Effects of Wet- and Dry-Season Fires on *Jacquemontia curtisii,* a South Florida Pine Forest Endemic

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ABSTRACT: South Florida pine forests have a diverse endemic flora that has evolved under the influence of recurrent fire. We studied the response of *Jacquemontia curtisii* Peter ex Hallier f. (pineland clustervine), a perennial herbaceous member of that flora, to experimental fires during wet and dry seasons. In each of three populations, three treatments were applied: wet-season (June) prescribed fire, dry-season (January) pre-scribed fire, and an unburned control. Flowering, fruiting, and seedling establishment were followed for up to one year. Mortality of adult plants was twice as great after wet-season burns than after dry-season burns even though fire temperatures were higher in the dry-season burns. Within a season of burning, mortality was greater for the more severely burned plants or the smaller plants. Wet-season burns produced over three times more flowers than not burning, in spite of mortality of more than half the plants. Burning stimulated germination from the soil seed bank. Dry-season burns resulted in five times more seedlings than wet-season burns and more of these seedlings were alive one year after the burn. It is likely that the long-term viability of *Jacquemontia curtisii* populations is favored by diversity in fire season and severity.

Index terms: fire ecology, flowering, plant mortality, prescribed fire, recruitment

INTRODUCTION

Fire has been a primary selective force in the development and maintenance of South Florida vegetation patterns (Egler 1952, Robertson 1953, Wade et al. 1980), pat-terns that have been much the same for the last 5,000 years (Gleason and Stone 1994). The natural landscape of southern peninsular Florida consists of predominantly graminoid- and cypress *(Taxodium* spp.)-dominated wetlands, with limited upland areas dominated by South Florida slash pine *(Pinus elliottii* var. *densa* Little & Dorman) forests (Snyder et al. 1990). Some 65 vascular plant taxa are endemic to south-ern Florida; more than half are herbs and low shrubs restricted to pine rocklands (Avery and Loope 1980). In the absence of fire for two or three decades, pine forests develop closed hardwood canopies and lose the characteristic understory flora (Robertson 1953, Snyder et al. 1990).

Southern Florida has mild, dry winters and hot, rainy summers. It may be charac-terized as having a tropical seasonal cli-mate with wet and dry seasons, although temperatures occasionally drop below freezing. About 75% of the annual rainfall of 140 cm falls in the wet season from May to October, a period when convective thunderstorms are common (Duever et al. 1994). The number of lightning-caused fires increases during May and June, peaks in July, then decreases in August through October. The largest and most severe light-ning fires occur early in the wet season before water levels have risen. Human-caused wildfires are most common during the dry season, with frequency and area burned increasing as the dry season progresses (Robertson 1953, Snyder 1991). Lightning was probably the dominant source of ignition before the arrival of European settlers. However, Native Amer-icans have been present in southern Florida for thousands of years (Can and Beriault 1984, Gleason and Stone 1994), and they may have used fire extensively at certain times, including the dry season.

Prescribed fire has been used in South Florida for natural area management for many decades. Prescribed burning began in the pinelands of Everglades National Park in 1958. Prescription burns were generally conducted during the cooler dry-season months, which was the traditional practice for range management in Florida (Wade et al., 1980, Snyder 1991). In re-cent years there has been increasing interest in using prescribed fires during the wet season for managing natural areas (Rob-bins and Myers 1992).

One of the most conspicuous consequences of fire, next to the immediate impact on aboveground biomass, is the increased flowering of perennial species (Gill 1981, Whelan 1995). The season in which the fire occurs influences the degree to which flowering is stimulated (Platt et al. 1988, Robbins and Myers 1992). Little attention has been directed to comparing the life history and demographics of individual plant species after fires at different times of the year.

In South Florida pine forests many herb-layer species flower profusely after burning at certain seasons (Robertson 1953, Wade et al. 1980, Snyder et al. 1990). This study was undertaken to compare the population biology—flowering, fruiting, mortality, and recruitment—of an endemic pine forest herb in response to fires in the wet season (when lightning-ignited fires occur) with its population biology in response to fires in the dry season (when most human-caused fires occur). It is assumed that the response of *Jacquemontia curtisii*, an obligate member of the South Florida pine-land flora, has been shaped by the fire regime that has existed throughout the development of this pine forest community. Therefore, if wet-season fires have been the norm, more favorable population responses should occur after wet-season burning than after dry-season burning.

METHODS

Study Species

Jacquemontia curtisii Peter ex Hallier f. (Convolvulaceae) is a perennial procumbent vine with a woody base that enables it to survive periodic fire. Numerous stems up to 1 m long radiate from the base and may twine up neighboring plants. Flowering occurs year-round (Long and Lakela 1976) but the peak is from November through June (Robertson 1971). The conspicuous white flowers are 2–3 cm in diameter and are solitary or arranged in axillary cymes. The fruit is a globose capsule 5–6 mm long that dehisces by four valves to release four brown seeds 3–3.2 mm long (Robertson 1971). The seeds show no obvious dispersal mechanism other than gravity.

There is some confusion associated with the spelling of *Jacquemontia curtisii*. The relevant manuals and floras (e.g., Long and Lakela 1976, Wunderlin 1982) spell the specific epithet *curtissii* because the species name commemorates Allan Hiram Curtiss. However, Hallier validly published the name in 1897 and deliberately used a single "s" (Robertson 1971).

Jacquemontia curtisii is restricted to pine forests on outcroppings of Miami and Tamiami limestone in Dade, Collier, Mon-roe, and Hendry Counties (Austin 1979, Wunderlin 1982). Most of its extant range is included within Everglades National Park and Big Cypress National Preserve. *Jacquemontia curtisii* is listed by the Florida Department of Agriculture as threatened and was previously under review for federal listing by the U.S. Fish and Wild-life Service (Wood 1994).

Study Area

Populations of *J. curtisii* were studied in the Raccoon Point area of Big Cypress National Preserve (26°00'N, 80°55'W), approximately 70 km west of Miami, Florida. Raccoon Point is a mosaic of upland South Florida slash pine forests and wet-land pond cypress *(Taxodium ascendens* Brongn.) forests. The pinelands have a shrub layer composed primarily of palms, *Sabal palmetto* (Walt.) Lodd. *ex* J.A. & J.H. Schultes and *Serenoa repens* (Bartr.) Small, and a grassy herb layer dominated by *Schizachyrium rhizomatum* (Swallen) Gould, *Rhynchospora divergens* Chapman *ex* M. *A.* Curtis, and *Muhlenbergia filipes* M.A. Curtis (Gunderson and Loope 1982). In addition to *J. curtisii* and *S. rhizomatum*, *Dyschoriste angusta* (Gray) Small, *Hyptis alata* var. *stenophylla* Shinners, and *Tripsacum floridanum* Porter *ex* Vasey are endemic to these pinelands (Avery and Loope 1980; and author, pers. obs.).

Soils consist of fine to coarse sands covering Tamiami limestone bedrock to an average depth of 20 cm (Gunderson and Loope 1982, Duever et al. 1986). Soils may remain wet for a few months during the rainy season when the water table is at or near the soil surface. These pinelands are intermediate between the more tropical Miami rock ridge pinelands on oolitic limestone in southeastern Florida and typical coastal-plain pine flatwoods on acid sands to the north (Snyder et al. 1990).

Treatments

Sites were established in three pine stands approximately 3.5 km apart. The pine stands had relatively dense populations of *J. curtisii* and had not burned for at least three years. At each site, three groups of 40 adult *J. curtisii* plants were marked with aluminum tags and each group was randomly assigned to one of three burning treatments: (1) wet-season (lightning sea-son) burn, (2) dry-season (traditional pre-scribed burning season) burn, and (3) an unburned control. The diameter of the woody base of each tagged plant was measured to the nearest millimeter.

The irregularly shaped treatment plots ranged from 0.1 to 1.0 ha. In each plot the total numbers of adult *J. curtisii* plants and pine trees (>5 cm dbh) were counted and shrub cover was estimated using the Braun-Blanquet cover-abundance scale (Mueller-Dombois and Ellenberg 1974).

Burn temperatures were measured with sets of 10 temperature-sensitive pellets that melt at temperatures ranging from 50"C to 500°C (Tempil° Pellets, Tempil° Division, Air Liquide America, Corp., South Plain-field, N.J.). The sets of pellets were placed on the ground at 10 locations in each plot. Environmental conditions, including ambient temperature, relative humidity, wind speed at ground level, and rates of spread of the fire front, were monitored during each burn. Immediately after the burns, temperature pellets were evaluated and each *J. curtisii* was categorized according to the severity of burn damage it had received: 1 = plant consumed, only stem bases remaining; 2 = partially burned, part of plant consumed but some leaves remaining; 3 = scorch damage only, all leaves remaining.

Measurement of Response

Plant mortality was assessed when data collection on flowering was initiated eight to nine weeks after burning. Flowering and fruit set were monitored weekly in all plots. Flowers remain open for only one day so the total number of flowers for the week was estimated by counting all open flowers and flowers with withered corollas. This procedure does not account for losses to herbivory or early dehiscence of flowers, so it underestimates the total number of flowers produced. Only mature fruits were counted.

Plants in the wet-season burn treatment and control plots were observed for one year. Plants in the dry-season burn plots were observed for six months, a period that included the peak flowering season. By the end of June, virtually no flowers could be found in any plot, and collection of flowering data ceased.

Seedlings germinating within 0.564 m of tagged plants (circular plot with area of 1 m^2) were counted and marked monthly. If seedlings were within 0.564 m of more than one adult plant, they were assigned proportionately to each plant. In the burn plots, *J. curtisii* seedlings were counted and marked during the first three months following the burn. These seedlings were attributed to fire-stimulated germination from the seed bank because there were few, if any, mature seeds produced within the first three months by surviving plants. Seedling mortality in burn plots was based on the number of seedlings produced in the first three months that were dead at the end of one year. Seedlings appearing in the unburned plots were counted and marked during one year. The estimate of mortality in unburned plots was based on the number of seedlings produced during the year that had died by the end of the year. This procedure overestimates the number of seedlings and underestimates mortality in control plots relative to burned plots.

Differences among treatments or sites were tested by analysis of variance (*F* statistic) or Kruskal-Wallis tests (Chi-square statistic). Comparisons between seasons of burning were generally tested with Mann-Whitney U tests (z statistic).

RESULTS

Site Composition

The three sites differed in understory shrub cover and pine tree density (Table 1). Site 3 had a predominantly mixed-grass under-story with low shrub cover, and site 2 had a shrub-dominated understory. Site 1 had intermediate shrub cover. Pine tree density ranged from 160 to 660 trees ha-' and was greatest at site 2. Densities of *J. curtisii* ranged from 0.3 to 6.4 plants m^{-2} and varied widely among plots at a given site (Table 1). The size (basal stem diameter) of the tagged plants also differed among the plots ($F = 15.8$, $p < 0.001$).

Table 1. Descriptive measures at each *Jacquemontia curtisii* study site in South Florida. Treatment W = wet-season burn, treatment D = dry-season burn, treatment C = unburned control.

	Site 1			Site 2			Site 3		
Measure	W	D	C	W	D	C	W	D	C
Shrub cover class	3	3	4	5	5	4	2	3	3
Pine density (#/ha)	160	170	170	330	660	310	160	290	170
J. curtisii density (#/m^2)	0.35	2.40	0.33	0.71	5.50	0.32	6.35	2.41	1.83
basal diam. (mm) (mean ± 1 SE)	8.1 ±0.7	13.2 ±1.0	9.8 ±0.6	5.1 ±0.3	9.1 ±0.7	5.5 ±0.5	6.6 ±0.4	8.3 ±0.6	9.1 ±0.6

Effects of Burn Treatments

Experimental burns were conducted on June 22, 1989 (wet season) and January 3, 1990 (dry season). The wet-season burns occurred soon after the rainy season had begun so that fuel moisture was higher than for the dry-season burns. Ambient temperature and relative humidity were slightly higher for the wet season bums than for the dry season burns (29°C and 63% for wet season, and 26°C and 60% for dry season). Wind speeds were light and variable—from 0 to 10 km hr' during the wet-season burns and relatively consistent at about 5 km hr' for the dry-season burns. Wet-season burns were ignited as backing and flanking fires with rates of spread no greater than 100 m hr'. The dry-season burns were burned with head fires with rates of spread from 200 to 300 m hr'.

Mean fire temperature of the dry-season burns (184 ± 10.4°C) was significantly higher than that of the wet-season burns (125 ± 4.7°C) ($F = 14.92$, $p < 0.0005$) be-cause of drier fuel conditions. Fire temperatures differed among the three sites during each season of burning (Figure 1), but no interaction occurred between site and season ($F = 0.82$, $p = 0.444$). Site 3 had the lowest fire temperatures and site 2 had the highest.

The degree of bum damage also differed between seasons (Figure 2), with dry-season bums completely consuming more plants than wet-season burns ($z = -6.94$, $p < 0.0005$). No significant differences were detected among the three sites after the dry-season burns (Chi-square = 2.84, $p = 0.241$) be-cause most plants sustained category 1 dam-age at all three sites. The damage to marked plants after wet-season burning differed sig-

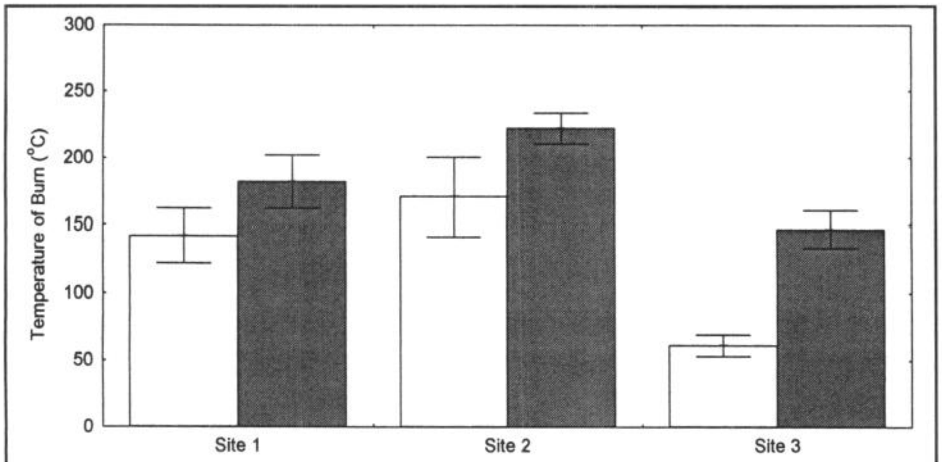

Figure 1. Temperatures of experimental wet-season (open bar) and dry-season (shaded bar) burns in South Florida study area (mean ± standard error, n=10).

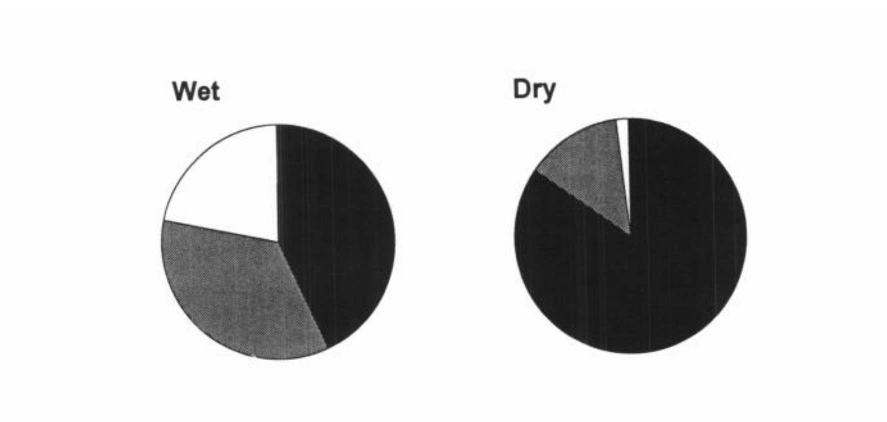

Figure 2. Proportion of adult *Jacquemontia* curtisii plants sustaining different degrees of damage during wet- and dry-season burns in the South Florida study area. Solid = all aboveground parts consumed (category 1), shaded = stems and leaves partially consumed (category 2), and open = scorching only (category 3). N = 120 for each season.

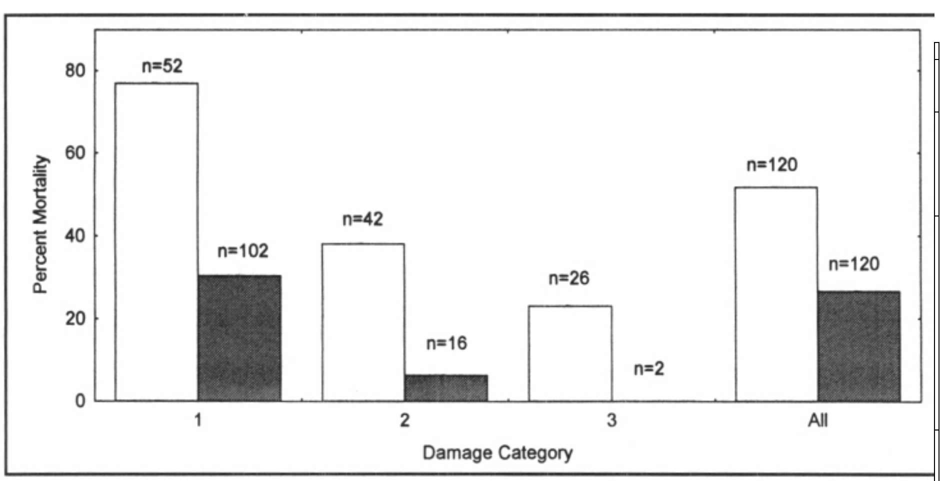

Figure 3. Postfire mortality of adult *Jacquemontia curtisii* plants that sustained varying degrees of damage after wet-season (open bar) and dry-season (shaded bar) burns in the South Florida study area. Category 1 = all aboveground parts consumed, category 2 = stems and leaves partially consumed, and category 3 = plants only scorched.

nificantly among the three sites (Chi-square = 25.52, $p < 0.001$). In the site 3 wet-season burn, which had the lowest mean temperature of all six burns, almost half of the plants sustained no damage beyond scorching. Site 2, which experienced the hottest burns for both seasons, had the most plants with category 1 damage. Site-to-site variability in fire temperature and burn damage was influenced by differences in fuel loads, which are related to shrub cover and pine tree density (Table 1).

Adult Mortality

Even though the aerial portion of most plants was completely consumed and fire temperatures were higher in the dry-season burns, mortality after wet-season burns was twice that after dry-season burns (51.7% vs. 26.7%) (Figure 3). Mortality after wet-season burns was highly associated with the degree of burn damage (Chi-square = 24.89, $p < 0.0005$). Those plants that were merely scorched (category 3) had 23.1% mortality, while those whose aboveground parts were consumed (category 1) had 76.7% mortality. No statistically significant relationship was found between degree of burn damage and mortality after dry-season burns, probably because almost all plants were completely burned (Figure 2). Eighty-five percent of the dry-season burned plants were completely consumed, yet they experienced only 30.4% mortality (Figure 3).

The mean stem base diameter of plants that died was smaller than that of the survivors (6.3 ± 0.35 mm vs. 9.7 ± 0.42 mm; $t = 6.26$, $p < 0.0005$). The mean size of tagged plants differed among the plots, and plants had smaller diameters in the wet-season plots than in the dry-season plots ($t = -6.38$, $p < 0.0005$) (Table 1). The greater mortality after wet-season burns was not due entirely to the smaller size of plants, however. Plants with basal diameters < 6.0 mm were significantly more likely to die after wet-season burns than after dry-season burns (76% vs. 37% mortality, respectively; test of independence, Chi-square = 11.67, $p < 0.001$). For larger plants the effect of season was not significant (32% vs. 24% mortality; Chi-square = 1.30, $p > 0.1$). Within a season the mean

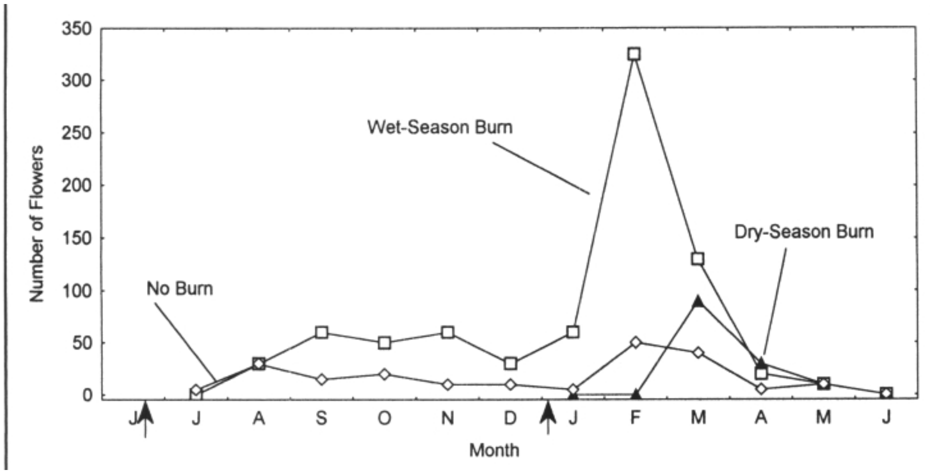

Figure 4. Flowering phenology of *Jacquemontia curtisii* in the South Florida study area after wet-season burns, dry-season burns, and no burn. Arrows indicate times of burns.

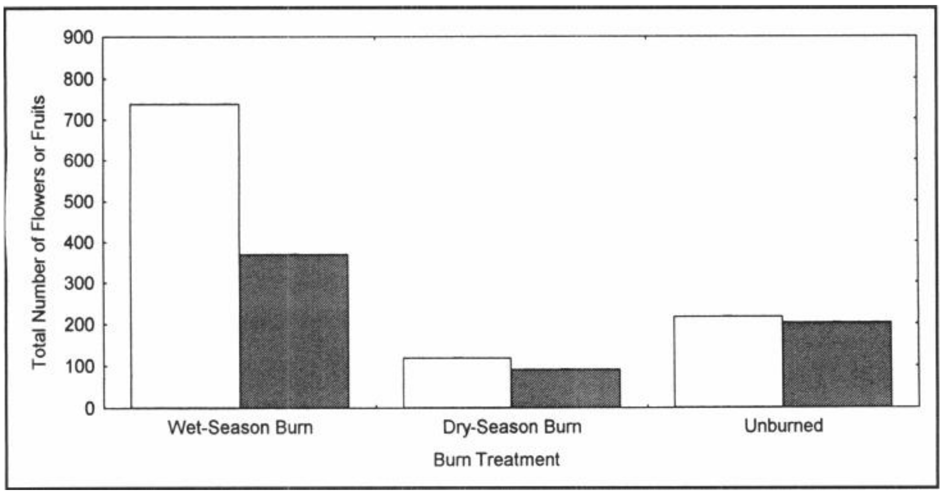

Figure 5. Total number of *Jacquemontia curtisii* flowers and fruits produced in each treatment in the South Florida study area. Open bar = flowers, shaded bar = fruits.

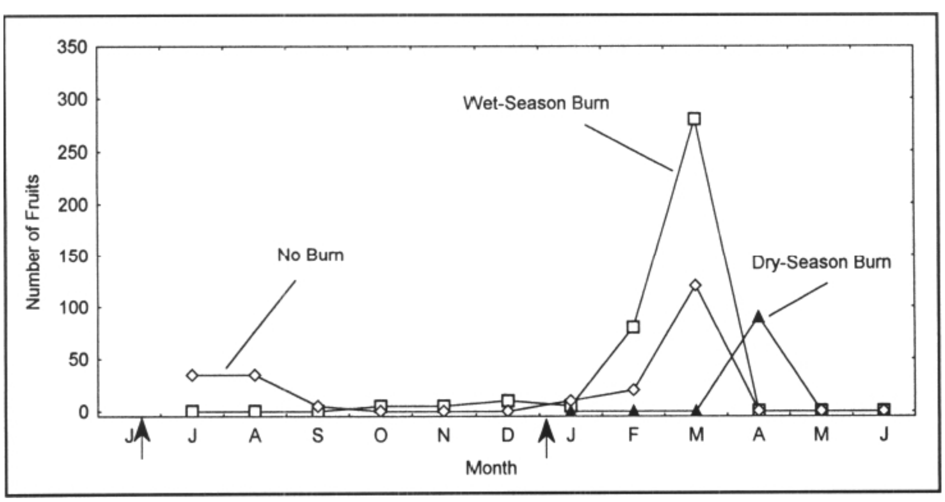

Figure 6. Fruiting phenology of *Jacquemontia curtisii* after wet-season burns, dry-season burns, and no burn in the South Florida study area. Arrows indicate times of burns.

diameter of the plants that died was smaller than that of the plants that survived (dry season, $t = 3.13$, $p = 0.003$; and wet season, $t = 4.53$, $p < 0.0005$).

Flowering and Fruit Production

Plants that survived the burns resprouted from the root crown. Flowering began eight weeks after the wet-season burns and nine weeks after the dry-season burns. Peak flowering in unburned plots and after wet-season burns occurred in February; peak flowering after dry-season burns was delayed until March (Figure 4).

The number of flowers produced after wet-season burns was higher than after either dry-season burns or not burning at all (Figure 5), even though fewer than half of the plants survived wet-season burns. The mean number of flowers produced by each plant surviving the wet-season burns was 12.7 ± 3.28 (n=58), 1.4 ± 0.29 (n=88) for plants surviving the dry-season burns, and 1.8 ± 0.39 (n=120) for the unburned plants ($F = 16.85$, $p < 0.0001$).

Flowering after the dry-season burns was underestimated relative to the wet-season burns and the unburned plots because flowers were counted for only six months after the dry-season fires. However, even if they had been counted for an additional six months, the dry-season burns would not have produced many more flowers than the unburned plots. In observing of a wide range of species in South Florida, we have found that stimulation of flowering after fire occurs within the first flowering sea-son after fire and is no longer apparent by the second season.

Peak fruiting occurred about four weeks after peak flowering, in March for wet-season burns and control plots and in April for dry-season burns (Figure 6). There was a significant difference among the three treatments in the mean number of fruits produced by surviving plants (Chi-square = 9.70, $p = 0.008$), with the greatest number of fruits following wet-season burns and the smallest number after dry-season burns (Figure 5). As with flowering, the number of fruits in the dry-season burned plots would probably have been similar to the number in the unburned plots if they had been counted for a full year.

Half (50.1%) of the flowers in the wet-season burns produced mature fruits. Fruit set in the other treatments was substantially higher, with 77.3% of the flowers observed after the dry-season burns and 93.5% of the flowers observed in the unburned plots yielding mature fruits. Even though a smaller percentage of the flowers appearing after wet-season burns produced fruits, the wet-season burns resulted in the greatest number of fruits.

Seedling Recruitment

Seedlings appearing within three months of the treatment burns were assumed to result from germination of seeds stored in the soil or litter layer. Following the wet-season burns, 154 seedlings appeared around marked plants from July through September; only 3 new seedlings were produced in October. After the dry-season burns, a total of 910 seedlings were counted in February and March, with a sharp decrease to 47 in April, when postburn flowering began to produce new seeds (Figure 6).

The unburned control plots successfully recruited a few seedlings, generally in open areas with little litter, although the mean number of seedlings per plant produced in a 1-year period (0.20) was much lower than that found within three months after either burning treatment (Chi-square = *7.20, p* = 0.027). The mean number of seedlings recruited after dry-season burns (5.25) was more than five times the number appearing after the wet-season burns (0.94) ($z = -6.94$, $p < 0.001$) (Figure 7).

The number of seedlings found after burning is related to fire severity. The Site 2 dry-season burn had the highest mean temperature of all six burned plots (Figure 1), and the number of seedlings recruited there was much higher than at all other sites. In addition, greater numbers of seedlings appeared around the more severely burned adult plants within season of burning, especially after dry-season burns (Figure 7).

Seedlings recruited after dry-season burns had a greater chance of survival than those recruited after wet-season burns or those germinating in unburned areas. Seedlings appearing after the dry-season burns experienced 18.5% mortality, whereas 35.2% of those germinating after wet-season burns died. About half (50.3%) of the few seedlings that appeared in the control plots were dead at the end of the year.

DISCUSSION

The experimental burns were representative of prescribed wet-season and dry-season fires in South Florida pinelands. The environmental conditions at the time of the burns were approximately similar in the two seasons, but rains shortly before the wet-season burns dampened fuels and resulted in lower fire temperatures. It is possible for wet-season burns to have higher fire temperatures than dry-season burns (e.g., Snyder 1986); a wet-season burn following several days without rain would be much hotter than a dry-season fire the day after one of the infrequent winter rains. However, fuels generally have higher moisture content during the wet season and, therefore, fires are usually less severe at that time.

While the majority of wet-season fires in South Florida, including these experimental fires, burn under relatively benign conditions extensive, high-intensity fires can occur if they ignite early in the wet season (May, June) while drought conditions still prevail (Snyder 1991). Prescribed burning is not done under such severe conditions for safety reasons, but since this type of fire must have often occurred under natural conditions it is necessary to consider how *J. curtisii* might respond to such fires.

The wet-season burns were unfavorable to the survival of adult plants; some of their higher mortality can be attributed to the smaller size of the plants burned during the wet season. These plants were six months younger than the plants burned in the dry season, so some of the difference in size is probably due to the age of the plants. Most of the plants were at least three years old because, based on the results of this study, they would have be-come established after a previous fire. Unfortunately, nothing is known of growth rates or the potential longevity of individuals of *J. curtisii*. It is possible that some of the difference in basal diameter is attributable to seasonal changes in food storage. The June burns may have occurred after the plants depleted most of their re-sources in flowering, fruiting, and surviving drought conditions (Bloom et al. 1985). Increased mortality of woody plants following growing-season (i.e., summer- or wet-season) burns is often attributed to decreased carbohydrate reserves (Robbins and Myers 1992).

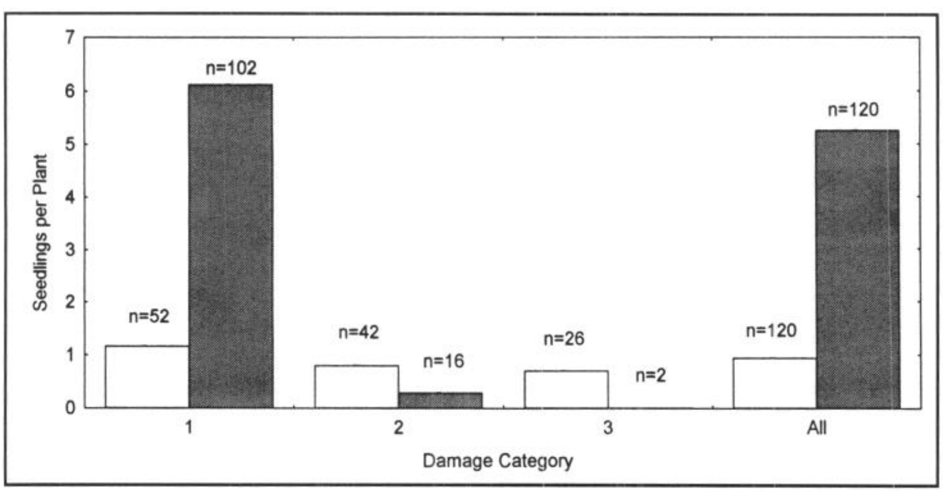

Figure 7. Mean number of seedlings appearing around adult *Jacquemontia curtisii* plants that sustained varying degrees of damage after wet-season (open bar) and dry-season (shaded bar) burns in the South Florida study area. Category 1 = all aboveground parts consumed, category 2 = stems and leaves partially consumed, and category 3 = plants only scorched.

Little work has been done on the effect of season of burning on mortality of herbaceous plants. And, in common with much research involving season of burning, it is difficult to separate the effect of fire intensity or temperature from the effect of sea-son. For example, in a study of a clonal pineland herb in northern Florida, there was higher mortality after January and August burns than after May burns (Brewer and Platt 1994), but there was no mention of the temperatures generated by the experimental fires. It is possible that the May burns were simply less intense than the others.

In the case of *J. curtisii* there is clearly some seasonal variability in its inherent ability to survive fires: smaller plants suffered greater mortality after wet-season burns than after dry-season burns even though the dry-season burns were hotter. It is apparent that wet-season fires under more severe conditions, the sort of fires postulated to have occurred often in the history of these pinelands, would lead to even greater mortality.

Fire often stimulates flowering of herbaceous plants (Daubenmire 1968, Gill 1981, Robbins and Myers 1992, Whelan 1995), so the vigorous response of *J. curtisii* to wet-season fires was not surprising. There is no way of knowing what effect burning at other times would have had on the flowering of *J. curtisii*. In some species the flowering response to fire is sensitive to differences in burning date as small as four days (Benning and Bragg 1993). It is possible that burning earlier in the wet season, for instance, in May, would still elicit a heavy flowering response, although if there were higher mortality the total flowering could easily be less than that which occurred here after the June burns. There was no evidence of increased flowering of *J. curtisii* after an April burn in Everglades National Park (Gunderson et al. 1983).

In a postfire environment there is often an increase in herbivory (Moreno and Oechel 1991a), and the relatively low proportion of flowers producing fruits after the wet-season burns in our study was due to heavy insect damage during the summer and fall. Flowers produced in January and February were more likely to mature, either because the insects were satiated or be-cause herbivore populations were lower.

In general, long-lived seeds are characteristic of disturbed habitats, such as those subject to frequent, recurring fires (Harper 1977, Hartnett and Richardson 1989). Seed germination in fire-prone environments is often associated with fire intensity (Moreno and Oechel 1991b), and members of the Convolvulaceae are known to exhibit fire-stimulated germination (Gill 1981). Be-cause germination of *J. curtisii* is to such a large degree dependent on fire temperature, it seems that a hotter wet-season fire would stimulate greater germination. Therefore an intense May burn might result in more seedlings than were seen in this study after the January dry-season burns.

The results from these experimental burns show that wet-season burns are not necessarily more favorable for all aspects of the life cycle that were examined. This is not to say that, overall, wet-season burns were unfavorable to the long-term viability of J. *curtisii* populations. The number of germinated seedlings surviving one year after the wet-season burn is sufficient to compensate for fire-caused mortality of adults, and the number of seeds produced was greatly in excess of the number of seeds germinating, so there could potentially be an increase in the soil seed bank. On the other hand, the dry-season burns did not appear to be detrimental to the health of J. *curtisii* populations, but rather there was a shift to larger numbers of plants and a smaller seed bank.

In the absence of longer term studies we suggest that *J. curtisii* is tolerant of a wide range of fire seasons, and that variability in season of burning will favor different aspects of the species' life history that may contribute to maintenance of genetically diverse populations. A prudent approach to managing the pine forest habitat of J. *curtisii* should involve prescribed burning at different times of the year and with a range of fire intensities.

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Jim Snyder is a research biologist with the U.S. Department of Interior stationed at Big Cypress National Preserve. His re-search interests include fire effects on vegetation, site restoration, and contml of invasive exotic plant species.

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