The influence of vines on the growth of *Liquidambar styraciflua* L. (sweetgum)

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The effect of vines on diameter growth of *Liquidambar styraciflua* L. (sweetgum) in a 40-year-old abandoned field was measured by vine removal experiments. Removal of vines from the trunk, branches, and ground had a significant positive effect on growth during each of the 4 years of the study, but removal of vines from only the trunk and branches did not produce a significant increase in growth. The data suggest that vines influence forest production by competing with trees even after trees have grown tall enough to avoid direct physical suppression.

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L'auteur a étudié l'effet des plantes grimpantes sur la croissance en diamètre de *Liquidambar styraciflua* L. poussant dans un champ abandonné depuis 40 ans. L'extirpation des plantes grimpantes du tronc, des branches et du sol a eu un effet positif significatif sur la croissance, à chacune des 4 années qu'a duré l'étude. Cependant, l'extirpation des plantes grimpantes seulement du tronc et des branches n'a pas suffi à produire un effet significatif sur la croissance. Ces données suggèrent que les plantes grimpantes influencent la production forestière en compétitionnant avec les arbres, même lorsque ces derniers ont atteint des dimensions qui leur permettent d'échapper à une suppression physique directe.

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Introduction

Vines have been shown to have deleterious effects on temperate forests when they are present in large numbers (Siccama et al. 1976). Exotic vines, which may be more problematic than native species, are known to negatively affect forest tree species by direct physical suppression and (or) shading (Slezak 1976; Thomas 1980). For example, *Lonicera japonica* Thunberg (Japanese honeysuckle) has become widespread in North America (Leatherman 1955) and has been shown to have negative effects on vegetation in disturbed forests, undisturbed forests, and in abandoned old fields (Little 1961; Slezak 1976; Thomas 1980; Friedland and Smith 1982). The impact is most severe in low-lying areas (Thomas 1980; Bruner 1967), but honeysuckle can also become widespread and suppress recruitment of trees in mature upland forests, particularly in forest gaps and in areas disturbed by logging (Boring et al. 1981; Davison and Forman 1982; Slezak 1976).

Vines may also have more subtle long-term influences on forest structure and function. Slezak (1976) has shown that vines can dominate canopy openings with the result that some overstory openings or "gaps" fail to be filled for indefinite periods of time. Over decades, this process locally results in conversion of forest into a vine-dominated disclimax (Thomas 1980). Vines may also influence forest production by competing with canopy and understory trees for nutrients and water. For example, Japanese honeysuckle is an evergreen species and has an extended growing season. This, when coupled with its dense rhizome–root system, could enable *Lonicera* to depress the growth rate of trees by effectively competing with surface feeder roots (Kennedy 1981; Thomas 1980). The present study was conducted to test the hypothesis that vines suppress growth of trees even after they have grown large enough to avoid mortality owing to physical suppression.

Methods

The project was conducted in an abandoned field on the property of the Smithsonian Environmental Research Center (SERC), located approximately 15 km south of Annapolis, Maryland, U.S.A. The field has been undergoing secondary succession for approximately 40 years, but trees had not yet formed a continuous canopy. Instead, there are scattered individuals primarily of *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Prunus serotina* Ehrhart, *Diospyros virginiana* L., and *Juniperus virginiana* L. Vines cover the entire area and grow on all trees. In some parts of the field, vines form dense thickets and all trees are excluded. *Lonicera japonica* and poison ivy (*Rhus radicans* L.) dominate the vine community and occur on all trees. Wild grape (*Vitis* sp.), Virginia creeper (*Parthenocissus quinquefolia* (L.) Planchon), and trumpet vine (*Campsis radicans* (L.) Seeman) are also abundant. Wild rose (*Rosa multiflora* Thunberg) is also common and assumes an almost vinelike habit when it grows into the lower branches of trees.

Forty-five individuals of sweetgum were randomly chosen for study in the winter of 1977. Trees were chosen only if they supported numerous vines on the trunk and lower branches and approximately the upper quarter of each tree was free of vines. In addition, only trees were chosen which were isolated from all adjacent trees. From the set of 45 trees, three groups of 15 trees were randomly chosen and treated as follows: (*i*) all vines removed from the tree and the ground cleared of all vegetation to a distance of 1 m beyond the outer perimeter of the branches, (*ii*) all vines cut from the bole and branches, and (*iii*) no vines removed (control). There were no differences between the experimental and control groups in diameter at 1.5 m (diameter at breast height, DBH), tree height, or percent of total tree height occupied by vines (Table 1). Vines and all other vegetation were removed from the trees before the 1978 growing season began. Vines were cut from treatments 1 and 2 with clippers and all ground vegetation removed from treatment 1 trees with a model 234.795410 gas-powered "weedwacker" (Sears, Roebuck Co.). The "weedwacker" was used to cut all vegetation as close to the ground surface as possible. The cut material was left in place and rhizomes growing just beneath the soil surface were removed by hand. Removal of the rhizomes disturbed the soil surface, but it was not possible to include this factor into the experimental design because there were no instances where the ground beneath sweetgum trees was free of vines nor was it possible to mimic the disturbance factor beneath trees which had vines present. The disturbance factor was minimal after the initial clearing because there was little recolonization of the cleared areas. Vine cutting and clearing of vegetation on the ground was repeated in 1979, 1980, and 1981 in early March, late June and (or) July, and late September.

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TABLE 1. Pretreatment data for trees used in this study. Data are tree height, diameter (DBH), and percent of total tree height occupied by vines. All values are means ± 1 standard deviation (N = 15)

	Vines removed from tree and ground	Vines removed from tree	Control
Diameter (cm)	15.8±3.1	14.9±4.6	16.3±4.5
Height (m)	7.2±1.5	6.2±1.3	7.2±1.2
Vine height as a % of tree height	69.4±15.2	77.8±9.1	82.9±7.2

Since sweetgum has a very rough bark, the bark of each tree was smoothed with a wood file at a height of 1.5 m prior to the attachment of stainless steel growth bands. The bark was removed carefully so that the cambium was not damaged. The growth bands were made of 1/2 in. (1 in. = 2.54 cm) wide Monel stainless steel using a Dymo model 1011 tapewriter (Forestry Suppliers, Inc., Jackson, MS). A model 505 stainless steel vernier caliper (Forestry Suppliers, Inc., Jackson, MS) was then used to measure the distance between two arbitrarily chosen indentations on each growth band. The indentations were made using the period symbol of the tapewriter. Because there were small shifts in the growth bands for several weeks after they were placed on the trees, measurements were made weekly until there were no noticeable differences between consecutive readings. Initial measurements, time 0, were then made on each tree before the 1978 growing season began. The distance between the same two points was then measured during the last week in October between 1978 and 1981. Measurements were made between 1300 and 1500 on clear days when there had been no rainfall for at least 3 previous days. It was not possible to match weather conditions each year, but there were no extreme differences in either maximum or minimum temperatures on the days of measurement. Daily maximum and minimum temperatures were as follows: 1978, maximum = 10°C, minimum = 2°C; 1979, maximum = 10°C, minimum = 1°C; 1980, maximum = 12°C, minimum = −1°C; 1981, maximum = 12°C, minimum = 7°C. Yearly increases in circumference were converted to diameter equivalents and the data analyzed using a two-way analysis of variance for repeated measures (Dixon et al. 1981) to test for treatment and time effects.

Results

There were significant effects owing to treatment (F = 13.21, df = 2, $P \leq 0.001$) and time (F = 13.91, df = 3, $P \leq 0.001$) but the treatment × time interaction was not significant (F = 0.41, df = 6, $P \leq 0.873$). Diameter increases varied yearly with slower growth rates measured in 1979 for all treatments (Fig. 1). All treatments showed the same year to year fluctuations and they were always in the same relationship. Growth of trees with vines removed from trunk, branches, and ground ranged between approximately 0.3 and 0.4 cm · year^{-1} which was a significantly higher rate than either of the other groups, which ranged between approximately 0.18 and 0.28 cm · year^{-1} (Fig. 1). Trees with vines removed only from the trunk and branches showed a faster mean growth rate than trees in the control group, but the differences were not significant.

There was a significant difference when total growth for the 4 years was compared (F = 13.14, df = 2, $P \leq 0.001$). Total growth of trees with vines removed from the boles and ground was significantly larger ($\bar{x}$ = 1.43 ± 0.08 cm) than total growth of trees with vines removed from the boles and branches ($\bar{x}$ = 1.04 ± 0.05 cm) and the control group ($\bar{x}$ = 0.93 ± 0.07 cm). There was no significant difference between the latter two groups.

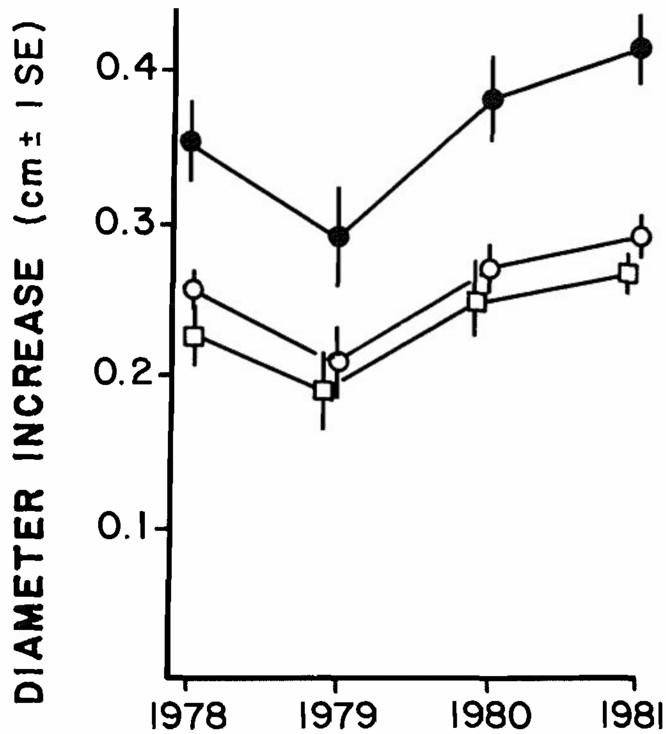

FIG. 1. Diameter increases of sweetgum between 1978 and 1981. Treatments were as follows: (*i*) closed circles, vines removed from trunk, branches, and ground; (*ii*) open circles, vines removed from trunk and branches; and (*iii*) open squares, control. N = 15 for each treatment. Each value is the mean ± 1 standard error (SE) of the mean.

Discussion

Complete vine removal clearly had an effect on growth of sweetgum and the effect was most likely owing to interference, defined to include both competition and allelopathy (Walters and Gilmore 1976). The data also demonstrate that removal of vines from only the trunk and branches of the tree resulted in at most a slight (and not statistically significant) change in the rate of diameter increase. Thomas (1980) also has suggested that the presence of *Lonicera* on elms only has a minor effect on vigor. What type of competition and (or) allelopathic effects occur to decrease the growth of sweetgum? Competition for moisture and nutrients can affect tree growth (Kramer and Kozlowski 1979) and it has been shown that fescue (*Festuca arundinacea*) can reduce growth of small sweetgum seedlings through allelopathic effects (Walters and Gilmore 1976). Rice (1979) reviewed available information on allelopathy and his paper did not contain any information which would identify vines, particularly Japanese honeysuckle, as being able to maintain dominance through allelopathic effects. The primary effect of vines on understory vegetation seems to be physical suppression and shading of seedlings, saplings, and herbs (Thomas 1980).

There is also some evidence to suggest that competition for nutrients would be more important than allelopathy. Japanese honeysuckle responds quickly to fertilizer application and its leaves contain high levels of nitrogen throughout the year (Segelquist et al. 1972). This, combined with its long growing season (Thomas 1980), suggests that the vine would be a good competitor for soil nutrients.

What long-term effects can vines have on succession and forest functional processes? The impact that vines can have on succession have been documented to be extremely deleterious (Slezak 1976; Thomas 1980). Established forests can ultimately be converted to open vine dominated disclimax situations, especially on mesic sites and in forests where canopy disturbances are common (Slezak 1976). This is observed at the SERC site where areas initially colonized by short-lived tree species (*Sassafras albidum* (Nuttall) Nees., *Robinia pseudo-acacia* L., *Diospyros virginiana* L.) are becoming more open owing to die off of senescent trees, while understory replacement has been completely suppressed by vines. In these forests, the gaps created by death of canopy trees close only slowly by lateral ingrowth or fail to close altogether because there is no regeneration from the understory. On other sites at SERC, closed canopy successional forests dominated by *L. styraciflua, Acer rubrum* L., *L. tulipifera*, and *P. serotina* have become established but a continuous cover of vines, mainly Japanese honeysuckle and poison ivy, has developed in the understory. In these forests, vines are able to persist for long periods of time in low-light environments (Thomas 1980), particularly on moist sites, and they have almost completely suppressed recruitment into the understory (D. Whigham and D. Higman, unpublished data).

Vines, particularly introduced species, have been shown to be important components in a number of disturbed situations. Hull and Scott (1982) found that vines, especially *Lonicera japonica*, were more important in debris avalanches than were shrubs and herbs. Vines can also affect early regeneration following complete or partial clear cutting (Boring et al. 1981; Nixon et al. 1981).

Results of this study suggest that the presence of an extensive understory of vines can also suppress the growth of the canopy trees. Whether the long-term effects of decreased stem production will ultimately cause increased mortality of canopy trees is not known, but Slezak (1976) has shown that older forests are very susceptible to vine disturbance, particularly if the understory is not well developed.

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