Implementation and Monitoring of the NJDEP Plan for Protection and Enhancement of Certain Broom Crowberry Populations in the South Jersey Dwarf Pine Plains

Final Report

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EXECUTIVE SUMMARY

The purpose of this study was to collect baseline monitoring data and initiate ecological forestry / fire hazard reduction management to conserve extant populations of the state endangered plant broom crowberry (*Corema conradii*) and restore open-canopy dwarf pine plains habitat, in sites located in a portion of East Plains Natural Area unburned since 1971. Objectives within the study area were to: a) sample vegetation and environmental factors within and outside populations to evaluate influences on broom crowberry distribution and to establish monitoring plots; b) conduct surveys of existing populations of broom crowberry; c) update existing distribution maps of broom crowberry populations from Windisch (1998); d) establish photo monitoring points within broom crowberry populations; and e) apply various clear-cutting, slash removal and litter removal methods in several management units, to reduce fuel loads and risk to broom crowberry populations from wildfires and planned prescribed burns, and to allow for future study of various management approaches and effects.

Vegetation analysis indicated that the presence of broom crowberry is negatively correlated with presence of litter, canopy, and ericoid shrubs; lending support to our initial assumption that broom crowberry persists in the open patches produced by fire, as well as offering a mechanistic explanation of broom crowberry's failure to persist after a burned area revegetates. This also seems to suggest that clear-cutting and litter removal would reduce the factors with which broom crowberry is negatively correlated.

The contracted cost per acre for the clearing/silvicultural prescription for this project, according to the vendor (Green Thumb), was insufficient even with seed/cone sales. Green Thumb estimates future similar work will cost twice as much as they charged the State in this

contract. This revised estimate of future costs for a similar clearing operation plus Gyrotrac costs should be an incentive to try other approaches that may make future endeavors more cost effective (if this approach proves to be effective in its ecological goals for the broom crowberry populations). We also suggest exploring the possibility that lichen mats may serve as competition-free refugia for broom crowberry.

INTRODUCTION

The need for increased management and implementation of South Jersey's forests, particularly areas home to certain threatened and endangered species was particularly apparent where high intensity wildfires in long unburned pine plains habitat have destroyed a number of broom crowberry (*Corema conradii*) populations whose tolerance of hot fires is low. However, broom crowberry survival and cushion proliferation do appear to rely on fire or disturbance for habitat creation/regeneration (Dunwiddie 1990, Windisch 1998 and 2007). Broom crowberry tends to establish in open patches created by disturbance or frequent mixed-intensity fire, although weak dispersal capability appears to limit its spread (Windisch 1998). In the New Jersey Pinelands, a large region of fire-maintained xeric pine-oak forests, such patches were historically abundant, particularly in areas subjected to frequent wildfires such as the dwarf pine plains (Harshberber 1916, Lutz 1934, Boerner 1981).

There has been an increase in biomass accumulation (i.e. fuel loading) in many of South Jersey forests as fire suppression programs have reduced fire frequency in forests that are adapted to more frequent mixed-intensity fires. This decrease in fire frequency, coupled with an insufficient amount of prescribed burns and/or forestry to simulate post-fire structures and reduction in fuel loads, has lead to extreme fires that are too hot for many species to tolerate. The biomass buildups increase danger to human populations (from potential crown fires) and increase plant species crowding and interspecific competition (Forman and Boerner 1981, Boerner 1981). Moreover, typical low-intensity control burns do not burn off the humus horizon, and thus do not produce large openings of mineral soil (Boerner 1981) required for broom crowberry

establishment. Dr. Andrew Windisch, an ecologist in the NJDEP Office of Natural Lands Management (ONLM), has studied dwarf pine plains fire ecology and disturbance history for a number of years. His analysis of historical records and aerial photos, as well as on-the-ground broom crowberry surveys and ecological management planning for the Natural Areas Program and other DEP lands has lead him to author a proposal for protection and restoration of some broom crowberry populations located within East Plains Natural Area and West Plains Natural Area (Windisch 2007).

PROJECT DESIGN AND METHODS

1. VEGETATION SAMPLING AND ANALYSIS

We have taken measurements of the vegetative growth closely associated with broom crowberry by plotting 30-meter line transects both in and outside of established polygons of crowberry (see Map 1 Appendix 1). We then drew square-meter plots every three meters along either side of the transect line at random lateral distances from the line and counted the type and extent of vegetative growth within each of those plots. We also mapped the ends of the transect lines according to the protocol above, editing the points to lines rather than area classes in *ArcView*. We established a total of 30 transects, 15 in the crowberry-dominated areas (IN) and 15 in the surrounding forest matrix (OUT). Preliminary Principal Component Analysis (PCA) achieved good separation between IN and OUT transects.

The number of stems of shrubs and forbs within the 1 m^2 plots were counted, and the percent cover was determined for lichen, moss, bare soil, litter, crowberry, bear berry and grasses (since individual stems are indistinguishable, percent cover provides a better estimate of

vegetation density. Moreover, since the number of stems is not indicative of the number of individuals, percent cover is a more accurate measure (Sedia and Ehrenfeld, 2005) and it allows for direct comparisons among different habitats). We also counted the number of oak and pine stems if they happen to fall within a quadrat. We measured the litter depth in three random places within the quadrat and recorded the average depth in inches.

The canopy cover was determined for each of the quadrats as percent coverage by the branches and leaves directly above the plot based on visual estimate while looking directly up through a PVC tube divided into four quadrats. Open areas with no trees were recorded as 0 percent (%) cover; if half of the sky above the plot was covered by branches, it was recorded as 50%, and so on. The depth of litter was also measured, and the primary component of it was recorded (e.g., pine needles, oak leaves, etc.).

For all of our statistical analyses (with the exception of correlation matrices) we treated broom crowberry as a dependent variable, while the rest of the variables (such as canopy, litter, moss, lichen, bare soil, ericaceous shrubs, and other vegetation) have been treated as independent variables. We only did analyses on vegetation common enough to appear in more than three transects. All analyses were completed using SAS 9.1.

2. BROOM CROWBERRY POPULATION SURVEY

Consistent with the methodology of the New Jersey Natural Heritage Program and Windisch (1998), we estimated the size of broom crowberry populations by counts of "cushions" (i.e. roughly circular, more or less discrete patches of broom crowberry vegetation), which may or may not correspond to "genets" (i.e., genetically discrete individuals derived from a single seed). Based on an absence of connecting stems or rhizomes, all isolated cushions correspond to single genets, as well as most circular cushions with discrete perimeters, even if growing closely in clusters (A. Windisch, personal observations). However, large irregular patches of broom crowberry appear to be composites of multiple genets which have grown together over time. Closely spaced or merging cushions can also be derived from a single genet by central cushion dieback or clonal expansion, with connecting stems or rhizomes often discernable. No attempt was made to identify genets during this study.

Cushions were tallied in five class sizes (0-0.5 ft, 0.5-1 ft, 1-2 ft, 2-3 ft, and > 3 ft in diameter). Additionally, we characterized density of living broom crowberry tissue within each of the cushions (100%, 30-90%, < 30% coverage of live tissue). In order to roughly estimate total area covered by broom crowberry within each polygon, we multiplied the midpoint of each diameter class (i.e. 0.25, 0.75, 1.5, 2.5 and 3.0, with the exception that we used 3.0 for the > 3 ft diameter class), by the midpoint of each live tissue coverage class (i.e. 100%, 60%, 15%, with the exception that we used 100% for the 100% coverage class), by the number of cushions in each of those class combinations. The sum of these was used to estimate the grand total area covered by broom crowberry in the study area. Percent cover of broom crowberry within each

polygon was roughly estimated based on the total area covered by broom crowberry for that polygon, divided by polygon area, times 100. The average of these was used to estimate the average percent cover of broom crowberry in the study area polygons.

3. BROOM CROWBERRY POLYGON MAPPING

Using GIS maps of broom crowberry occurrences provided by ONLM based on Windisch (1998), and a Trimble GeoExplorer GPS unit (with post processing), we verified some polygons and edited other polygons from the original map. We also mapped new polygons not found on the original map.

4. PHOTO MONITORING POINTS

We randomly selected 67 photo monitoring points that were serially photographed in panorama (usually about 12 photos with overlaps of about 20% starting north and going clockwise) and took four photographs of the ground cover around each point at West, North, East, and South. We permanently marked each point with a metal fire-resistant pipe engraved with the polygon identification number and photographed it. Photos were taken with an Olympus 1040SW camera. Each photograph has a resolution of about 10 megapixels. The photos were taken from summer of 2008 through March 2010.

5. VEGETATION CLEARING

ONLM obtained DEP and Pinelands Commission approvals needed for the clearing project in 2008. A subcontract was awarded by Richard Stockton College to Green Thumb

Reforestation in September 2008 for the clearing of about 20 acres in Sites A, B and C, reduced from an area of "up to 27 acres" in the original grant proposal. Clearing activities were contracted to occur between October 2008 and May 30, 2009, but extensions were requested and granted that pushed the activity period to between February 2009 and March 2010. Due to the contract extensions and proposals from Warren Grove Range (WGR) and New Jersey Forest Fire Service (NJFFS) to proceed with intense prescribed burns in surrounding units in early 2009, ONLM staff initiated some of the clearing work in Fall 2008 as a precaution to reduce the risk of prescribed fire escape and damage to unmanaged broom crowberry populations. This included the clearing of about 3.1 acres of pine plains with broom crowberry populations in and near Sites A and C, including about 1.5 acres within subcontracted areas. New areas of 1.25 acres were added to the southeast corner of Site A and 0.28 acres to Site C along the shoulders of Crossover Road, to maintain the 20 acres subcontracted, but about 1.16 acre of Site B was later deleted to maintain buffers along Range Road and reduce the subcontractor's total acreage to about 18.5 acres.

We were approached by the contracted vendor, Green Thumb Reforestation, early in their work for permission to salvage the pine cones (and contained seeds) from cleared areas to supplement their income on the project, when it became apparent to them that the time and cost of clearing was more than anticipated. Permission was granted to salvage pine cones at the project site, since the cones and seeds were going to be destroyed anyway during the process of slash piling and burning. It also provided an opportunity to evaluate if an economically viable resource (i.e., decorative cones and pitch pine seed) was present in the pine plains to help offset

future management costs, since the conventional wood products derived from larger trees were not available.

In Fall 2008, NJFFS installed Gyrotrac fuel breaks in units planned for their prescribed burning program, including parts of the broom crowberry management area. Several fire lines from 16 to 32 feet wide were installed around Sites A, B and C and along roadsides, with guidance on locations from ONLM.

Clearing methods applied by Green Thumb Reforestation involved the use of clearing saws to clear-cut dwarf pines and shrub oaks in the designated management units totaling 18.5 acres. Units included dense broom crowberry areas and surrounding buffers cleared as fuel breaks which had little or no broom crowberry cover. Slash was removed by hand from areas with dense broom crowberry covering about 3 acres, where plants were flagged to alert contractors of sensitive areas closed to mechanized clearing. In surrounding buffers of Sites B and C (about 5 and 6 acres, respectively), slash removal was done by mechanized clearing (i.e. Forcat), but was done by hand in Site A buffers (about 5 acres). The contract encouraged "scarification" within buffer areas, by pushing slash over the ground surface during mechanized removal. Scarification mimics fire by removing leaf litter and low shrub stems, reducing fuel loads and creating sandy openings needed by broom crowberry and other early successional species. In contractor clearings, ONLM staff supervised all clearing activities, flagged broom crowberry concentrations, and assisted with slash removal in Sites A and C. In the 3.1 acres cleared by ONLM, all of which had dense broom crowberry populations, a clearing saw (Stihl FS-450) was used and only hand removal of slash was applied.

The Forcat is a small tracked vehicle with a low (< 2 psi) pressure footprint effective at avoiding soil compaction and associated impacts such as crushing snakes in underground dens. However, broom crowberry plants are sensitive to any crushing, and are highly impacted by scarification, so use of the Forcat within the 3 acres of dense populations was precluded. Protection of extant populations of this state endangered plant was a requirement under NJDEP and Pinelands Commission approvals for this project.

Management approaches were varied in the project area based on the subcontractor's capabilities and constraints by local site conditions, such as the distribution of dense broom crowberry populations, fire threats, road access, and proximity to sites suitable for slash piling/burning. The use of the Forcat to move slash required the availability of sites within or next to the clearing where slash could be piled and safely prescribed burned. Chipping of slash with dispersal of chips into designated non-sensitive areas planned for burning was made an option in the contract, but this management approach was not pursued by the subcontractor. Different areas were cut at different times of the year, providing an opportunity to evaluate season of cut effects.

Site A was viewed as a critical fuel break because of its location along the boundary with fire-prone Warren Grove Range to the west, and the large broom crowberry populations within and east (downwind) of the unit. Creating brush piles within, upwind or downwind of Site A would have reduced control of WGR fires and increased fire risk to downwind populations, so it had to be avoided. Site A had good accessibility from roads and Gyrotrac fuel breaks, which allowed use of standard vehicles to transport slash away from the site. The contractor's Forcat was also unavailable at the time Site A was being cleared. Based on these factors, slash from

most of Site A was moved by hand to road shoulders, loaded in the ONLM pickup truck and transported ½ mile to an abandoned gravel pit within the natural area for future burning. In the 1.25 acre section added to Site A, slash removal was also by hand, but piling was done on site immediately south of the unit perimeter/Gyrotrac fire line, within a pine plains unit planned for prescribed burning. Site A was cut and cleared June 8 – August 10, 2009.

Sites B and C had broom crowberry populations concentrated near the unit center totaling about 1 acre in each, surrounded by 5-6 acres of buffer area in each unit. In both sites, slash was first moved by hand from broom crowberry areas and temporarily piled a few feet away in buffers, after which the Forcat was used to move slash from the entire buffer area and pile it just outside the unit perimeter/Gyrotrac fire line, within pine plains units planned for prescribed burning. Scarification was done in most of the buffer area of Sites B and C during the removal of slash with the Forcat.

Site B was cut and cleared of slash in February-March 2010. Site C was cut in 3 stages in 2009 and 2010. Stage 1 included areas along both shoulders and east of Watering Place Pond Road, and both shoulders of Crossover Road, which were cut in February 2009. The stage 1 area included some broom crowberry sites cut by ONLM in January 2009. Stage 2 included a 2.4 acre broom crowberry site immediately east of the gravel pit, which was cut in March 2009. Stage 3 included the remaining 4.8 acres of broom crowberry patches and buffers of Site C, which was cut in Sept 28- November 2009. Slash removal was finished at Site C in January 2010.

6. SEED BANK and GERMINATION EXPERIMENTS

In our proposal we suggested an experiment with broom crowberry seedbank parameters and some germination experiments. Since this experiment was beyond the scope of work requested by ONLM and due to delays with the NJDEP response with regard to collection permits for rare species, the supplemental seedbank/germination work was abandoned.

RESULTS AND DISCUSSION

1. VEGETATION ANALYSES

We have performed a series of analyses looking primarily at the association of broom crowberry with other common pinelands species, as well as in comparison with a variety of environmental variables (canopy, litter, litter depth, bare soil).

The open canopy of pitch pine (*Pinus rigida*) and shrub oaks (a mix of blackjack oak, *Quercus marilandica,* and scrub oak, *Q. ilicifolia*) has an associated understory of *Vaccinium pallidum* Ait. (lowbush blueberry), *Gaylussacia baccata* (Wang.) K. Koch. (black huckleberry) and *Gaylussacia frondosa*, *Kalmia latifolia* (mountain laurel) and other ericads, such as *Arctostophylos uva-ursi* (bearberry) and *Vaccinium corymbosum* (highbush blueberry). Areas with little or no tree canopy were usually dominated by broom crowberry (*Corema conradii*), sparse grasses (mostly *Schizachyrium scoparium* Nash and *Panicum virgatum* Linn.), and large patches of lichens, mosses and mixtures of the two cryptogams. The lichen mats consisted of a mixture of closely related species including *Cladonia uncialis* (L.) F. H. Wigg., *Cladonia subtenuis* (Abbayes) Mattick, *Cladonia mitis* Sandst. and *Cladonia alpestris* (L.) Nyl. with similar habitat requirements. Moss mats were composed of *Polytrichum juniperinum* Hedw.

Additionally, since the previous research has indicated that the establishment and survival of aforementioned vascular plants is often negatively correlated with the presence of lichens and positively correlated with the presence of mosses, we analyzed the distribution of broom crowberry in relation to these variables. We have performed a principal component analysis (PCA) to discern the overall pattern of vegetation, as well as obtain separation between sites

where crowberry was present and where it was not. In addition, a factorial ANOVA and a series of one-way ANOVA analyses were performed to assess the significance of vegetation factors. All analyses were completed using SAS 9.1. Data were tested for symmetrical distribution and transformed as needed. After completing our quality assurance survey (ten transects were resampled), we used the newly collected data. We note that they were not substantially different from the data originally collected.

Correlation Analysis.

Correlation between Crowberry cover and canopy and other environmental and vegetation variables:

	Canopy	Blueberry	Gaylussacia	Black Huckleberry	Litter	Bare Soil	Lichen	Moss
R^2	-0.262	-0.221	-0.244	-0.216	-0.518	-0.026	0.101	0.048
Prob	<0.0001	<0.0001	<0.0001	<0.0001	<.0001	0.6464	0.0778	0.4046

The above table summarizes correlation coefficients between broom crowberry cover and environmental factors we expected to be important. Canopy and litter as well as ericoid shrubs seem to be the most significant factors affecting crowberry distribution.

Additionally, if we consider the presence of crowberry (as a yes/no variable), it is significantly correlated with lichen cover (R^2= 0.153, $p<0.0001$), and the correlation with ericaceous shrubs is increased to -0.252 for blueberry and -0.284 for Gaylussacia (the summary variable for black and blue huckleberry). The absence of negative correlation with lichen cover is noteworthy (despite the fairly low correlation coefficient) because previous research (Sedia and Ehrenfeld 2003, 2005, 2006) has indicated that many Pine Barrens' vascular plants are

negatively correlated with the presence of lichens. It seems possible that the crowberry and lichens share habitat preferences for open, sunny areas, as well as that lichens can serve as potential competition-free refugia for crowberry plants (Jean Marie Hatrman, Rutgers University, pers. comm.).

The correlation matrix (Table 1) between all the variables seems to largely confirm this overall pattern: blueberry, litter, and canopy are all negatively correlated with crowberry cover, with litter exhibiting the highest correlation coefficient (R^2= -0.57). Surprisingly, however, there seems to be low correlation between crowberry and lichen. It seems that crowberry is not inhibited by lichen mats, which may allow the lichen mats to function as competition-free refugia for crowberry.

Table 1. Correlation Matrix between all measured vegetation variables.

	Canopy	Highbush_ Blueberry	Blueberry	Black_ Huckleberry	Blue_ Huckleberry
Canopy	1.0000	0.2428	-.0555	0.3348	0.1167
Blueberry	0.2428	1.0000	-.0884	0.2797	-.0579
Highbush Blueberry	-.0555	-.0884	1.0000	-.0720	-.0294
Black Huckleberry	0.3348	0.2797	-.0720	1.0000	-.0154
Blue Huckleberry	0.1167	-.0579	-.0294	-.0154	1.0000
Gaylussacia	0.3559	0.2370	-.0782	0.9218	0.3735
Bear Berry	0.1473	0.2658	-.0417	0.1006	0.0475
Hudsonia	-.2737	-.1315	-.0298	-.1830	0.0536
Crowberry	-.2618	-.2208	0.0221	-.2158	-.1138
CrowPresence	-.2271	-.2522	-.0251	-.2767	-.0709
Litter	0.4946	0.3275	-.0007	0.3476	0.1743
Bare Soil	-.3038	-.1770	-.0274	-.2175	-.0423
Lichen	-.2680	-.1502	0.0127	-.1605	-.0838
Moss	-.1773	-.0601	-.0158	-.1502	-.0706
Soil Crust	-.0463	-.0919	0.0084	-.0637	-.0271
Pitch Pine	0.2509	0.0870	-.0194	0.0649	0.0261
Shrub Oak	-.0110	-.0725	-.0009	-.1222	-.0604
Staggerbush	-.0133	-.0404	-.0168	-.0256	-.0273

(Table 1 continued)

	Gaylussacia	Bear_ Berry	Hudsonia	Crowberry	Crow-Presence	Litter	Soil
Canopy	0.3559	0.1473	-.2737	-.2618	-.2271	0.4946	-.3038
Blueberry	0.2370	0.2658	-.1315	-.2208	-.2522	0.3275	-.1770
Highbush_Blueberry	-.0782	-.0417	-.0298	0.0221	-.0251	-.0007	-.0274
Black_Huckleberry	0.9218	0.1006	-.1830	-.2158	-.2767	0.3476	-.2175
Blue_Huckleberry	.3735	0.0475	0.0536	-.1138	-.0709	0.1743	-.0423
Gaylussacia	1.0000	0.1118	-.1490	-.2443	-.2842	0.3901	-.2182
Bear_Berry	0.1118	1.0000	-.0891	-.1039	-.0981	0.1613	-.0835
Hudsonia	-.1490	-.0891	1.0000	0.0242	0.0731	-.1494	0.1541
Crowberry	-.2443	-.1039	0.0242	1.0000	0.5815	-.5178	-.0264
CrowPresence	-.2842	-.0981	0.0731	0.5815	1.0000	-.3412	0.0353
Litter	0.3901	0.1613	-.1494	-.5178	-.3412	1.0000	-.5186
Bare_Soil	-.2182	-.0835	0.1541	-.0264	0.0353	-.5186	1.0000
Lichen	-.1814	-.0828	0.2177	0.1012	0.1530	-.3996	0.0573
Moss	-.1668	-.0446	0.1300	0.0479	0.1043	-.3040	0.0413
Soil_Crust	-.0696	-.0249	0.1059	0.1688	0.1112	-.1410	0.1162
Pitch_Pine	0.0703	-.0710	-.1592	-.0972	-.0356	0.2764	-.1658
Shrub_Oak	-.1367	-.0668	-.0621	-.1097	0.0788	0.0426	-.0488
Staggerbush	-.0344	-.0393	-.0204	-.0025	0.0810	0.0285	-.0229

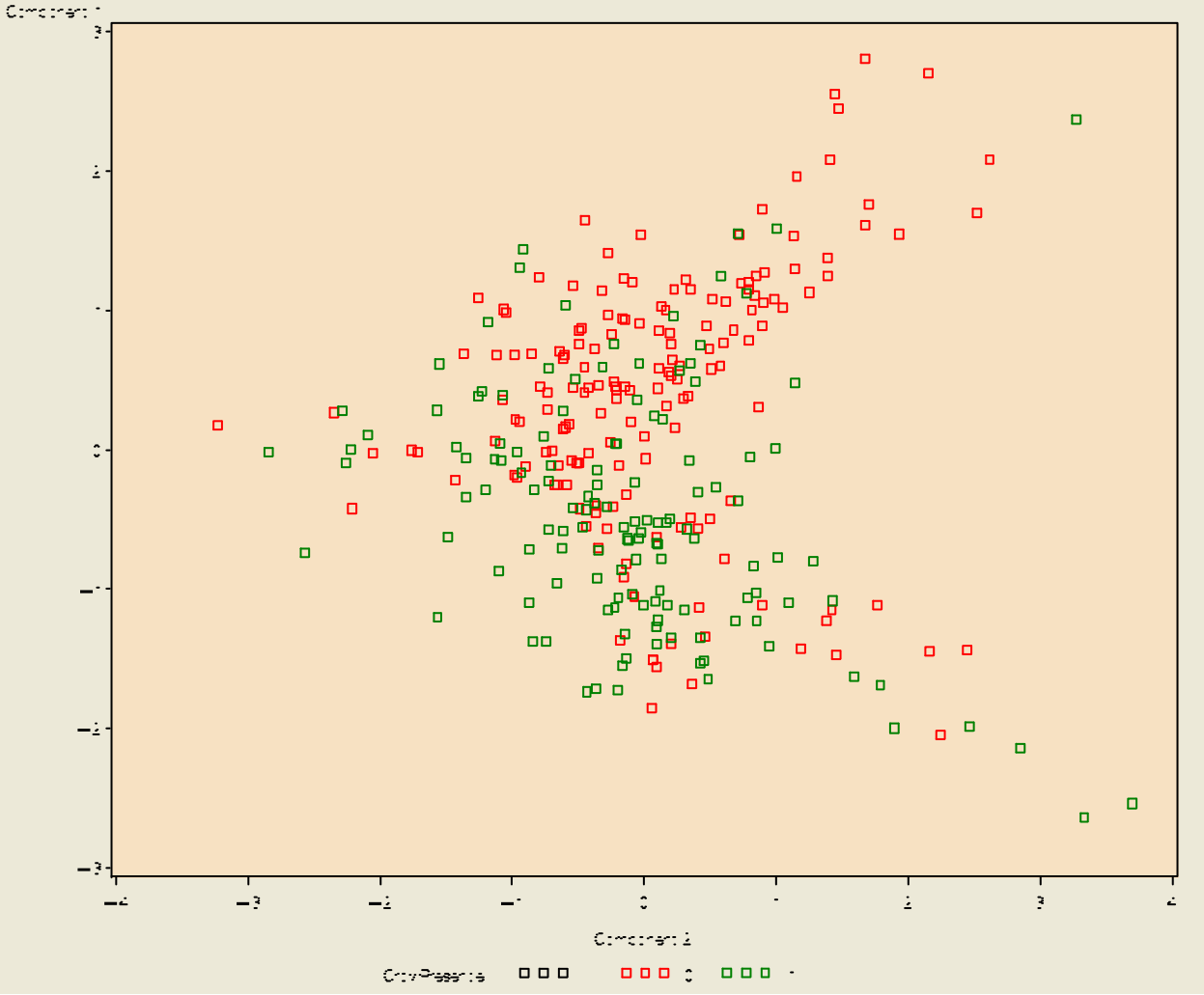
(Table 1 continued)

	Lichen	Moss	Soil_ Crust	Pitch Pine	Shrub_Oak	Staggerbush
Canopy	-.2680	-.1773	-.0463	0.2509	-.0110	-.0133
Blueberry	-.1502	-.0601	-.0919	0.0870	-.0725	-.0404
Highbush_Blueberry	0.0127	-.0158	0.0084	-.0194	-.0009	-.0168
Black_Huckleberry	-.1605	-.1502	-.0637	0.0649	-.1222	-.0256
Blue_Huckleberry	-.0838	-.0706	-.0271	0.0261	-.0604	-.0273
Gaylussacia	-.1814	-.1668	-.0696	0.0703	-.1367	-.0344
Bear_Berry	-.0828	-.0446	-.0249	-.0710	-.0668	-.0393
Hudsonia	0.2177	0.1300	0.1059	-.1592	-.0621	-.0204
Crowberry	0.1012	0.0479	0.1688	-.0972	-.1097	-.0025
CrowPresence	0.1530	0.1043	0.1112	-.0356	0.0788	0.0810
Litter	-.3996	-.3040	-.1410	0.2764	0.0426	0.0285
Bare_Soil	0.0573	0.0413	0.1162	-.1658	-.0488	-.0229
Lichen	1.0000	0.4885	-.0343	-.1300	-.0787	-.0275
Moss	0.4885	1.0000	-.0104	-.0741	-.0307	-.0150
Soil_Crust	-.0343	-.0104	1.0000	-.0860	0.0069	0.0662
Pitch_Pine	-.1300	-.0741	-.0860	1.0000	-.0247	0.0687
Shrub_Oak	-.0787	-.0307	0.0069	-.0247	1.0000	0.0867
Staggerbush	-.0275	-.0150	0.0662	0.0687	0.0867	1.0000

PCA Analysis.

As can be seen from the Figure 1, PCA achieved a very modest success in differentiating between the sites that contain crowberry and those that do not. However, Eigen values (Table 2) indicate that the first PC correlates highly with presence of ericoid shrubs (huckleberry and blueberry), as well as canopy and litter, while being negatively correlated with crowberry, bare soil, moss, and lichen cover. The second PC seems to be mostly positively correlated with lichen and moss, and negatively correlated with trees (shrub oaks and pitch pine). It seems likely that the first PC axis is indicative of litter accumulation and ground cover, while the second indicates shade.

Figure 1 – PCA; green – plots in which crowberry was found; red- sites with no crowberry.



Axis 1 corresponds to the Principal Component 1, and Axis 2 – to Principal Component 2

Table 2. Principal Components and Eigen values.

	Prin1	Prin2	Prin3
Canopy	0.337285	-.136395	0.043851
Blueberry	0.250937	0.104881	-.104630
Highbush_Blueberry	-.034647	-.099544	-.098808
Black_huckleberry	0.353639	0.277811	0.355701
Blue_Huckleberry	0.118633	0.131106	0.128157
Gaylussacia	0.374089	0.308576	0.379695
Bear_Berry	0.135783	0.107112	-.034688
Hudsonia	-.172808	0.271228	-.108188
Crowberry	-.276641	-.173272	0.557041
CrowPresence	-.273186	-.246959	0.414585
Litter	0.410531	-.166128	-.159290
Bare_Soil	-.222028	0.184248	-.132961
Lichen	-.238428	0.398645	-.059214
Moss	-.189379	0.356312	-.121656
Soil_Crust	-.099294	-.076179	0.248557
Pitch_Pine	0.149744	-.284266	-.027932
Shrub_Oak	-.023477	-.329077	-.265946
Staggerbush	-.012400	-.229187	0.022845

Table 3. Factorial ANOVA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	229	60.75279814	0.26529606	1.97	0.0047
Error	43	5.80397842	0.13497624		
Corrected Total	272	66.55677656			

R-Square	Coeff Var	Root MSE	CrowPresence Mean
0.912797	87.21546	0.367391	0.421245

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blueberry	39	2.24532896	0.05757254	0.43	0.9959
Black_huckleberry	49	4.02664678	0.08217646	0.61	0.9532
Bear_Berry	33	5.83465497	0.17680773	1.31	0.2012
Switch_Grass	7	2.24689709	0.32098530	2.38	0.0379
Litter	25	8.52984737	0.34119389	2.53	0.0037
Bare_Soil	16	5.28418339	0.33026146	2.45	0.0100
Lichen	13	2.64194265	0.20322636	1.51	0.1546
Moss	9	1.70782495	0.18975833	1.41	0.2158
Soil_Crust	3	1.27126991	0.42375664	3.14	0.0349
Pitch_Pine	6	0.89113377	0.14852229	1.10	0.3778
Schrub_Oak	10	0.52121137	0.05212114	0.39	0.9459

We used the statistically significant variables in Table 3 for producing an additional factorial ANOVA analysis, in order to determine R^2 for the new model. These results are summarized in Table 4.

Table 4. One-way ANOVAs for significant variables from Table 3. Overall R^2 for the revised model was 0.62.

	F	P
Switch grass	2.80	0.0058
Litter	9.55	<0.0001
Bare soil	3.57	<0.0001
Soil crust	0.99	0.3996

As can be seen from Table 3, the larger model accounts for 91% of presence/absence data for crowberry, while the significant variables alone (Table 4) account for 62 %. Interestingly, litter, bare soil and switch grass are the most significant factors that seem to be contributing to the presence of crowberry. Its presence is positively and significantly influenced by switchgrass and bare soil, while litter continues to be the most significant and negative effect.

These results seem to indicate that the overall distribution of crowberry is influenced by availability of sites – as indicated by low canopy and presence of bare soil free of established trees and shrubs. Presence of canopy and litter is obviously indicative of the sites already colonized by trees, shrubs, or both. On the other hand, grasses and soil crusts appear to indicate open areas. Overall, presence of crowberry appears to be associated with low accumulation of litter, which raises interesting questions about crowberry's own litter deposition: despite being a long-lived shrub, it doesn't seem to accumulate litter at the rate of other shrubs.

What seems apparent from the PCA and factorial ANOVA analyses is that the sites in which crowberry establishes are similar to the sites left by a hot burn – that is, bare sand with no canopy overhanging it and no litter accumulated on the ground. The negative correlation between crowberry and other shrubs appears to indicate competition for available sites, and litter accumulation seems to be playing a role as well – that is, rather than direct competition, ericoid

shrub establishment leads to litter accumulation. In addition, they commonly appear in the understory, under the tree canopy, and as such seem to be tolerant of shading, unlike crowberry.

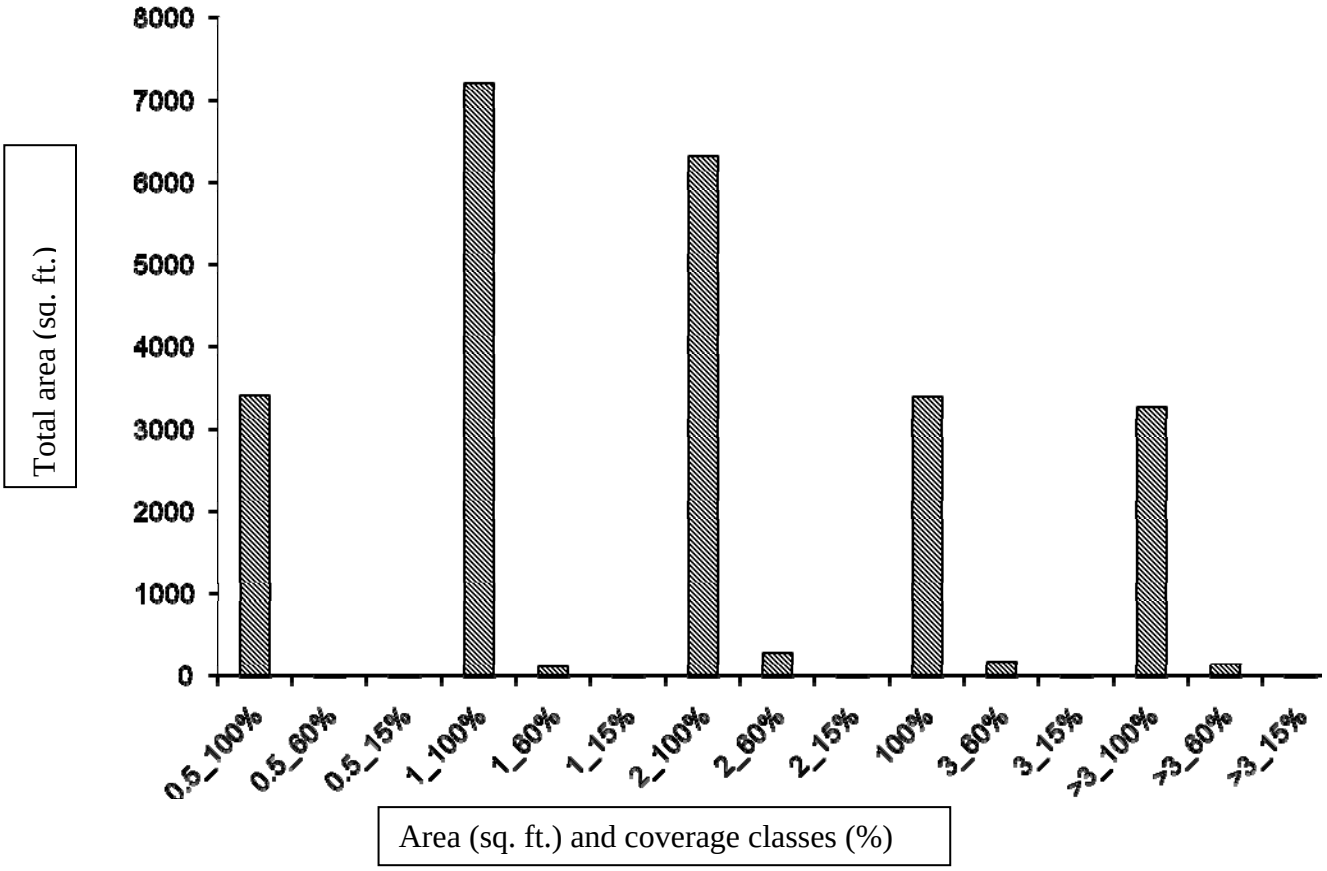
These patterns confirm the need of the open, high sunlight, low canopy cover and low litter cover sites in order for broom crowberry to establish. Such sites are usually created by burns, on which broom crowberry is dependent for its survival. However, based on vegetation data, it appears that removal of competing vegetation and litter using other methods may be appropriate for creating microsites suitable for broom crowberry.

3. BROOM CROWBERRY POPULATION SURVEY

A total of 30,715 cushions of broom crowberry were tallied in study area polygons, with an average of 119 cushions per polygon. This broom crowberry was covering 24,351 square feet (0.56 acres), out of a total polygon area of 187,247 square feet (4.3 acres), for an average of 13.0 percent cover of broom crowberry among all polygons. However, this area also included other vegetation growing within these concentrated broom crowberry populations.

The distribution of size classes is represented in Figure 2 below. The Y axis denotes the total area of broom crowberry in square feet, and X axis denotes cushion diameter size class (first number) and live tissue coverage class (second number).

Figure 2. Distribution of size/coverage classes of crowberry populations.



3. POLYGON MAPPING SURVEYS

Our technicians found new and significant broom crowberry sub-populations as well as some substantive revisions to some of the polygons originally mapped by Windisch (1998) and ONLM and supplied to us as a Geographic Information Systems (GIS) file at the beginning of the project.

There were 259 polygons (which delineated the perimeter of spatial concentrations of broom crowberry cushions) in the original GIS shape file given us in the beginning of the project (see Maps 2 and 3, Appendix 1). Our survey and mapping operations found 54 polygons that either were new (39 not mapped before) or in need of editing (15 needed edits). Of the 15 edited original polygons, four were ‘extensions’ that appended the original polygon area in a significant amount and eleven were ‘revisions’ to existing polygons which changed the general shape of the polygon and increased its spatial accuracy. Most of the ‘revisions’ to existing polygons were done to small circular polygons that Dr. Windisch could not finely draw with the techniques he used to create the original shape file (for example we increased the size of revised polygons from 15 to 200 square feet -an 800% increase). In one case, the polygon extensions appended the previous polygons from 150 to 5300 square feet.

The 39 new polygons and all the rest of the polygons can be found in our “FinalCrowMerge” coverage seen in Maps 2 and 3 (Appendix1) . The FinalCrowMerge coverage metadata (which meets FGDC content standards for digital geospatial metadata) can be found in Appendix 2. Because a few of the original broom crowberry polygons were burned and destroyed in a recent wildfire or succumbed to succession, only the surviving polygons were

measured. Therefore, zeros were recorded for population counts in those ‘empty’ or destroyed polygons.

Our GPS-mapped data have a final base station corrected accuracy of less than 1 meter. However, we did experience a few technical problems with our Trimble units but all problems were corrected.

4. PHOTO MONITORING POINTS

The location of the 67 permanently marked photographic monitoring points can be seen in Map 4 (Appendix 1). Appendix 3 presents an example of the panoramic series taken and the ground cover pictures around each pipe.

5. VEGETATION CLEARING

Extant broom crowberry populations were not impacted by the clearing activities, with nearly all concentrated areas of plants surviving unscathed during the cutting and slash removal process. Thoroughly flagging the broom crowberry concentrations, hand removing the slash and avoiding mechanized removal in these areas was effective at conserving extant populations. Skilled operation of the small and maneuverable Forcat was effective at avoiding the clusters of broom crowberry plants where slash was first moved several feet off of the plants by hand. A few small populations and scattered individual broom crowberry plants were impacted during mechanized slash removal, but the vast majority was untouched.

The clearing activities were effective at a) reducing the extreme fuel loads and fire hazard of the closed-canopy pine plains unburned since 1971, b) restoring a historically open-canopy structure and c) creating broad fuel breaks around several of the major broom crowberry

populations. These broad fuel breaks will greatly reduce the intensity of any fires entering the area, and help to increase the survival of extant broom crowberry populations during wildfires or prescribed burns. The final configuration of Site A was designed to form an L-shaped fuel break on the exposed west and south sides of this broom crowberry mega-population which is still largely unmanaged, fitting up against Range Road and Governors Branch firebreaks which provide some protection from fire on the north and east sides. Additional clearing in the broom crowberry populations and buffers adjacent to Site A are planned.

Scarification by pushing pine plains slash over the ground with the Forcat was only slightly effective at reducing surface fuels where applied in 11 acres of buffer area in Sites B and C. Scarification temporarily reduced live heath brush (mainly black huckleberry) by severing up to half the stems, but many severed stems were only dropped and not removed, and most severed stems were quickly replaced by new sprouts. Surface litter was slightly reduced in thickness in some areas, but was rarely reduced enough to expose mineral soils. Heath rhizomes and humus layers were largely unaffected. Larger commercial applications of scarification during forestry in arborescent pine barrens have been much more effective at reducing all the above surface fuels and exposing mineral soils (such as applied by Robert Williams of Land Dimensions Engineering), since larger heavier bundles of tree logs and slash were being pushed over the ground with larger heavier equipment. The small Forcat appears to lack the size and power to push a slash pile heavy enough to completely scarify a site. Larger equipment capable of pushing larger slash piles over the ground might be more effective at scarifying buffer sites in pine plains, but use of larger, less maneuverable equipment would need to be limited to the outer parts of buffers where no large populations of broom crowberry occur.

Severe but patchy mechanical treatments in buffer areas that remove all vegetation and expose mineral soils may be the most effective means of creating new broom crowberry habitat, and for creating firebreaks that stop or impede the spread of fire into extant major populations which occupy sandy openings (Windisch 1998). Some severe treatment approaches being considered include using maneuverable forestry bulldozers to scrape vegetation and humus layer (containing most heath roots) in 50-100 ft wide patches, as well as to disk, drum-chop, plow or roto-till fire lines. Placing many of these severe treatments near extant populations is considered necessary to facilitate colonization, since broom crowberry appears to have a very limited seed dispersal distance (Windisch 1998). Fire lines which limit fire spread into major broom crowberry openings will facilitate prescribed burning restoration of buffer areas without damage to extant populations. Application of herbicides to eliminate heaths in some patches of cleared buffers may also be tested. Many of these approaches were previously recommended for the next phase of the broom crowberry management plan (Windisch 2007) and approved by the Natural Areas Council. For both economic and ecological reasons, large patches of pine plains without broom crowberry will continue to be managed with prescribed burning using mixed intensity fires, such as the hundreds of acres burned in 2008, 2009 and 2010 in East Plains Natural Area, and the even larger areas burned in Warren Grove Range.

The season of cutting in pine plains may have an effect on basal sprout recovery rates. For parts of Site C which were cut in Fall 2009 (September 28 – November), rates of basal sprouting were close to zero, based on preliminary observations in June 2010. This suggests higher rates of dwarf pitch pine genet mortality in fall cuts. Other sites cut in January through July had much higher percentages of dwarf pine genet basal sprouting. While more formal

research is needed on the possible seasonal effect of cutting on subsequent basal sprouting; timing of the cutting (i.e. fall cuts) might be useful and experiments over multiple years should be pursued to see if there is any seasonal effect.

A number of additional insights were gained in conversations, after this operation, with Robert Williams, consulting forester, and the vendor Green Thumb who have the most experience of anyone in the State on such matters. Green Thumb estimates, if another contract for similar work were to become available, they would have to bid double the price from what the State was charged on this contract (this takes into account their cone and seed sales). Higher competitive bids from contractors could make future operations more expensive. It is therefore a good idea in the future to experiment on a small scale with more cost efficient silvicultural methods that might produce similar ecological outcomes within broom crowberry populations.

With the high cost of clearing operations and the use of Gyrotrac at $410 per hour (source: Jon Klischies, NJ Forest Service), it also makes sense to integrate the use of more cost efficient methods of fuel hazard reduction near broom crowberry populations. For example, more cost efficient approaches are currently being tested by NJDEP staff and volunteers that use smaller, more targeted areas of hand tool clearing, slash removal and litter raking immediately near major broom crowberry populations. These will be ringed by buffers with a network of plowed fire lines, bulldozer scrapes and small controllable prescribed burning units, greatly reducing the amount of hand tool clearing and Gyrotrac use in buffers relative to this project.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This project is very much in its beginning stages – we have established patterns of existing vegetation as well as broom crowberry's populations and the environmental factors their presence is correlated with. For future research, we would recommend establishing a variety of treatments in the cleared area to assess the long-term effects of different silvicultural prescriptions on broom crowberry persistence, and to compare the success of such populations with the populations that experience varied fire frequency. We hope there will be experimentation, on a small scale for now, of other methods to reduce interspecific competition and fuel loads in the hopes of bringing costs down while still enhancing broom crowberry coverage and health. We also suggest exploring the possibility that lichen mats may serve as competition-free refugia for broom crowberry.

RECOMMENDATIONS AND APPLICATION BY NJDEP

This study had established that broom crowberry abundance and presence is strongly and negatively correlated with a number of environmental factors – canopy, litter, and presence of ericoid shrubs, all of which are associated with established vegetation. We hope that the NJDEP will continue work on broom crowberry conservation, and will use this study to inform their future restoration management. We also hope that in the near future studies will be conducted monitoring the survival of broom crowberry colonies in the cleared areas. We also hope that NJDEP will conduct studies looking at the broom crowberry's survival and regeneration under different fire frequency and mechanical disturbance regimes.

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Sedia E.G. and J.G. Ehrenfeld (2005). Soil respiration and potential nitrogen mineralization in lichen-, moss –and grass-dominated areas of the New Jersey Pinelands. Oecologia 144: 137-147.

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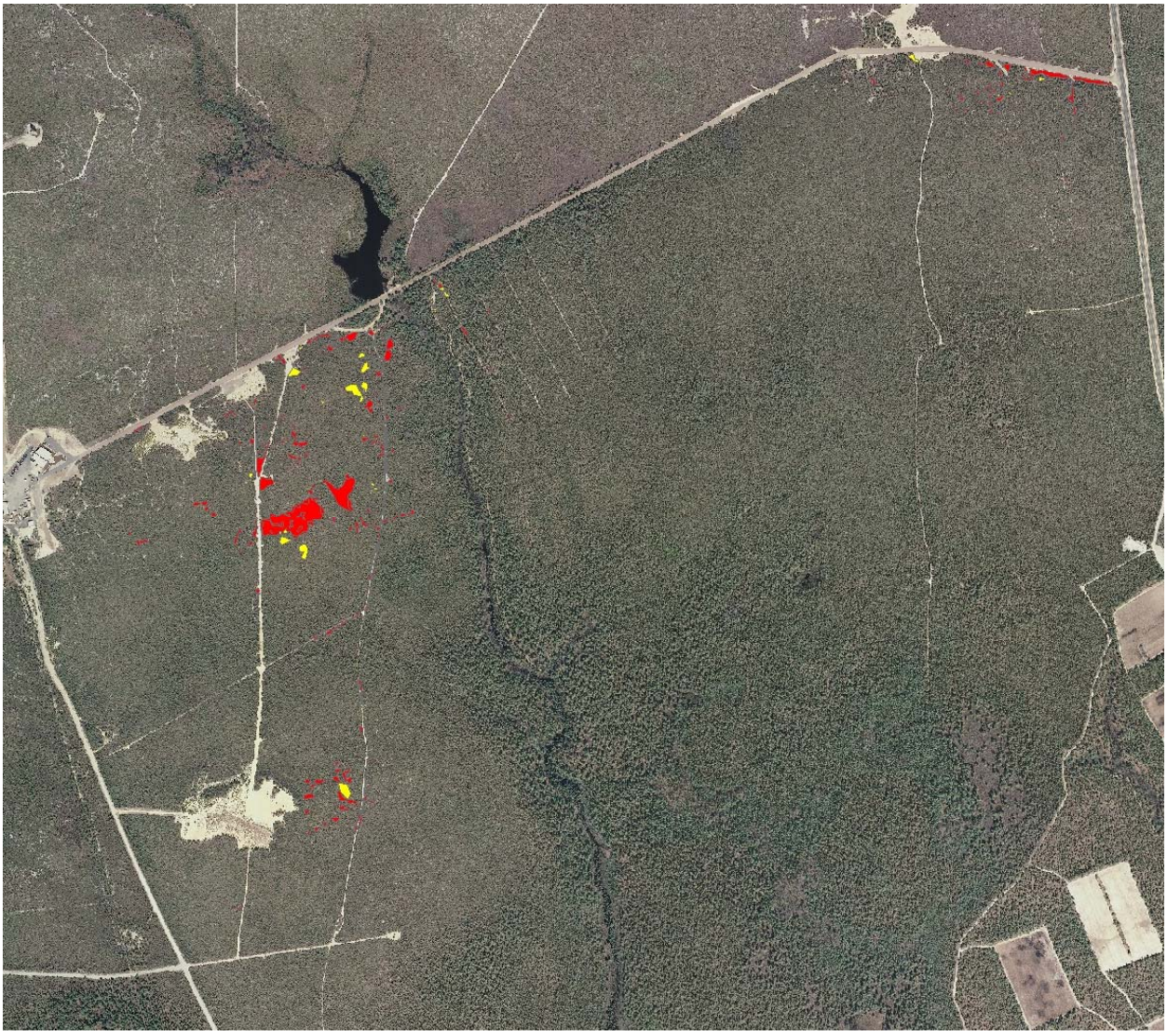
APPENDIX 1

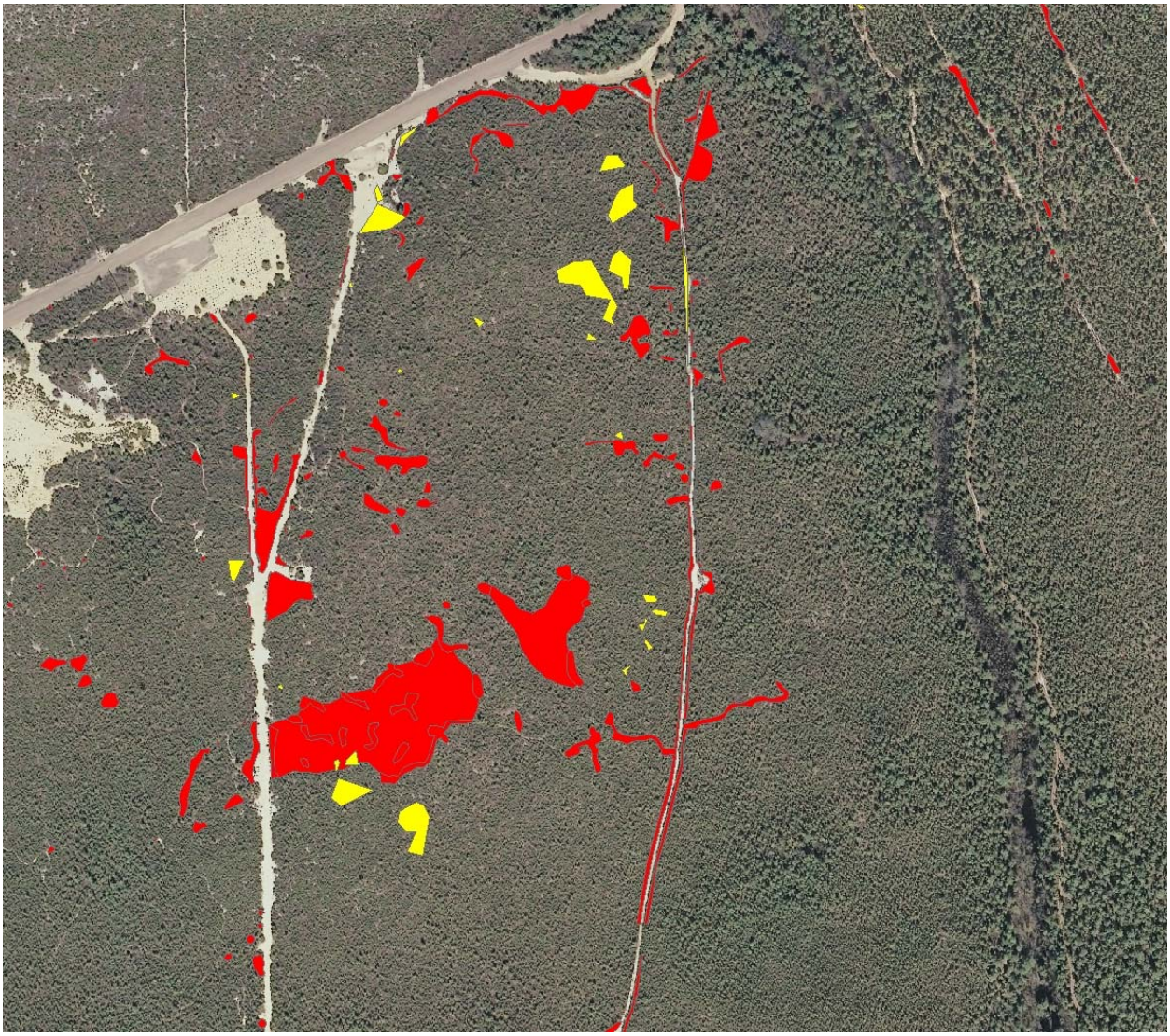
Map of Study Sites and Sample Transects

Map 1: Map of location of vegetation transects (yellow lines) 2008-9.

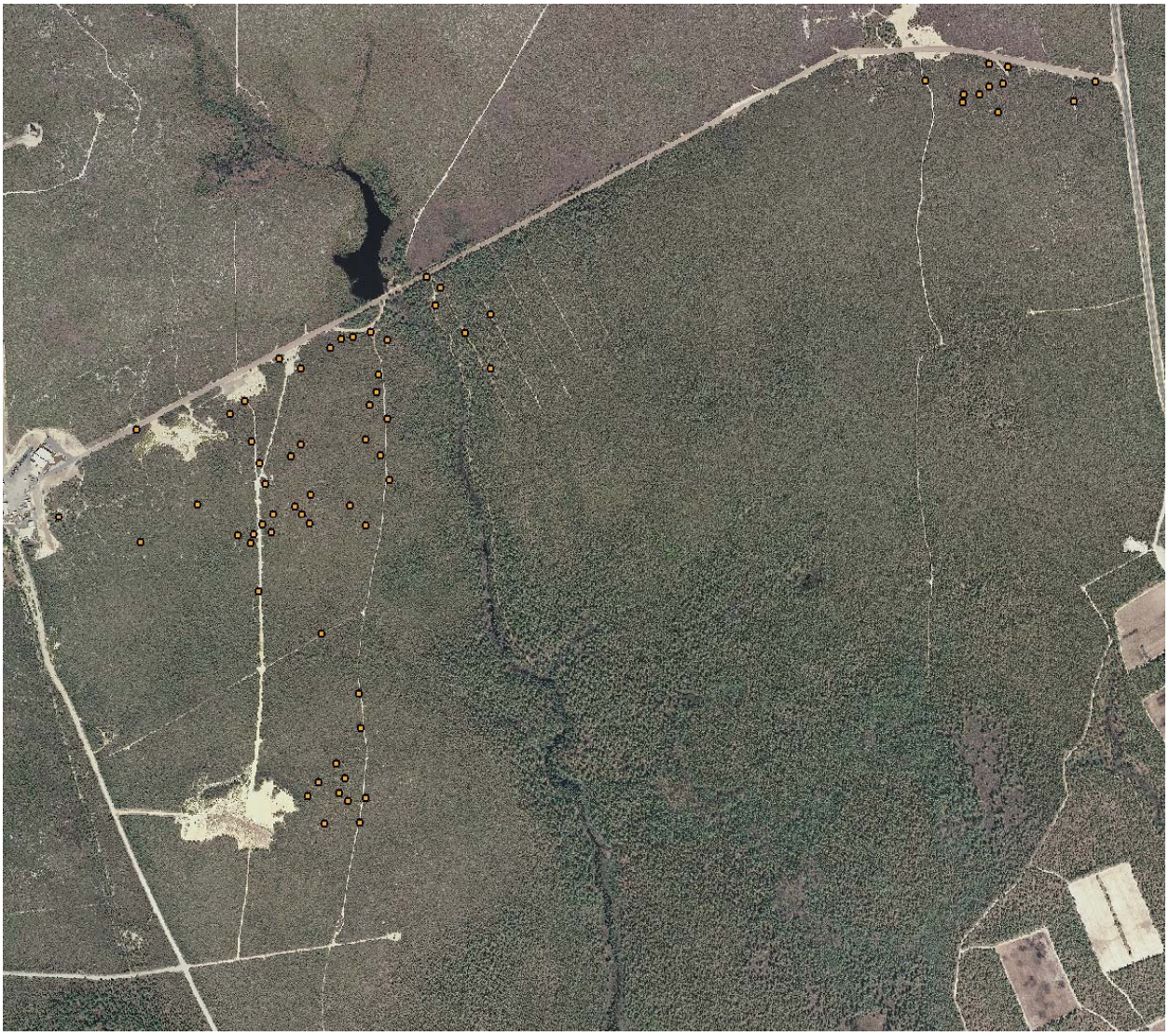
Map 2: Original broom crowberry colonies (red polygons) mapped by Windisch (1998). Revisions and additions during this study are in yellow.



Map 3: A detail showing a portion of the original broom crowberry colonies (red polygons) mapped by Windisch (1998). Revisions and additions during this study are in yellow.



Map 4: Locations (orange circles) for the panoramic photographs and photographs of ground covers done in 2008-9.



APPENDIX 2

GPS MAPPING/GIS METADATA

"FINALCROWMERGE"

Metadata:

Identification_Information:
Citation:
Citation_Information:
Originator: Matthew Ray and Christopher Kunigelis
Publication_Date: Unpublished Material
Title: 1109FinalCrowRSCNJ
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Not Yet Published
Online_Linkage:
\\ac.stockton\root\gisusers\stk29435\Broom_Crowberry\export2\FinalCrowMerge.shp
Description:
Abstract:
Area and spatial information about the extent of growth of broom-crowberry in the New Jersey Pine Barrens.
Purpose:
To create pre-treatment data about the extent of growth of broom crowberry colonies to compare against post-treatment and ongoing evaluations of this rare species' growth patterns. This coverage appends and edits the original Dr. Andrew Windisch coverage of these colonies.
Supplemental_Information:

Use GPS handhelds to plot broom crowberry cushions on an aerial map of their region of growth.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 5/10/2008
Ending_Date: 8/30/2008
Currentness_Reference: Data Collection Time Period
Status:
Progress: Complete
Maintenance_and_Update_Frequency: Weekly
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -75.671175
East_Bounding_Coordinate: -75.671132
North_Bounding_Coordinate: 39.092035
South_Bounding_Coordinate: 39.091967
Keywords:
Theme:
Theme_Keyword_Thesaurus: Library of Congress Subject Headings
Theme_Keyword: Ecology
Theme_Keyword: Ecological Succession
Theme_Keyword: Ecological Surveys
Theme_Keyword: Diversity
Theme_Keyword: Biodiversity
Theme_Keyword: Species Diversity
Theme_Keyword: Endangered Species
Theme_Keyword: Plant Species
Theme_Keyword: Rare Species
Place:
Place_Keyword: New Jersey Dwarf Pine Plains
Place_Keyword: Broom-Crowberry Study Area
Access_Constraints: Query Andy Windisch
Use_Constraints: Restricted to grant and research-related analysis
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Andrew Windisch
Contact_Organization:
New Jersey Department of Environmental Protection, Parks and Forestry
Contact_Position: Office of Natural Lands Management
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 404

City: Trenton
State_or_Province: New Jersey
Postal_Code: 08625
Country: United States of America
Contact_Voice_Telephone: (609) 984-7370
Contact_Electronic_Mail_Address: andrew.windisch@dep.state.nj.us
Data_Set_Credit: George Zimmermann, Matthew Ray, Christopher Kunigelis
Security_Information:
Security_Classification: Restricted
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.2.5.1450

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Attribute values are based on the positional accuracy of GPS points. Sixty points were averaged to create each vertex within a polygon in order to reduce the effect of errors. Polygons were constructed from vertices using the "X-tools" extension for ArcView; this induces insignificant or unknown error during creation of polygons.
Logical_Consistency_Report:
We re-map areas to ensure statistically-significant consistence.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: Accurate to within a meter after postprocessing
Quantitative_Horizontal_Positional_Accuracy_Assessment:
Horizontal_Positional_Accuracy_Value: 0-1
Horizontal_Positional_Accuracy_Explanation:
After postprocessing using the New Jersey Department of Environmental Protection's GPS Station in Trenton, New Jersey (approximately 41 miles from the New Jersey Air National Guard's Warren Grove Consolidated Air-to-Ground Range, our sample site), the accuracy of our GPS points is increased from between 1 and 3 meters to less than 1 meter.
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Trimble Navigation Limited
Publication_Date: September, 2003
Title: GPS Pathfinder Office 3.00
Edition: 3.00
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: <http://www.trimble.com>
Source_Scale_Denominator: None

Type_of_Source_Media: computer program
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: September 2003
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: GPS Pathfinder Office 3.00
Source_Contribution: Trimble Navigation Limited
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Source_Citation:
Citation_Information:
Originator: Environmental Systems Research Institute (ESRI)
Publication_Date: May, 2002
Title: ArcView 3.3
Edition: 3.3
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Online_Linkage: <http://www.esri.com>
Source_Scale_Denominator: None
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Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: May 2002
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: ArcView
Source_Contribution: Environmental Systems Research Institute (ESRI)
Source_Information:
Source_Citation:
Citation_Information:
Originator: Mike Delaune
Publication_Date: September, 2003
Title: "X-tools" Extension for ArcView
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: <http://arcscripts.esri.com/details.asp?dbid=11526>
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Type_of_Source_Media: computer program
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: September 2003
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: "X-tools" Extension for ArcView
Source_Contribution: Mike Delaune
Source_Information:

Source_Citation:
Citation_Information:
Originator: Environmental Systems Research Institute
Publication_Date: August 2006
Title: ArcMap 9.2
Edition: 9.2
Geospatial_Data_Presentation_Form: vector digital data
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Source_Scale_Denominator: None
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Time_Period_Information:
Single_Date/Time:
Calendar_Date: August 2006
Source_Currentness_Reference: publication date
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Source_Contribution: Environmental Systems Research Institution (ESRI)
Source_Information:
Source_Citation:
Citation_Information:
Originator: Environmental Systems Research Institute
Publication_Date: August, 2006
Title: ArcCatalog 9.2
Edition: 9.2
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: <http://www.esri.com>
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: August 2006
Source_Currentness_Reference: publication date
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Process_Description:
We are using a Trimble 2005 series GeoExplorer XM model module and its proprietary TerraSync program. For our mapping needs we take point features, mapping 60 counts per point, set at a PDOP of 6.0, a minimum SNR of 4.0, a minimum elevation of 15 degrees, in the 1983 US State Plane Coordinate System in the New Jersey 2900 zone, using the NAD 1983 Datum, with altitude reference set to Height Above Ellipsoid, and units set as feet rather than meters. GPS points are taken from the portable Trimble units and transferred to GPS Pathfinder Office for postprocessing.
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Process_Date: 5/10/2008 - 8/30/2008
Source_Produced_Citation_Abbreviation: .SSF file
Process_Contact:

Contact_Information:
Contact_Person_Primary:
Contact_Person: George Zimmermann
Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Studies
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States of America
Contact_Voice_Telephone: (609) 652-1776
Contact_Electronic_Mail_Address: zimmerg@stockton.edu
Process_Step:
Process_Description:
These points are brought back for postprocessing, using Trimble's GPS Pathfinder Office software. For differential correction, we change the default settings to use the NJDEP's base station data, with filtering and smoothing within the code processing tab.
Source_Used_Citation_Abbreviation: GPS Pathfinder Office 3.00
Process_Date: 5/10/2008 - 8/30/2008
Source_Produced_Citation_Abbreviation: .cor file
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Contact_Information:
Contact_Person_Primary:
Contact_Person: George Zimmermann
Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Sciences
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States of America
Contact_Voice_Telephone: (609) 652*1776
Contact_Electronic_Mail_Address: zimmerg@stockton.edu
Process_Step:
Process_Description:
After the points are processed they are exported to separate folders for each polygon to be created. The information in these folders is loaded into ArcView, and X-tools is used to process each vertex into a polygon.
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Source_Used_Citation_Abbreviation: "X-Tools" Extension for ArcView

Source_Used_Citation_Abbreviation: GPS Pathfinder Office 3.00
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Contact_Information:
Contact_Person_Primary:
Contact_Person: George Zimmermann
Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Sciences
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States of America
Contact_Voice_Telephone: (609) 652-1776
Contact_Electronic_Mail_Address: zimmerg@stockton.edu
Process_Step:
Process_Description:
The polygons are loaded into ArcMap 9.2 and combined into a single file using the merge tool.
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Process_Date: Completed 11/09/08
Source_Produced_Citation_Abbreviation: ESRI Shapefile
Process_Contact:
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Contact_Person_Primary:
Contact_Person: George Zimmermann
Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Sciences
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States of America
Contact_Voice_Telephone: (609) 652-1776
Contact_Electronic_Mail_Address: zimmerg@stockton.edu
Process_Step:
Process_Description: Metadata created for the shapefile
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Process_Date: Ongoing through 11/09/08

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Contact_Information:
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Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Sciences
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States
Contact_Voice_Telephone: (609) 652-1776
Contact_Electronic_Mail_Address: zimmerg@stockton.edu
Cloud_Cover: Varied

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: G-polygon
Point_and_Vector_Object_Count: 54

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Horizontal_Coordinate_System_Definition:
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State_Plane_Coordinate_System:
SPCS_Zone_Identifier: 2900
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999900
Longitude_of_Central_Meridian: -74.500000
Latitude_of_Projection_Origin: 38.833333
False_Easting: 492125.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
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Entity_Type_Definition: Combination of unique polygons of Broom-Crowberry coverage
Entity_Type_Definition_Source: Matthew Ray and Chris Kunigelis
Attribute:
Attribute_Label: ACRES
Attribute_Definition: Acreage of the Polygon
Attribute_Definition_Source: ArcView
Attribute_Domain_Values:
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
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Attribute_Label: FID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry. (polygon)
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Polygon
Attribute:
Attribute_Label: AREA
Attribute_Definition: Area of the Polygon
Attribute_Definition_Source: ArcView
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
Attribute:
Attribute_Label: POP_INFO
Attribute_Definition: Background information known about Broom Crowberry at that location
Attribute_Definition_Source: Andrew Windisch
Attribute_Value_Accuracy_Information:

Attribute_Measurement_Frequency: As needed
Attribute:
Attribute_Label: ASSOC_SPP
Attribute_Definition: Species associated with the Broom Crowberry population at that location
Attribute_Definition_Source: Andrew Windisch
Attribute_Domain_Values:
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
Attribute:
Attribute_Label: MGT_UNIT
Attribute_Definition: Management unit as assigned by Andrew Windisch
Attribute_Definition_Source: Andrew Windisch
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
Attribute:
Attribute_Label: TEXT_ID
Attribute_Definition: Unofficial or informal ID for use in working with shapefiles only.
Attribute_Definition_Source: Christopher Kunigelis
Attribute_Domain_Values:
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
Attribute:
Attribute_Label: COREMA_ID
Attribute_Definition: Category for assigning official unique ID's
Attribute_Definition_Source: Andrew Windisch
Attribute_Domain_Values:
Attribute_Value_Accuracy_Information:
Attribute_Measurement_Frequency: As needed
Overview_Description:
Entity_and_Attribute_Overview:
This shapefile is a collection of 54 unique polygons representing coverage of Broom-Crowberry. Attributes of this entity include ACRES, FID, SHAPE, AREA, POP_INFO, ASSOC_SPP, MGT_UNIT, COREMA_ID and TEXT_ID
Entity_and_Attribute_Detail_Citation: ACRES represents the acreage of a polygon
Entity_and_Attribute_Detail_Citation: FID is a whole number unique to each polygon generated through merging data.
Entity_and_Attribute_Detail_Citation: SHAPE is the type of shape the data represents; in this case, polygons.
Entity_and_Attribute_Detail_Citation: AREA represents the area of the polygon in square feet
Entity_and_Attribute_Detail_Citation: POP_INFO is known background information about a specific Broom Crowberry population

Entity_and_Attribute_Detail_Citation: ASSOC_SPP is known information about species associated with a specific Broom Crowberry population
Entity_and_Attribute_Detail_Citation: MGT_UNIT is a field for the management unit under which the polygon is located in.
Entity_and_Attribute_Detail_Citation: COREMA_ID is a field for assigning official unique identification numbers.
Entity_and_Attribute_Detail_Citation: TEXT_ID is a field for assigning informal or unofficial unique identification labels in order to better manipulate data in ArcMap.

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Andrew Windisch
Contact_Organization:
New Jersey Department of Environmental Protection, Parks and Forestry
Contact_Position: Office of Natural Lands Management
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 404
City: Trenton
State_or_Province: New Jersey
Postal_Code: 08625
Country: United States of America
Contact_Voice_Telephone: (609) 984-7370
Contact_Electronic_Mail_Address: andrew.windisch@dep.state.nj.us
Resource_Description:
Unique polygons representing Broom-Crowberry coverage within the New Jersey Dwarf Pine Plains
Distribution_Liability:
Distribution privleges granted by Andrew Windisch of the NJDEP, Parks and Forestry Department, Office of Natural Lands Management
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: ESRI Shapefile
Format_Information_Content:
needs the associated .shx .dbf .sbn .xml and .sbx files to work correctly
Transfer_Size: 56.0kb
Ordering_Instructions: Contact Andrew Windisch
Custom_Order_Process:
Contact Andy Windisch at the NJDEP, Parks and Forestry Department, Office of Natural Lands Management

Technical_Prerequisites: Ability to use ArcGIS software

Metadata_Reference_Information:
Metadata_Date: 20081109
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Professor George Zimmermann
Contact_Organization: The Richard Stockton College of New Jersey
Contact_Position: Professor of Environmental Sciences
Contact_Address:
Address_Type: mailing address
Address: P.O. Box 195
City: Pomona
State_or_Province: New Jersey
Postal_Code: 08240
Country: United States of America
Contact_Voice_Telephone: 609-412-2924
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Access_Constraints: Contact Andrew Windisch
Metadata_Use_Constraints: Contact Andrew Windisch
Metadata_Security_Information:
Metadata_Security_Classification_System: Research Purposes Only
Metadata_Security_Classification: Restricted
Metadata_Security_Handling_Description:
Related to research for State of New Jersey Department of Environmental Protection Division of Science, Research and Technology grant number SR08-034, "Implementation and Monitoring of Initial Steps of NJDEP Plan for Protection and Enhancement of Certain Broom Crowberry Populations in South Jersey Dwarf Pine Plains"
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile

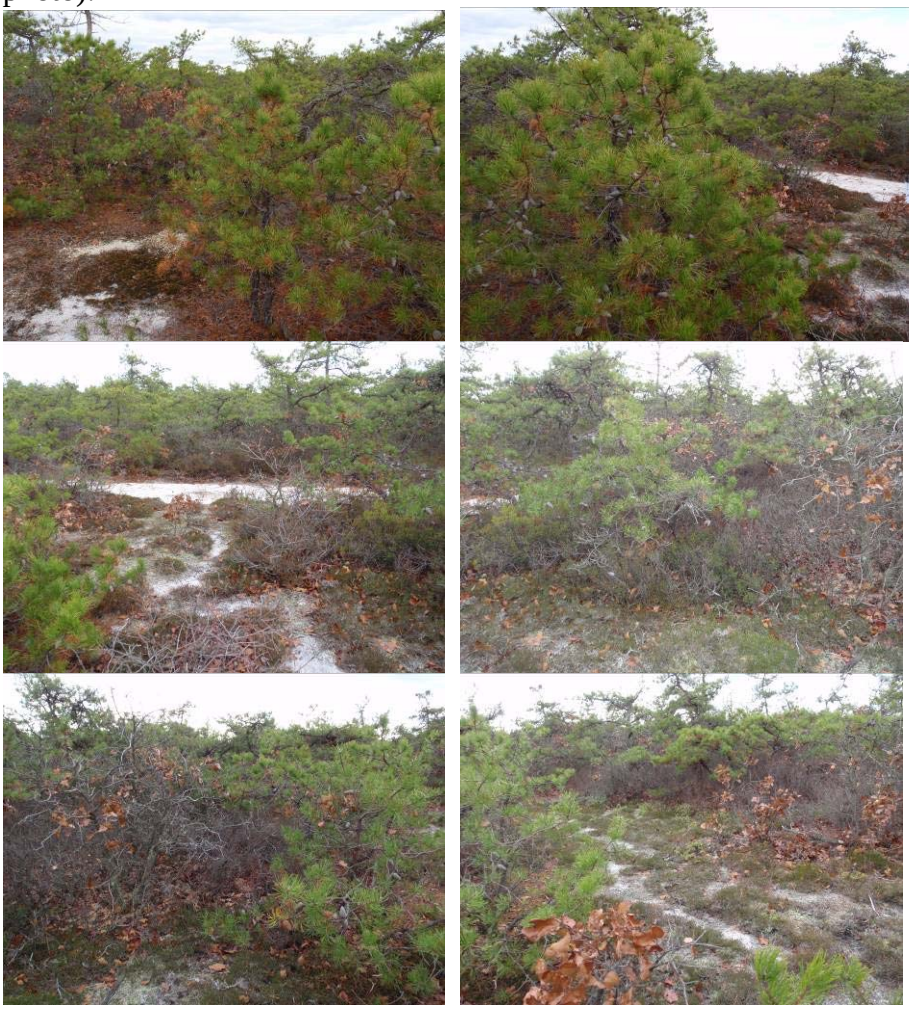
APPENDIX 3

SAMPLE OF PANORAMIC PICTURES TAKEN OF SITE AND GROUND

(POLYGON 145C)

LEFT: picture taken of each metal pipe marking the point for photographs

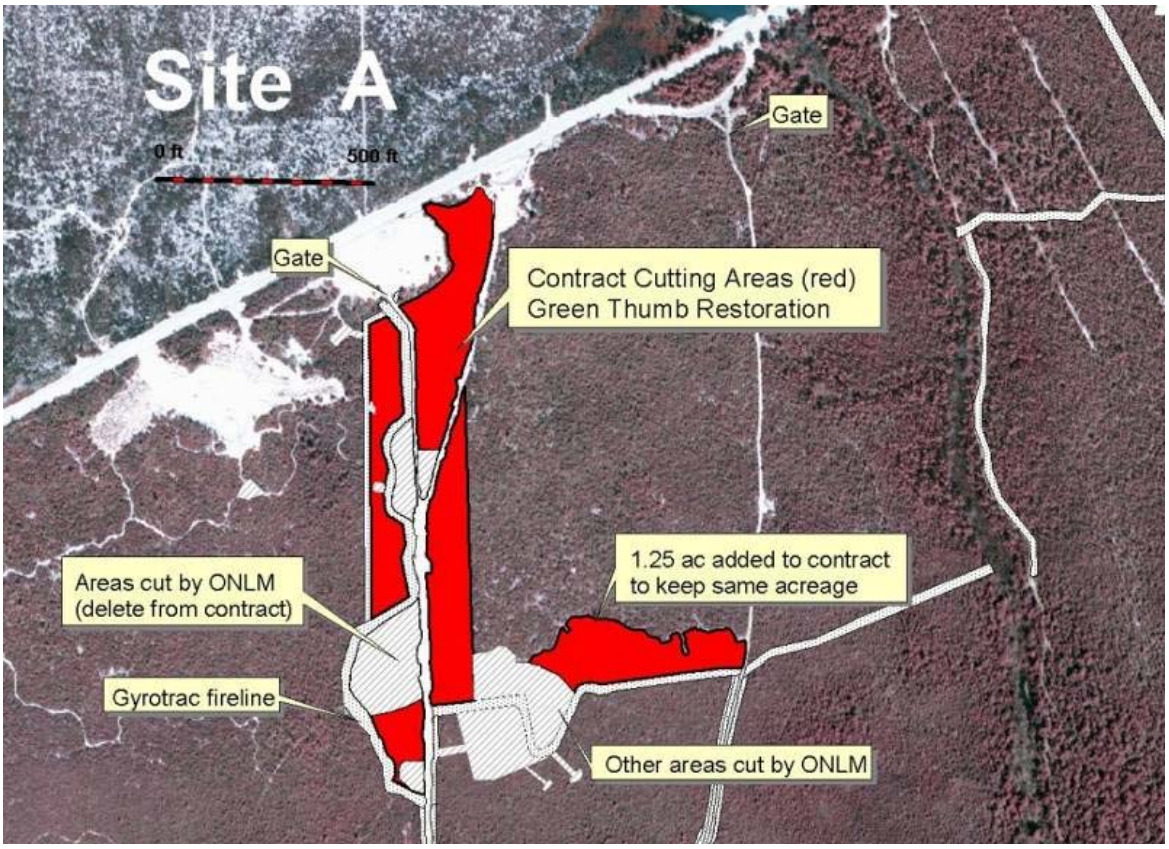
BELOW: starting at approximately true north a series of overlapping pictures (12 total here) were taken clockwise at each point for 360 degrees (approximately 20 to 50% overlap for each photo):

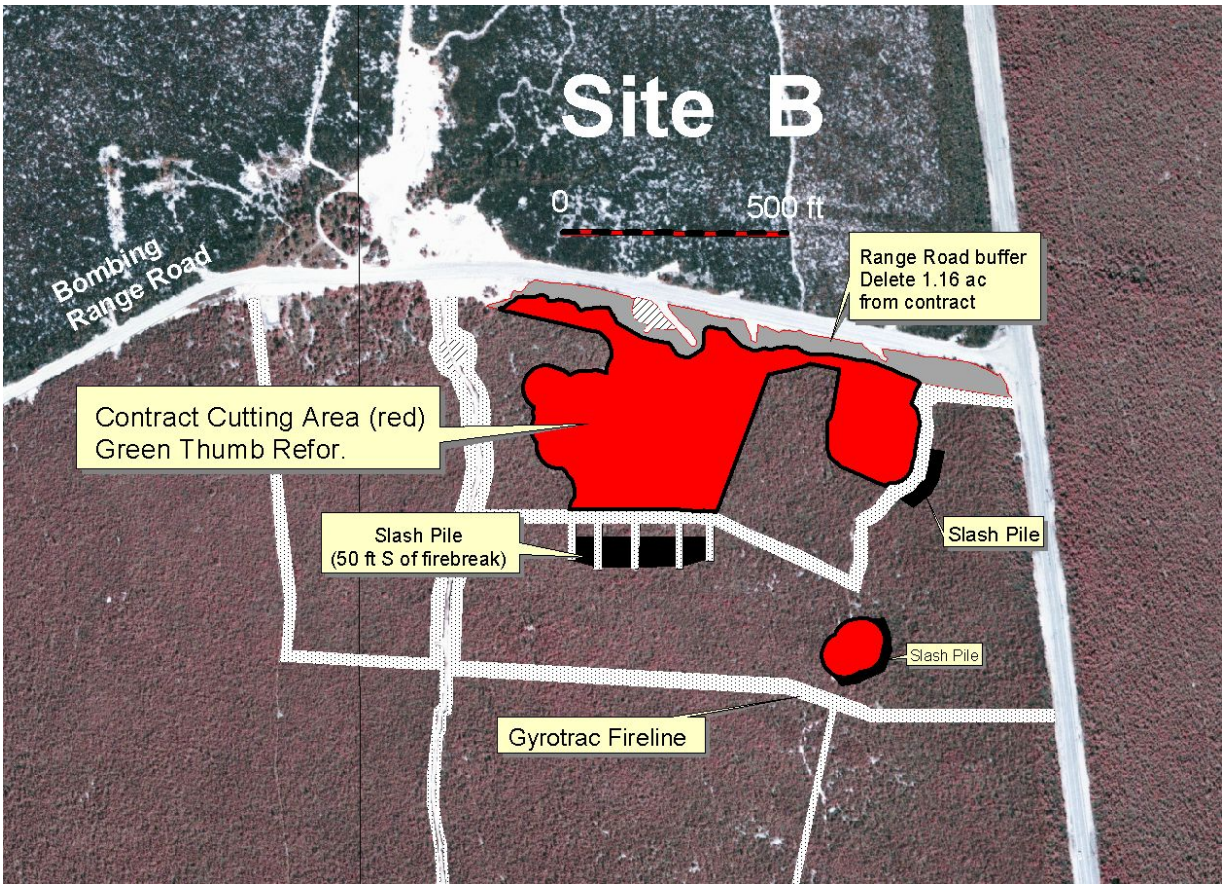


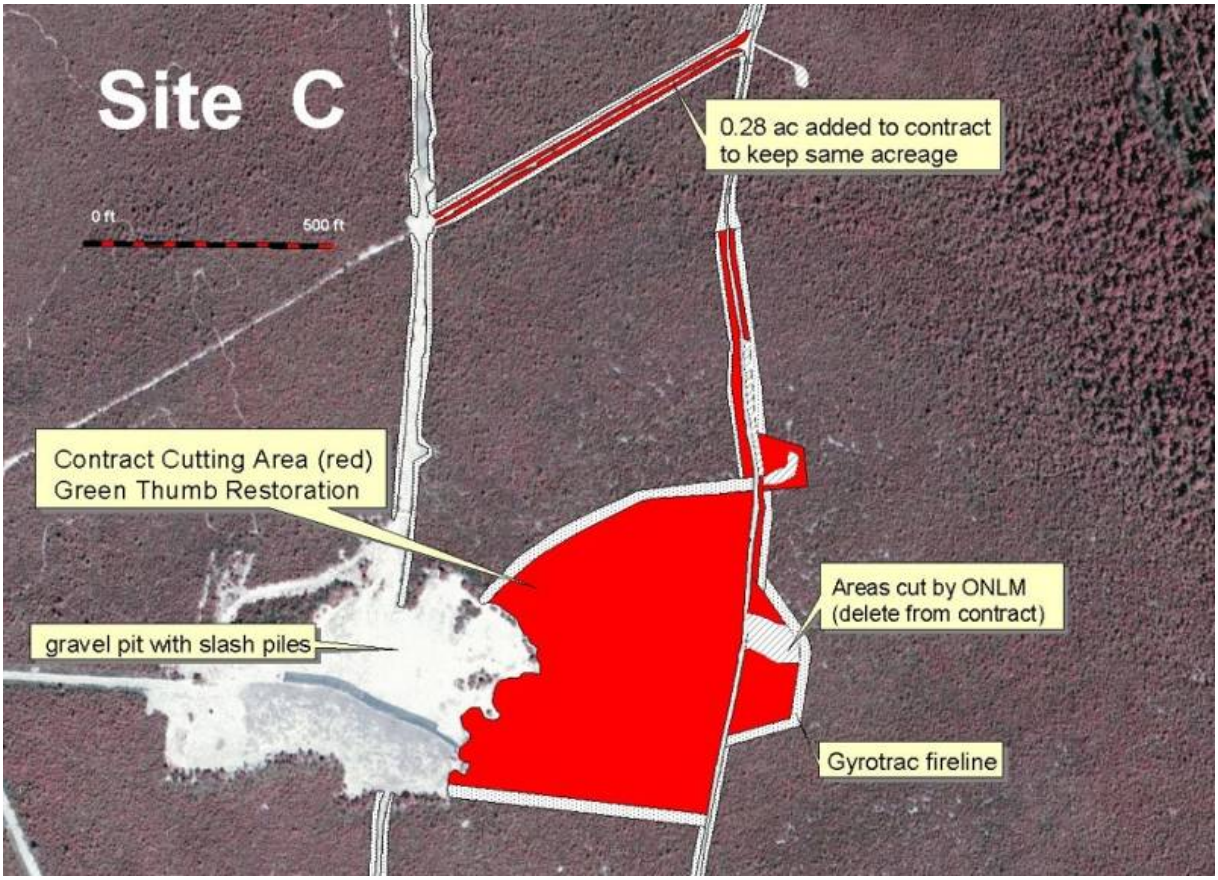
BELOW: four pictures of immediate ground cover surrounding point (metal pipe) taken approximately orthogonal to one another clockwise.

APPENDIX 4

Revised Clearing Sites for Green Thumb Reforestation Contract.




Site B
0
500 ft
Bombing Range Road
Range Road buffer
Delete 1.16 ac
from contract
Contract Cutting Area (red)
Green Thumb Refor.
Slash Pile
(50 ft S of firebreak)
Slash Pile
Slash Pile
Gyrotrac Fireline


Site C
0 ft
500 ft
0.28 ac added to contract
to keep same acreage
Contract Cutting Area (red)
Green Thumb Restoration
Areas cut by ONLM
(delete from contract)
gravel pit with slash piles
Gyrotrac fireline

APPENDIX 5

Additional Analyses

As a quality control procedure, we resampled 10 transects (the transects that are identified as QC in the attached Excel file with vegetation data). As can be seen from Fig. 1, the quality control transects fall well within the overall distribution of the PCA – that is, PCA analysis shows no difference between our original transects and their QC counterparts.

During resampling of the QC transects, however, we have noticed that some of the transects (the transects designated as Middle QC on the Excel datasheets) showed presence of *Gaylussacia frondosa* (blue huckleberry or dangleberry) that was not previously captured in our samples. We have re-run correlation analyses to ensure that our original data were not affected.

The correlation coefficients remained very similar and the significance levels stayed unchanged for both blueberry and black huckleberry (*Gaylussacia baccata*):

	Blueberry	Huckleberry (Gaylussacia baccata)	Blue huckleberry (dangleberry) (Gaylussacia frondosa)	Gaylusaccia
R^2 OLD NEW	-0.220 -0.252	-0.255 -0.277	NA -0.071	NA -0.284

Additionally, the newly mapped *G. frondosa* was shown to not be significantly correlated with any of the variables. However, we added a summary variable, named Gaylussacia – a sum of *G. baccata* and *G. frondosa*, since both species occur in similar areas and constitute a functional group. As can be seen, the correlation coefficient for the summary variable is extremely close to *G. baccata*, and we feel that these two can be used interchangeably.