# Tree Seedling Survivorship At Hutcheson Memorial Forest New Jersey

Sara E. Davison*
Department of Botany, Rutgers University, New Brunswick, New Jersey 08903

*Present address: The Nature Conservancy, Pennsylvania/New Jersey Field Office, 1218 Chestnut Street, Suite 1002 Philadelphia, Pennsylvania 19107

*Abstract.* Seedlings of eight forest tree species were monitored for one year and three months to determine patterns of seedling survivorship in upland well-drained soil. Data were collected at two intervals during the study, providing over-winter and over-summer survivorship patterns. Over-winter survivorship was greater than over-summer survivorship, despite the longer time period, for all species but two. The low over-summer survivorship can be attributed to the severe drought which occurred during the summer of 1980. The highest total survivorship was found for *Acer platanoides, Prunus serotina,* and *Quercus alba.* The lowest total survivorship was found for *Cornus florida* and *Acer rubrum.* Of the total number of seedlings labelled at the outset, 55% survived the entire study period. Tree seedling survivorship therefore was quite high during the 1979-1980 season despite the severe summer drought.

## Introduction

I observed a high density and diversity of tree seedlings in June of 1979 while sampling forest vegetation for a long-term vegetation study of the William L. Hutcheson Memorial Forest (HMF) on the New Jersey Piedmont. Because data from the same sample plots for previous years (Sulser 1971) and a nearby study by Monk (1961) indicated lower seedling diversity and frequency, 1979 was inferred to be a good year for seedlings. This high diversity provided a good opportunity to compare seedling survivorship between several species.

A variety of tree seedlings have been studied because of the theoretical and practical implications of their survivorship on eventual forest stand composition. Monitoring seedling populations has revealed low survivorship for many species. For oaks, Korstian (1927) and Wood (1938) were some of the first investigators to evaluate the numerous factors contributing to oak seedling survivorship. Northern hardwood seedling survivorship has been extensively studied by Bormann and Buell (1964) Hett and Loucks (1968, 1971, 1976), and Rose (1978). Much information on tree seedling survivorship has resulted from forestry studies of stand restocking (Krauch 1945, Spencer 1955).

Seedling populations reveal negative exponential age-class distributions because of high mortality. This distribution has been shown for several northern hardwood species by Hett and Loucks (1968, 1971, 1976). With increasing age, mortality generally decreases (Bormann and Buell 1964, Good and Good 1972).

Some of the most important abiotic factors affecting seedling survivorship have been shown to be light (Grim and Jeffrey 1965) and soil moisture (Ferrell 1953, Bordeau 1954, Hett and Loucks 1971). Herbivory and/or predation of seeds (Barnett 1977) and seedlings (Geis 1954, Snyder and Janke 1976, Beaman 1978) appear to significantly affect survivorship. Other biotic factors such as type of herb cover (Maguire 1979) and allelopathic interactions (Tubbs 1973) have also been implicated.

Tree seedling distribution and dominance have been explained in terms of physiological requirements and tolerances. Fine-scale studies such as Hutnick's (1952) revealed species-specific responses to microtopographic differences resulting from wind-throws. Bordeau (1954) demonstrated physiological differences between several species of oak seedlings which resulted in segregated distributions. Oak dominance has regularly been attributed to the resistance of oaks to fire (Starker 1934, Bromley 1935, Dix 1957, Christianson 1971). However, fire resistance may be more significant to older seedlings than studied here.

The objectives of this paper were to determine the general pattern of tree seedling survivorship at HMF for one year, and to determine species-specific survivorship patterns. This information enhances current studies of seedling predation and tree fruit production being conducted at HMF.

## Methods

The eight most common tree seedlings in 1979 were selected for study. Seedlings which occurred too infrequently in the forest to include in this study were: *Juniperus virginiana, Ailanthus altissima, Quercus velutina, Acer negundo, Celtis occidentalis, Quercus borealis,* and *Prunus virginiana.* Seedling plots were established in 2 x 0.5 m subplots which were originally used to sample the herb layer in a long-term vegetation study of HMF (Sulser 1971, Davison and Forman 1982). Seventeen of the original 100 plots were selected. Plots were selected if the seedling density was close to the average density found in 1979 (12.5 seedlings/plot). Layout of the plots can be found in Davison (1980), and a detailed description of the study area can be found in either Sulser (1971) or Davison (1980).

In July 1979, the seventeen seedling plots were roped off at chest height to deter human trampling, and the seedlings were identified to species. Individuals were labelled using a numbered, white plastic garden stake placed nearby. Seedling locations within each plot were then mapped to ensure future identification. For each species, an attempt was made to label only similarly-sized individuals. Size differences did exist between species as a result of age differences, growth form, and growth rate differences. From observations of cotyledons made in June 1979, it was assumed that all labelled individuals of *Acer rubrum, Cornus florida,* and *Fraxinus americana* were first-year seedlings. This assumption could not be made for the remaining species since cotyledons were not apparent, and many were slightly woody. No attempt was made to age seedlings. In the long-term vegetation study (Sulser 1971, Davison 1980), seedlings were defined as any tree species less than 31.5 cm in height. However, in this study, all labelled individuals were less than 12.7 cm in height.

In May 1980, the seedling plots were surveyed to assess over-winter survivorship. All surviving seedlings were noted, and qualitative notes on herbivory were made. Herbivory fell into two main categories: browsed, where the leafy top of the seedling had been removed leaving only the stem, and chewed, where part of a leaf or leaflet had been removed.

Over-summer survivorship was assessed by a final survey in October 1980. Plots were resurveyed in the same manner as in May 1980. Nomenclature follows Gleason (1968).

The soils of the study area are well drained, and developed from Triassic and red shale of the Brunswick formation (Ugolini 1964, Wolfe 1977). A thin, heterogeneous and nutrient-rich detritus layer has been described by Lang and Forman (1978). Annual precipitation averages approximately 112 cm and is distributed fairly evenly throughout the year (Biel 1958). Occasional summer droughts have been recorded (Small 1961). The average annual temperature is 11.7° C in January and 24° C in July (United States Weather Bureau 1959).

## Results

The results of the 1979-80 seedling survivorship are summarized in Table 1. Overall total seedling survivorship appeared to be quite high (55.4%). Marked differences were found between species for total survivorship as well as differences between over-winter and over-summer intervals. *Prunus serotina* (Black Cherry) showed high overall survivorship (82%) with very little difference between over-winter and over-summer intervals. *Quercus alba* (White Oak) also showed high overall survivorship (81%) with greater mortality occurring during the over-summer interval. A similar pattern was found for *Carya* spp. (Hickory) with high overall survivorship and greater over-summer mortality. *Acer platanoides* (Norway Maple) showed the highest overall survivorship, but differed from the above species by having greater mortality in the over-winter interval. No *A. platanoides* mortality was found during the over-summer interval.

*Prunus avium,* (Sweet Cherry), *Acer rubrum* (Red Maple), and *Cornus florida* (Flowering Dogwood) showed the lowest survivorship. *Cornus* survivorship was particularly low, with a total of only 3% surviving the entire study period.

Of the species that were assumed to be first-year seedlings, *Fraxinus americana* (White Ash) showed the highest overall survivorship. Seventy percent of *Fraxinus* seedlings survived the entire study period. This is considerably higher than the other two first-year seedlings, *A. rubrum* and *Cornus.*

Herbivory appeared to originate from two sources: insects and mammals (mice, rabbits, deer). The greatest amount of herbivory was found on *Quercus alba* and *Acer rubrum* seedlings, whereas the least amount of herbivory was found on *Fraxinus americana* and *Acer platanoides* seedlings. No species showed a greater tendency towards mammal versus insect herbivory.

In short, the results of this study show high overall survivorship for the total number of labelled seedlings, while differences between overall and seasonal survivorship were quite pronounced between some species.

## Discussion

Overall forest seedling survivorship appeared to be quite high during the period of this study. Species that

Table 1. Total number of labeled seedlings and percent survivorship of the over-winter and over-summer intervals.

| Species | Number in July 1979 | Number in May 1980 | Percent Over Winter Suvivorship | Number in October 1980 | Percent Over-Summer Survivorship | Percent Total Suvivorship |
|---|---|---|---|---|---|---|
| *Acer platanoides* | 23 | 19 | 82.6 | 19 | 100.0 | 82.6 |
| *Prunus serotina* | 11 | 10 | 90.9 | 9 | 90.0 | 81.8 |
| *Quercus alba* | 32 | 29 | 90.6 | 26 | 89.7 | 81.3 |
| *Carya* spp.* | 25 | 24 | 96.0 | 20 | 83.0 | 80.0 |
| *Fraxinus americana* | 44 | 37 | 84.1 | 31 | 83.7 | 70.5 |
| *Prunus avium* | 18 | 10 | 55.5 | 5 | 50.0 | 27.7 |
| *Acer rubrum* | 29 | 15 | 51.7 | 7 | 46.6 | 24.1 |
| *Cornus florida* | 31 | 5 | 16.1 | 1 | 20.0 | 3.2 |
| **Total** | 213 | 149 | 69.9 | 118 | 79.2 | 55.4 |

*Based on canopy individuals, these seedlings represent a mixture of *Carya ovata* and *C. ovalis.*

were assumed to be first-year seedlings showed markedly lower survivorship than the older seedlings, with the exception of *Fraxinus* which showed high survivorship. Survivorship, however, for both groups (1st year and > 1st year) was lower than what Good and Good (1972) found in a younger more xeric oak woods in New Jersey. They found 58% of the first-year seedlings survived and 85% of the entire seedling population (up to approximately 10 years) survived during their three year study.

In addition, Good and Good (1972) found high *Cornus florida* seedling survivorship. The low *Cornus* survivorship found in this study shows greater similarity to what Smith (1975) found in Illinois. Thirteen percent of the *Cornus* seedlings Smith studied survived over the summer, compared with 20% at HMF. Low over-summer *Cornus* survivorship might be expected particularly in drought years since Ferrell (1953) showed soil moisture to be the most important factor influencing first year *Cornus* seedling survivorship.

Studying *Acer saccharum* seedlings, Hett and Loucks (1971) found mortality to be density dependent. This may partially explain the low overall survivorship of *Acer rubrum* found in this study. *Acer rubrum* was the most clumped (low frequency, high density) seedling in 1979 (Davison 1980). Other seedlings in this study appeared to be more dispersed, although Sulser (1971) found *Cornus* seedlings to be highly clumped in her study.

Since no quantitative measurements were made on the amount of herbivory, few conclusions can be made. The two species with the least amount of herbivory, *Acer platanoides* and *Fraxinus americana*, had high overall survivorship. *Acer platanoides* is an introduced species which may partially explain the low amount of herbivory; however, *Prunus avium* is also introduced and exhibited low overall survivorship. Herbivory was very important in reducing survivorship of *Acer rubrum* in adjacent old fields of HMF (W. Rankin, pers. comm.).

These survivorship data may help explain the erratic seedling densities which have been measured at HMF during the past 30 years. In 1950, *Cornus florida* was the most common seedling in the well-drained portion of the forest (Sulser 1971). In 1956 and 1957 Monk (1961) found *Prunus avium* to be the most common seedling in the upland forest. In 1969, Sulser (1971) found *Cornus* again to be the most common seedling, and in 1979 Davison (1980) found *Fraxinus* to be most comon. Low survivorship found in this study for *Cornus* and *Prunus avium* may partially account for these fluctuations.

The severe drought of the summer of 1980 is reflected in the over-summer data. The over-winter interval was twice as long (10 months versus 5 months) and yet most species showed greater survivorship during this period. *Acer platanoides* was the only species which was not visibly affected by the drought. Soil microconditions may have contributed to higher *A. platanoides* survival during the drought since most of the labelled seedlings of this species were very localized. Alternatively, *A. platanoides* seedlings may be better adapted to drought than the other species studied.

Many authors have discussed the paucity of oak reproduction at HMF (Monk 1961, Sulser 1971, Forman and Elfstrom 1975, Lang and Forman 1978). Buell et al. (1954) discussed fire-frequency at HMF, and related frequent pre-colonial fires to the present oak dominance. This may also be a plausible explanation for the lack of oak saplings and transgressives in the forest today. Interestingly, this study indicates seedlings of canopy dominants, *Quercus alba* and *Carya*, to have high survivorship.

Studying *Acer saccharum* in New Hampshire, Mulcahy (1975) made the following hypothesis: Offspring from long-lived species which dominate a stand for hundreds of years may be less suitably adapted than their parents if selection pressures have changed during the species dominance. Perhaps forest selection pressures have changed at HMF since European colonization, resulting in poorer oak survivorship. Changes in the fire-frequency and an increase in aggressive, introduced species may be contributing factors.

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