Office of Science
Research Project Summary
January 2011

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

***Authors***
George Zimmermann and Ekaterina Sedia[1], Andrew Windisch[2], and Joseph Bilinski[3]

***Abstract***

Baseline monitoring data was collected by Richard Stockton State College and the NJDEP Division of Parks and Forestry for use in the initiation of ecological forestry / fire hazard reduction management to conserve extant populations of the state endangered plant broom crowberry (*Corema conradii*), and to 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 ($R^2$ = -0.518, $p < 0.0001$), canopy ($R^2$ = -0.262, $p < 0.0001$), and ericoid shrubs ($R^2$ = -0.284, $p < 0.0001$); 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 vegetation in a burned area regenerates. The results also seem to suggest that clear-cutting and litter removal would reduce the factors with which broom crowberry is negatively correlated.

## Introduction

The need for increased management and implementation of South Jersey's forests, particularly areas home to 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 adapted to more frequent mixed-intensity fires. This decrease in fire frequency, coupled with an insufficient amount of prescribed burns and/or management to simulate post-fire structures and reduction in fuel loads, has lead to extreme fires too hot for many species to tolerate. The biomass buildups increase the 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 consume the humus horizon, and thus do not produce large openings of mineral soil (Boerner 1981) required for broom crowberry establishment. Scientists within the NJDEP Office of Natural Lands Management (ONLM) have studied dwarf pine plains fire ecology and disturbance history for a number of years. ONLM's analysis of historical records and aerial photos, as well as on-the-ground broom crowberry surveys and ecological management planning for state lands have lead to a proposal for the protection and restoration of some broom crowberry populations located within

East Plains Natural Area and West Plains Natural Area (Windisch 2007).

## Methods

*Vegetation Sampling And Analysis*
Measurements were taken of the vegetative growth closely associated with broom crowberry by plotting 30-meter line transects both in and outside of established polygons of crowberry. Square-meter plots were drawn 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; points were edited to lines rather than area classes in *ArcView.* A total of 30 transects, 15 in the crowberry-dominated areas (IN) and 15 in the surrounding forest matrix (OUT), were established and analyzed using Preliminary Principal Component Analysis (PCA) to achieve good separation between IN and OUT transects.

The number of stems of shrubs and forbs within the plots were counted, and the percent cover was determined for lichen, moss, bare soil, litter, crowberry, bear berry and grasses (Sedia and Ehrenfeld, 2005). Oak and pine stems were also counted if present within each quadrat. Litter depth was measured in three random places within each quadrat and recorded to average depth in inches. Canopy cover was determined for each quadrat as percent coverage by the branches and leaves directly above the plot based on visual estimate. 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.

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

*Broom Crowberry Population Survey*
Consistent with the methodology of the New Jersey Natural Heritage Program and Windisch (1998), broom crowberry population size was estimated by counts of "cushions". "Cushions", defined as roughly circular, more or less discrete patches of broom crowberry vegetation, were tallied into 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, respectively), 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 was used to estimate the average percent cover of broom crowberry in the study area polygons.

*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. New polygons, not found on the original map, were also mapped.

*Photo Monitoring Points*
Randomly selected photo monitoring points (i.e. 67) were serially photographed in panorama (12 photos with overlaps of about 20% starting north and going clockwise – See Appendix 3, Final Report), then four photographs of the ground cover taken around each compass point (West, North, East, and South). Each point was permanently marked with a metal fire-resistant pipe engraved with the polygon identification number and photographed. Photos were taken with an Olympus 1040SW camera from the summer of 2008 through March 2010.

*Vegetation Clearing*
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 (see Appendix 4, Final Report). Clearing activities occurred 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.

In Fall 2008, NJFFS installed Gyrotrac fuel breaks in units planned for the 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 ONLM guidance on locations.

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. ONLM staff supervised all clearing activities, flagged broom crowberry concentrations, and assisted with slash removal in Sites A and C. Different areas were cut at different times of the year, providing an opportunity to evaluate season of cut effects.

## Results and Discussion

*Vegetation Analyses*

Analyses were performed 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). Since previous research (Sedia and Ehrenfeld, 2005) 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. A principal component analysis (PCA) was performed to discern the overall pattern of vegetation, as well as obtain separation between sites for crowberry presence and absence. In addition, a factorial ANOVA and a series of one-way ANOVA analyses were performed to assess the significance of vegetation factors. 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.

Canopy and litter as well as ericoid shrubs seem to be the most significant factors affecting crowberry distribution. From Table 1, if the presence of crowberry is considered (as a yes/no variable), it is found to be 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) since 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 lichens can serve as potential competition-free refugia for crowberry plants (Jean Marie Hartman, Rutgers University, pers. comm.).

**Table 1. Correlation between crowberry cover and canopy and other environmental and vegetation variables**

| | Canopy | Blueberry | Gaylussacia | Black huckleberry | Litter | Bare Soil | Lichen | Moss |
|---|---|---|---|---|---|---|---|---|
| R2 | -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 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 in turn allow the lichen mats to promote crowberry establishment.

### PCA Analysis

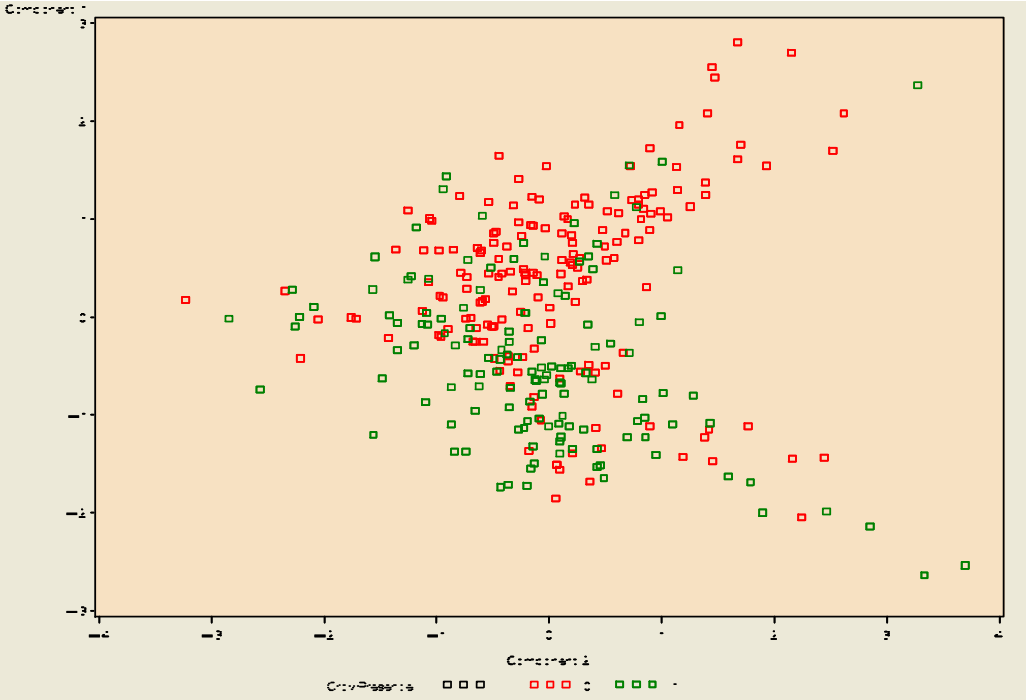
PCA achieved some modest success in differentiating between the sites that contain crowberry and those that do not (Figure 1, located on page 4). However, Eigen values indicate that the first PC correlates highly with presence of ericoid shrubs (huckleberry and blueberry), as well as canopy and litter, while being negatively correlated with crowberry, bare soil, moss, and lichen cover. The second PC seems to be 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.

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

**Table 2. One-way ANOVAs for significant variables. Overall R2 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 |

**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).**



These results seem to suggest that the overall distribution of crowberry is influenced by availability of sites, indicated by low canopy and presence of bare soil. Litter, bare soil and switch grass appear to be the most significant factors contributing to the presence of crowberry. Overall, presence of crowberry appears to be associated with low accumulation of litter. The patterns observed confirm the need of open area, high sunlight, low canopy cover and low litter cover sites in order for broom crowberry to establish, sites usually created by burns. However, based on the vegetation data, removal of competing vegetation and litter using other methods may be appropriate for creating microsites suitable for broom crowberry.

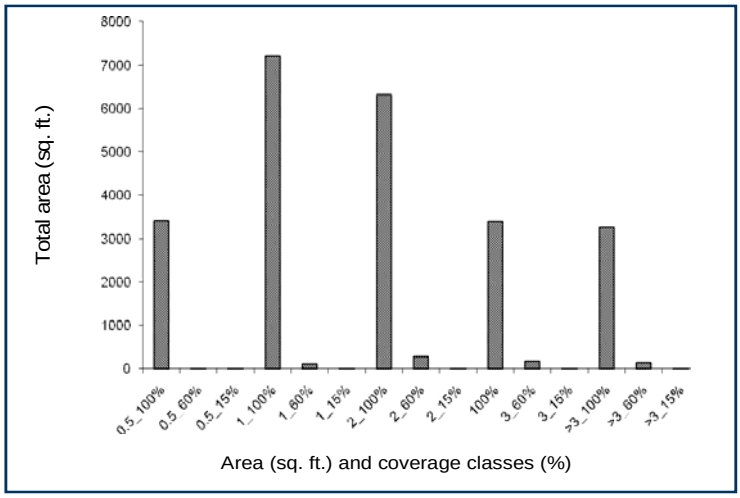
*Broom Crowberry Population Survey*

A total of 30,715 cushions of broom crowberry were tallied in study area polygons, with an average of 119 cushions per polygon. The distribution of size classes is represented in Figure 2. The Y axis denotes the total area of broom crowberry in square feet, and the X axis denotes cushion diameter size class in feet (first number) and percent live tissue coverage class (second number).

*Polygon Mapping Surveys*

New and significant broom crowberry sub-populations were discovered as well as some substantive revisions to some of the polygons originally mapped by Windisch (1998) and ONLM (i.e. 259) (see Maps 2 and 3, Final Report). The survey found 54 polygons

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




that either were new (39 not mapped before) or in need of editing (i.e. 15). 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.

*Vegetation Clearing*

Extant broom crowberry populations were not impacted by the clearing activities, with nearly all concentrated areas of plants surviving during the cutting and slash removal process. A few small populations and scattered individual plants were impacted during mechanized slash removal, but the vast majority were untouched.

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 major broom crowberry populations.

Scarification by pushing pine slash over the ground with the Forcat was only slightly effective at reducing surface fuels. Scarification temporarily reduced live heath brush (mainly black huckleberry) by severing up to half the stems. However, many severed stems were only dropped and not removed, and most 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.

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 (Windisch 1998). Placing 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. 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.

## Conclusions and Recommendations

The broom crowberry monitoring project has been successful in establishing present patterns of broom crowberry populations within the southern New Jersey pine forests, in addition to verifying the locations and sizes of known populations and the discovery of new groupings. The study has also established patterns of existing vegetation within crowberry habitat, and the environmental factors their presence is correlated (both strongly and negatively), specifically canopy, litter, and presence of ericoid shrubs. Data gaps with respect to broom crowberry coverage were filled as one of the main objectives of this project, adding to the existing NJDEP GIS database on this species in the study area (i.e. East Plains Natural Area, Stafford Forge, and Warren Grove Range). Approaches for maximizing cost efficiency were tested by NJDEP staff and volunteers in the immediate vicinity of major broom crowberry populations. Areas of disturbance (i.e. open soils, open canopy, sparse shrub/scrub competitors, etc.) are crucial for the establishment of broom crowberry, thus clearing of existing and aggressive vegetation is often necessary for proliferation. Methods such as handtool clearing, slash removal and litter raking immediately near major broom crowberry populations and buffers can be employed, along with bulldozer scrapes and small controllable prescribed burning units, which can reduce the need for costly mechanized (e.g. Gyrotrac) methods. With respect to the logistics of broom crowberry habitat management, the most cost effective approaches with minimized impact still need to be ascertained.

Recommendations for future research and study should focus on monitoring the survival of broom crowberry colonies in the cleared areas (manual disturbance and fire clearing), in addition to management techniques that favor broom crowberry establishment and proliferation. Forestry management techniques involving alternations between manual (e.g. hand tools) vs. mechanized (e.g. bulldozer, Gyrotrac, etc.) habitat manipulation should be explored with effects in the short and long terms. Consideration should specifically be given with respect to which technique, or combination thereof, results in the successful establishment of broom crowberry, causes the least impact to the affected habitat, and lastly the most cost effective. The practice of prescribed burns with differing degrees of applied intensity and frequency should also be examined both in the short and long term, although the investigators agree that intense fires have an overall negative impact on the species. Furthermore, the principal investigators recommend establishing a variety of treatments in cleared areas 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. The role of lichen mats in providing competition-free refugia for broom crowberry, as well as other species-crowberry interactions, should also be examined in future studies.


### Funding

This project was funded by the NJDEP Office of Science under contract number SR08-034.



### Prepared By

[1]George Zimmermann and Ekaterina Sedia (Richard Stockton College of New Jersey); [2]Andrew Windisch (NJDEP – Office of Natural Lands Management) and [31]Joseph Bilinski (NJDEP - Office of Science)

### Principal Investigators

George Zimmermann and Ekaterina Sedia (Richard Stockton College of New Jersey), and Andrew Windisch (NJDEP – Office of Natural Lands Management)

## *RESEARCH PROJECT SUMMARY*

Please send comments or requests to:
Office of Science
Mail code 428-01, P.O. Box 420
Trenton, NJ 0862

Phone: 609 984-6070
Visit the DSRT web site @ www.state.nj.us/dep/dsr

**Office of Science**
*Dr. Gary Buchanan, Manager*

**STATE OF NEW JERSEY**
*Chris Christie, Governor*

**Department of Environmental Protection**
*Bob Martin, Commissioner*