

Herbivory by white-tailed deer on invasive plants in

suburban/exurban forests Megan Fertitta, Catherine Zymaris,

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Abstract

Pressure from overabundant white-tailed deer populations and an increased presence of non-native, invasive species have led to depauperate understories in suburban/exurban forests. As non-native species become more abundant in such forests, they themselves may become important targets of herbivory by deer. This study focused on the invasive plants garlic mustard (*Alliaria petiolata*, ALPE) and Japanese stilt-grass (*Microstegium vimineum*, MIVI), and how overall deer pressure may influence abundance of and herbivory on these species. In 12 forests in central New Jersey, we measured vertical shrub cover as an index of chronic deer pressure. We then scored MIVI and ALPE abundance and browse herbivory during 10-minute visual scans along 9 deer or hiking paths in each forest. Of the 64 paths with ALPE, 17% showed browse on ALPE, and 23% of the 97 paths with MIVI showed browse on MIVI. We used structural equation modeling (SEM) to investigate the related influences of chronic deer pressure and ALPE and MIVI abundances on herbivory of ALPE and MIVI. Deer herbivory on ALPE was higher in forests with lower shrub cover and higher ALPE abundance, which were positively correlated. In contrast, herbivory on MIVI was higher due to lower shrub cover, but MIVI abundance had no influence, and was negatively correlated with shrub cover. However, ALPE abundance strongly and positively influenced herbivory on MIVI. We also collected 10 deer pellet groups from each forest in Fall 2011 as an additional way to detect herbivory on MIVI, which was in fruit. We planted the pellets in the greenhouse; MIVI has grown from two samples so far. It is clear that deer do browse on these two invasive species (and even possibly contribute to dispersal). This suggests that, in highly invaded and deer-impacted forests, deer's previous role as a facilitator of invasion may be altered. When two co-invasive species like ALPE and MIVI differ in how they are impacted by deer, then deer may become an important factor in their relative abundance and the resulting community structure.

Introduction

Increased levels of anthropogenic activities over the last century have led to dramatic changes in land use. Farmlands and dense, old-growth forests have transitioned into residential/commercial areas, resulting in the proliferation of small, fragmented forests. Combined with the loss of natural predators, this has resulted in overabundant populations of white-tailed deer. Additionally, invasions of non-native plants have redefined forest plant communities. Deer may avoid unpalatable invasive plants, which may help account for their success, but some research also suggests that deer do eat these plants when other vegetation is scarce. In this case, deer may even act as seed dispersers.

It is important to better understand the relationship of deer populations and invasive plants in order to prevent and halt further forest degradation. We assessed the relative abundance and quantified deer herbivory on two invasive herb-layer plants: Japanese stilt-grass (*Microstegium vimineum*, MIVI) and garlic mustard (*Alliaria petiolata*, ALPE). Our study was conducted across 12 forest stands in central New Jersey with varying levels of apparent deer pressure, quantified through vertical shrub cover measures. This study has provided us with useful information for further studies on the unknown interactions between white-tailed deer, Japanese stilt-grass, and garlic mustard.

Methods

We surveyed 12 forest stands in central New Jersey with both ALPE and MIVI present. We scored:

1) **Chronic deer pressure.** Drawing from our previous research on methods to assess deer pressure in suburban forests, we chose to use visual, quantitative measures of vertical percent foliage cover of native woody plants, taken at 40 points per forest (Fig. 1).

2) **Abundance of ALPE and MIVI.** In each forest, we conducted nine 10-minute visual scans of paths that were in ALPE and MIVI stands: three hiking paths, three interior deer paths, three deer paths extending from the forest edge to the interior (Fig. 2). During each scan, we scored the surrounding area's abundance of each species on a scale from 0 (absent) to 4 (75 - 100 % cover). We measured abundances in Fall 2011, before leaf fall.

3) **Deer herbivory on ALPE and MIVI.** During each scan, we counted the number of plants with evidence of deer browse (shreddy, bitten stem ends). We counted MIVI in Fall 2011, and ALPE in Fall 2011 and mid-Winter 2012.

We also collected 8-10 deer pellet groups per forest in November 2011. After air-drying and removal of any exterior soil, we planted half of each pellet group in the greenhouse, and cold/moist-stratified the other halves for an additional six weeks and then planted. We checked for emerging MIVI plants weekly.

4) **Analysis.** We did structural equation modeling (SEM), using AMOS software and maximum likelihood estimation, with observed variable models. We modeled two response variables for each species (n = 11 forests, where both species were present): 'number of paths with herbivory present' and 'mean number of plants with herbivory per path' (only for paths with the species present). We specified the initial models to reflect our theoretical predictions that:

- Deer herbivory on ALPE and MIVI is influenced by the level of chronic deer pressure in the forest;
- Deer herbivory is influenced by the species' abundance in the forest;
- Native shrub cover and the abundances of ALPE and MIVI are correlated.

We then compared the initial models with models that included additional influences of the abundance of one of the species on herbivory of the other species. The data were transformed as $\log_{10}(x + 0.5)$ before SEM in order to improve the fit to normality.

Results

Fig. 3. Number of paths (n= 9/forest; 12 forests) having one or more MIVI or ALPE plants with deer herbivory. ALPE data (a) were collected in Fall 2011 and mid-Winter 2012. MIVI data (b) were only collected in Fall 2011. About 25% of paths for ALPE Winter had deer herbivory, while only about 10% of paths for ALPE Fall had herbivory. About 25% of paths for MIVI had herbivory.

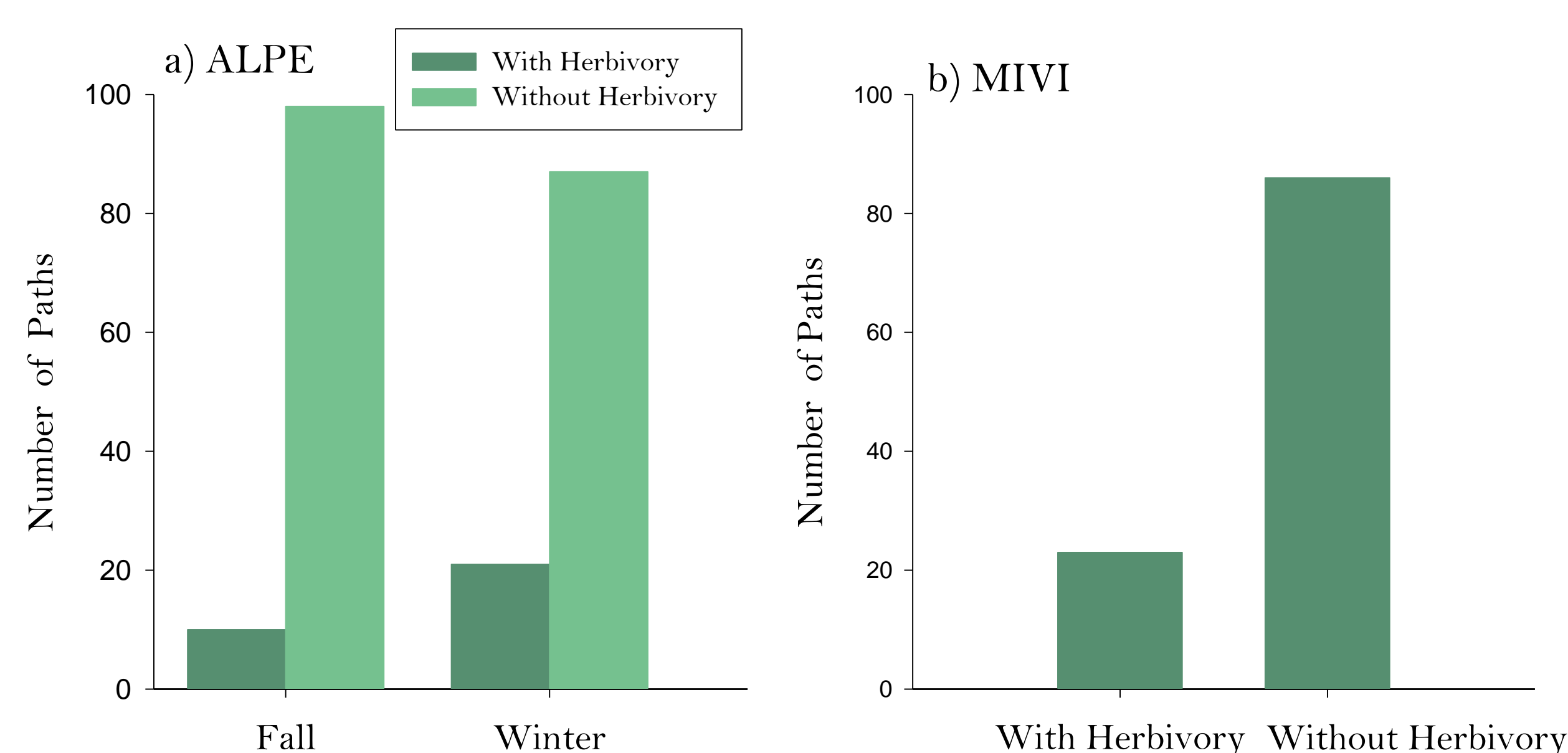


Fig. 4. Relationship between mean vertical percent cover of shrub layer (n= 40/forest) and the mean number of browsed plants per path: (a) ALPE and (b) MIVI. Data were collected in Fall 2011.

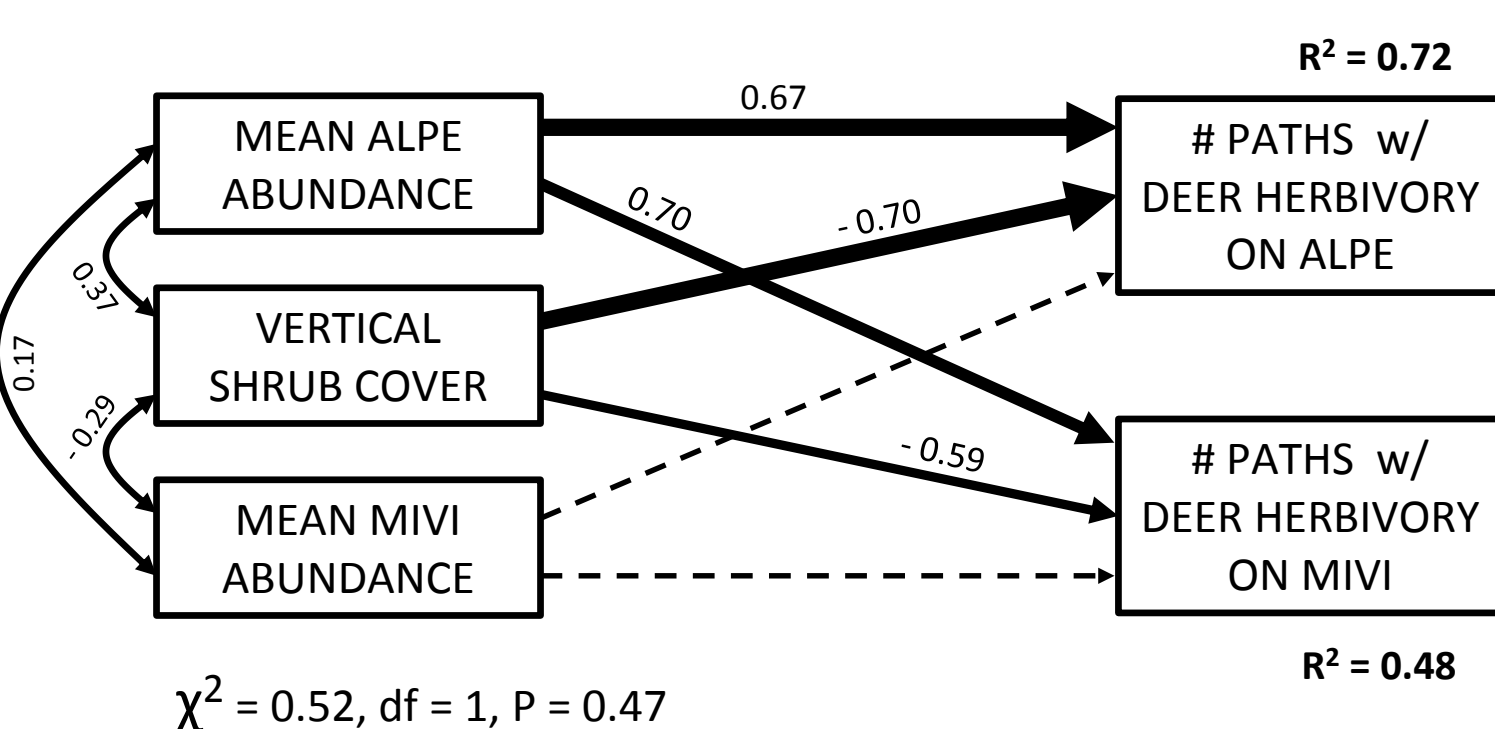
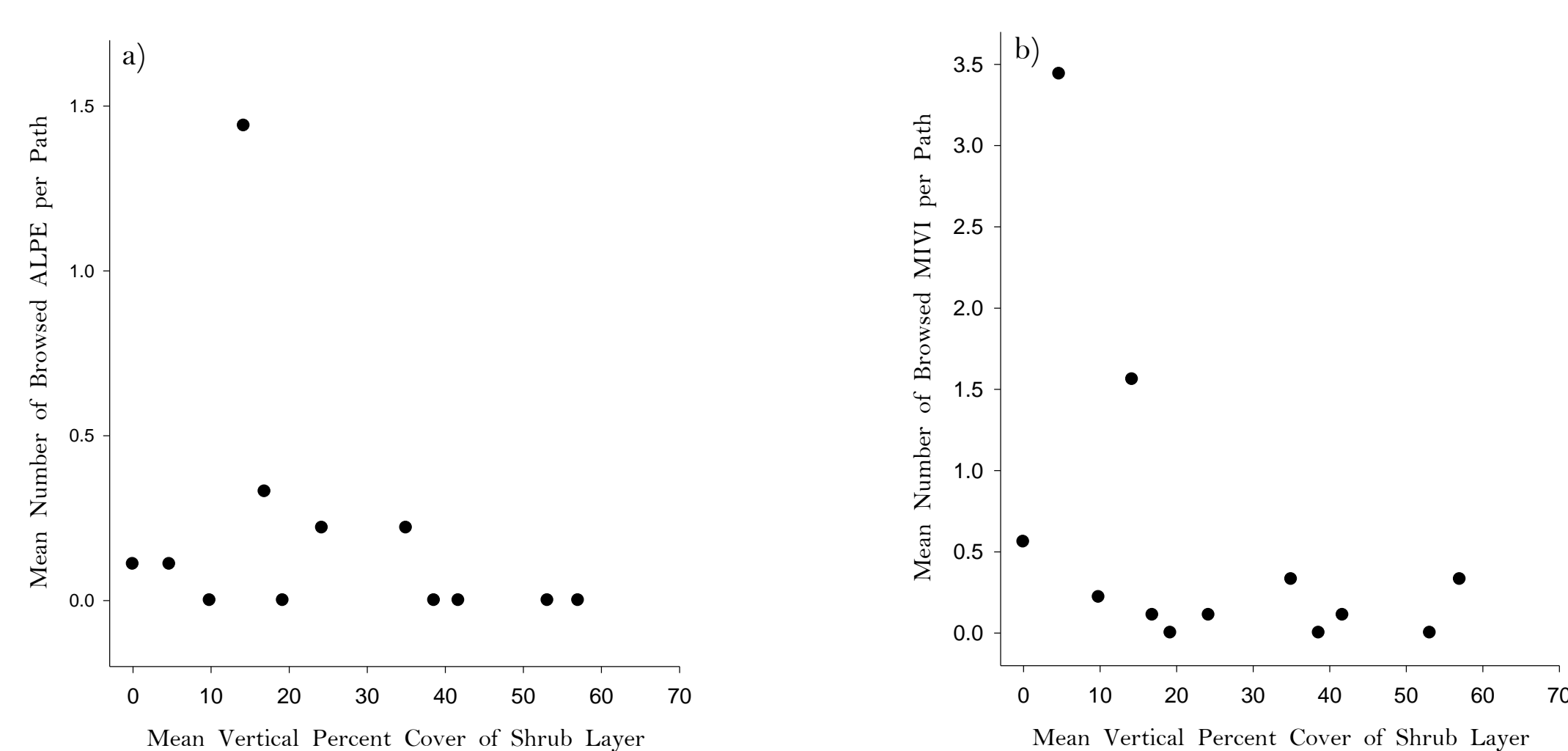


Fig. 5. Structural equation modeling (SEM) yielded this best model, indicating:

- Presence of herbivory on ALPE was higher in forests with lower shrub cover (i.e. chronic deer pressure) and higher ALPE abundance.
- Presence of herbivory on MIVI was higher in forests with lower shrub cover, but the overall MIVI abundance was not important. However, higher ALPE abundance led to higher presence of MIVI herbivory.
- The model explains more of the variation for ALPE than for MIVI.

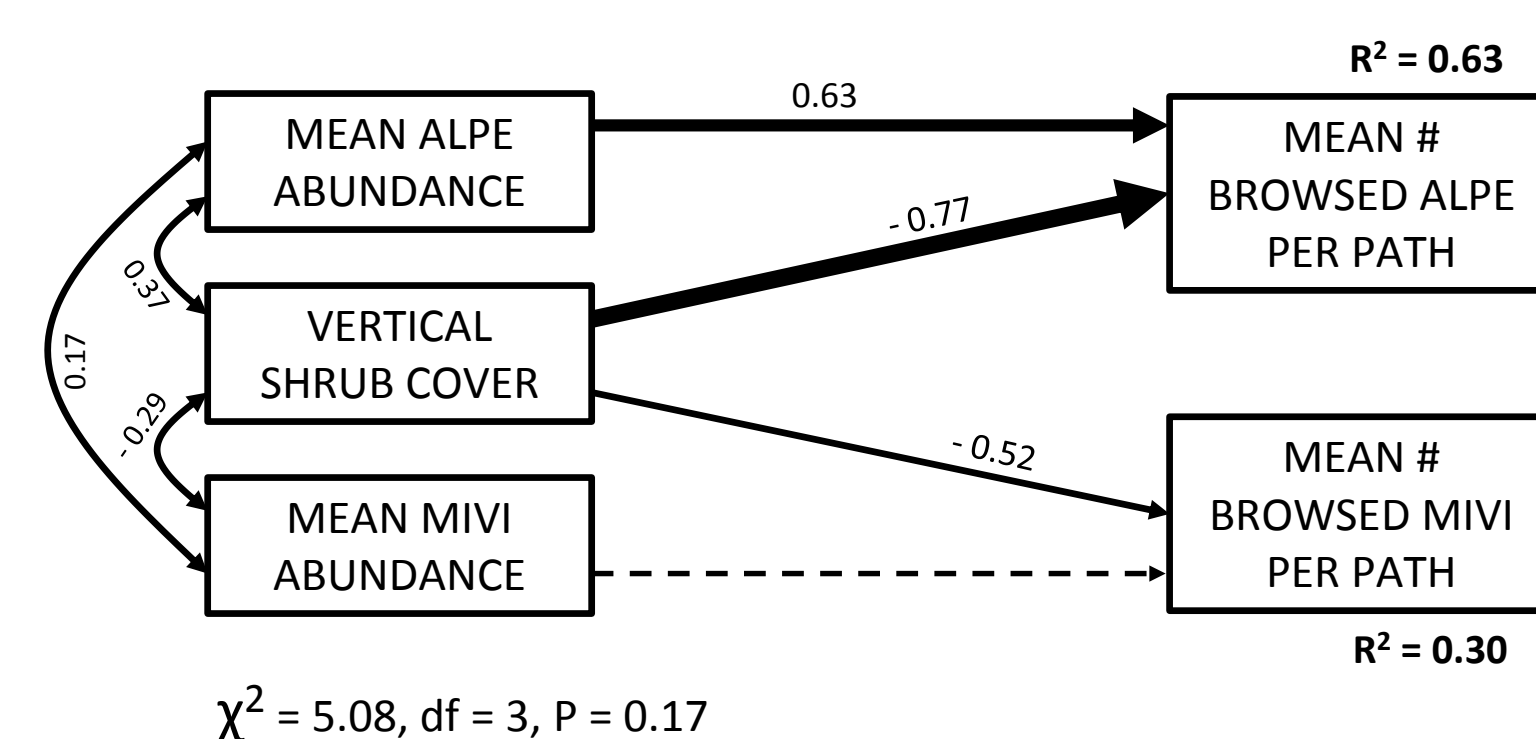


Fig. 6. Structural equation modeling (SEM) yielded this best model, indicating:

- Mean number of browsed ALPE (on paths where ALPE was present) was higher in forests with lower shrub cover and higher ALPE abundance.
- Mean number of browsed MIVI (on paths where MIVI was present) was higher in forests with lower shrub cover, but the overall MIVI abundance was not important.
- For this response variable, inclusion of paths from abundance of the other species to herbivory did not improve the initial model.
- The model explains more of the variation for ALPE than for MIVI.

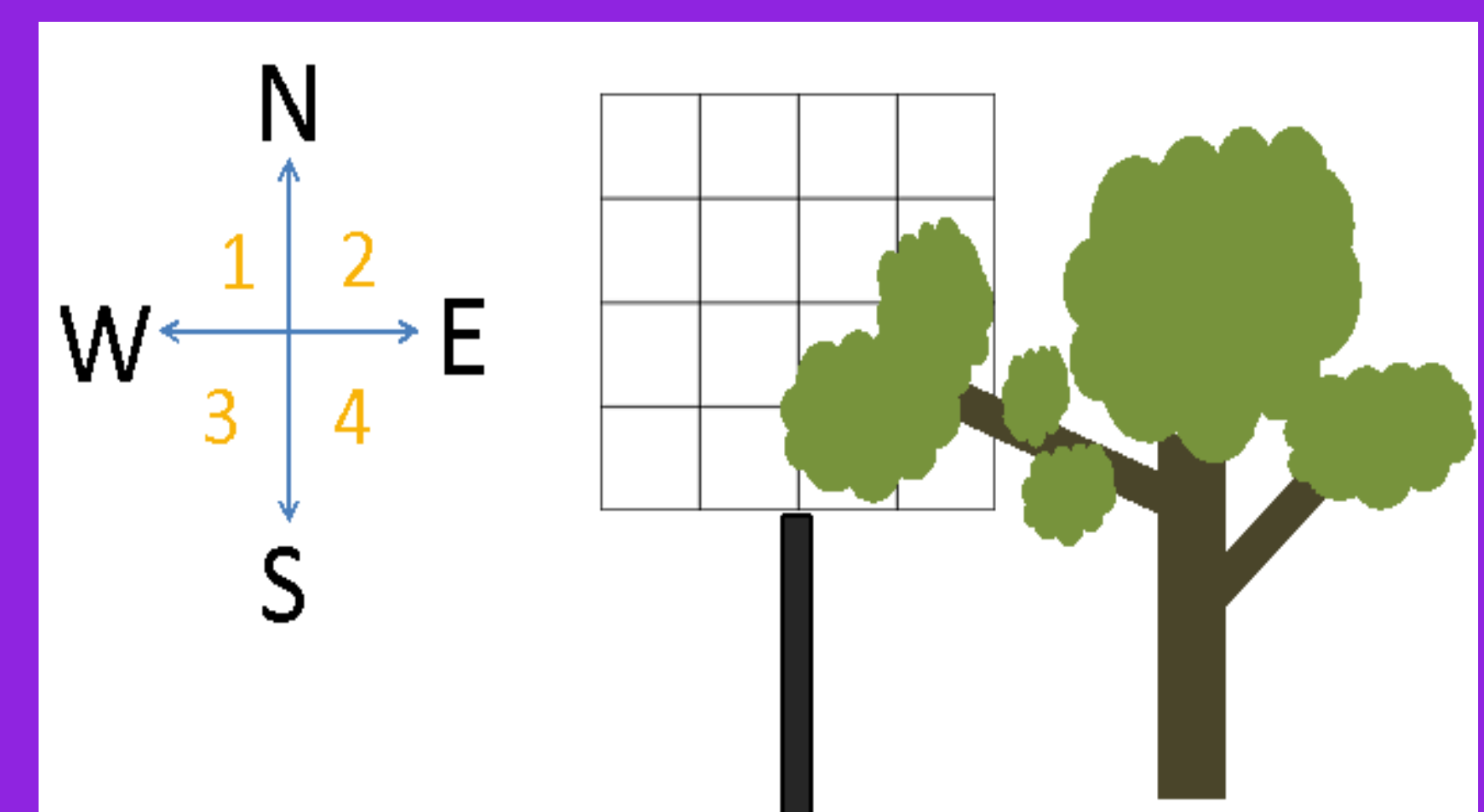


Fig. 1. Diagram of vertical shrub cover measure depicting obstruction of eight squares. Observations were recorded in four cardinal directions at ten points in each forest.

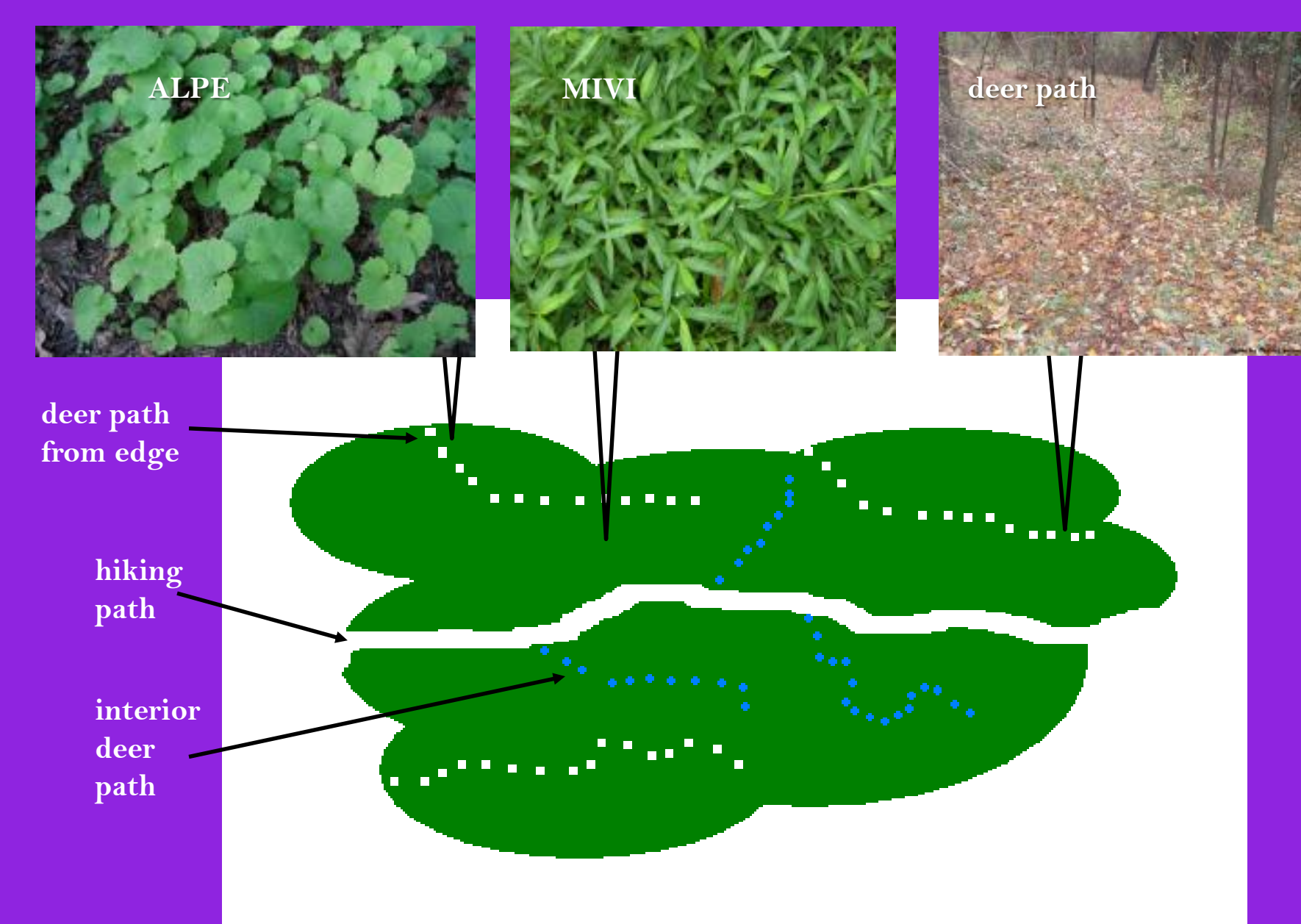


Fig. 2. Diagram of paths walked during survey periods (n= 9/forest). Three hiking paths, three deer paths from the forest edge, and three deer paths stemming from the hiking paths. Photos show typical stands of ALPE, MIVI, and a deer path.

Discussion

Forests in the suburban/exurban matrix, as in central New Jersey, experience various levels of chronic white-tailed deer browse. In our study of 12 forests, mean vertical shrub cover ranged from 0-57%. These forests typically also harbor large populations of multiple non-native, invasive species, such as garlic mustard and Japanese stilt-grass. **Our results challenge the common assumption that deer avoid these species; instead, we observed deer herbivory on both species to be present, but variable, in all forests.**

Herbivory was more likely to be present on MIVI and, when present, more MIVI plants were affected, on average. This is

particularly notable because MIVI was the more abundant species. Both species possess characteristics that should repel herbivores (garlic mustard's plant chemistry and stilt-grass's tough, fibrous tissues), but deer appear to be deterred more by garlic mustard. Our pellet group study confirms that deer readily eat grasses; by far the most numerous plants growing out of deer pellets are two grass species. **These results suggest a possible role for deer during the co-invasion process; they may have a more negative effect on MIVI than on ALPE, thus promoting invasion by ALPE.**

The structural equation modeling provided further insight into the species' and forests' differences. Although ALPE experienced less herbivory, a simple model that included the inter-related effects of shrub cover and ALPE and MIVI abundance explained a much greater

amount of the variation in ALPE herbivory among forests than it did variation in MIVI herbivory. Specifically, herbivory was generally higher in forests with less shrub cover, but this was a much stronger path for ALPE. Additionally, ALPE abundance had a strongly significant positive path to ALPE herbivory. In contrast, the path from MIVI abundance to MIVI herbivory was not significant, and interestingly, the model for herbivory presence also included a significant path between *ALPE abundance* and MIVI herbivory. **The models show that deer most readily turn to ALPE where native plant browse is scarce and ALPE is more abundant. For MIVI herbivory, the models suggest the need for further information: how does ALPE abundance influence deer herbivory on MIVI, and what other, as yet unmeasured, factors are also important?**