatment.


Figure 10. Mean duff and litter depth in millimeters.

Appendix A. Herb Layer species percent frequency overall and by treatment.

| Name | Cut | Reserve | SeedTree | Shelterwood | total |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Clintonia borealis | 88 | 94 | 91 | 94 | 92 |
| Maianthemum canadense | 63 | 94 | 94 | 92 | 91 |
| Aster macrophyllus | 88 | 75 | 87 | 95 | 89 |
| Aralia nudicaulis | 50 | 88 | 91 | 92 | 88 |
| Streptopus roseus | 75 | 100 | 89 | 84 | 87 |
| Rubus pubescens | 100 | 69 | 91 | 84 | 86 |
| Lycopodium dendroideum | 50 | 100 | 85 | 85 | 85 |
| Diervilla lonicera | 88 | 38 | 92 | 79 | 80 |
| Abies balsamea | 75 | 94 | 75 | 77 | 78 |
| Corylus cornuta | 100 | 81 | 83 | 71 | 78 |
| Carex pedunculata | 38 | 94 | 77 | 76 | 76 |
| Oryzopsis asperifolia | 75 | 75 | 83 | 68 | 75 |
| Anemone quinquefolia | 0 | 56 | 89 | 76 | 74 |
| Galium triflorum | 75 | 75 | 79 | 69 | 74 |
| Acer spicatum | 38 | 100 | 57 | 71 | 67 |
| Lonicera canadensis | 25 | 81 | 60 | 71 | 65 |
| Viola sp. | 0 | 81 | 85 | 53 | 65 |
| Trientalis borealis | 25 | 81 | 68 | 63 | 65 |
| Cornus canadensis | 75 | 63 | 74 | 44 | 59 |
| Lycopodium clavatum | 25 | 38 | 55 | 37 | 43 |
| Calamagrostis canadensis | 75 | 44 | 47 | 34 | 42 |
| Amelanchier sp. | 63 | 19 | 64 | 21 | 40 |
| Populus tremuloides | 25 | 0 | 51 | 19 | 29 |
| Rubus idaeus var. strigosus | 38 | 44 | 36 | 15 | 27 |
| Vaccinium myrtilloides | 0 | 6 | 53 | 11 | 26 |
| Prunus virginiana | 50 | 19 | 38 | 13 | 25 |
| Dryopteris carthusiana | 25 | 69 | 21 | 16 | 24 |
| Athyrium filix-femina | 38 | 50 | 17 | 21 | 24 |
| Acer rubrum | 13 | 50 | 6 | 32 | 23 |
| Sorbus americana | 0 | 81 | 19 | 15 | 23 |
| Luzula acuminata | 0 | 25 | 28 | 19 | 22 |
| Apocynum |  |  |  |  |  |
| androsaemifolium | 25 | 13 | 30 | 18 | 22 |
| Ribes triste | 25 | 56 | 23 | 13 | 22 |
| Lycopodium annotinum | 0 | 63 | 21 | 11 | 20 |
| Carex | 0 | 13 | 25 | 19 | 19 |
| Lonicera hirsuta | 63 | 6 | 26 | 11 | 19 |
| Carex arctata | 25 | 31 | 23 | 11 | 19 |
| Rosa acicularis | 0 | 0 | 23 | 21 | 18 |
| Actaea rubra/alba | 0 | 6 | 30 | 13 | 18 |
| Vaccinium | 13 | 0 | 19 | 21 | 17 |
| Picea glauca | 50 | 19 | 17 | 11 | 17 |
| Linnea borealis | 0 | 19 | 28 | 8 | 17 |
| Fragaria virginiana | 38 | 0 | 25 | 10 | 16 |
| Mertensia paniculata | 0 | 19 | 21 | 8 | 14 |

Appendix A continued

| Name | Cut | Reserve | SeedTree | Shelterwood | total |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Rosa | 38 | 0 | 17 | 10 | 13 |
| Betula papyrifera | 25 | 19 | 8 | 13 | 12 |
| Corallorhiza maculata | 0 | 0 | 21 | 8 | 12 |
| Ribes | 0 | 13 | 19 | 6 | 12 |
| Cornus stolonifera | 25 | 0 | 23 | 3 | 12 |
| Gymnocarpium dryopteris | 0 | 38 | 6 | 10 | 11 |
| Viola canadensis | 63 | 25 | 0 | 10 | 11 |
| Coptis trifolia | 0 | 6 | 23 | 3 | 11 |
| Actaea rubra | 38 | 0 | 2 | 16 | 10 |
| Huperzia lucidula | 0 | 31 | 6 | 10 | 10 |
| Pyrola sp. | 13 | 6 | 9 | 10 | 9 |
| Pteridium aquilinum | 13 | 6 | 9 | 10 | 9 |
| poaceae | 0 | 0 | 17 | 6 | 9 |
| Carex gracillima | 0 | 25 | 2 | 11 | 9 |
| Thelypteris phegopteris | 0 | 38 | 2 | 8 | 9 |
| Lathyrus venosus | 13 | 0 | 2 | 15 | 8 |
| Thuja occidentalis | 13 | 19 | 0 | 11 | 8 |
| lycopodium | 0 | 0 | 0 | 16 | 7 |
| Alnus incana | 25 | 0 | 11 | 2 | 6 |
| Epilobium angustifolium | 0 | 0 | 6 | 8 | 6 |
| Lycopodium complanatum | 0 | 0 | 11 | 3 | 6 |
| Mitella nuda | 0 | 6 | 2 | 8 | 5 |
| Unknown | 0 | 0 | 6 | 6 | 5 |
| Viburnum rafinesquianum | 0 | 0 | 9 | 3 | 5 |
| Picea mariana | 0 | 0 | 9 | 3 | 5 |
| Betula allegheniensis | 0 | 44 | 0 | 0 | 5 |
| Osmorhiza claytonii | 0 | 6 | 2 | 6 | 4 |
| Trilliam cernuum | 0 | 0 | 8 | 3 | 4 |
| Acer | 0 | 6 | 8 | 2 | 4 |
| Vaccinium angustifolium | 25 | 0 | 8 | 0 | 4 |
| Monotropa uniflora | 0 | 6 | 4 | 3 | 4 |
| Actaea alba | 13 | 6 | 2 | 3 | 4 |
| Equisetum sylvaticum | 0 | 0 | 8 | 2 | 4 |
| Anaphalis margaritacea | 13 | 0 | 6 | 2 | 4 |
| Salix | 25 | 0 | 6 | 0 | 4 |
| Cinna latifolia | 0 | 0 | 0 | 6 | 3 |
| Aster | 0 | 0 | 4 | 3 | 3 |
| Fraxinus nigra | 0 | 6 | 2 | 3 | 3 |
| Pyrola elliptica | 0 | 0 | 6 | 2 | 3 |
| Melampyrum lineare | 0 | 0 | 6 | 2 | 3 |
| Cornus | 0 | 0 | 6 | 2 | 3 |
| Acer saccharum | 0 | 0 | 6 | 2 | 3 |
| Thalictrum dioicum | 0 | 6 | 4 | 2 | 3 |
| Carex trisperma | 0 | 6 | 4 | 2 | 3 |

Appendix A continued

| Name | Cut | Reserve | SeedTree | Shelterwood | total |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Achillea millefolium | 0 | 0 | 8 | 0 | 3 |
| Viola renifolia | 0 | 0 | 0 | 5 | 2 |
| Rubus | 0 | 0 | 0 | 5 | 2 |
| Sorbus decora | 0 | 0 | 2 | 3 | 2 |
| Equisetum | 0 | 0 | 2 | 3 | 2 |
| Sorbus | 0 | 0 | 4 | 2 | 2 |
| Solidago | 0 | 0 | 4 | 2 | 2 |
| Aster puniceus | 0 | 0 | 4 | 2 | 2 |
| Carex intumescens | 0 | 6 | 2 | 2 | 2 |
| Rubus parviflorus | 0 | 13 | 0 | 2 | 2 |
| Taraxacum officinale | 0 | 0 | 6 | 0 | 2 |
| Petasites frigidus | 0 | 6 | 4 | 0 | 2 |
| Sambucus racemosa | 0 | 13 | 2 | 0 | 2 |
| Brachyelytrum erectum | 0 | 13 | 2 | 0 | 2 |
| Aster lanceolatus | 38 | 0 | 0 | 0 | 2 |
| Oxalis | 0 | 0 | 0 | 3 | 1 |
| Carex pensylvanica | 0 | 0 | 0 | 3 | 1 |
| Pyrola | 0 | 0 | 2 | 2 | 1 |
| Polygonatum pubescens | 0 | 0 | 2 | 2 | 1 |
| Carex deweyana | 0 | 6 | 0 | 2 | 1 |
| Viburnum trilobum | 0 | 0 | 4 | 0 | 1 |
| Thalictrum | 0 | 0 | 4 | 0 | 1 |
| Ribes glandulosum | 0 | 0 | 4 | 0 | 1 |
| Convolvulus spithameus | 0 | 0 | 4 | 0 | 1 |
| Chimaphila maculata | 0 | 0 | 4 | 0 | 1 |
| Bromus | 0 | 0 | 4 | 0 | 1 |
| Aster ciliolatus | 0 | 0 | 4 | 0 | 1 |
| Sambucus canadensis | 13 | 0 | 2 | 0 | 1 |
| Thalictrum dasycarpum | 0 | 0 | 0 | 2 | 1 |
| Schizachne purpurascens | 0 | 0 | 0 | 2 | 1 |
| poa species | 0 | 0 | 0 | 2 | 1 |
| Pinus strobus | 0 | 0 | 0 | 2 | 1 |
| Clematis virginiana | 0 | 0 | 0 | 2 | 1 |
| ranunculus | 0 | 0 | 2 | 0 | 1 |
| Lonicera oblongifolia | 0 | 0 | 2 | 0 | 1 |
| Ledum groenlandicum | 0 | 0 | 2 | 0 | 1 |
| Arctostaphylos uva-ursi | 0 | 0 | 2 | 0 | 1 |
| Antennaria neglecta | 0 | 0 | 2 | 0 | 1 |
| Urtica dioica | 0 | 6 | 0 | 0 | 1 |
| Osmunda claytoniana | 0 | 6 | 0 | 0 | 1 |
| Populus balsamifera | 13 | 0 | 0 | 0 | 1 |
| Lysimachia | 13 | 0 | 0 | 0 | 1 |
| circium | 13 | 0 | 0 | 0 | 1 |
| Bromus purgans | 13 | 0 | 0 | 0 | 1 |

Appendix B.

## Manitou 2009-Forest Condition and Management Monitoring Protocol

Transect based sampling is used for most variables in this project.
The primary unit is a 50 m line and belt transect.
50 meter transects will be laid out at random locations along a compass bearing. Transect starting points will be spaced at 50-100 m along compass bearing. GPS readings will be taken at the mid-point of each transect plot. Actual transect direction is randomized at each location to eliminate bias in CWD sampling. From transect midpoint, pick a random bearing for transect direction.

At each transect plot midpoint ( 25 m ) record slope degree, aspect (degrees), and topographic position, and evidence of disturbance (recent treefall gap, blowdown, fire scars, burnt snags, insect related mortality etc.) Topographic position codes: $1=$ draw or stream bottom, $2=$ flat, $3=$ lower slope, $4=$ mid-slope, $5=$ upper slope, $6=$ ridgetop.
Data Elements

1) Life-Form and Structure. From plot center, list life-form categories by height class and cover code using DNR Releve system.
2) Coarse Woody Debris (CWD). 1x50m. Use vertical plane intercept approach. Tally intersection 10-20, $20-30 \mathrm{~cm}$ dm classes. Measure dm at intersection of pieces $>=30 \mathrm{~cm}$. Record decay class: $1=$ sound, $2=$ decayed.
3) Tree regeneration. $2 x 5 \mathrm{~m}$ belt transect. Start at 22.5 m mark, end at 27.5 m mark. Measure $\mathbf{1 m}$
 Include stems of shrub species. Within areas of high density, use $2 \times 2 \mathrm{~m}$ belt transect.
4) Stems $2.5-10 \mathrm{~m} \mathrm{~cm} \mathrm{dbh}$. $2 \times 20 \mathrm{~m}$ belt transect, tally stems by species. Start at 15 m mark, end at 35 m . Include live and dead stems, include height estimate.
5) Stems $>10 \mathrm{~cm} \mathrm{dbh}$, including snags. 10 BAF prism from plot center measure dbh by species. Record height class (releve system), and live or dead.
6) Litter and duff. 11 m 2 circular plot. Locate plot 2 m directly north of transect center point. Estimate litter cover by class (deciduous, conifer, grass, forb). Measure litter abd duff in 5 locations in plot to nearest mm. Start at plot center.
7) Herb and shrub cover. (Use \#3 above, tree regeneration plot). Estimate herb and shrub cover in 10 m 2 plot. Use braun-blanquet scale to estimate cover by species $<\mathbf{1 m} \mathbf{~ h t}$. a. List species occurring along transect line, no cover classes.
8) Gap fraction. Record length (m) of each intersected gap along 50 m transect. Gap is defined as the distance between foliage of trees that define gap. Record gaps where trefalls intersect transect line.
9) Permanent plot markers. Metal stake at transect center and end points. Attach metal tags, or use numbered tree tags.
10) Photo points. Take photos of transect from each end point.
