

Introduction

Use of environmental variables as predictors of vegetation distribution patterns has long been a focus of ecology. However, the effect of edaphic factors on vegetation pattern is often measured using surrogates such as topography, because accurate measures of soil fertility and nutrients are unavailable or rare (Marage and Gégout 2009). *Kalmia latifolia* and *Rosa multiflora* exhibit contrasting regional vegetation patterns in which *K. latifolia* is more abundant in north central Pennsylvania and eastern West Virginia than in western West Virginia and eastern Ohio. In contrast, *R. multiflora* is more abundant in eastern Ohio and eastern West Virginia than it is in western West Virginia and north central Pennsylvania (FIA 2007). The distribution of these two species could be explained by changes in elevation over this region, and increasing elevations have been correlated with decreasing temperatures, decreasing soil moisture, decreasing soil pH, increasing organic matter, and increasing soil C (Niklinska and Klimek 2007). Studying the two species at the regional scale as well as local scale (under which the topographic conditions are more similar) will enable us to evaluate the relative importance of non-topographic variables, such as soil fertility (soil pH and nutrients).

Kalmia latifolia is a native shrub species of eastern forests that is typically associated with more xeric site conditions, and is considered invasive by some land managers (Chastain and Townsend 2008, Monk and Day 1985). The ability of *K. latifolia* to inhabit such xeric sites is potentially linked to a tight mineral cycle due to its ability to slowly return nutrients from very slowly decaying litter (Chastain and others 2006). *Rosa multiflora* is a nonnative invasive shrub that was intentionally introduced as a hedgerow species for pastures in the 1930s and has been spreading throughout the Eastern, Midwestern, and Western United States, including into closed canopy forests. There is evidence that *R. multiflora* has a preference for more fertile and mesic habitats (Huebner and Tobin 2006), which suggests that *K. latifolia* and *R. multiflora* should rarely coexist.

The purpose of this research is to determine if a soil fertility gradient exists across both regional and local scales and if this fertility gradient helps

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Chapter 15. Documenting the Regional and Local Distribution of *Kalmia latifolia* and *Rosa multiflora* in West Virginia, Ohio, and Pennsylvania Forests along a Soil Fertility Gradient

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explain the regional vegetation pattern or local presence of *K. latifolia* or *R. multiflora*.

Methods

We conducted this study from June to August in 2007 and 2008. In 2007, we randomly located (starting point) four 1-km transects within forests 70 years or older in each State's national forest (i.e., Monongahela, Allegheny, and Wayne National Forests, in West Virginia, Pennsylvania, and Ohio, respectively), resulting in a total of 12 transects. Along each transect, a 100-m² plot was located every 100 m, with each transect therefore having ten 100-m² plots. Four 10-m² plots were nested within each of the 100-m² plots and percent cover of all shrub species was estimated in each. We sampled canopy and subcanopy trees using a 10-factor wedge prism at each 100-m² plot center. Four B horizon soil cores were taken outside each 10-m² plot, totaling 16 subsamples for each 100-m² plot; subsamples were mixed for each 100-m² plot. We collected elevation, slope, aspect, light, and canopy opening data at the center of each 100-m² plot.

In 2008, we randomly established 10 plots per State and species from known locations of either *K. latifolia* or *R. multiflora*. Each individual shrub was at least 2 m in diameter and served as the center of each plot. These plots were located within forests at least 70 years old. Openings and other disturbances were avoided. Eight B-horizon soil samples were collected and mixed from each of the 30 shrub plots (four

from under the shrub canopy and four 2 m away from the canopy edge). We also sampled eight 1-m² subplots (four under the shrub canopy and four 2 m outside the canopy) of each shrub for herb/shrub/vine and tree seedling cover and calculated richness and diversity for each 1-m² subplot. Topographic and canopy/subcanopy tree data were collected using the 2007 methods. We collected 10 leaves from each shrub for nutrient analysis. Nutrients measured in plant tissue included total nitrogen (N), carbon (C), calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P), iron (Fe), manganese (Mn), and zinc (Zn); analyses conducted on the soil samples included pH, total N, Ca, K, Mg, P, Fe, Mn, Na, and Zn. Tissue analyses data were collected in order to relate measured soil nutrient availability with plant nutrient uptake and storage.

The soil and plant nutrient data and topographic data were analyzed by State and species using a generalized linear model (Proc GenMod, SAS v. 9.01) with a gamma distribution and log link function for all the variables except herb/shrub/vine diversity, which was normally distributed. No significant differences were noted for soil samples directly under the shrubs and those taken 2 m outside the shrub canopies.

Results

There were a total of 12, 8, and 20 shrub species in West Virginia, Pennsylvania, and Ohio, respectively, along the random transects. Based on relative importance values, *Smilax rotundifolia* was the most important shrub in both Ohio

and West Virginia and *Rubus* sp. was the most important shrub in Pennsylvania. *Kalmia latifolia* was the fifth most important shrub in both West Virginia and Pennsylvania but did not occur on the Ohio transects. *Berberis thunbergii* only occurred in the West Virginia and Pennsylvania transects, *Lonicera x bella*, both of which are nonnative invasive species, only on the Pennsylvania transects, and *R. multiflora* only on the Ohio transects. Ohio was the only State that had an exotic shrub (*R. multiflora*) that ranked in the top 10 most important species. Ohio tree diversity (calculated with the Shannon-Weaver index) along the transects was greater than that of Pennsylvania. Ohio shrub diversity was greater than that of both West Virginia and Pennsylvania, and West Virginia shrub diversity was greater than that of Pennsylvania. The State transects did not differ significantly in terms of canopy cover, but Ohio transects were located on steeper slopes, while Pennsylvania transects were located on slopes that were more northeast-facing than those of Ohio and West Virginia. Ohio transects were located at lower elevations than both Pennsylvania and West Virginia transects. Results confirmed a significant regional soil pH and fertility gradient, revealing higher soil pH and Ca (with K and Mg showing similar results) in Ohio followed by Pennsylvania and West Virginia (figs. 15.1A, 15.1B). An inverse relationship was found for N as well as Mn (except West Virginia) and Zn (fig. 15.1C,

15.1D; Zn is not shown). These differences in soil pH and nutrients are likely correlated with the topographic differences found among the States.

At the local scale, *R. multiflora* plots were located on more shallow slopes, at lower elevations, and under more open canopies than *K. latifolia*, but only in West Virginia. *Rosa multiflora* plots were associated with higher levels of plant species diversity (but not significantly so in Pennsylvania). *Kalmia latifolia* plots were found on more acidic soils than *R. multiflora*, but only in Ohio (fig. 15.2A). In fact, the soil pH for the *K. latifolia* plots in Ohio was significantly lower than the *K. latifolia* plots in Pennsylvania and West Virginia. *Rosa multiflora* plots were generally located on soils with higher levels of soil Ca, K, Mg, and Mn than *K. latifolia*, with Ohio having the highest values of soil Ca, K, and Mg (not shown) and West Virginia having the highest values of Mn (figs. 15.2B, 15.2C, 15.2D). The amount of soil N occurring within *R. multiflora* and *K. latifolia* plots did not differ between species, though West Virginia plots were higher in soil N than Pennsylvania and Ohio plots. In contrast, *R. multiflora*'s tissue was higher in N and K (with West Virginia having the highest values), as well as Ca (with Ohio having the highest values) (figs. 15.3A, 15.3B, 15.3C). *Kalmia latifolia* tissue had higher levels of Mn (as well as Zn) than *R. multiflora* in all three States (fig. 15.3D).

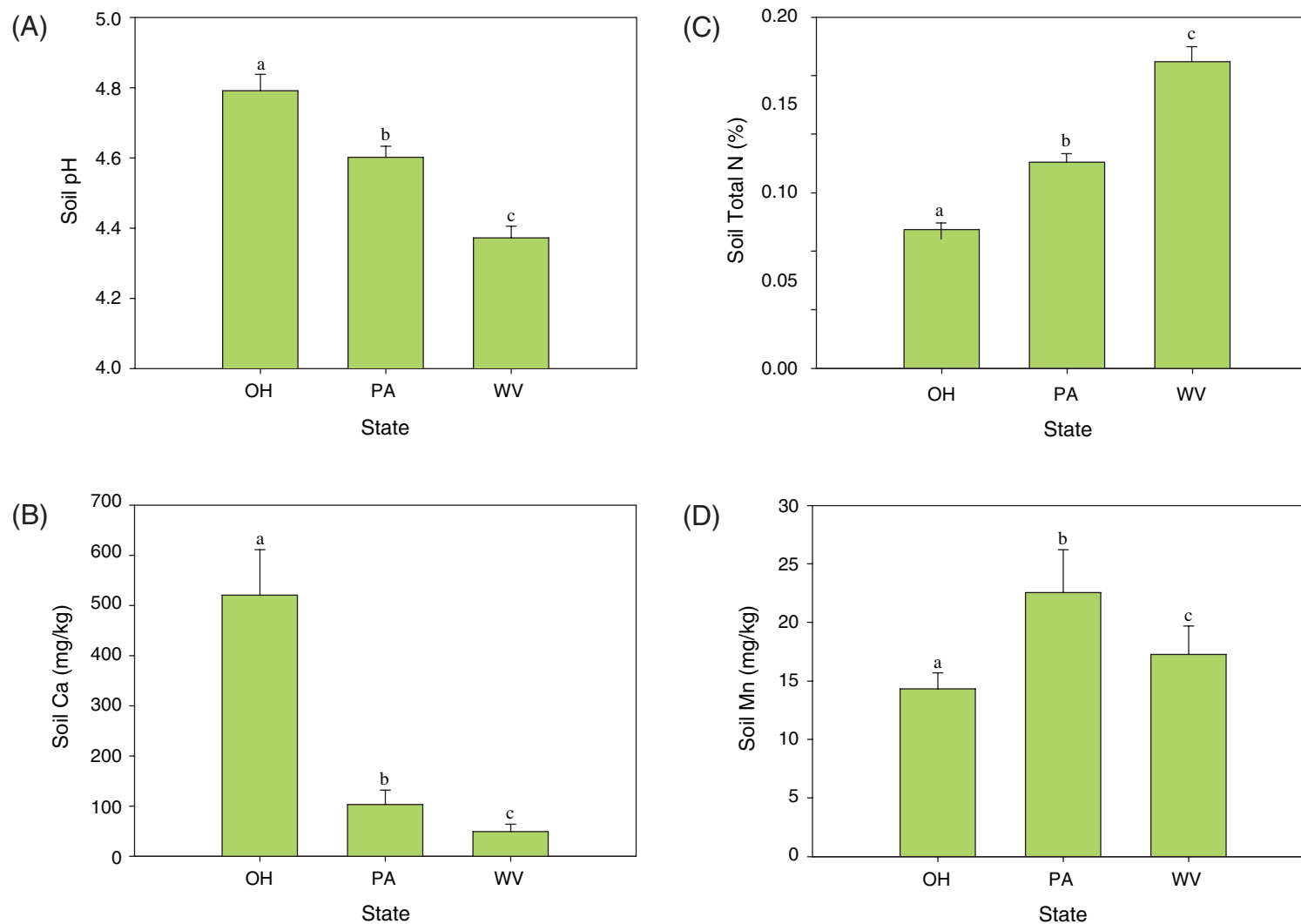


Figure 15.1—Soil pH (A), soil calcium (mg/kg) (B), soil total N (percent) (C), and soil manganese (mg/kg) (D) in Ohio, Pennsylvania, and West Virginia. Lowercase letters indicate statistical differences among groups.

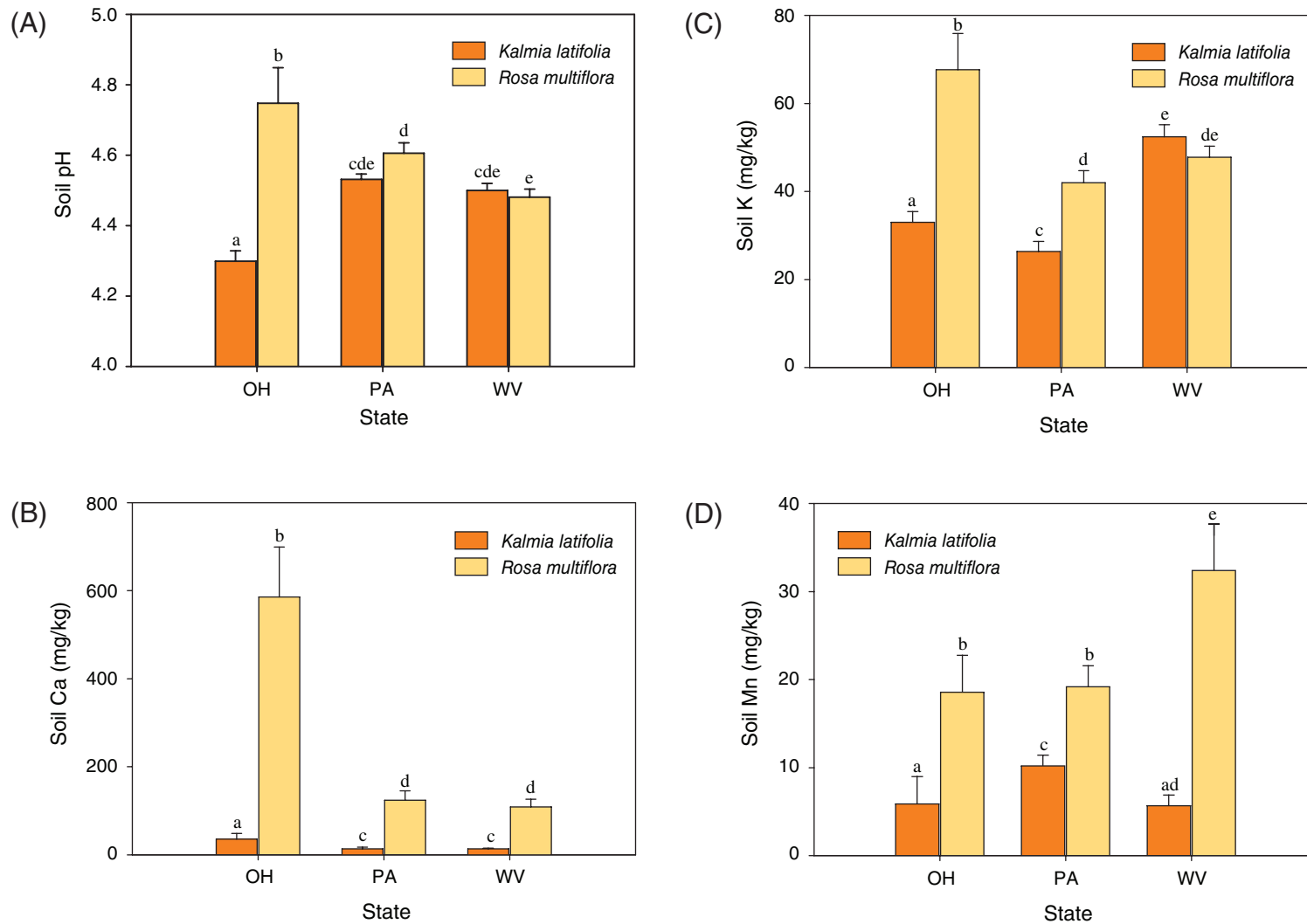


Figure 15.2—Soil pH (A), soil calcium (mg/kg) (B), soil potassium (mg/kg) (C), and soil manganese (mg/kg) (D) on *Kalmia latifolia* and *Rosa multiflora* plots in Ohio, Pennsylvania, and West Virginia. Lowercase letters indicate statistical differences, or lack of statistical differences, among groups.

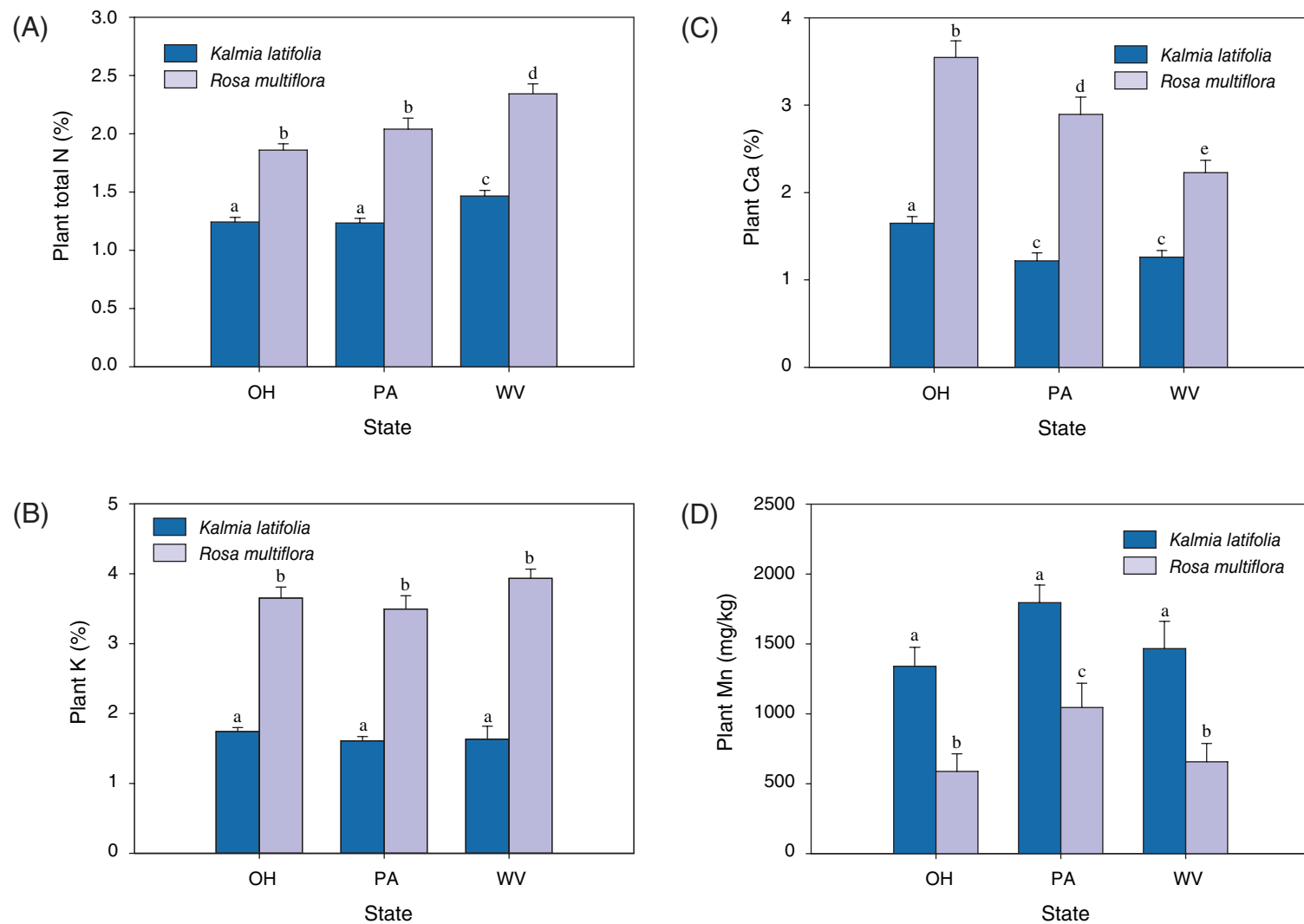


Figure 15.3—Plant total nitrogen (percent) (A), plant potassium (percent) (B), plant calcium (percent) (C), and plant manganese (percent) (D) of *Kalmia latifolia* and *Rosa multiflora* plots in Ohio, Pennsylvania, and West Virginia. Lowercase letters indicate statistical differences, or lack of statistical differences, among groups.

Discussion and Conclusions

K. latifolia is regionally more abundant than *R. multiflora* (and other exotic invasive species) but less likely to be present in areas of high soil fertility or low acidity. Nonetheless, topographic differences, including elevation, remain important. At the local scale, soil pH and nutrients appear to play a more important role in determining the distribution of these two species in Ohio and Pennsylvania than topography, while topography is still a key factor at the local scale in West Virginia. While these results enable us to predict that invasion of *R. multiflora* is more likely in areas of high soil fertility, we can only separate out the importance of these soil variables from topographic factors at the local scale in Ohio and Pennsylvania. The strongest pattern was for *R. multiflora* to be associated with soils high in Ca, K, Mg, and Mn. The higher soil values of Ca, K, and Mg associated with *R. multiflora* were also evident in its tissue, but this was not true for Mn. In contrast, *K. latifolia* apparently stores larger amounts of Mn than *R. multiflora*, despite being located in soils lower in Mn than soils near *R. multiflora*. *Kalmia latifolia* may be limited by Mn (and Zn). However, the extreme acidity on which *K. latifolia* was found in Ohio may also result in absorption of Mn to toxic levels. The poor condition of *K. latifolia* shrubs in Ohio may provide support for possible Mn toxicity. While elevation, moisture

gradients, and historic disturbances likely play an important role in the current distribution of both species regionally and locally in West Virginia, our data show that soil pH and nutrients are also significant factors that may explain local distribution patterns that cannot be explained by topography.

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