Analysis of Field Data for the Shawangunks Grassland and Forests Birds Habitat Study

Report #3: Undercliff Oak Forest Management

March 2, 2011

Prepared for

The Nature Conservancy
Shawangunks Program
New Paltz, NY

Prepared by:

Michael S. Batcher
Ecologist and Environmental Planner
1907 Buskirk-West Hoosick Rd.
Buskirk, NY 12028

Table of Contents

Tables

Figures and Maps

Acknowledgements

The following individuals worked to collect data in 2008, 2009 and 2010 used in these analyses:

Gabe Chapin	The Nature Conservancy
Becca Hamil	The Nature Conservancy/SCA
Evan Schachtel	The Nature Conservancy/SCA
Erik Hawes	The Nature Conservancy/SCA
Adam Cohn	Volunteer
Dan Schniedewind	Volunteer
Denise Magretto	Volunteer
Alexandra (Allie) Weill	University of Chicago Intern

Gabe Chapin (The Nature Conservancy), Tray Biasiolli (NY State Office of Parks, Recreation and Historic Preservation),[1] Mathew Medler (NY State Office of Parks, Recreation and Historic Preservation),[2] T. Scott Sillett (Smithsonian Migratory Bird Center), Louis Iverson (USDA Forest Service), Michael Hallworth (George Mason University), Michael Morgan (Audubon New York),[3] Julie Lundgren (New York Natural Heritage Program), John Thompson (Mohonk Preserve), Tim Howard (New York Natural Heritage Program), Becky Shirer (The Nature Conservancy), Carol Rietsma (SUNY-New Paltz) and Marc Abrams (Pennsylvania State University) provided advice on methods. Robert Unnasch of Sound Science LLC assisted with the development of field protocols. The Nature Conservancy provided funding for this project with portions provided through a grant from the New York State Department of Environmental Conservation.

[1] Currently with the U.S. Forest Service Pacific Southwest Research Station in Davis, CA.
[2] Currently with the Cornell Laboratory of Ornithology
[3] Currently with the New York State Department of Environmental Conservation

Summary

As part of a study on the effects of prescribed fire on forest bird habitat, we established 16 plots within a 35.7 acre (14.4 ha) treatment unit in 2009. Target bird species were Black-throated Blue Warbler (*Dendroica caerulescens*), Scarlet Tanager (*Piranga olivacea*), Wood Thrush (*Hylocichla mustelina*) and Worm-eating Warbler (*Helmitheros vermivorum*), all of which are Species of Greatest Conservation Need (SCGN). We collected data on tree, shrub, sapling and seedling abundance. We also collected data specific to shrub nesting birds by measuring shrub abundance at 0.5 m height increments from zero to three meters. We burned the unit in late April and early May of 2010 and resurveyed all 16 plots.

Live woody stems and leaves were found relatively evenly distributed by height class prior to treatment in 2009. Most mountain laurel stems and leaves were found at a height of between 0.5 and 1.5 meters. Following the burn, shrubs were top killed, so that nearly all live woody material was relegated to less than 0.5 m as plants resprouted.

Tree mortality was negligible, and canopy cover did not change significantly, though there was some increase overall. There were small, but statistically significant reductions in litter cover and increases in duff.

Total seedling density in the 16 plots ranged from 5,333 to 18,416/ha prior to treatment and 7,666 to 31,250 after treatment. Both oaks and red maples showed a significant increase in density between pre and post treatment. Total sapling density ranged from 500 to 2,166/ha, prior to treatment and 0 to 750/ha after treatment. Sapling density decreased significantly for all species, though red maple did increase in one subunit. The proportion of hardwood and/or red maple to oak saplings was higher than for seedlings, both before and after treatment.

Both Black-throated Blue and Canada Warblers nest in the dense shrub layers of 1-3 meters that were reduced in height and cover by the prescribed fire. Clearly the fire was not favorable to those habitat characteristics needed for those species. Increases in seedling densities and regrowth of mountain laurel will likely result in suitable habitat again, though we cannot predict the time frame for that from this study. At the same time, there was negligible change in tree density or canopy cover, so some of the appropriate habitat characteristics for these species remain. Scarlet Tanagers require large, unbroken forests with closed canopy, so their habitat requirements remain unchanged. Litter cover remained relatively unchanged, and new litter will fall to replace what was burned. Therefore, habitat for Worm-eating Warblers should also remain relatively unchanged.

The methods used here could be modified for monitoring site treatments, and recommendations are included for both future research and monitoring.

I. Introduction

The chestnut oak forest in the Shawangunks is one of the largest in New York State (Shawangunk Ridge Biodiversity Partnership 2003). The chestnut oak forest is highly variable, with three major types distinguished by the shrub and herbaceous layers: a tall shrub dominated forest with 60-90% cover of mountain laurel, a short shrub forest with heaths including blueberry and huckleberry and an herbaceous dominated forest with primarily Pennsylvania sedge (Edinger et al. 2002). Fire is critical to maintenance of such oak forests in the northeastern United States (Nowicki and Abrams 2008), and prescribed fire will be a critical management tool for maintaining this forest system.

To evaluate the effects of prescribed fire on the chestnut oak forest and habitat characteristics for several forest nesting birds, a treatment unit was established in the Undercliff area of the Mohonk Preserve. This report compares habitat and other vegetation characteristics within that unit from data collected prior to treatment in 2009 to data collected following spring burns in 2010.

Following an extensive review of the literature habitat requirements of four SCGN (Species of Greatest Conservation Need) bird species were identified (Batcher 2009): Black-throated Blue Warbler (*Dendroica caerulescens*), Scarlet Tanager (*Piranga olivacea*), Wood Thrush (*Hylocichla mustelina*) and Worm-eating Warbler (*Helmitheros vermivorum*). These species were chosen due to their conservation status and because they utilize different strata within forest habitat. During surveys in 2008 following the Overlooks wildfire at Minnewaska State Park Preserve, no Worm-eating Warblers were detected. However, Canada Warblers (*Wilsonia canadensis*), another SCGN species, were detected. Like Worm-eating Warblers, Canada Warblers nest at or near the ground. Like Worm-eating Warblers, they prefer dense shrub habitats, though they also prefer hillsides and ravines.

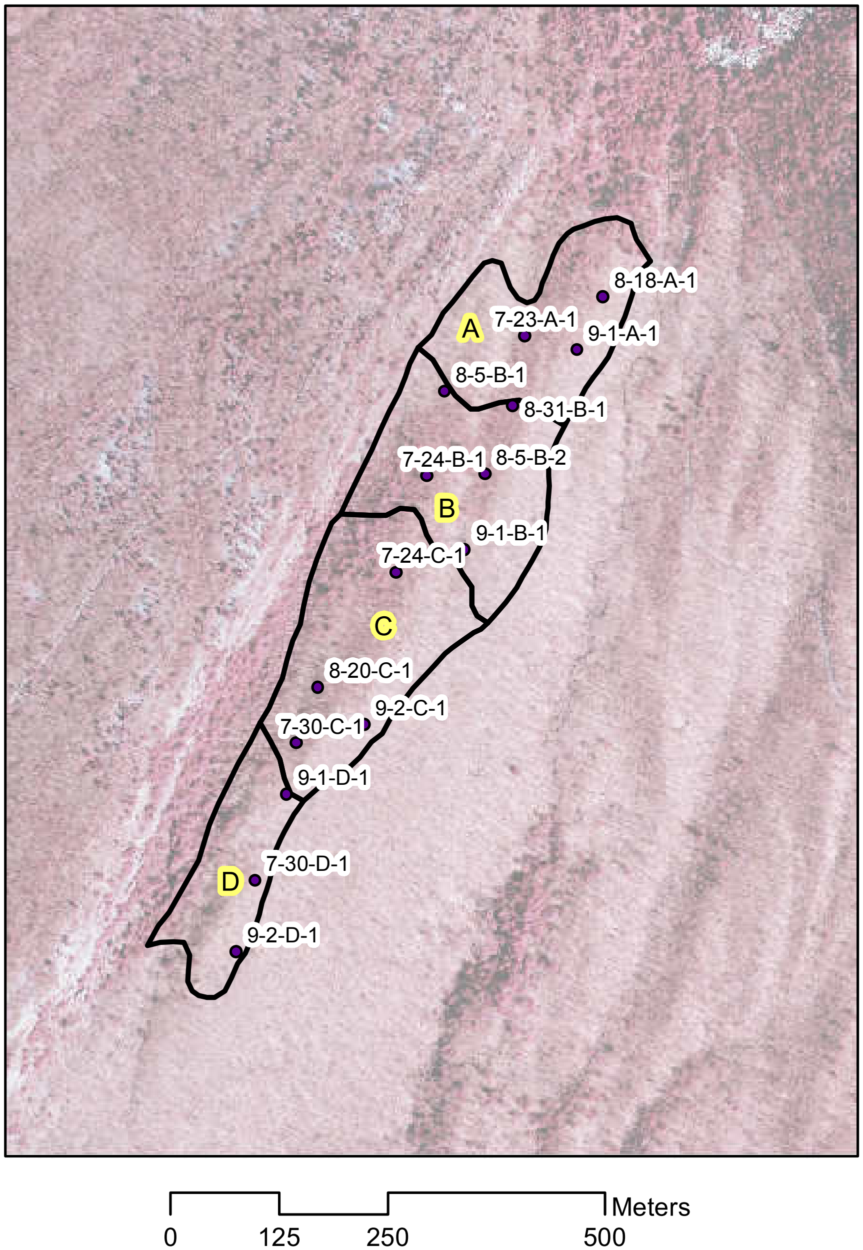
II. Study Area, Treatments and Field Method

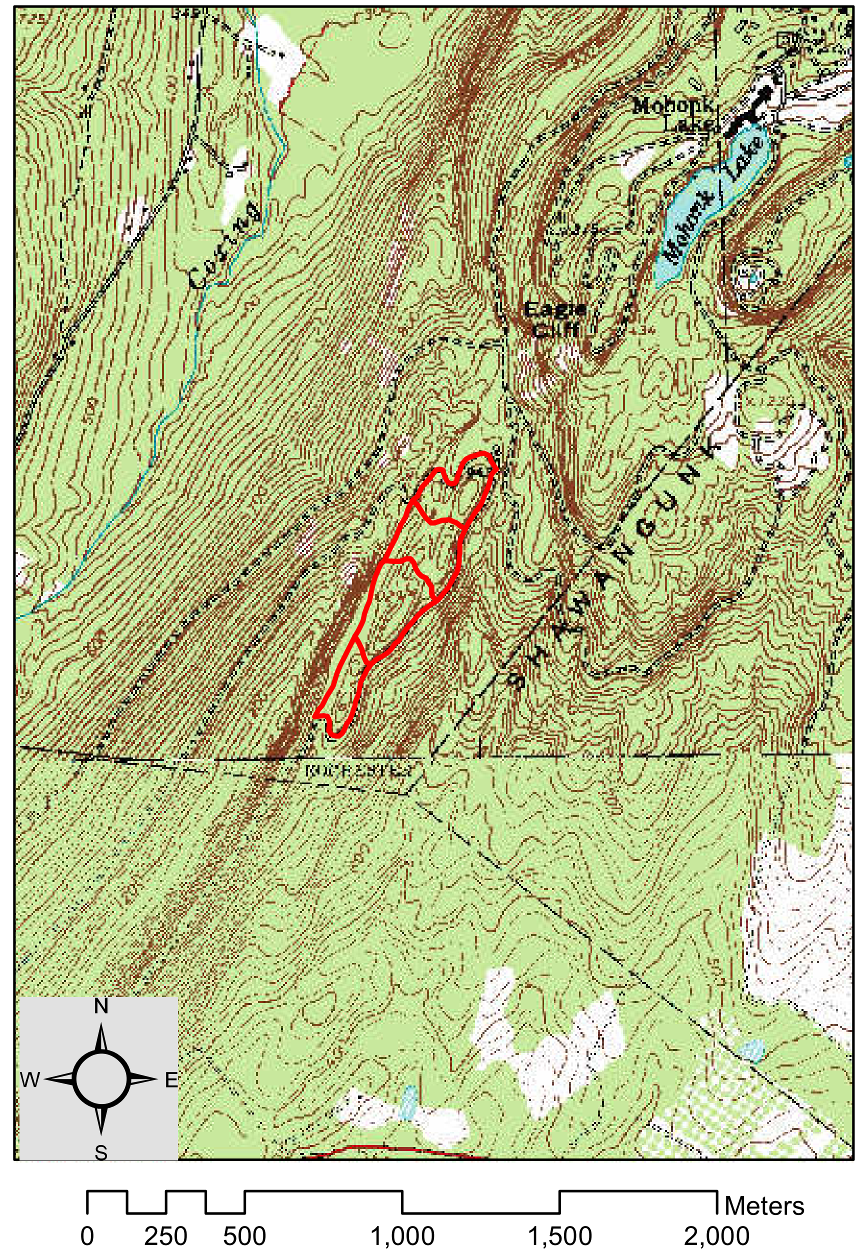
Within the Mohonk Preserve, the Undercliff treatment area, divided into four subunits, was established off Undercliff Road (Map 1, Table 1). Sixteen 20 x 20 meter plots were randomly located and established within the treatment area. Plot corners were marked with rebar and tagged and the species, bearing, distance and dbh of the nearest tree recorded. Complete methods are described in Batcher (2010).

All trees greater than 10 cm dbh were measured by species, including snags. Within three 2 x 20 meter belt transects, which corresponded to three of the line transects described below, saplings (2.5-10 cm dbh and > 1.5 m tall) and seedlings (<1.5 m tall) were tallied by species.

Using a modified version of the line-point intercept method, cover data was collected for life forms (grass, herbaceous, mountain laurel leaf and stem and other woody leaf and stem) within 0.5 m height increments from 0 to 3 m along five 20 m

Map 1. Undercliff Oak Forest Units





transects (N=100) to arrive at cover by height. Surface cover was also measured using the line-point intercept method, and canopy cover was measured using a densitometer, which is a tube through which one can view a point. In this case, we recorded whether open sky or some form of cover (leaf, branch, etc.) appeared in that point when viewed vertically. Burns were initiated both on April 23, 2010 and April 30, 2010, but had to be shut down as the relative humidity fell below prescription parameters. Most of the unit was burned on May 7, 2010, when conditions were appropriate.

Table 1. Summary of treatments in the Undercliff unit.

Subunits	Size (ha)	Plots (N=16)	Treatment
A	3.45	7-23-A-1, 8-18-A-1, 9-1-A-1	Burned 30 April 2010
B	3.98	7-24-B-1, 8-5-B-1, 8-5-B-2, 8-31-B-1, 9-1-B-1	Burned 7 May 2010
C	4.70	7-24-C-1, 7-30-C-1, 8-19-C-1, 8-20-C-1, 9-2-C-1	Burned 7 May 2010
D	2.31	9-1-D-1	Portion burned 23 April 2010;
		7-30-D-1, 9-2-D-1	Remainder burned 7 May 2010

III. Oak Forest Vegetation Data Analyses

A. Data Analyses Methods

Generally we can determine whether two or more samples are independent (that is, whether the null hypothesis that they are the same is true or not) using t tests for two samples, analysis of variance for three or more samples, or Chi square for binomial (yes/no; true/false) data. For measurements of surface cover, canopy cover, and cover by height class, we counted whether our narrow pole hit each category, thereby recording “successes” or “failures” or 1s and 0s for hits and misses so most of our data is binomial. Binomial data has a different distribution then the data we collected on numbers of seedlings and saplings, which are examples of continuous data.

For much of these analyses, I have provided charts to visually show changes between pre and post treatment. Where necessary, I used Chi square analyses to determine if samples for each surface cover types and canopy cover were independent, focusing on the most important types: litter, duff, and others.

B. Cover and Height Data

Shrub cover within the chestnut oak forest provides habitat for both nesting and foraging for the Black-throated Blue and Canada Warblers. Black-throated Blue Warblers locate their nests 0.5-1.5 m above the surface, and sometimes somewhat higher in dense shrub thickets. Canada Warblers use similar areas and both forage in areas of high shrub density with shrub heights of 2-6 m (Batcher 2009). Figure 1 below shows the total number of hits recorded prior to the prescribed burn (2009), using our modified line-point intercept method, in 0.5 m height classes for the major types of woody plants in all 16 of the forest plots. The number of hits of herbaceous vegetation was minimal and relegated primarily to the first 0.5 m. Most hits occurred in the 0-1.0 m range for mountain laurel (*Kalmia latifolia*), while other woody hits, primarily heaths in the 0-1m height increment and witch hazel (*Hamamelis virginiana*) above were spread throughout the height ranges. Dead mountain laurel leaves were included in the category "dead woody," so total mountain laurel hits would actually be higher in 0.5 and 1.0 m height categories.

Figure 1. Total number of hits by height category in 2009

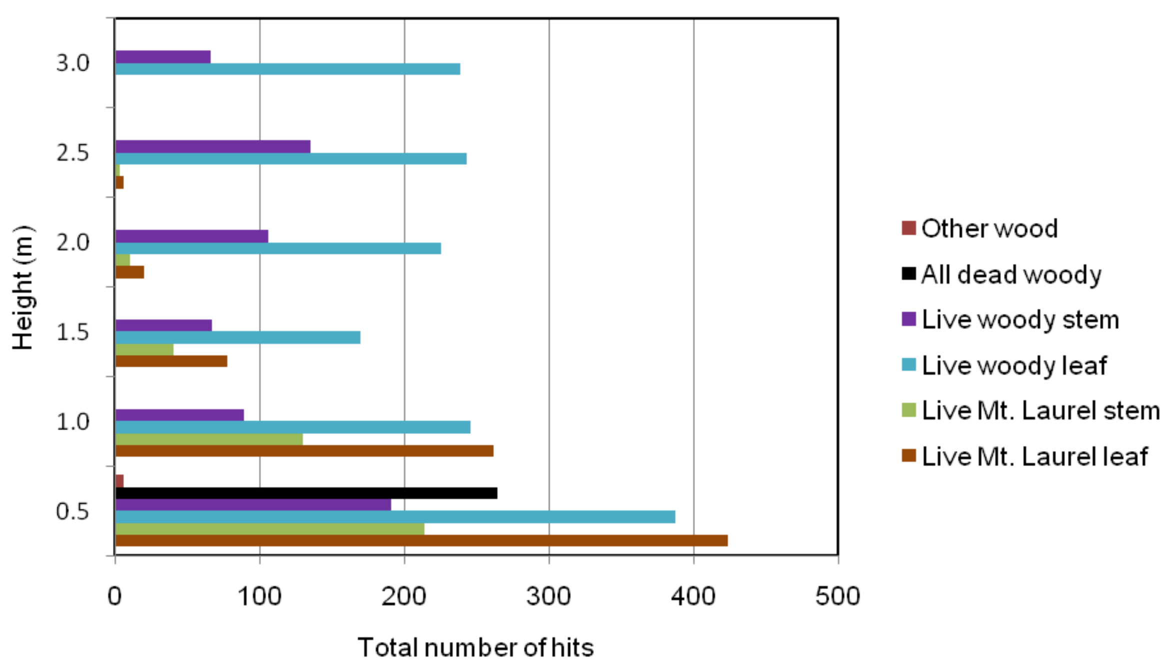
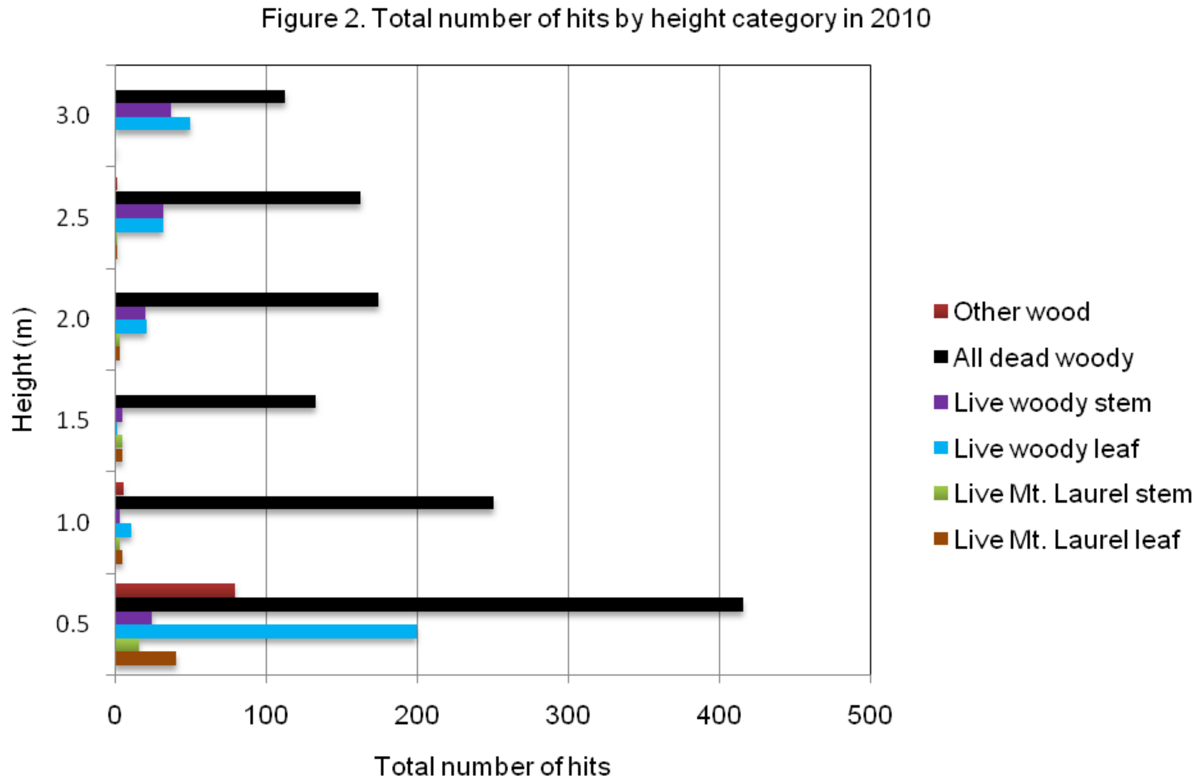


Figure 2 shows the number of hits in the same cover and height categories following the 2010 prescribed burn. As can readily be seen, what were live branches prior to the burn were standing dead following that burn. Live plant material was found primarily in the lower height categories as shrubs resprouted as the growing season progressed.



The photographs below of Plot 7-24-C-1 show pre (2009) and post (2010) burn vegetation. There is some live mountain laurel at 1-2 meters, though less live woody material than 2009.

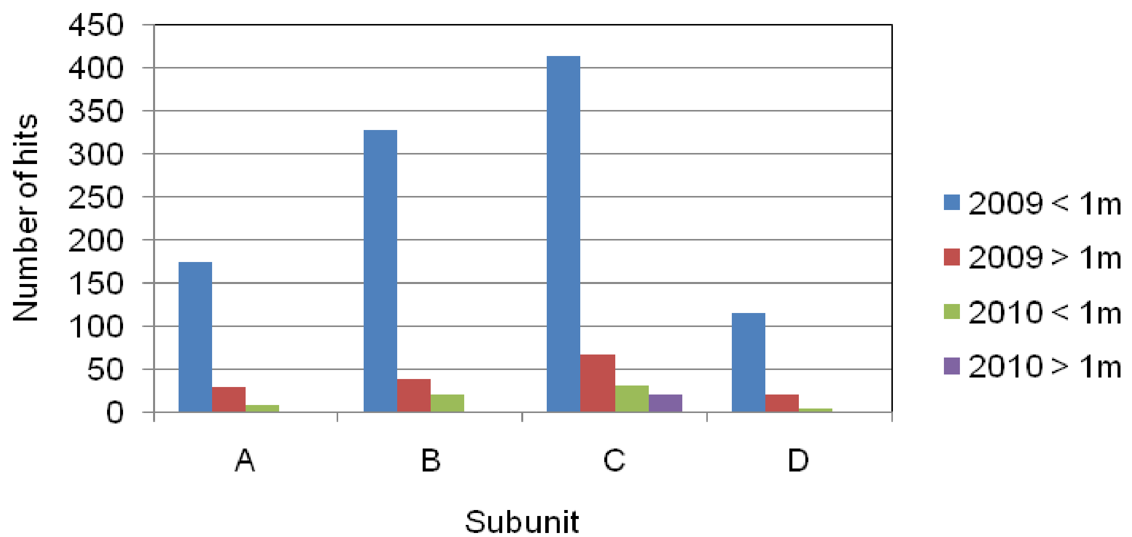
2009 (left) and 2010 (right) photographs of Plot 7-24-C-1

The photographs below of Plot 8-18-A-1 show a greater degree of contrast between the live woody material, which was primarily mountain laurel, and standing dead post fire in 2010.


2009 (left) and 2010 (right) photographs of Plot 8-18-A-1

Mountain laurel (*Kalmia latifolia*) is a "keystone" species in the chestnut oak forest as it is a dominant shrub, used by several shrub nesting birds, it can outcompete oak seedlings, and it is highly flammable. Figure 3 below shows the change in the total number of live mountain laurel hits below one meter and above one meter in height between 2009 and 2010. As can be seen, the total number of hits is reduced in both height categories. The figure also indicates that mountain laurel abundance varied across the subunits, but the change was similar across all of them. Fire behavior is dependent on weather conditions, particularly wind and relative humidity, the amount, type and distribution of fuels (in this case leaf litter, mountain laurel and other shrubs), and topography. While fire behavior likely varied across the unit, especially as the burns were carried out over three days, the effects on mountain laurel were similar.

Figure 3. Total hits of live mountain laurel above and below 1 m by subunit



C. Tree Data

Tree mortality can be a significant outcome from both wildfire and prescribed fire. We measured trees > 10 cm dbh in each of the 20x20 m plots. Following data collection in 2010, we noted significant differences that would not be expected, primarily a greater number of trees identified in 2010 than 2009. We determined from reviewing the data sheets and revisiting the plots that errors had occurred in measuring trees or including trees at the edges of the plots where tapes may have been laid differently between corner points in one year vs. the next. So, we measured each tree again and tagged those trees to allow us to track them over time. So, the data indicated in Table 2 as 2009 and 2010 is what was originally collected in each year and 2010 "tagged" is the data we collected after finding these errors.

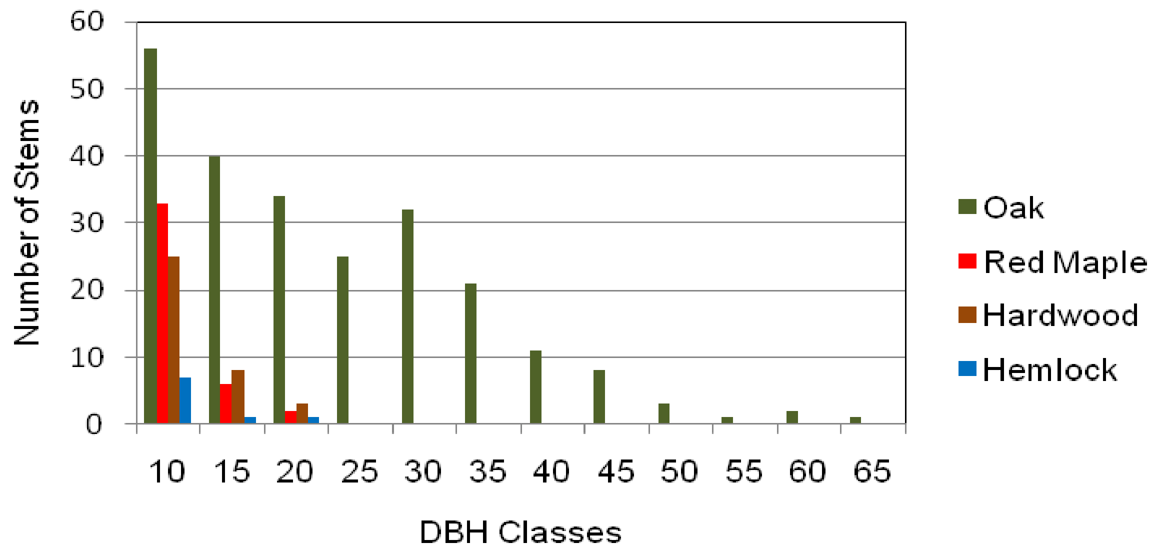
Table 2. Comparison of number of live and dead trees from 2009 to 2010 in the Undercliff treatment unit.

	2009			2010			2010 Tagged				
Species	Dead	Live	Total	Dead	Live	Total	Species	Dead	Live	Total	Live Stems/ha
Acer pensylvanicum		1	1		1	1					
Acer rubrum	1	38	39		38	38	*Acer rubrum*		40	40	62.5
Betula lenta		5	5		5	5	*Betula lenta*		7	7	10.9
Betula populifolia					2	2					
Carya glabra		1	1				*Carya ovata*	1		1	0.0
Carya sp.		10	10		8	8	*Carya sp.*		11	11	17.2
Castanea dentata	1	2	3	4	2	6	*Castanea dentata*	4	2	6	3.1
Nyssa sylvatica		8	8		16	16	*Nyssa sylvatica*		11	11	17.2
Tsuga canadensis		7	7	3	5	8	*Tsuga canadensis*	2	7	9	10.9
Hardwood	19	1	20	1	2	3	*Quercus sp.*	25		25	0.0
Quercus coccinea		4	4								
Quercus montana	41	61	102	44	74	118	*Quercus montana*	30	65	95	101.6
Quercus rubra	2	93	95	16	99	115	*Quercus rubra*	2	108	110	168.8
Oak Subtotal	**62**	**159**	**221**	**61**	**175**	**236**	**Oak Subtotal**	**57**	**173**	**230**	**270.3**
Grand Total	**64**	**231**	**295**	**68**	**252**	**320**	**Grand Total**	**64**	**251**	**315**	**392.2**

Despite the data collection errors, one important finding is that there was little change in the number of dead trees following the 2010 burn, with a total of 68 counted in 2009 and 64 counted in 2010. Clearly these plots should be tracked for a longer period than provided for in this study, especially to monitor mortality. However, there did not seem to be an immediate and significant mortality of trees following the 2010 burn.

Figure 4 below shows the distribution of size classes. Hardwoods, which include hickory, American chestnut, black birch and black gum, along with red maple and eastern hemlock are in the smaller classes, while oaks are distributed throughout and dominate the larger classes greater than 15 cm dbh. I separated red maple from other hardwoods due to the importance of this species the changing composition of oak forests in the northeast (Nowacki and Abrams 2008).

Figure 4. Total number of stems by size class for species groups from 2010 data collected in the Undercliff treatment unit



D. Seedlings and Saplings

Table 3 below summarizes total tallies for seedlings and saplings for 2009 and 2010. These have been organized into species groups for further analyses. The hardwood group is fairly diverse. Several of the species such as shadbush (*Amelanchier* spp.), striped maple (*Acer pensylvanicum*), gray birch (*Betula populifolia*), and American Chestnut (*Castanea dentata*) are generally found in the subcanopy, though they may compete with canopy species.

Other studies of oak forests indicate that red maple (*Acer rubrum*) and Sassafras (*Sassafras albidum*) can become very abundant following application of fire or thinning operations in oak forests (Batcher 2009). Therefore, these are assessed along with oaks as the primary species groups of concern.

Table 3. Total number of seedling and sapling plants by species and species group between 2009 and 2010 in the Undercliff treatment unit				
	Seedlings 2009	Seedlings 2010	Saplings 2009	Saplings 2010
Hardwood	**151**	**436**	**77**	**15**
Acer pensylvanicum	54	26	6	1
Acer saccharum	2	0	0	0
Amelanchier sp.	4	137	0	0
Betula alleghaniensis	18	0	7	0
Betula lenta	2	16	4	6
Betula populifolia	0	62	0	2
Betula sp.	0	25	0	0
Carya sp.	17	27	8	1
Castanea dentata	50	78	48	4
Nyssa sylvatica	4	59	4	1
Prunus sp.	0	5	0	0
Unknown	0	1	0	0
Oak	**1715**	**2486**	**141**	**24**
Quercus coccinea	0	0	3	0
Quercus montana	1123	1494	43	5
Quercus rubra	592	992	95	19
Red Maple	**97**	**226**	**38**	**20**
Acer rubrum	97	226	38	20
Sassafras	3	39	0	2
Sassafras albidum	3	39	0	2
Softwood	**11**	**1**	**5**	**2**
Pinus rigida	1	1	0	0
Pinus strobus	5	0	1	0
Tsuga canadensis	5	0	4	2
Grand Total	1977	3207	261	63

In 2009, nearly all of the saplings and seedlings were single stemmed plants. In 2010, many of these had formed multiple sprouts. Therefore, we counted plants and the number of individual stems in each. Table 4 below summarizes these data for 2010. If one looks at Tables 3 and 4, one may interpret that there were many new plants, and not just resprouts, between the two years. For example, nearly all of the 1,715 oak seedlings in 2009 were single stemmed. In 2010, we counted 2,486 oak seedling plants with a total of 6,183 stems. Resprouting is clearly an important mode of reproduction. It is likely that the number of sapling stems will increase as the living ones resprout and seedlings grow into that size class.

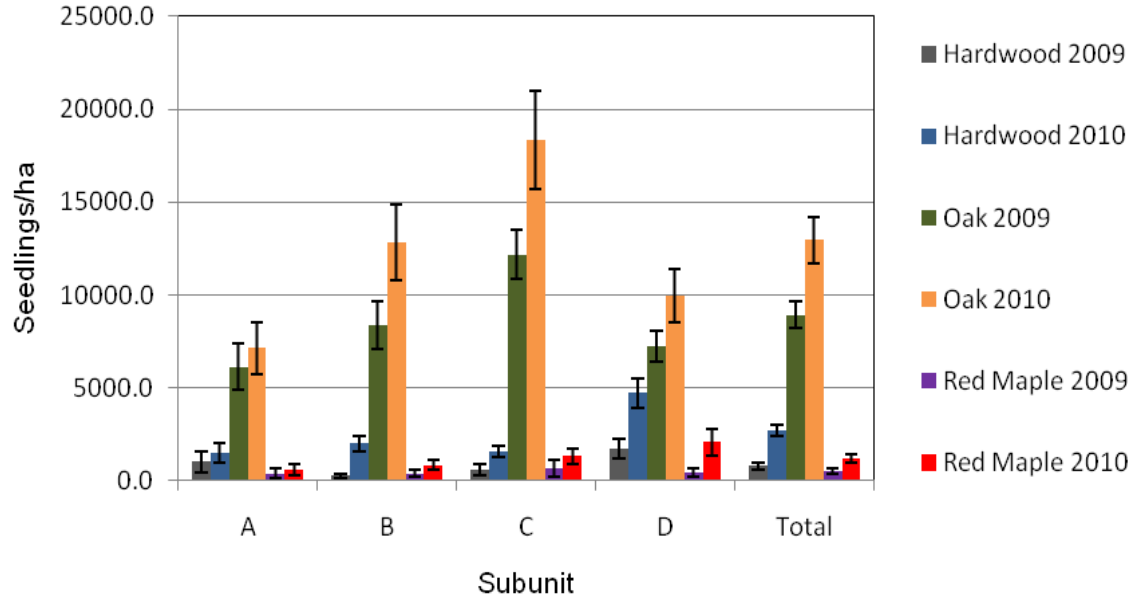
Table 4. Total number of seedling and sapling plants and stems in 2010 in the Undercliff treatment units.				
Group	Seedling Plants	Seedling Stems	Sapling Plants	Sapling Stems
Hardwood	436	1166	15	17
Oak	2486	6183	24	24
Red Maple	226	881	20	24
Sassafras	39	59	2	2
Shrub	19	19	0	0
Softwood	1	4	2	3
Grand Total	3207	8312	63	70

1. Seedlings

Total seedling density in the 16 plots ranged from 5,333 to 18,416/ha prior to treatment and 7,666 to 31,250 after treatment. There was a significant increase in both oaks and red maples between pre and post treatment (Table 5). These changes were fairly consistent across the entire treatment unit (Figure 5).

Table 5. Comparison of oak and red maple seedling densities pre and post treatment in the Undercliff treatment units.							
Species Group	N	2009	2010	t	p	df	Power
Oak	48	X=8932.29 SD=4853.9 SE=700.6	X=12947.9 SD=8550.2 SE=1234.1	-2.93	0.006	74.44 separate 94.00 pooled	0.86
Red Maple	48	X=505.21 SD=1128.1 SE=162.8	X=1177.1 SD=1559.1 SE=225.0	-2.42	0.017	85.63 separate 94.00 pooled	0.76

Figure 5. Mean densities for hardwood, oak and red maple seedlings pre and post treatment. Error bars are standard error of the mean.



2. Saplings

Total sapling density ranged from 500 to 2,166/ha, prior to treatment and 0 to 750/ha after treatment. This decrease would be expected as this size class is particularly vulnerable to high intensity fires carried through mountain laurel shrubs. Sapling density decreased significantly for hardwoods and oaks but not for red maple (Table 6). Red maple sapling density increased in subunit C (Figure 6) due to a total change of five red maple saplings in 2009 to nine in 2010. This may have been a result of variability of fire behavior, rapid regrowth following the fire, higher survivability of red maple, or a miscount between 2009 and 2010. In fact, if I take subunit C out of the analysis, the decrease in red maple saplings is also significant.

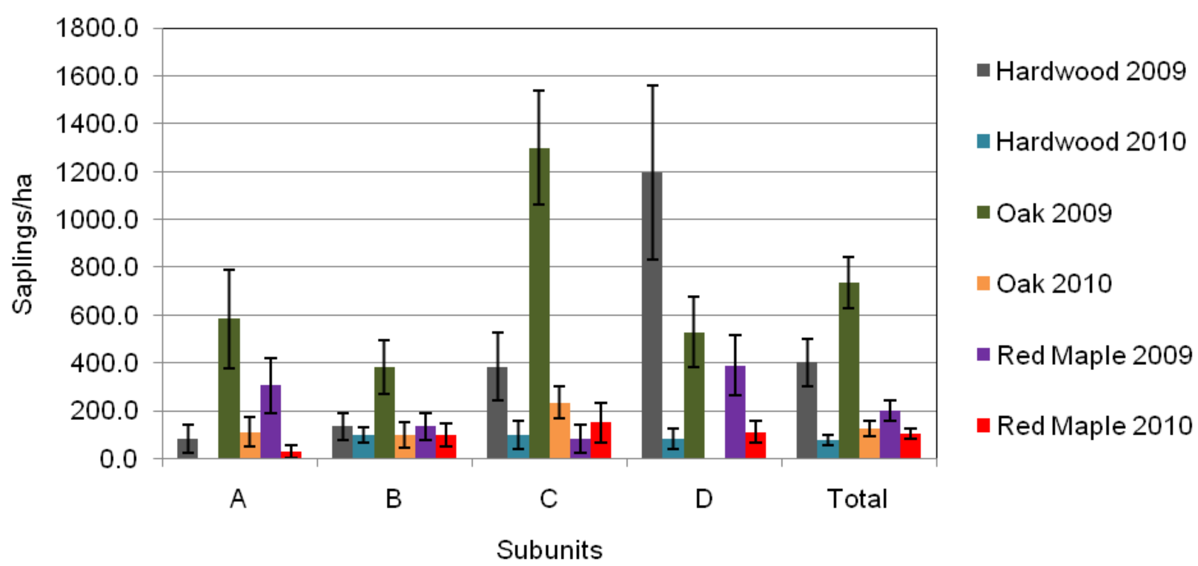
Table 6. Comparison of hardwood, oak and red maple sapling densities pre and post treatment in the Undercliff treatment units.

Species Group	N	2009 Mean	2010 Mean	t	p	df	Power
Hardwood	48	401.0 SD=689.5 SE=99.5	78.1 SD=156.1 SE=22.5	3.165	0.001	51.8 separate 94.0 pooled	0.91
Oak	48	734.4 SD=744.5 SE=107.5	125.0 SD=212.6 SE=30.7	5.453	0.000	54.7 separate 94.0 pooled	0.99
Red Maple	48	197.9 SD=296.1 SE=42.7	104.2 SD=217.8 SE=31.4	1.767	0.080	86.3 separate 94.0 pooled	0.54

Table 6. Comparison of hardwood, oak and red maple sapling densities pre and post treatment in the Undercliff treatment units.							
Species Group	N	2009 Mean	2010 Mean	t	p	df	Power
Red Maple (excluding Subunit C)	33	250.0 SD=312.5 SE=54.4	83.3 SD=148.8 SE=25.9	2.766	0.008	45.8 separate 64.0 pooled	0.832

The proportion of hardwood and/or red maple to oak saplings is higher than for seedlings, both before and after treatment.

Figure 6. Mean densitis for hardwood, oak and red maple saplings pre and post treatment. Error bars are standard error of the mean.



E. Surface and Canopy Cover

Table 7 compares the pre and post treatment number of hits of litter, duff, rock/soil (or bare surface) combined categories of wood, moss, and others. As described above, canopy cover was also measured using a hit (1) or miss (0) using a densitometer. Statistically significant changes in the number of hits of litter, duff, rock/soil and moss did occur, though the largest proportion of surface cover remained litter. Fire reduces litter exposing duff below the litter. In some cases, soil or rock may be exposed. The changes are relatively miner as litter is generally dry at the surface in the spring but moist below, so fires burn the top of the litter and do not smolder. There was little litter smoldering following the fires.

Table 7. Comparison of surface and canopy cover measurements from 2009 to 2010 in the Undercliff treatment units. Cover types indicated with a * had a statistically significant change (p<0.05) between 2009 and 2010.

	2009			2010			Chi-square (df=1)		
Category	# Hits	N	Proportion	# Hits	N	Proportion	Statistic	p	Power
*Litter	1355	1600	0.847	1122	1600	0.701	97.01	0.000	1.00
*Duff	49	1600	0.031	248	1600	0.155	146.98	0.000	1.00
Canopy	1071	1600	0.670	1096	1600	0.685	0.89	0.345	0.24
*Rock/Soil	15	1600	0.009	28	1600	0.018	3.98	0.046	0.71
*Moss (live and dead)	39	1600	0.024	61	1600	0.038	5.00	0.025	0.74
Wood/bark	140	1600	0.088	151	1600	0.094	0.46	0.498	0.16
Ash, charcoal, fungi, other	4	1600	0.003	11	1600	0.007	3.78	0.052	0.56

Canopy cover showed a slight increase from 2009 to 2010. I also compared canopy cover from data collected in plots that burned in April vs. those in May of 2010 as the earlier fire appeared to be more intense. Again, the proportion of canopy cover actually increased slightly from 2009 to 2010 in the areas burned in either April or in May.

IV. Discussion

A. Bird Habitat

The purpose of this study was to assess the effects of prescribed fire on habitat characteristics of several bird species of conservation concern. Table 8 below summarizes those characteristics (see Batcher 2009 for a more complete treatment).

Table 8. Summary of habitat characteristics for the Black-throated Blue Warbler, Canada Warbler, Wood Thrush, Scarlet Tanager and Worm-eating Warbler. Source: Batcher 2009

Nest Site Characteristics	Foraging Characteristics	Other Characteristics
Black-throated Blue Warbler		
Nests located 0.5-1.5 m (generally at knee height) above ground in crotch of a branch, generally at the edges of the shrubs. Nesting habitat consists of dense shrubs 0.1.5 m above ground and more sparse above. The density of trees from 10-20 cm and > 20 cm dbh was higher outside than inside territories. They often use paper birch for nest material, though other materials, including Rhododendron bark has been reported.	Forages in shrubs and trees 3-9 m; Males may forage higher (5.9 m) than females (3.3 m) from leaves and twigs	In areas where shrubs are lacking, may respond to canopy openings that promote shrub and sapling growth Black-throated Blue Warblers may utilize territories where shrub density is above some threshold, but patchy. Nest site selection appears to depend on dense shrubs, but territories do not.

Table 8. Summary of habitat characteristics for the Black-throated Blue Warbler, Canada Warbler, Wood Thrush, Scarlet Tanager and Worm-eating Warbler. Source: Batcher 2009		
Nest Site Characteristics	**Foraging Characteristics**	**Other Characteristics**
Canada Warbler		
Nests in thickets on or near ground on slopes, rocky areas, banks or near tree stump or fallen log High foliage density 2-2.5 m and 1.5-2 m High shrub density 2-6 m in height and < 8 cm dbh Generally found in forested wetlands or mature upland forests, some with canopy gaps	Primarily forages on lower tree branches and shrubs though sometimes on ground Forages in shrubs and trees 3-5 m	Often use tree emergent above the shrub canopy with 5 m of exposure around it for display Forest floor is complex with hummocks, root masses, logs, rocks
Scarlet Tanager		
Uses large, mature forests of different species, though prefers deciduous trees for nesting, and may prefer oaks. Canopy is closed and tall and a dense shrub layer may be present. High canopy and basal area. Nests range from 6-9 m though may extend to 2-24 m Large trees (> 22 cm or > 30 cm dbh) generally used	Forages on insects and fruit primarily in leaves, twigs and branches of mid-canopy with canopy height of 22 m, mean foraging height of 12.8 m. Females may forage higher than males	Forested blocks of 2500 acres with 70% forested important Size of forest patch important with minimum approximately 10 ha; Forest cover within 1 km also important
Wood Thrush		
Found on edges and interiors of deciduous and mixed forests with trees > 16 m, moderate subcanopy and shrub density, open forest floor, moist soil and decaying leaf litter Tree density, canopy height and cover shrub density and shrub height important for nesting success Nests generally 3-4 m above ground though this may extend to 0.5-21 m. Dense foliage for nest concealment important.	Forages primarily in leaf litter in areas of little herbaceous cover, generally in moist soil and decaying leaf litter	Possibly near wetlands Tall trees important for song perches
Worm-eating Warbler		
Uses a variety of forest types, but forest age, size and presence of hillsides, ravines and dense shrub cover important. Nests on ground on hillsides or ravines in leaves or dense shrubs such as huckleberry or blueberry.	Feeds on a variety of insects found on leaves and twigs	Steep slopes, rock outcrops/near streams

In reviewing our findings, we can readily say that shrub height and cover were reduced following the fire. Both Black-throated Blue and Canada Warblers nest in those very shrubs, so the fire was unfavorable to those habitat characteristics needed for those species. At the same time, there was negligible change in tree density or canopy cover, so that some of the appropriate habitat characteristics for these species remain. Scarlet Tanagers require large, unbroken forests, so their habitat requirements remain unchanged. Litter cover remained relatively unchanged, and new litter will fall to replace what was burned. Therefore, habitat for Worm-eating Warblers should also remain relatively unchanged.

Recovery of the shrub layer will be important for the shrub nesting species. This could occur as mountain laurel recovers or if seedlings reach sapling height (> 1-2m) and are sufficiently dense, both horizontally and vertically.

B. Tree Abundance

Despite our measurement problems, we detected no tree mortality. Canopy cover actually increased from 2009 to 2010. However, trees damaged by the fire may be suffer mortality over time, so this should be tracked over the next five years, especially given the mortality observed two years after the Overlooks wildfire (Batcher 2011). In addition, field crew observed extensive damage to the bark of many red maples that may lead to mortality over time.

C. Seedlings and Saplings

Total seedlings in the 16 plots ranged from 5,333 to 18,416/ha prior to treatment and 7,666 to 31,250 after treatment. Saplings ranged from 500 to 2,166/ha, prior to treatment and 0 to 750/ha after treatment. As discussed above, there was a larger proportion of both hardwood and red maple saplings to total saplings than was the case for seedlings.

On six shale sites on the Mohonk Preserve, Abrams (2009) found a range of 13,700 to 34,200 seedlings/ha. Oaks ranged from 0 to 15,700/ha and red maple from 0 to 2,300/ha. Recruitment to the sapling stage was low and deer browse evident. Red maple was the most frequent sapling. On conglomerate sites, seedling densities ranged from 2,400 to 9,700/ha., with a large proportion (700-3,200/ha) red maple seedlings. Abrams counted witch hazel as tree and we counted it as a shrub, so comparable numbers to our study for seedlings on shale sites would be 9,300 to 34,200/ha. Comparable numbers for saplings ranged from 1,000 to 1,850/ha. For conglomerate sites comparable ranges would be 2,400 to 9,700 for seedlings and 750 to 1,700 for saplings.

Seedling and sapling densities have wide ranges on sites where fire has not occurred in at least the past 50 years as well as where fire has been applied recently. Clearly tree species are successfully recruiting on these sites.

D. Future Research and Monitoring

At a minimum, tree mortality should be tracked over the next five years to determine the degree of change. We tagged trees greater than 10 cm dbh in each plot, so this should be relatively easy.

Bird habitat and shrub height and cover should be remeasured after five years. Some of the cover categories could be eliminated to save field time with measurements of live vs. dead woody and live vs. dead mountain laurel retained. This would provide a measure of recovery following burning which would be useful to determine how long it takes for habitat to recover and how much time is needed between burns to maintain a given amount of shrub cover by height class. Other studies have indicated that mountain laurel can recover quickly, and outcompete oak seedlings and saplings (Moser et al. 1996).

It may be possible to categorize the photographs taken prior to and after treatment by shrub cover. These categories could then be used to assess changes using photographs taken from the same locations in future years. In addition, some form of visual obstruction measurements could be used by taking photographs of poles or boards and recording the maximum height that an increment is obscured or by using software to count pixels of the white board vs. the portion obscured.

Oak regeneration is critical to maintaining the chestnut oak forest. From these samples we can determine the number of samples needed to determine whether a desired density of seedlings and saplings has been achieved. Table 9 below summarizes sample size calculations for oak and red maple seedlings and saplings based on 2009 data. I assumed we would want measure a change (increase or decrease) of 30% and achieve a statistical power of 0.9 with an alpha of 0.10.

Table 9. Sample size calculations for oak seedling and sapling changes.

Variable	Mean and SD	30% Change	Sample size to detect 30% change
2009 Oak Seedling Density	8932.29 (4853.9)	2679.7	29
2009 Oak Sapling Density	734.38 (744.5)	220.2	99
2009 Red Maple Seedling Density	505.2 (1128.1)	151.6	475
2009 Red Maple Sapling Density	197.9 (296.1)	59.4	214

As can be seen, the number of samples required varies dramatically. Statistical power is dependent on the mean and variance for both the base year (2009) and subsequent years, but generally we use one year to calculate power and sample size.

Seedling and sapling counts are time consuming. Counting only saplings would reduce field time and focus on those individuals more likely to enter the subcanopy and canopy. In measuring vegetation height and cover, we did not separate tree from shrub species, and this could be added to measure frequency by size classes. I believe this would be an easier and more accurate measure than counting plants and stems, which can be easy to confuse by even experienced field workers. So, we could arrive at measures of frequency for major woody species categories, including tree species, and density for saplings.

V. References

Abrams, M. 2009. Oak forest overstory and tree regeneration survey on contrasting soil types in the Mohonk Preserve. Report prepared for the Mohonk Preserve, Daniel Smiley Research Center, New Paltz, NY.

Batcher, M. 2011. Analysis of field data for the Shawangunks grassland and forests birds habitat study, Report #4: Overlooks wildfire study. Report prepared for The Nature Conservancy, Shawangunk Program Office, New Paltz, NY.

Batcher, M. 2010. Undercliff Oak Forest Burn Unit Protocols at the Mohonk Preserve, Version 3.5 (Finalized July 21, 1010), Draft report prepared for The Nature Conservancy, Shawangunk Program Office, New Paltz, NY.

Batcher, M. 2009. Effects of prescribed fire on bird habitat of selected oak forest bird species. Memorandum to Gabe Chapin, Shawangunks Program, The Nature Conservancy, New Paltz, NY.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002 Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reshke's Ecological Communities of New York State (Draft for review). New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

Moser, W.K., M.J. Ducey and P.M.S. Ashton. 1996. Effects of fire intensity on competitive dynamics between red and black oaks and mountain laurel. *Northern Journal of Applied Forestry* 13 (3): 119-123.

Nowacki G.J. and M.D. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. *Bioscience* 58 (2): 123-138.

Shawangunk Ridge Biodiversity Partnership 2003. Protection and Management Guidelines for the Shawangunk Mountains of New York: Vision, Goals, Strategies, and Actions for Conservation of the Shawangunk Mountains. Prepared by the Shawangunk Ridge Biodiversity Partnership.