SOUTH FLORIDA RESEARCH CENTER

Report SFRC-83/04

Fire Effects on Flowering and Fruiting Patterns of Understory Plants in Pinelands of EVER

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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Fire Effects on Flowering and Fruiting Patterns of Understory Plants in Pinelands of Everglades National Park

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INTRODUCTION

Studies of the phenologic patterns of flowering and fruiting form a component of the knowledge about the reproductive strategies of individual plants and plant assemblages. This information, when combined with seed dispersal mechanisms, germination requirements, and other regeneration modes, can provide insight into observed distributions of plant species.

Loope (1980) characterized flowering and fruiting activity in the pinelands of Everglades National Park (EVER). He stated that some pineland species were probably stimulated to flower and fruit by fire, but found no system level fire effects. He also found that the number of species reproductively active remained fairly constant throughout the year, a pattern not attributable to annual fluctuations in climate.

This study was aimed primarily at evaluating post-fire flowering and fruiting patterns of understory species in the pinelands of Everglades National Park. Although Loope (1980) included some of the data in his analysis, this study added another year of observation and a more intensive look at individual and group patterns. Secondarily, this study attempted to correlate observed flowering and fruiting patterns with annual climatic fluctuations. Documented fire effects on reproductive activity can have direct implications to management strategies. If certain species, or groups of species, can be shown to benefit or suffer from certain prescribed fire treatments, then management actions can be modified to select for or against these species or groups. For example, a reduction of hardwood shrub species may be one management objective. If a certain fire regime were to impair flowering or fruiting patterns, then this fire regime may be implemented to help contain hardwood population expansion. Or, if a "window" of low flowering or fruiting activity was found for the understory assemblege, then burning prescriptions may be modified to take advantage of a "dormant" period.

METHODS

The study site was located in Long Pine Key of Everglades National Park (Fig. 1). The five 40 x 40 m plots which were used in this study were previously studied by Werner (1977) to evaluate effects of various fire regimes on the understory flora. Three plots (numbers 1, 8, and 9 in Werner 1977) had burned on 15 April 1977, nine months prior to the initiation of this study. These plots were monitored for flowering and fruiting activity for the period from 9 to 32 months post-fire (January 1978 through December 1979). The two plots (numbers 6 and 12 in Werner 1977), which were monitored as control plots, had burned on 16 November 1974, 62 months prior to the start of sampling.

Thirty-six understory species were monitored in each of the five plots during the middle of each month for the duration of the study. The 36 species are listed in Table 1, indicating growth form, fruit type, and flower color where appropriate. The monitored species consisted of 20 shrubs (including small trees, shrubs, and woody vines), 13 forbs, 2 palms, and one sedge. Nomenclature follows Avery and Loope (1980).

At each visit, an assessment of flowering and fruiting activity was made for each species in each plot. An index (ranging from one to five) was used to assign a level of activity. The index was determined based on a subjective evaluation of the flowering and fruiting displayed by all individuals of a species in the plot. An index of one described a situation where a small amount of flowering or fruiting was observed. An index of five was assigned when the "maximum" activity was noticed.

Climatic conditions, including rainfall, temperature, water levels, and photoperiod, were gathered from a variety of sources. Mean monthly rainfall totals at Royal Palm station (actually measured at Pine Island, Everglades National Park) were taken from the Florida annual summary for 1979 (NOAA, 1980). Temperature data were also taken at Pine Island, Everglades National Park (Fig. 1). Mean monthly water level data for NP-44 (Fig. 1) are from Rose et al. (1981). Hours of sunlight were calculated from sunrise-sunset times published in the Miami Herald for the calendar year 1976.

RESULTS AND DISCUSSION

Mean monthly summaries of rainfall and water levels show typical south Florida patterns (Fig. 2). Monthly rainfall is low during fall, winter, and spring (November through April), increases precipitously in June with bimodal peaks in June and September. Water levels follow a similar annual pattern with a slight time-lag. Highest yearly levels usually occur during July through October, decrease steadily over the winter, and reach lowest points during April and May. Water levels in the pinelands usually remain below ground with mean monthly levels ranging from 40 cm to 160 cm below the surface.

Temperatures and sunlight follow annual sinusoidal patterns (Fig. 3). Mean monthly temperatures vary from a low of 15°C to a high of 28°C during February and August, respectively. Mean monthly hours of daylight, as an indicator of photoperiod, ranged from 10.5 hours in December to 13.0 hours in June.

Summary graphs of the mean monthly flowering and fruiting indices for each species over the two year period are presented in Figures 4 through 21. Monthly values are averages of recorded activity for each species in each set of time-since-fire plots. The graphs are presented in alphabetical order by genus. The exceptions to this order are Gerardia (Agalinis) and Spermacoce (Borreria).

Many patterns are observed among the 36 species. Most of the species showed distinct annual periods of flowering and fruiting (Gerardia, Angadenia, Fig. 4). The length of the period varied from year to year, both among species and in the same species. Other species exhibited year-long reproductive activity, indeed, some were observed to have either flowers and/or fruits throughout the study. Species with continuous reproductive activity were of the genera Spermacoce (Fig. 5), Chamaesyce (Fig. 9), Dichromena (Fig. 10), Hedyotis (Fig. 13), and Phyllanthus (Fig. 18).

Fruiting and flowering were observed to occur simultaneously in each of the herbaceous species, due to short development times of the fruits. Fruits did not persist in these species, as evidenced by the flowering and fruiting periods ending at the same time.

Three endemic taxa were among the 36 observed species: Chamaesyce pinetorum, C. porteriana var. porteriana, and Phyllanthus pentaphyllus var. floridanus (Avery and Loope 1980). All three endemic species exhibited extended flowering and fruiting periods, indeed, were reproductively active throughout the year.

Summary graphs of the number of species in flower and fruit (Fig. 22) indicate no seasonal or annual pattern, consistent with the interpretation of Loope (1980). During the two year period, the number of species in flower (both sets of time-since-fire plots) was variable and ranged from 17 percent to 56 percent of the total monitored. Numbers of species in fruit per month were comparable, with values ranging from 19 percent to 67 percent of the total. Annual (or seasonal) environmental fluctuations of temperature, photoperiod, precipitation, and rainfall do not appear to influence the number of species in flower during any given month. Some of the monthly variation may be attributed to observer error, as various individuals did the assessments throughout the study. Other understory species including grasses, were not monitored, so a pattern of "all" pineland understory plants may be somewhat different.

No difference in the total number of species in flower or fruit was discerned between the time-since-fire plots. This is because an equal number of species had positive fire effects as those with negative effects. Also, the study was initiated at 9 months post-fire or about one full growing season after burning. Monitoring of this 9 month period may have indicated more dramatic impacts on the number of species in post-fire bloom.

A mean monthly flowering index and fruiting index per species was determined to assess phenologic patterns of these activities for the understory association. The mean index was calculated by summing the recorded indices for all species during a month, then dividing by the total number of species (36). No differences were observed in either the average flowering or fruiting activity between the 9 and 62 month plots (Fig. 23). No seasonal or annual pattern was observed in the mean fruiting index (Fig. 23), yet one was observed in the flowering index.

The mean level of flowering activity showed a distinctly seasonal pattern that was repeated during the two-year study (Fig. 23). Higher activities, initiated during March and April, remained high until August and September.

Because of the repeated pattern and no observed difference between the time-since-fire plots, all the data were averaged to yield a mean flowering index for each month. These indices were regressed against climatic variables of mean monthly rainfall, water level, temperature, and sunlight.

Poor correlations were obtained between flowering activity and rainfall, water level, and temperature (Fig. 24 and 25). The best correlation was obtained between flowering and mean monthly hours of sunlight, but the correlation was still low ($r^2 = 0.51$). Two scattergrams (temperature and photoperiod) had obvious outliers, both for the months of August and September. During these months, flowering was low, while photoperiod and temperatures remained high. By discarding these two months, the correlations were improved with r^2 of 0.73 and 0.70 for flowering versus photoperiod and flowering versus temperatures, respectively. These coefficients indicate a less than significant accounting of the regression variability, but are high enough to indicate that the flowering activity may be more in synchrony with the temperature/photoperiod cycle than the annual rainfall or water level cycle. Even though the bulk of the species are either endemic or tropical in origin (70%), the system appears to be cued to the same stimuli as many temperate systems, and probably not the rainfall patterns as observed in wet-tropical forests (Croat 1969; Croat 1975; Frankie et al. 1974; and Jackson 1978).

Growth-Form Groups

Three growth form groups were established to evaluate season of flower and fruit initiation and duration of these activities among the groups. Herbs included all forbs, herbaceous vines, and sedges. Small shrubs included any small (generally less than 2 m tall) woody plant, including vines. Large shrubs included all hardwoods that attain heights greater than 2 m. No palms were included.

More species (38%) initiated flowering during the spring months of March, April, and May (Fig. 26) than any other season. The spring initiation is attributed to the number of large shrubs that flower. Eight species (4% of total) flower all seasons of the year. The fewest number of species (3 or 8%) flower during the fall, September through November (Fig. 26).

Whereas the number of species flowering was highest in spring months, summer months had the highest number of species (13 or 33%) initiating fruit. Seven of these species had flowered during the spring, then set fruit in the summer. The remainder (six species) flowered and fruited during summer months. Fall was also the season of the lowest number of species initiating fruit.

The herbs had the longest duration of flowering and fruiting (Fig. 27) among the groups. The distribution fell into two sets of flower and fruit duration. Six species had flowers and fruits present from 8 to 12 months of the year, with eight species displaying flowers and fruits from 2 to 6 months.

Most small shrubs were in flower and fruit for 2 to 4 months/year, but two species were active up to 10 months of the year.

Large shrubs showed the most compressed flowering duration among the groups. Seven of the eight species had flowers present for less than 2 months. The presence of fruit was observed for a longer time, from 2 to 8 months, due to longer development times and fruit persistence.

Fire Effects

Fire effects were assessed by visual examination of the graphed data for each species. Minor differences between the 9- and 62-month plots were attributed to observer or classification error and, therefore, considered insignificant. A fire effect was designated when activity was observed in one of the two sets of plots and not in the other, or the magnitude of the difference was two to three times the lower set of values. Two types of fire effects were observed. The first type was a higher flowering and/or fruiting activity in the 9-month plots than the 62-month plots. The second type of effect was a lower level of activity in the 9-month plots than in the 62-month plots. Both types of alteration were only observed during the first year of the study. By the second year, all patterns in the two sets of plots appeared to have synchronized, and all noticeable fire effects on flowering and fruiting of understory pineland species had disappeared as of two years post-fire.

No alteration in the flowering or fruiting pattern was noticed in 21 of the 36 species (58%). Some species, certain grasses and forbs, may have displayed alterations to their phenologic patterns during the initial 9 months post-fire, but were unnoticeable by the time this study was initiated.

Six species (17%) exhibited more flowering and fruiting in the 9-month plots than in the older plots. The six species included five forbs, Cassytha filiformes, Chiococca parviflora, Dyschoriste oblongifolia, Melanthra angustifolia, and Spermacoce verticillata, as well as, one palm, Serenoa repens. C. filiformes and D. oblongifolia were not observed to flower in the five-year rough, even though they were present. D. oblongifolia may have flowered in the older plots, but is very difficult to see among the other vegetation. S. verticillata, S. repens, C. parviflora, and M. augustifolia flowered and fruited in both sets of plots, but the activity was interpreted to be significantly higher in the newly-burned sites. S. repens was the only one of these species with previously reported fire effects on the flowering and fruiting patterns. Hilmon (1968) observed enhanced flowering on S. repens during the first year post-fire, but found that many of the fruit failed to develop.

No unique characteristics were noted for this group of fire-enhanced species. These species were simlar to other non-affected species with regards to growth-form, fruit type, or origin of the species (i.e., endemic, temperate, or tropical). All of the enhanced species regenerated from perennating rootstocks, but again, so did other non-affected species.

Species with reduced flowering or fruiting activity in the 9-month plots were all hardwood shrubs. Five species which had no or obviously lesser activity in these recently burned areas were Bumelia salicifolia, Metopium toxiferum, Myrica cerifera, Myrsine floridana, and Dodonea viscosa. Three other hardwoods, Ilex cassine, Rhus copallina, and Tetrazygia bicolor, appeared to exhibit lessened flowering and fruiting, but the significance of the difference is questionable.

The reduced or omitted flowering periods are probably a result of diversion of starch reserves and photosynthetic production into stem and foliage growth, and not into reproductive material. Patterns of the affected species had synchronized with plants in the 5-year plots by the second year of observation. Generally, two calendar years (and two growing seasons) passed before the patterns had fully synchronized for the affected hardwood species.

Frequent fires (at a 2-year interval) may inhibit establishment of some hardwood species. It appears that a two-year period is required before flowering and fruiting patterns are normalized. Frequent fires, therefore, may limit fruit production for the interval between fires. If fruit production is decreased, then the probability of hardwood regeneration (by seed) would also be decreased. Fruit production is only one factor in the establishment process and needs to be linked with dispersal mechanisms, as well as requirements for germination and seedling establishment, before evaluating total impact of fire on hardwood establishment.

Implication to Fire Management

If hardwood control is a desirable objective, burning under certain conditions may limit or contain population expansion by seed. It appears that frequent burning limits available seed sources. Many hardwood species have depressed fruiting activity for at least two years post-fire. Frequent burning then would not only deplete root reserves, but also lessen the amount of seed available for recolonization. Many of the hardwoods flower during a short period in spring, followed by a summer-long fruit development period. Spring burning with top-kill would, of course, remove the flowers and eliminate fruiting for that year. Summer burning would behave the same. The chance of having ripe fruit available for colonization would probably increase through the summer into the fall--that is, of course, if the fruits survive a fire.

Flowering activity of the group, comprised of the monitored understory flora, appears to exhibit a seasonal pattern (Fig. 23). The average flowering activity is low during the months of September through December and is higher from March through July. Burning of the pinelands during one of these "windows" of activity may have little or no effect on the post-fire species composition. Post-fire recovery is primarily achieved by vegetative resprouts from remnant unburned root stocks. Perennial herbs, hardwood shrubs, and suffrutescent species all recover via this mechanism. Therefore, understory species composition generally does not change much following a typical fire that does not damage root systems. An unburned area, that has flowers present (and subsequent fruits and seeds), may be important to the colonization of a severely burned area, where vegetative recovery has been eliminated. However, knowledge of dispersal vectors and germination requirements of these species is necessary before predictions of alterations in species composition can be made.

SUMMARY AND CONCLUSIONS

1. Flowering and fruiting patterns over two years are presented for 36 species in plots burned 9 and 62 months prior to sampling.

2. Flowering activity of the group comprised of monitored species shows a seasonal pattern that is best correlated to temperature and photoperiod patterns, and not the rainfall or water level pattern.

3. More species initiated flowering activity in the spring months than any other season, whereas, the majority of species initiated fruiting during the summer months.

4. Large, hardwood shrubs had the shortest flowering period and the longest fruiting period due to slow fruit development and persistence.

5. Six (17% of total) species exhibited enhanced flowering and fruiting in the younger (time-since-fire) plots, with no discernable common character among these species.

6. Eight (22% of total) species showed reduced flowering and fruiting in the younger (time since fire) plots and all were hardwood shrubs.

7. Implications to fire management are discussed.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Avery, G., and L. L. Loope. 1980. Plants of Everglades National Park: a preliminary checklist of plants. National Park Service, South Florida Research Center Report T-574. Homestead, FL. 41 p.

Croat, T. B. 1969. Seasonal flowering behavior in Central Panama. Ann. Mo. Bot. Gdn. 56: 295-307.

Croat, T. B. 1975. Phenological behavior of habit and habitat classes on Barro Colorado Island (Panama Canal Zone). Biotropica 7(4): 270-277.

Frankie, G. W., H. G. Baker, and P. A. Opler. 1974. Comparative phenological studies of trees in tropical lowland west and dry forest sites of Costa Rica. J. Ecology 62: 881-913.

Hilmon, J. B. 1968. Autecology of saw palmetto (Serenoa repens). Unpublished PhD. Thesis, Dept. Botany, Duke Univ., Durham, NC. 190 p.

Jackson, J. F. 1978. Seasonality of flowering and leaf-fall in a Brazilian subtropical lower montane moist forest. Biotropica 10(1): 38-42.

Long, R. W., and O. Lakela. 1971. A flora of tropical Florida. Banyan Press, Miami. 962 p.

Loope, L. L. 1980. Phenology of flowering and fruiting in plant communities of Everglades National Park and Biscayne National Monument, Florida. National Park Service, South Florida Research Center Report T-593. Homestead, FL. 50 p.

NOAA. 1980. Climatological data. Florida, Vol. 84, Jan.-Dec. Environmental Data Service, National Climatic Center, Asheville, NC.

Rose, P. W., R. M. Lew, and P. C. Rosendahl. 1981. Annual hydrology review: Everglades National Park and Big Cypress National Preserve, Water Year 1978. National Park Service, South Florida Research Center Report T-611. Homestead, FL. 131 p.

Werner, H. W. 1977. The effect of fire type along a relative humidity gradient in a rockland pine forest. National Park Service, Everglades National Park, Homestead, FL. 31 p.

Table 1. Growth-form, flower color, and fruit type of species monitored in study.

Species	Growth Form	Flower Color	Fruit Type
Angadenia sagraei	small shrub-vine	yellow-cream	follicle
Ardisia escallonioides	large shrub-tree	white	drupe
Bumelia salicifolia	large shrub-tree	white	berry
Cassia chapmanii	small shrub	yellow	legume
Cassia deeringiana	small shrub	yellow	legume
Cassytha filiformis	forb-vine	-	drupe
Chamaesyce pinetorum	forb	-	capsule
Chamaesyce porteriana var. *porteriana*	forb	-	capsule
Chiococca parviflora	small shrub-vine	white	drupe
Crotalaria pumila	forb	yellow-orange	legume
Croton linearis	small shrub	white	capsule
Dichromena colorata	sedge	white	achene
Dodonaea viscosa	small shrub	yellow	capsule
Dyschoriste oblongifolia	forb	purple	capsule
Gerardia purpurea	forb	purple	capsule
Guettarda elliptica	small shrub	pink-red	drupe
Guettarda scabra	small shrub	white-red	drupe
Hedyotis nigricans	forb	white	capsule
Ilex cassine	large shrub-tree	white	drupe
Jacquemontia curtissii	small shrub-vine	white	capsule
Melanthera angustifolia	forb	white	achene
Metopium toxiferum	large shrub-tree	yellow	drupe
Mikania scandens	forb-vine	white	achene
Morinda royoc	small shrub-vine	white-red	drupe
Myrica cerifera	large shrub-tree	-	drupe
Myrsine floridana	large shrub-tree	white	berry
Persea borbonia	large shrub-tree	green	drupe
Phyllanthus pentaphyllus	forb	-	capsule
Physalis viscosa	forb	green-yellow	berry
Rhus copallina	large shrub-tree	white-green	drupe
Sabal palmetto	palm	yellow-white	drupe
Samolus ebracteatus	forb	white	capsule
Serenoa repens	palm	white	drupe
Smilax auriculata	small shrub-vine	yellow-green	berry
Spermacoce verticillata (*Borreria terminalis*)	forb	white	capsule
Tetrazygia bicolor	small shrub	white	berry

Nomenclature follows Avery and Loope, 1980, flower and fruit information from Long and Lakela, 1971.

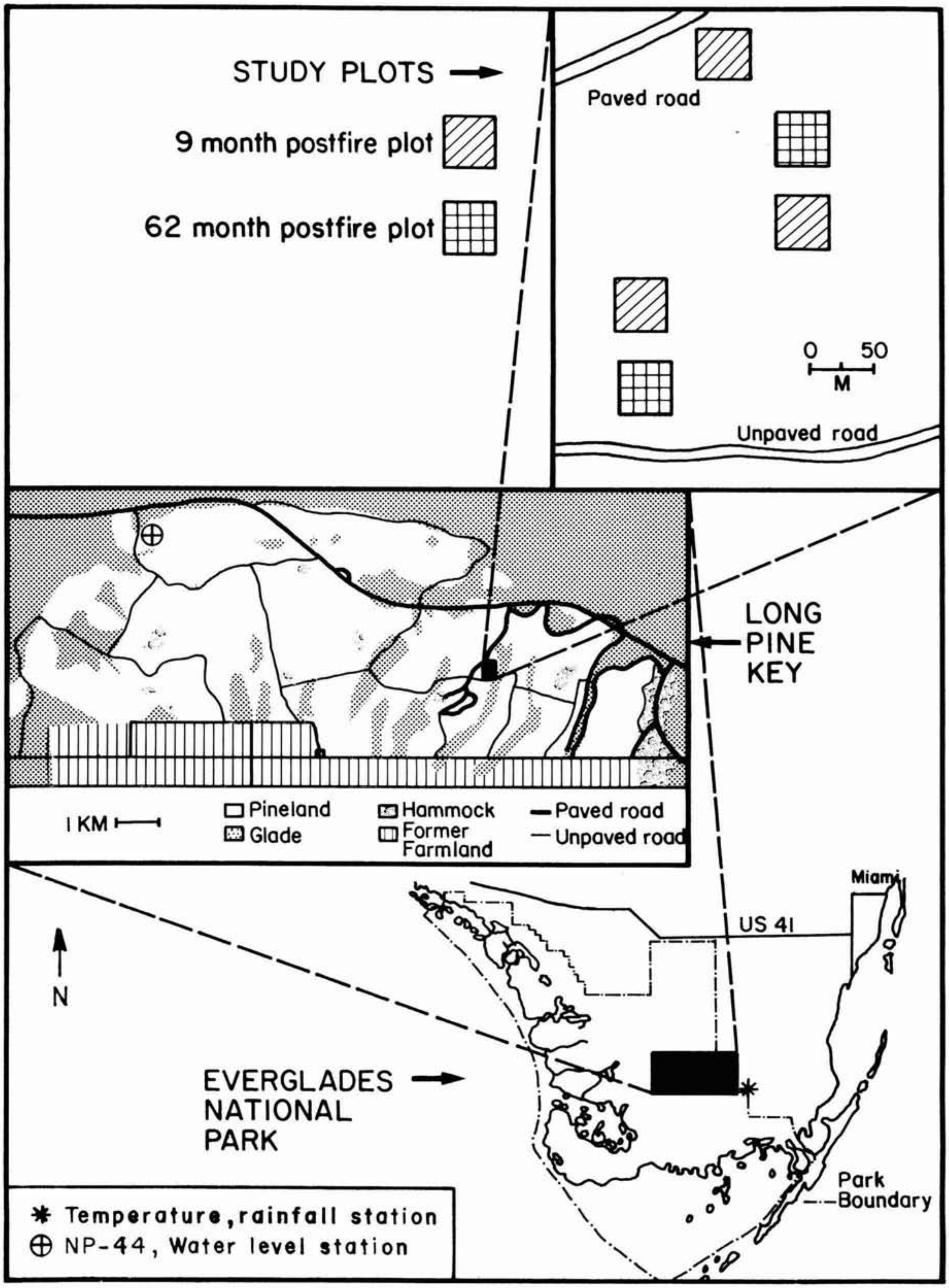

Figure 1. Location of study plots in Long Pine Key, Everglades National Park.

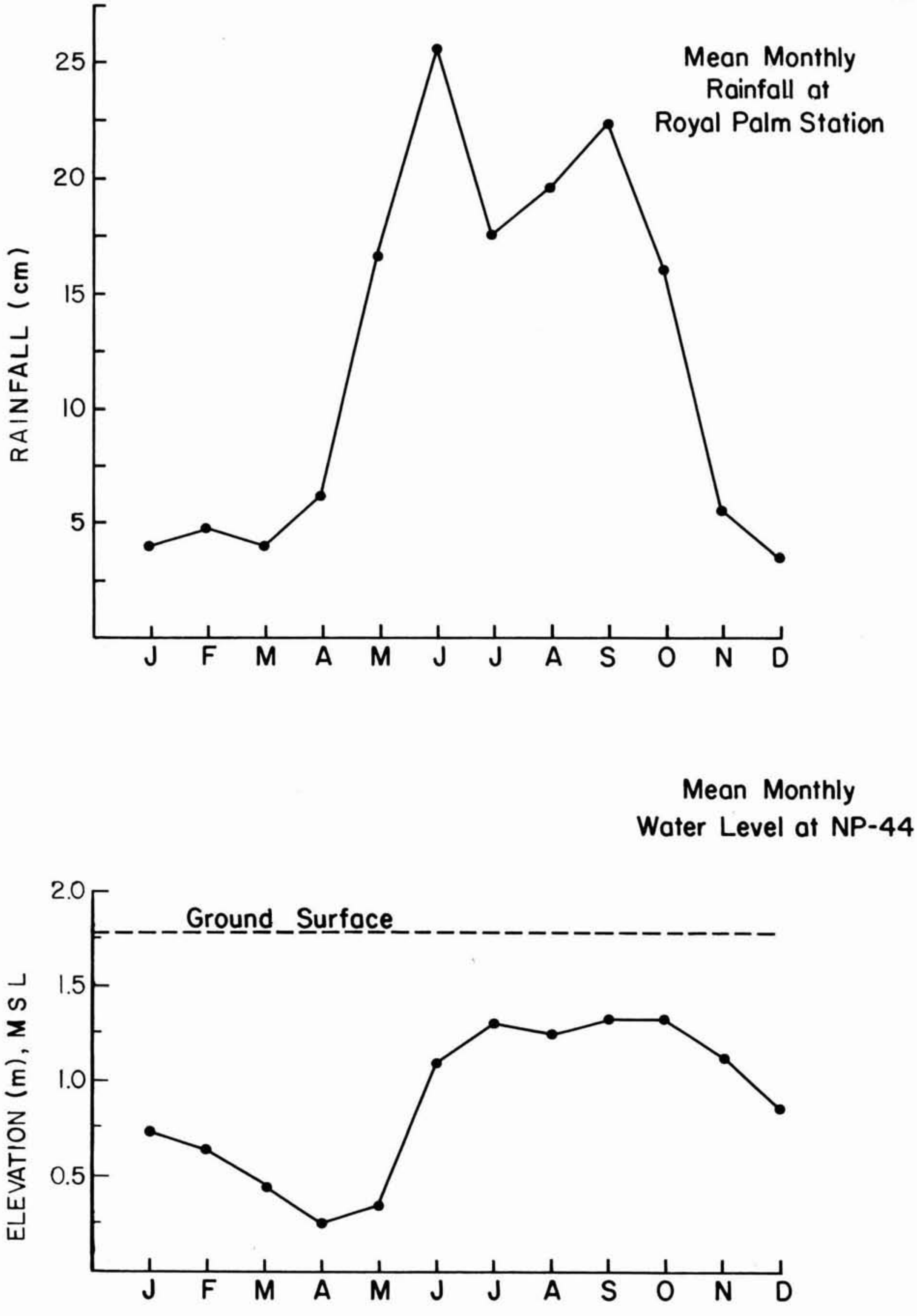

Figure 2. Annual patterns of monthly rainfall and water levels near study sites.

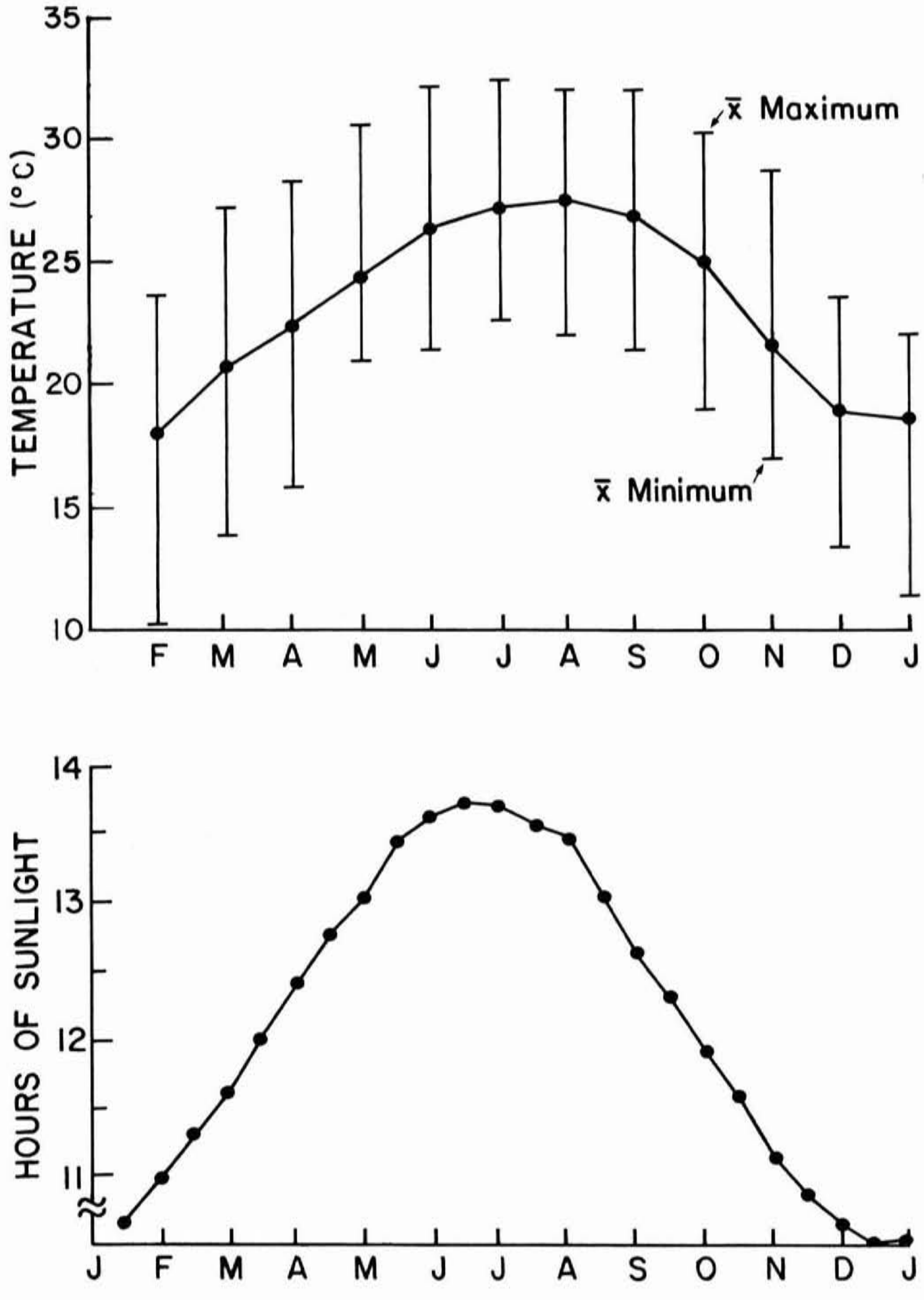

Figure 3. Annual patterns of mean monthly temperatures and hours of sunlight near study site.

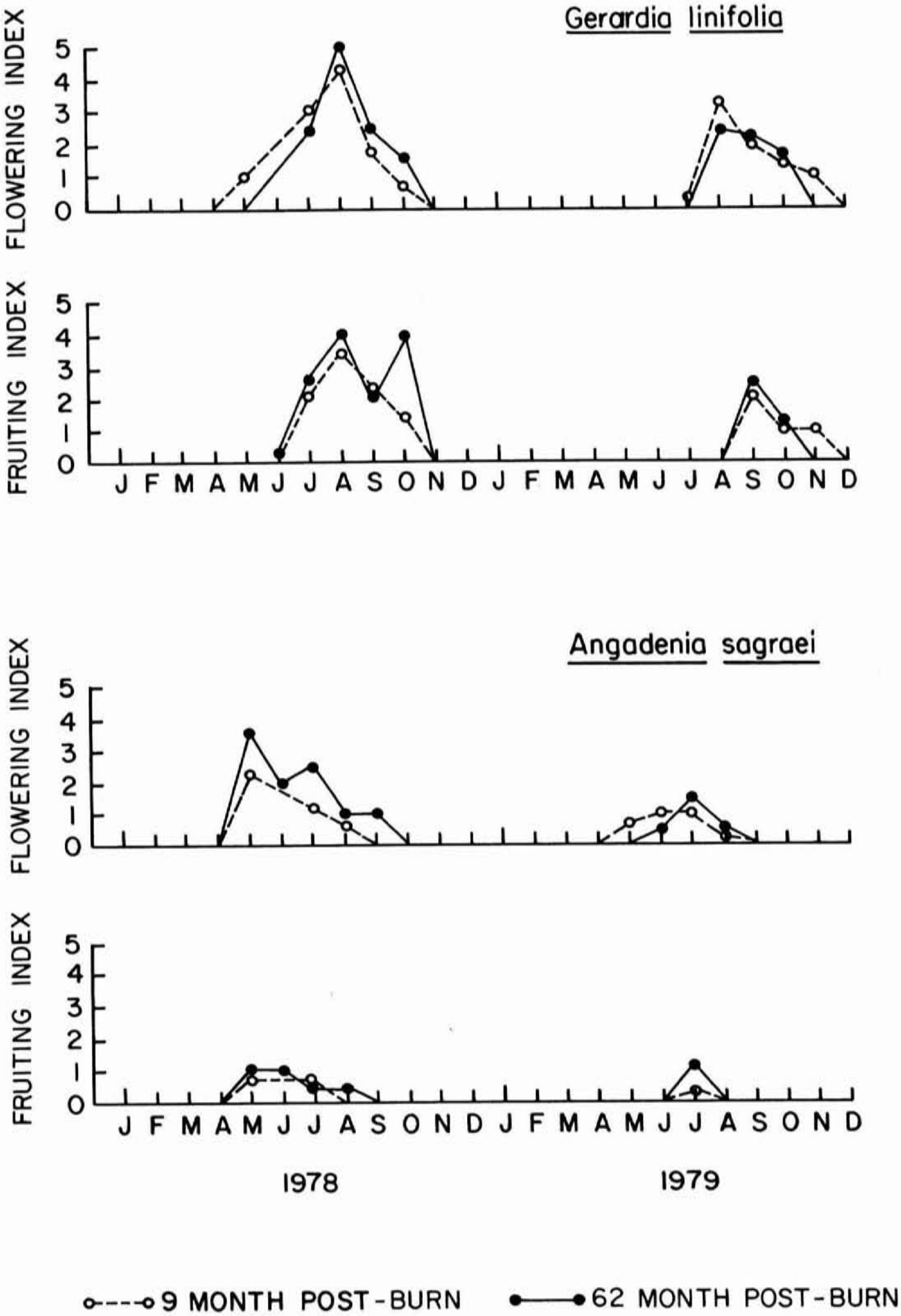

Figure 4. Flowering and fruiting patterns of <u>Gerardia</u> <u>linifolia</u> and <u>Angadenia</u> <u>sagraei</u> in 9-month and 62-month post-fire plots.

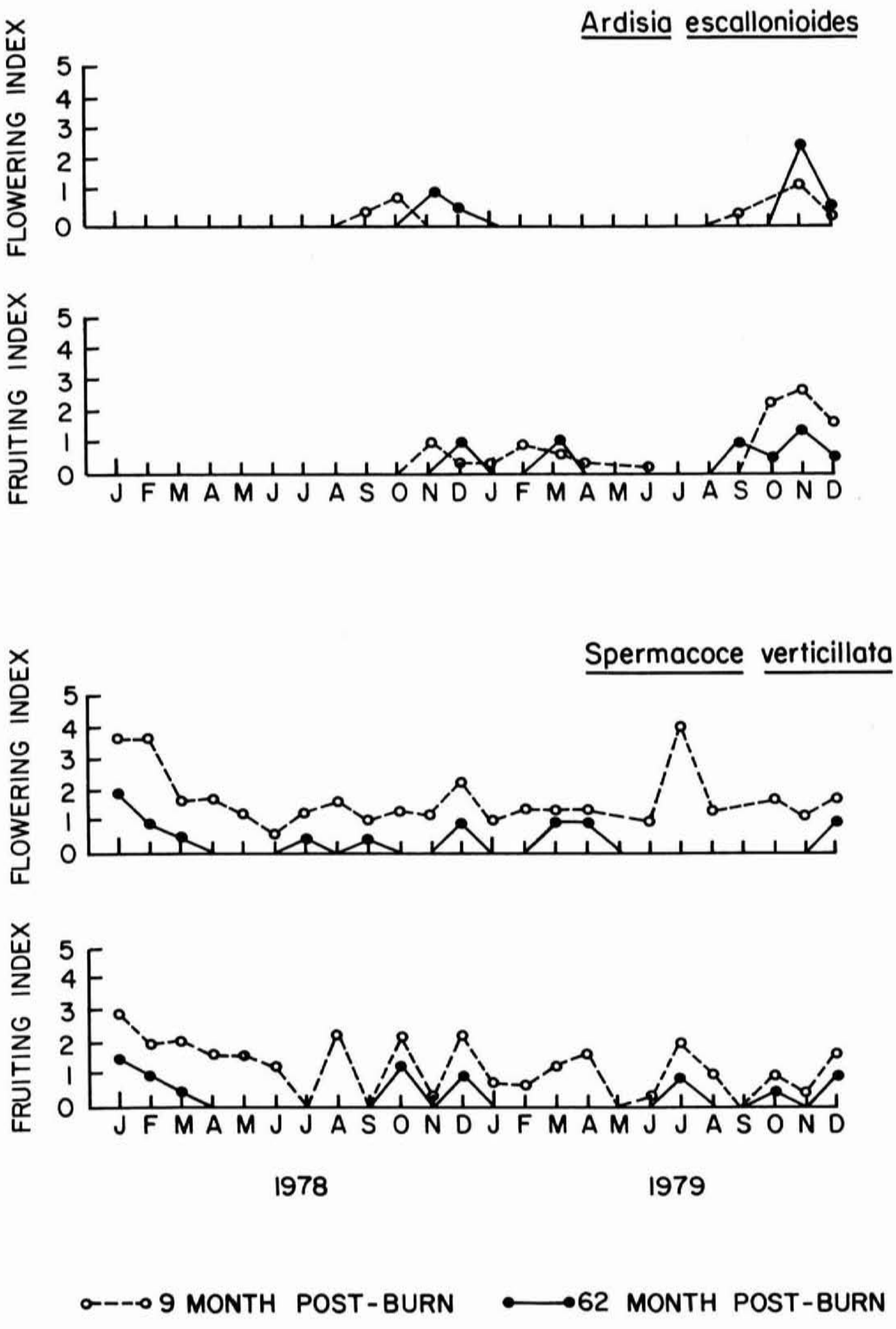

Figure 5. Flowering and fruiting patterns of Ardisia escallonioides and Spermacoce verticillata in 9-month and 62-month post-fire plots.

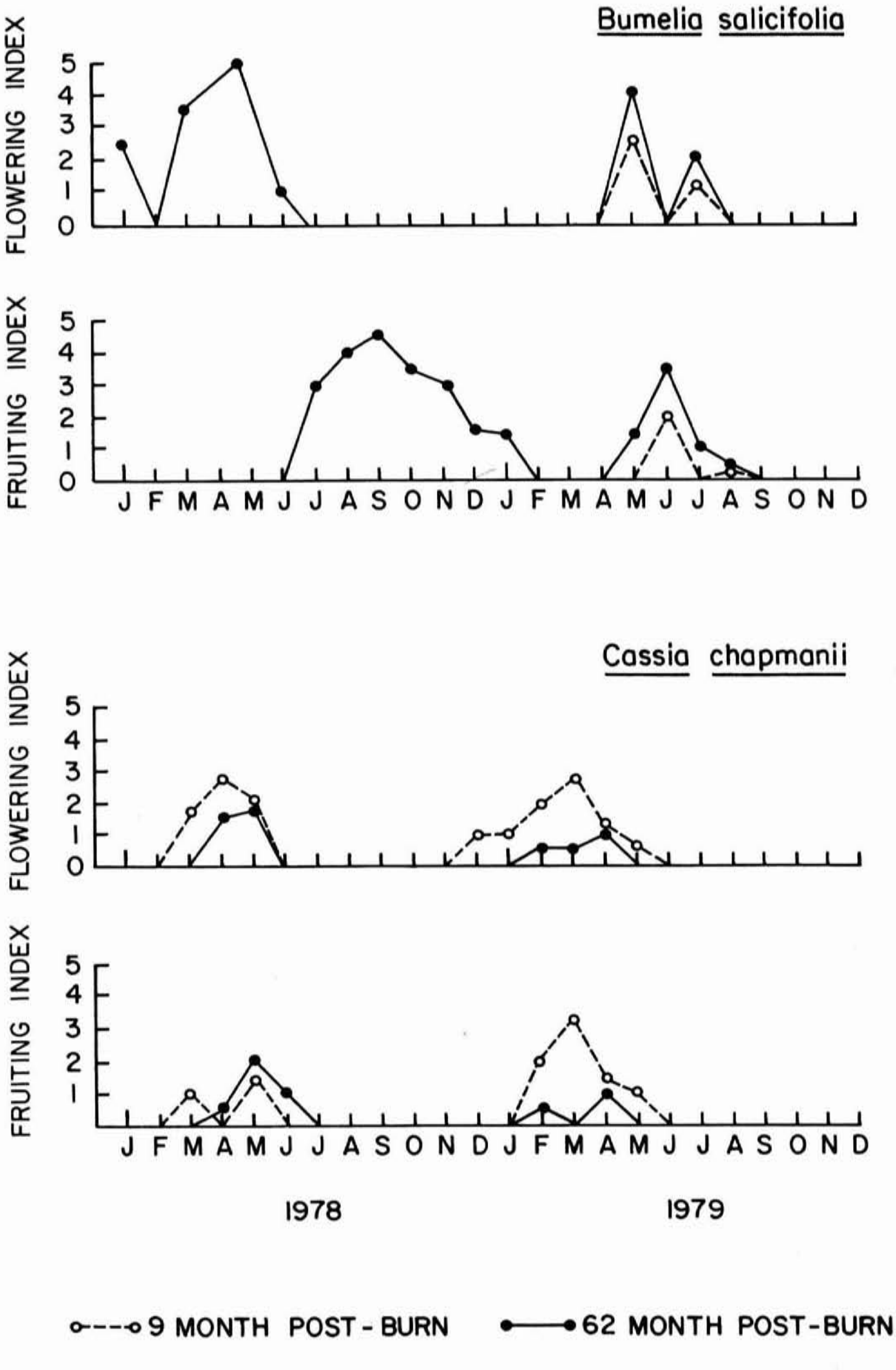

Figure 6. Flowering and fruiting patterns of Bumelia salicifolia and Cassia chapmanii in 9-month and 62-month post-fire plots.

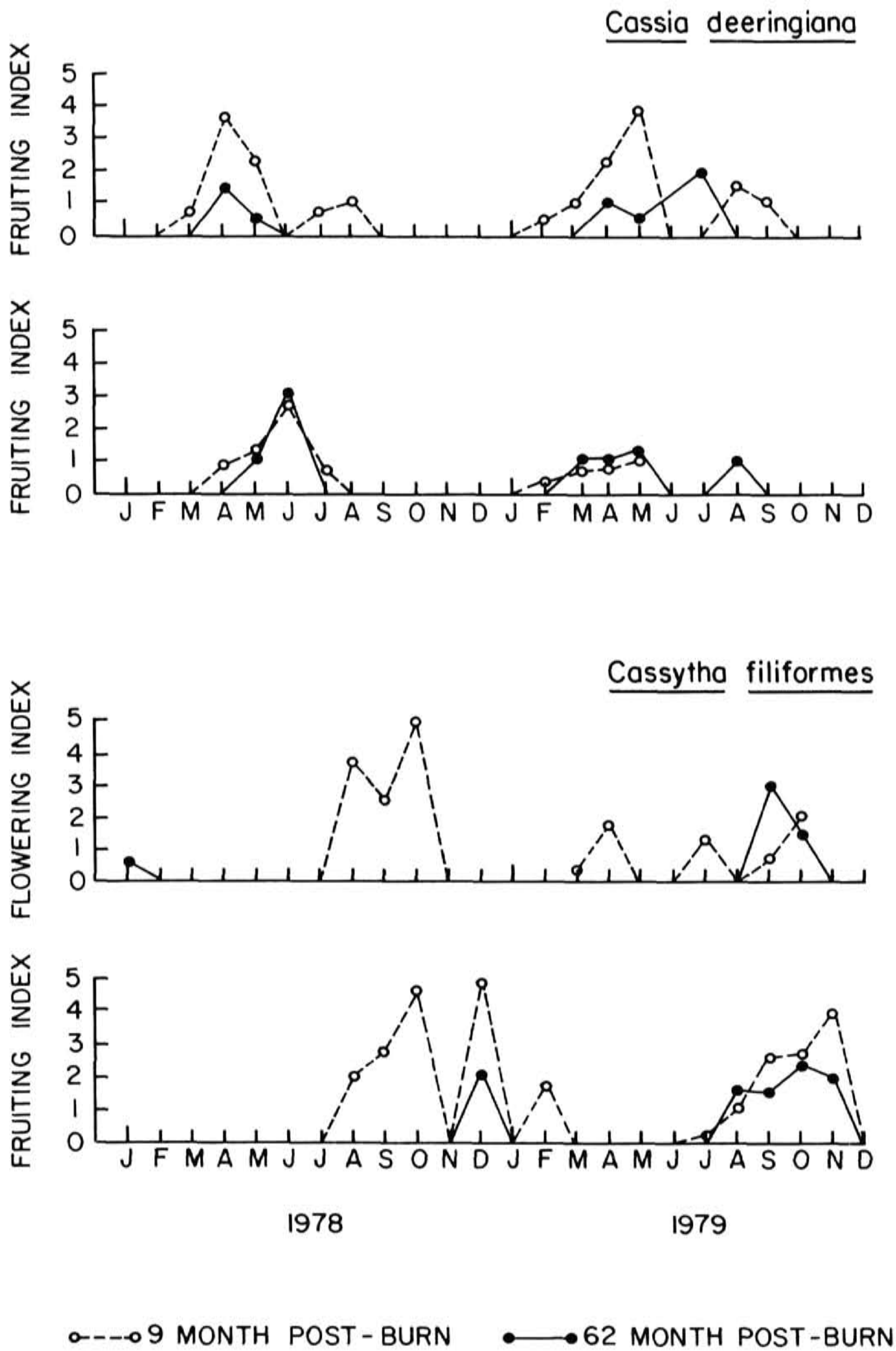

Figure 7. Flowering and fruiting patterns of Cassia deeringiana and Cassytha filiformes in 9-month and 62-month post-fire plots.

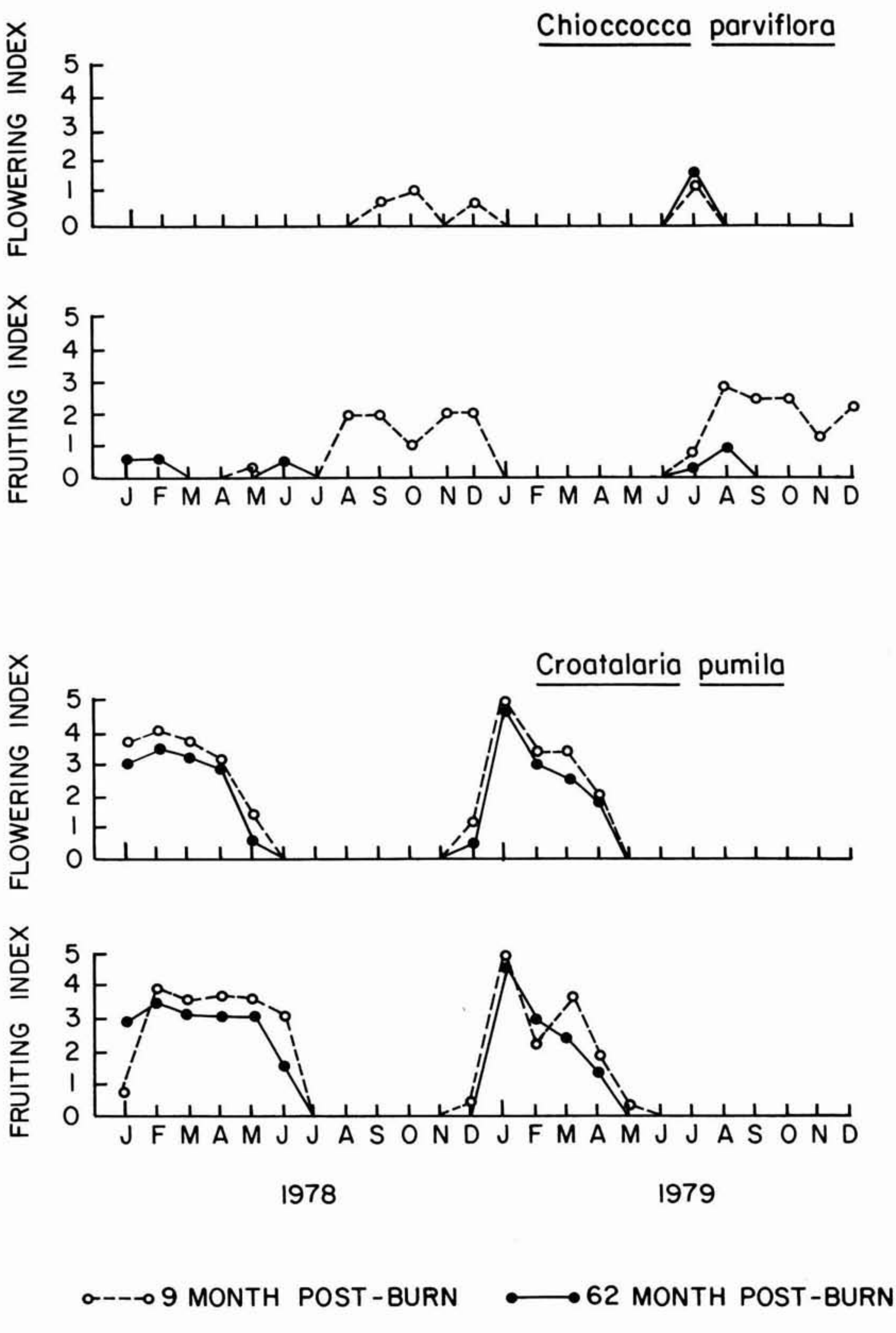

Figure 8. Flowering and fruiting patterns of Chioccocca parviflora and Croatalaria pumila in 9-month and 62-month post-fire plots.

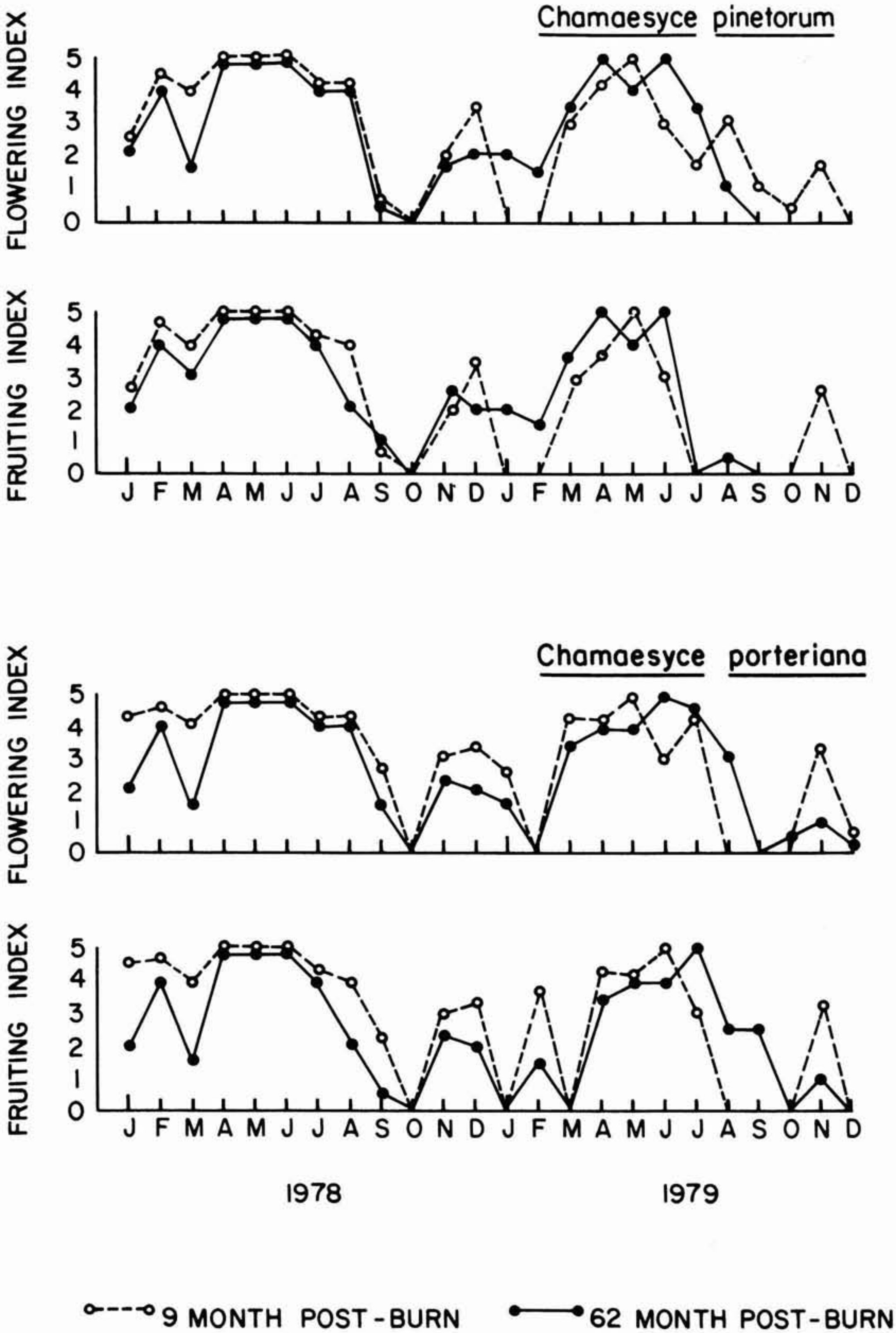

Figure 9. Flowering and fruiting patterns of Chamaesyce pinetorum and Chamaesyce porteriana in 9-month and 62-month post-fire plots.

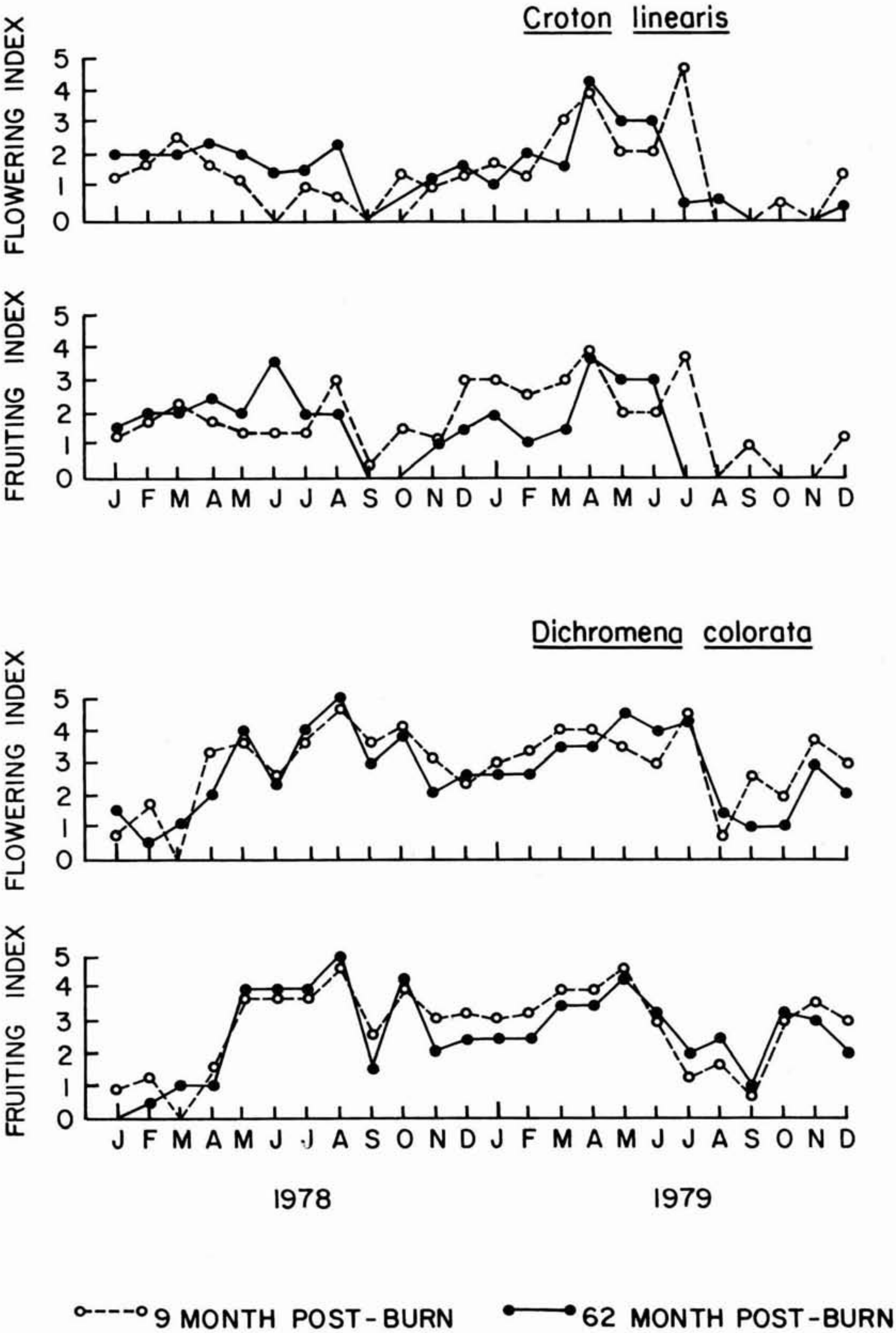

Figure 10. Flowering and fruiting patterns of Croton linearis and Dichromena colorata in 9-month and 62-month post-fire plots.

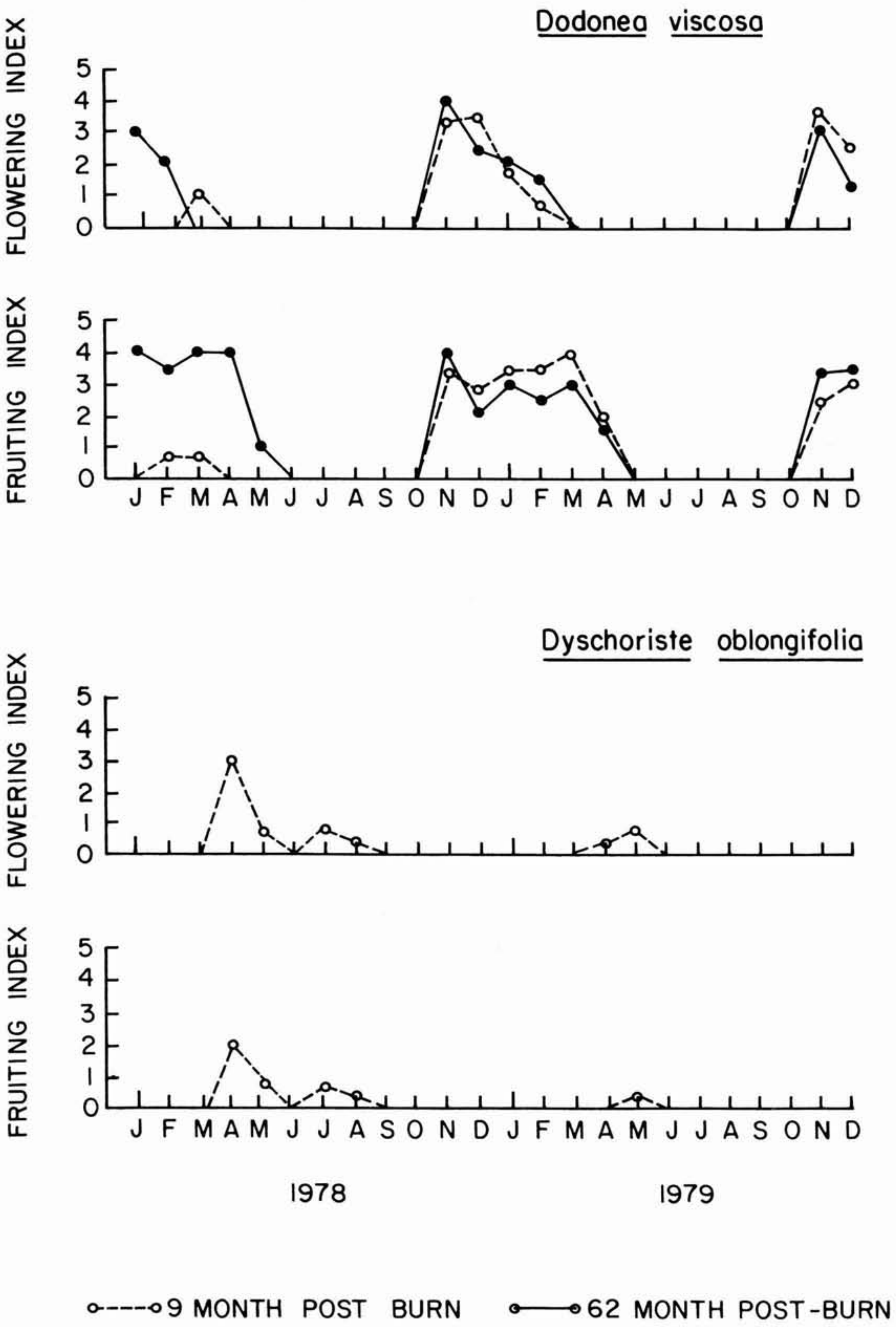

Figure 11. Flowering and fruiting patterns of Dodonea viscosa and Dyschoriste oblongifolia in 9-month and 62-month post-fire plots.

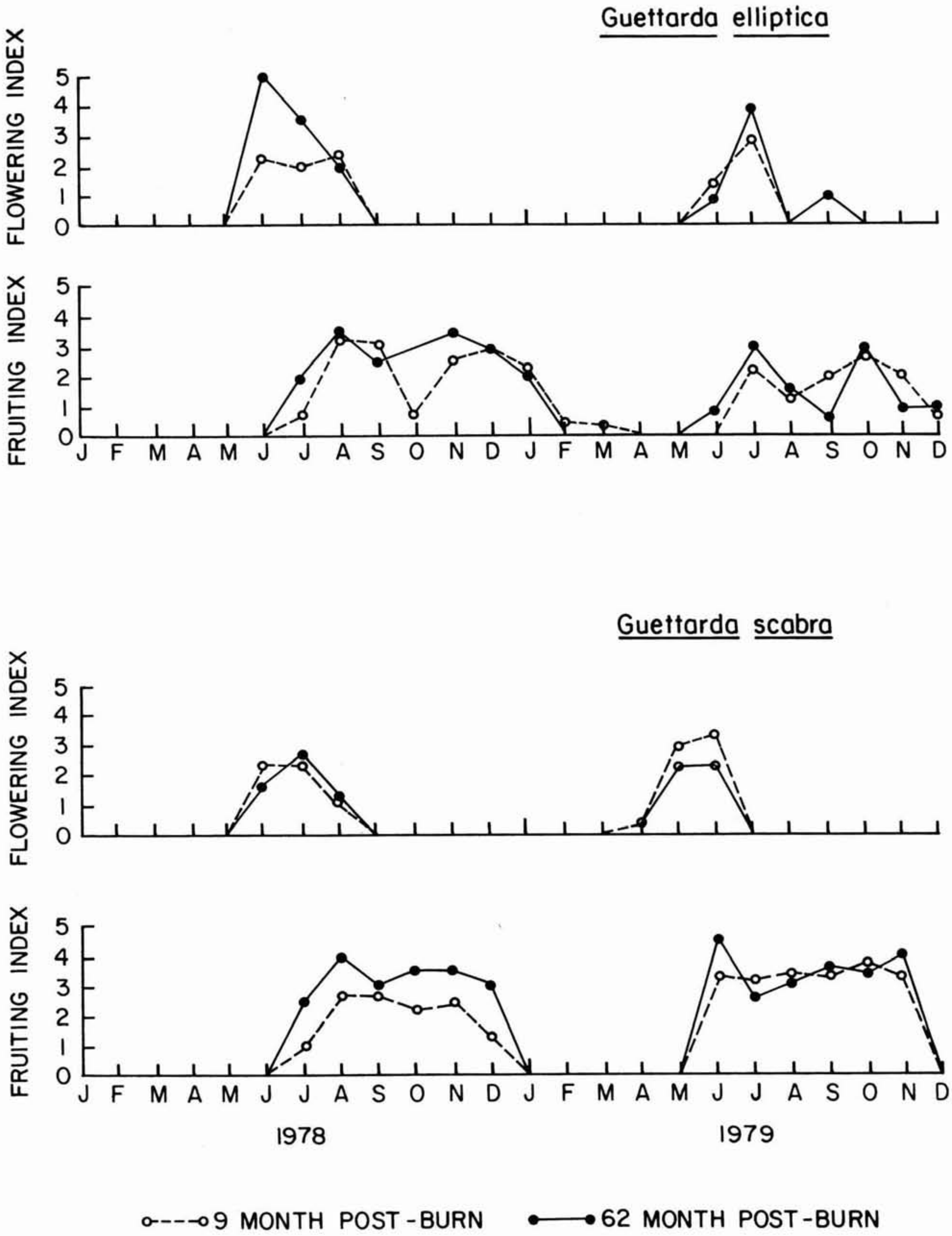

Figure 12. Flowering and fruiting patterns of Guettarda elliptica and G. scabra in 9-month and 62-month post-fire plots.

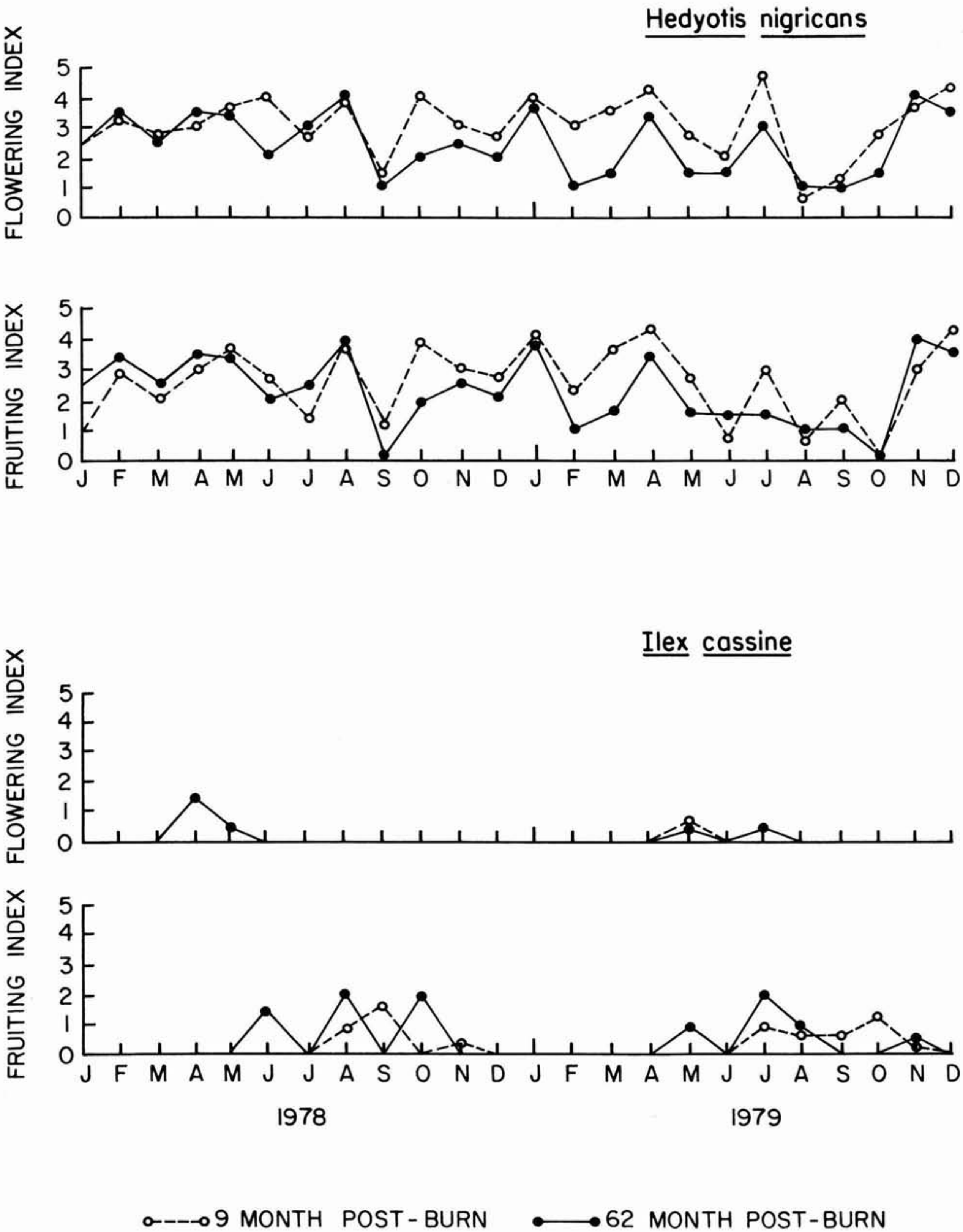

Figure 13. Flowering and fruiting patterns of Hedyotis nigricans and Ilex cassine in 9-month and 62-month post-fire plots.

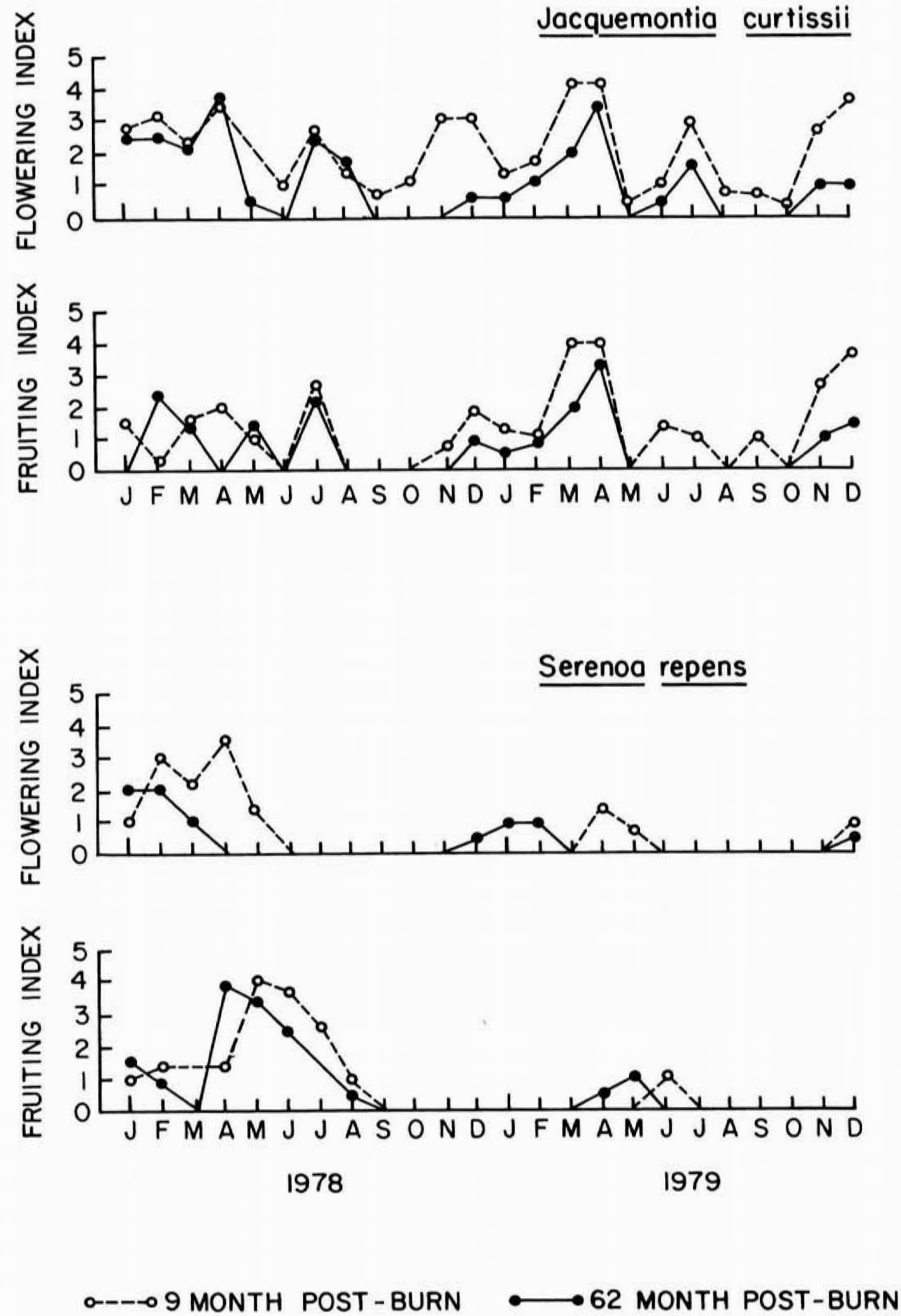

Figure 14. Flowering and fruiting patterns of Jacquemontia curtissii and Serenoa repens in 9-month and 62-month post-fire plots.

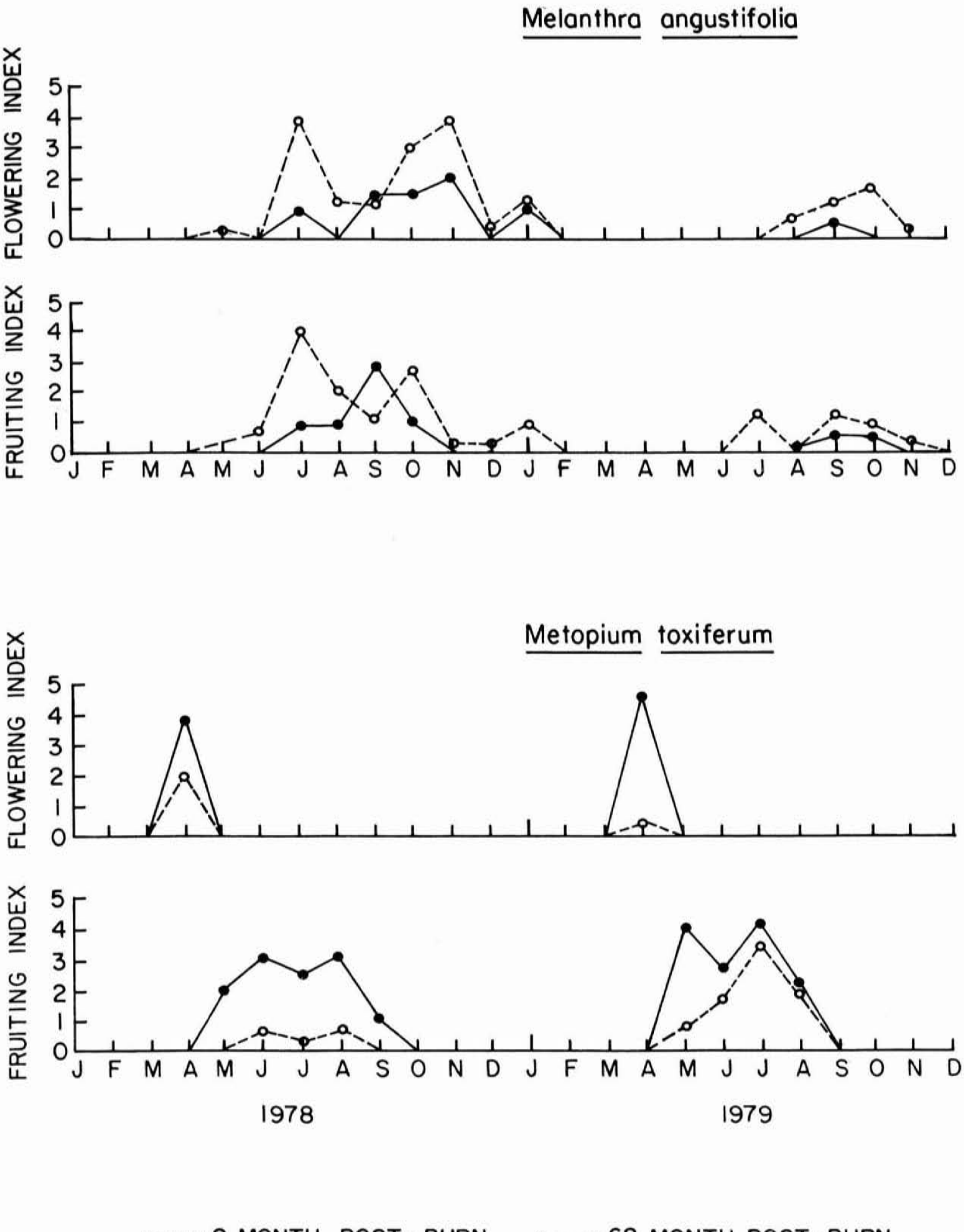

Figure 15. Flowering and fruiting patterns of Melanthra angustifolia and Metopium toxiferum in 9-month and 62-month post-fire plots.

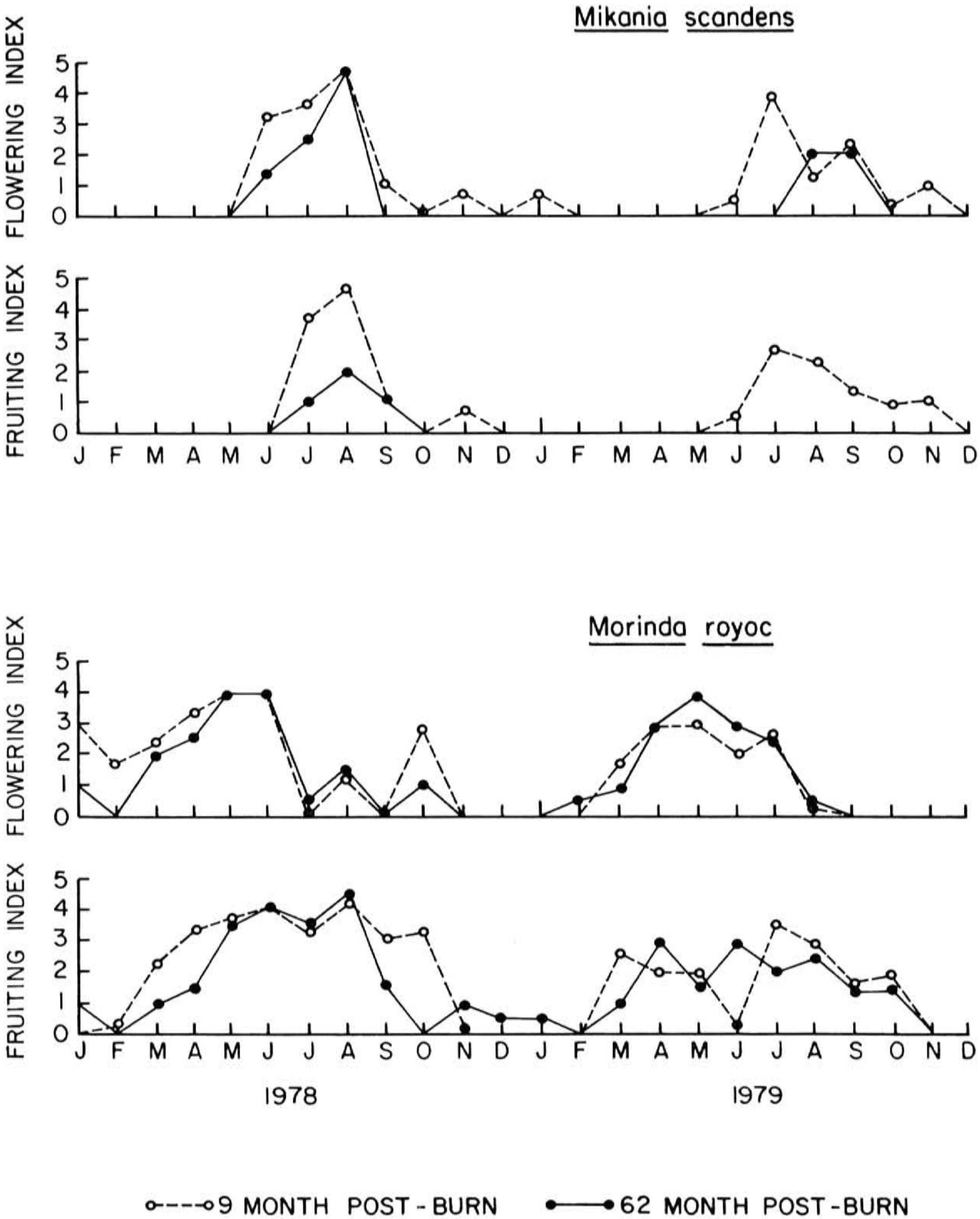

Figure 16. Flowering and fruiting patterns of Mikania scandens and Morinda royoc in 9-month and 62-month post-fire plots.

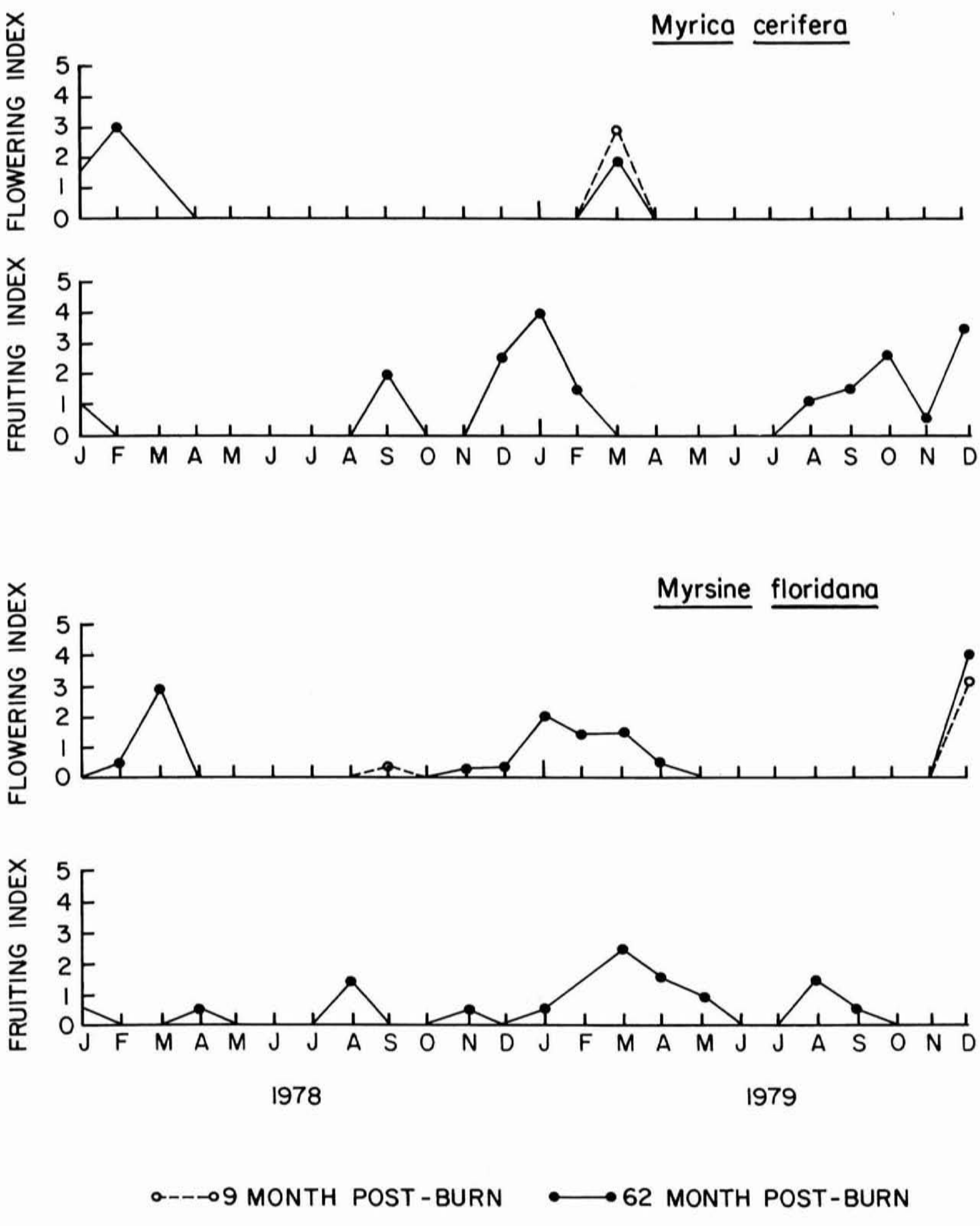

Figure 17. Flowering and fruiting patterns of Myrica cerifera and Myrsine floridana in 9-month and 62-month post-fire plots.

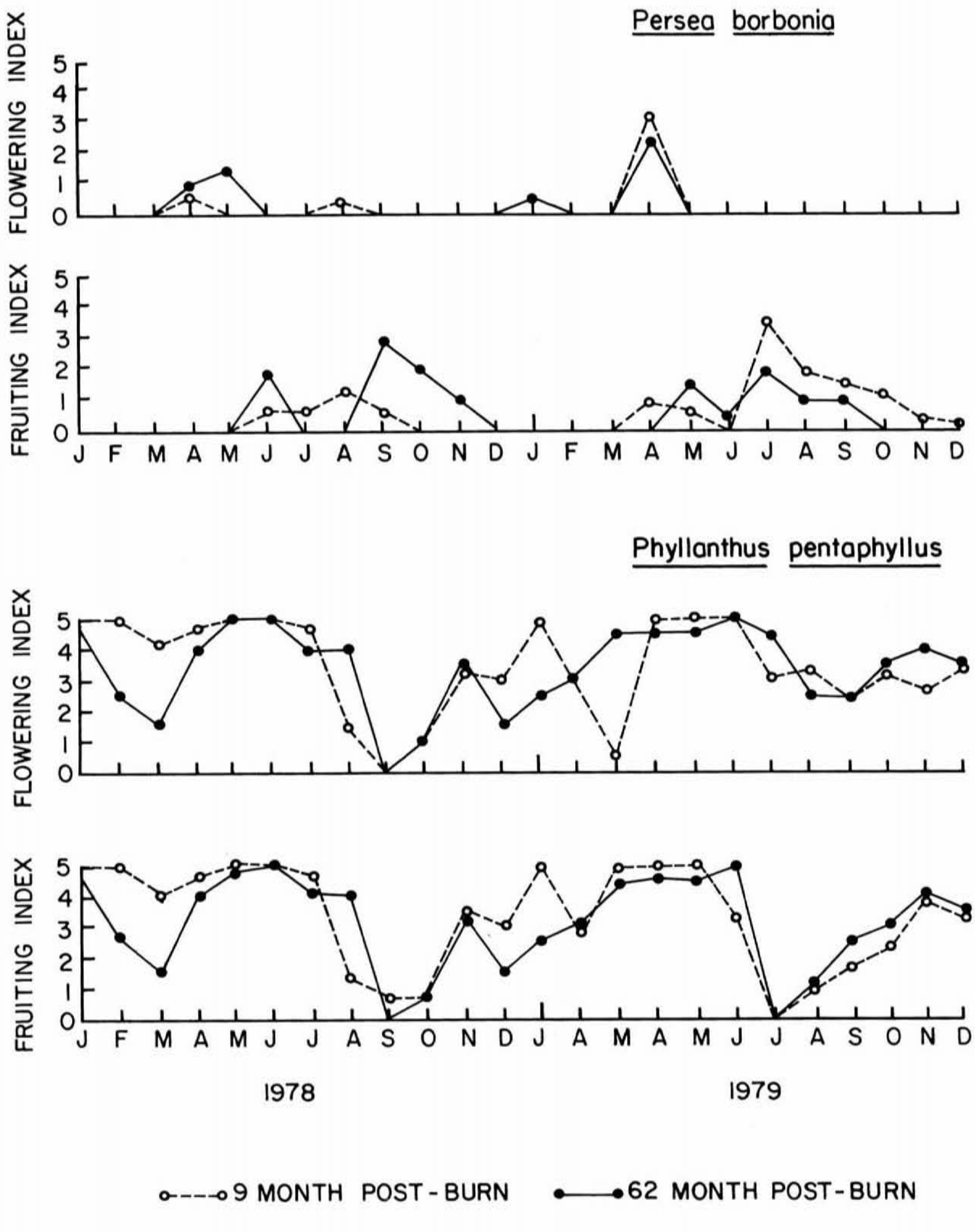

Figure 18. Flowering and fruiting patterns of Persea borbonia and Phyllanthus pentaphyllus in 9-month and 62-month post-fire plots.

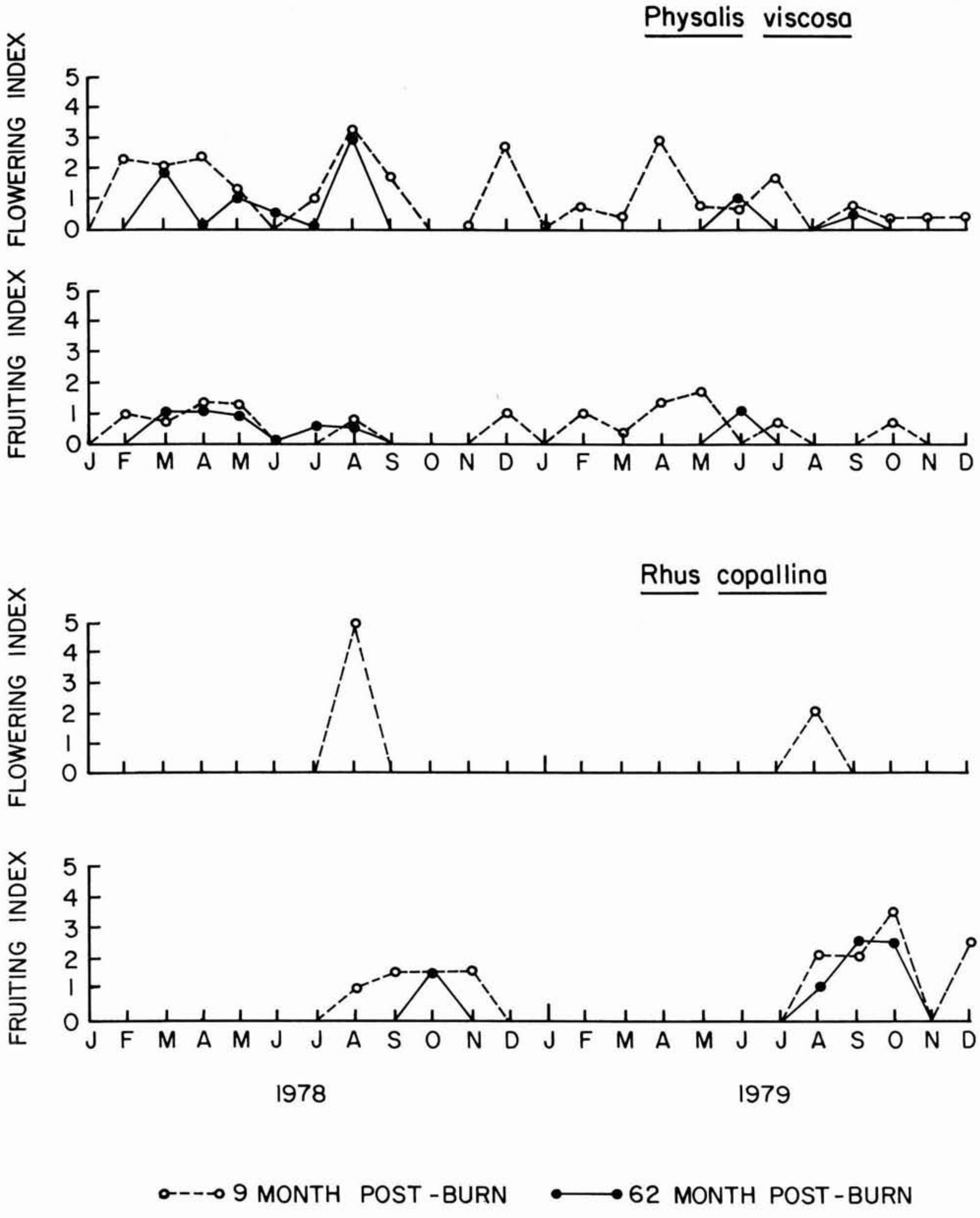

Figure 19. Flowering and fruiting patterns of Physalis viscosa and Rhus copallina in 9-month and 62-month post-fire plots.

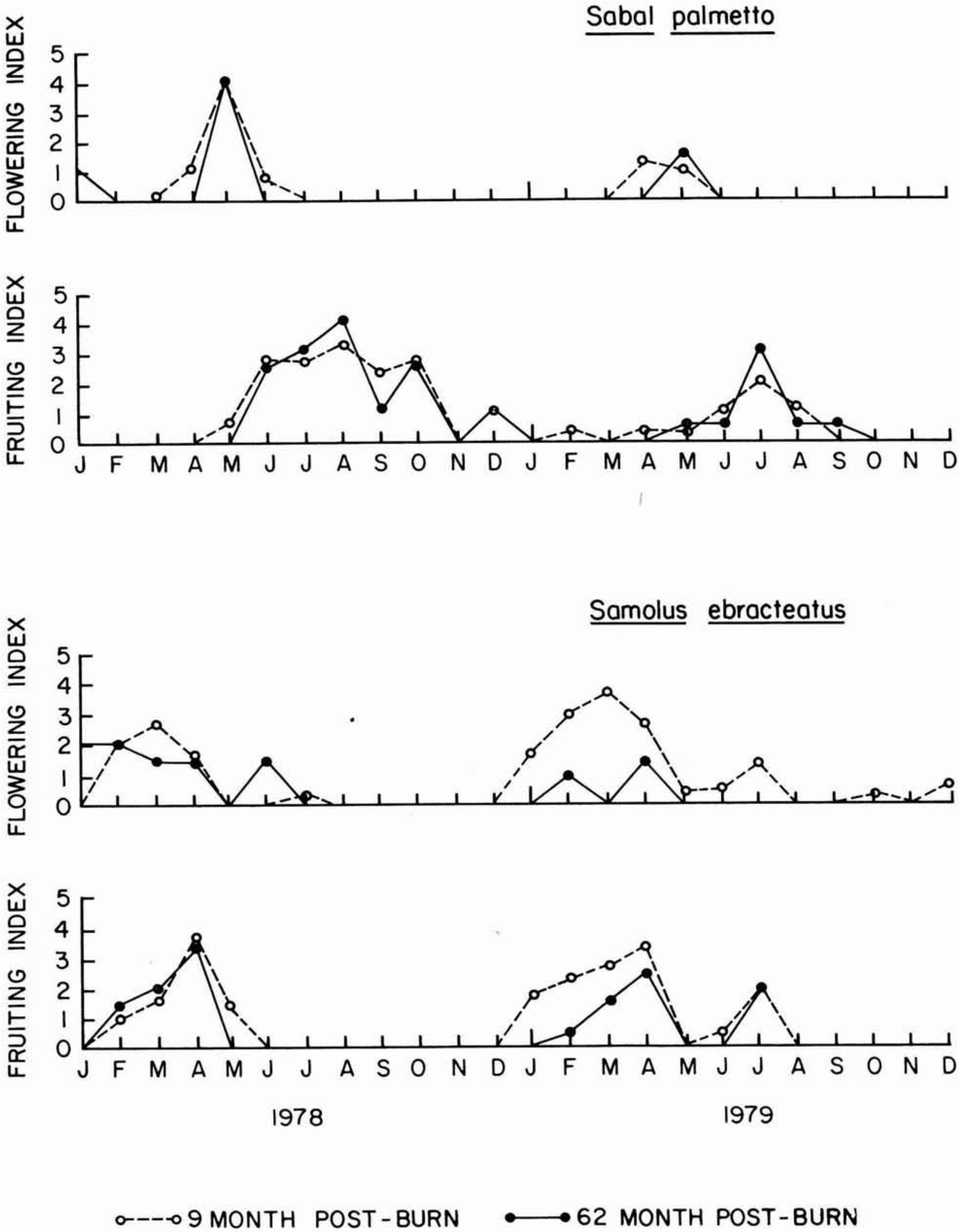

Figure 20. Flowering and fruiting patterns of Sabal palmetto and Samolus ebracteatus in 9-month and 62-month post-fire plots.

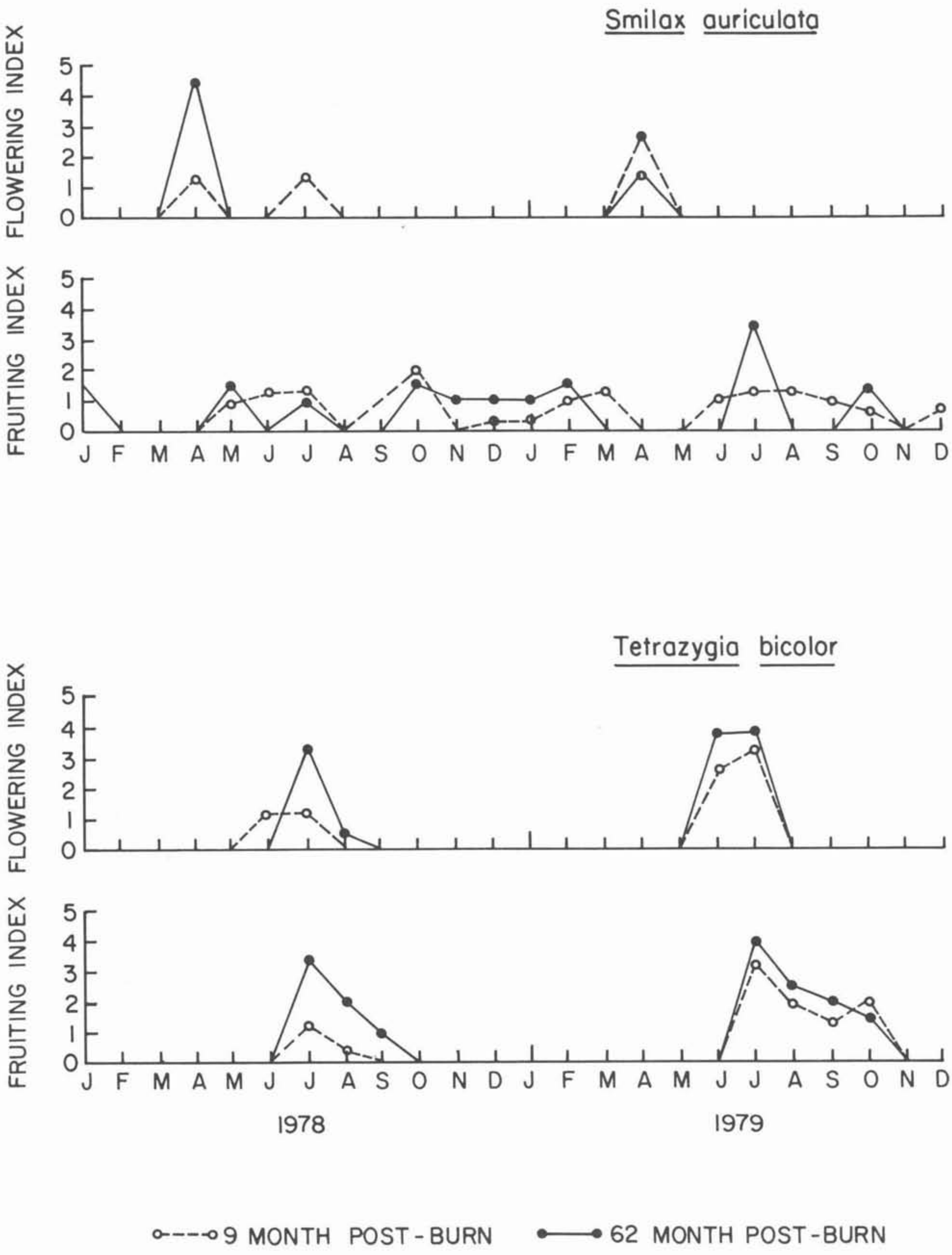

Figure 21. Flowering and fruiting patterns of Similax auriculata and Tetrazygia bicolor in 9-month and 62-month post-fire plots.

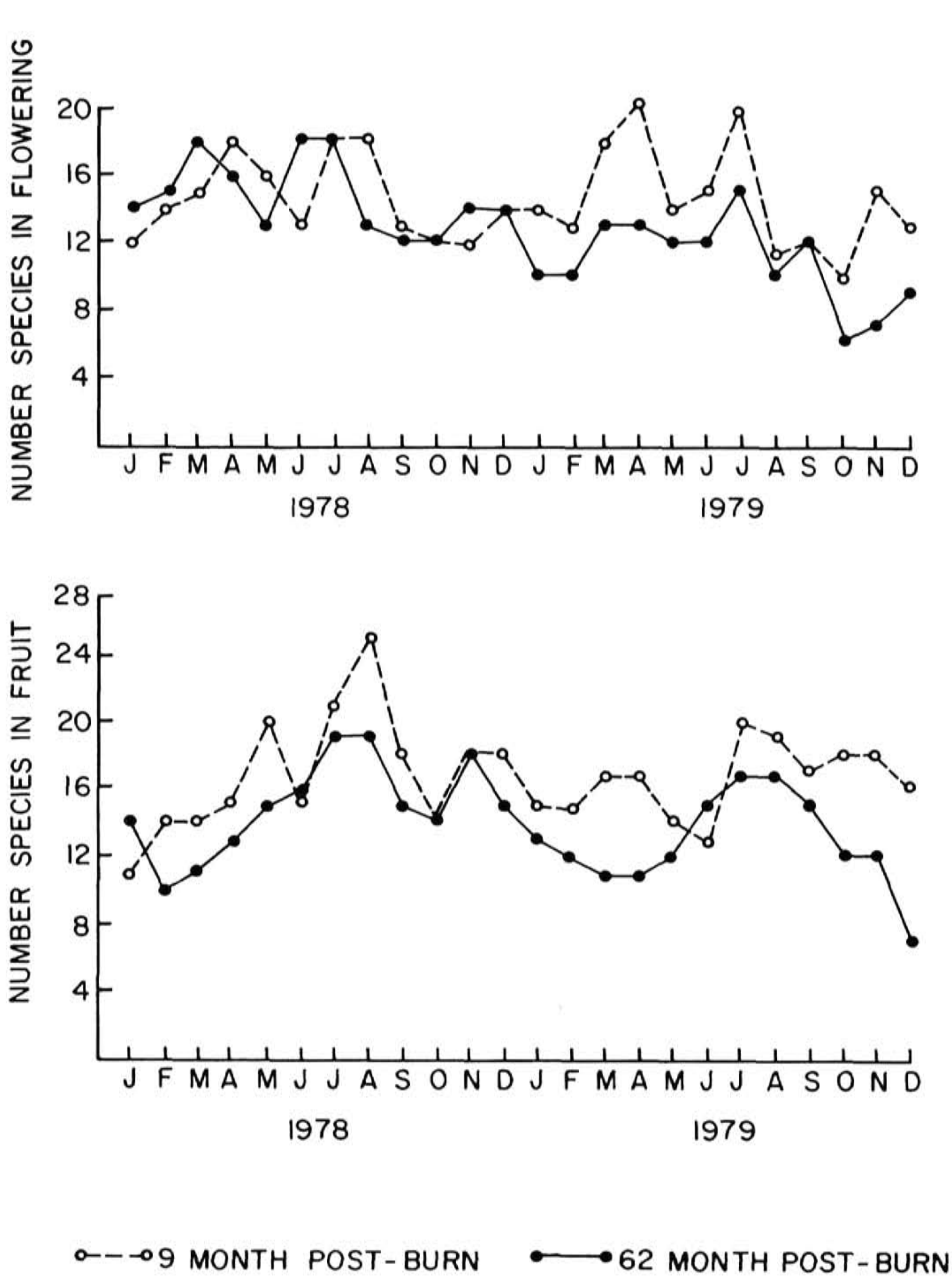

Figure 22. Total number of species observed to be flowering or fruiting during each month (1978-1979) in the 9-month and 62-month post-fire plots.

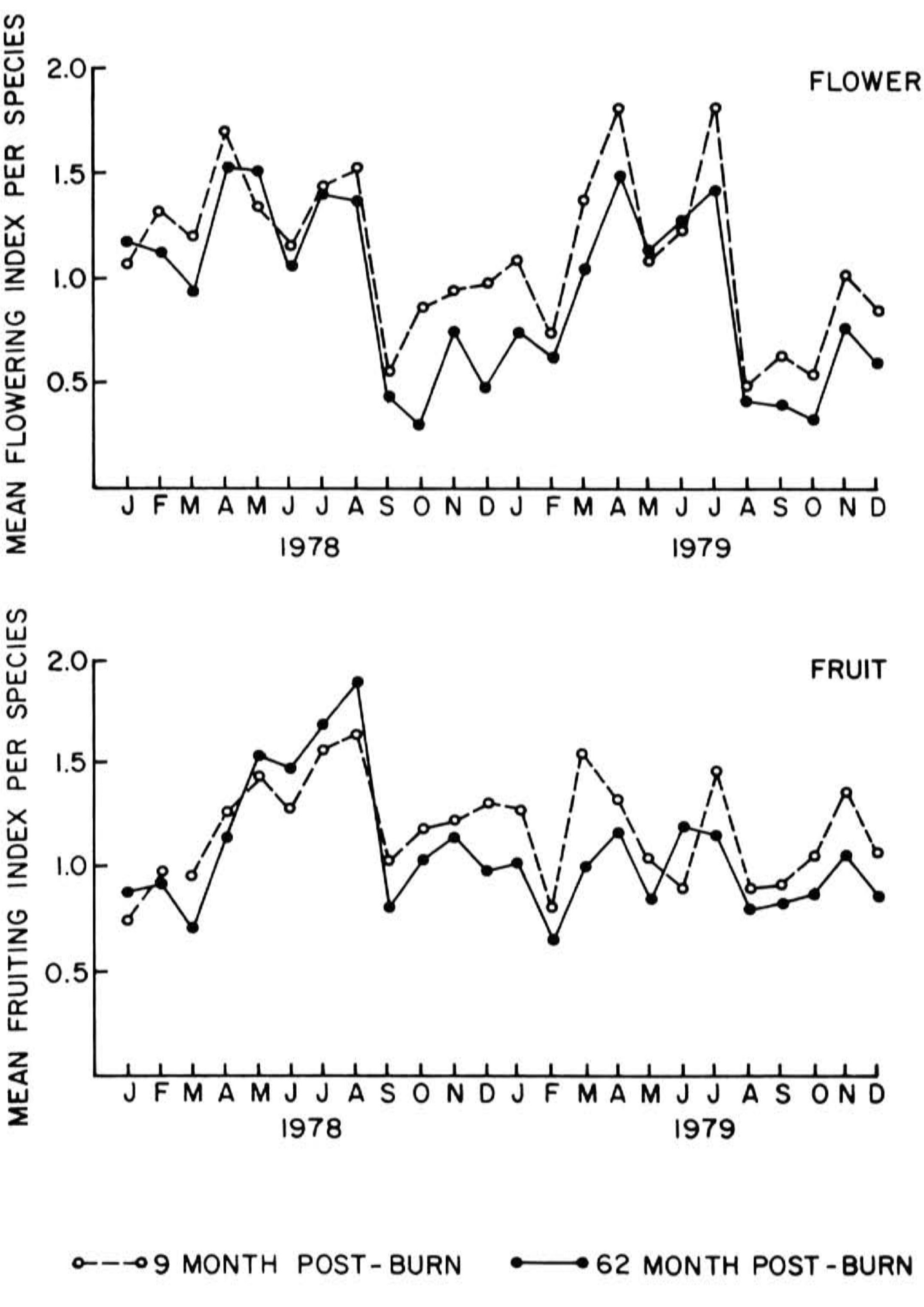

Figure 23. Annual patterns of mean monthly flowering and fruiting indices (1978-1979) in 9-month and 62-month post-fire plots.

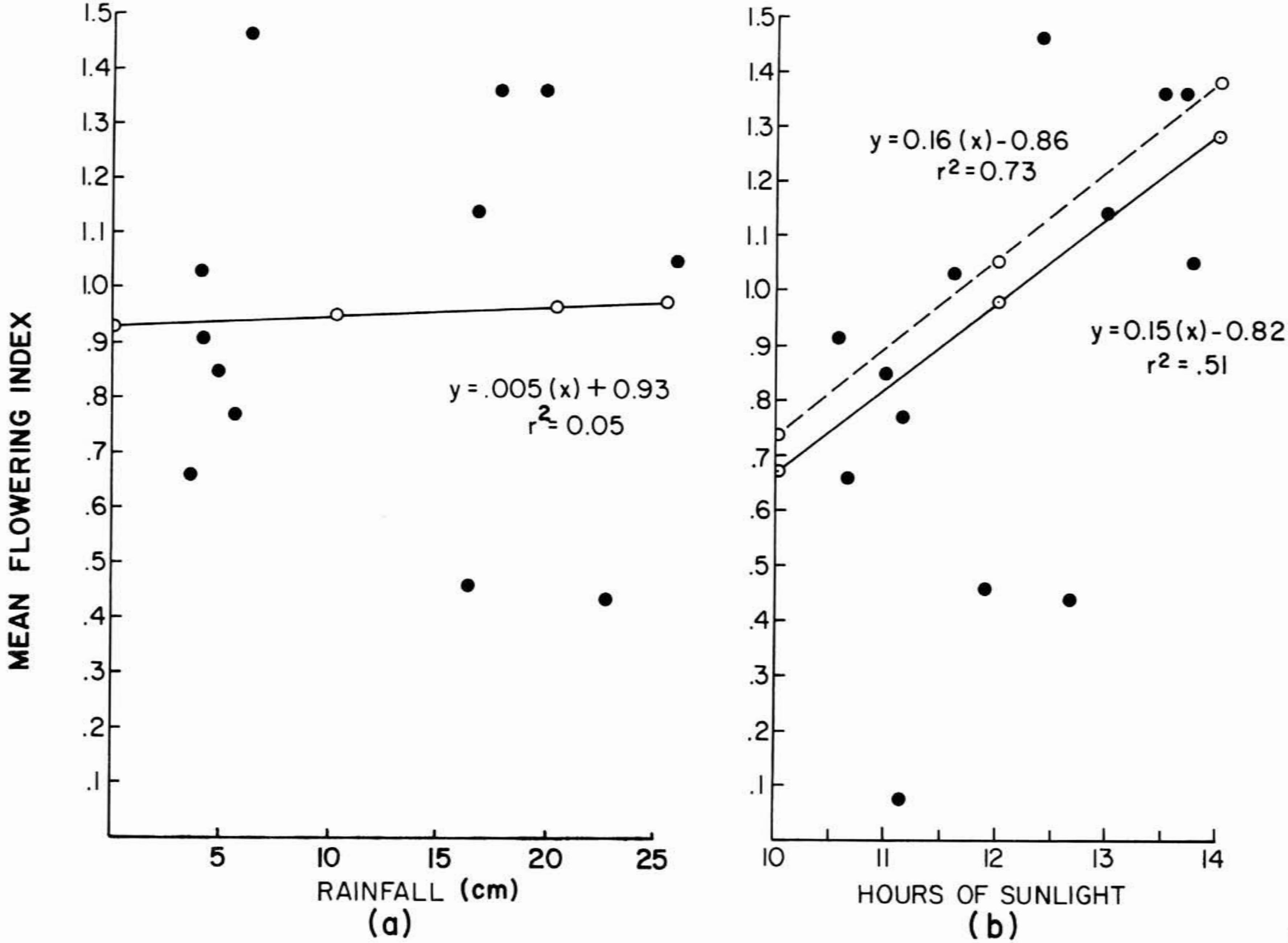

Figure 24. Correlations between a.) mean monthly flowering index and mean monthly rainfall. b.) mean monthly flowering index and mean monthly day length.

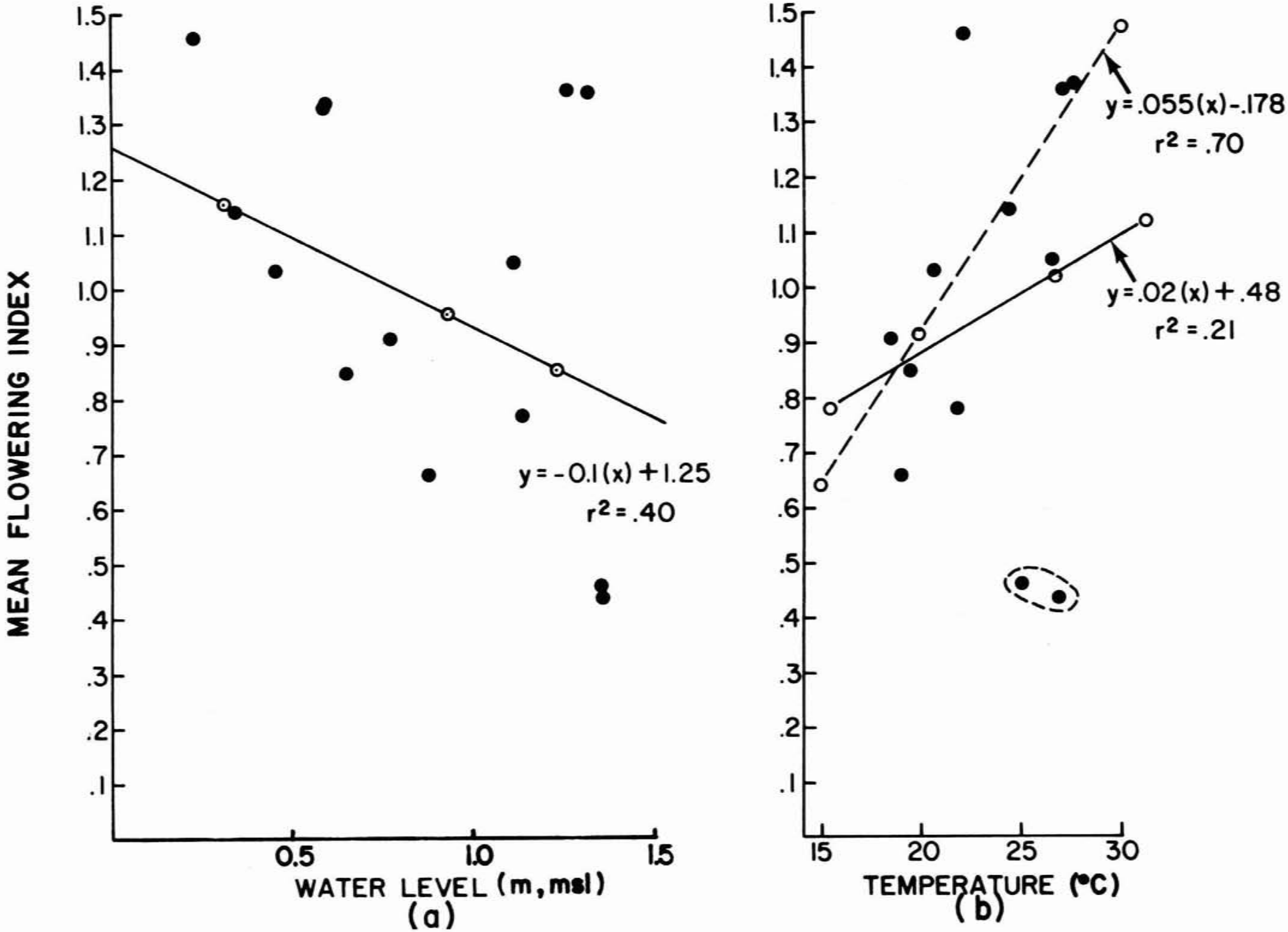

Figure 25. Correlations between a.) mean monthly flowering index and mean monthly water level. b.) mean monthly flowering index and mean monthly temperature.

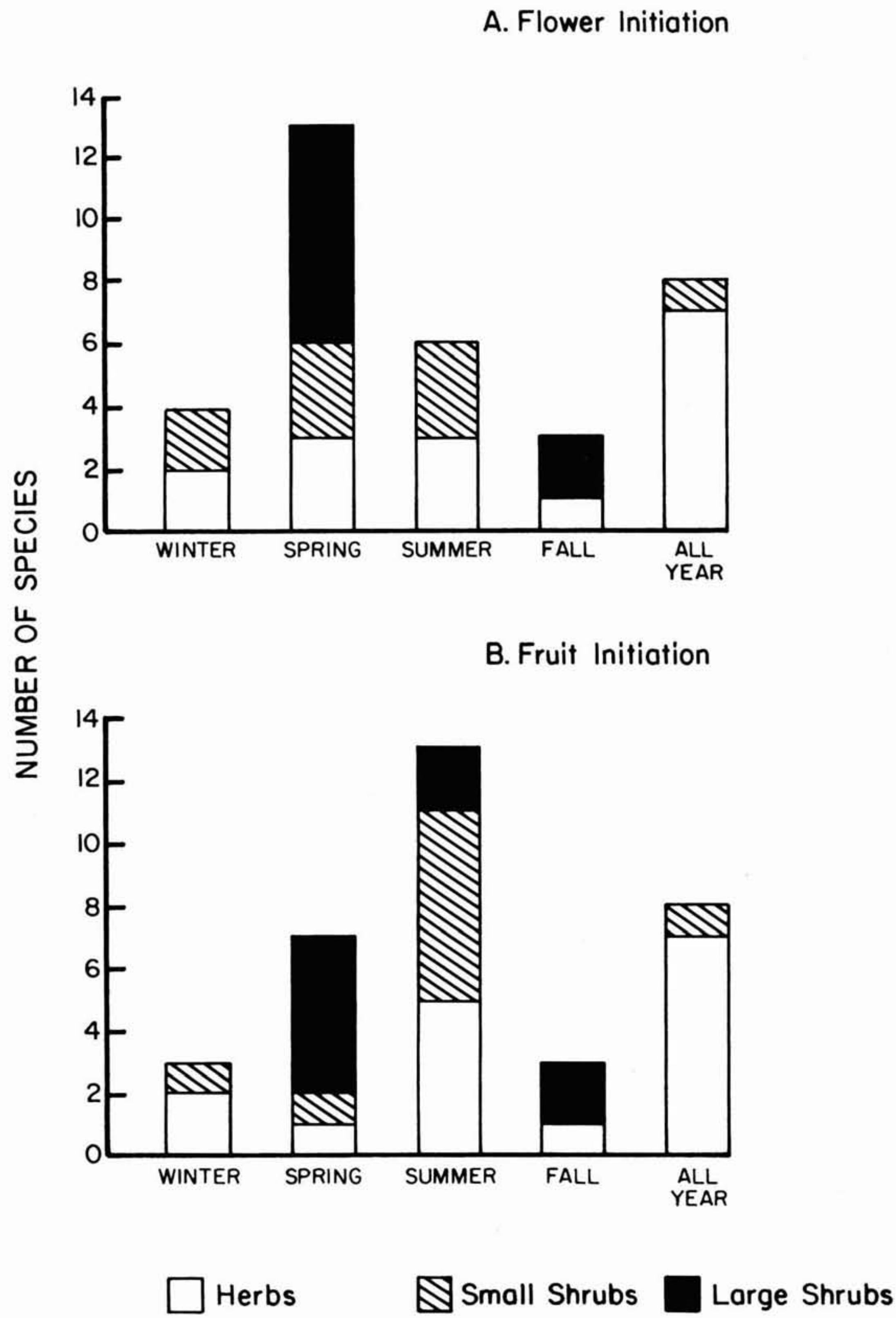

Figure 26. Season of flower and fruit initiation in three growth-forms.

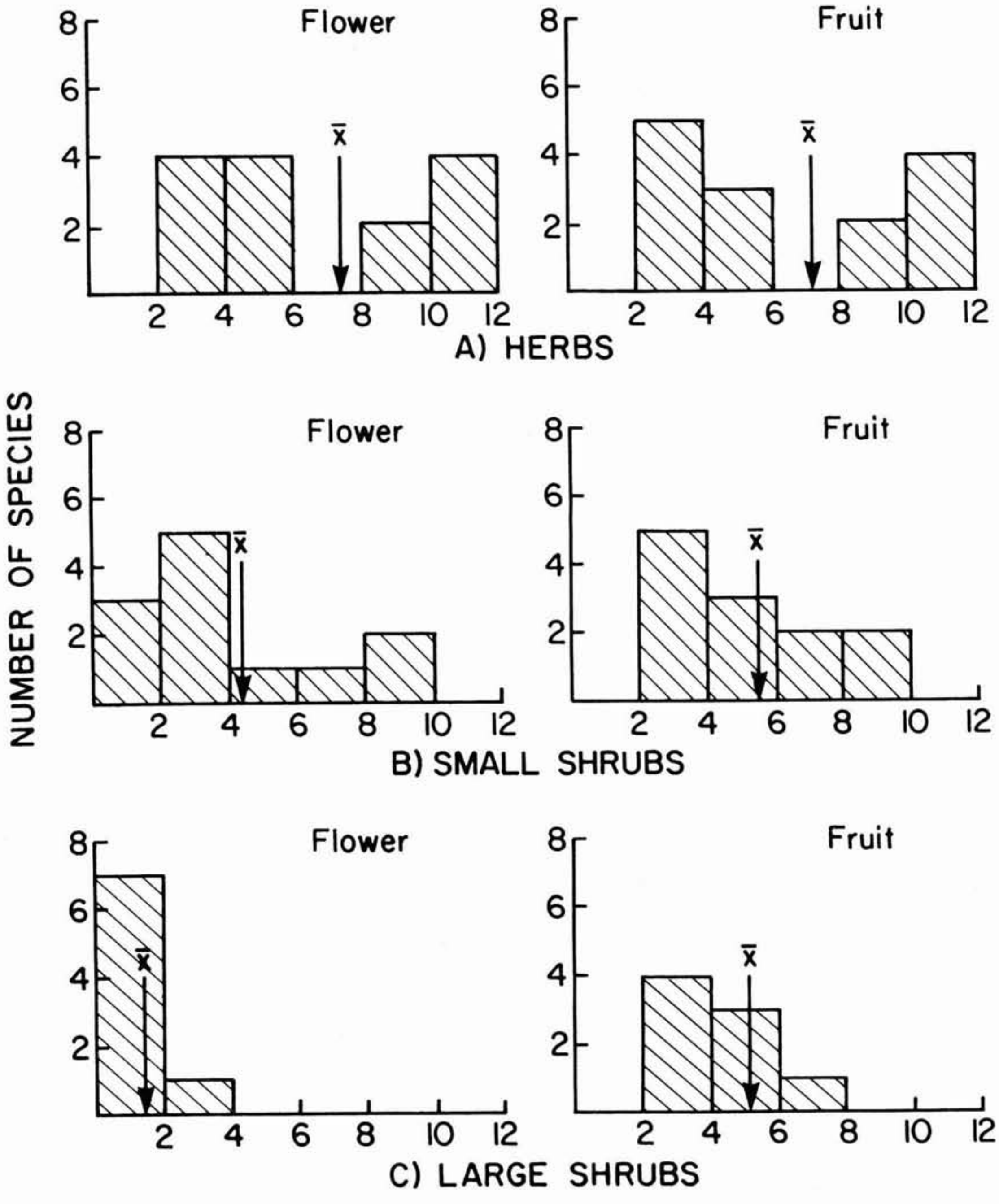

Figure 27. Duration of flowering and fruiting activity in three growth-forms.