Progress Report

October 1, 2006

Population Viability Analysis of Eastern Prairie Fringed Orchid, Pitcher's Thistle and Savanna Blazing Star

Grant Agreement Number: 06-004W

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Time-frame of the report

The grant agreement commenced on July 1, 2005. The original termination date was June 30, 2006.

Grantee Representative completing the report:

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Project Objectives:

1) Learn state-of-the-art approaches to population viability analysis, including individual-based modeling, mark-recapture modeling and spatially explicit modeling.
2) Apply these advanced techniques to over ten years of demographic data for populations of Eastern Prairie Fringed Orchid (EPFO), Pitcher's Thistle (PT), and the Illinois threatened Savanna Blazing Star (SBS).
3) Prepare reports and publications to disseminate the results and management recommendations.

Project Description:

For over a decade, volunteers, researchers and conservation professionals have collected demographic data for populations of the federal threatened Eastern Prairie Fringed Orchid (*Platanthera leucophaea*), Pitcher's Thistle (*Cirsium pitcheri*) and the Illinois threatened Savanna Blazing Star (*Liatris scariosa* var. *nieuwlandii*). These data were principally collected in nature preserves and other public lands throughout Northern Illinois. Because the demographic data was collected in areas differing in burn treatments (*P. leucophaea*), disturbance (*C. pitcheri*) and grass competition (*L. scariosa*), this is a unique and valuable data set which can be used to assess population viability as well as provide information useful for managing these species. Unfortunately, a thorough analysis of this data has yet to be achieved for these populations, largely because I have a heavy teaching load at Chicago State University (CSU), and therefore have not had the time to do so.

I propose to use my sabbatical leave from CSU, starting in August 2005, to learn advanced methods in population viability analysis (PVA), analyze this demographic data and provide management

recommendations for these species. CSU provides a semester of sabbatical leave at full salary or two semesters at half salary. A single semester is too short for complete analysis of all three species. I am therefore seeking funds from a variety of federal, state and local sources to match my CSU salary so I can devote two semesters to this project.

Because the effectiveness of PVA analysis is improved by using advanced PVA methods, I will enhance the usefulness of this analysis by spending three months at Archbold Biological Station in Florida and learning state-of-the-art PVA methods from Eric Menges, the leading expert on plant demographic analysis. The remaining time will be used to apply these analytical methods to the demographic data and preparing reports and publications to disseminate the results and management recommendations.

Summary of Project Accomplishments:

Introduction

The ultimate objective of listing species as endangered or threatened is for them to recover sufficiently, through a combination of management and new population introductions, so that they can be removed form the list. Recovery targets are typically based on reaching a minimum number of viable populations. But, how do we know when a natural or introduced population can be considered viable? Population viability analysis (PVA) is a popular method (or rather suite of methods) for addressing this question.

For over a decade, volunteers, researchers and conservation professionals have collected demographic data for populations of the federal threatened Eastern Prairie Fringed Orchid (*Platanthera leucophaea*), Pitcher's Thistle (*Cirsium pitcheri*) and the Illinois threatened Savanna Blazing Star (*Liatris scariosa* var. *nieuwlandii*). These data were principally collected in nature preserves and other public lands throughout Northern Illinois. Because the demographic data was collected in areas differing in burn treatments (*P. leucophaea*), disturbance (*C. pitcheri*) and grass competition (*L. scariosa*), this is a unique and valuable data set which can be used to assess population viability as well as provide information useful for managing these species.

During my sabbatical leave from Chicago State University (CSU), from August 2005 to August 2006, I intended to learn advanced PVA methods and apply these methods to analyze this demographic data and provide management recommendations for these three species. I accomplished the first part of this project and completed analyses for Pitcher's Thistle. The analyses for Eastern Prairie Fringed Orchid and Savanna Blazing Star are not complete, however.

I visited the Archbold Biological Station Plant Ecology Lab for three nonconsecutive months: in October 2005, February 2006 & May/June 2006. During those visits I interacted with Eric Menges and members of his lab, as well as with Pedro Quintana-Ascencio, a former post doc in the Menges lab and currently a member of the faculty at Central Florida University, Orlando, FL. When not at the Archbold Biological Station, I worked in the Plant Conservation lab of Marlin Bowles at the Morton Arboretum where I am a Research Associate.

During this period, I applied new analytical techniques to the demographic data for Pitcher's Thistle, including survival analysis, spatial analysis, and tests for autocorrelation. The results of these analyses were presented at annual meetings of both the Botanical Society of America and the Ecological Society of America.

Materials & Methods

Cirsium pitcheri

Pitcher's Thistle was reintroduced at Illinois Beach State Park over a period of 10 years beginning in 1991 where a former population was extirpated in the 1930s. One subpopulation occurs in a section of the park that is highly disturbed by foot traffic and the other occurs in a less disturbed nature preserve. Individual transplants and their descendants were marked and monitored yearly for survival, growth and reproduction. Multiple regression and logistic regression were used to determine the relative effect of weather, microhabitat and location on vital rates of transplants and natural recruits, Survival analysis was used to compare transplants and natural recruits with respect to survival time and time to flower, as well as the effect of microhabitat and location. With assistance of Pedro Quintana-Ascencio, a Maloney algorithm was written for MatLab software and used to determine the appropriate size classes to be used in population projection matrices.

Originally, the location of individuals was mapped relative to transects or plot center stakes. Beginning in 2003, the location of individual plants, transect markers and plot center stakes were determined using global position system (GPS). Subsequently, the mapped locations of all individuals from 1991 to 2005 were converted to GPS coordinates. The Mantel test and other spatial analyses were used to investigate the effect of plant density on fecundity and the correlation between transplant number and subpopulation persistence.

Platanthera leucophaea

Demographic data has previously been collected, under permit, by volunteers from more than fifteen populations of Eastern Prairie Fringed Orchid through a project funded by the US Fish & Wildlife Service and coordinated by The Nature Conservancy. Management histories, such as burning and brush clearing, as well as hand pollination treatments, are also available for these sites, and in many cases linked directly to the demographic data.

Starting in 2000, I visited most Illinois populations. During summer 2006, I visited many Eastern Prairie Fringed Orchid populations in Iowa, Ohio, Maine, Michigan and Wisconsin in the company of the people responsible for monitoring the population. During these visits, I compiled information on site history, population viability, habitat quality, and management issues. This information will be used in combination with demographic monitoring data to develop PVA analyses and compare effects of management practices on population persistence.

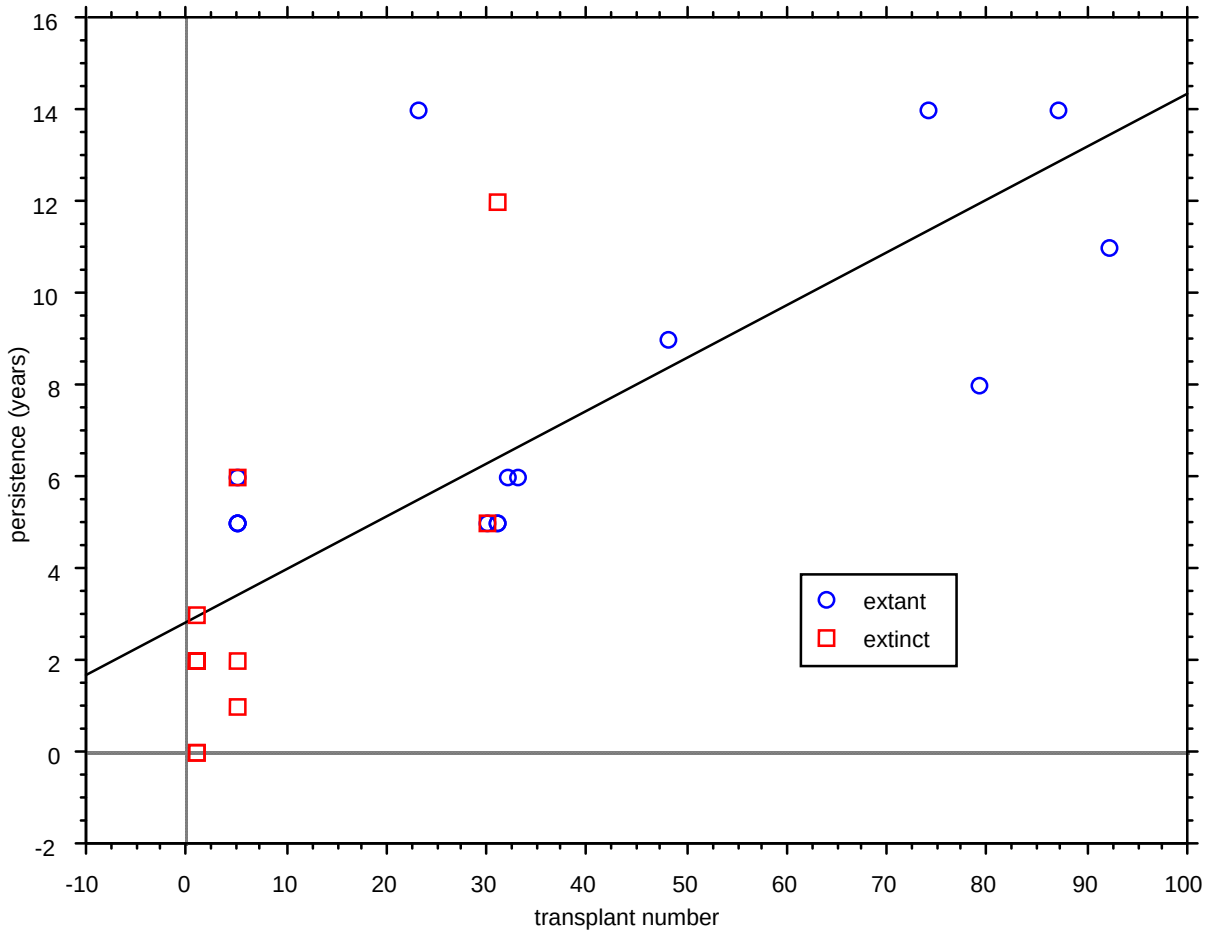
In order to determine whether inbreeding depression or outbreeding depression occurs in Eastern Prairie Fringed Orchid, crossing experiments were conducted in the field in 2000, 2002 and 2004. Plants were either self pollinated, crossed within a population or crossed between populations. Populations used in the latter category were separated by from as little as 5 km to as much as 300km. Fruits were collected at the end of the growing season, and Larry Zettler at Illinois College tested seed viability and germination.

Liatris scariosa var. *nieuwlandii*

I began collecting Savanna Blazing Star demographic data in 1995 using 80 permanent 0.5 m^2 plots varying in Big Bluestem density. Big Bluestem cover was measured in each plot and plots were classified into six Big Bluestem cover classes ranging from zero to 100% cover. Savanna Blazing Star transition matrices were developed separately for each cover class, and these will be used compare viability for populations differing in Big Bluestem cover.

Results

Cirsium pitcheri



persistence (years) = 2.808 + .115 * transplant number; R^2 = .59

Figure 1. Relationship between transplant number and persistence for Pitcher's Thistle at Illinois Beach State Park. Persistence for extant subpopulations is the number of years between 2005 and the year of transplant.

Regression and survival analyses indicated that naturally recruited plants have significantly higher survivorship and longer lifespan than transplants. The proportion of plants flowering was higher for transplants, but naturally recruited plants had greater number of flower heads. Time to flower and fecundity decrease with initial transplant size. Survival was significantly related to drought in April, July and September. Survival, growth and probability of flowering is greater on dunes compared to interdune habitats.

The size class analysis using the Maloney algorithm indicated that four size classes for juvenile plants is most appropriate for population projection matrices.

Subpopulation persistence increased with transplant number (Figure 1).

Platanthera leucophaea

For all three years, seed viability and germination was lower for selfed crosses that for either outcrossing treatment. Viability and germination of seed from crosses between individuals within populations did not differ significantly from those between populations, but there was a trend for higher values for seeds from crosses between populations.

Liatris scariosa var. *nieuwlandii*

Preliminary analysis indicates that the Hickory Creek Barrens population of Savanna Blazing Star peaked in 2003 and is currently declining in study plots. Big bluestem cover is increasing in the study plots. Savanna Blazing Star density, recruitment, flowering, survivorship, and population growth rates decrease with increasing Big Bluestem cover. Savanna Blazing Star extinction probabilities are greater than 70% in sites with 10% or more Big Bluestem cover, which occurs in over half of the study plots.

Discussion & Summary

Cirsium pitcheri

The higher survivorship, longer lifespan and increased number of flower heads of naturally recruited compared to transplants is most likely due to the shock that transplants experience when being moved from garden conditions to the natural dune habitats. The higher proportion of flowering for transplants may be explained by induction of flower buds due to the improved growing conditions they experience in the garden before transplant into dunes habitat. Because time to flower and fecundity decrease with initial transplant size, smaller plants should be used for transplanting to establish populations of Pitcher's Thistles. The higher survival, growth and probability of flowering on dunes compared to interdune habitats indicates that dune habitat is preferred by this species and transplanting should only occur in dune habitats. Because survival is significantly related to drought in April, July and September and since drought is not predictable, multiple introduction events should be used when establishing new populations of Pitcher's Thistle in order to spread the risk of drought over many years.

The size class analysis using the Maloney algorithm indicated that four size classes for juvenile plants are most appropriate for population projection matrices. A similar analysis performed on an Indiana Dunes population of Pitcher's Thistle also indicated that four size classes for juvenile plants is most appropriate for population projection matrices.

The increase in subpopulation persistence with transplant number indicates that forty or plants should be used when establishing a new population using transplants.

Future GIS studies include using aerial photography to determine the amount of available habitat at Illinois Beach State Park and Pitcher's Thistle densities in occupied sites to determine whether there is sufficient available habitat at Illinois Beach to reach MVP.

Platanthera leucophaea

The results of crossing experiments indicates that the use of multiple seed sources for establishing new populations of Eastern prairie Fringed Orchid should not result in outbreeding depression and may be preferred over using only one seed source.

Liatris scariosa var. *nieuwlandii*

Although the Savanna Blazing Star population at Hickory Creek Barrens does not appear to be in immediate danger of extinction due to the heterogeneous nature of the site, those portions of the prairie that contain Big Bluestem will most likely not allow the persistence of Savanna Blazing Star. Small-scale management trials are currently planned at Hickory Creek Barrens in order to determine the effect of disturbance, fire and mowing on reducing Big Bluestem cover and increasing Savanna Blazing Star densities.

Deliverables:

- Photos (species, project sites, activities, etc.)
  - *Cirsium pitcheri*
    - CpIllinoisBeach.jpg [looking up the dune]
    - CpIllinoisBeach2.jpg [looking down the dune]
    - Cp tagged seedling.jpg [note larger Pitcher's Thistle plant above seedling]
  - *Platanthera leucophaea*
    - EPFO.jpg [closeup of large infloresence]
    - EPFOhabitat.jpg [wooden stakes used to mark plants in background]
    - EPFOtaged.jpg [tags indicate flowers used in crossing experiments]
  - *Liatris scariosa* var. *nieuwlandii*
    - Liatris at bluestem edge.jpg [Hickory Creek Barrens]
    - Liatris whopper.jpg [large blazing star at Hickory Creek Barrens]
    - Lost of liatris.jpg [Hickory Creek Barrens note that bluestem density is low]

How native plants benefited

- Pitcher's Thistle (*Cirsium pitcheri*)
  - How they benefited
    - Pitcher's Thistle is federally threatened and has been extirpated in Illinois. The reintroduction at Illinois Beach State Park in the only available habitat in Illinois increases the probability that this species will persist. In addition, this reintroduction has provided important information about introduction methods that can be applied in future introductions at Illinois Beach State Park, as well as other sites throughout the range of the species.
  - Specific audience affected
    - Illinois residents that use Illinois Beach State Park for recreational purposes.
  - Measurable outcomes achieved
    - Vital rate analysis of a reintroduced population of the federally threatened Pitcher's Thistle
  - List of products resulting from project

A portion of the results from this study was presented at the 2006 annual meetings of the Botanical Society of America and the Ecological Society of America. Abstracts attached.

Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)

How they benefited

Introductions of new populations of Eastern Prairie Fringed Orchid can safely use seed from multiple source populations without the danger of outbreeding depression.

Specific audience affected

Residents of Illinois

Measurable outcomes achieved

Analysis of crossing effects study

List of products resulting from project

BSA 2007 Symposium proposal by Marlin Bowles & Tim Bell:

Symposium title: Conservation Biology of Eastern Tallgrass Prairie: integrating issues of management and restoration for the 21st Century

The goal of this symposium will be to explore conservation biology issues for eastern tall grass prairie. This vegetation formerly occurred as a peninsula extending from the Mississippi River eastward through southern Wisconsin and Illinois into Indiana and Ohio. Virtually all of this former prairie biome has been reduced to an archipelago of small remnants in an agricultural or urban matrix. This loss of habitat and area constrains prairie remnants through effects on immigration and extinction processes, population genetics, landscape fire processes, and direct anthropogenic impacts, as well as conflicting management and restoration needs of plants and animals. In this symposium, researchers working on eastern tallgrass prairie remnants and restorations will explore these issues with applied research and case studies as well as theoretical approaches. Questions that we hope to address include how species distributions are enumerated within and among sites, how well restorations replicate natural populations, communities and processes, and whether management can sustain natural community composition and structure over time.

Potential speakers and topics include:

- Roger Anderson, Illinois State University (deer browsing effects on prairie quality)
- Tim Bell, Chicago State University, Larry Zettler, Illinois College, et al. (crossing effects on seed viability of Eastern Prairie Fringed Orchid).
- Jim Bever, Indiana University (VAM fungal diversity in Chicago region prairie remnants)
- Marlin Bowles, The Morton Arboretum (long-term changes in prairie remnants in relation to fire frequency)
- Ron Panzer, Northeastern Illinois University (fire frequency and remnant size effects on obligate prairie insects)
- Brenda Molano Flores, Illinois Natural History Survey (plant breeding systems and restoration requirements)

- Dennis Nyberg, University of Illinois at Chicago (making plant species assessments - based on the Woodworth Prairie)
- John Taft, Illinois Natural History Survey (edge and area effects on plant diversity)

Savanna Blazing Star (*Liatris scariosa* var. *nieuwlandii*)

How they benefited

The effect of increasing Big Bluestem densities on the largest population of Savanna Blazing Star at Hickory Creek Barrens is now known. This information can be used for management decisions affecting other populations of Savanna Blazing Star in Illinois and other states.

Specific audience affected

Residents of Illinois

Measurable outcomes achieved

Analysis of demography of Savanna Blazing Star

List of products resulting from project

Management trial to determine the effect of disturbance, fire and mowing on reducing Big Bluestem cover and increasing Savanna Blazing Star densities.

Total Project Expenditures:

Name & address of vendor	Item description	Quantity purchased	Date item purchased	Amount
Timothy Bell 324 Nassau Street, Park Forest, IL	Salary for sabbatical leave August 2005 to August 2006	1	N/a	$62172
Archbold Biological Station, Lake Placid, FL	Room, board and fees	90 days	N/a	$4594.4
Southwest Airlines, Dallas, TX	Roundtrip Flight from Chicago to Orlando Florida	1	May 15, 2006	$234.60
ATA	Roundtrip Flight from Chicago to Orlando Florida	1	Feb 1, 2006	$160.60
AirTran Airways, Atlanta, GA	Roundtrip Flight from Chicago to Orlando Florida	1	October 3, 2005	$140.40
Total				$67302

The majority of the funds for this project were used to support half of my salary while on sabbatical leave from Chicago State University from August 2005 to August 2006.

Project Expenditures paid by other funds

Organization	Amount
Chicago State University – year sabbatical leave at half salary	$31086

National Fish & Wildlife Foundation	$20000
National Science Foundation Supplemental Grant	$14216
Total	$65302

Abstract Detail

Ecological Section

Bell, Timothy [1], Bowles, Marlin [2].

Vital rates differ between transplants and their naturally recruited descendants in a reintroduction of the federally threatened Pitcher.

PITCHER'S thistle (*Cirsium pitcheri*) is a short-lived herb endemic to western Great Lakes sand dunes where it colonizes successional habitats and requires frequent cohort replacement to maintain populations. This federally threatened plant became extinct in Illinois before 1920. As part of federal and state recovery planning, suitable reintroduction habitat was identified at a former site in Illinois Beach Nature Preserve and reintroduction began in 1991. Because this species is monocarpic, we used annual translocation of greenhouse-propagated plants from 1991 to 2000 to build up large cohort numbers. We monitored all transplants and their naturally recruited descendants since reintroduction began. Natural recruitment began in the 5th year of reintroduction, and the number of naturally recruited plants surpassed the number of transplants in the 11th year. The last transplant died in 2005. Mean population size from 1991 to 2005 was 150 and population size in 2005 was 168. Transplants and their naturally recruited descendants differed in survival, growth and fecundity. Survival, growth and fecundity significantly increased with plant size, decreased with drought severity and was related to location. Naturally recruited seedlings had lower survival rates than first year transplants. Naturally recruited seedlings had significantly higher survival in a relatively undisturbed area with steeper dune slopes, while survival of transplants did not differ between habitats. Conversely, fecundity did not differ between sites for naturally recruited plants but was significantly lower for transplants in disturbed habitats. Understanding these relationships will provide more realistic stochastic models for projecting the future of this reintroduction.

Log in to add this item to your schedule

1 - Chicago State University, Biological Sciences, 9501 South King Drive, Chicago, Illinois, 60628, USA
2 - The Morton Arboretum, 4100 Illinois Route 53, Lisle, Illinois, 60532, USA

Keywords:
Cirsium pitcheri
reintroduction
vital rates
threatened species.

Presentation Type: Oral Paper:Papers for Sections
Session: 66-3
Location: 266/Holt
Date: Wednesday, August 2nd, 2006
Time: 8:30 AM
Abstract ID:*595*

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PARENT SESSION

Thursday, August 10, 1:30-5:00 pm

COS 100 - Conservation ecology II

L-12, Lobby Level, Cook Convention Center

Presiders: N Nicholas

Vital rates differ between transplants and their naturally recruited descendants in a reintroduction of the federally threatened Pitcher's Thistle (*Cirsium pitcheri*).

Bell, Timothy[*,1, 2], Bowles, Marlin[2], [1] Chicago State University, Chicago, IL[2] The Morton Arboretum, Lisle, IL

ABSTRACT- Pitcher's thistle (*Cirsium pitcheri*) is a short-lived herb endemic to western Great Lakes sand dunes where it colonizes successional habitats and requires frequent cohort replacement to maintain populations. This federally threatened plant became extinct in Illinois before 1920. As part of federal and state recovery planning, suitable reintroduction habitat was identified at a former site in Illinois Beach Nature Preserve and reintroduction began in 1991. Because this species is monocarpic, we used annual translocation of greenhouse-propagated plants from 1991 to 2000 to build up large cohort numbers. We monitored all transplants and their naturally recruited descendants since reintroduction began. Natural recruitment began in the 5th year of reintroduction, and the number of naturally recruited plants surpassed the number of transplants in the 11th year. The last transplant died in 2005. Mean population size from 1991 to 2005 was 150 and population size in 2005 was 168. Transplants and their naturally recruited descendants differed in survival, growth and fecundity. Survival, growth and fecundity significantly increased with plant size, decreased with drought severity and was related to location. Naturally recruited seedlings had lower survival rates than first year transplants. Naturally recruited seedlings had significantly higher survival in a relatively undisturbed area with steeper dune slopes, while survival of transplants did not differ between habitats. Conversely, fecundity did not differ between sites for naturally recruited plants but was significantly lower for transplants in disturbed habitats. Understanding these relationships will provide more realistic stochastic models for projecting the future of this reintroduction.

Key words: reintroduction, conservation biology, *Cirsium pitcheri*

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