Task 3: Resample vegetation transects and landing sites for invasive species colonization and composition and structure, Survey roads and skid trails for soil disturbance and invasive species colonization.

Mark A. White
Forest Ecologist
The Nature Conservancy, Minnesota and the Dakotas

As per the grant agreement between the Nature Conservancy and the Minnesota Department of Natural Resources, please accept this report which fulfills Task 3, Submitted July 27, 2011.

Forest vegetation transect sampling methods are described in detail in Appendix A, Sampling methods. We used the identical transect methods used for baseline sampling in 2009. Per this grant agreement, we sampled 32 transects within the area harvested during the summer of 2010. Included in this data summary are an additional 32 transects from harvested area sampled under a separate contract to Matthew Tyler from the MN DNR Adaptive Forest Management Program. Of the 64 transects 52 were within shelterwood blocks and 12 in Seed tree treatments (Figure 1).

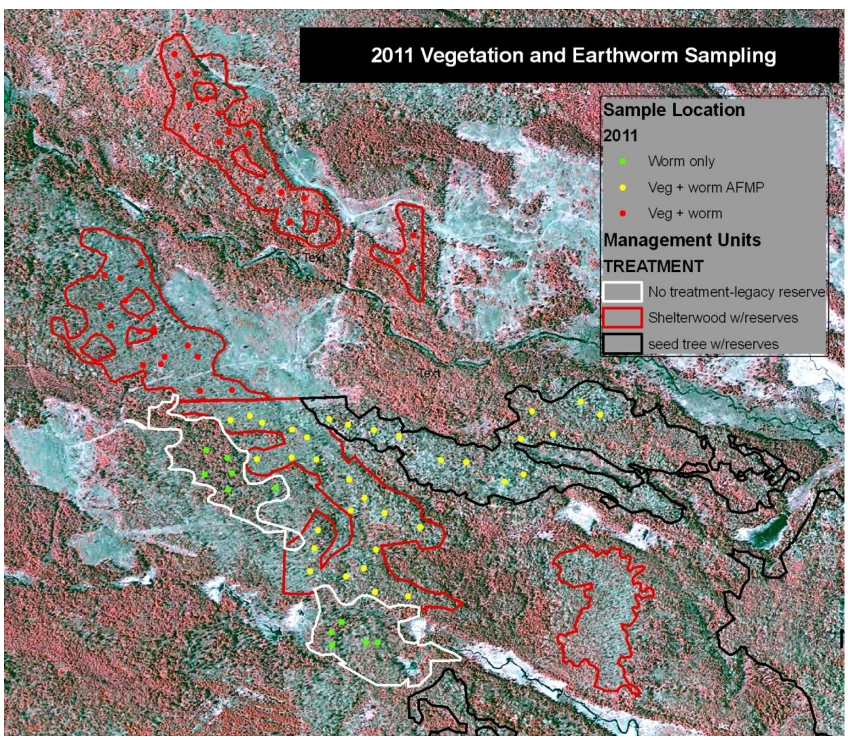


Figure 1. Locations for vegetation transects and invasive earthworm samples.

Results

Basal Area and Density

In the shelterwood treatment, live basal of stems > 4" dbh changed 92.2 to 33ft^2/acre, a 64% change in basal area. Paper birch changed from 55 to18 ft^2/acre while white spruce, black spruce and white cedar had much smaller reductions in basal area (Figure 2a). Density changes followed a similar pattern (Figure 2b). These three species were not harvested in this treatment, so decreases in basal area and density were due to either post-harvest blowdown or were removed for roads and skid trails. The original basal area target was approximately 40 ft^2/acre; the residual basal area of 33 ft^2/acre is somewhat lower. This may in due in part to post harvest blowdown, as significant numbers of residual white spruce went down in the period between harvest and sampling.

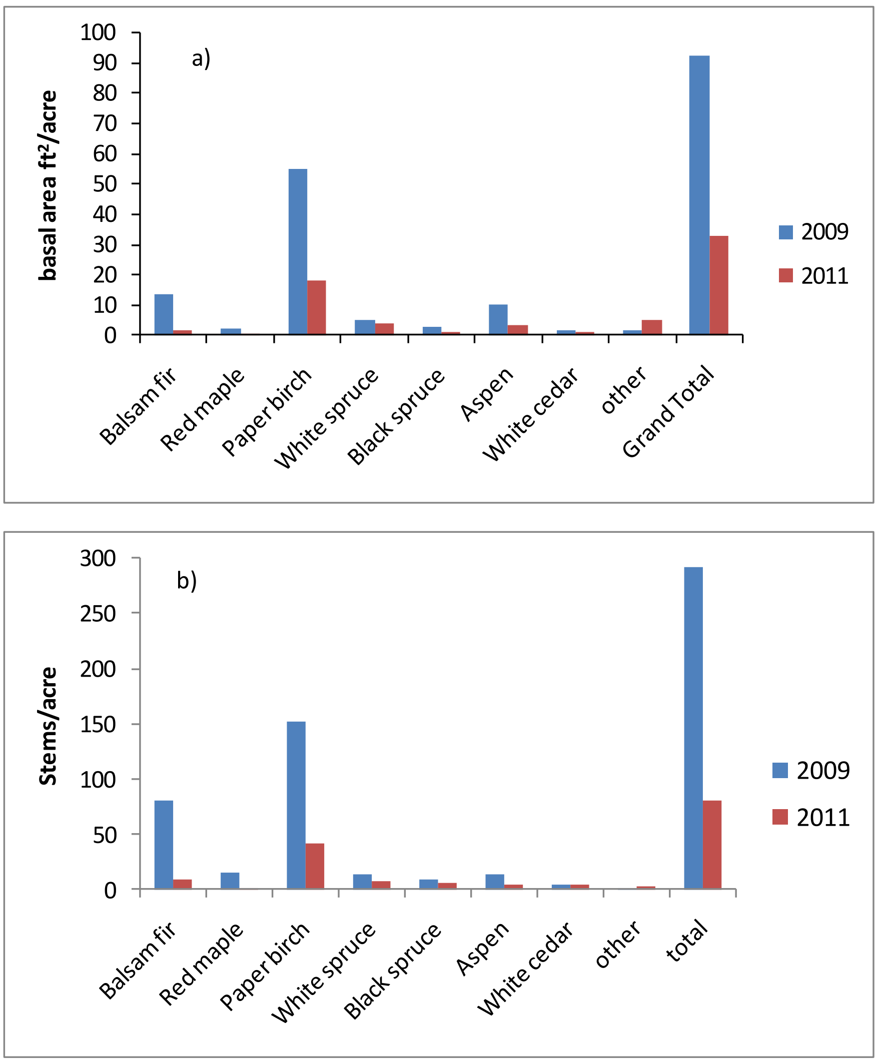
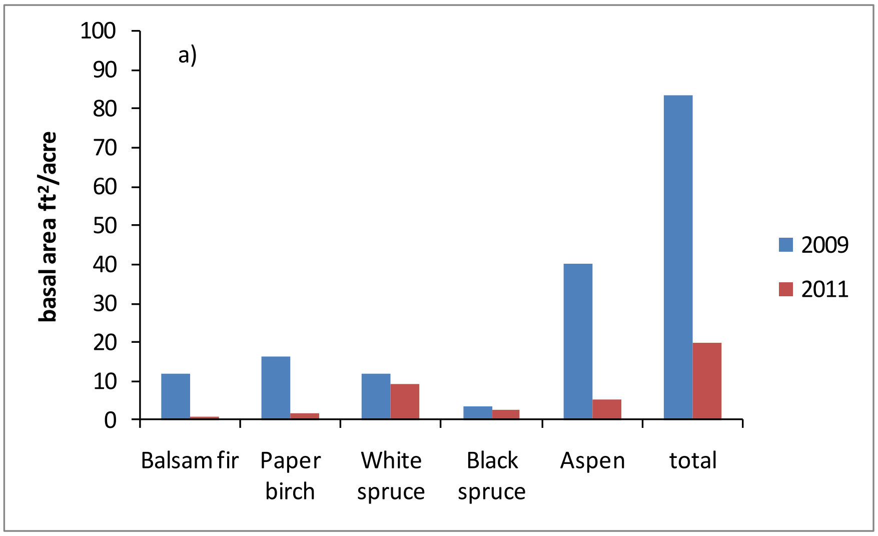


Figure 2. Basal area a) and density b) for the shelterwood treatment transects.

Basal area in the seed tree block decreased from 84 to 20 ft2/acre, a 76% change in basal area. Some large residual aspen and paper birch were retained, white and black spruce were reserved and showed small decreases in basal area, primarily due to post-harvest blowdown (Figure 3b). These changes are consistent with the higher removal levels and larger gaps in the seed tree treatment. Aspen and birch retention averaged 14 stems/acre, which is consistent with 10-18 trees/acre in the prescription (Figure 3c).



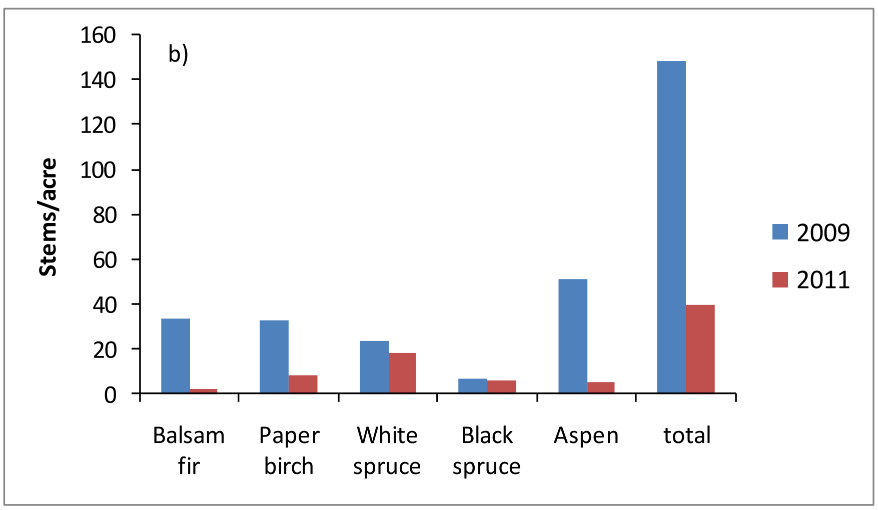


Figure 3. Basal area a) and density b) for the seed tree treatment transects.

<u>Tree Regeneration: Seedling-Sapling-Pole Stems</u>

In the shelterwood treatment, sapling-pole stems (1-4” dbh) decreased from 252 to 53 stems/acre with balsam fir making up 87% of residual stems (Figure 3a). Red maple and white spruce were retained at low densities (< 4/acre) (Figure 4a).

Seedling-sapling stems (< 1”) increased from pre-treatment levels (6400 vs. 6521/acre). Paper birch, white pine, white spruce, white cedar, and aspen all showed some increase. The paper birch increase resulted from both sprouts and some newly germinated seedling on mineral soil, aspen stems were all sprouts. Increases in pine, spruce, and cedar were all the result of post-treatment planting during spring of 2011 (Figure 4b).

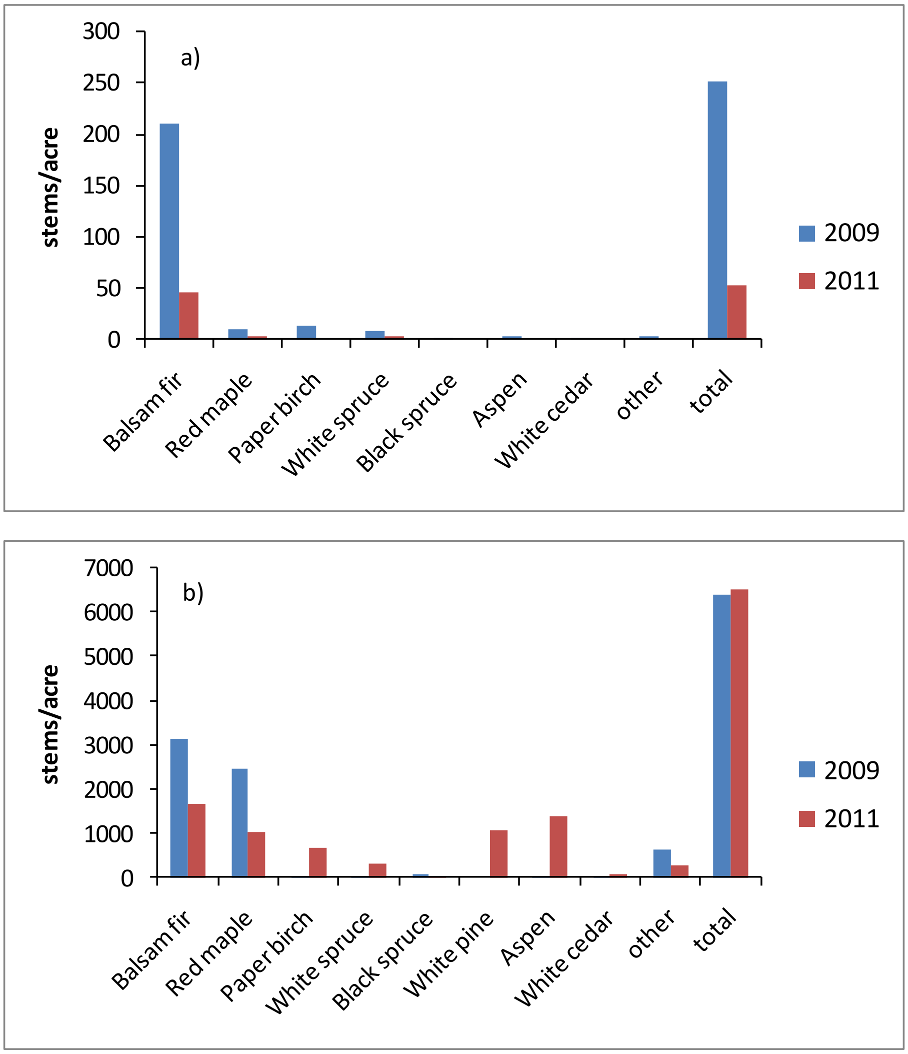


Figure 4. Density per acre for stems a) 1-4 inches dbh and b) stems < 1 inch dbh for the shelterwood treatment.

Within the seed tree block, sapling-pole stem decreased from 74 to 37 stems/acre, with balsam fir the only species recorded in this layer in 2011 (Figure 5a).

Seedling-sapling stems (< 1”) increased from 4200 to nearly 12,000 stems/acre; as paper birch, white pine, white spruce, white cedar, and aspen all increased. Aspen increases were due to sprouting while pine, spruce, and cedar change was due to planting during the spring of 2011. Paper birch increases are probably a combination of sprouting and some seedling establishment. We recorded over 4000 aspen and over 1700 white pine stems/acre (Figure 5b).

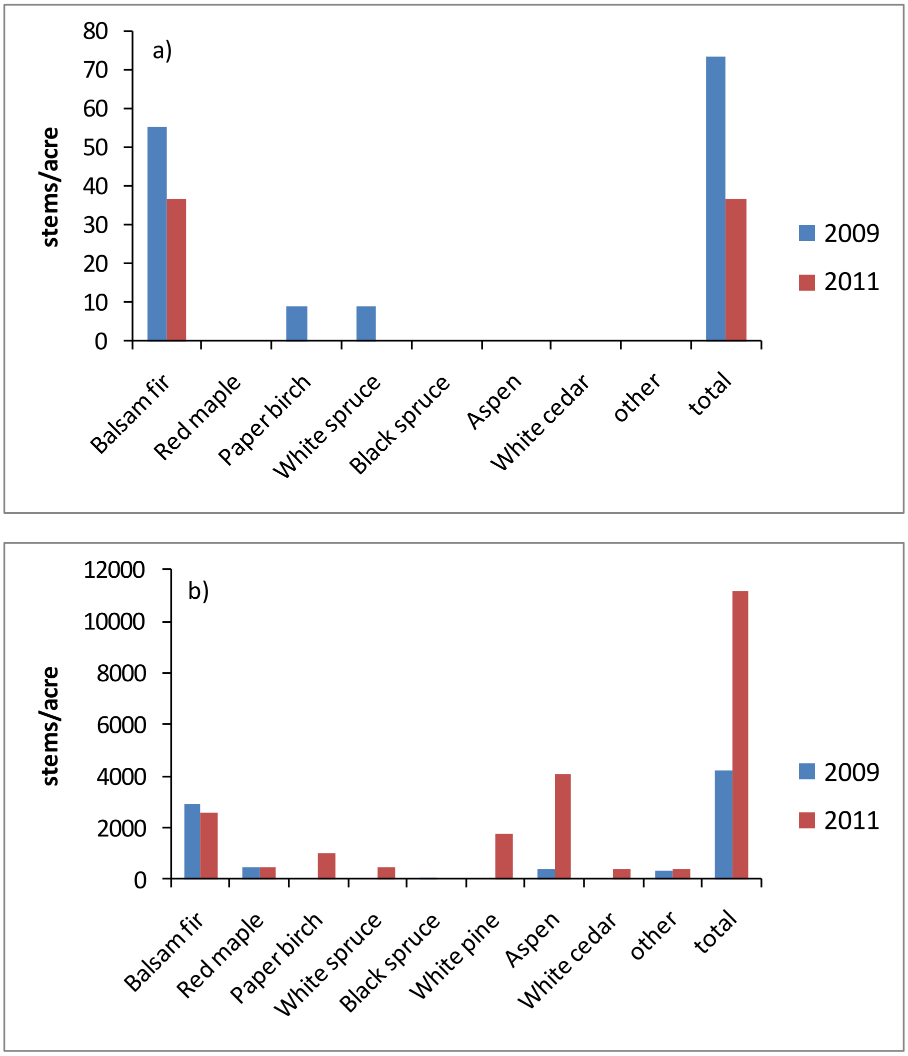
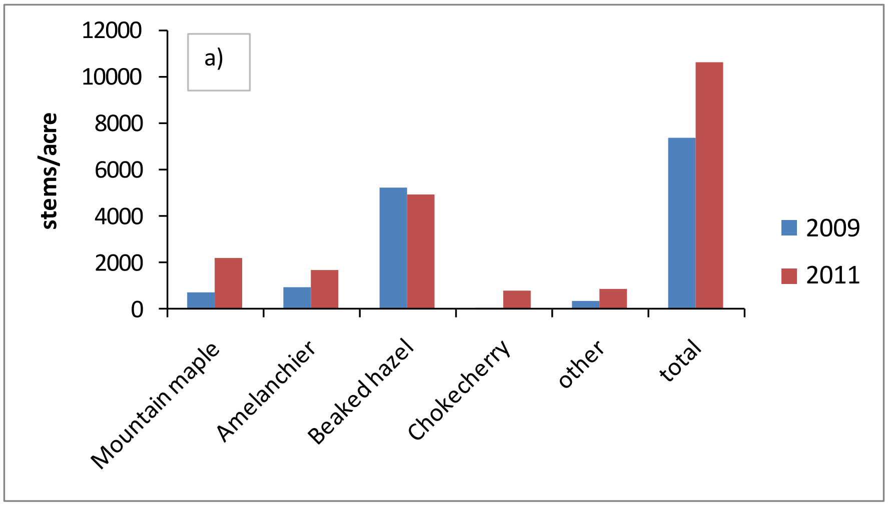


Figure 5. Density per acre for stems a) 1-4 inches dbh and b) stems < 1 inch dbh for the seed tree treatment.

<u>Shrub Density</u>

Shrub density showed differing responses in the two treatments. The seed tree treatment had an overall increase in shrub density while density in the shelterwood blocks decreased (Figure 6). Within the seedtree treatment, mountain maple, amelanchier, and chokecherry all increased while hazel had a small decrease. Mountain maple and hazel showed small density decreases in the shelterwood treatment. The increased density in the seedtree relative to the shelterwood is due to the higher light levels and lower basal area in the seed tree block. Shrub density should increase dramatically in both blocks over the next 3 years.



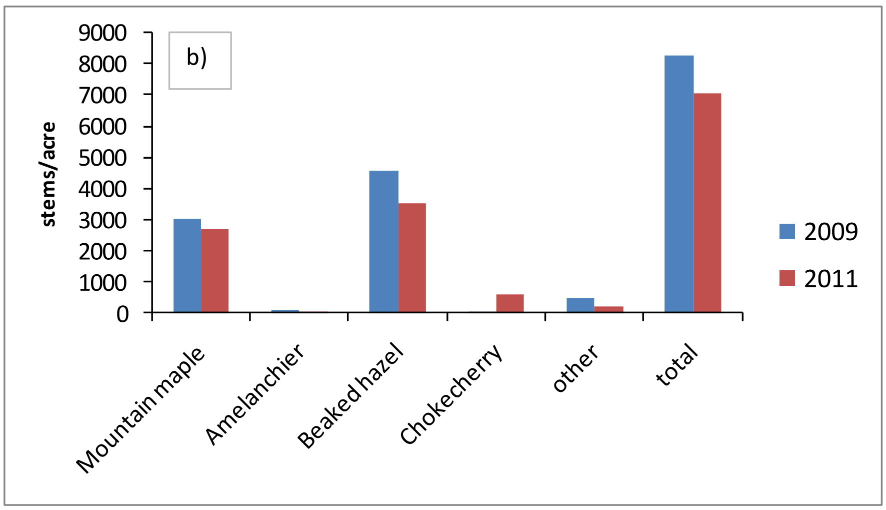
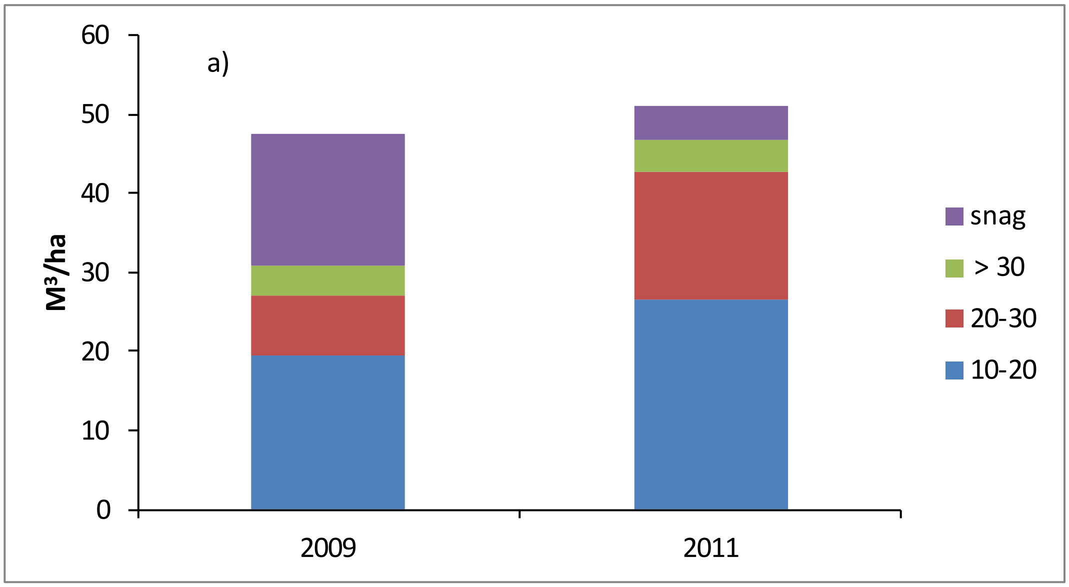


Figure 6. Density per acres for shrub species within a) seed tree and b) shelterwood treatments.

Standing Dead and Downed Wood

Within the shelterwood treatment, overall dead wood volume showed little change. However, within pools, there were significant changes. The 10-20 and 20-30 cm size classes increased, while snag volume decreased substantially from pre-harvest levels (figure 6). 2009 snags may have been knocked down during harvest operations or else fell post harvest. Either way these snags are in part responsible for the increase in the downed wood pools.

The seed tree block showed a significant increase in dead wood volume (41 to 70 m3/ha). All three downed wood pools increased, while similar to the shelterwood treatment, snag volume decreased significantly (Figure 7).



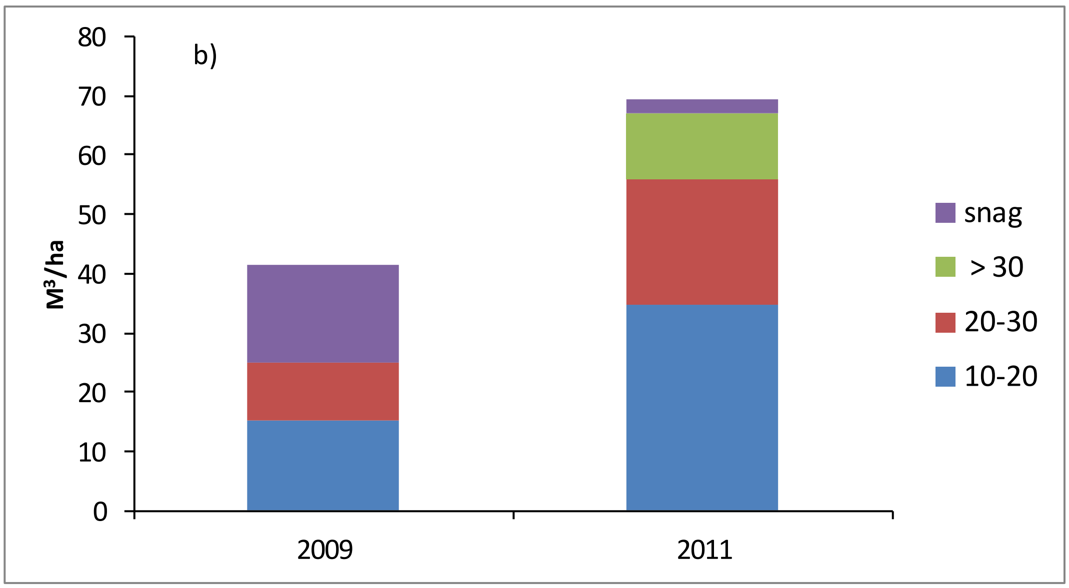


Figure 7. Standing dead and downed wood volume within a) seed tree and b) shelterwood treatment. For downed wood, size classes are in centimeters. Snags were greater than 10 cm dbh (4 inches).

<u>Invasive Plant Species</u>

Forest Vegetation Transects

No non-native species were recorded within forest vegetation transect samples.

Landing Transects

We sampled 25 landing transects during June of 2011 (Figure 8). Canada thistle (*Cirsium arvense*) and bull thistle (*C. vulgare*) were recorded on the northern most landing site (Figure 8, green circle). These were single occurrences just outside the main landing area. This is very close to the main access road where both cirsium species were observed in 2010. Both occurrences were beyond the seedling stage so they may have established in 2010 after harvesting, or root/rhizome material could have been moved by logging equipment.

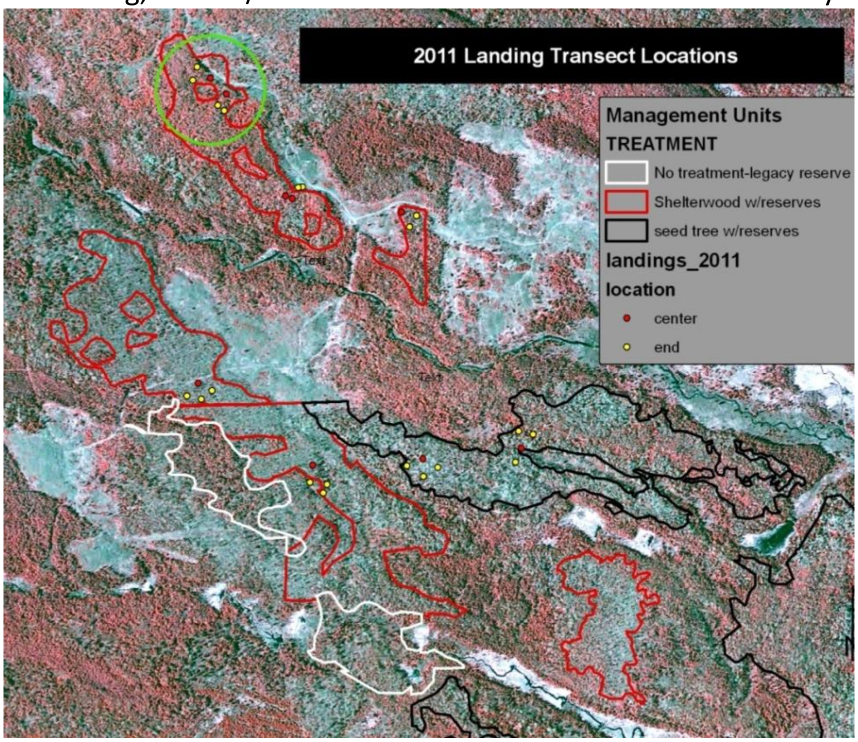


Figure 8. Landing transects sampled in 2011. Green circle shows location of invasive plant species occurrences.

Road and Skid Trail Plots

We sampled 129 30 m^2 plots on road and skid trails within harvested sites for percent bare soil, litter, native plant, and invasive plant cover (Figure 9.). See appendix A for methods. Litter cover was similar in both treatments; bare soil was higher in the shelterwood, and native plant cover higher in the seedtree treatment. Because spring 2011 was very cool, understory plant development was late. The shelterwood area was sampled earlier, this, and the more open nature of the seed tree treatment may account for the higher native plant cover in the seedtree treatment. No non-native invasive plant species were recorded in these samples. Sampling occurred in June, almost one year after harvest disturbance. These plots should be resurveyed 2-4 years after harvest to examine for invasive species colonization.

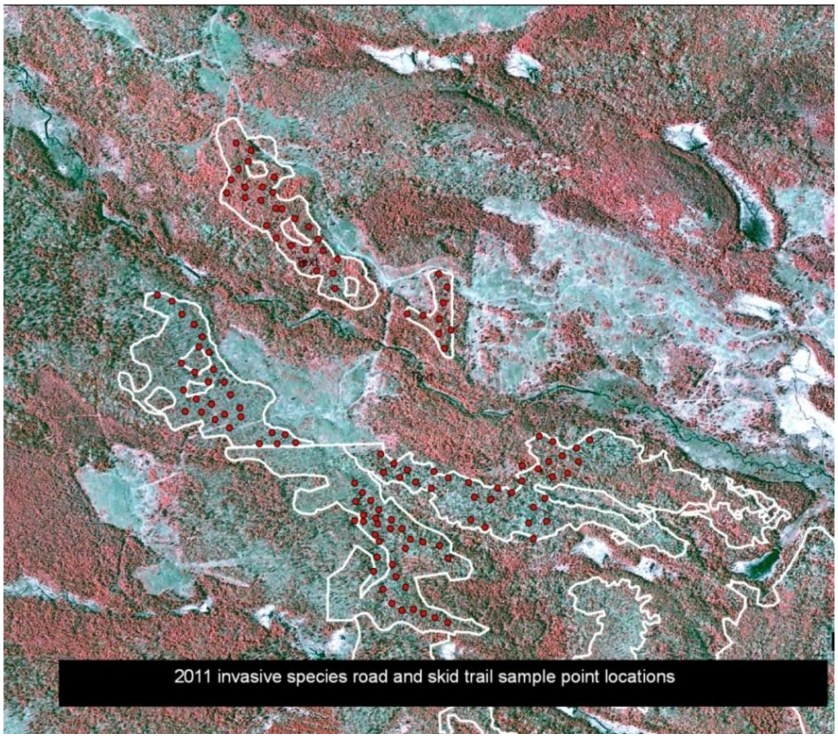


Figure 9. Locations for skid trail-logging road samples for soil disturbance and invasive species.

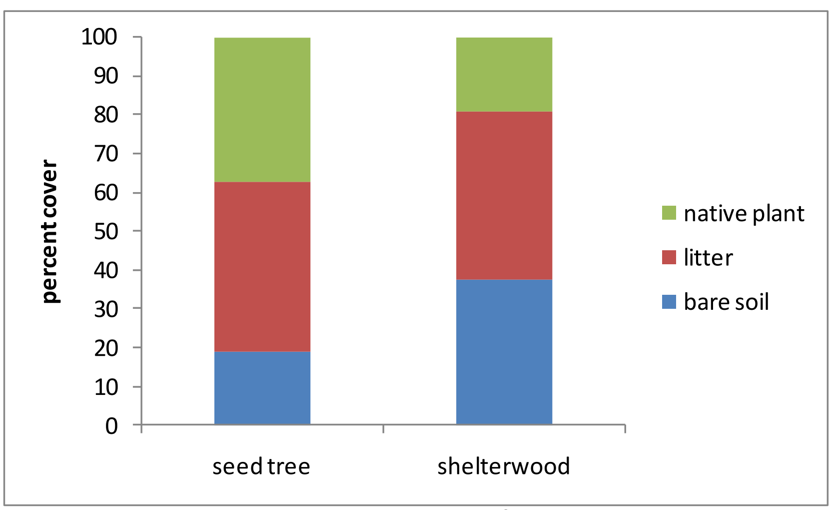
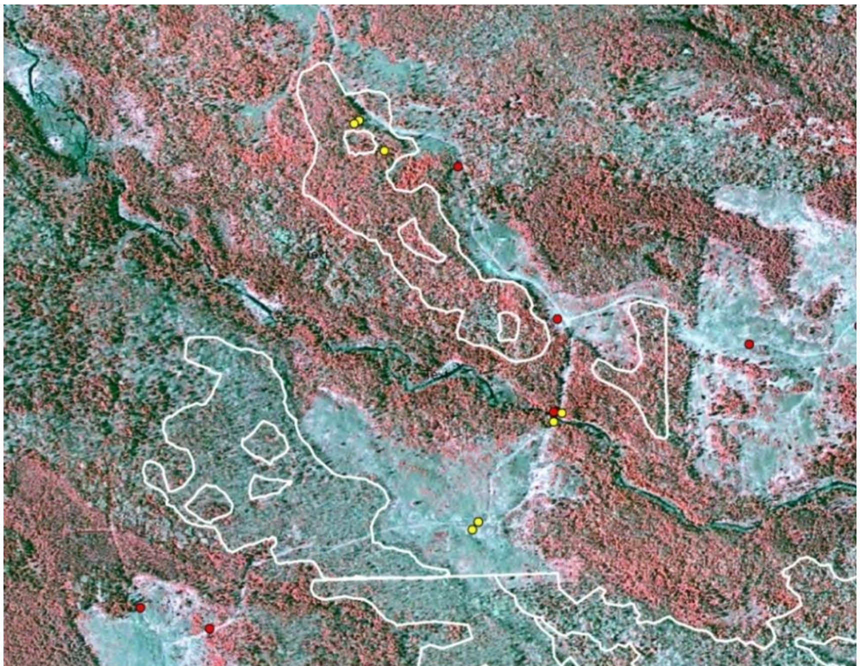


Figure 10. Skid trail-logging road 30 m^2 plots.

High Use-Larger Logging Roads

Walking surveys of high use logging roads that constructed or enlarged for timber harvest showed 5 occurrences of non-native invasive plant species on recently disturbed road areas.

We found three occurrences of Canada thistle on the newly constructed road on the south side of the Little Manitou River. One occurrence had greater than 50 plants. Rhizomes spread by logging equipment are the likely cause of these occurrences. We also recorded new occurrences of tansy ragwort (*Tanacetum vulgare*) and common St.Johnswort (*Hypericum perforatum*).



2010 (red) 2011 (yellow) invasive species within the primary harvested area.

Invasive Plant Species Summary

Previous surveys in 2009 and 2010 indicated that invasive plant species already occurred within the patch project area on roads, trails, landings and other disturbed sites. This area was logged in the late 1990s, so invasive plant colonization may date from that disturbance. In addition, invasive plant species are present on surrounding roads, trails, landings and other disturbed areas such as power line corridors. We know that logging equipment was power washed prior to moving to the Manitou patch project site. Per USFS regulation and contract specifications, the previous site where this equipment was operated had documented invasive species occurrences, so power washing was required prior to moving to the Manitou site. When invasive species already occur on a site, power washing equipment may have little effect on future invasive species colonization. Any areas in northern Minnesota that have had relatively recent logging along with the associated roads and trails may already have significant invasive species occurrences similar to this site. One way to limit the spread of invasive plants species in this situation would be to treat existing populations before any harvesting and associated road building and soil disturbance occur.

Non-Native Earthworms

We adapted indicators from the Invasive Earthworm Rapid Assessment Tool developed by Ryan Huffmaier and Cindy Hale (University of MN-Duluth, Natural Resources Research Institute). See appendix A for methods. We observed soil and forest floor conditions on 72 transects within seedtree (12), shelterwood (50) and reserve blocks (10). We classified each plot on a 1-5 ranking from 1-no earthworms to 5-heavey infestation. This is a rapid sampling method that looks for indicators of earthworm invasion from forest floor (leaf litter, duff) organic (O) and mineral soil (A) soil horizons. Earthworms reduce litter and duff and mix O and A soil horizons. Earthworm infested areas generally have litter only from the previous year's litter fall, low duff levels, and a mixed forest floor that does not have recognizable layers. Casts and middens are also important indicators and can be easily identified. Earthworms were present on all 72 plots and low (rank 2) to moderate (rank 3) levels (Figure 10). Rank 3 was by far the most frequent class with 60% in the reserve blocks, 92% in the seedtree and 70% in the shelterwood. The soil disturbance from harvesting operations may have influenced the results somewhat, because of lower duff and litter levels in the harvested treatments (Figure 11). However rank 3 made of 60% of transects within the unharvested reserve blocks.

Results from this study and other recent work suggests that non-native earthworms may be more widespread than previously thought. Most survey work has been done in northern hardwood forests, while relatively little work has been done in mesic fire dependent forests such as those occurring on the Manitou site. We found no sites free of non-native earthworms; this may be the norm for mesic forests in the Manitou region. The ecological effects of earthworms are better understood for northern hardwood forest where they can lead to a suite of negative impacts including, lower understory plant diversity, low levels of tree regeneration, lower productivity, and facilitation of invasive plant species colonization. We assume that earthworms have similar impacts on mesic fire dependent forests. Although these forests may be less productive than northern hardwood forest and produce less leaf litter, and therefore support lower populations of non-native earthworms.

The rapid assessment method we used takes less than 10 minutes per sample. This approach should be used on a broader geographic range in northern Minnesota to better determine the distribution of non-native earthworms.

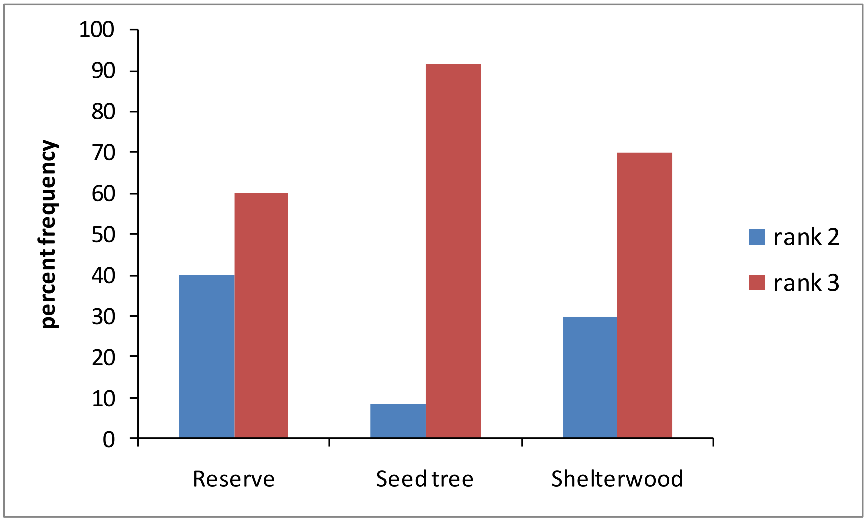


Figure 10. Percent frequency for non-native earthworm classification. Possible rankings range from 1-no earthworms present to 5-heavily infested.

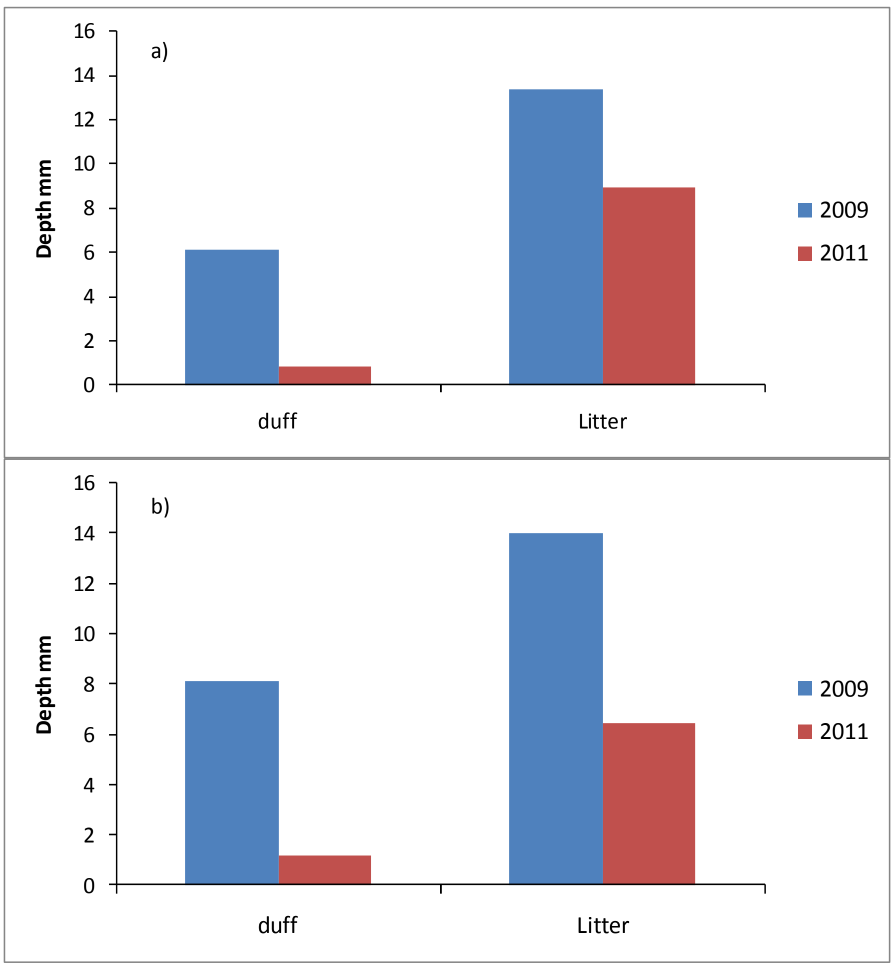


Figure 11. Duff and litter depth for a) seed tree and b) shelterwood treatments.

Appendix A: Monitoring Protocols

Protocol 1: Vegetation Composition and Structure Monitoring

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 cm dm classes. Measure dm at intersection of pieces >= 30 cm. Record decay class: 1 = sound, 2 = decayed.

3) Tree regeneration. 2x5 m belt transect. Start at 22.5m mark, end at 27.5 m mark. Measure 1 m on either side of transect. Record species density by height class (< 50, 50-1m, > 1 m, < 2.5 cm dbh). Include stems of shrub species. Within areas of high density, use 2x2 m belt transect**.**

4) Stems 2.5-10m cm dbh. 2x20 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 cm dbh, including snags. 10 BAF prism (variable radius plot) from plot center; record dbh by species. Record height class (releve system), and live or dead.

6) Litter and duff. 1 1m2 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 by species in 10m2 plot. Use braun-blanquet scale to estimate cover by species < 1m ht. Moss and lichen are included but not by species.

a. List species occurring within 1 meter along either side of 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 tree falls intersect transect line.

9) Permanent plot markers. Metal stake at transect center and end points. Record GPS coordinates for each of these points. Attach metal tags, or use numbered tree tags.

10) Photo points. Take photos into transect from each end point.

Protocol 2-Landing Site

Patch Project Landing Sites

1. Place 2-3 three 50m transects radiating out from the edge of each landing area (4-6 landings, 12-24 transects). The first transect will be assigned a random compass bearing, subsequent transects will placed at 50-120 degree intervals from the first transect. Record GPS coordinates at endpoints of transects, and place metal stakes and tags.
2. Along each transect, place 1m^2 plots every 10meters. Within each plot, record percent cover of each non-native species (recording individual species) and percent cover of native species.

Protocol 3 Skid trails, logging Roads, and landing areas

At 50 m intervals along all logging roads and a subset of skid trails, we will estimate bare soil, invasive species, and native species cover using a 30m^2 circular fixed radius (r = 3.1 m) plot. Plots will be marked with permanent markers and locations recorded in GPS.

Large logging roads that received heavy use from equipment were surveyed by walking the total length and recorded presence of invasive plants using the landscape survey protocol. Species and an estimate of abundance (number of stems were recorded at each location.

Protocol 4-Invasive Earthworm Sampling

We used a 25 m2 belt plot along each vegetation transect. Centered on center point, go 6.25 m in each direction: 31.25 and 18.75. Use 1 m on either side of transect. Check the 25m2 area for the following worm indicators.

Previous year's litter only (yes or no)
Frag Lvs > 1yr (yes or no)
intact FF (yes or no)
duff layer present (yes or no)
middens (yes or no)
casts (yes or no, abundance: low, medium or high).

We used these indicators to classify each site into one of the following classes.

Earthworm Classes and Characteristics

Rank = 1

1. Humus fully intact and layered
2. Roots present in humus and leaf fragments
3. Forest floor with intact recognizable layers
4. No earthworms or earthworm signs present

Rank = 2

1. Humus present in patches, may be slightly mixed with mineral soil, the rest of the forest floor is intact (large and small fragmented leaves).
2. Some roots in the forest floor, but not thick. Small earthworms found in the forest floor.
3. No large casting or Lumbricus terrestris middens.
4. Small castings may be present in the humus layer of an otherwise intact and layered forest floor.

Rank = 3

1. Larger, mostly intact leaves from the previous litterfall present, also includes mostly intact partially decayed leaves of the previous year
2. Small leaf fragments present under intact leaves
3. No humus (duff layer)
4. Mineral soil and earthworm casting present
5. L. terrestris middens absent or rare

Rank = 4

1. Larger, mostly intact leaves from the previous litterfall present, also includes mostly intact partially decayed leaves of the previous year
2. No humus or small leaf fragments present
3. Mineral soil and earthworm casting abundant
4. L. terrestris middens absent or rare
5. Plant roots absent in forest floor

Rank = 5

1. No forest floor or only larger mostly intact leaves from the previous litter fall present only
2. No humus (duff) or small leaf fragments present
3. Mineral soil and earthworm castings abundant
4. L. terrestris middens present
5. Plant roots absent in the forest floor