# Abundance and Production of Berry-producing Plants on the MOFEP Study Sites: The Soft Mast Study Pre-harvest Conditions (1994-1995)

Debby K. Fantz and David A. Hamilton[1]

Abstract.—We surveyed the permanent Missouri Ozark Forest Ecosystem Project (MOFEP) forest vegetation cluster plots in 1994 and 1995 to determine pre-treatment frequency of occurrence, amount of vegetative cover, and number of berries for plants that produce soft mast. Mean percentage occurrence of selected plants for each site ranged from 0.1 to 33.0 for *Vaccinium* sp., and from 0 to 8.6 for *Rubus* sp. Mean percentage vegetative cover (0-1 m) for each site ranged from <0.1 to 1.1 for *Vaccinium* sp., and from 0 to 0.3 for *Rubus* sp. Mean numbers of berries for each site ranged from 0 to 20.3 for *Vaccinium* sp., and from 0 to 1.2 for *Rubus* sp. Generally, few soft mast plants were found, they provided little vegetative cover, and they rarely produced fruit in the pre-treatment plots. Some significant differences were detected, mainly due to year and block effects.

Natural resource agencies involved in forest management are continually being challenged to justify traditional silvicultural practices, especially the use of clearcutting in even-aged forest management systems. Some environmental advocacy groups have been increasingly successful in persuading natural resource management agencies to replace clearcutting with uneven-aged forest management and non-traditional cutting practices. However, the effects of these timber management practices on wildlife species and habitats, including the abundance of plants producing soft mast (soft fruit) and the production of soft mast, have not adequately been examined.

Plants that produce soft mast provide food for a variety of wildlife species. The abundance of both soft and hard mast can dramatically influence the population dynamics of some wildlife species, including gray squirrels (*Sciurus carolinensis*), eastern chipmunks (*Tamias striatus*), and black bears (*Ursus americanus*) (Beeman and Pelton 1977, Cherry and Deardon 1975, Gorman and Roth 1989, Gurnell 1983, Nixon and McClain 1969, Nixon *et al.* 1975, Rogers 1976). The needs of wildlife for consistent and dependable food sources, and for cover requirements, were the primary concerns of wildlife managers that led to the eventual acceptance of even-aged forest management as an important wildlife management tool in forested landscapes. The need to achieve a balance of timber age- and size-classes, to provide sustained forage, and to limit large-scale conversion of hardwood forests to pine plantations helped to shape management programs on public forests in Missouri, which had been largely based on even-aged silvicultural systems (Evans 1974).

Some concern exists among wildlife managers that uneven-aged silvicultural systems will not provide habitat conditions that will meet the needs of wildlife species dependent upon early successional plant fruits or vegetation structure because of limited canopy removal and rapid canopy closure of small openings following timber harvests. Past research has convincingly shown the relationship between increasing amounts of crown closure and decline in wildlife forage.

In one study in the Ozarks of Arkansas, clearcuts in upland hardwood stands initially produced four times as much wildlife forage as selective cuts (Crawford and Harrison 1971). Likewise, soft mast production was higher in even-aged managed forests than in uneven-aged forests in the Adirondack Mountains, and in regenerating stands of red pine (*Pinus resinosa*)

[1] Wildlife Staff Biologist and Wildlife Research Biologist, respectively, Missouri Department of Conservation, 1110 S. College Ave., Columbia, MO 65201.

and 9- to 16-year-old regenerating aspen (*Populus* sp.) in Minnesota than in uneven-aged stands or those unmanaged (Costello 1992, Noyce and Coy 1990). None of these studies had pre-treatment data.

In Missouri, a few studies were conducted that measured various aspects of fruit production in forested habitats (Murphy and Crawford 1970, Murphy and Ehrenreich 1965). In an early study of fruit-producing trees and shrubs in Missouri's Ozark forests, abundance of fruiting plants and the percentage producing fruit were both influenced by crown cover of overstory trees (Murphy and Ehrenreich 1965). None of the fruiting species had a high percentage of plants with fruit, perhaps because of the relative lack of substantial openings in the forest. No studies of soft mast production have been conducted in Missouri for either even-aged or uneven-aged forest management systems.

The Missouri Ozark Forest Ecosystem Project (MOFEP) is a comprehensive research project designed to examine the landscape-scale effects of forest management practices (even- and uneven-aged management) on selected flora, fauna, and abiotic components of the southern Missouri oak-hickory (*Quercus* sp. - *Carya* sp.) forest (Brookshire *et al.* 1997, Sheriff and He 1997). One component of MOFEP is a study to determine if even- and uneven-aged forest management practices have a landscape-scale effect on the abundance of plants producing soft mast and on the production of soft mast of selected species on MOFEP sites. The development of such a long-term study of the impacts of these silvicultural practices in Missouri oak-hickory forests represents a unique opportunity to gather information about the abundance and production of berry-producing plants resulting from these treatments.

This paper reports on the pre-treatment (1994-1995) abundance and production of seven focal soft mast producing species: *Vaccinium arboreum* (farkleberry), *V. stamineum* (deerberry), *V. vacillans* (lowbush blueberry), *Rubus enslenii* (dewberry), *R. flagellaris* (dewberry), *R. occidentalis* (black raspberry), and *R. pensilvanicus* (high-bush blackberry). Common names follow Steyermark (1963).

## METHODS

### Field Sampling

We surveyed the MOFEP permanent forest vegetation cluster plots for selected plants that produce soft mast (Appendix A). The permanent forest vegetation cluster plot sampling design included 645 permanent 1/2-acre plots in 1993 and 1994, and 648 permanent 1/2-acre plots in 1995. Each 1/2-acre plot contains four 1/20-acre subplots, four 1/100-acre subplots, and sixteen 1-m$^2$ quadrats (Brookshire *et al.* 1997). These plots occur on 12 ecological landtypes (ELT); most are on southwest-facing slopes (ELT17) (40 percent) and northeast-facing slopes (ELT18) (33 percent).

We conducted a pilot study during the summer of 1993 to evaluate methods of estimating soft mast production and to determine when fruits ripen. Measurements were taken on seventeen 1/2-acre plots and 272 1-m$^2$ quadrats within six sites in 4- to 6-year-old clearcuts next to MOFEP sites on Deer Run State Forest and Peck Ranch Conservation Area in Shannon and Carter Counties. We measured the frequency of occurrence of soft mast plants in these plots, estimated their percentage vegetative cover, and counted and weighed berries.

Information on plant species producing soft mast within the MOFEP permanent forest vegetation cluster plots was collected between mid-May and mid-October in 1994 and from late May to late September in 1995. We used a two-tiered approach to data collection that used the intensive efforts of the MOFEP botany crews that measure herbaceous and small woody vegetation in each of the 1-m$^2$ quadrats ($\leq$1 m tall), and the MOFEP tree measurement crews that measure woody vegetation appropriate to plots and subplots (1/2-acre plots: d.b.h. $\geq$4.5 inches, 1/20-acre subplots: d.b.h. $\geq$1.5 inches and <4.5 inches, 1/100-acre subplots: d.b.h. <1.5 inches and $\geq$1 m tall). We sampled berry production in all plots identified by the forest vegetation crews as containing fruit-bearing species during the preceding field season. Therefore, our 1994 sampling occurred on plots identified in the 1993 forest vegetation data as containing soft mast species, and our 1995 sampling was based on the 1994 forest vegetation data. The 1-m$^2$ quadrats were sampled first and then the 1/2-acre plots and 1/20-acre subplots. No sampling was done in the 1/100-acre subplots because we believed that most vegetation in these plots was immature and would produce few or no berries (woody vegetation; d.b.h. <1.5 inches and ≥1 m tall). Information for the three plots added in 1995 was not included in our analysis.

### 1-m$^2$ Quadrat Sampling

Within plots known to have soft mast producers, all soft mast plants within the 1-m$^2$ quadrats (even those that grow beyond 1 m in height) were recorded. Between mid-May and mid-September 1994, we sampled all 1-m$^2$ quadrats within plots identified by the 1993 forest vegetation data as containing soft mast species. Between late May and late August 1995, we sampled all 1-m$^2$ quadrats within plots identified by the 1994 forest vegetation data as containing soft mast species.

Sampling was based on the fruiting periods of two core plant genera, *Vaccinium* and *Rubus*. During the 1993 pilot year, we determined that *Vaccinium* sp. fruit before *Rubus* sp. Therefore, plots containing any *Vaccinium* sp. were sampled first and all soft mast plants were recorded. Then plots containing any *Rubus* sp. were sampled and all soft mast plants were recorded. Plots were sampled only once (some plots containing *Vaccinium* sp. also contained *Rubus* sp.; these plots were not resampled). Plots containing other soft mast species that had not been surveyed for *Vaccinium* or *Rubus* were sampled last.

Within the 1-m$^2$ quadrats, we estimated percentages for litter; down, dead, and woody material; moss; bare ground; rock; total herbaceous cover; and total vegetative cover. All soft mast species were identified, their percentage vegetative cover from 0-1 m and 1-2 m in height was estimated, and numbers of plants and berries were counted. Numbers of berries were divided according to seven condition classes: flowers, green, red, ripe, dry, damaged and missing (berry stem present). A sample of ripe berries from outside, but adjacent to, the plot was collected and weighed, and an average weight per berry was calculated. Soft mast plants rooted outside the quadrat that provided vegetative cover within the quadrat were also recorded.

### 1/2-Acre Plot and 1/20-Acre Subplot Sampling

Trees with a d.b.h. greater than 4.5 inches were sampled within pre-selected 1/2-acre plots, and trees with a d.b.h. from 1.5 to 4.5 inches were sampled within pre-selected 1/20-acre subplots. Analysis and discussion of the 1/2-acre plot and 1/20-acre subplot data are beyond the scope of this report and will be presented in a subsequent paper.

### Statistical Analysis

Mean percentage occurrence, mean percentage vegetative cover, and mean number of berries between sites and years were calculated for seven species: *Vaccinium arboreum, V. stamineum, V. vacillans, Rubus enslenii, R. flagellaris, R. occidentalis,* and *R. pensilvanicus.* We surveyed 9,104 of 10,320 1-m$^2$ forest vegetation quadrats for soft mast plants in 1994 and 9,280 of 10,320 1-m$^2$ quadrats in 1995. Quadrats not sampled within a year were assumed to have no soft mast species. Multivariate repeated measures analysis of variance (with year as the repeated factor) (SAS 1989) was used to examine the effect of year, treatment, and block, and their interactions on the pre-treatment conditions of these seven species. We used 0.10 as the alpha level for our analysis.

## RESULTS

### General

We surveyed 9,104 (88 percent) of the 10,320 1-m$^2$ forest vegetation quadrats for soft mast plants in 1994 and 9,280 (90 percent) of the 10,320 1-m$^2$ quadrats in 1995. The forest vegetation crews identified 40 of the soft mast target species (+2 plants we identify only to genera) in 1993, 38 target species (+2 plants we identify only to genera) in 1994, and 39 target species (+2 plants we identify only to genera) in 1995 (Appendix A). *Vaccinium arboreum, V. stamineum, V. vacillans, Rubus enslenii, R. flagellaris,* and *R. pensilvanicus* were found on all nine sites, and *R. occidentalis* was found on eight sites during 1993, 1994, and 1995. *Rubus trivialis* was found only in two quads in two plots on Site 1 in 1993; it is therefore, not considered in the analysis. All 12 ELT's were surveyed, but numbers of plots within individual ELT's were not equal. Most quadrats were on southwest-facing slopes (42 percent) and northeast-facing slopes (32 percent).

### Mean Percentage Occurrence - *Vaccinium* sp. and *Rubus* sp.

Mean percentage occurrence for *Vaccinium* sp. for each site ranged from 0.5 (*V. arboreum*) to 33.0 (*V. vacillans*) in 1994, and from 0.1 (*V. arboreum*) to 32.2 (*V. vacillans*) in 1995 (table 1). *V. vacillans* had the greatest mean percentage occurrence on all sites for both years, followed by *V. stamineum* then *V. arboreum*, except on site 7 where *V. stamineum* had a larger mean percentage occurrence than *V. vacillans* in 1994 and 1995. The *Rubus* sp. did not exhibit such clear trends. The mean percentage occurrence for *Rubus* sp. for each site ranged from 0.0 (*R. occidentalis*) to 5.8 (*R. flagellaris*) in 1994, and from 0.0 (*R. occidentalis*) to 8.6 (*R. enslenii*) in 1995 (table 2). *Rubus occidentalis* consistently had the lowest mean percentage occurrence per site in both years (except for site 2 in 1994 and site 5 in 1995), and was not found on three sites (block 3, the Peck Ranch sites) in 1994 and two sites in 1995. The other three species were found on all sites in both years. *Rubus flagellaris* was the dominant plant in 1994, but *R. enslenii* was dominant in 1995. However, we

Table 1.—*Mean percentage occurrence of* Vaccinium *sp. for each MOFEP site and all sites combined by year (data from MOFEP forest vegetation study). Yearly means for all sites combined represent means of means, and standard deviations (s.d.) are based on nine sites.*

| | *V. arboreum* | | *V. stamineum* | | *V. vacillans* | |
|---|---|---|---|---|---|---|
| Site | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 1 | 1.3 | 1.5 | 5.4 | 6.9 | 33.0 | 32.2 |
| 2 | 2.5 | 1.2 | 4.1 | 2.8 | 13.8 | 16.1 |
| 3 | 1.0 | 1.0 | 5.1 | 4.4 | 11.7 | 13.8 |
| 4 | 1.3 | 0.9 | 5.4 | 5.0 | 13.2 | 14.5 |
| 5 | 0.5 | 0.1 | 3.6 | 3.6 | 8.5 | 9.7 |
| 6 | 1.1 | 0.6 | 4.8 | 3.1 | 15.4 | 18.0 |
| 7 | 2.9 | 1.6 | 19.2 | 17.1 | 12.2 | 15.1 |
| 8 | 2.9 | 1.7 | 10.0 | 16.1 | 22.1 | 18.6 |
| 9 | 2.0 | 1.4 | 14.3 | 11.0 | 23.6 | 28.4 |
| All sites | 1.7 | 1.1 | 8.0 | 7.8 | 17.1 | 18.5 |
| (s.d.) | (0.90) | (0.52) | (5.42) | (5.59) | (7.71) | (7.23) |

Table 2.—*Mean percentage occurrence of* Rubus *sp. for each MOFEP site and all sites combined by year (data from MOFEP forest vegetation study). Yearly means for all sites combined represent means of means, and standard deviations (s.d.) are based on nine sites.*

| | *R. enslenii* | | *R. flagellaris* | | *R. occidentalis* | | *R. pensilvanicus* | |
|---|---|---|---|---|---|---|---|---|
| Site | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 1 | 1.4 | 2.2 | 3.3 | 2.0 | 0.1 | 0.2 | 0.8 | 0.9 |
| 2 | 0.9 | 2.7 | 3.0 | 1.1 | 1.5 | 1.1 | 0.9 | 1.5 |
| 3 | 0.8 | 4.0 | 4.3 | 0.4 | 0.1 | 0.1 | 0.4 | 1.0 |
| 4 | 1.9 | 3.5 | 2.1 | 0.8 | 0.3 | 0.1 | 1.9 | 2.2 |
| 5 | 2.1 | 8.6 | 2.8 | 0.1 | 0.2 | 0.2 | 5.5 | 3.0 |
| 6 | 0.2 | 2.2 | 1.2 | 0.2 | 0.1 | 0 | 1.5 | 0.9 |
| 7 | 1.1 | 0.6 | 1.0 | 0.9 | 0 | 0.1 | 4.7 | 4.9 |
| 8 | 0.3 | 1.9 | 3.0 | 0.5 | 0 | 0.1 | 1.8 | 2.1 |
| 9 | 1.7 | 5.9 | 5.8 | 1.2 | 0 | 0 | 3.4 | 4.3 |
| All sites | 1.1 | 3.5 | 3.0 | 0.8 | 0.2 | 0.2 | 2.3 | 2.3 |
| (s.d.) | (0.68) | (2.42) | (1.49) | (0.59) | (0.46) | (0.35) | (1.79) | (1.50) |

suspect that crews had difficulty distinguishing *R. flagellaris* from *R. enslenii* and, therefore, these trends may change if they are combined into one dewberry category. Mean percentage occurrences for *Vaccinium* sp. and *Rubus* sp. by year, block, and treatment type are presented in tables 3 and 4. Block 3 tended to have higher estimates, but no trends were detected for treatment types.

Significant differences were detected for block (*V. stamineum, V. arboreum, R. pensilvanicus*), treatment (*V. arboreum, R. enslenii*), year (*V. arboreum, R. flagellaris, R. enslenii*), and year x treatment (*R. flagellaris, R. enslenii*) (tables 5-9). A significant year and year x treatment effect was detected for *Vaccinium* sp. and *Rubus* sp. combined (table 10). No significant effects were detected for *V. vacillans* or *R. occidentalis*.

Mean percentage occurrence by ELT also was calculated. Mean values for *Vaccinium* sp. ranged from 0 to 26.6 in 1994, and 0 to 27.8 in 1995 (table 11). Mean values for *Rubus* sp. ranged from 0 to 13.5 in 1994, and from 0 to 16.7 in 1995 (table 12). For *Vaccinium* sp., southwest-facing slopes (ELT17) consistently had higher mean percentage occurrences when compared to northeast-facing slopes (ELT 18), but *Rubus* sp. estimates were mostly higher for northeast-facing slopes (ELT 18) when compared to southwest-facing slopes (ELT 17). A brief description of ELT's is presented in Appendix B. No repeated measures analysis of variance was conducted on the ELT data.

Table 3.—*Mean percentage occurrence of* Vaccinium *sp. and* Rubus *sp. by block, year, and combined years (data from MOFEP forest vegetation study). Standard deviations (s.d.) are based on 2 years of three sites.*

| | Block 1 | | | Block 2 | | | Block 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Species** | **1994** | **1995** | **Comb.(s.d.)** | **1994** | **1995** | **Comb. (s.d.)** | **1994** | **1995** | **Comb. (s.d.)** |
| *V. arboreum* | 1.6 | 1.2 | 1.4 (0.57) | 0.9 | 0.5 | 0.7 (0.43) | 2.6 | 1.6 | 2.1 (0.65) |
| *V. stamineum* | 4.9 | 4.7 | 4.8 (1.38) | 4.6 | 3.9 | 4.2 (0.95) | 14.5 | 14.7 | 14.6 (3.57) |
| *V. vacillans* | 19.5 | 20.7 | 20.1 (9.77) | 12.4 | 14.1 | 13.2 (3.56) | 19.3 | 20.7 | 20.0 (5.91) |
| *R. enslenii* | 1.0 | 3.0 | 2.0 (1.24) | 1.4 | 4.7 | 3.1 (2.89) | 1.0 | 2.8 | 1.9 (2.05) |
| *R. flagellaris* | 3.6 | 1.1 | 2.4 (1.49) | 2.0 | 0.3 | 1.2 (1.07) | 3.2 | 0.9 | 2.1 (2.02) |
| *R. occidentalis* | 0.5 | 0.5 | 0.5 (0.62) | 0.2 | 0.1 | 0.1 (0.90) | 0 | 0.1 | <0.1 (0.05) |
| *R. pensilvanicus* | 0.7 | 1.1 | 0.9 (0.38) | 2.9 | 2.0 | 2.5 (1.62) | 3.3 | 3.8 | 3.5 (1.33) |

Table 4.—*Mean percentage occurrence of* Vaccinium *sp. and* Rubus *sp. by treatment type, year, and combined years (data from MOFEP forest vegetation study). Standard deviations (s.d.) are based on 2 years of three sites.*

| | Treatment type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Even-aged | | | Uneven-aged | | | Control | | |
| | **1994** | **1995** | **Comb. (s.d.)** | **1994** | **1995** | **Comb. (s.d.)** | **1994** | **1995** | **Comb. (s.d.)** |
| *V. arboreum* | 1.1 | 0.8 | 1.0 (0.69) | 2.2 | 1.2 | 1.7 (0.79) | 1.7 | 1.3 | 1.5 (0.76) |
| *V. stamineum* | 7.7 | 6.3 | 7.0 (4.53) | 9.6 | 8.3 | 8.9 (7.21) | 6.8 | 8.7 | 7.7 (4.71) |
| *V. vacillans* | 14.6 | 17.3 | 16.0 (8.14) | 13.1 | 15.3 | 14.2 (1.39) | 23.5 | 22.9 | 23.2 (7.58) |
| *R. enslenii* | 1.5 | 6.2 | 3.8 (2.96) | 1.3 | 2.2 | 1.8 (1.12) | 0.6 | 2.1 | 1.4 (0.93) |
| *R. flagellaris* | 4.3 | 0.6 | 2.4 (2.30) | 2.0 | 0.9 | 1.5 (0.89) | 2.5 | 0.9 | 1.7 (1.28) |
| *R. occidentalis* | 0.1 | 0.1 | 0.1 (0.08) | 0.6 | 0.4 | 0.5 (0.62) | 0.1 | 0.1 | 0.1 (0.06) |
| *R. pensilvanicus* | 3.1 | 2.8 | 2.9 (1.95) | 2.5 | 2.9 | 2.7 (1.69) | 1.4 | 1.3 | 1.3 (0.57) |

Table 5.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Vaccinium stamineum *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 5.7579 | 0.64 | 0.58 |
| Block | 2 | 203.6156 | 22.47 | <0.01 |
| Error (Blk X Trt) | 4 | 9.0614 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.011 | 0.0444 | 1 | 4 | 0.84 |
| Yr X Trt | 0.3639 | 1.1444 | 2 | 4 | 0.40 |
| Yr X Blk | 0.0368 | 0.0764 | 2 | 4 | 0.93 |

Table 6.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Vaccinium arboreum *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.8789 | 24.34 | <0.01 |
| Block | 2 | 2.7155 | 75.20 | <0.01 |
| Error (Blk X Trt) | 4 | 0.0361 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.7916 | 15.192 | 1 | 4 | 0.02 |
| Yr X Trt | 0.4587 | 1.6946 | 2 | 4 | 0.29 |
| Yr X Blk | 0.5086 | 2.0704 | 2 | 4 | 0.24 |

Table 7.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Rubus pensilvanicus *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 4.428 | 1.81 | 0.27 |
| Block | 2 | 10.5079 | 4.31 | 0.10 |
| Error (Blk X Trt) | 4 | 2.4402 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.0011 | 0.0045 | 1 | 4 | 0.95 |
| Yr X Trt | 0.1647 | 0.3943 | 2 | 4 | 0.70 |
| Yr X Blk | 0.5106 | 2.0866 | 2 | 4 | 0.24 |

Table 8.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Rubus flagellaris *on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 1.5076 | 1.18 | 0.40 |
| Block | 2 | 2.1936 | 1.72 | 0.29 |
| Error (Blk X Trt) | 4 | 1.2759 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.9201 | 46.0414 | 1 | 4 | <0.01 |
| Yr X Trt | 0.7645 | 6.4919 | 2 | 4 | 0.06 |
| Yr X Blk | 0.2092 | 0.5289 | 2 | 4 | 0.63 |

Table 9.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Rubus enslenii *on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 10.5093 | 5.64 | 0.07 |
| Block | 2 | 2.5232 | 1.35 | 0.36 |
| Error (Blk X Trt) | 4 | 1.8621 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.9066 | 38.8408 | 1 | 4 | <0.01 |
| Yr X Trt | 0.8239 | 9.3546 | 2 | 4 | 0.03 |
| Yr X Blk | 0.4663 | 1.7477 | 2 | 4 | 0.28 |

Table 10.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage occurrence of* Vaccinium *sp. and* Rubus *sp. combined on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 48.7126 | 0.31 | 0.75 |
| Block | 2 | 565.1224 | 3.65 | 0.13 |
| Error (Blk X Trt) | 4 | 154.9775 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.8306 | 19.6145 | 1 | 4 | 0.01 |
| Yr X Trt | 0.7782 | 7.0163 | 2 | 4 | 0.05 |
| Yr X Blk | 0.4469 | 1.6159 | 2 | 4 | 0.31 |

Table 11.— *Mean percentage occurrence of* Vaccinium *sp. for each MOFEP ELT by year (data from MOFEP forest vegetation study).*

| ELT | *V. arboreum* | | *V. stamineum* | | *V. vacillans* | |
|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 05 | 0.4 | 0.6 | 4.8 | 5.4 | 4.4 | 7.1 |
| 06 | 0 | 0 | 0 | 0 | 0 | 0 |
| 07 | 2.1 | 0 | 3.1 | 5.2 | 9.4 | 10.4 |
| 11 | 0.8 | 0.8 | 7.8 | 7.9 | 7.9 | 8.3 |
| 15 | 0 | 0 | 8.8 | 11.3 | 6.3 | 6.3 |
| 17 | 2.9 | 1.9 | 10.0 | 8.9 | 25.1 | 27.8 |
| 18 | 0.9 | 0.2 | 6.4 | 6.9 | 15.3 | 16.2 |
| 19 | 1.0 | 1.6 | 3.9 | 2.6 | 4.9 | 5.6 |
| 20 | 0 | 0 | 2.3 | 3.1 | 7.8 | 7.0 |
| 21 | 4.7 | 6.3 | 9.4 | 15.6 | 26.6 | 18.8 |
| 22 | 2.1 | 0 | 2.1 | 6.3 | 12.5 | 12.5 |
| 23 | 2.1 | 1.4 | 14.6 | 13.2 | 4.9 | 6.9 |

Table 12.— *Mean percentage occurrence of* Rubus *sp. for each MOFEP ELT by year (data from MOFEP forest vegetation study).*

| ELT | *R. enslenii* | | *R. flagellaris* | | *R. occidentalis* | | *R. pensilvanicus* | |
|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 05 | 2.0 | 8.7 | 5.6 | 1.8 | 0 | 0 | 7.5 | 7.7 |
| 06 | 0 | 0 | 3.1 | 3.1 | 0 | 0 | 0 | 0 |
| 07 | 9.4 | 12.5 | 13.5 | 5.2 | 0 | 0 | 11.5 | 13.5 |
| 11 | 1.6 | 3.2 | 3.0 | 1.9 | 0.8 | 0.6 | 1.8 | 1.8 |
| 15 | 0 | 1.3 | 2.5 | 1.3 | 0 | 0 | 0 | 0 |
| 17 | 0.8 | 2.3 | 2.2 | 0.5 | 0.2 | 0.1 | 1.5 | 1.7 |
| 18 | 1.1 | 3.9 | 2.9 | 0.7 | 0.1 | 0.1 | 2.3 | 2.1 |
| 19 | 2.0 | 6.3 | 2.6 | 0 | 1.0 | 0.7 | 3.0 | 1.3 |
| 20 | 0.8 | 10.2 | 8.6 | 1.6 | 0 | 0.8 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 3.1 | 1.6 |
| 22 | 0 | 0 | 8.3 | 0 | 0 | 0 | 10.4 | 16.7 |
| 23 | 0 | 2.8 | 1.4 | 0 | 0 | 0 | 3.5 | 2.8 |

### Mean Percentage Vegetative Cover - *Vaccinium* sp. and *Rubus* sp.

Mean percentage cover (0-1 m) for *Vaccinium* sp. for each site ranged from <0.1 (*V. arboreum*) to 0.9 (*V. stamineum, V. vacillans*) in 1994 and from <0.1 (*V. arboreum*) to 1.1 (*V. vacillans*) in 1995 (table 13). *V. vacillans* had the greatest mean percentage cover (0-1 m) on all sites for both years, except for site 7 in 1994, and sites 7 and 8 in 1995 (*V. stamineum* had the greater mean percentage cover). *V. arboreum* had the lowest 0-1 m mean percentage cover values for all sites in both years. Mean percentage cover from 1 to 2 m indicated that *V. arboreum* tends to grow taller than *V. stamineum* or *V. vacillans*.

The *Rubus* species did not exhibit clear trends for 0- to 1-m mean percentage covers. Ranges were from 0 (*R. occidentalis*) to 0.3 (*R. pensilvanicus*) in 1994 and 1995 (tables 14-15). *R. occidentalis* tended to have the lowest 0- to 1-m mean percentage cover and *R. pensilvanicus* the highest for both years. *R. enslenii* and *R. flagellaris* did not grow above 1 m in 1994 or 1995, but *R. occidentalis* and *R. pensilvanicus* did on some sites. Estimates of mean percentage cover for *Vaccinium* sp. and *Rubus* sp. by year, block, and treatment type are presented in tables 16-17. Block 3 tended to have higher mean percentage cover estimates, but no trends were detected for treatment types.

Table 13.—*Mean percentage cover (0-1 m and 1-2 m) of* Vaccinium *sp. for each MOFEP site and all sites combined by year (data from MOFEP forest vegetation study). Yearly means for all sites combined represent means of means.*

| | *V. arboreum* | | | | *V. stamineum* | | | | *V. vacillans* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | |
| Site | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 |
| 1 | 0.1 | 0.1 | <0.1 | <0.1 | 0.2 | 0.3 | 0 | 0 | 0.9 | 1.1 | 0 | 0 |
| 2 | 0.1 | <0.1 | 0.1 | 0.1 | 0.2 | 0.1 | <0.1 | <0.1 | 0.5 | 0.6 | 0 | 0 |
| 3 | <0.1 | <0.1 | 0 | 0 | 0.3 | 0.3 | <0.1 | <0.1 | 0.3 | 0.4 | 0 | 0 |
| 4 | <0.1 | <0.1 | <0.1 | <0.1 | 0.2 | 0.2 | 0 | <0.1 | 0.4 | 0.4 | 0 | 0 |
| 5 | <0.1 | <0.1 | <0.1 | <0.1 | 0.2 | 0.2 | <0.1 | 0 | 0.4 | 0.3 | 0 | 0 |
| 6 | <0.1 | <0.1 | <0.1 | <0.1 | 0.2 | 0.1 | 0 | 0 | 0.5 | 0.5 | 0 | <0.1 |
| 7 | 0.1 | <0.1 | <0.1 | <0.1 | 0.9 | 0.8 | <0.1 | <0.1 | 0.3 | 0.4 | 0 | <0.1 |
| 8 | 0.1 | <0.1 | <0.1 | <0.1 | 0.4 | 0.8 | 0 | <0.1 | 0.6 | 0.5 | 0 | <0.1 |
| 9 | 0.1 | <0.1 | 0.1 | 0.1 | 0.7 | 0.6 | <0.1 | <0.1 | 0.9 | 1.0 | 0 | <0.1 |
| All sites | 0.1 | <0.1 | <0.1 | <0.1 | 0.4 | 0.4 | <0.1 | <0.1 | 0.5 | 0.6 | 0 | <0.1 |

Table 14.—*Mean percentage cover (0-1 m and 1-2 m) of* Rubus *sp. for each MOFEP site and all sites combined for 1994 (data from MOFEP forest vegetation study). Yearly means for all sites combined represent means of means.*

| | *R. enslenii* | | *R. flagellaris* | | *R. occidentalis* | | *R. pensilvanicus* | |
|---|---|---|---|---|---|---|---|---|
| Site | 0-1 m | 1-2 m | 0-1 m | 1-2 m | 0-1 m | 1-2 m | 0-1 m | 1-2 m |
| 1 | <0.1 | 0 | 0.1 | 0 | <0.1 | 0 | <0.1 | 0 |
| 2 | <0.1 | 0 | 0.1 | 0 | 0.1 | <0.1 | 0.1 | 0 |
| 3 | <0.1 | 0 | 0.1 | 0 | <0.1 | 0 | <0.1 | 0 |
| 4 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 |
| 5 | <0.1 | 0 | 0.1 | 0 | <0.1 | 0 | 0.3 | <0.1 |
| 6 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | 0 |
| 7 | <0.1 | 0 | <0.1 | 0 | 0 | 0 | 0.2 | <0.1 |
| 8 | <0.1 | 0 | 0.1 | 0 | 0 | 0 | 0.1 | <0.1 |
| 9 | <0.1 | 0 | 0.2 | <0.1 | 0 | 0 | 0.1 | <0.1 |
| All sites | <0.1 | 0 | 0.1 | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 |

Table 15.—*Mean percentage cover (0-1 m and 1-2 m) of* Rubus *sp. for each MOFEP site and all sites combined for 1995 (data from MOFEP forest vegetation study). Yearly means for all sites combined represent means of means.*

| | *R. enslenii* | | *R. flagellaris* | | *R. occidentalis* | | *R. pensilvanicus* | |
|---|---|---|---|---|---|---|---|---|
| Site | 0-1 m | 1-2 m | 0-1 m | 1-2 m | 0-1 m | 1-2 m | 0-1 m | 1-2 m |
| 1 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 |
| 2 | 0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 | 0.1 | <0.1 |
| 3 | 0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 |
| 4 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 |
| 5 | 0.2 | 0 | <0.1 | 0 | <0.1 | <0.1 | 0.2 | 0 |
| 6 | <0.1 | 0 | <0.1 | 0 | 0 | 0 | <0.1 | 0 |
| 7 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.3 | <0.1 |
| 8 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0.1 | <0.1 |
| 9 | 0.1 | 0 | <0.1 | 0 | 0 | 0 | 0.1 | <0.1 |
| All sites | 0.1 | 0 | <0.1 | 0 | <0.1 | <0.1 | 0.1 | <0.1 |

Table 16.—*Mean percentage cover (0-1 m and 1-2 m) of* Vaccinium *sp. and* Rubus *sp. by block and year (data from MOFEP forest vegetation study).*

| | Block 1 | | | | Block 2 | | | | Block 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | |
| | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 |
| *V. arboreum* | 0.1 | 0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| *V. stamineum* | 0.2 | 0.2 | <0.1 | <0.1 | 0.2 | 0.1 | <0.1 | <0.1 | 0.7 | 0.7 | <0.1 | <0.1 |
| *V. vacillans* | 0.6 | 0.7 | 0 | 0 | 0.4 | 0.4 | 0 | <0.1 | 0.6 | 0.6 | 0 | <0.1 |
| *R. enslenii* | <0.1 | 0.1 | 0 | 0 | <0.1 | 0.1 | 0 | 0 | <0.1 | <0.1 | 0 | 0 |
| *R. flagellaris* | 0.1 | <0.1 | 0 | 0 | <0.1 | <0.1 | 0 | 0 | 0.1 | <0.1 | <0.1 | 0 |
| *R. occidentalis* | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0 | <0.1 | 0 | <0.1 | 0 | 0 |
| *R. pensilvanicus* | <0.1 | 0.1 | 0 | <0.1 | 0.1 | 0.1 | <0.1 | <0.1 | 0.1 | 0.2 | <0.1 | <0.1 |

Table 17.—*Mean percentage cover (0-1 m and 1-2 m) of* Vaccinium *sp. and* Rubus *sp. by treatment type and year (data from MOFEP forest vegetation study).*

| | Treatment type | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Even-aged | | | | Uneven-aged | | | | Control | | | |
| | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | | 0-1 m | | 1-2 m | |
| Species | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 | 94 | 95 |
| *V. arboreum* | <0.1 | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| *V. stamineum* | 0.4 | 0.3 | <0.1 | <0.1 | 0.4 | 0.4 | <0.1 | <0.1 | 0.3 | 0.4 | 0 | <0.1 |
| *V. vacillans* | 0.5 | 0.6 | 0 | <0.1 | 0.4 | 0.5 | 0 | <0.1 | 0.7 | 0.7 | 0 | <0.1 |
| *R. enslenii* | <0.1 | 0.1 | 0 | 0 | <0.1 | <0.1 | 0 | 0 | <0.1 | <0.1 | 0 | 0 |
| *R. flagellaris* | 0.1 | <0.1 | <0.1 | 0 | 0.1 | <0.1 | 0 | 0 | 0.1 | <0.1 | 0 | 0 |
| *R. occidentalis* | <0.1 | <0.1 | 0 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0 | 0 |
| *R. pensilvanicus* | 0.1 | 0.1 | <0.1 | <0.1 | 0.1 | 0.2 | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |

Significant differences were detected for block (*V. stamineum, V. arboreum*), treatment (*R. enslenii*), year (*V. arboreum, R. flagellaris, R. enslenii*), and year x treatment (*R. enslenii*) for 0- to 1-m coverage (tables 18-21). A significant block effect was detected for *Vaccinium* sp. and *Rubus* sp. combined (table 22). No significant effects were detected for *V. vacillans, R. occidentalis* or *R. pensilvanicus*. No repeated measures analysis of variance was conducted on the 1-2 m coverage data.

### Mean Number of Berries - *Vaccinium* sp. and *Rubus* sp.

Mean numbers of berries per square meter for *Vaccinium* sp. for each site ranged from 0 (all three species) to 6.3 (*V. stamineum*) in 1994, and from 0 (*V. arboreum, V. stamineum*) to 20.3 (*V. arboreum*) in 1995 (table 23). *V. stamineum* tended to have the highest mean number of berries in both years. In 1995, only three *V. arboreum* plants with berries were found on site 7. One plant had two berries, one had one berry, and the third had 1,440 berries. Because of the unusually high number of berries on one plant, *V. arboreum* was not included for statistical analysis. Mean numbers of berries per square meter for *Rubus* sp. for each site ranged from 0 (all four species) to 0.4 (*R. pensilvanicus*) in 1994, and from 0 (all four species) to 1.2 (*R. pensilvanicus*) in 1995 (table 24). No berries were found on *R. occidentalis* plants in 1994 or 1995. Mean numbers of berries for *Vaccinium* sp. and *Rubus* sp. by year, block, and treatment type are presented in tables 25 and 26. Block 3 had a higher mean number of berries, but no trends were detected for treatment types.

Significant differences were detected for block (*V. stamineum, Vaccinium sp.*), year (*V. vacillans, Vaccinium sp., R. pensilvanicus, R. flagellaris, Rubus* sp.), and year x treatment (*V. vacillans, R. flagellaris*) tables 27-32). No repeated measures analysis of variance was conducted for *V. arboreum, R. enslenii,* or *R. occidentalis.*

Table 18.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage cover (0-1 m) for* Vaccinium stamineum *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.007 | 0.51 | 0.64 |
| Block | 2 | 0.5184 | 37.53 | <0.01 |
| Error (Blk X Trt) | 4 | 0.0138 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.00003 | 0.0001 | 1 | 4 | 0.99 |
| Yr X Trt | 0.3528 | 1.0904 | 2 | 4 | 0.42 |
| Yr X Blk | 0.1267 | 0.2901 | 2 | 4 | 0.76 |

Table 19.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage cover (0-1 m) for* Vaccinium arboreum *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.0005 | 1.47 | 0.33 |
| Block | 2 | 0.0057 | 17.81 | 0.01 |
| Error (Blk X Trt) | 4 | 0.0003 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.6841 | 8.6606 | 1 | 4 | 0.04 |
| Yr X Trt | 0.2019 | 0.5061 | 2 | 4 | 0.64 |
| Yr X Blk | 0.5512 | 2.456 | 2 | 4 | 0.20 |

Table 20.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage cover (0-1 m) for* Rubus enslenii *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.0057 | 5.87 | 0.06 |
| Block | 2 | 0.0003 | 0.27 | 0.77 |
| Error (Blk X Trt) | 4 | 0.001 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.894 | 33.7179 | 1 | 4 | <0.01 |
| Yr X Trt | 0.8481 | 11.1696 | 2 | 4 | 0.02 |
| Yr X Blk | 0.1637 | 0.3914 | 2 | 4 | 0.70 |

Table 21.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage cover (0-1 m) for* Rubus flagellaris *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.0014 | 1.36 | 0.36 |
| Block | 2 | 0.0022 | 2.03 | 0.25 |
| Error (Blk X Trt) | 4 | 0.0011 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.7917 | 15.2007 | 1 | 4 | 0.02 |
| Yr X Trt | 0.5435 | 2.3815 | 2 | 4 | 0.21 |
| Yr X Blk | 0.181 | 0.4421 | 2 | 4 | 0.67 |

Table 22.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean percentage cover (0-1 m) for all* Vaccinium *sp. and* Rubus *sp. combined on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.0114 | 0.06 | 0.94 |
| Block | 2 | 1.0546 | 5.82 | 0.07 |
| Error (Blk X Trt) | 4 | 0.1813 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.0286 | 0.1176 | 1 | 4 | 0.75 |
| Yr X Trt | 0.2521 | 0.674 | 2 | 4 | 0.56 |
| Yr X Blk | 0.3938 | 1.2993 | 2 | 4 | 0.37 |

Table 23.—*Mean number of berries per square meter for* Vaccinium *sp. for each MOFEP site by year (data from the MOFEP soft mast study).*

| | ***V. arboreum*** | | ***V. stamineum*** | | ***V. vacillans*** | |
|---|---|---|---|---|---|---|
| **Site** | **1994** | **1995** | **1994** | **1995** | **1994** | **1995** |
| 1 | 0 | 0 | 0 | 2.8 | 0.1 | 1.5 |
| 2 | 0 | 0 | 0 | 0. 9 | 0 | 0.3 |
| 3 | 0 | 0 | 0.8 | 3.4 | 0.1 | 0.3 |
| 4 | 0 | 0 | 0 | 0 | 0.1 | <0.1 |
| 5 | 0 | 0 | 0 | 1.4 | 0 | 2.2 |
| 6 | 0 | 0 | 0.1 | 0.4 | 0 | 3.0 |
| 7 | 0 | 20.3 | 4.4 | 13.9 | 0.6 | 1.8 |
| 8 | 0 | 0 | 1.4 | 8.3 | 0.7 | 3.4 |
| 9 | 0 | 0 | 6.3 | 4.3 | 0.2 | 0.8 |

Table 24.—*Mean number of berries per square meter for* Rubus *sp. for each MOFEP site by year (data from the MOFEP soft mast study).*

| Site | *R. enslenii* 1994 | *R. enslenii* 1995 | *R. flagellaris* 1994 | *R. flagellaris* 1995 | *R. occidentalis* 1994 | *R. occidentalis* 1995 | *R. pensilvanicus* 1994 | *R. pensilvanicus* 1995 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.4 | <0.1 | 0 | 0 | 0 | 0 | 0.4 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 |
| 3 | 0 | 0 | 0 | <0.1 | 0 | 0 | 0 | 0.4 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 |
| 5 | 0 | <0.1 | <0.1 | 0.6 | 0 | 0 | 0.4 | 1.2 |
| 6 | 0 | 0 | 0 | <0.1 | 0 | * | 0 | 0 |
| 7 | 0 | 0.3 | 0 | 0.2 | * | 0 | 0.1 | 1.2 |
| 8 | 0 | <0.1 | 0 | 0.1 | * | 0 | 0 | 0 |
| 9 | 0.1 | <0.1 | 0 | 0.9 | * | * | 0 | 0.3 |

* species was not present within 1 -$m^2$ quadrats on that site for that year.

Table 25.—*Mean number of berries per square meter for* Vaccinium *sp. and* Rubus *sp. by block and year (data from the MOFEP soft mast study).*

| | Block 1 1994 | Block 1 1995 | Block 2 1994 | Block 2 1995 | Block 3 1994 | Block 3 1995 |
|---|---|---|---|---|---|---|
| *V. arboreum* | 0 | 0 | 0 | 0 | 0 | 6.8 |
| *V. stamineum* | 0.3 | 2.4 | <0.1 | 0.6 | 4.0 | 8.8 |
| *V. vacillans* | 0.1 | 0.7 | <0.1 | 1.8 | 0.5 | 2.0 |
| *R. enslenii* | 0 | 0.1 | 0 | <0.1 | <0.1 | 0.1 |
| *R. flagellaris* | <0.1 | <0.1 | <0.1 | 0.2 | 0 | 0.4 |
| *R. occidentalis* | 0 | 0 | 0 | 0 | 0 | 0 |
| *R. pensilvanicus* | 0 | 0.3 | 0.1 | 0.6 | <0.1 | 0.5 |

Table 26.—*Mean number of berries per square meter for* Vaccinium *sp. and* Rubus *sp. by treatment type and year (data from the MOFEP soft mast study).*

| | Treatment type | | | | | |
|---|---|---|---|---|---|---|
| | Even-aged 1994 | Even-aged 1995 | Uneven-aged 1994 | Uneven-aged 1995 | Control 1994 | Control 1995 |
| *V. arboreum* | 0 | 0 | 0 | 6.8 | 0 | 0 |
| *V. stamineum* | 2.4 | 3.0 | 1.5 | 4.9 | 0.5 | 3.9 |
| *V. vacillans* | 0.1 | 1.1 | 0.2 | 0.7 | 0.3 | 2.6 |
| *R. enslenii* | <0.1 | <0.1 | 0 | 0.1 | 0 | 0.1 |
| *R. flagellaris* | <0.1 | 0.5 | 0 | <0.1 | <0.1 | <0.1 |
| *R. occidentalis* | 0 | 0 | 0 | 0 | 0 | 0 |
| *R. pensilvanicus* | 0.1 | 0.6 | <0.1 | 0.7 | 0 | 0.1 |

Table 27.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Vaccinium stamineum *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 1.5863 | 0.29 | 0.77 |
| Block | 2 | 64.5901 | 11.66 | 0.02 |
| Error (Blk X Trt) | 4 | 5.54 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.4838 | 3.749 | 1 | 4 | 0.12 |
| Yr X Trt | 0.2005 | 0.5016 | 2 | 4 | 0.64 |
| Yr X Blk | 0.313 | 0.9113 | 2 | 4 | 0.47 |

Table 28.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Vaccinium vacillans *on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 1.7615 | 3.98 | 0.11 |
| Block | 2 | 1.1264 | 2.54 | 0.19 |
| Error (Blk X Trt) | 4 | 0.4428 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.8536 | 23.3228 | 1 | 4 | <0.01 |
| Yr X Trt | 0.6945 | 4.5457 | 2 | 4 | 0.09 |
| Yr X Blk | 0.4191 | 1.443 | 2 | 4 | 0.34 |

Table 29.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Vaccinium staminium *and* V. vacillans *combined on MOFEP sites during 1994-1995.*

| Between Site Effects | | | | |
|---|---|---|---|---|
| **Source** | **df** | **Mean square** | **F-value** | **P** |
| Treatment | 2 | 0.2451 | 0.03 | 0.97 |
| Block | 2 | 77.8554 | 10.54 | 0.03 |
| Error (Blk X Trt) | 4 | 7.3882 | | |

| Within Site Effects | | | | | |
|---|---|---|---|---|---|
| **Source** | **Pillai's Trace** | **F-value** | **Numerator df** | **Denominator df** | **P** |
| Year | 0.6256 | 6.6824 | 1 | 4 | 0.06 |
| Yr X Trt | 0.2445 | 0.6473 | 2 | 4 | 0.57 |
| Yr X Blk | 0.2673 | 0.7296 | 2 | 4 | 0.54 |

Table 30.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Rubus pensilvanicus *on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 0.1757 | 1.00 | 0.45 |
| Block | 2 | 0.0581 | 0.33 | 0.74 |
| Error (Blk X Trt) | 4 | 0.1761 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.7352 | 11.1074 | 1 | 4 | 0.03 |
| Yr X Trt | 0.4355 | 1.543 | 2 | 4 | 0.32 |
| Yr X Blk | 0.0459 | 0.0961 | 2 | 4 | 0.91 |

Table 31.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Rubus flagellaris *on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 0.0976 | 3.85 | 0.12 |
| Block | 2 | 0.048 | 1.89 | 0.26 |
| Error (Blk X Trt) | 4 | 0.0253 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.6470 | 7.3329 | 1 | 4 | 0.05 |
| Yr X Trt | 0.6935 | 4.5261 | 2 | 4 | 0.09 |
| Yr X Blk | 0.5680 | 2.6292 | 2 | 4 | 0.19 |

Table 32.—*Results of repeated measures analysis of variance examining the effect of year, block, treatment, and their interactions on mean number of berries for* Rubus pensilvanicus, R. enslenii, *and* R. flagellaris *combined on MOFEP sites during 1994-1995.*

**Between Site Effects**

| Source | df | Mean square | F-value | P |
|---|---|---|---|---|
| Treatment | 2 | 0.3601 | 1.15 | 0.40 |
| Block | 2 | 0.1295 | 0.41 | 0.69 |
| Error (Blk X Trt) | 4 | 0.3143 | | |

**Within Site Effects**

| Source | Pillai's Trace | F-value | Numerator df | Denominator df | P |
|---|---|---|---|---|---|
| Year | 0.7579 | 12.5247 | 1 | 4 | 0.02 |
| Yr X Trt | 0.3427 | 1.0426 | 2 | 4 | 0.43 |
| Yr X Blk | 0.1952 | 0.4849 | 2 | 4 | 0.65 |

V. stamineum and R. pensilvanicus tended to have the higher percentage of plants with berries in both years (tables 33 and 34). Block 3 tended to have more plants with berries, but no trends were detected for treatment types (tables 35 and 36).

## DISCUSSION

Generally, few soft mast plants were found, they provided little vegetative cover, and they rarely produced fruit in the MOFEP pre-treatment plots. Numerous previous studies identified a direct relationship between the amount of sunlight reaching the forest floor, and the abundance of fruiting plants and their production of fruit. Since the amount of upper canopy cover is the primary determinant of light intensity and duration, it is not unexpected that there were few soft mast plants and limited production of fruit in the pre-treatment forest sites at MOFEP.

In Minnesota, pin cherry (*Prunus pensylvanica*), raspberry (*Rubus strigosus*), blackberry (*Rubus allegheniensus*), and dogwood (*Cornus* sp.) were more abundant and had higher fruit biomass along edges of forested stands where crown

Table 33.—*Percent of 1-m² quadrats with berries (number of quadrats with berries/number of quadrats where that species was found) for* Vaccinium *sp. for each MOFEP site and all sites combined by year.*

| | *V. arboreum* | | *V. stamineum* | | *V. vacillans* | |
|---|---|---|---|---|---|---|
| Site | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 1 | 0 | 0 | 0 | 9.6 | 0.5 | 3.6 |
| 2 | 0 | 0 | 0 | 9.7 | 0 | 3.0 |
| 3 | 0 | 0 | 12.1 | 17.1 | 1.3 | 3.5 |
| 4 | 0 | 0 | 0 | 0 | 0.7 | 0.7 |
| 5 | 0 | 0 | 0 | 2.9 | 0 | 8.4 |
| 6 | 0 | 0 | 4.2 | 7.7 | 0 | 2.9 |
| 7 | 0 | 23.1 | 9.2 | 17.0 | 4.0 | 9.3 |
| 8 | 0 | 0 | 14.9 | 18.9 | 5.0 | 12.1 |
| 9 | 0 | 0 | 3.2 | 12.5 | 1.9 | 3.3 |
| all | 0 | 4.4 | 6.8 | 13.3 | 1.4 | 4.7 |

Table 34.—*Percent of 1-m² quadrats with berries (number of quadrats with berries/number of quadrats where that species was found) for* Rubus *sp. for each MOFEP site and all sites combined by year.*

| | *R. enslenii* | | *R. flagellaris* | | *R. occidentalis* | | *R. pensilvanicus* | |
|---|---|---|---|---|---|---|---|---|
| Site | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 | 1994 | 1995 |
| 1 | 0 | 5.8 | 2.1 | 0 | 0 | 0 | 0 | 20.0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14.3 |
| 3 | 0 | 0 | 0 | 5.6 | 0 | 0 | 0 | 20.0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18.8 |
| 5 | 0 | 5.3 | 3.2 | 3.4 | 0 | 0 | 17.4 | 32.0 |
| 6 | 0 | 0 | 0 | 3.7 | 0 | 0 | 0 | 0 |
| 7 | 0 | 15.6 | 0 | 15.0 | 0 | 0 | 6.3 | 15.0 |
| 8 | 0 | 4.2 | 0 | 11.1 | 0 | 0 | 0 | 0 |
| 9 | 6.3 | 8.6 | 0 | 16.7 | 0 | 0 | 0 | 11.1 |
| all | 1.8 | 5.2 | 0.8 | 8.6 | 0 | 0 | 6.3 | 17.9 |

Table 35.—*Percent of 1-m² quadrats with berries (number of quadrats with berries/number of quadrats where that species was found) for* Vaccinium *sp. and* Rubus *sp. by block, year, and combined years.*

| | Block 1 | | | Block 2 | | | Block 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | Comb. | 1994 | 1995 | Comb. | 1994 | 1995 | Comb. |
| *V. arboreum* | 0 | 3.0 | 1.5 | 0 | 0 | 0 | 0 | 8.3 | 4.5 |
| *V. stamineum* | 3.5 | 11.0 | 7.6 | 1.0 | 2.4 | 1.8 | 8.8 | 13.2 | 11.5 |
| *V. vacillans* | <1.0 | 2.6 | 1.6 | <1.0 | 3.0 | 1.7 | 3.1 | 5.0 | 4.2 |
| *R. enslenii* | 0 | 2.5 | 1.9 | 0 | 2.4 | <1.0 | 3.2 | 9.9 | 5.7 |
| *R. flagellaris* | <1.0 | 5.6 | 1.5 | 1.5 | 2.7 | 2.2 | 0 | 15.8 | 9.1 |
| *R. occidentalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *R. pensilvanicus* | 0 | 13.0 | 6.9 | 6.3 | 18.6 | 12.7 | 1.6 | 7.6 | 4.6 |

Table 36.—*Percent of 1-m² quadrats with berries (number of quadrats with berries/number of quadrats where that species was found) for* Vaccinium *sp. and* Rubus *sp. by treatment type, year, and combined years.*

| | Treatment type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Even-aged | | | Uneven-aged | | | Control | | |
| | 1994 | 1995 | Comb. | 1994 | 1995 | Comb. | 1994 | 1995 | Comb. |
| *V. arboreum* | 0 | 0 | 0 | 0 | 11.5 | 5.8 | 0 | 0 | 0 |
| *V. stamineum* | 4.4 | 10.7 | 8.1 | 6.0 | 11.5 | 9.2 | 8.3 | 11.1 | 9.9 |
| *V. vacillans* | 1.3 | 3.1 | 2.3 | 1.5 | 3.3 | 2.5 | 1.2 | 4.2 | 2.8 |
| *R. enslenii* | 3.6 | 5.1 | 4.2 | 0 | 5.5 | 3.2 | 0 | 4.9 | 2.6 |
| *R. flagellaris* | <1.0 | 10.1 | 5.9 | 0 | 6.4 | 2.8 | 1.3 | 5.6 | 2.7 |
| *R. occidentalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *R. pensilvanicus* | 5.2 | 17.1 | 11.1 | 1.9 | 12.3 | 7.9 | 0 | 6.1 | 2.8 |

closure of overstory trees was lower (Noyce and Coy 1990). In an earlier study, Arimond (1979) found that production of fruits important to black bears in Minnesota (blueberry, raspberry, and pin cherry) was significantly higher in forested stands with low densities of overstory trees (<800 trees/ha). These stands included clearcuts, strip-cuts, and selection cuts.

In New York's Adirondack Mountains, raspberry and pin cherry abundance was highest in even-aged managed habitats cut less than 16 years before sampling (Costello 1992). Non-managed habitats had the lowest abundance of these species, recognized as important black bear foods in New York. Berry counts for raspberry ranged from 54,000 berries/ha to 733,000 berries/ha and averaged 382,000 berries/ha in even-aged stands.

In sharp contrast, in Missouri on MOFEP plots during 1994 and 1995, there was no black raspberry production, and the highest mean blackberry production figure was only 6,000 berries/ha on block 2 in 1995. The highest berry yields among our selected species were for *V. stamineum*, which produced an average of 232 berries/ha on block 2 in 1994 at the low end and 88,000 berries/ha on block 3 in 1995, the highest yield overall. In our 1993 pilot study on clearcuts adjacent to MOFEP sites, we found an average of 656,000 blackberries/ha in 4- to 6-year-old clearcuts, and 111,000 blackberries/ha in 7- to 10-year-old clearcuts.

Some significant differences exist between blocks, years, and treatments, based on measurements of abundance of soft mast plants and production of berries on the MOFEP sites. Block differences are attributed to block 3 (the Peck Ranch sites). This block is physiographically different from blocks 1 and 2. Significant differences between blocks supports the use of the randomized block design for the MOFEP experiment by attributing some differences in results to local geographic variation. As expected, there were a few differences due to year effect, primarily related to increased berry production across the board in 1995 and perhaps associated with the slight difference between sampling periods between years. Few treatment type effects were observed during this pre-treatment measurement effort, and though a few effects were statistically significant, it appears that they may be small and easily overcome if there are substantial responses due to actual treatment.

There may be small, negative bias of the sampling plan. Quadrats that we sampled were those that contained soft mast plants the previous year. Out of a total of 10,320 quadrats, 1,216 (12 percent) were not sampled in 1994 and 1,040 (10 percent) were not sampled in 1995. We assumed that no soft mast plants existed within these quadrats, but some new plants may have emerged. This may have resulted in lower calculated means, but we believe this to be of minor consequence. These plants would be very small and would not produce fruit until several years old.

The MOFEP experiment provides an excellent opportunity to examine the effects of forest management practices on soft mast. This pretreatment research shows a framework for a successful project examining the effects of silvicultural treatments on the abundance of soft mast plants and production of soft mast. Following cutting, data for control sites will be compared with even- and uneven-aged sites to determine if differences exist between treatment types.

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Appendix A.—*Presence of soft mast species within the permanent MOFEP forest vegetation cluster plot 1-$m^2$ quadrats by site during 1993-1995 (data from MOFEP forest vegetation study). An X indicates presence of that species within the 3-year period.*

| Species | Site 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| *Amelanchier arborea* | X | X | X | X | X | X | X | X | X |
| *Asimina triloba* | — | X | X | X | X | X | X | X | X |
| *Ceanothus americanus* | X | X | X | X | X | X | X | X | X |
| *Celtis* sp. | X | X | X | X | X | X | X | X | X |
| *Celtis occidentalis* | X | X | X | X | X | X | X | X | X |
| *Cornus drummondi* | X | X | — | X | — | — | — | — | — |
| *Cornus florida* | X | X | X | X | X | X | X | X | X |
| *Corylus americana* | X | X | X | X | X | X | X | X | X |
| *Crataegus* sp. | X | X | X | X | X | X | X | X | X |
| *Diospyros virginiana* | X | X | X | X | X | X | X | X | X |
| *Fragaria virginiana* | X | X | — | — | — | — | — | X | — |
| *Lindera benzoin* | — | X | X | X | X | X | X | X | X |
| *Morus* sp. | — | X | X | X | X | — | X | X | X |
| *Morus rubra* | — | X | X | X | X | X | X | X | X |
| *Nyssa sylvatica* | X | X | X | X | X | X | X | X | X |
| *Phytolacca americana* | — | — | — | — | — | — | X | — | — |
| *Prunus americana* | X | X | X | X | X | X | X | X | X |
| *Prunus serotina* | X | X | X | X | X | X | X | X | X |
| *Rhamnus caroliniana* | X | X | X | X | X | X | X | X | X |
| *Rhus aromatica* | X | X | X | X | X | X | X | X | X |
| *Rhus copallina* | — | X | — | X | X | — | X | X | X |
| *Rhus glabra* | — | X | — | — | X | X | X | X | — |
| *Ribes missouriense* | — | X | X | — | — | X | — | — | — |
| *Rosa* sp. | X | X | X | X | X | X | — | X | X |
| *Rosa carolina* | X | X | X | X | X | X | X | X | X |
| *Rosa multiflora* | X | X | X | X | X | — | X | X | X |
| *Rosa setigera* | X | X | X | X | X | X | X | X | X |
| *Rubus* sp. | X | X | X | X | X | X | X | X | X |
| *Rubus enslenii* | X | X | X | X | X | X | X | X | X |
| *Rubus flagellaris* | X | X | X | X | X | X | X | X | X |
| *Rubus occidentalis* | X | X | X | X | X | X | X | X | — |
| *Rubus pensilvanicus* | X | X | X | X | X | X | X | X | X |
| *Rubus trivialis* | X | — | — | — | — | — | — | — | — |
| *Sambucus canadensis* | — | X | — | — | — | X | — | X | — |
| *Sassafras albidum* | X | X | X | X | X | X | X | X | X |
| *Smilacina racemosa* | X | X | X | X | X | X | X | X | X |
| *Smilax* sp. | X | X | X | X | X | X | X | X | X |
| *Smilax bona-nox* | X | X | X | X | X | X | X | X | X |
| *Smilax glauca* | X | X | X | X | — | X | X | X | X |
| *Smilax herbacea* | X | X | X | X | X | X | X | X | X |
| *Smilax pulverulenta* | X | X | X | X | X | X | X | X | X |
| *Smilax rotundifolia* | X | X | X | X | X | X | X | X | X |
| *Smilax tamnoides* | X | X | X | X | X | X | X | X | X |
| *Symphoricarpos orbiculatus* | X | X | X | X | X | X | X | X | X |
| *Vaccinium* sp. | X | X | X | X | X | X | X | X | X |
| *Vaccinium arboreum* | X | X | X | X | X | X | X | X | X |
| *Vaccinium stamineum* | X | X | X | X | X | X | X | X | X |
| *Vaccinium vacillans* | X | X | X | X | X | X | X | X | X |
| *Viburnum rufidulum* | X | X | X | X | X | X | X | X | X |
| *Vitis* sp. | X | X | X | X | X | X | X | X | X |

Appendix B.—*Description of ecological landtypes (ELT's) associated with the MOFEP permanent forest vegetation cluster plots (Brookshire and Hauser 1993, Randy Jensen personal communication).*

| ELT | Land form | Aspect | Percent slope | Soil series | Vegetation community |
|---|---|---|---|---|---|
| 5 | Upland waterway | Neutral | 0-4 | Midco | Dry bottomland forest |
| 6 | Upland waterway | Neutral | 0-4 | Midco | Dry-mesic bottomland forest |
| 7 | Toe slope | All | 0-14 | Viraton | Mesic forest |
| 11 | Ridge | Neutral | 0-8 | Clarksville<br>Poynor<br>Gepp | Dry chert forest |
| 15 | Flat | Neutral | 0-8 | Viburnum | Dry chert forest |
| 17 | Side slope | South and West | 8-99 | Clarksville<br>Poynor<br>Gepp | Dry chert forest |
| 18 | Side slope | North and East | 8-99 | Clarksville<br>Poynor<br>Gepp | Dry-mesic chert forest<br>Dry-mesic sand forest |
| 19 | Side slope | South and West | 8-99 | Bardley | Glade savanna |
| 20 | Side slope | North and East | 8-99 | Bardley | Dry mesic limestone forest |
| 21 | Side slope | All | 5-99 | Gasconade<br>Rockland | Dolomite glade<br>Limestone glade |
| 22 | Side slope | All | 5-99 | Gasconade<br>Rockland | Xeric limestone forest |
| 23 | Side slope | All | 5-99 | Gasconade<br>Rockland | Dry limestone forest |