

Documenting the Regional and Local Distribution of Native and Exotic Interfering Shrub Species in West Virginia, Ohio, and Pennsylvania Forests along a Soil Fertility Gradient

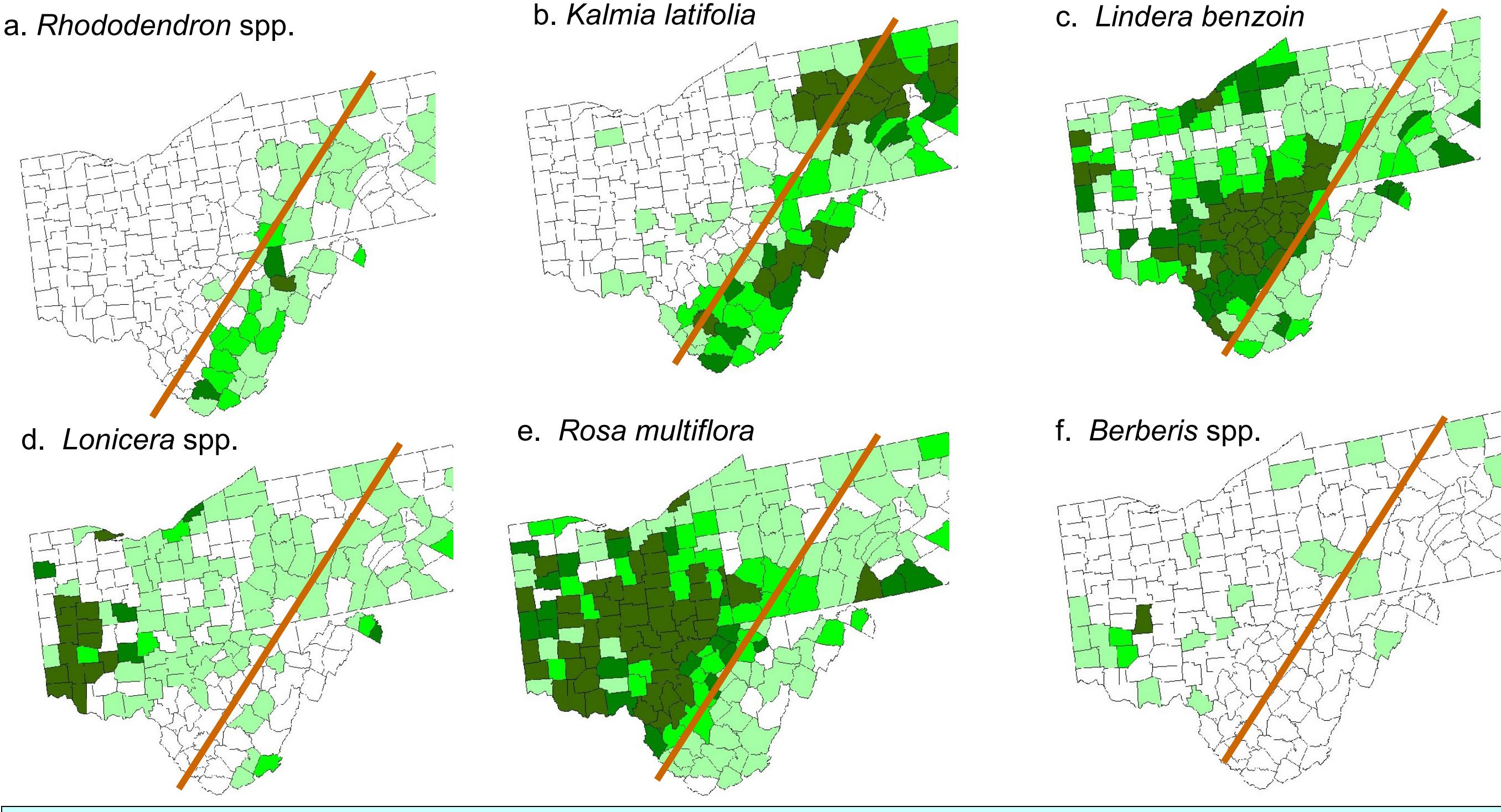
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Introduction

Soil fertility gradients have typically been viewed as unimportant compared to soil moisture gradients, topography, or local disturbances when defining vegetation distribution. Analysis of Forest Inventory and Analysis (FIA) data reveals an approximate northwest to southeast distribution gradient (line) of *Rhododendron* spp., *Kalmia latifolia*, *Lindera benzoin*, *Lonicera* spp., *Rosa multiflora*, and *Berberis* spp. with *Rhododendron* and *Kalmia* being most abundant to the southeast and the remaining species being more abundant to the northwest (Figs. 1a-f; darker counties have a greater abundance of the species).

Fig. 1a-f.



If regional distribution of these plants along a soil fertility gradient can be documented, our ability to predict spread of local populations in response to local disturbances, such as harvesting, fire, or pathogen infestations, improves. Likewise, our ability to predict regional spread of these species improves as the soil fertility gradient changes in response to global climate change or acid deposition.

Methods

This study was conducted from June - August 2007 and 2008. In 2007, four 1-km transects were randomly located within forests 70+ years of age in each state's National Forest (e.g., Monongahela (WV), Allegheny (PA), and Wayne (OH) National Forests), resulting in a total of 12 transects. Along each transect ten 100 m² plot were located every 100 m. Four 10 m² plots were nested within each of the 100 m² plots and cover of all shrub species was estimated in each 10 m² plot. Canopy and subcanopy trees were identified and tallied from each 100 m² plot center using a 10-factor wedge prism. Four soil cores of the B horizon were taken from each cardinal direction just outside the 10 m² plots and were mixed for each 100 m² plot. Elevation, slope, aspect, light, and canopy opening data were collected at the center of each 100 m² plot.

In 2008, ten plots per state were randomly established using *Kalmia latifolia* and *Rosa multiflora* (shrubs being at least 2 m in diameter) as the center of each plot. These plots were located within 70+ year old forests, and openings and other disturbances were avoided. Eight B-horizon soil samples were collected and mixed from each of the 30 shrub plots. Eight 1 m² plots either under or within 2 m of each shrub were sampled for herb/shrub/vine and tree seedling cover. Topographic and canopy/subcanopy tree data were collected using the 2007 methods. Herb/shrub/vine and tree seedling richness and diversity for each 1 m² plot were calculated. Ten leaves from each shrub were collected for nutrient analysis. Nutrients measured for plant tissue included: total N and C, Ca, K, Mg, P, Fe, Mn, and Zn; measurements taken for the soils data included pH, acidity, CEC, total C/N, Ca, K, Mg, P, Fe, Mn, Na, and Zn.

The 2007 and 2008 species compositional data were analyzed using nonmetric multidimensional scaling (NMS, PCord v. 5). 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.

Results

Fig. 2. NMS ordination of the four transects in each of the three states. Red diamond is WV; green circle is PA; blue square is OH. The final stress for this 3-dimensional solution was 17.99 with an instability of 0.00198 after 250 iterations. The OH sites are more well-separated than the WV and PA sites and are defined by higher pH, Ca, and Mg values.

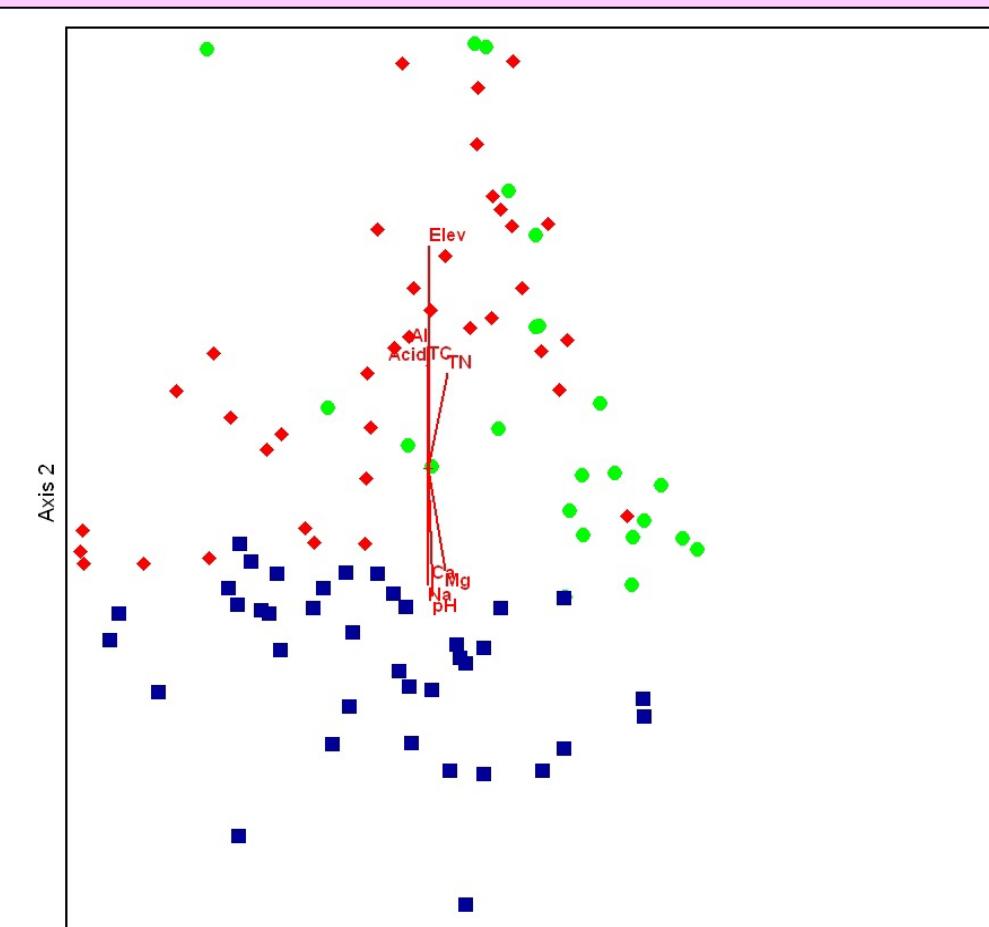


Fig. 3 a and b. Transect soil data revealing a soil pH and soil total N gradient across the three states. (Total C showed a similar gradient as total N.)

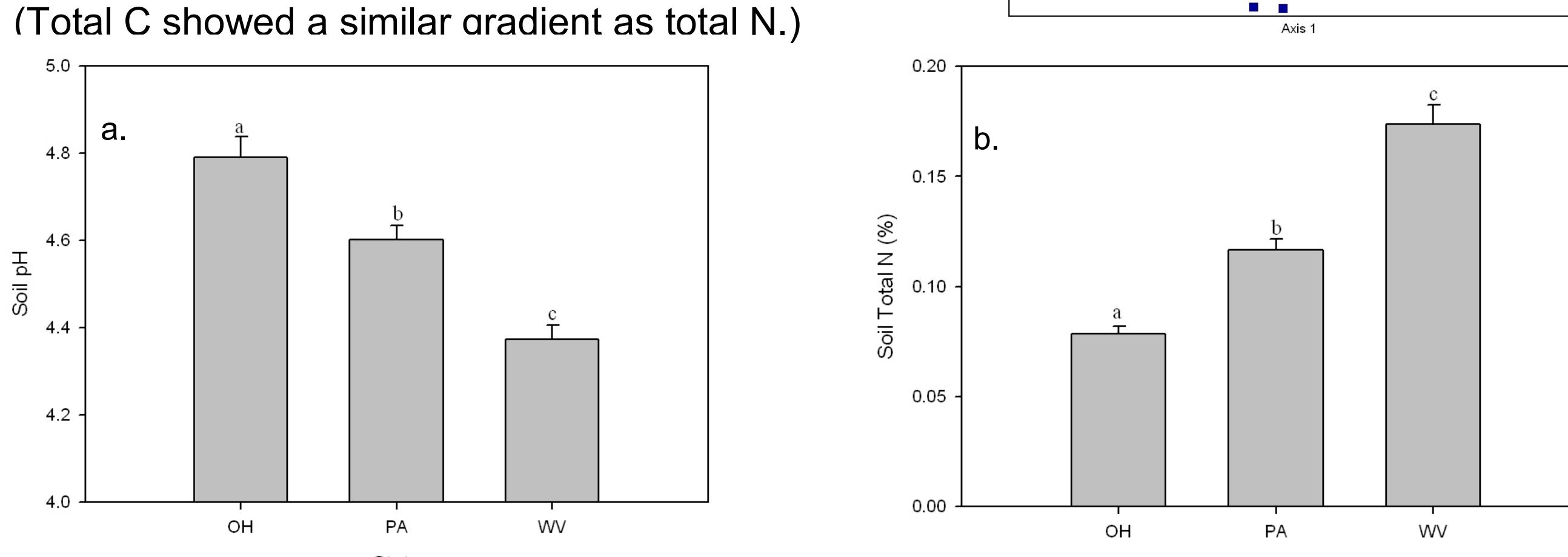


Fig. 3 cont. c, d, and e. Transect soil data revealing a soil Ca gradient across the three states (similar results found for Mg and K) and significantly lower values of Mn and Zn in OH.

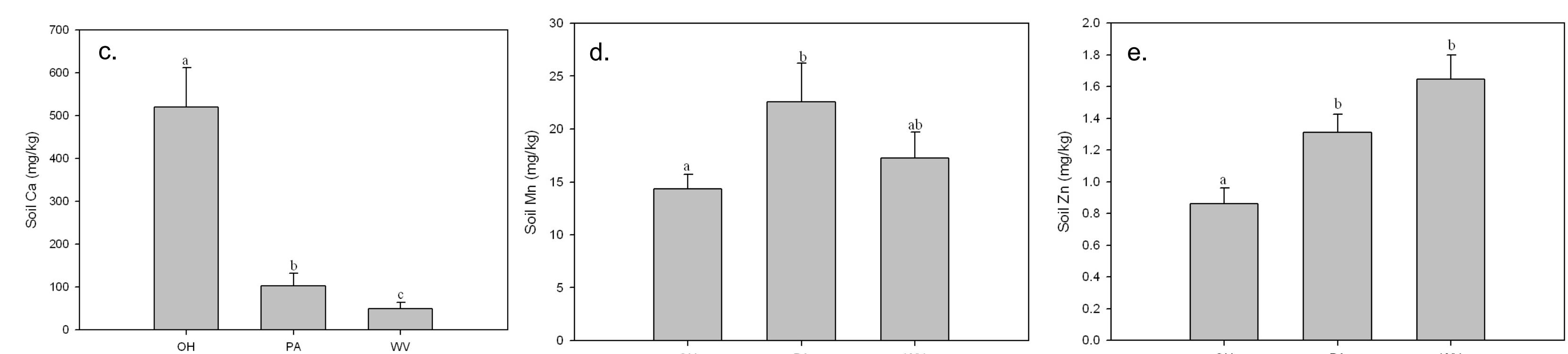


Fig. 7 a -l. Comparison soil and plant tissue nutrients by state and species. Brown border = soil data; green border = plant data.

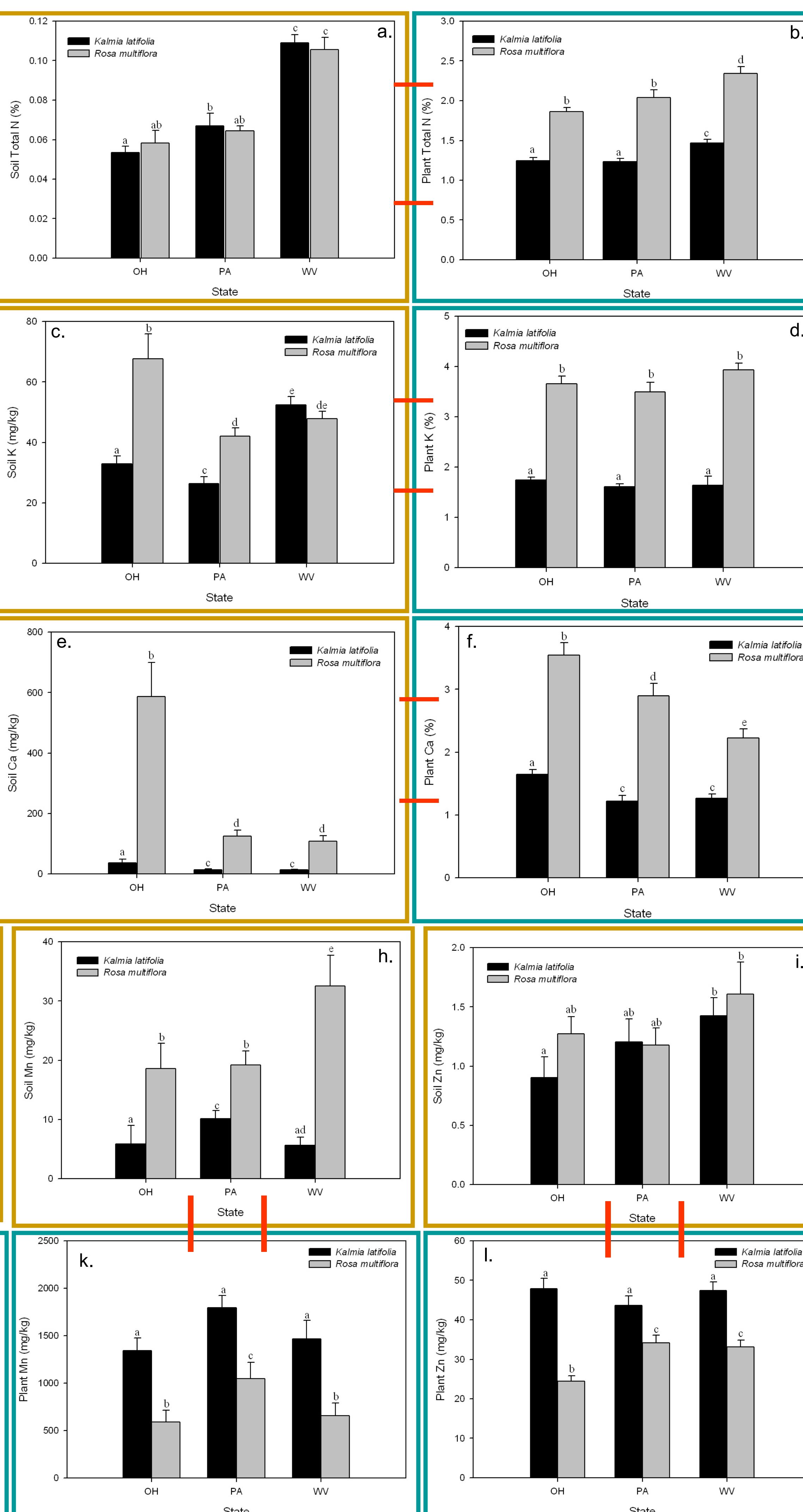


Fig. 5 a, b, c, and d. Comparison of topographic (slope; aspect showed no significant differences), environmental (canopy opening and bare ground), and biotic (herb/shrub/vine diversity) data by state and species in the shrub plots.

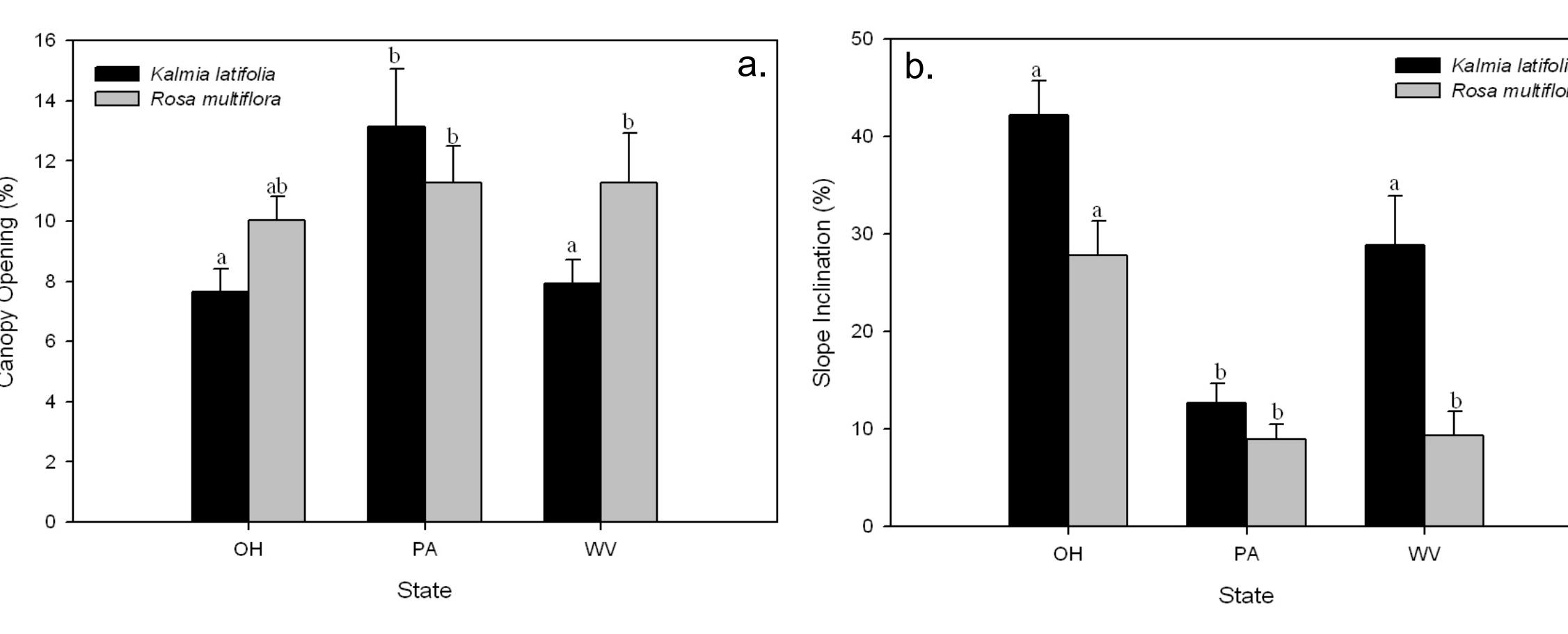
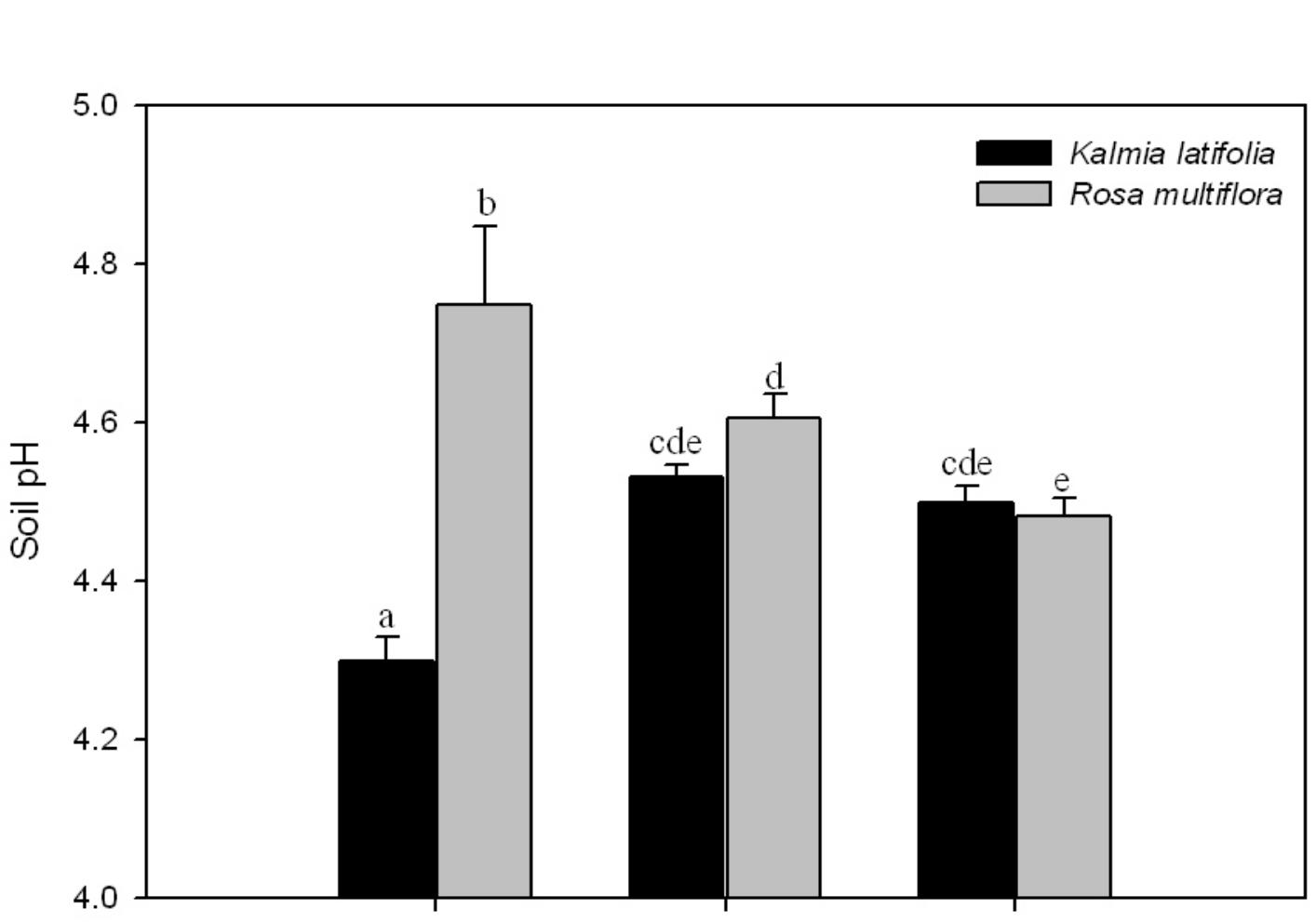


Fig. 6. Comparison of soil pH by state and species.



The OH shrub plots were located on steeper slopes for both species, while the WV plots had more light (data not shown) reaching the forest floor (possibly because there was an insignificant trend for more WV sites on SW aspects. In both OH and WV, the *R. multiflora* plots were found under more open canopies, but this was not true for PA. For all states, the *K. latifolia* plots had more tree basal area (data not shown) than the *R. multiflora* plots. The amount of bare ground beneath *K. latifolia* plants in OH was significantly greater than that found for either species in PA or WV. WV had the most soil N, but *R. multiflora* tissue was composed of more total N than *K. latifolia* in all states. For N, Ca, Mg, K, and P, there was either no significant difference in abundance among the states or OH tended to have higher soil amounts and *R. multiflora* had more of these nutrients in its tissue than *K. latifolia*. *Kalmia latifolia* was associated with sites having higher levels of soil Fe, but *R. multiflora* tissue contained more Fe than *K. latifolia* tissue. In contrast, *K. latifolia* tended to be located on sites with lower amounts of Mn and Zn than *R. multiflora* sites, but *K. latifolia* had significantly higher levels of Mn and Zn in its tissue. The transects showed that OH had significantly less soil Mn and Zn, which may lead to a preliminary conclusion that *K. latifolia* is rare in OH because Mn and Zn may be limiting or Mn and Zn are being absorbed at toxic levels. Mn toxicity is known to increase in acidic soils.

Thus, we have documented a fertility gradient at both a regional and local (shrub) scale. *Rosa multiflora* shows a preference for high soil fertility and may be expected to spread more rapidly in such areas. *Kalmia latifolia* is limited to more acidic sites, but only in OH, and would not be expected to become a problem species in more fertile soils than found in WV or PA.

Conclusions

Soil data and the species compositional data from the 1-km transects in each state confirm a pH and nutrient gradient at a regional scale, with OH having the highest pH, with particular nutrients (Ca, Mg, and K) being more abundant. Total N and C, however, were most abundant in WV, followed by PA. The fact that *R. multiflora* had a relatively high importance value in OH may indicate that some exotic species will be more likely to spread in these more nutrient rich soils.

A similar pH gradient was noted for the *R. multiflora* shrub plots. However, *Kalmia latifolia* plots only in OH were limited to more acidic sites than *R. multiflora*. Compositionally, the OH shrub plots were well-separated from the other states and defined by species richness and more strongly defined by plant Ca, Mg, and K than soil nutrients. The two species separated distinctly in the NMS ordination and *R. multiflora*, like the state of OH, was defined by higher species richness/diversity and more abundant plant Ca, P, Fe, N, and K than found for *K. latifolia*.