

Fire effects on Cape Sable seaside sparrow demography

(Relates to MSRPIS tasks S1.4, s4.2, h3.1; 3.3 h2.3; h3.2, h3.3, h3.4, h3.5)

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INTRODUCTION

Between 1948 and 1992 the wetland areas of Everglades National Park experienced 752 fires for an average of 17 fires per year (Gunderson and Snyder 1994). Fire is a necessary component of the Everglades. It maintains a habitat mosaic and prevents hardwood shrubs from invading the characteristically open Everglades marshes (Robertson 1953, Egler 1952, Taylor 1983). The Cape Sable seaside sparrow (*Ammodramus miratimus mirabilis*), an endangered subspecies endemic to the southern Everglades, relies on marl prairies that are influenced by fire regimes (Werner 1975). The sparrow lives exclusively on Federally protected land, principally within Everglades National Park (ENP). Currently ENP manages fires through prescribed burning and strategic control of naturally caused fires. Of central concern to ENP officials is the development of a fire management protocol that promotes USFWS recovery goals for this subspecies. The conception of this fire management plan is profoundly inhibited by the lack of knowledge surrounding the sparrow's response to, and recovery from, fire.

I propose a detailed demographic study of individuals subjected to a recent fire event. By allowing a recent fire to burn through a portion of an existing study plot, I have the option of utilizing a study design that can better detect fire effects than previous research. This includes evaluating the possibility that sparrow populations are not noticeably effected by fire (except through the immediate loss of individuals), and evaluating the nature of any lasting population effects. The demographic information collected can also be used to project the fates of sparrow populations subjected to proposed fire management plans (Whelan 1995). This study is designed to compliment existing information on how sparrow populations respond to flooding regimes, allowing for the possibility of projecting population changes caused by the combined effects of

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fire and flood. Finally, conceptually this study fits squarely between concurrent research, and thus can serve to mechanistically tie together fire effects observed at other spatial and temporal scales.

REVIEW OF CURRENT KNOWLEDGE

The first accounts of fire effects on sparrows portrayed burning as a threat. Stimson (1956, 1968) recorded the loss of isolated populations of sparrows due to their decimation of grassy marshes. Fires move through Everglades marshes fueled almost exclusively by grass (Gunderson and Snyder 1994). Given that sparrows place their nests near the ground and well within the grass layer, a fire that burns during the breeding season (the driest time of the year) will almost certainly cause the destruction of most active nests. It is not as clear whether fire causes the death of adults since they are highly vagile and there are no obvious impediments to their escaping fire via flight.

H. Werner and D. Taylor countered this view by suggesting that fire serves to maintain vegetation in a state that is suitable for sparrow breeding (Taylor 1983, Werner 1975, Werner and Woolfenden 1983). Werner and Taylor observed individuals recolonizing a burned site one-year post-fire, thus documenting that the direct negative effects of fire may not persist. Using existing spatial patterns in time since fire, Werner also deduced that sparrow density declined within sites that did not burn for four or more years. Taylor (1983) documented that the rate at which vegetation recovers post-fire is the principle determinant of how quickly sparrows will return to a site, and how long they will occupy that site. Werner and Woolfenden (1983) speculated that fires prevent shrub invasion and decrease the accumulation of dead vegetation. They suggest that preventing these processes were key to maintaining the suitability of habitat for sparrows. These studies lead to recommendations that frequent (e.g., four-year interval) prescribed fires be considered a necessary component to the maintenance of sparrow populations (Werner and Woolfenden 1983, Kushlan and Bass 1983, Taylor 1983).

Curnutt et al. (1998), using a greatly expanded spatial scale than either Werner or Taylor, countered this recommendation. Using density estimates combined with spatially explicit maps of fire extent within ENP, Curnutt et al. (1998) could find no decrease in sparrow density for up to 10 years post-fire. Using the same database, Curnutt et al. (1998) found that sparrow densities responded to season of fire, and fire frequency, such that dry season fires that burn often (sometimes once or more per year) significantly decrease sparrow densities. They suggest that very short-interval, dry season, human-ignited fires may have driven northeastern sparrow populations extinct (Curnutt et al. 1998).

The role of fire in sustaining populations of the Cape Sable seaside sparrow remains a murky issue. Given the natural prevalence of fire in the everglades ecosystem and the results of Werner and Taylor, it seems certain that sparrow populations are not permanently harmed by natural fire events. However, there is little that is natural about the current fire regime, and Curnutt et al. (1998) show that human-induced changes to this regime could pose a serious risk to sparrow recovery. If we are to effectively manage sparrow populations we must be able to distinguish between fires, and fire regimes, that enhance sparrow numbers versus those that do not. Existing studies that relate fire regimes to sparrow populations have important limitations that preclude our making such distinctions.

By necessity and circumstance, previous research relied heavily on point-in-time observations and study designs that severely limit our ability to produce broader inferences. Stimson's conclusions were based on exemplary natural history observations, but no quantitative analysis. Werner (1975) and Curnutt et al. (1998) rely on synchronic study designs, where existing spatial patterns in time since fire are assumed to mimic patterns we would observe by temporally following several populations through a fire event (Figure 1, top panel). Although the dominate method for studying the effects of fire on vertebrate populations (e.g., Davis et al. 2000, Breininger and Schmalzer 1989, Pylypec 1991, Dees et al. 2001), this approach confounds the effects of fire with unrelated differences between sites (Whelan 1995). Thus, observed differences in sparrow density between sites could reflect unaccounted for variance in soil depth, hydrologic flow, or elevation as easily as it could reflect differences due to time since fire (Tyre et al. 2000).

Some of Werner's and Taylor's analyses avoided such problems by documenting sparrow densities just before a prescribed fire, and again just after that fire (i.e. they were diachronic or longitudinal study designs; Figure 1, bottom two panels). However, these study's suffered from problems in inference because (1) they often did not compare sparrow densities within the burned plots to unburned "control" plots (Figure 1, middle panel) and (2) observations did not extend long enough before or after fire to adequately account for natural variations in the sparrow's annual population size (Whelan 1995). Thus, it is difficult to affirm that changes in sparrow density after burning were due to the fire's effects, and not to unaccounted for variables that also determine fluctuations in sparrow densities such as food supplies, predator densities, or over-wintering survival rates.

In sum, previous research provides sufficient evidence that fires effect sparrow populations, and that this effect is positive given certain circumstances. However, we can not adequately determine if fire always produces positive

effects, nor can we realistically determine how quickly sparrow populations will recover from the effects of fire.

PROPOSED STUDY DESIGN AND METHODOLOGY

An effect that is seen consistently in replicates of a well-designed experiment can only reasonably be explained by the manipulation of experimental variables (Manly 2001). Thus, Whelan (1995) suggests that studies of the effects of fire on vertebrate populations should utilize experimental study designs whenever possible (Figure 1, bottom panel). Fire is the manipulated experimental variable, and thus fire is introduced to several replicate study plots. Some replicate plots are not subjected to fires, thus serving as controls. The effects of fire (e.g., changes in sparrow density) are monitored before and after the experimental manipulation across all plots, including the controls. This study design effectively distinguishes between natural variation in the effect variable (i.e. sparrow density) and variation caused by the experimental manipulation (i.e. fire).

This approach solves problems associated with previous research. However, fully implementing an experimental design here is impossible for two reasons. First, the manipulated variable (i.e. fire) has a direct effect on the survival of sparrow populations. It is possible (maybe even probable) that fire will have a benign or positive effect on sparrow populations. However, we can not discount the possibility that the experimental manipulation will 'cause harm' to the sparrow. Given that the Cape Sable seaside sparrow is listed as Federally endangered, subjecting populations to harm is against Federal law, and is not particularly prudent. Second, even if Federal approval were granted for such experimental manipulations, the scale over which meaningful experiments should be conducted assures that plots will not serve as useful replicates of one another. Sparrow's maintain territories of 2ha in diameter (Lockwood et al. 2001). To incorporate a sufficient number of sparrow territories into each plot to satisfy sample size requirements, tens of hectares are needed in each replicate plot. Confounding variables such as elevation, hydrologic flows, soil depth, and local weather patterns vary at scales well within this spatial extent.

When replication is not feasible, the same basic study design is still desirable (Manly 2001, Stewart-Oaten et al. 1986, Whelan 1995). Care must be taken in the choice of statistical methods and in the interpretation of results. However, it is possible to draw robust inferences from such quasi-experimental designs (Manly 2001, Whelan 1995). A quasi-experimental design employs a two-group comparison without randomization (Figure 1, bottom panel; Manly 2001). The manipulation (i.e. fire) is introduced into one plot, while another is left unaffected. The effect variable of interest (e.g., sparrow density) is monitored before and after the manipulation. In order to account for underlying annual

variations in the effect variables, Whelan (1995) suggests monitoring the plots for equal amounts of time before and after the manipulation is introduced. For vertebrate populations, this typically requires two or more years of information collected before fire is introduced, followed by a further two or more years of post-fire information (Whelan 1995).

It is possible to utilize a quasi-experimental design here because an unplanned fire was allowed to burn through approximately 40% of an existing study plot in May 2001 (Figure 2). We have been marking individual sparrows, mapping breeding territories, locating and monitoring nests, measuring vegetation, and documenting food items at this site since 1998; three years pre-fire (Lockwood 2000). The thrust of this proposal is then to continue collecting this same information for four years post-fire. By collecting information within and outside the burned area, we can more effectively account for natural variation between the burned and control sites, as well as for annual variations in sparrow population dynamics. This proposed study design is thus capable of providing more clarity on the response of sparrow populations to fire.

The assumption in such designs is that any naturally occurring (i.e. unaccounted for) changes in density will be nearly the same in the control and burned plots. Any extreme changes in density within the burned plot can then be attributed to the fire (Manly 2001). Evidence for an effect of fire on sparrow populations is provided by a statistically significant change in the difference between the control and burned plot before and after the time of burning. On the other hand, if the two plots remain exactly the same before and after fire, then there is no evidence of an effect on sparrow population dynamics (Figure 3). To assure that the control and burned sites are sufficiently similar in terms of confounding differences between sites, we will collect information on vegetation, local water flows, elevation, and soil depth.

This study design also allows us to determine the nature of any lasting effects of fire on sparrow populations (although only up to three or four years post-fire). There are at least four lasting effects fire may have on sparrow populations (Figure 3). First, sparrow numbers may decrease after fire and never returns to levels equal to the control site (i.e. Stimson's view). Second, sparrow numbers may decrease after fire and eventually recover to levels that are indistinguishable from the control site (i.e. Curnutt's view). Third, sparrow numbers may significantly increase after fire and never return to control site levels. Fourth, numbers may increase after fire but eventually return to control site levels (i.e. Werner and Taylor's view). It is possible to objectively choose between these competing models using maximum likelihood statistics, even when problems of pseudo-replication are apparent (Steward-Oaten et al. 1986).

We not only want to understand how sparrow numbers change after fire, but also why they change. Another limitation of previous research was their exclusive reliance on sparrow density as a gauge to the effect of fire on sparrow populations. Density is a crude measure of a population's response to local disturbances such as fire (Whelan 1995). Using density information we may learn that the number of individuals increases or decreases after a fire, however we have little knowledge as to the response of demographic attributes such as fecundity, mortality, and dispersal. Any one, or all, of these demographic variables could be effected. A detailed understanding of how sparrow demography responds to a fire provides a great deal more insight into how fire may be managed to minimize risks to the subspecies' survival (Akçakaya et al. 1999).

For example, each life stage (e.g. adults, juveniles, nestlings) may experience unique rates of mortality, fecundity, and dispersal. These characteristic responses can be incorporated into a stage- or age-structured model allowing population size to be projected into the future (Akçakaya et al. 1999). The variability observed in these numbers, and the rates at which these variables return to normal, can also be incorporated. Using this approach, the effects of proposed fire regimes can be inferred from the results of relatively short-term studies (Wellington and Noble 1985, Whelan 1995). Demographic variables are re-set to their post-fire state based on proposed burning schedules. Each burning schedule is modeled independently and the range of possible effects on sparrow populations are produced. These projections can then allow managers to choose a fire management option that best minimizes the risk of sparrow extinction while maximizing other ecosystem benefits (Akçakaya et al. 1999). Because we have detailed demographic information that includes the effects different flood regimes (Lockwood et al. 2001), we can also overlay the sparrow's demographic response to fire onto their demographic response to altered hydrologic flows (e.g., within ATLSS simulations; Curnutt et al. 2001).

The information required for such a forecasting approach is based on an initial banding effort, regular censuses, and time. Thus, the methodology needed is equivalent to that needed to document various fire effects from above. We already have three years of detailed demographic information. We also have dispersal and survivorship information collected immediately after the burn (in June 2001). By continuing to monitor and mark the population, find and monitor nests, and map the location of territories for the next three to four years, we can collect enough information to make a modeling approach feasible.

Because the fire incorporated into this study design was unplanned, it is not possible to document the immediate effects of fire on fecundity and mortality. However, because we know a great deal about the limiting factors for the sparrow, we can begin to document the reasons why reproduction, mortality,

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and dispersal may change in the years after a fire. The primary limits on reproduction are predation, localized weather patterns that flood active nests, and food availability (Lockwood et al. 1997, Lockwood et al. 2001). The primary limits on juvenile and adult survival rates are less clear, but are likely influenced by predation and food availability (Dean and Morrison 2001). The quasi-experimental study design allows us to document differences between the control and burned sites in these secondary variables and then look any correlations to changes in demographic variables.

For example, to document demographic changes related to the availability of food we can measure body condition of adults, fledging weight of young, and types of food brought to nestlings. Similarly, we can document reasons why fecundity varies between sites by documenting differences in nest predation rates, and types of nest predators, between sites. Finally, we can document changes to important vegetation components between the two sites (e.g., percent ground cover, presence and height of perching substrate, presence and cover of bunchgrasses). Any significant changes are then evaluated for their role in determining demographic differences between sites (e.g., using regression).

Migration between burned and unburned habitat is likely to play a relatively large role in the degree of fire impact, and the rate of population recovery after fire. Populations may recovery quickly if displaced adults and mobile juveniles simply move to adjacent unburned habitat and then return immediately after the habitat returns to a suitable breeding condition. Similarly, differences in reproduction and mortality between the burned and control sites may reflect the tendency for young birds to preferentially recolonize recently burned sites. Because we are following a population that was marked before the fire event, we can document changes in their distribution after fire and how long these changes persist. Changes in sparrow distribution can be documented by carefully mapping the locations of all territory holding adults and identifying the location and movements of any unmated individuals. We will also resight fledglings throughout the breeding season and early non-breeding season, documenting their movements and eventual site of settlement. The opportunity to collect such information on vertebrate populations subjected to fire is rare (Whelan 1995), and thus our results should be of general interest.

RELATIONSHIP OF PROPOSED STUDY TO CONCURRENT RESEARCH

There are at least two other proposed (or funded) studies that address the relationship between fire and Cape Sable seaside sparrow populations. This proposal was designed to compliment these approaches by recognizing their various limitations and spatially linking population and ecosystem-wide fire effects. This study is limited in two important respects, each reflecting a fundamental trade-off between obtaining detailed demographic information

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versus incorporating the full complexity of the combined effects of fire and flooding.

First, the proposed study can not adequately address how sparrow habitat responds to the combined effects of fire and flood. The study is uniquely conceived to address how sparrow demography responds to one fire event. I have purposefully limited the spatial extent of the study such that the burned and control sites differ as little as possible; this includes differences in vegetation and flood regime. Because this study will correlate changes in demographic parameters to fire-induced changes in vegetation (given a static flooding regime), the results can be combined with the proposed research of M. Ross and colleagues at Florida International University. Their study plan calls for a detailed analysis of how fire and flood alter vegetation, and can thus provide the basis for predicting how alterations in sparrow habitat will induce sparrow population changes across the entirety of the sparrow's range.

Second, this study is limited in spatial and temporal extent. Thus, I can not address long-term (>4 year) changes in sparrow populations except through projection matrix models. Further, this study can not address the effects of fires that burn at other times of the year (i.e., wet-season fires), are ignited by resource managers or lightening, or burn over much larger (or smaller) areas. The information exists to document how segments of the sparrow population responded to 10+ years of fire events, including analyzing how sparrow populations and habitat responded to landscape-scale differences between these events. This is the spatial and temporal domain of the proposed work of S. Pimm at Columbia University. The results of my proposal will provide needed insight into why various patterns emerge from Pimm's analyses, and whether or not we would have predicted the presence of these patterns given what we know about how demographic variables respond to fire. The two approaches also provide important checks on one another, especially when attempting to project the response of sparrow populations to proposed fire management options. If results from the two approaches reinforce one another, this provides a stronger assurance that any fire management actions adopted will satisfy, and not obstruct, recovery goals (Tyre et al. 2000, Hilborn and Mangel 1997).

BUDGET AND JUSTIFICATION

This budget is projected over a four-year span, with the caveat that the first year's budget is the most certain. There are two primary expenses; personnel and equipment. The study site is in a portion of Everglades National Park that is only accessible via helicopter. Relatively constant monitoring is required to obtain reliable demographic information, thus the successful completion of the study requires very frequent overnight stays within a backcountry camp. Using prior funds, we have built (and rebuilt) a camp within this study plot (see Figure

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2 for its location). We have found the camp a comfortable residence for visits that last three nights and four days. Staffing this backcountry camp thus requires the rotation of skilled and independent research assistants over the span of the breeding season (4+ months). These research assistants work independently and must therefore show very good personal safety and data collection judgement. For these reasons, the majority of requested funds are to hire an experienced research associate that will reside in Florida, oversee the majority of the day-to-day field operations (including banding), and provide post-field season assistance. Also included are funds to support a graduate student. In consultation with the PI, this student will be responsible for the analysis and publication of resulting information. This student will also likely reside in Florida (as much as is feasible) and, together with the research associate, provide the backbone of the yearly field crew. Associated personnel expenses include the support of student interns, travel funds, and PI summer salary.

Of considerably less magnitude, but providing the remainder of the budget costs, is the acquisition of equipment. From previous funds, we already possess needed equipment for camp living and for frequent helicopter flights. This budget includes costs associated with keeping this equipment in good condition, replacing lost or damaged items, and maintaining the camp structure. Additional equipment costs include the acquisition of computers, GPS receivers, banding equipment, solar chargers (for powering electronics while at the camp), and automated dataloggers.

The field season will run from March to August. Data analysis, and preparation of annual reports, will occur from August to February. Annual reports will be produced by March 1st of each year. To coordinate the progress of the various concurrent projects, we suggest an annual fire management retreat be convened in October or November. Given the establishment of such a retreat, I will present updated findings to resource managers and associated research personnel annually.

LITERATURE CITED

- Akçakaya, H.R., M.A. Burgman, and L.R. Ginzburg. 1999. Applied population biology. Sinauer Associates, Inc. Sunderland, MA.
- Breining, D.R. and P.A. Schmalzer. 1989. Effects of fire and disturbance on plants and birds in Florida Oak/Palmetto scrub community. *American Midland Naturalist* 123:64-74.
- Curnutt, J.L., A.L. Mayer, T.M. Brooks, L. Manne, O.L. Bass Jr., D.M. Fleming, M.P. Nott, and S.L. Pimm. 1998. Population dynamics of the endangered Cape Sable seaside-sparrow. *Animal Conservation* 1:11-21.
- Curnutt, J.L., J. Comiskey, M.P. Nott, and L.J. Gross. 2000. Landscape-based spatially explicit species index models for Everglades restoration. *Ecological Applications* 10 (6):1849-1860
- Davis, M.A., D.W. Peterson, P.B. Reich, M. Crozier, T. Query, E. Mitchell, J. Huntington, and P. Bazakas. 2000. *Restoration Ecology* 8:30-40.
- Dean, T.F. and J.L. Morrison. 2001. Non-breeding season ecology of the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Final Report submitted to USFWS, South Florida Ecosystem Office, Vero Beach, FL.
- Dees, C.S., J.D. Clark, and F.T. Van Manen. 2001. Florida panther habitat use in response to prescribed fire. *Journal of Wildlife Management* 65:141-147.
- Egler, F.E. 1952. Southeast saline Everglades vegetation, Florida, and its management. *Vegetatio* 3:213-265.
- Gunderson, L.H. and J.R. Snyder. 1994. Fire patterns in the southern Everglades. In *Everglades: the ecosystem and its restoration* (S.M. Davis and J.M. Ogden, eds.). Pages 291-306, St. Lucie Press, Boca Raton, FL.
- Hilborn, R. and M. Mangel. 1997. *The ecological detective*. Princeton University Press, Princeton, N.J.
- Kushlan, J.A. and O.L. Bass Jr. 1983. Habitat use and the distribution of the Cape Sable sparrow. In: *The seaside sparrow, its biology and management*. (Quay, T.L., J.B. Funderburd Jr., D. Lee, E.F. Potter, and C.S. Robbins, eds). North Carolina Biological Survey and North Carolina State Museum.

- Lockwood, J.L., K.H. Fenn, J.M. Caudill, D. Okines, O.L. Bass Jr., J.R. Duncan, and S.L. Pimm. 2001. The implications of Cape Sable seaside sparrow demography for Everglades restoration. *Animal Conservation* 4:275-281.
- Lockwood, J.L., K. H. Fenn, J.L. Curnutt, D. Rosenthal, K.L. Balent, and A.L. Mayer. 1997. Life history of the endangered Cape Sable seaside sparrow. *Wilson Bulletin* 109:720-731.
- Manly, B.F.J. 2001. Statistics for environmental science and management. Chapman & Hall/CRC Press, Boca Raton, FL.
- Pylypec, B. 1991. Impacts of fire on bird populations in fescue prairie. *Canadian Field-Naturalist*. 105:346-349.
- Robertson, W.B. Jr. 1953. A survey of the effects of fire in Everglades National Park, Everglades National Park, National Park Service, U.S. Department of Interior, Homestead, FL.
- Stewart-Oaten, A, W.W. Murdoch, K.R. Parker. 1986. Environmental impact assessment: "pseudo-replication" in time? *Ecology* 67:929-940.
- Stimson, L.A. 1956. The Cape Sable sparrow: Its former and present distribution. *Auk* 73:489-502
- Stimson, L.A. 1968. Cape Sable sparrow. In: Life histories of North American Cardinals, Grosbeaks, Buntings, Towhees, Finches and Sparrows. (O.L. Austin Jr., ed.) Pages 859-868. U.S. Nat. Mus. Bull. 237, Part 2.
- Taylor, D.L. 1983. Fire management and the Cape Sable sparrow. In: The seaside sparrow, its biology and management. (Quay, T.L., J.B. Funderburd Jr., D. Lee, E.F. Potter, and C.S. Robbins, eds). North Carolina Biological Survey and North Carolina State Museum.
- Tyre, A.J., B. Tenhumberg, M.A. McCarthy, and H.P. Possingham. 2000. Swapping space for time and unfair tests of ecological models. *Austral Ecology* 25:327-331.
- Wellington, A.B. and I.R. Noble. 1985. Post-fire recruitment and mortality in a population of the mallee *Eucalyptus incrassata* in semi-arid, southeastern Australia. *Journal of Ecology* 73:645-656.
- Werner, H. 1975. The biology of the Cape Sable seaside sparrow. Report to US Fish and Wildlife Service. Everglades National Park, Homestead, FL.

- Werner, H. and G.E. Woolfenden. 1983. The Cape Sable seaside sparrow: its habitat, habits and history. In: The seaside sparrow, its biology and management. (Quay, T.L., J.B. Funderburd Jr., D. Lee, E.F. Potter, and C.S. Robbins, eds). North Carolina Biological Survey and North Carolina State Museum.
- Whelan, R.J. 1995. Ecology of fire. Cambridge University Press, Cambridge, UK.

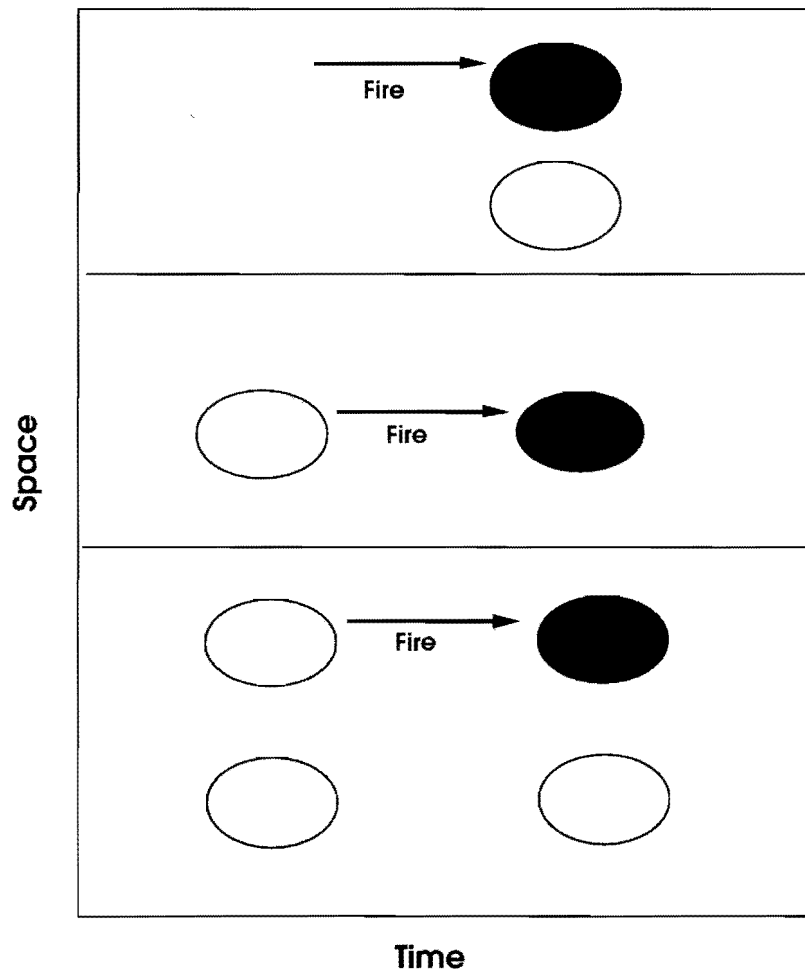


Figure 1. Study designs used, or proposed, for determining the impact of fire on Cape Sable seaside sparrows populations. Top panel represents the synchronic design utilized by Werner (1975) and Curnutt et al. (1998). Middle panel represents a diachronic, one-group pre-test/post-test design (Werner 1975, Taylor 1983). The bottom panel, if replicated, represents a two-group comparison that satisfies experimental protocols. If not replicated, the bottom panel represents a quasi-experimental design typical of ecological impact assessments (Manly 2001).

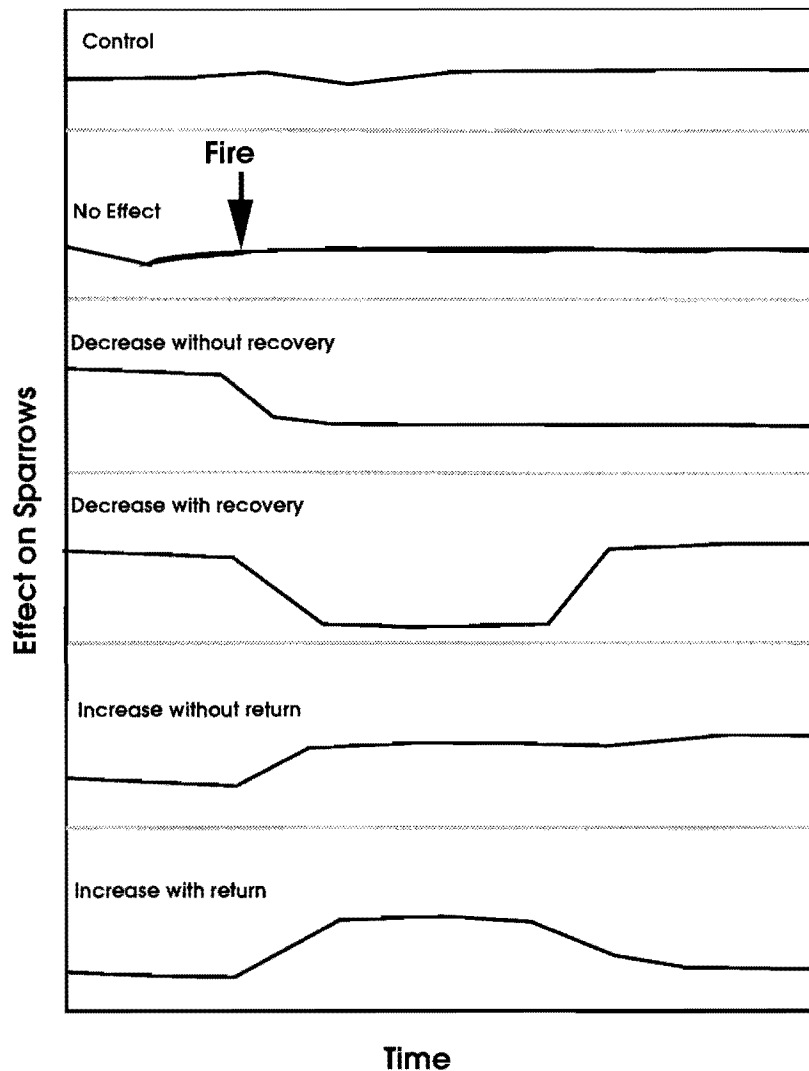


Figure 3. Possible long-lasting effects of fire on Cape Sable seaside sparrow populations. Choosing between these effects relies on comparison of demographic traits between sparrows living within the control (i.e. unburned) site and the burned site.

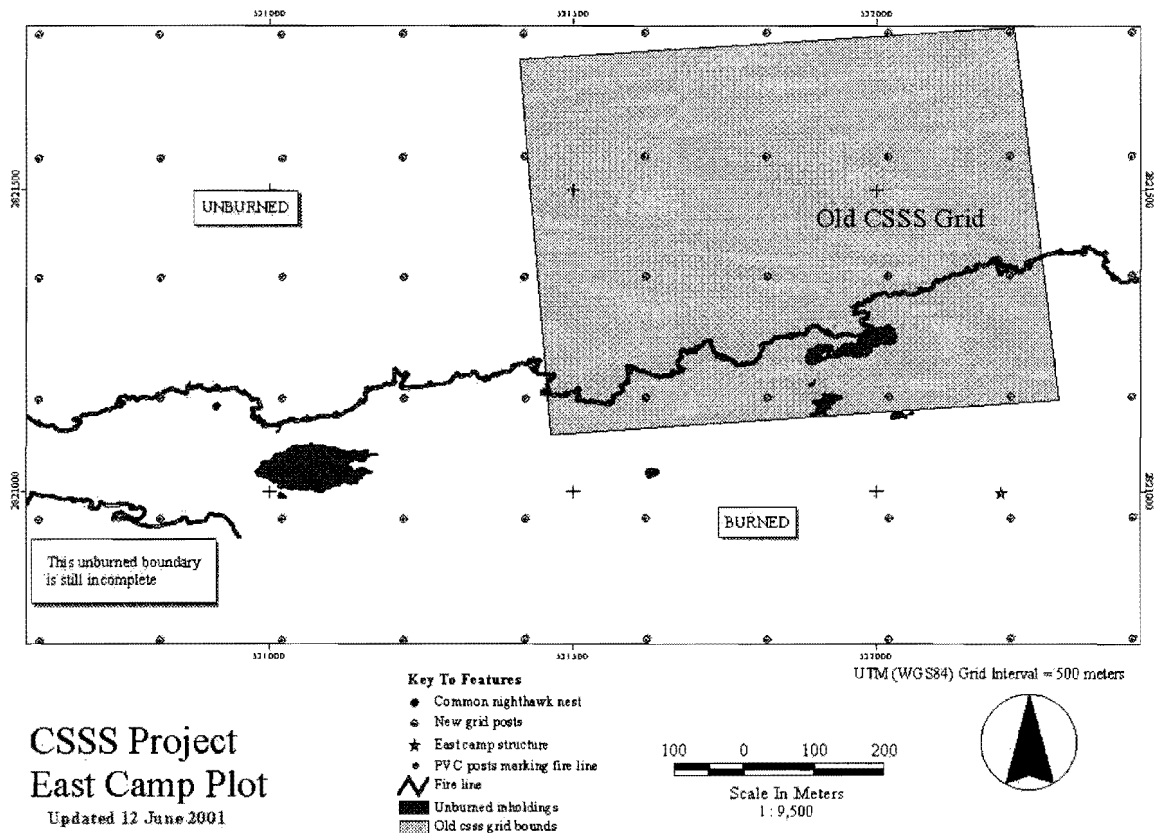


Figure 2. Overview of East Camp study plot post-2001 fire. From 1998-2000 we managed a plot that encompassed nearly the entire area pictured here. In 2000, we established a smaller plot labeled here as 'Old CSSS Grid' that was equal in size to other long-term plots. We are proposing to re-occupy the entirety of the former plot in order to document the effects of the May 2001 (Lopez) fire. This map is now complete and is available upon request.

First Year Budget

Salaries

PI summer salary	2.5 months		\$10,125.00
Fringe		9.20%	\$931.50

Research Associate	1 year		\$25,000.00
Graduate Research Assistantship	1 quarter		\$5,588.00
Graduate summer salary	three months		\$3,600.00
	sub-total		\$45,244.50

Travel

Car rental	5 weeks @ \$200		\$1,000.00
Airfare	4 trips @ 600.00		\$2,400.00
Housing	1 month @1000		\$1,000.00
Perdiem for volunteers	6 months at \$600.00		\$3,600.00
	sub-total		\$8,000.00

Other costs

supplies			\$10,000.00
	sub-total		\$10,000.00

Direct Costs			\$63,244.50
Overhead		15%	\$9,486.68
Grand total			\$72,731.18

Appendix: Study plots

Our permanent study plots are distributed throughout the Cape Sable seaside sparrow's range. We established 12 study plots between the 1993 and 2000 field seasons. We provide brief descriptions of each below. Study plots are permanently established rectangular areas that originally spanned from 36 to 1100 ha in extent. All active plots were standardized in 1999 to 0.5km² (50ha). We placed them non-randomly, with their location being determined by the nature of the question we wished to address. Thus, nest observations, feeding observations, and survival estimates of large numbers of birds are best approached in areas with high densities of sparrows, and within areas that are easily accessible. For that reason we have established most plots within population B, along either Main Park Road (SB, DL, NM, AH) or Old Ingraham Highway. (OIHN, OIHS, FE). In order to understand why sparrows may avoid certain sites, and hopefully to document any population recovery, it was necessary to establish plots that do not contain sparrows (FG, TS). We have established four plots outside of the 'core' population B (TP, CP, AJ, and SV). Three of these require access via helicopter (TP, CP, SV). Each of these peripheral plots has experienced drastically different hydrologic flows. Two of these sites (AJ and CP) experienced sharp declines in sparrow numbers early on in our study. The study population at CP was extirpated in 1995. For this reason, AJ and CP were dropped from our study relatively early. In response, we established replacement peripheral plots within population A (SV) and E (TP) in 1997 and 1998 respectively.

Description of study plots

Taylor Slough (TS) est. 1993 – This plot is 1100m by 600m (66 ha) and lies within the plot that Harold Werner established in 1974. It runs along the East Side of Taylor Slough and is bisected by the Main Park Road. The vegetation is dominated by sawgrass (*Cladium jamaicense*) with some muhly grass (*Muhlenbergia filipes*), and consists of large areas of "pinnacle rock" (exposed limestone) with infrequent patches of well-developed soil. Being at the edge of the slough, and downstream from a floodgate, this plot can become inundated early in the wet season by rain or by the opening of the floodgate. This plot is located within population D, and is no longer in use.

Aerojet (AJ) est. 1993 – This plot is 600m by 600m (36 ha) and is located halfway between the two sets of buildings on the former Aerojet Corporation property (now jointly managed by the South Florida Water Management District and the Florida Game and Freshwater Fish Commission). The area is predominantly long-hydroperiod and dominated by sawgrass; however, there are small, dryer

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patches dominated by muhly grass. This plot is located in one such patch, which accounts for its small size. This plot is within population D, and is no longer in use.

Sweetbay (SB) est. 1993 – This plot is located ca. 400m southeast of Sweetbay Pond, south of the remnants of Old Ingraham Highway within population B. The plot is dominated by sparse to moderate muhly grass, but remnant furrows from past agricultural activity provide habitat for a wide range of other herbaceous species. This plot usually remains dry throughout April and May.

Curnutt Plot (CP) est. 1993 – This plot is located on the west side of Shark Slough within population A. The plot is 800m by 800m (64 ha), and when originally established in 1993 was about 40% sawgrass and 60% mixed prairie. There were substantial patches of muhly grass. This plot was completely inundated throughout the 1993 field season, remained dry through most of the 1994 season, but was inundated again in 1995. The vegetation changed dramatically, and the study population was extirpated. For this reason, this plot has not been monitored since 1995.

Old Ingraham Highway North (OIHN) est. 1993 – This plot is located less than 100m north of the west end of the Old Ingraham Highway, within population B. The plot is mixed prairie habitat dominated by muhly grass and sawgrass, and remains dry throughout April and May.

Old Ingraham Highway South (OIHS) est. 1994 – This plot is located south of the west end of Old Ingraham Highway, within population B. The northeast corner of this plot is ca. 500m south of the Old Ingraham Highway North (OIHN) plot established in 1993. Like OIHN, the plot is mixed prairie habitat dominated by muhly grass and sawgrass, with little surface water throughout April and May. However, the grass cover at this plot is, on the whole, much more dense than OIHN.

Dogleg (DL) est. 1994 – This plot, located within population B between the Main Park Road and the remnants of the Old Ingraham Highway, is much longer than wide (hence its name) but is 50ha. Muhly grass and sawgrass dominate the vegetation.

Finger Glade (FG) est. 1995 – This plot is located in a large finger glade west of the Hole-in-the-Donut and north of the (unpaved) Long Pine Key Road, within population B. The vegetation is dominated by muhly grass and *Spartina* spp. Cover is very dense throughout the plot, indicating a lack of fire in recent years. Remnants of furrows indicate that much of the plot has been farmed sometime in the past. Sparrows have never occupied this plot, and thus we have not visited this plot since 1996.

North Mahogany (NM) est. 1996 – This plot is located 0.5 miles North of the Mahogany Hammock turnoff along Main Park Road, within population B. The plot originally encompassed both sides of the road, but now is only present east of the road. This plot is dry throughout April and May, and is dominated by sawgrass and muhly grass. In the summer of 1994, the back portion of this plot burned.

Alligator Hammock (AH) est. 1996 – This plot is located along Main Park Road, directly across from DL and Sweetbay pond, within population B. Despite its close proximity to DL, it is more densely covered in vegetation, and sawgrass cover is more common than muhly grass. The area floods earlier, and stays wet longer, than the plots on the east side of Main Park Road. The road itself acts as a levy, restricting water flow and forcing water to accumulate on its 'upstream' side within this plot.

Far East (FE) est. 1997 – This plot is located directly east of OIHN, along the north side of the Ingraham Highway, and within population B. The two plots share a boarder. Despite its close proximity to OIHN, this plot has less cover and vegetation is much sparser. Muhly grass and sawgrass, with significant amounts of *Schzyachrium rhizomatum* dominate the plot. This plot is dry throughout April and May, and usually stays drier than either OIHN or OIHS.

Shark Valley (SV) est. 1997 – This plot is located in population A, about 5 miles southwest of the Shark Valley Lookout Tower. This plot lies along the western boarder between Everglades National Park and Big Cypress National Preserve. This plot is by far the wettest, typically containing standing water in all months except April and May. The plot is dominated by sawgrass, and contains no muhly grass.

Tomato Patch (TP) est. 1998 – This plot is located in population E, about 1 mile north of an old tomato field (hence its name) and 1 mile northeast of Context Road. The plot remains dry for several months of the year; it is the last of our study plots to hold standing water during the summer storms. Sawgrass and muhly grass dominate this plot, although it contains much *Schzyachrium rhizomatum*. This plot lies adjacent to the former (pre-1980s) eastern boundary of Everglades National Park, and as such contains a mosaic of burn frequencies.