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FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)		**0105063**
DEB - Population Biology		

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Florida International University	Division of Sponsored Research/Training University Park Campus Miami, FL. 33199
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IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ FOR-PROFIT ORGANIZATION ☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS

TITLE OF PROPOSED PROJECT: Dissertation Research: Effects of Fires on Population Dynamics and Viability of Chamaecrista keyensis (Caesalpinioideae), An Endemic Herb of the Lower Florida Keys

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
$ 7,847	12 months	05/01/01	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.6)
- ☐ NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.C.9)
- ☐ HISTORIC PLACES (GPG II.C.9)
- ☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.C.11)
- ☐ VERTEBRATE ANIMALS (GPG II.C.11) IACUC App. Date ______
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- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED ______
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.E.1)

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Received :11/17/2000

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators:

I certify to the best of my knowledge that:

(1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and
(2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of this proposal.

I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001).

Name (Typed)	Signature	Social Security No.*	Date
PI/PD Suzanne Koptur		SSNs are confidential and are not displayed •ON FASTLANE SUBMISSIONS•	
Co-PI/PD Hong Liu			
Co-PI/PD			
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Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 01-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuring award is a criminal offense (U. S. Code, Title 18, Section 1001).

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This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

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The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

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(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
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Summary

Disruption of the historical fire regime has posed threats to some fire-dependent ecosystems and the endemic species therein. In this study, I determine the effects of experimental fire regimes on demography of *Chamaecrista keyensis*, an endemic herb of a fire dependent ecosystem in South Florida. Three experimental treatments, summer burn, winter burn, and control unburned, were imposed on two blocks of pine rockland of different ages since last fire in 1998. Preliminary results from census data indicate that the winter burn may be the most beneficial treatment for maintaining or increasing population of *C. keyensis*. These seasonal fire treatments have been (1999) and will be repeated at four other blocks to see whether this trend holds. In addition, I am carrying out several experiments to determine seed bank dynamics under different fire regimes. Population viability analyses under contrasting fire regimes will be conducted based on the above ground census and seed bank data. Furthermore, I will determine the relationship of *C. keyensis* demographic processes with fire-mediated habitat variables. Results from this study will shed light on the processes that can lead to local population decline and extinction.

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For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

I. Introduction

Disturbance has been widely recognized as an important agent influencing population dynamics of plants and animals (Sousa 1984, Pickett and White 1985). Fire is the most ubiquitous terrestrial disturbance after human urban and agricultural activities, and studying the effects of fire on plant population in various fire-prone ecosystems has been an important topic in ecology (Whelan 1996, Bond and van Wilgen 1996). In many fire-prone ecosystems of North America, the historical fire regimes have been disrupted for decades (Pyne 1982, Pyne et al. 1996), resulting in decline and disappearance of certain ecosystems and endemic species that reside in them. As the conservation of natural area and their rare and endangered species becomes a prominent issue, restoring historical fire regimes is desirable. In some cases, however, it is difficult to identify the historical fire regimes (Snyder et al 1990). Studying demographic responses of the endemic species to experimental fire regimes may solve this issue, as it is reasonable to expect a favorable population response of endemic taxa to the fire regime in which they evolved (Menges and Kohfeldt 1995).

Many fire-related studies measure only certain features of plant populations, such as post-fire mortality, fecundity or recruitment (Whelan 1996). Such information is important, but not enough to infer the effects of fire on population dynamics. Instead, long-term demographic monitoring of replicated populations that have subjected to experimental fire treatments is desirable (Whelan 1996, Streng et al. 1993). Such data can be put together in population matrix models to infer the effects of fire on population dynamics. Demographic analysis through population matrix modeling is strongly recommended in conservation of rare and endangered species because it offers analytical tools to identify the life history stages that most affect population growth (Menges 1990, 2000, Schemske et al. 1994). Population matrix models have rarely been used to characterize effects of fire on populations of endangered species (but see Quintana-Ascencio 1997, Kirkman et al. 1998). Population viability analysis via matrix models provides more or less realistic assessments of population extinction risk, depending on the quality of the demographic data (Menges 2000).

In communities that experience periodic disturbance, the environments change cyclically instead of randomly, with disturbance frequency determining the cycle length. By combining the scenario of disturbance frequency, season, and intensity with the demographic responses to such disturbance regimes, the impact of periodic disturbance and of subsequent recovery on population dynamics can be modeled (Menges 2000). An alternative approach for modeling population dynamics in cyclic environments is the use of megamatricies to combine the vegetation recovering rate with the associated population dynamics (Alvarez-Buylla 1994, Cipollini et al. 1994, Valverde and Silvertown 1997, Pascarella and Horvitz 1998). Only recently has modeling population dynamics in relation to disturbance cycles has been done. Modeling disturbance cycles is a powerful tool for comparing different disturbance management regimes (Menges 2000), but yet has rarely used in fire-dependent communities (but see Burgman and Lamont 1992, Quintana-Ascencio 1997, Enright et al. 1998).

Although seed banks are recognized to have important demographic and genetic functions, such as reducing extinction risk (Kalisz and McPeek, 1992) and buffering the local extinction of genotypes (Silvertown and Lovett Doust 1993), dynamics of seeds in the soil are difficult to study. One way to alleviate this problem is to employ experimental seed banks to explore the dynamics of seeds. However, such an approach has rarely been used in demographic studies (Menges 2000).

Besides demographic analysis, microhabitat analysis is also important to conservation efforts as it provides succinct description of habitat requirements of a species. Most microhabitat analyses, however, have focused on only seeds and seedlings (e.g. Silvertown and Smith 1989, Facelli and Pickett 1991, Guzman-Grajales and Walker 1991, Molofsky and Augsburger 1992, Barkham 1992). Microhabitat parameters may influence plant demography at any stages of their life cycle. For example, canopy openness has been showed to influence fecundity of 82 ground level species in oak savannas in southern Wisconsin (Leach and Givish 1999). Nevertheless, few studies have explored explicitly the effects of microhabitat variation on demographic parameters (but see Menges and Kimmich 1996, Lesica 1997, 1999, Quintana-Ascencio and Morales-Hernandez 1997). Knowledge of how demographic parameters, including rates of growth, flowering, and survival of the species change in relation to microhabitat parameters will add to our understanding of the mechanisms determining persistence of plant populations.

II. Research Goals

I am studying the effect of fires on the demography of *Chamaecrista keyensis*, a narrow endemic understory herb of Pine Rocklands of the lower Florida Keys. The goals of my study are: (1) Determine the direct effects of fire of two seasons (wet vs. dry) on mortality, seed production, and seed germination of populations of *C. keyensis*. (2) Characterize seed bank dynamics of *C. keyensis* via natural seed bank sampling and experimental seed banks. (3) Characterize population dynamics in relation to the post-fire succession using site-specific population matrices. (4) Explore the relationship between succession-related microhabitat variables and demographic parameters of *C. keyensis*. (5) Characterize forest recovery / succession rate via canopy cover and litter depth. (6) Simulate population extinction probability under different fire regimes with stochastic population models, and with a megamatrix model, incorporating the forest succession rate with associated population dynamics. The fire regimes are defined specifically by fire seasonality and return interval.

III. Study System

Study Species -- *Chamaecrista keyensis* (Pennell) Britton & Rose is a pine rockland understory herbaceous plant. It has multiply branched ligneous stems that arise from a contorted rootstock and is capable of resprouting after the top is killed (by fire or herbivory). Plants flower and fruit mainly during the summer (April-August). 5-10 seeds may be found in a mature seedpod, with no obvious dispersal mechanism except for limited projecting force provided by twist-opened seed pot. Plants of *C. keyensis* suffer from herbivory by leaf-tying moths and by Key Deer browsing, as well as moth and fly pre-dispersal seed predators.

C. keyensis, known to only occur in the Lower Florida Keys (Isely and Barneby 1982), is currently listed as endangered by the State of Florida and the Nature Conservancy, and recommended for listing by the US Fish and Wildlife (Wood 1986). A recent survey (Ross and Ruiz 1996) found it only on Big Pine Key, an island with the largest piece of pine rockland in the Lower Keys. Habitat destruction is an obvious reason for the disappearance and declining of this species on some islands. Invasion and shading from heavy shrubs may be responsible for the disappearance of *C. kensis* from islands where the pine rocklands are protected under the National Key Deer Refuge. One way to test this hypothesis is to study the remaining *C. keyensis* population on Big Pine Key.

Study Area -- Pine rocklands occur on outcroppings of limestone of extreme southern Florida. Land clearing in pine rocklands has rapidly reduced and fragmented the area of pineland habitat, leaving pine rockland a globally endangered ecosystem (Snyder et al. 1990). The canopy of pine rockland is monotypic, composed of slash pine (*Pinus elliottii* var. *densa*). In contrast, a diverse shrub and herb layer is present in pine rocklands due to the relatively open canopy (Snyder et al. 1990).

Florida pine rockland is a fire dependent ecosystem. A fire succession pattern where a gradual increases of fire-sensitive hardwoods over a long time period can be seen after a fire (Snyder et al. 1990). Long periods of fire exclusion (several decades) largely reduce herb diversity, presumably due to the invasion and shading of the shrubby components, and allow succession proceeding to hardwood hammock (Robertson 1955, Alexander 1967, Snyder et al. 1990). The historical fire regime before European settlements is controversial (Snyder et al. 1990).

Big Pine Key, with the largest pine rockland fragments in the Lower Keys, is an important food habitat for the federally endangered Key Deer and home of an array of rare, endangered and endemic plant species (Dickson 1955, Alexander & Dickson 1972). Pinelands on Big Pine Key are a mosaic of open and shrubby pinelands, created by a sporadic regime of prescribed burns (Bergh and Wisby 1996). The open pinelands on Big Pine have a relatively sparse shrub layer and a well-developed herb layer (hereafter "open pineland"). In contrast, shrubby pinelands have a dense shrub layer and poorly developed herb layer (hereafter "shrubby pineland"). From 1985, prescribed burns were conducted in the Refuge mainly for fuel reduction and to promote new growth for Key Deer consumption, without much consideration for other ecological factors. This practice may critically affect growth, survivorship, seed production, and seedling recruitment of a population, because the evolved life history characteristics of a species may either conflict or coincide with the altered disturbance regimes.

A five-year study is underway on Big Pine Key to develop ecological criteria for prescribed fire in lower Keys pine rockland (Ross et al. 1997). My proposed dissertation project has and will continue utilize the experimental design of this ongoing fire seasonality and vegetation study. Experimental burns will be carried out on both open pinelands and shrubby pinelands. For each type of pineland a block is randomly chosen each of three years for a total of 6 blocks (two vegetation types x three years, from 1998 to 2000) (Table 1). Within each block, three experimental units (100 x 100 meter^2 each) are established: one unit to receive a wet season burn, another to receive a dry season burn, and the third to remain unburned as a control. Standing vegetation is surveyed before each burn and further monitored at regular intervals after the burns. Twenty shrub plots (8 m in diameter) are established in a stratified random manner within each experimental unit to measure shrubby plants that are greater than 1 meter tall (Figure 1). For plants less than 1 meter tall, four herb plots (1m^2 each) are nested at four locations (Figure 2) at each shrub plot. Four fuel loading plots (0.5 x 0.5 m) are established for each shrub plot (Figure 2). In summary, there are 20 shrub, 80 herb, and 80 fuel loading plots in each experimental unit, making a total of 60 shrub, 240 herb, and 240 fuel loading plots in each block of the ongoing fire seasonality and vegetation study.

IV. Methods

Demographic censuses of *C. keyensis* -- I use the herb plots nested within each experimental unit to conduct *C. keyensis* annual censuses. I map individual *C. keyensis* within each herb plot and record the length of every stem and the total number of stems, number of flower buds, flower, and fruit present at the time of census. Signs of insect or Key-deer herbivory are also noted. Censuses are started in the summer (flowering season) right before each wet season burn at each block and once a year after the burns. These censuses will be used to estimate plant growth, mortality and to some extent, fecundity. Additional censuses are carried out to estimate immediate above ground consumption by fire, fruit production, seed production, and naturally occurred seedling survivorship.

Currently, all six blocks with 18 experimental units have been established (Table 1). Due to the large, 10-fold differences in plant density between the open and shrubby vegetation sites (Table 1), two sets of sampling regimes have been adopted. For high *C. keyensis* density experimental units, only the stratified randomly established herb plots are used. In contrast, in low *C. keyensis* density units, in addition to all 80 random herb plots, I census 10-25 non-random *C. keyensis* plots (of the same size as herb plots) at each experimental unit to increase the number of individuals censused (Table 1). These plots were placed at where there are *C. keyensis* plants and are excluded from density calculations. These sampling regimes ensure a more or less even number of plants are censused at each experimental unit, which provide a good estimation of parameters for stage transition (Eric Menges, personal communication), yet keeps the field work load manageable.

Both the direct and indirect effects of two fire seasons will be determined by comparing survivorship, proportion of reproductive vs. vegetative plants, and proportion of seedlings among the burn sites and those of the controls using Chi-square tests. Year to year differences of these variables at one unit will also be tested. Initial results of the direct effects of two seasonal fires on *C. keyensis* indicated that winter burn caused lower mortality (Table 2) and increased sexual reproduction (Table 3).

Seed Bank Dynamics -- To characterize seed bank dynamics of *C. keyensis*, I am employing a four fold approach: 1) soil sampling, 2) experiment on seed mortality due to a fire event, 3) seed bank experiment with bagged seeds, and 4) seed bank experiment with loose seeds. Results of these experiments will compliment each other to generate information such as the natural range of seed density, seed mortality due to fire, seed longevity in the soil, and proportion of seeds remaining dormant each year (up to two years). Results from the two experimental seed banks with confined vs. loose seeds will provide a chance for comparisons of the methodologies that are commonly used in demographic studies. Experimental seedling survival will also be compared with naturally occurred seedling survival.

<u>Soil Sampling</u> -- To estimate a natural range of *C. keyensis* seed density in soil, and how seed density in soil is affected by fire events and the subsequent succession, I will conduct a series of soil seed bank sampling. The ground surface of the pine rockland is characterized by mosaics of very shallow soil, exposed rocks, and solution holes of varies sizes and depth, ranging from less than 1 cm in diameter and 5 cm deep to more than 5 m in diameter and 1 m deep (personal observation). This feature makes a conventional soil sampling tools and methods virtually useless.

To overcome this methodological challenge, I utilize a battery-powered vacuum cleaner to pick up the soil. I arbitrarily placed soil quadrats (0.25 x 0.25 m^2) clockwise next to the east and west fuel plots (Figure 1). Soils up to 5 cm deep within soil quadrats are loosened and sucked up with a vacuum. Soil from the east and west soil plots from the same shrub plot are combined to form a single sample.

Soil sampling started in summer 1998 (blocks 1 and 2) and summer 1999 (blocks 3 and 4). Ten soil samples were taken at randomly selected shrub plots twice a year, with one during the dry season and the other during the wet season, for two more years. Soil plots were placed clockwise next to the previous ones. However, only 5 soil samples were collected in 2000 due to constraints of greenhouse space. Nevertheless, this sampling regime will capture spatial and temporal variation of seed density within each experimental unit, with and without a fire event.

Soil samples were brought back to the greenhouse located at the main campus of Florida International University. I quantify seeds of *C. keyensis* in the soil using the seedling emergence method. Soil samples are spread soon after being collected in a layer of 1 cm thick on 2-3 cm of moistened and sterilized standard potting soil in 50x20x5 cm flats, with one soil sample per flat. I check seedling emergence biweekly and record the total number of *C. keyensis* seedlings that emerge from the soil samples. Soil samples collected in 1998 were kept in the greenhouse for 6 months, but subsequent soil samples are kept for one year.

Seed Mortality Due To Fire -- Thirty seeds are spread into each of ten (0.25x0.25m^2) plots (selected stratified randomly, Figure 1) one day before the burn. The top litter/soil layer at each plot is retrieved the same day of the prescribed fire, but after the fire event. *C. keyensis* seeds are picked out from the mixture of seeds, litter and soil. The retrieved seeds are counted and then planted in potting soils for germinability test for two months. The remaining litter is planted to detect overlooked *C. keyensis* seeds. An average of 36 % ± 33% (n=10) seeds survived a summer fire event. The same experiment will be repeated in 2000 burns to detect variations in effect of fire on seed mortality.

Seed Bank Experiment With Bagged Seeds -- These experiments are to detect the existence of a long-term soil seed bank of *C. keyensis* in the field. Ten seed bank experiment plots are chosen at an experimental unit (Figure 1). Seed bags (10 x 10cm) made of fine-mesh aluminum window screen material, with 20 seeds per bag, are placed at the soil surface around the plot center after prescribed summer burn event. Freshly collected seeds from outside the experimental units are used (at least 98% are viable at the beginning of the experiment). I have put out two bags per plot at the summer burned and control units in block 3 and 4 in July 1999. One bag per plot is to be retrieved at 1 and 2 years after burial, respectively, to determine seed fates. I classify seed fates into the following categories: germinated in the field, viable, dead, and missing. I have retrieved the first batch of the seed bags. Seeds in the burned sites had a higher percent of long-term dormancy (Figure 3). Winter burn units at these two blocks were not used because the dry-season prescribed fires were delayed for one year. In order to capture the temporal and spatial variation of seed bank dynamics, I repeated the experiment in the same plots in early August of year 2000 using freshly produced seeds, with only one bag at each plot. In addition, 7 seed bags were put out at 7 randomly selected shrub plots, with one bag per plot in all 6 experimental units in blocks 1 and 2 (which burned in 1998). All new and remaining seed bags will be retrieved in summer 2001. Two-way ANOVA will be used to test the differences in transformed percent dormant seeds among experimental units and years. Two-sample t-tests will be used to test the differences between sites.

Seed Bank Experiment With Loose Seeds -- This experiment is designed to obtain data on seed germination and seedling survival in the field. Ten (0.25 x 0.25m) field seed germination plots were established near the seed bank experiment plots with bagged seeds in block 3 and 4. Twenty seeds were spread into each of these plots in early August 2000 (natural seed germination occurs most frequently from July to February). These plots are monitored for seedling emergence and survival biweekly for two months and will be monitored once a month for one year (2000-2001). New seedlings at each survey will be marked with color and shape coded toothpicks. Seed germination and seedling survival will be recorded each month. A same size area (0.25 x 0.25 m^2) just next to the seed germination plot was used as a control plot for monitoring background (naturally occurring) seedlings. Annual percent seed germination from this experiment will be compared with that of the confined seed bank experiment, and the seedling survival will be compared with the naturally occurring seedling survival obtained from the regular censuses using one-way ANOVA.

Effects of fire-mediated microhabitat, mid-scale habitat, and macrohabitat variables on *C. keyensis* demography --

Microhabitat -- Microhabitat data will be collected at the scale of a census plot (1 m^2) to explore the relationship between demographic parameters and fire-mediated microhabitat variables. Preliminary microhabitat data have been collected in summer 2000 in two experimental units in blocks 5 and 6 that have not yet been burned. Abiotic variables including litter cover and depth, soil depth, and vertical canopy cover at 0.5 meter above ground using a spherical densiometer were collected at each census plot in these two units. A stepwise logistic regression analysis (Fienberg 1987) shows that only canopy openness significantly predicts the presence or absence of *C. keyensis*. However, two-sample t tests show that both the vertical canopy cover at 0.5 meter and litter depth were significantly different between plots with and without *C. keyensis*. Based on these results, I will measure vertical canopy cover at 0.5 meter above ground and litter depth at each census plot. In addition, biotic variables including the presence of woody and palm species, their density and percent cover, will be recorded. In plots with *C. keyensis*, effects of microhabitat variables on the % mortality, mean growth, and mean reproductive output will be analyzed using multivariate ANOVA and significant variables will be re-examined with univariate ANOVA.

Mid-scale habitat -- Mid-scale habitat variables will be evaluated at the shrub plot level (50 m^2). In the fire seasonality and vegetation study, four variables are measured to characterize annual shrub growth at each shrub plot: shrub (> 1 meter tall) biomass, derived from volume-biomass regressions, and horizontal canopy covers at 0.5, 1.5, and 3 m above ground, which are measured using a vegetation profile method (MacAthur and MacAthur 1961). These four variables, along with mean litter depth and vertical canopy cover readings at each shrub plot, will be used as mid-scale habitat variables to predict the presence or absence of *C. keyensis* using a stepwise logistic regression model. Effects of mid-scale habitat variables on the % mortality, mean growth, and mean reproductive output will be analyzed using multivariate ANOVA and significant variables will be re-examined with univariate ANOVA.

Macrohabitat -- Effects of macrohabitat variables on *C. keyensis* demography will be evaluated at the experimental unit scale (100 x 100 m^2). There are two ways to characterize the vertical canopy cover at this level. One way is the mean canopy cover over all the herb plots in each unit. The other is to arbitrarily assign the value of vertical canopy cover of each herb/census plot into one of the two categories: light vs. heavy canopy cover, with the mid point being the average vertical canopy cover for plots with *C. keyensis*. Percent of plots in the light canopy cover category will be calculated for each unit. Effects of vertical canopy cover, mean shrub biomass, mean horizontal canopy cover at 0.5, 1.5, and, 2.5 meter above ground at each experimental unit on % mortality, mean growth, mean fecundity, and the finite rate of growth (λ) for the associated unit will be analyzed using multivariate ANOVA. Significant variables will be re-examined with univariate ANOVA.

Population dynamics and fire succession -- Based on the demographic and seed bank dynamics data, I will construct a Lefkovich matrix model for each experimental unit and one-year census period. Plants will be classified based on their size and reproductive stages (Figure 4). A total of 32 matrices will be constructed representing populations at different ages since last fire (ages 1-3 years from the experimental burns, 7-15 from open controls, and greater than 20 from shrubby controls). These matrices will allow me to infer the effect of fire return interval on demography of *C. keyensis* on Big Pine Key, using a method termed the synchronic method (Pickett 1989). Analytical parameters of the matrix models will be calculated for each matrix. Sensitivity and elasticity analyses will be conducted to identify the life history stages that most affect population growth. Among the 32 matrices, 20 will represent populations 1 to 3 years of age since prescribed burning of either wet or dry seasons. The analytical parameters from these 20 matrices will be used to compare the effects of fire in wet and dry seasons.

Population viability analysis -- Extinction probabilities of *C. keyensis* after an arbitrary length of time (e.g. 500 years) under various fire regimes will be estimated from simulations of stochastic population trajectories. I will use a selected program with an algorithm that projects a sequence of different matrices with their probabilities of occurrence related to the age since last fire. For example, there will be four matrices representing first year populations after a wet season burn. These four matrices will be given equal probability to represent the first year population in a simulation of a wet season burning regime. Scenarios of fire regimes will vary in fire return interval (burn every 10 years vs. every 20 years, or alternate the two) and burning season (wet vs. dry, or alternate of the two).

Alternatively, extinction probability of *C. keyensis* can be determined through a megamatrix approach, where individual matrices describing the behavior of individual populations are linked into aggregate matrices that include transitions representing shifts among successional stages (Menges 2000). Pine rockland succession rate can be inferred from changes in canopy structure, including horizontal canopy covers and vertical canopy cover with time since fire. Since pine rockland succession rate may differ based on fire season and vegetation type (open vs. shrubby) before burn, different megamatrices may be constructed to reflect the burning season and fire return interval, which determines the vegetation type for the next burn.

V. Feasibility

All the prescribed fires required in this study are carried out by the fire seasonality and vegetation study. Thus, the financial and social challenge of prescribed burning in Big Pine Key is minimized. Most the proposed experimental procedures have either already successfully implemented, or preliminary data has been collected, except for computer simulations. Once field data collection is complete, I will conduct the simulations under Dr. Eric Menges' guidance. To add the microhabitat analysis and as the workload accumulates with time, field assistance is needed in order to complete the proposed work in a timely fashion for year 2001 field season.

VI. Research Significance

Population matrix models have rarely been used to characterize the effects of fire on populations, especially herbaceous species (but see Silva et al. 1991, Kirkman et al. 1998, Quintana-Ascencio 1997). A matrix model is a powerful tool in a population ecology study because it summarizes the overall demographic conditions of a given environment and allows room to incorporate many ecological factors (e.g. disturbance frequency, seasonality, and intensity) to determine their effects on population growth rate. This research will take full advantage of these analytical functions. Nevertheless, the quality of a population viability analysis using population metric models depends largely on the quality of the empirical data on which it is based. The empirical data of this research are of high quality, as they cover multiple sites that are representative of the whole species range over 4-year period. In addition, seed bank and seedling dynamics, the most difficult challenge of demographic studies, are being studied in several experiments.

In addition, results from the two experimental seed banks with confined vs. loose seeds will provide a chance for comparisons of methodologies. These two methods are commonly used in seed bank studies, yet rarely used for the same species. Experimental seedling survival will also be compared with the naturally occurred seedling survival. Experimental seedling survival experiments are often used in demographic studies when naturally occurred seedlings are rare. To my knowledge, there is no study comparing results from the two methods for the same species.

With NSF funding, I will be able to collect the microhabitat data, which include vertical canopy cover for experimental units at a broad range of ages since last fire. This information, along with the horizontal vegetation covers, will be used to infer the vegetation recovering rate after fire, which is essential for population viability analysis using megamatrix models. This will allow me to conduct population viability analysis using two methods: simulation of a sequence of matrices with particular probabilities and megamatrix models. Both population viability analyses are recommended in conservation studies (Menges 2000). To my knowledge, no study has applied both analyses to the same species to compare their relative efficacy.

Results of this research will provide solid scientific bases for making an appropriate management plan for conserving this narrowly endemic species. In addition, the demographic responses of this endemic species will help to infer the historical fire regime that shaped the pine rockland community in the lower Florida Keys. More generally, knowledge from this research will add to our understanding on the role of disturbance in shaping plant life history.

Table 1. Summary of C. keyensis census regime at each experimental unit

Block	Experimental treatment	Vegetation type	Average density /m^2	# of census plot	Census start year	Prescribed burn year
1	Control	open	2.9	60	1998	NA
	Wet-season burn	open	3.1	60	1998	1998
	Dry-season burn	open	2.3	60	1998	1998
2	control	shrubby	0.51	100*	1998	NA
	Wet-season burn	shrubby	0.15	100*	1998	1998
	Dry-season burn	shrubby	0.32	90*	1998	1998
3	control	open	0.86	95*	1999	NA
	Wet-season burn	open	1.03	95*	1999	1999
	Dry-season burn	open	0.27	105*	1999	2000
4	control	shrubby	0.25	105*	1999	NA
	Wet-season burn	shrubby	0.47	105*	1999	1999
	Dry-season burn	shrubby	0.96	85*	1999	2000
5	control	open	1.73	60	2000	NA
	Wet-season burn	open	3.26	50	2000	2001
	Dry-season burn	open	5.5	40	2000	2000
6	control	shrubby	0.19	90*	2000	NA
	Wet-season burn	shrubby	0.46	90*	2000	2001
	Dry-season burn	shrubby	0.75	90*	2000	2000

* Additional non-random plots are included.

Table 2. Comparison of individual plant fates in one year period (1998-1999) in three experimental units in Orchid block.

			Experimental unit		
			Control [a]	Summer burn [b]	Winter burn [c]
Plant fate	dead	count	60	114	104
		%	26.5	69.1	41.9
	survived	count	115	26	82
		%	50.9	15.8	33.1
	New individual	count	51	25	62
		%	22.6	15.2	25.0

Note: Units with different superscripted letters are statistically significant from each other based on Pearson Chi-square and Likelyhood ratio tests ($p < 0.05$).

Table 3. Comparison of 1999 (post-burn) proportion of reproductive vs. vegetative adult plants (longest stem > 10 cm) in three experimental units in Orchid block.

			Experimental unit		
			Control [a]	Summer burn [a]	Winter burn [b]
Reproductive state	vegetative	count	71	14	25
		%	59.2	41.2	30.9
	Flower/fruit	count	49	20	56
		%	40.8	58.8	69.1

Note: Units with different superscripted letters are significantly different from each other based on Pearson Chi-square and Likelyhood ratio tests ($p < 0.05$). No plants with the longest stem <= 15 cm flower. Pre-burned proportions of reproductive adult plants are not significantly different among these three units.

Figure 1. Distribution of shrub plots within an experimental unit. Note that 20 shrub plots and 10 seed bank related experiment plots are randomly selected among the 32 stratified points.

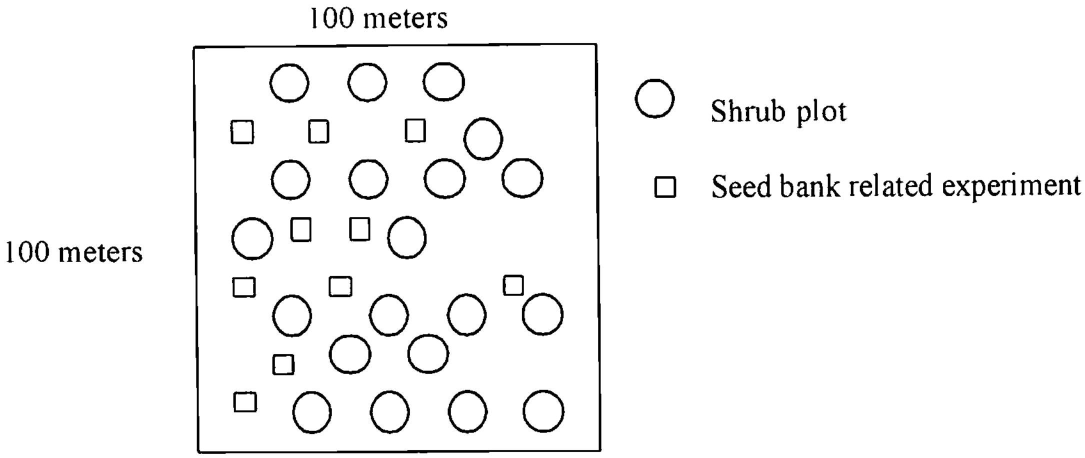


Figure 2. Distribution of herb, field loading, and soil sample plots within each shrub plots.

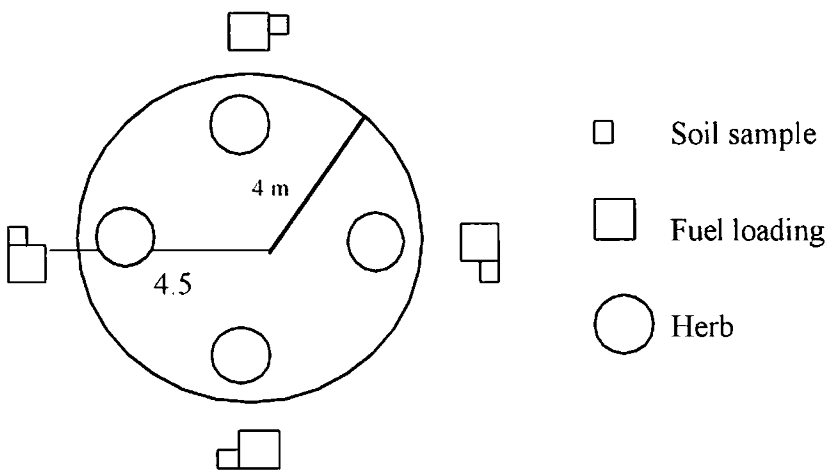
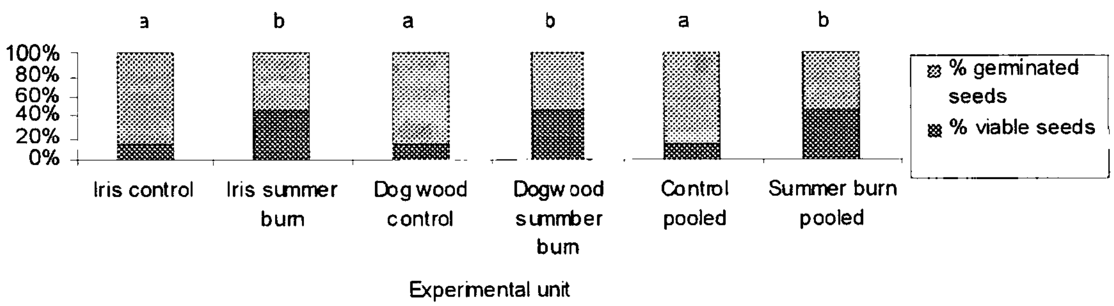


Figure 3. Comparison of propotions of seed fates after one year in the artificial seed banks at different experimental units (for recovered seeds only). Columns sharing different letters are significant different from each other (Mann-Whitney U tests).



References Cited

Alexander, T. R. 1967. A tropical hammock on the Miami (Florida) limestone - A twenty-five-year study. Ecology 48: 863-867.

Alexander, T. R., and J. D. Dickson. 1972. Vegetational changes in the National Key Deer Refuge – II. Quarterly Journal of the Florida Academy of Sciences 35: 85-96.

Alvarez-Buylla, E. R. 1994. Density dependence and patch dynamics in tropical rain forests: matrix models and applications to a tree species. American Naturist 143: 156-191.

Barkham, J. P. 1992. Population dynamics of the wild daffodil (*Narcissus pseudonarcissus*). IV. Clumps and gaps. Journal of Ecology 80: 797-808.

Bergh, C., and J. Wisby. 1996. Fire history of Lower Keys pine rocklands. The Nature Conservancy, Key West.

Bond, W. J., and B. W. van Wilgen. 1996. Fire and Plants. Chapman & Hall, London.

Burgman, M. A. and B. B. Lamont. 1992. A stochastic model for the viability of *Banksia cuneata* populations: environmental, demographic, and genetic effects. Journal of Applied Ecology 29: 719-727.

Cipollini, M.L., D. A. Wallace-Senft, and D. F. Whigham. 1994. A model of patch dynamics, seed dispersal, and sex ratio in the dioecious shrub *Lindera benzoin* (Lauraceae). Journal of ecology 82:621-633.

Dickson, J. D. 1955. An ecological study of the Key Deer. Florida Game and Fresh Water Fish Commission Technical Bulletin No. 3.

Enright, N. J., R. Marsula, B. B. Lamont, and C. Wissel. 1998. The ecological significance of canopy seed storage in fire-prone environments: a model for resprouting shrubs. Journal of Ecology 86: 960-973.

Facelli, J. M., and S. T. A. Pickett. 1991. Plant litter: its dynamics and effects on plant community structure. Botanical Review 57: 1-32.

Fienberg, S. E. 1987. The analysis of cross-classified categorical data. Massachusetts Institute of Technology, Cambridge.

Guzman-Grajales, S. M., and L. R. Walker. 1991. Different seedling responses to litter after Hurricane Hugo in the Luquillo Experimental Forest, Puerto Rico. Biotropica 23: 407-413.

Isely and Barneby 1982. The American Cassiinae, a synoptical revision of Leguminosae, tribe Cassieae, subtribe Cassiinae in the New World. Memoirs of the New York Botanical Garden 35: 1-918.

Kalisz, S., and M. McPeek. 1992. Demography of an age-structured annual: resampled projection matrices, elasticity analyses, and seed bank effects. Ecology 73: 1982-1093.

Kirkman, L. K., M. B. Drew, and D. Edwards. 1998. Effects of experimental fire regimes on the population dynamics of *Schwalbea americana* L. Plant Ecology 137:115-137.

Leach, M. K., and T. J. Givinish. 1999 Gradients in the composition, structure, and diversity of remnant oak savannas in southern Wisconsin. Ecological Monographs 69: 353-374.

Lesica, P. 1997. Demography of the endangered plant, *Silene spaldingii* (Caryophyllaceae) in northwest Montana. Madrono 44: 347-358.

Lesica, P. 1999. Effects of fire on the demography of the endangered, geophytic herb *Silene spaldingii* (Caryophyllaceae). American Journal of Botany 86: 996-1002.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42: 594-598.

Menges, E.S. 1990. Population viability analysis for an endangered plant. Conservation Biology 4:52-62.

Menges, E. S. 2000. Population viability analysis in plants: challenges and opportunities. Trends in Ecology and Evolution 15: 51-56.

Menges, E. S., and J. Kimmich. 1996. Microhabitat and time-since-fire: effects on demography of *Eryngium cuneifolium* (Apicceae), a Florida scrub endemic plant. American Journal of Botany 83: 185-191.

Menges, E. S., and N. M. Kohfeldt. 1995. Life history strategies of Florida scrub plants in relation to fire. Bulletin of Torrey Botanical Club 122: 282-297.

Molofsky, J., and C. K. Augspurger. 1992. The effect of leaf litter on early seedling establishment in a tropical forest. Ecology 73: 68-77.

Pascarella, J. B., and C. C. Horvitz. 1998. Hurricane disturbance and the population dynamics of a tropical understory shrub: Megamatrix elasticity analysis. Ecology 79: 547-563.

Pickett, S. T. A. 1989. Space-for-time substitution as an alternative to long-term studies. pp110-135 in G. E. Likens, ed. Long-term Studies Ecology: Approaches and Alternatives. Springer-Verlag, Berlin.
Pickett, S. T. A., and P. S. White, eds.1985. The ecology of Natural Disturbance. Academic Press, New York.
Pyne, S. J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton University Press, Princeton.
Pyne, S. T., P. L. Andrews, and R. D. Laven. 1996. Introduction to Wildland Fire. 2nd ed. John Wiley and Sons. Inc. New York.
Quintana-Ascencio, P. F. 1997. Population viability analysis of a rare plant species in patchy habitats with sporadic fire. Ph. D. dissertation. State University of New York at Stony Brook.
Quintana-Ascencio, P. F. and M. Morales-Hernandez. 1997. Fire-mediated effects of shrubs, lichens, and herbs on the demography of *Hypericum cumulicola* in patchy Florida scrub. Oecologia 112: 263-271.
Robertson, W. B. 1955. An analysis of the breeding-bird populations of tropical Florida in relation to the vegetation. Ph.D. Dissertation, University of Illinois, Urbana.
Ross, M. S., S. Koptur, and J. R. Snyder (1997) Developing ecological criteria for prescribed fire in south Florida pine rockland ecosystems. Proposal funded by Department of Interior Fire Coordination Committee.
Ross, M. S., and P, Ruiz. 1996. A study of the distribution of several South Florida endemic plants in the Florida Keys. Report to the USFWS.
Schemske, D. W., B. C. Husband, M. H. Ruckelhaus, C. Goodwillie, I. M. Parker, and J. G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75:584-606.
Silva, J. F., J. Raventos, H. Caswell , and M. C. Trevisan. 1991. Population responses to fire in a tropical savanna Grass, *Andropogon semiberbis*: A matrix model approach. Journal of Ecology 79:345-356.
Silvertown, J., and J. Lovett Doust. 1993. Introduction to plant population biology. Blackwell Science, Osney Mead, Oxford.
Silvertown, J., and B. Smith. 1989. Mapping the microenvironment for seed germination in the field. Annals of Botany 63: 163-167.
Snyder, J. R., A. Herndon, and W. B. Robertson. 1990. South Florida rockland. pp. 230-277 in R. L. Myers, and J. J. Ewel, eds. Ecosystems of Florida. University of Central Florida Press, University Presses of Florida, Orlando.
Sousa, W. P. 1984. The role of disturbance in natural communities. Annual Review of Ecology and Systematics 15: 353-391.
Streng, D. R., J. S. Glitzenstein, and W. J. Platt. 1993. Evaluating effects of season of burn in longleaf pine forests: A critical literature review and some results from an ongoing long-term study. pp. 227-263 in S. M. Hermann, ed. Eighteenth Proceedings of the Tall Timbers Fire Ecology Conference. Tall Timbers Research Station, Tallahassee.
Valverde, T., and J. Silvertown. 1997. A metapopulation model *for Primula vulgaris*, a temperate forest understory herb. Journal of Ecology 85:193-210.
Whelan, R. J. 1996. The ecology of fire. Cambridge University Press. Cambridge.
Wood, D. A., comp. 1986. Official lists of endangered and potentially endangered fauna and flora in Florida (2 September 1986). Florida Game and Fresh Water Fish Commission, Tallahassee.

SUZANNE KOPTUR - BIOGRAPHICAL SKETCH
Department of Biological Sciences, Florida International University,
Miami, FL 33199

Born: 20 January 1955; Detroit, Michigan, U.S.A.

Professional Preparation:

University of Michigan, B.S., honors in Botany, 1976
University of California, Berkeley, Ph.D. in Botany, 1982
Postdoctoral Investigator in the Naturalist-Ecologist Training Program, University of Michigan Biological Station. Summer 1983, and 1986.
Postdoctoral Associate in Zoology, University of Iowa. 1982-1984.
NATO Postdoctoral Fellow, University of York, England. 1984.

Appointments:

Professor of Biology, Florida International University, 1998 – present.
Honors College Faculty (FIU) 1998 – present.
Visiting Associate Professor in Ecology and Systematics, Cornell University, Fall 1993.
Fulbright-Hayes Garcia Robles Research Fellow 1993-94.
Associate Professor of Biology, Florida International University, 1989 - 1998.
McKnight Junior Faculty Development Fellowship. 1989-90.
Co-coordinator for Organization for Tropical Studies course 85-3, June-August 1985.
Assistant Professor of Biology, Florida International University, 1985 - 1989.
Lecturer in Plant Ecology, University of California, Berkeley, Spring 1982.
American Association of University Women Graduate Fellow 1981-1982.
Smithsonian Tropical Research Institute Noble Fellow 1976.

Publications most closely related to project:

Koptur, S. 1984. Experimental evidence for defense of Inga (Mimosoideae) saplings by ants. Ecology 65: 1787-1793.

Koptur, S. 1985. Alternative defenses against herbivores in Inga (Fabaceae: Mimosoideae) over an elevational gradient. Ecology 66(5): 1639-1650.

Koptur, S. and J.H. Lawton. 1988. Interactions among vetches bearing extrafloral nectaries, their biotic protective agents, and herbivores. Ecology 69: 278-283.

Koptur, S., C.L. Smith, and J.H. Lawton. 1996. Effects of Artificial Defoliation on Reproductive Allocation in the common vetch, Vicia sativa (Fabaceae: Papilionoideae). American Journal of Botany 83(7): 886-889.

Koptur, S., V. Rico-Gray, and M. Palacios-Rios. 1998. Ant protection in neotropical ferns bearing foliar nectaries. American Journal of Botany 85(5): 736-739.

Other significant publications:

Koptur, S. 1984. Outcrossing and pollinator limitation of fruit set: breeding systems of neotropical Inga trees. Evolution 38(5): 1130-1143.

Koptur, S. 1989. Is extrafloral nectar production an inducible defense? Pp. 323-339 in J. Bock & Y. Linhart (eds.) Evolutionary Ecology of Plants. Westview Press, Boulder, CO.

Koptur, S. 1992. Interactions between Insects and Plants Mediated by Extrafloral Nectaries. In Bernays, E. (ed.) CRC series on Insect/Plant Interactions. Volume 4, pp. 85-132.

Koptur, S. 1994. Floral and extrafloral nectars of neotropical Inga trees: a comparison of their constituents and composition. Biotropica 26(3): 276-284.

Koptur, S. and Ni Truong. 1998. Facultative Ant/Plant Interactions: Nectar sugar preferences of introduced pest ant species in South Florida. Biotropica 30(2): 179-189.

Synergistic Activities

- Rainforest Workshops for public school teachers and various organizations (1987-1995)
- Workshops for Girls in Science in collaboration with FIU Education Colleagues (1990 – 1996)
- Presented workshop on Innovative Teaching in Large Courses for FIU faculty (April 2000)
- Many high school students and work/study students assist in my research laboratory
- Reviewer for many journals in Botany, Ecology, Conservation, and Evolution, NSF, USDA
- I serve as a mentor for the FIU Women's Center, Faculty Senator, Library Committee Head
- Panelist for Fulbright Andean region 1996 – present, NSF DDI panelist 1993-94

Collaborators:

Dr. Carol Horvitz (University of Miami); Dr. Christopher Kernan (The Nature Conservancy); Dr. Mary Ann B. Lee (St. John's River Water Management District); Dr. Steve Oberbauer (FIU), Dr. Jennifer Richards (FIU), Monica Palacios-Rios (Instituto de Ecologia, Xalapa), Dr. Victor Rico-Gray (Instituto de Ecologia, Xalapa, Veracruz, Mexico).Dr. James R. Snyder (Big Cypress National Preserve).Dr. Mike Ross (Southeast Environmental Research Center, F.I.U.)

Graduate Students (total number advised, 24):

Lisa Hardin (M.S. 1987) - Pollination ecology of Passiflora edulis in south Florida.
Lisa Spier (M.S. 1991) - The influence of fire on the reproductive biology of Jacquemontia
Carl Weekley (M.S. 1993) - Gall insects on the black-bead, Pithecellobium guadalupense.
Sandra Vardaman (M.S. 1994) - Reproductive biology of Melaleuca in south Florida.
Maria Cristina Rodriguez (M.S.1995) - Herbivore diversity on the wild tamarind, Lysiloma
Piyal Kariyawasam (M.S. 1996) - Stress and death in south Florida slash pine
Joe O'Brien (M.S.1997) - Population ecology of Galactia spp. in south Florida
Sherine El-Sawa (M.S.1998) - Pollination of jackfruit in south Florida
Anne Cox (Ph.D. 1998) - Comparative reproductive ecology of pawpaws (Asimina)
Eileen Smith (M.S. 2000) - Atala butterfly population dynamics and restoration.
Suzanne Kennedy (M.S. 1998) - Seed bank dynamics of Tiny Polygala
John Geiger (M.S. candidate) - Pollination in pine rockland fragments.
Hong Liu (PhD candidate) - Effects of fire on endemic Chamaecrista keyensis.
Lauren Linares (M.S. student) - Habitat restoration for endangered Amorpha crenulata.
Yuria Cardel (PhD student) – Herbivory and pollination in Centrosema virginiana.
Jed Redwine (PhD student) – Phenology of fruit availability in tropical hardwood hammocks.
New Fall 2000: David LaPuma, Elena Pinto-Torres, Heather Gamper

Graduate and postdoctoral advisors:

Herbert G. Baker, University of California, Berkeley (PhD)
Henry F. Howe, University of Illinois, Chicago (then at University of Iowa)
John H. Lawton, Imperial College, Silwood Park, UK (then at University of York)

Biographical Sketch – Hong Liu

a. Professional Preparation

Nanjing University, P.R. China	Plant Ecology	B.S.	1989
Clemson University, USA	Botany	M.S.	1995-1997
Florida International University	Biology	Ph.D. candidate	1998-present

b. Appointments

1998-present Research Assistant, Department of Biological Sciences, Florida International University.

1997-1997 Teaching Assistant, Department of Biological Sciences, Clemson University

1996-1997 Research Assistant, Department of Biological Sciences, Clemson University

1995-1996 Teaching Assistant, Department of Biological Sciences, Clemson University

1989-1994 Research Assistant, Guangxi Biotechnology Research Center. Nanning, P.R. China

c. Publications

Liu, H. and T.P. Spira. 2000. The influence of seed age and inbreeding on seed vigor in *Hibiscus moscheutos*. Journal of Torreys Botanical Society. In press.

Spira, T.P., A.A. Snow, and H. Liu. 2000. The relative importance of pollen vigor versus pollen arrival time in *Hibiscus moscheutos*. American Journal of Botany. In press.

Liu, H. and S. Buchmann. 2000. The evolution of poricidal anthers in angiosperms – a phylogenetic perspective. In preparation.

Liu, H., S.G. Platt, and C.K. Borg. 2000. The seed dispersal functions of common Box Turtles in a sub-tropical forest. In preparation.

Gu, C.E., R.J. Pang, and H. Liu, 1992. The application of Qianglujing (TCCA) as germicide to sterilize inoculation environment for edible fungus culture. Edible Fungi (in Chinese) 3: 60-65.

d. Synergistic Activities that focus on the Intergration, transfer and creation of knowledge

Tour leading for the Florida Native Plant Society on the endemic plants on Big Pine Key. May 2000.

Interpreter (English/Chinese) for Chinese Delegation to the Department of Forestry Resources and Management, Clemson University. 1997

Interpreter (English/Chinese) for a Chinese visiting artist to the Department of Visual Arts and History, Clemson University, 1997

Interpreter (English/Chinese), First International Symposium of Golden *Camellia*, Nanning, 1993.

Interpreter (English/Chinese), International Symposium of *Ganoderma lucidum*, Beijing, 1991.

e. **Collaborators and other affiliations**

(i) **Collaborators.**

Chris K. Borg, Department of Biological Sciences, Florida International University.
Steven Buchmann, The Bee Works Co. Lit.
Steve G. Platt, Wildlife Conservation Society, New York.
Alison A. Snow, Department of Biologcial Sciences, Ohio State University.
Timothy P. Spira, Department of Biological Sciences, Clemson University.

(ii) **Graduate and Postdoctoral Advisors.**

Timothy P. Spira, MS thesis advisor, Department of Biological Science, Clemson University.
Suzanne Koptur, Ph.D. thesis advisor, Department of Biological Science, Florida International University.

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Florida International University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Suzanne Koptur

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Suzanne Koptur - none	0.00	0.00	0.00	$ 0	$
2. Hong Liu - none	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (1) UNDERGRADUATE STUDENTS				3,120	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				3,120	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				239	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				3,359	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				4,488	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				7,847	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				7,847	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 7,847	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Suzanne Koptur		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: **Florida International University**				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Suzanne Koptur**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Suzanne Koptur - none	0.00	0.00	0.00	$ 0	$
2. Hong Liu - none	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0:00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (1) UNDERGRADUATE STUDENTS				3,120	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				3,120	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				239	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				3,359	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				4,488	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				7,847	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				7,847	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 7,847	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI / PD TYPED NAME & SIGNATURE* **Suzanne Koptur**	DATE	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date Of Rate Sheet / Initials - ORG

NSF Form 1030 (10/99) Supersedes all previous editions

C*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

Budget Justification

B. Undergraduate stipend:	\$3120 = \$6.5 x 20 hr/week x 4 week/month x 6 months
Fringe benefits (FIU rate 7.65%):	\$239

E. Travel (Domestic) includes housing subsidy and travel expenses

Housing subsidy for assistant:	\$2400 = \$400 x 6 months
Travel expenses for Hong Liu: (Between FIU campus and Big Pine Key)	\$2088 = \$0.29/mile x 300 miles/trip x 4 trips/month x 6 month

Total: \$7847

June 2001 to December 2001 will be my last yet the most intensive field season for the proposed project. My 4-year research assistantship ends in December 2001. During this period, I would like to be able to collect microhabitat data in addition to the fourth annual census of all 18 experimental units. However, each of these tasks will take me 4.5 months, a total of 9 months to complete both on my own. I may have to focus on just one task instead of both to avoid introducing the confounding seasonal component in the data. It will be financially difficult me to work beyond December 2001 without my research assistantship. In addition to a stipend, my assistantship covers partial rental cost of an apartment on Big Pine Key. A fourth year of census data is essential for the continuity of the research for inferring effects of fire on *C. keyensis* populations and will therefore be given the top priority. Yet collection of microhabitat data will significantly contribute to the conservation biology aspect as it not only allows me to examine the relationship between *C. keyensis* demographic processes and fire-mediated habitat variables, it also provides opportunity to compare two important approaches of population viability analysis.

A field assistant will help me to speed up these data collections and complete the proposed field work in 6 months (3 months for census, 3 months for microhabitat data collection), a time frame that is acceptable. In the past two years, I was able to receive some funds from two different sources (Tropical Biology Research Fund from FIU and Key West Garden Club Scholarship) to support a field assistant, which has been crucial for me to conduct the proposed project in a timely fashion. But these funds will run out before summer 2001. Reapplication to those funds for a field assistant is not possible. I therefore request funding from NSF to support an undergraduate field assistant for the period of June 2000 to December of 2001. The fund includes a limited stipend and a housing subsidy, to provide the assistant with room and board. With this funding, there will be an educational and training opportunity in ecology to a minority student as I would like to hire an undergraduate student from Florida International University, a minority institution.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Suzanne Koptur**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Developing Ecological Criteria for Prescribed Fire in South Florida Pine Rockland Ecosystems**

Source of Support: **Department of the Interior**

Total Award Amount: $ **0** Total Award Period Covered: **08/31/97 - 12/31/01**

Location of Project: **Big Pine Key, Florida**

Person-Months Per Year Committed to the Project. Cal: **2.00** Acad: **0.00** Sumr: **2.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Restoration of the Federally Endangered Crenulate Lead-plant, Amorpha crenulata (Fabaceae): a preliminary study**

Source of Support: **U.S. Fish and Wildlife Service, Vero Beach Office**

Total Award Amount: $ **149,565** Total Award Period Covered: **09/01/00 - 08/30/03**

Location of Project: **Dade County, Florida**

Person-Months Per Year Committed to the Project. Cal: **1.00** Acad: **0.00** Sumr: **1.00**

Support: ☐ Current ☐ Pending ☒ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Effects of Habitat Fragmentation on Pollination of Pine Rockland Plants**

Source of Support: **National Science Foundation**

Total Award Amount: $ **0** Total Award Period Covered: **01/01/00 - 01/01/00**

Location of Project: **Dade County Florida**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Dissertation Research: Effects of Fires on Population Dymanics and Viability of Chamaecrista Keyensis (Caesalpiiodeae), An Endemic Herb of the Lower Florida**

Source of Support: **NSF**

Total Award Amount: $ **7,847** Total Award Period Covered: **05/01/01 - 04/30/02**

Location of Project: **FIU and Florida Keys**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Hong Liu**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Seed bank dynamics of pine rocklands in the Lower Keys**

Source of Support: **Florida Native Plant Society**

Total Award Amount: $ **500** Total Award Period Covered: **05/01/99 - 04/30/00**

Location of Project: **Big Pine Key, Florida**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Demography of Chamaecrista keyensis**

Source of Support: **Key West Garden Club**

Total Award Amount: $ **1,000** Total Award Period Covered: **07/01/00 - 06/30/01**

Location of Project: **Big Pine Key, Florida**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Seed bank of Lower Keys Pine Rockland**

Source of Support: **FIU Tropical Biology Research Award**

Total Award Amount: $ **2,000** Total Award Period Covered: **05/01/98 - 09/01/98**

Location of Project: **Big Pine Key and FIU**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Demographic Studies of Chamaecrista keyensis**

Source of Support: **FIU Tropical Biology Research Award**

Total Award Amount: $ **2,000** Total Award Period Covered: **05/01/99 - 09/01/99**

Location of Project: **Big Pine Key**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Dissertation Research: Effects of Fires on Population Dymanics and Viability of Chamaecrista Keyensis (Caesalpiiodeae), An Endemic Herb of the Lower Florida**

Source of Support: **NSF**

Total Award Amount: $ **7,847** Total Award Period Covered: **05/01/01 - 04/30/02**

Location of Project: **FIU and Florida Keys**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory: 1) Field lab at USFWS bunkhouse on Wilder Rd, Big Pine Key. Set up for plant and insect collection, study, and storage. Small shadehouse facility for plant propagation.
2) OE 268/270 (ca 600 sq. ft.) on FIU campus in Miami for computer work and specimen

Clinical:

Animal:

Computer: FIU mainframe with SAS, BMDP; field lab computer (Pentium 122) hookup via modem. FIU lab computer (Pentium S66) networked with Ethernet. E-mail is invaluable for project correspondence between Miami and the Keys.

Office: 1) Office in field lab at USFWS bunkhouse on Big Pine Key. Plant identification books and relevant leterature. Telephone.
2) FIU campus: PI office OE 232 (100 sq. ft.); grad student office in PI lab (OE 268). Journals and books relevant to project.

Other: Ongoing and long-term research on pine rockland plants in south Florida and the Keys. Necessary federal and local permits have been obtained.

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

Leica (Wild) dissecting microscope for detailed plant and insect examination; ancient Zeiss compound scope.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.