THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF THE ENVIRONMENT AND LIFE SCIENCES

Department of Natural Resources Science
Coastal Institute
1 Greenhouse Road
Kingston, RI 02881
T 401.874-2026 F:401-874-4561
www.nrs.uri.edu

June 30, 2018

Final Report for NRCS Conservation Innovation Grant
"Monitoring and Evaluation of NRCS Practices to Create Early Successional Habitat"
Scott McWilliams, PI, Bill Buffum, Co-PI
NRCS Agreement No: 69-1535-14-02, URI Project: 500-2013-0000-0004551

Submitted by: Scott McWilliams and Bill Buffum
Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881
Email: srmcwilliams@uri.edu, buffum@uri.edu Phone: SM: 401-874-7531, BB 401 874 7532

1. Introduction

This is the final report for a URI Conservation Innovation Grant (CIG) from NRCS entitled "Monitoring and Evaluation of NRCS Practices to Create Early Successional Habitat". NRCS approved the grant of $50,000 on 9/29/2014, and approved a one-year, no-cost extension until 3/31/2018. URI provided match funding of $50,000. Scott McWilliams and Bill Buffum implemented the project with the assistance of four URI undergraduate students.

2. Activities

The Project Agreement included four objectives and 20 milestones to be completed during the project period. We summarize the achievements related to each objective below. For details on the achievement of milestones, see ***Attachment 1***.

Objective 1. Develop a monitoring and evaluation approach for NRCS practices aimed at creating early successional habitat (ESH).

We field-tested five methods for assessing ESH vegetation during the growing season to determine the most appropriate method for NRCS monitoring of ESH practices. This study included four methods that are often used in studies of ESH vegetation: (a) Line Intercept, (b) Roble Pole, (c) Cover Board and (d) Height of Obstruction. We also piloted a promising new method - Photo Analysis - that uses ImageJ software to analyze digital photographs of regenerating vegetation in front of a cover board. The software is able to calculate the percentage of the cover board that is obscured by vegetation (Figure 1). We were optimistic that this method would be less time-consuming than other four existing methods, and thus more appropriate for NRCS monitoring.

In order to assess the advantages and disadvantages of each method, we applied all five methods in 30 research plots. We concluded that Photo Analysis is an excellent method for estimating the density of ESH vegetation. Unlike the other methods, it does not rely on ocular estimates and thus avoids much of the bias associated with the other methods. Furthermore, the photos provide a rich documentation that permits quality control and other analyses to be conducted after completing the fieldwork. However, we discovered that Photo Analysis is much more time consuming than the other methods. Therefore, we recommend either Cover Board or Robel Pole methods for NRCS monitoring of ESH cuts during the growing season.

Figure 1. Applying Photo Analysis to ESH Monitoring

We wrote an article on the results of this study that was published in the open-access journal "Current Trends in Forestry Research". The article is available at:
https://www.gavinpublishers.com/admin/assets/articles_pdf/1514440512article_pdf278182290.pdf

We have included a copy of the journal article as ***Attachment 2.***

We also developed two protocols and datasheets for NRCS monitoring of ESH practices in the summer (leaf-on) and winter (leaf-off), which are available in in ***Attachment 3.***

Objective 2. Develop a network of ESH demonstration sites in Rhode Island.

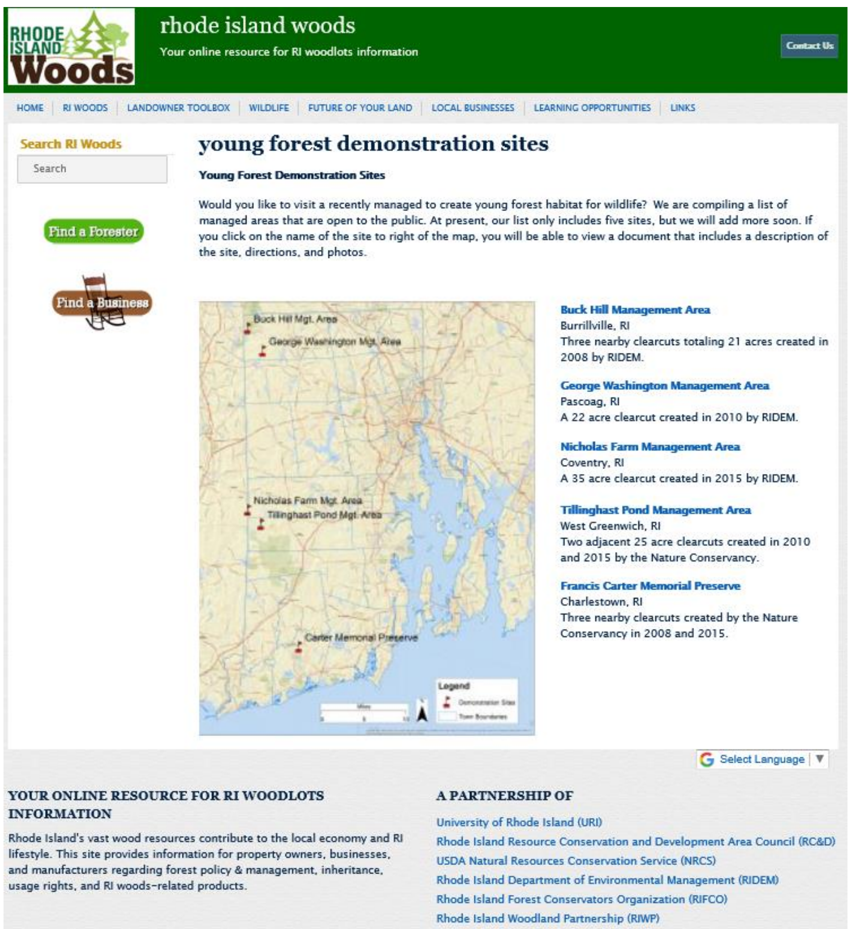
We identified and developed easily-accessible information materials for five ESH demonstration sites on publicly accessible land belonging to the state, land trusts, and conservation agencies. We believe that that these demonstrations will be a valuable training resource for landowners who are considering creating ESH on their properties and would like to see examples of clearcuts of different ages. The five sites are:

- Buck Hill Management Area, RIDEM
- George Washington Management Area, RIDEM
- Nicholas Farm Management Area, RIDEM
- Tillinghast Pond Management Area, TNC
- Francis Carter Memorial Preserve, TNC

For each site, we prepared descriptions that include maps, photographs and directions. We have posted the descriptions to a new section in the Rhode Island Woods website called "Young Forest Demonstration Sites" (https://rhodeislandwoods.uri.edu/young-forest-demonstration-sites).

We have included an example of a site description as ***Attachment 4***.

Figure 2. Rhode Island Woods Website - Young Forest Demonstration Sites



Objective 3. Provide recommendations for NRCS practices to create ESH, including revising the related NRCS job sheets

In addition to our study about methods of assessing ESH vegetation, we conducted three analyses to (a) better understand the factors that affect the growth of vegetation in ESH cuts, and (b) assess the contribution of private landowners to creating ESH in Rhode Island. Based on these analyses, we offer some recommendations for applying the NRCS ESH practice in Rhode Island. We summarize the findings of these studies below, and provide more details in ***Attachment 5***.

Soil drainage and woodland suitability: We conducted a study in 31 clearcuts to assess the influence of soil drainage and forestry suitability on the growth rate of the regenerating vegetation. We collected data on growth rates, and utilized data on soil drainage and forestry suitability from the NRCS soil survey. As expected, the cuts on sites that were dryer or had low ratings for woodland suitability exhibited lower vegetation growth rates. However, the differences in growth rates were not statistically significant, which increased our confidence that successful ESH cuts can be established on dry as well as moist sites.

We were particularly interested in assessing clearcuts on dry sites that are currently dominated by huckleberry and blueberry. Many foresters are concerned that a combination of dry soils and heavy deer browse will prevent regeneration of tree species, and that these sites will become long-term “huckleberry thickets”. Our observations confirmed that regeneration of tree species in these clearcuts is delayed, although eventually species such as white pine do emerge (Figure 3).

Figure 3. White pine emerging in a clearcut dominated by huckleberry/blueberry

If the main objective of the landowner is timber production, the delayed regeneration of tree species is certainly a concern. However, if the main objective is wildlife habitat, the longer persistence of ESH vegetation could actually be an advantage. Furthermore, the URI team preparing the URI Bird Atlas has confirmed that many shrubland bird species utilize this type of site. Therefore, we recommend that NRCS continue to support ESH cuts in dry as well as moist sites, including those that are likely to be dominated by huckleberry and blueberry, even though more rapid and diverse regeneration can be expected in the moister sites.

Slash retention and deer browse: We conducted a rapid assessment during the winter in 40 research plots in four large clearcuts to assess the impact of retaining slash (also called coarse woody debris) in reducing damage from deer browse. The USDA Forest Service has developed a methodology for summer assessment of deer browse that is highly appropriate for use in mature forests or recent clearcuts with limited regeneration[1]. However, we believe that winter assessments of deer browse are more practical in sites with very dense shrubby vegetation.

We found that the percentage of stems browsed varied widely by species, ranging from 75% for Greenbriar to only 1% for American Holly, Pitch Pine and Grey Birch. Despite the small sample size, we observed that sites with more slash generally had less damaged from deer browsing and taller vegetation. Therefore, we strongly endorse the current NRCS recommendation about retaining slash in ESH cuts.

We also observed several advantages to conducting ESH assessments in the winter. Summer assessments produce better estimates of the density of the vegetation, which is critical for many shrubland bird species, and plant identification is much easier in the summer. However, winter assessments produce useful estimates of winter vegetation cover, which is critical for wildlife species such as New England Cottontail. Moreover, it is much easier to move through dense shrubby vegetation in the winter.

Spatial analysis of the creation of ESH by private landowners: We compared the extent of young forest vegetation created in Rhode Island during two seven-year periods (1997-2004, and 2004-2011) by private landowners, government agencies, and non-government organizations. The amount of ESH created in clearcuts of at least 1 ha in Rhode Island almost doubled from 37.9 hectares (ha) per year during the earlier period to 73.9 ha/year during the later period. Furthermore, the portion of ESH created by private landowners increased from 62% during the earlier period to 73% during the later period (Table 1).

[1] "The Ten-tallest Method", Thomas J Rawinski. https://flnps.org/articles/1161/monitoring-white-tailed-deer-impacts-ten-tallest-method-draft

Table 1. Extent of ESH created in Rhode Island during two time periods by ownership class

Fee Ownership	Conservation Status	1997-2004		2004-2011	
		Ha	Percent of total	Ha	Percent of total
State	Conserved	7.4	3%	55.4	11%
Federal	Conserved	0	0%	2.7	1%
Land Trust	Conserved	8.6	3%	7	1%
Municipal	Conserved	81.4	31%	49.3	10%
NGO	Conserved	0.3	0%	20 1	4%
Private	Conserved	3.6	1%	3.6	1%
Private	Non conserved	164.1	62%	378.9	73%
Total		265.3	100%	517	100%
Total per year		37.9		73.9	

Note: based on clearcuts of at least 1 ha that were not converted to non-forest land use five years after the end of the time period.

We are far from creating the amount of ESH in Rhode Island that wildlife biologists have recommended to stabilize populations of American woodcock and other species that require ESH. Nevertheless, we were encouraged to see that the amount of ESH created per year in RI has increased, and that this is largely due to the efforts of private landowners. We cannot attribute all of this increase to the outreach programs that NRCS and URI are conducting with other partners, but we are confident that our outreach program has made a positive contribution and that further increases are possible if we intensify our efforts.

Recommendations for NRCS ESH Job Sheet:

The May 2016 Rhode Island ESH Job Sheet provides an excellent description of the importance of creating ESH. It also provides clear guidance for patch size, restrictions on the timing of forest management activities, retention of slash. However, we believe that some portions of the job sheet could be improved.

- **Retention of Slash**: we would strengthen the recommendation to retain slash to provide wildlife cover and food and reduce deer browse. The 2nd paragraph of "Management Specifications" states this recommendation clearly. However, the 5th paragraph weakens this recommendation by mentioning that woody material could be chipped or removed from the site, and that all slash should be removed when the goal is regenerating aspen. At least two studies have concluded that slash retention benefits aspen regeneration by reducing browse, even though aspen suckers grow faster with direct sunlight[2]. Therefore, we recommend deleting this paragraph entirely.

- **Requirement for Forest Management Plan:** We would strengthen the statement that a forest management plan is required for ESH practices on forested land. The 2nd sentence of first paragraph of "Management Specifications" may confuse some landowners. We would shorten and simplify this sentence it as follows: "If the site is currently forested, a current forest management plan that identifies the need and specifications for this practice is required."

- **Timing of Assessment for re-cut:** the recommendation in the 2nd paragraph of "Management Specifications" to assess the need for a re-cut within 10 years does not seem compatible with the statement in "Operations and Maintenance" that ESH cuts should be allowed to grow for 10-15 years prior to cutting. We would change the initial recommendation to "assess the need for a re-cut after 10-15 years".

Objective 4. Provide training to NRCS staff in monitoring and evaluation of ESH.

We presented all of the activities of the URI CIG grant, including our analysis of the advantages and disadvantages of different methods for monitoring ESH plots, during an in-service training for NRCS staff on May 16, 2018.

List of Attachments

Attachment 1. Progress in achieving project actions and milestones

Attachment 2. Journal Article: "Assessing the Density of Vegetation for Wildlife Cover in Regenerating Clearcuts"

Attachment 3. Winter and Summer Protocols for NRCS monitoring of ESH practices

Attachment 4. Example of a description of an ESH Demonstration site that has been posted the new website on RhodeIslandWoods.uri.edu

Attachment 5. Additional ESH studies conducted as part of the CIG project.

[2] See Doucet, R. (1989). Regeneration Silviculture of Aspen. The Forestry Chronicle **65**(1): 23-27; and Rumble, M. A., et al. (1996). Effects of logging slash on aspen regeneration in grazed clearcuts. The Prairie Naturalist **28**(4).

Attachment 1. Progress in achieving project actions and milestones

Action/milestone in Project Agreement)	Notes
1. Project initiation.	Completed. We initiated the project as soon as the agreement between NRCS and URI was approved on September 29, 2014.
2. Renew NRCS clearance to access client files using the NRCS Protracts database. Generate list of NRCS clients who implemented ESH practices.	Completed. Bill Buffum completed a NRCS training in Information Security Awareness and received a USDA Link Pass, which allowed him access NRCS client files via the NRCS Protracts database. This allowed him to generate a list of clients who had completed ESH practices with NRCS support.
3. Send joint letter from URI to NRCS asking them to participate in the study.	Completed. We decided to concentrate our fieldwork in large sites that would allow us to implement multiple research plots. We requested approval from four landowners to do the research on their properties. • Joslin Property, Prov. Water Supply Board (NRCS funded) • Great Swamp Management Area (RIDEM funded) • Tillinghast Property, The Nature Conservancy (TNC and RIDEM funded) • Viale Property, Narrow River Land Trust (NRCS funded)
4. Select ten ESH plots for initial fieldwork.	Completed. By conducting the fieldwork on properties with large ESH cuts, we were able to increase the number of ESH plots from 10 to 45.
5. Graduate student starts work on project.	Completed. We originally planned to involve one graduate student and one undergraduate Coastal Fellow in this project. However due to the delay in finalizing the project agreement, we had to delay the recruitment of the new graduate student. As a result, our selected candidate could only join in September 2015, so we decided to hire two undergraduate Coastal Fellows to work on this project.
6. Develop strategy for adding forestry demos to RI Woods website, including web design, soliciting inputs from the RI Woodland Partnership.	Completed. We met with a sub-group of the RI Woodland Partnership to discuss the forestry demonstrations. We developed a draft format for the descriptions of the demonstration sites. We also held a meeting of the three organizations that established the Rhode Island Woods website (URI, NRCS and RC&D Council) to discuss how best to maintain and update the website in the future.

Action/milestone in Project Agreement)	**Notes**
7. Review past URI experience with vegetative monitoring, develop draft monitoring approach.	Completed. We developed a draft protocol to compare five alternative methods of monitoring ESH vegetation by applying the five methods in each plot. • Photo Analysis: analysis of photos taken horizontally of vegetation in front of a white board (2m high x 0.5 m wide) from 4 meters away. The photos are analyzed using ImageJ software, which can compute the amount of the white board obscured by vegetation. • Line Intercept: ocular estimate of how much of a horizontally stretched measuring tape is covered by vegetation in different height classes. • Robel Pole: ocular estimate of how much of a vertical pole is obscured by vegetation in different height classes when viewed horizontally from 4 meters away. • Cover Board: ocular estimate of how much of a vertical rectangular cover board pole is obscured by vegetation in different height classes when viewed horizontally from 4 meters away. • Height of Obstruction: ocular estimate of the maximum height of a vertical pole obscured by vegetation when viewed horizontally from 4 meters away.
8. Submit 1st semi-annual report to NRCS.	Completed. NRCS asked us to submit quarterly rather than semi-annual reports. We submitted the first report on 12/10/14.
9. Undergraduate Coastal Fellow starts work on project for 8 months.	Completed. We advertised in March 2015 for two undergraduate Coastal Fellows to participate in the project, received 8 applicants, and selected two (Ms. Brianne Fontaine and Mr. Dillon Connelly).
10. Test new approach in RIDEM ESH plots. Revise approach as necessary.	Completed. We started the fieldwork on May 17, 2015 with a visit to a RIDEM property in the Great Swamp. We constructed a cover board to use with Image J photography, and borrowed URI equipment for the other methods. We field tested the approach in the URI North Woods and finalized the protocol for our fieldwork.

Action/milestone in Project Agreement)	Notes
11. Complete fieldwork to analyze vegetation and GIS assessment of surrounding areas for Yr 1 plots.	Completed. We applied the methodology to 15 plots in each of the three sites, for a total of 45 plots, and completed all of the field work during the summer of 2015. We completed the Image J Photo analysis during the summer of 2016.
12. Submit 2nd semi-annual report to NRCS, including draft monitoring protocol and draft recommendations for improving ESH practice.	Completed. We attached the draft vegetation monitoring protocol to the March 2016 progress report. We decided to postpone developing recommendations for improving ESH practice until our final report.
13. Select 10 more plots for fieldwork in Year 2.	Completed. We planned to split our target of 20 sites between two years, but were able to exceed our target and select 45 sites in the first year (see No. 4 above). However, based on the results of our initial 45 plots, all of which were conducted in the summer, we decided to conduct a second study in the winter focusing on the impact of slash retention on deer browse and vegetation height.
14. Submit 3rd semi-annual report to NRCS.	Completed.
15. Provide training to NRCS staff in use of vegetation monitoring protocol.	Completed. After discussions with Chris Modisette and Gary Casabona, we decided to offer this as part of an in-service training for NRCS field staff in May 2018. During the training, we presented our recommendations for vegetation monitoring and discussed the other activities of the CIG grant.
16. Complete fieldwork and GIS assessment of surrounding areas for Year 2 plots.	Completed. This was carried out February-April 2017 by Bill Buffum and a URI undergraduate student, Sarah Semenza. Based on this fieldwork, we developed a 2nd protocol for winter monitoring of NRCS ESH practices that includes assessing damage from deer browse.

Action/milestone in Project Agreement)	Notes
17. Prepare descriptions of five forestry demonstration sites and post on Rhode Island Woods website.	Completed. We prepared descriptions of five young forestry demonstration sites that are open to the public with descriptions, maps and photographs. We have added the descriptions to the Rhode Island Woods website under "Learning Opportunities/Young Forest Demonstration Sites": https://rhodeislandwoods.uri.edu/young-forest-demonstration-sites/ The five sites are: • Buck Hill Management Area, RIDEM • George Washington Management Area, RIDEM • Nicholas Farm Management Area, RIDEM • Tillinghast Pond Management Area, TNC • Francis Carter Memorial Preserve, TNC
18. Submit draft final progress report to NRCS for comments.	Completed. This draft final progress report was submitted on April 31, 2018.
19. Submit final progress report to NRCS.	Completed.
20. Submit final financial report to NRCS.	Completed. The final quarterly financial report was submitted to NRCS on 4/27/2018

GAVIN PUBLISHERS

Current trends in Forest Research

Buffum B and McWilliams SR. Curr Trends Forest Res: CTFR-102.

Research Article

DOI: 10.29011/ CTFR-102. 100002

Assessing the Density of Vegetation for Wildlife Cover in Regenerating Clearcuts via Analysis of Digital Imagery

Bill Buffum[*], **Scott R. McWilliams**

Department of Natural Resources Science, University of Rhode Island, 1 Greenhouse Road, Kingston, Rhode Island 02881, USA

[*]**Corresponding author:** Bill Buffum, Department of Natural Resources Science, University of Rhode Island, 1 Greenhouse Road, Kingston, Rhode Island 02881, USA. Tel: +14018747532; Fax: +14018744561; Email: buffum@uri.edu

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

Received Date: 25 November, 2017; **Accepted Date:** 11 December, 2017; **Published Date:** 18 December, 2017

Abstract

Increasing the availability of shrubland habitat is a major conservation priority in the Northeastern United States because many wildlife species require this habitat and its extent has been decreasing in recent decades. Conservation agencies often monitor the number of hectares of shrubland habitat created, but rarely monitor the density of the resulting vegetation because the process is tedious and time-consuming. The current study tested a new approach to assess vegetation density: Digital Imagery Vegetation Analysis (DIVA). We compared the density estimates of DIVA with four other methods (Cover Board, Robel Pole, Height of Obstruction, and Line Intercept), and assessed the advantages and disadvantages of using these five methods in shrubland studies. We concluded that DIVA offers two main advantages over the other methods: (a) it directly measures the vertical structure of the vegetation and thus better captures the complex wildlife habitat characteristics required by many wildlife, and (b) it does not rely on ocular estimates and thus avoids much of the bias associated with the other methods that estimate vertical structure. Furthermore, DIVA provides a rich documentation that permits quality control and other analyses to be conducted after the fieldwork is completed. However, DIVA is more time consuming than the other methods, thus we recommend either Robel Pole or Cover Board for routine monitoring.

Introduction

Increasing the availability of shrubland habitat is a major conservation priority in the Northeastern United States because many wildlife species require this habitat [1-4] and its extent has been decreasing in recent decades in the region [3,5]. Conservation agencies recommend creating shrubland habitat on state and private land by clearcutting blocks of forest and allowing them to regenerate naturally [1,6]. Some of the proposed habitat creation programs are very ambitious: Williamson [7] recommended creating shrubland and young forest on 31% of forests (890,000 ha) in the Northeastern United States to restore populations of American woodcock (*Scolopax minor*) and other shrubland bird species. It is important to closely monitor these programs because the density of the resulting shrubland can be affected by various management decisions, such as selecting sites with appropriate slope, aspect and soil moisture [8], retaining coarse woody debris to reduce deer browsing [9,10], or retaining a small number of mature reserve trees in clearcuts to and provide a food source for wildlife [11].Conservation agencies can easily monitor the number of hectares of shrubland created by mapping the clearcuts with Global Positioning System (GPS) equipment, but few agencies directly monitor the density of the resulting vegetation because the process is tedious and time-consuming.

Four methods are often applied to studies of shrubland habitat: Cover Board [12,13], Robel Pole [14-17], Height of Obstruction [14, 18,19], and Line Intercept [18, 20-22]. Our study applied these four methods along with a potentially more rapid and convenient method of assessing the density of shrubland cover based on digital imagery vegetation analysis (DIVA). In recent years, DIVA has been used in a range of analyses, including calculating leaf area index [23], studying individual leaves of plants [24], assessing vegetative cover by analyzing aerial photos [25], assessing understory canopy cover by taking digital photos looking downward [26,27], assessing overstory canopy cover by taking digital photos looking upward [28], and assessing visual obstruction of prairie grasses by taking digital photos looking

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

horizontally [29]. However, we know of no study to date that has used DIVA to assess the density of shrubland cover in regenerating clearcuts. The objective of our study was to compare the cover estimates of DIVA with the four traditional methods and assess the advantages and disadvantages of using these five methods in shrubland studies.

Methods

In the summer of 2014, we conducted fieldwork at two sites in the state of Rhode Island where blocks of forest had recently been clearcut to create shrubland habitat for wildlife. The first site was in the Great Swamp Management Area of the Rhode Island Department of Environmental Management in South Kingstown, Rhode Island (lat 41.4564, long -71.5892) which was clearcut in 2012. This second site belonged to the Providence Water Supply Board in Scituate, Rhode Island (lat 41.7706, long -71.6490) and was clearcut in 2009.

In each site, we established 15 rectangular plots (24m x 8m) in locations without bare areas or trees taller than 3m. We did not select the plot locations randomly as our objective was to compare the five methods rather than to assess the entire sites. Each plot consisted of three adjacent 8 x 8m subplots, with a 24m transect running through the center of the subplots (Figure 1). We marked the centers of each subplot to use as locations for holding cover boards or poles (for all methods except Line Intercept), and the centers of the four sides of each subplot to use as viewing stations.

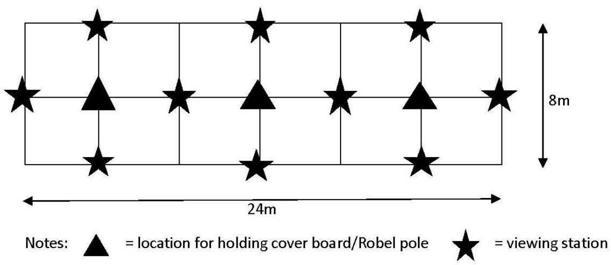


Figure 1: Layout of a plot with three adjacent subplots.

In each subplot, we applied five methods (DIVA, Cover Board, Robel Pole, Height of Obstruction, and Line Intercept) to assess the density of low shrub (0.5–1 m tall) and high shrub (1-2 m tall). The density of shrubs and saplings less than 2 m tall is a critical habitat attribute for many shrubland bird species [4,30]. For each height class, we used the mean density of the three subplots to produce our plot estimates.

We did not distinguish between species when estimating density. However, in order to describe the two study sites, we estimated the cover of each species detected in each site through ocular estimations using a modified Daubenmire scale with five cover classes [31]. We averaged the midpoint values of the cover classes for the 15 plots in each site to estimate the cover for each species detected (Table 1).

DIVA: We estimated vegetation density by taking digital photos of a vertical rectangular board constructed for this study (2 m tall and 0.5 m wide, with no markings) from a distance of 4 m and a standard height of 1 m. We selected this distance to maximize variation in foliage cover following the advice of Nudds [12]: if the distance is too great, the board will usually be fully obscured, whereas if the distance is too low the board will usually be fully visible.

We held the cover board in the center of each subplot, and took photos of it from each side of the subplot. We used a monopod to ensure that all photos were taken at the same camera height of 1 m. We recorded the plot number and photo direction on a small white board that we held next to the cover board in the original photos. We processed the photos using ImageJ, a public domain Java image processing program [32] which allows the user to (a) straighten the photos of the cover board when necessary, (b) crop the photos to the extent of the cover board, including the lower portion of the board that is obscured by vegetation, and (c) convert the photos to binary black and white which allows for an automated calculation of the percentage of the cover board obscured by vegetation. We ran separate analyses for the top half of the board, the bottom half, and the entire board. See Figure 2 for examples of original, cropped and binary photos of the entire board.

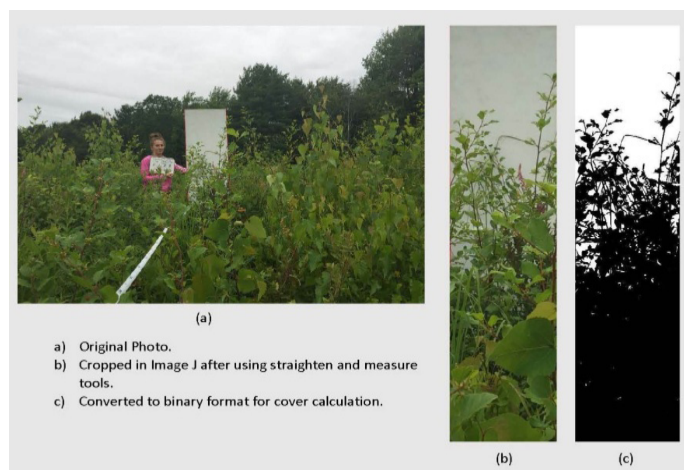


Figure 2: Example of original, cropped and binary photos used for an automated calculation of the percent of the cover board obscured by vegetation.

Cover Board: We estimated vegetation cover by making ocular estimates of the percentage of a rectangular cover board obscured by vegetation in four 0.5 m intervals [12,13]. We used a 2 m tall and 0.25 m wide cover board that our university has used in other field studies, which includes markings for each 0.5 m interval. We held the cover board in the center of the subplot, and took readings of each 0.5m interval from the four sides of the subplot.

Robel Pole: The approach was similar to Cover Board, but used

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

a vertical pole (2 m tall, 3 cm diameter, with markings for each 10 cm) instead of a board for the ocular estimates [14-17]. We recorded the percentage of the pole that was obscured by vegetation in four 0.5m intervals.

Height of Obstruction: We used the same pole described above to estimate the lowest height of the vertical pole that was not obscured by vegetation [14,18,19]. This involved only one reading from each side of the subplot.

Line Intercept: We estimated vegetation cover in two height classes (0.5-1 m, 1-2 m) by recording the amount of vegetation that covered each meter of the transect [18,20-22]. Our transects were 24 m long, and passed though the center points of the three subplots.

We analyzed the results using IBM SPSS Version 24, and tested for differences between the cover estimates of DIVA and the four other methods, and for correlations. We ran separate tests for two height classes (0.5-1 m, 1-2 m) and for the combined height classes (0.5-2 m). A Kolmogorov-Smirnov test revealed that the data for some height classes did not have normal distributions (Table 2), so we used non-parametric tests to produce consistent results for all height classes. We tested for differences between medians with Wilcoxon Z (exact) and for correlations with Kendal's Tau.

Results

General

We detected 28 species in the two study areas: 18 species at Great Swamp dominated by *Acer rubrum* and *Smilax rotundifolia,* and 16 species at Providence Water dominated by *Betula populifolia* and *Frangula alnus*, with only five species common to both sites (Table 1). Neither of the sites included wetlands, but the Providence Water site was more xeric and included a very different species mix with lower and less dense vegetation.

Scientific Name	Common Name	Average Cover (Percent) *	
		Great Swamp	Providence Water
Acer rubrum	Red maple	69	8
Achillea millefolium	Common yarrow		5
Baptisia tinctoria	Yellow wild indigo		14
Betula populifolia	Grey birch	29	66
Clethra alnifolia	Sweet pepperbush	30	
Comptonia peregrina	Sweet fern		6
Dennstaedtia punctilobula	Hay-scented fern	6	
Rhamnus frangula	Glossy buckthorn		47
Gaylussacia baccata	Black huckleberry	25	
Hamamelis virginiana	American witch-hazel	38	
Ilex opaca	American holly	15	
Osmunda cinnamomea	Cinnamon fern	26	
Parthenocissus quinquefolia	Virginia creeper		12
Panicum clandestinum	Deer tongue		1
Pinus strobus	White pine		1
Populus tremuloides	Quaking aspen		18
Quercus bicolor	Swamp white oak	23	
Quercus palustris	Pin oak	7	1
Rhododendron viscosum	Swamp azalea	7	
Rubus hispidus	Dewberry	7	12

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

Rubus occidentalis	Black raspberry		7
Sassafras albidum	Sassafras	57	
Smilax glauca	Catbrier	12	
Smilax rotundifolia	Common greenbrier	71	
Toxicodendron radicans	Poison ivy	7	7
Vaccinium angustifolium	Lowbush blueberry	25	1
Vaccinium pallidum	Early lowbush blueberry	13	
Vitis labrusca	Fox grape		25
* We estimated the cover of each species by averaging the midpoint values of the cover class estimates for all plots in each site.			

Table 1: Plant species detected in the two study areas and cover by species.

The median cover estimates of DIVA were significantly higher than the other methods in 18 of 22 site/height class combinations, and there were no cases of the DIVA estimates being significantly lower than any method in any height class in either site (Tables 2 & 3).

Height Class	Site	Result	Percent Cover				
			DIVA	Robel Pole	Cover Board	Height of Obstruction	Line Intercept
Combined height classes-0.5-2 m	Great Swamp	Mdn	37	34	30	16	NA
		M	37	35	31	17	NA
		SD	15	13	13	13	NA
	Providence Water	Mdn	27	15	17	7	NA
		M	26	20	22	12	NA
		SD	19	18	19	15	NA
0.5 – 1 m	Great Swamp	Mdn	55	56	46	45	27
		M	56	55	47	43	29
		SD	15	15	15	28	10
	Providence Water	Mdn	48	33	39	22	21
		M	43	35	39	30	27
		SD	25	27	28	31	17
1 – 2 m	Great Swamp	Mdn	26	21	20	0	6
		M	28	25	23		7
		SD	16	14	14		7
	Providence Water	Mdn	14	8	8	0	4
		M	18	13	13		7
		SD	17	16	15		7
Notes: Shaded attributes have normal distributions and include M and SD values. NA = not available because Line Intercept results for different height classes cannot be combined.							

Table 2: Median (Mdn), mean (M) and standard deviation of Mean (SD) cover estimates by method and site (N=15 per site) and normality of the distributions.

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

Height Class	Site	Z Scores for differences with DIVA			
		Robel Pole	Cover Board	Height of Obstruction	Line Intercept
Combined height classes: 0.5 – 2 m	Great Swamp	*NS*	-3.764**	-5.807**	NA
	Providence Water	-2.929**	-2.150*	-5.119**	NA
0.5 – 1 m	Great Swamp	NS	-3.595**	-2.602**	-5.582**
	Providence Water	-2.737**	*NS*	-2.613**	-3.493**
1 – 2 m	Great Swamp	*NS*	-2.997**	-5.841**	-5.412**
	Providence Water	-2.557**	-2.139*	-5.514**	-5.514**
Notes: * significant at the 0.05 level (2-tailed). ** significant at the 0.01 level (2-tailed). NA = not available because Line Intercept results for height classes cannot be combined. Shaded attributes have normal distributions. NS = not significant.					

Table 3: Wilcoxon Test (Z scores) for differences between median cover estimates of DIVA and other methods by site and height class (N = 15 per site).

The DIVA cover estimates exhibited significant correlations with the other methods in 19 of 22 site/height class combinations, with the strongest correlations with Robel Pole, slightly weaker correlations with Cover Board, and considerably weaker correlations with Height of Obstruction and Line Intercept (Table 4).

Height Class	Sites	Kendal Tau correlations with DIVA			
		Robel Pole	Cover Board	Hieght of Obstruction	Line Intercept
Combined height classes – 0.5 – 2 m	Great Swamp	.810**	.689**	.448*	NA
	Providence Water	.619**	.657**	.657**	NA
0.5 – 1 m	Great Swamp	.543**	.619**	.440*	NS
	Providence Water	.619**	.676**	.638**	NS
1 – 2 m	Great Swamp	.733**	.657**	NS	.371*
	Providence Water	.593**	.651**	.443*	.591**
Notes: * significant at the 0.05 level (1-tailed). ** significant at the 0.01 level. NA = not available because Line Intercept results cannot be combined for height classes. Shaded attributes have normal distributions					

Table 4: Correlations (Kendal Tau) between DIVA Cover estimates with four other methods by site and height class (N = 15 per site).

In terms of time in the field, DIVA was comparable to the other field methods, as most of the time for all methods was involved in laying out transects and locating positions for taking readings or photos. DIVA did not require separate estimates for each height class as did the other methods, but a comparable amount of time was spent recording the plot number and photo direction on the small white board and ensuring that it was visible in the photo. Line Intercept required measuring the vegetative cover over the entire length of each transect, but it was not necessary to record any data to the left and right of the transects as in the other methods, and one person could record all of the data whereas two persons were required for the other methods.

However, processing the photos for DIVA was very time consuming: we found that an experienced technician required 1.2 hrs per plot in the office, as compared to approximately 10 minutes for each of the other methods. Thus, DIVA required much more total time than the other four methods.

Discussion

We compared five methods for estimating shrubland cover in regenerating clearcuts. Each method offers advantages and disadvantages - unlike forest tree monitoring; there is a lack of precision and uniformity in the monitoring of shrubland vegetation [22]. Like DIVA, Cover Board, Robel Pole and Height of Obstruction assess vegetation density by taking horizontal readings of a vertically held board or pole. Other studies have found this general approach to be more effective than the vertical readings of Line Intercept in

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

capturing the complex wildlife habitat characteristics influenced by mechanical, optical and thermal density properties of vegetation [12,16]. As we expected, our DIVA results were closely correlated with Cover Board and Robel Pole. However, DIVA produced significantly higher cover estimates in both of our study sites. After re-examining our binary photos, we became more confident in the DIVA cover estimates, and assume that our ocular estimates slightly under-estimated the density when using the Cover Board and Robel Pole methods. Other studies have also concluded that ocular estimates that increase the likelihood of observer bias [26,29].

The cover estimates from Height of Obstruction and Line Intercept were much lower and more weekly correlated with DIVA, which we attribute to the difference between the methodologies. Height of Obstruction measures horizontal density as does DIVA, but only considers the lower portion of the pole that is fully obscured. This method was designed for grasslands that generally would not obscure much of the vertical pole above the recorded height of obstruction. However, shrubby vegetation, in which Height of Obstruction has also been applied [19,33], is much more likely to obscure the higher sections of the pole even though the lower portions may be visible. This explains why our Height of Obstruction cover estimates were lower. Line Intercept is even more different from DIVA, as it measures vegetation density by looking down at a transect rather than looking horizontally at a board or pole. Furthermore, Line Intercept is considered to be most appropriate for sparsely vegetated shrubland [34], whereas shrubland in the Northeastern United States tends to be densely vegetated. These findings make us question the validity of using either Height of Obstruction or Line Intercept to estimate the density of shrubland cover in the Northeastern United States.

We hoped that DIVA would be less time-consuming than the other methods, but this was not the case due to the time required to prepare the photos for analysis. The ImageJ software converted the photos to a binary format before doing an automatic density calculation, but we had to carefully check each binary photo and adjust the sensitivity to eliminate false positive or false negative readings. We could have limited this problem by taking all of our photos on one overcast day [26], but this would not be practical for assessing a large number of plots. In theory our method could be streamlined by reducing the number of photos per subplot from four to two, which could be achieved by eliminating the two photos that were taken in our study from points perpendicular to the transect. In addition to reducing the number of photos, this approach would allow the study team to move across the study area in a straight line, which would be more efficient. The photo processing time could also be reduced by making one estimate of density for the combined height classes, rather than separate estimates for high and low vegetation as we did.

Conclusions

We concluded that DIVA is a promising method for monitoring the density of vegetation in areas clearcut to produce shrubland habitat. Monitoring these areas is critical in the Northeastern United States because the extent of this habitat is decreasing, and the public often has a negative impression of clearcutting. DIVA offers two main advantages over the other methods used in the study: (a) it directly measures the vertical structure of the vegetation, and (b) it does not rely on ocular estimates and thus avoids much of the bias associated with other methods that estimate vertical structure. Furthermore, the photos provide a rich documentation that permits quality control and other analyses to be conducted after the fieldwork is completed. However, DIVA is more time consuming than the other methods, and is probably not appropriate for routine monitoring, for which we recommend either Robel Pole or Cover Board.

Acknowledgements

We are grateful to Mr. Dillon Connelly and Ms. Bryanne Stiles for assisting with the fieldwork for this study, and to the anonymous reviewers for their comments on the manuscript. This work was supported by the Natural Resources Conservation Service of the United States Department of Agriculture (Award 68-1535-15-03), and the Rhode Island Department of Environmental Management (Award 3394024). It is contribution #5459 of the University of Rhode Island Agricultural Experiment Station. The authors have no conflict of interest to declare.

References

1. DeGraaf RM, Yamasaki M (2003) Options for managing early-successional forest and shrubland bird habitats in the northeastern United States. Forest Ecology and Management 185: 179-191.

2. Litvaitis, John A (2003) Are pre-Columbian conditions relevant baselines for managed forests in the northeastern United States? Forest Ecology and Management 185: 113-126.

3. Foster DR, Aber JD (2004) Forests in time: the environmental consequences of 1,000 years of change in New England. Yale University Press, New Haven.

4. Schlossberg S, King DI (2007) Ecology and management of scrub-shrub birds in New England: a comprehensive review. 0022-541X, Natural Resources Conservation Service, Resource Inventory and Assessment Division, Beltsville, Maryland, USA.

5. Buffum B, McWilliams SR, August PV (2011) A spatial analysis of forest management and its contribution to maintaining the extent of shrubland habitat in southern New England, United States. Forest Ecology and Management 262: 1775-1785.

6. Buffum B, Modisette C, McWilliams SR (2014) Encouraging Family Forest Owners to Create Early Successional Wildlife Habitat in Southern New England. PLoS ONE 9(2): e89972.

Citation: Buffum B, McWilliams SR (2017) Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery. Curr Trends Forest Res: CTFR-102. DOI: 10.29011/ CTFR-102. 100002

7. Williamson S (2008) Bird Conservation Region 30: New England/Mid-Atlantic Coast.*in* Kelley J, Williamson S, Cooper TR, editors. American Woodcock Conservation Plan. p 138-147. Wildlife Management Institute, Cabot, Vermont.

8. Thompson F, Dessecker D (1997) Gen. Tech. Rep. NC-195. St. Paul, MN: US Department of Agriculture, Forest Service, North Central Forest Experiment Station.

9. Grisez TJ (1960) Slash helps protect seedlings from deer browse. Journal of Forestry 58: 385-387.

10. Cardinal E, Martin JL, Tremblay JP, Côté SD (2012) An experimental study of how variation in deer density affects vegetation and songbird assemblages of recently harvested boreal forests. Canadian Journal of Zoology 90: 704-713.

11. Buffum B, McGreevy TJ Jr, Gottfried AE, Sullivan ME, Husband TP (2015) An Analysis of Overstory Tree Canopy Cover in Sites Occupied by Native and Introduced Cottontails in the Northeastern United States with Recommendations for Habitat Management for New England Cottontail.

12. Nudds TD (1977) Quantifying the Vegetative Structure of Wildlife Cover. Wildlife Society Bulletin (1973-2006) 5: 113-117.

13. Hovick TJ, Elmore RD, Fuhlendorf SD (2014) Structural heterogeneity increases diversity of non-breeding grassland birds. Ecosphere 5: 1-13.

14. Robel R, Briggs J, Dayton A, Hulbert L (1970) Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23: 295-297.

15. Fettinger JL (2002) Ruffed Grouse Nesting Ecology and Brood Habitat in Western North Carolina. Master's Thesis, University of Tennessee.

16. Musil DD (2011) Use of Dwarf Sagebrush by Nesting Greater Sage-Grouse. In Sandercock BK, Martin K, Segelbacher G (Eds.), Ecology, Conservation and Management of Grouse. Berkeley, California: University of California Press.

17. Dittmar EM, Cimprich DA, Sperry JH, Weatherhead PJ (2014) Habitat selection by juvenile black-capped vireos following independence from parental care. The Journal of Wildlife Management 78: 1005-1011.

18. Casazza, M.L., Coates, P.S. & Overton, C.T. (2011) Linking Habitat Selection and Brood Success in Greater Sage-Grouse. In Sandercock BK, Martin K, Segelbacher G (Eds.), Ecology, Conservation and Management of Grouse. Berkeley, California: University of California Press.

19. McGranahan DA, Engle DM, Fuhlendorf S, Winter SJ, Miller JR et al. (2012) Spatial heterogeneity across five rangelands managed with pyric-herbivory. Journal of Applied Ecology 49: 903-910.

20. Canfield RH (1941) Application of the Line Interception Method in Sampling Range Vegetation. Journal of Forestry 39: 388-394.

21. Etchberger RC, Krausman PR (1997) Evaluation of Five Methods for Measuring Desert Vegetation. Wildlife Society Bulletin (1973-2006) 25: 604-609.

22. Gayton D (2014) Grassland and Forest Understory Vegetation Monitoring: An Introduction to Field Methods. Journal of Ecosystems and Management 14(3):1-9.

23. Licata JA, Gyenge JE, Fernández ME, Schlichter TM, Bond BJ (2008) Increased water use by ponderosa pine plantations in northwestern Patagonia, Argentina compared with native forest vegetation. Forest Ecology and Management 255: 753-764.

24. Morsky SK, Haapala JK, Rinnan R, Tiiva P, Saarnio S et al. (2008) Long-term ozone effects on vegetation, microbial community and methane dynamics of boreal peatland microcosms in open-field conditions. Global Change Biology 14: 1891-1903.

25. Rood SB, Bigelow SG, Polzin ML, Gill KM, Coburn CA (2015) Biological bank protection: trees are more effective than grasses at resisting erosion from major river floods. Ecohydrology 8: 772-779.

26. Vanha-Majamaa I, Salemaa M, Tuominen S, Mikkola K (2000) Digitized photographs in vegetation analysis - a comparison of cover estimates. Applied Vegetation Science 3: 89-94.

27. Mortensen B, Wagner D, Doak P (2011) Defensive effects of extrafloral nectaries in quaking aspen differ with scale. Oecologia 165: 983-993.

28. Childress ES, Koning AA (2013) Polydomous *Crematogaster pilosa* (Hymenoptera: Formicidae) Colonies Prefer Highly Connected Habitats in a Tidal Salt Marsh. Florida Entomologist 96: 235-237.

29. Jorgensen CF, Stutzman RJ, Anderson LC, Decker ES, Powell LA et al. (2013) Choosing a DIVA: a comparison of emerging digital imagery vegetation analysis techniques. Applied Vegetation Science 16: 552-560.

30. Buffum B, McKinney RA (2014) Does Proximity to Wetland Shrubland Increase the Habitat Value for Shrubland Birds of Small Patches of Upland Shrubland in the Northeastern United States? International Journal of Forestry Research 2014.

31. Coulloudon B, Eshelman K, Gianola J, Habich N, Hughes L et al. (1999) Sampling vegetation attributes: Interagency technical reference, Second Revision. Technical Reference 1734-4, 163 pp. Denver, CO: USDI Bureau of Land Management, National Applied Resource Sciences Center.

32. Schindelin J, Rueden CT, Hiner MC, Eliceiri KW (2015) The ImageJ ecosystem: An open platform for biomedical image analysis. Molecular Reproduction and Development 82: 518-529.

33. Hansen CP, Schreiber LA, Rumble MA, Millspaugh JJ, Gamo RS et al. (2016) Microsite selection and survival of greater sage-grouse nests in south-central Wyoming. The Journal of Wildlife Management 80: 862-876.

34. Walter CA, Burnham MB, Gilliam FS, Peterjohn WT (2015) A reference-based approach for estimating leaf area and cover in the forest herbaceous layer. Environmental Monitoring and Assessment 187: 657.

Attachment 3. Winter and Summer Protocols for NRCS monitoring of ESH practices

We developed two protocols for monitoring ESH in the summer and winter. Summer assessments produce better estimates of the density of the vegetation, which is critical for many shrubland bird species, and plant identification is much easier in the summer. However, winter assessments produce useful estimates of winter vegetation cover, which is critical for wildlife species such as New England Cottontail. In addition, it is easier to assess deer browse in dense shrubby vegetation in the winter when twigs are more visible.[3] Moreover, it is much easier to move through dense shrubby vegetation in the winter.

A. Summer (leaf-on) ESH Assessment

1. Make a GIS map of the clearcut

Before going to the field, make a GIS map of the clearcut. Record the area of the cut, and look for environmental gradients (slope, plant community type (from RI Ecological Communities layer) soil drainage and forest productivity attributes (from NRCS Soil survey). In general, we recommend two transects per cut. The first transect should follow the major environmental gradient, and the second transect should be approximately perpendicular to the gradient, although this may not be practical depending on the shape of the clearcut. For a long thin cut without any district environmental gradient, a single transect crossing the widest portion of the cut may be sufficient. Calculate the total length of the transect(s) that you have drawn on the map.

We recommend 10-20 plots per cut. A greater number of plots will produce more accurate data, but 10 locations should be adequate for a relatively small clearcut. Divide the total length of your transect(s) by the number of plots to establish the distance between plots. When you go to the field, you will pace that distance to reach your sampling plots.

2. Field Study

Depending on the specific objectives of your study, you may not need to collect all of the data mentioned below.

- Record (a) the dominant tree species on the perimeter of the cut; and (b) the approximate number of reserve trees retained inside the cut.
- Using the GIS map, locate each plot by pacing the calculated distance along the transect. Mark the center of the plot (a tall stake or old ski pole is convenient). In each plot, record the following attributes within 5 meters (see attached datasheet, which should be printed front and back):
    - **Overall plot cover**: estimate the % tree/shrub cover, % herb cover, and % no vegetation (the total of three classes should equal 100%). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).

---

[3] The USDA Forest Service has developed a methodology for summer assessment of deer browse (The Ten-tallest Method, Thomas J Rawinski) that is highly appropriate for use in mature forests or recent clearcuts with limited regeneration. https://flnps.org/articles/1161/monitoring-white-tailed-deer-impacts-ten-tallest-method-draft However, we believe that winter assessments are more practical in sites with very dense shrubby vegetation.

- **Tree/Shrub data**. For each species of tree or shrub, record the following:
  - Species name
  - Predominant height of this species: locate an example and measure (cm).
  - Cover: the percent of all tree/shrub vegetation in the plot that this species represents (the total for all species should be 100%). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).
- **Slash:** estimate the amount of the plot that is covered with slash (coarse woody debris). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).
- **Vegetation Density:** We recommend the use of a Cover Board or Robel Pole for estimating the density of vegetation in of regenerating clearcuts. Both methods are relatively easy to apply, and produce good estimates of the density of the regenerating vegetation. For small samples (10 plots per clearcut), we recommend the cover board. For larger samples or sites that involve a long walk, we recommend the Robel Pole, which is easier to transport. For a detailed discussion of the advantages and disadvantages of these and several other methods, see: Buffum and McWilliams (2017)[4].
- **Cover Board:**
  - **Board construction**: We recommend a 2 m tall and 0.25 m wide cover board, painted in alternating colors for each 0.5 m height interval. Our board was made of light plywood.
  - **Measurements:** The first team member holds the board at the center of the plot and records the data. The second team member takes readings from the four cardinal directions, from a height of 1-m off the ground and at a distance of 4-m from the pole. Each reading includes an estimate of the percentage of the board covered by vegetation in four height classes: 0-0.5-m, 0.5-1-m, 1-1.5-m and 1.5-2-m.
- **Robel Pole**
  - **Pole Construction:** The pole should be round, approximately 4 cm in diameter, 2 meters high, and painted in alternating colors (0.5 meter high each, i.e. bright pink and bright blue) which are easy to differentiate from vegetation colors. We cut our PVC pole into two sections for easier transportation, and connected them with a PVC coupling. A four-meter rope can be attached to the pole to easily measure distance between the pole and the team member making the cover estimates. A spike can be internally attached to the bottom of the pole so that one person can work independently, but it is convenient to have a two-person team.
  - **Measurements:** The first team member holds the Roble Pole at the center of the plot and records the data. The second team member takes readings from the four cardinal directions, from a height of 1-m off the ground and at a distance of 4-m from the pole. Each reading includes an estimate of the percentage of the pole covered by vegetation in four height classes: 0-0.5-m, 0.5-1-m, 1-1.5-m and 1.5-2-m.

---

[4] Buffum, B. and S. R. McWilliams (2017). "Assessing the density of vegetation for wildlife cover in regenerating clearcuts via analysis of digital imagery." Current Trends in Forest Research 2017(1): 7.

Summer ESH Assessment **Site:** **Date:**
Observers: **Distance between Plots:** **Approx. number Reserve Trees:**
Dominant Perimeter Tree Species:

PLOT						
Overall Plot						
% Tree/shrub						
% Herb						
% No Veg						
Slash Rating						
Shrub cover						
North						
East reading						
South						
West						
Shrub cover						
North						
East reading						
South						
West reading						
Shrub cover						
North						
East reading						
South						
West						
Shrub cover						
North						
East reading						
South						
West reading						

For all % estimates, round to nearest 10%. 0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.

[5] Total of Tree/shrub cover, Herb cover, and no veg = 100%

Spec 1. Name						
Predom						
% Cover[6]						
Spec 2. Name						
Predom						
% Cover						
Spec 2. Name						
Predom						
% Cover						
Spec 3. Name						
Predom						
% Cover						
Spec 4. Name						
Predom						
% Cover						
Spec 5. Name						
Predom						
% Cover						
Spec 6. Name						
Predom						
% Cover						
Spec 7. Name						
Predom						
% Cover						
Spec 4. Name						
Predom						
% Cover						
Spec 5. Name						
Predom						
% Cover						
Spec 6. Name						
Predom						
% Cover						

[6] Total cover of all species = 100%

B. Winter (leaf-off) ESH Assessment

1. Make a GIS map of the clearcut

Before going to the field, make a GIS map of the clearcut. Record the area of the cut, and look for environmental gradients (slope, plant community type (from RI Ecological Communities layer) soil drainage and forest productivity attributes (from NRCS Soil survey). In general, we recommend two transects per cut. The first transect should follow the major environmental gradient, and the second transect should be approximately perpendicular to the gradient, although this may not be practical depending on the shape of the clearcut. For a long thin cut without any district environmental gradient, a single transect crossing the widest portion of the cut may be sufficient. Calculate the total length of the transect(s) that you have drawn on the map.

We recommend 10-20 plots per cut. A greater number of plots will produce more accurate data, but 10 locations should be adequate for a relatively small clearcut. Divide the total length of your transect(s) by the number of plots to establish the distance between plots. When you go to the field, you will pace that distance to reach your sampling plots.

3. Field Study

- Record (a) the dominant tree species on the perimeter of the cut; and (b) the approximate number of reserve trees retained inside the cut.

Using the GIS map, locate each plot by pacing the calculated distance along the transect. Mark the center of the plot (a tall stake or old ski pole is convenient). For the first few plots, use a 5m rope or measuring tape to identify the border of a 5m radius plot. After several plots, you will be able to visualize the plot size. In each plot, record the following attributes (see attached datasheet, which should be printed front and back).

- Overall cover class of plot: estimate the % Tree/shrub cover, % herb cover, and % no vegetation (the total of three classes should equal 100%). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).
- Tree/Shrub data. For each species of tree or shrub, record the following:
    - Species name
    - Predominant height of this species: locate an example and measure (cm).
    - Species cover: the percent of all tree/shrub vegetation in the plot that this species represents (the total for all species should be 100%). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).
    - Browse: select nearest seedling or stump site of predominant height and record % of sprouts or branches (on perimeter of plant at a height of approx. 1 m) with deer browsing. Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).
  - Slash: estimate the amount of the plot that is covered with slash (coarse woody debris). Ocular estimate, round to nearest 10% (0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.).

Winter ESH Assessment **Site:** **Date:**
Observers: **Distance between Plots:** **Approx. number Reserve Trees:**
Dominant Perimeter Tree Species:

PLOT						
Overall Plot						
% Tree/shrub						
% Herb cover						
% No Veg						
Slash (%)						
Spec 1. Name						
Predom height						
% Cover[8]						
% Browse						
Spec 2. Name						
Predom height						
% Cover						
% Browse						
Spec 2. Name						
Predom height						
% Cover						
% Browse						
Spec 3. Name						
Predom height						
% Cover						
% Browse						
Spec 4. Name						
Predom height						
% Cover						
% Browse						

For all % estimates, round to nearest 10%. 0 = none; 5 = 1-10%, 15 = 11-20%, 25 = 21-30%, 35 = 31-40%, etc.

[7] Total of Tree/shrub cover, Herb cover, and no veg = 100%
[8] Total cover of all species = 100%

Spec 5. Name						
Predom height						
% Cover						
% Browse						
Spec 6. Name						
Predom height						
% Cover						
% Browse						
Spec 7. Name						
Predom height						
% Cover						
% Browse						

Attachment 4. Description of ESH Demonstration posted to Rhode Island Woods website.

Nicholas Farm Management Area
RI Department of Environmental Management
Coventry, RI

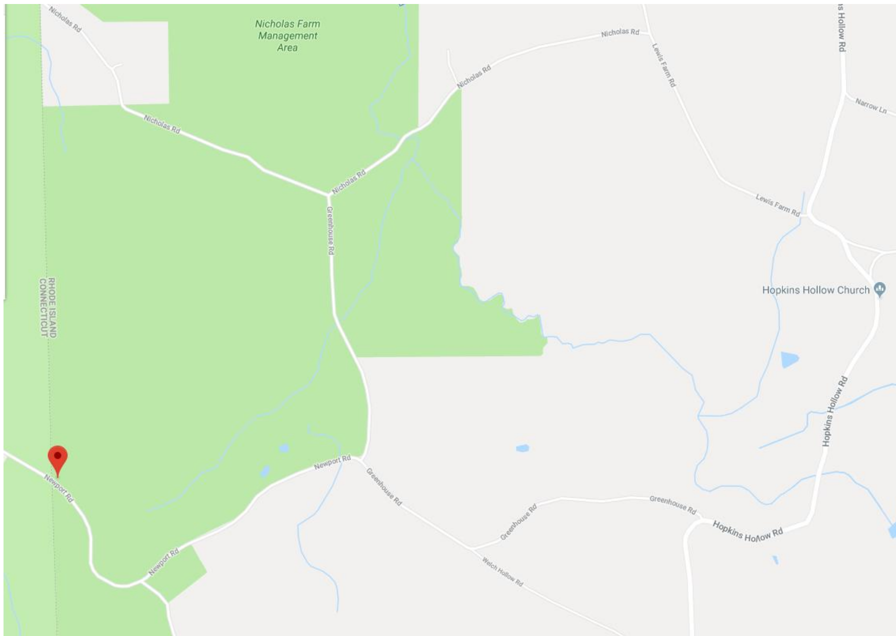
Introduction

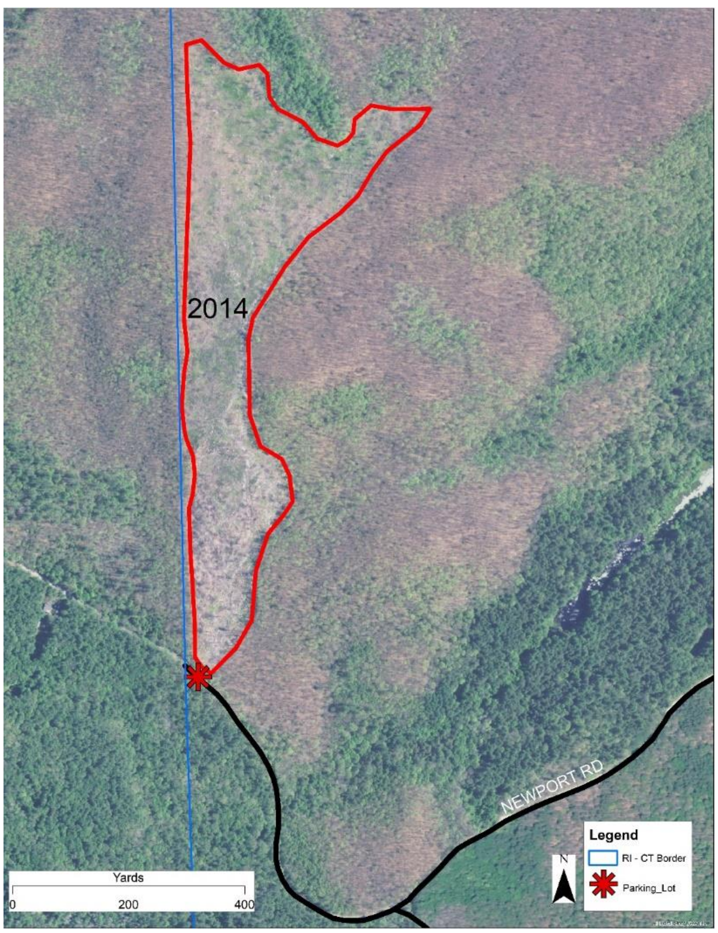
This site, which is owned and managed by RIDEM, is easy to access at any time of the year, and offers the chance to view a 35 acre clearcut harvested in 2014/2015 that is still in the early stage of regenerating.

Access

The clearcut is in the southern portion of Nicholas Farm Management Area. It is just north of Newport Road, where the road crosses the RI border with Connecticut. There are several ways to reach Newport Road from Rt 102, including one route that passes through Connecticut and then back into RI.

During hunting season, all visitors should wear fluorescent orange clothing (for RIDEM regulations about clothing during hunting season, see http://www.eregulations.com/rhodeisland/hunting/general-information).


Nicholas Farm Management Area
Nicholas Rd
Nicholas Rd
Nicholas Rd
Nicholas Rd
Lewis Farm Rd
Lewis Farm Rd
Narrow Ln
Greenhouse Rd
RHODE ISLAND
CONNECTICUT
Hopkins Hollow Church
Hopkins Hollow Rd
Newport Rd
Newport Rd
Newport Rd
Greenhouse Rd
Greenhouse Rd
Greenhouse Rd
Hopkins Hollow Rd
Welch Hollow Rd


2014
NEWPORT RD
Legend
RI - CT Border
Parking_Lot
N
Yards
0
200
400

You can park on the side of Newport Road next to the clearcut.

You can walk on a hiking trail along the eastern perimeter of the cut, or you can walk through the middle of the clearcut.

Description

The clearcut is long and thin, generally less than 150 yards wide (east-west) but more 1,000 yards long (north-south). The surrounding forests to the east, west and north are dominated by mixed oak and white pine, and to the south by black oak and red maple mixed hardwoods. Inside the clearcut, most of the regenerating vegetation ranges in height from 2-5 feet (as of 2017), with some bare areas. Many areas are dominated by blueberry and huckleberry, but many other species are present including American chestnut, big toothed aspen, black cherry, black oak, pitch pine, red maple, sassafras, scrub oak, white oak, white pine, and yellow birch. During the harvest, many mature pine and hardwood trees were retained to serve as seed trees and provide mast for wildlife. A large amount of slash was left on the ground to reduce browsing damage from deer.

Wildlife species detected during a 2017 visit included mourning dove, white tailed deer, eastern towhee, red squirrel, white breasted nuthatch, northern flicker, and eastern bluebird.

Photo credits: Ryan Healey

Attachment 5. Additional Studies of ESH

1. Soil drainage and woodland suitability

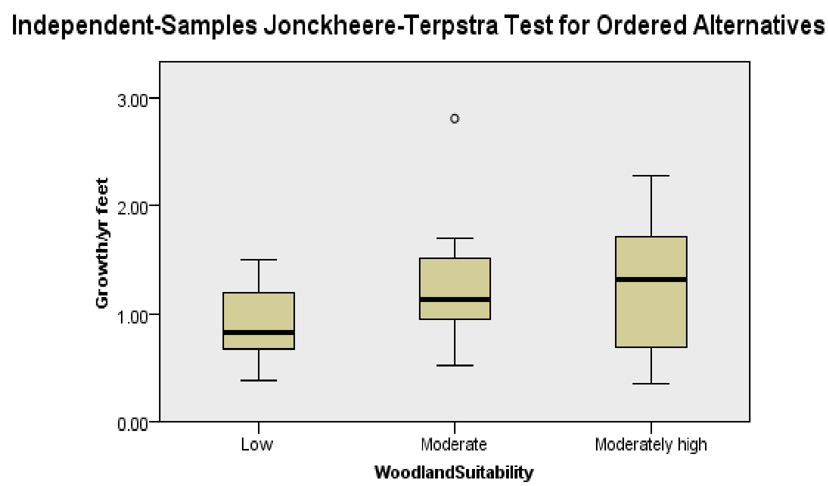
We conducted a study in 31 clearcuts to assess the influence of soil drainage and forestry suitability on the growth rate of the regenerating vegetation. In each site, we estimated the annual growth rate by dividing the current vegetation height by the age of the clearcut. We extracted data on soil drainage and forestry suitability from the NRCS soil survey. The average annual growth rate of the regenerating vegetation was 1.2 feet per year (0.37 meters). The same annual growth rate was recorded in a 10 year old Tennessee clearcut[9].

The 31 clearcuts fell into three of the five woodland suitability classes (moderately high, moderate, and low).

We combined the drainage classes in the NRCS Soil Survey into three categories: excessively drained, well drained, and poorly drained. The clearcuts fell into two of our three drainage classes (excessively drained, well drained).

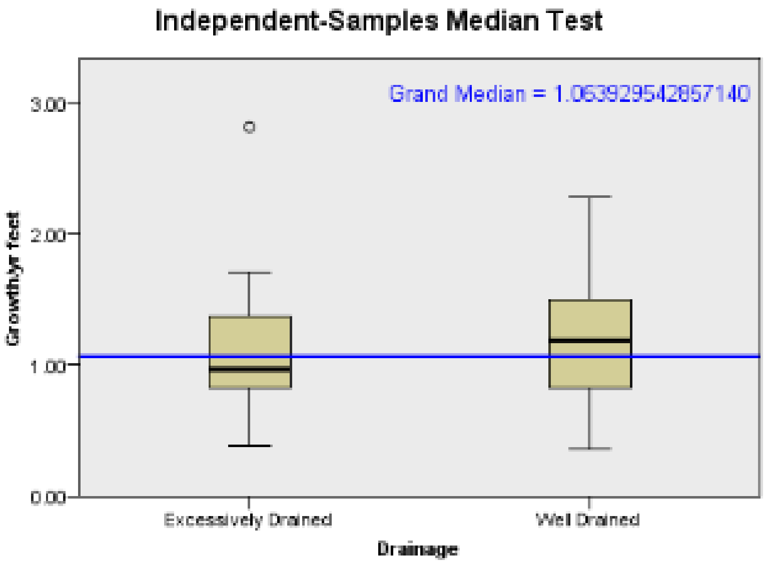
As expected, we found lower growth rates on sites that had lower woodland suitability ratings (Figure 1) or had excessively drained soils (Figure 2). However, the differences in growth rates were not statistically significant, which increases our confidence that successful ESH cuts can be carried out on dry as well as moist sites.

Figure 1. Growth rate of vegetation in 31 RI Clearcuts by Woodland Suitability



[9] Tennessee Valley Authority. 1993. Tennessee River chip mill terminals: environmental impact statement.

Figure 2. Growth rate of vegetation in 31 RI Clearcuts by Drainage Class



We were particularly interested in assessing clearcuts on dry sites that are currently dominated by huckleberry and blueberry. Many foresters are concerned that a combination of dry soils and heavy deer browse will prevent regeneration of tree species, and that these sites will become long-term "huckleberry thickets". Our observations confirmed that regeneration of tree species in these clearcuts is delayed, although eventually species such as white pine do emerge (Figure 3).

Figure 3. White pine emerging in a clearcut dominated by huckleberry/blueberry

If the main objective of the landowner is timber production, the delayed regeneration of tree species is a legitimate concern. However, if the main objective is wildlife habitat, the longer persistence of ESH vegetation is actually be an advantage. Furthermore, the URI team preparing the URI Bird Atlas has confirmed that many shrubland bird species utilize this type of site. Therefore, we recommend that NRCS continue to support ESH cuts in dry as well as moist sites, including those currently dominated by huckleberry and blueberry, even though more rapid growth can be expected in the moister sites.

2. Slash retention and deer browse

We conducted a rapid assessment in 40 research plots in four large clearcuts to assess the impact of retaining slash (also called coarse woody debris) in reducing damage from deer browse. The clearcuts included two cuts in the Great Swamp Management Area, one in Arcadia Management Area, and one in North Kingstown belonging to the Narrow River Land Trust. All of the cuts had been carried out 2-4 years previously.

In each plot, we estimated the percentage of stems of each plant species browsed by deer, and classified the amount of slash in four categories. The percentage of stems browsed by deer varied widely by the plant species, ranging from 75% for Greenbriar to only 1% for American Holly, Pitch Pine and Grey Birch (Table 1).

Table 1. Browse rate by species

Species	N Plots	Mean Browse
Greenbriar	29	53%
Scrub Oak	10	34%
Black Cherry	19	25%
Red Maple	24	22%
Clethra	3	22%
Sassafras	7	21%
White Oak	18	16%
Huckleberry	15	14%
Swamp Azealia	4	11%
Blueberry	15	10%
Sweet fern	3	5%
Nyssa Sylvatica	5	3%
Inkberry	2	3%
Autumn Olive	3	2%
American Holly	18	1%
Pitch Pine	10	1%
Grey Birch	9	1%

We tested for relationships between the amount of slash, browse, and height for all species that were represented in at least 10 plots and had a mean browse rate of at least 10%. The test results for individual species were insignificant due to the small sample size. However, these site visits convinced us that retention of slash results in less browse and increased growth of vegetation. Therefore, we strongly endorse the current NRCS recommendation about retaining slash in ESH cuts, and recommend a larger-scale study of the impact of slash-retention be conducted to confirm the trends from this small-scale study.

3. Spatial analysis of the creation of ESH by private landowners

Private landowners are critical to the conservation of wildlife that require early successional habitat (ESH) in southern New England, where private ownership of forests is 77% in Connecticut, 79% in Massachusetts, and 85% in Rhode Island[10]. For this reason, a consortium of federal, state university and private conservation agencies[11] in Rhode Island has been collaborating since 2008 to encourage private landowners to create habitat for woodcock and other species that require ESH.

We compared the extent of ESH created in Rhode Island during two seven-year periods (1997-2004 and 2004-2011) by private landowners, government agencies, and non-government organizations. We used ArcGIS version 10.4.1[12] with datasets and imagery that are publicly available on the Rhode Island Geographic Information System: land use/land cover (1997, 2004 and 2011), conservation status (2014) and imagery (1997, 2004, 2008, 2011, 2016). We identified parcels with an area of at least 1 ha that were classified as forest in 2004 and as non-forest in 2011. We used the 2004 and 2011 imagery to confirm that the plots had actually been clearcut. We used the 2016 imagery to exclude plots that had already been converted to land uses other than ESH by 2016. Finally, we classified the ownership status of the remaining ESH plots into six categories of conservation land (state, federal, municipal, land trust, non-governmental organization (NGO), private) and one category of non-conservation land. We compared the results to data from a previous URI study that used a similar approach to study the extent of ESH created between 1997 and 2004[13].

[10] Butler, B. J., et al. (2011). The Forests of Southern New England, 2007: A report on the forest resources of Connecticut, Massachusetts, and Rhode Island. NRS. 55 Newtown Square, PA, : U.S. Department of Agriculture, Forest Service, Northern Research Station**:** 48.
[11] The consortium is led by four agencies: the RI Department of Environmental Management (RIDEM), the University of Rhode Island (URI), the USDA Natural Resources Conservation Service (NRCS), and the RI Resource Conservation and Area Development Council (RC&D).
[12] Environmental Systems Research Institute, Redlands, CA.
[13] Buffum B, McWilliams SM, August PV. (2011). "A spatial analysis of forest management and its contribution to maintaining the extent of shrubland habitat in southern New England, United States." Forest Ecology and Management **262**(9): 1775-1785.

The amount of ESH created in clearcuts of at least 1 ha in Rhode Island increased from 37.9 ha/year during the period of 1997-2004 to 73.9 ha/year during the period of 2004-2011 (Table 2). In both time periods, most of the ESH was created on privately-owned land without any conservation status, which applies to most landowners who apply for NRCS support. Most of the ESH produced on conservation lands was created by municipal organizations during the first time period, and by the State in the second time period.

Table 2. Amount of ESH created in Rhode Island between 1997-2004 and 2004-2011 by ownership type

Fee Ownership	Conservation Status	1997-2004		2004-2011	
		Ha	Percent of total	Ha	Percent of total
State	Conserved	7.4	3%	55.4	11%
Federal	Conserved	0	0%	2.7	1%
Land Trust	Conserved	8.6	3%	7	1%
Municipal	Conserved	81.4	31%	49.3	10%
NGO	Conserved	0.3	0%	20 1	4%
Private	Conserved	3.6	1%	3.6	1%
Private	Non conserved	164.1	62%	378.9	73%
Total		265.3	100%	517	100%
Total per year		37.9		73.9	

Note: based on clearcuts of at least one ha that had not been converted to non-forest land use five years after the end of the time period.

In both time periods, most of the ESH that was subsequently converted to other land-uses was for residential and commercial construction, with much smaller amounts used for agriculture, gravel mines, and lawns. Most of these conversions took place within a few years: our analysis of the 2016 imagery revealed that only 7% of the ESH created between 1997-2004 that was still forest in 2008 was converted to other land uses by 2016.

These findings on the extent of ESH created on state land are consistent with data compiled by RIDEM, which show that the extent of clearcuts on State land increased considerably after 2004. This trend can be expected to continue due to planned clearcuts in 2018 and 2019 at the same level as the 2017 cuts. NRCS support to private landowners for creating ESH in Rhode Island also increased since 2006. The annual extent of ESH created by private landowners with support from NRCS for early successional habitat practices during 2012-2017 was almost three times the annual extent during 2006-2011.

We are far from creating the amount of ESH in Rhode Island that wildlife biologists have recommended to stabilize populations of American woodcock and other species that require this vegetation type. For example, Dettmers and Rosenberg[14] proposed addressing population objectives for priority shrubland bird species by maintaining ESH on 10% of forests in southern New England, which was almost double the 2011 extent in Rhode Island[15]. The 2008 Woodcock Conservation Plan [16] proposed an even more ambitious program of maintaining shrubland and ESH on 27% of forests in Rhode Island, which would require a greatly increased amount of clearcutting. Nevertheless, we were encouraged to see that the amount of ESH created per year in RI doubled after 2004, and that most of this increase was due to the efforts of private landowners. We cannot attribute all of this increase to the efforts of our consortium, but we are confident that our integrated program has made a positive contribution and that further increases are possible if we intensify our efforts.

[14] Dettmers, R. and K. V. Rosenberg (2000). Partners in Flight Landbird Conservation Plan: Physiographic Area 9: Southern New England, Partners in Flight. Available at http://www.partnersinflight.org/bcps/pifplans.htm.
[15] Buffum B, McWilliams SM, August PV. (2011). "A spatial analysis of forest management and its contribution to maintaining the extent of shrubland habitat in southern New England, United States." Forest Ecology and Management **262**(9): 1775-1785.
[16] Kelley, J et al. (2008) American woodcock Conservation Plan. Wildlife Management Institute. https://timberdoodle.org/demo/great-swamp-wildlife-management-area-washington-county-rhode-island.