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Competitive Interactions of Garlic Mustard (*Alliaria petiolata*) and Damesrocket (*Hesperis matronalis*)

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Competitive interactions between native plants and nonnative, invasive plant species have been extensively studied; however, within degraded landscapes, the effect of interspecific interactions among invasive plants is less explored. We investigated a competitive interaction between two sympatric, invasive mustard species that have similar life history strategies and growth forms: garlic mustard and damesrocket. Greenhouse experiments using a full range of reciprocal density ratios were conducted to investigate interspecific competition. Garlic mustard had a negative effect on the final biomass, number of leaves, and relative growth rate in height of damesrocket. Survival of damesrocket was not negatively affected by interspecific competition with garlic mustard; however, garlic mustard showed higher mortality because of intraspecific competition. These results indicated that although garlic mustard has been observed to be the dominant species in this landscape, it may not completely outcompete damesrocket in all situations. Studies of invasive species in competition are important in degraded landscapes because this is the common situation in many natural areas.

Nomenclature: Damesrocket, *Hesperis matronalis* L.; garlic mustard, *Alliaria petiolata* (Bieb.) Cavara & Grande.
Key words: Competition, invasive species, replacement series.

Plant communities worldwide (Mack et al. 2000) often contain multiple nonnative invasive plant species that compete not only with native species but also with other nonnative, invasive species present in that community (Morrison et al. 2007). However, most researchers focus on the native and invasive plant interactions to determine whether there is a negative effect (i.e., Flory and Clay 2010; Huenneke and Thomson 1995; Leicht et al. 2005; Meekins and McCarthy 1999). Unfortunately, because of the pervasiveness of invasive species, potential interaction among invasive species has become an important issue in many plant communities.

Often, when managers act to control invasive species on degraded land to restore it to a higher-quality natural area, new invasive species take the place of the ones that were removed (Erskine Ogden and Rejmánek 2005; Larson and Larson 2010; Pavlovic et al. 2009). The greater the number of invasive species present, the higher the potential becomes for another invasive species to take advantage of the removal of a key competitor. Thus, a better understanding of what drives invasive plant succession in these communities is necessary. Like all interactions among plant species, interactions between invasive species can be competitive, facilitative, or neutral. Invasive species may make the environment more conducive for additional invasive species to colonize (Simberloff and Von Holle 1999), or invaders may compete with each other (Belote and Weltzin 2006; Call and Nilsen 2005). Invasive species, by their very definition, are successful competitors within their new environments because they are able to infiltrate, establish, and proliferate in new locations, especially in disturbed habitats (Flory and Clay 2006; Hausman et al. 2010).

To examine interactions between invasive species, we studied two members of the mustard family (Brassicaceae). We were especially interested in these species because of previous research where we observed that garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande] was invading areas that already contained a dense layer of damesrocket (*Hesperis matronalis* L.) in northwest Indiana (Pavlovic et al. 2009). This observation lead to the following question: Would the regionally more-prevalent species (garlic mustard) outcompete the more-restricted damesrocket? This question is especially pertinent to land managers who often have to treat one or both of these

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Management Implications

In degraded habitats, nonnative, invasive plant species not only compete against the resident, native plant species but also compete against the other invasive species present. To take the first steps in understanding the dynamics of invasive plant competition, we conducted a greenhouse study in which we grew two species in competition that regularly occur together in northwest Indiana: garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande] and damesrocket (*Hesperis matronalis* L.). These two species are closely related (both are in the Brassicaceae [mustard] family) and share similar life histories (both are biennials). These species were grown both alone and together in a wide range of densities to determine which was the better competitor. Final aboveground biomass, final leaf number, height growth rate, and mortality were all monitored. At the end of the study, it was determined that when garlic mustard was grown in mixture with damesrocket, it had a negative effect on the aboveground biomass, final leaf number, and height growth rate of damesrocket. Garlic mustard, however, had greater mortality when grown in mixture with damesrocket because of intraspecific competition. Thus, based on this study, it is unclear which species would become dominant in areas where they coexist. Other factors, such as availability of light and moisture as well as differences in phenology, are most likely important in the final outcome and need to be researched further in field studies. The ability of damesrocket to survive in competition with garlic mustard indicates that despite the domination by garlic mustard in the northeastern U.S. landscape, damesrocket can compete with this species, at least in the context presented in the greenhouse study. Thus, it is possible that in certain scenarios, damesrocket may prove to be a threat similar to garlic mustard.

species in a given habitat. In addition, the study would provide information about what occurs when two nonnative, invasive species encounter and compete with one another. Garlic mustard is an herbaceous biennial that is a prominent invader of North American forests (Nuzzo 1993). This species has been extensively studied, with more than 100 articles written on its biology and ecology in the past 10 yr (2000 to 2010; Scopus literature search on "*Alliaria petiolata*"; www.scopus.com). Damesrocket is an herbaceous biennial or perennial plant that is another common invader of these same habitats. This species has not been studied as extensively, with fewer than 25 articles written during the same period (Scopus literature search on "*Hesperis matronalis*"). Despite being reported in the United States around the same period as garlic mustard (Mehrhoff 2003), the mechanisms by which damesrocket invades are not well understood, although it has a life history similar to that of garlic mustard (Francis et al. 2009).

To examine this interaction, we conducted a complete, additive-series greenhouse experiment using garlic mustard and damesrocket in competition at varying densities. We wanted to evaluate, without additional environmental influences, competition between these species, which could have implications for the patterns of these two species on the landscape. Our expectation was that garlic mustard would outcompete damesrocket by greater growth and greater survival if the two species were placed together in competition because garlic mustard is a more widespread invader in northwest Indiana than damesrocket (N. B. Pavlovic, personal observation).

Materials and Methods

Species. Garlic mustard is a nonnative, herbaceous, biennial plant introduced from Europe. It was first reported in eastern North America in 1868 (Nuzzo 1993) and has spread throughout the eastern half of the United States and as far west as Washington and Alaska (USDA–NRCS 2011). This species is mostly found in dry-mesic to mesic forested habitats, across a wide range of light availability and successional stages (McCarthy 1997; Meekins and McCarthy 2001; Nuzzo 1999). Previous studies have shown that this species is a strong competitor (Meekins and McCarthy 1999; Stinson et al. 2006, 2007) and is capable of exuding allelopathic chemicals that can negatively affect other forest species (Lankau 2010; Prati and Bossdorf 2004; Wixted and McGraw 2010).

Damesrocket is also a nonnative, herbaceous, biennial plant that can sometimes survive a second winter as a short-lived perennial (Francis et al. 2009). This species was introduced from Europe into the eastern United States as an ornamental species. Like garlic mustard, it was not reported until the mid-1800s, although it is thought to have been introduced much earlier (Adams 2004; Francis et al. 2009; Mehrhoff et al. 2003). This species is present in most of the United States, excluding the most southern states (USDA–NRCS 2011). Damesrocket is found in habitats similar to garlic mustard and is most common in open woods, mesic bottomlands, and roadsides (Francis et al. 2009; Mitchell and Ankeny 2001; Rothfels et al. 2002). Garlic mustard and damesrocket are often found growing together in the same habitats (Francis et al. 2009; Murphy et al. 2007).

Experimental Design and Data Collection. Seeds of garlic mustard and damesrocket were collected at Indiana Dunes National Lakeshore (Porter, IN) in the summer of 2008. Seeds were cold stratified during the winter at 4 C (39.2 F) and brought into a greenhouse to germinate in May 2009. Seedlings were allowed to grow until they had developed their first true leaf before transplanting in June 2009.

We planted the seedlings in 15.25-cm (6 in) diam, round pots in Ferti-lome (a mixture of sphagnum moss, perlite and dolomitic and calcitic limestone; Cheek Garden Products, Austin, TX) general purpose potting soil that was mixed with 16.5 g (0.58 oz) Osmocote Outdoor & Indoor Smart-Release plant food (19–6–12; Scotts-Sierra Horticulture Products Company, Marysville, OH). We used fertilizer to keep the plants from dying prematurely because of the inherent low-nutrient amounts in the potting soil.

Using a complete additive series (Gibson et al. 1999), we planted the two species in the following ratios (number of garlic mustard seedlings : number of damesrocket seedlings): 0 : 1, 0 : 2, 0 : 4, 0 : 8, 0 : 16, 1 : 0, 1 : 1, 1 : 2, 1 : 4, 1 : 8, 1 : 16, 2 : 0, 2 : 1, 2 : 2, 2 : 4, 2 : 8, 2 : 16, 4 : 0, 4 : 1, 4 : 2, 4 : 4, 4 : 8, 4 : 16, 8 : 0, 8 : 1, 8 : 2, 8 : 4, 8 : 8, 8 : 16, 16 : 0, 16 : 1, 16 : 2, 16 : 4, 16 : 8, and 16 : 16. Plants were spaced at equal distances depending on the number of seedlings in the pot. The highest values of these ratios were consistent with reported field densities of garlic mustard that were high enough to cause mortality (Anderson et al. 1996). Each ratio was replicated five times for a total of 175 pots (35 ratios by 5 replications). Pots were watered to keep them evenly moist and rotated in the greenhouse weekly to reduce spatial effects. The plants received approximately 41% of the ambient sunlight in the greenhouse conditions, providing sufficient light for these two species to grow. This experiment was conducted entirely on the first-year rosette stage of these plants to determine how density affects these species during their establishment. The basal rosette leaves of garlic mustard are petiolate and reniform, whereas those of damesrocket are sessile or short petioled and lanceolate.

Because the plants were in the rosette stage, we measured the initial heights from soil level to the top of the tallest leaf of all the plants in mid-June 2009 after letting them establish for a week. We ended the experiment in mid-August 2009. We noted survival and measured final height and final leaf number and then, harvested, dried at 65 C (149 F) to constant mass, and weighed each individual plant to obtain aboveground biomass.

Analysis. We conducted analyses to characterize the effects of initial plant densities of two species on the resulting aboveground biomass, final leaf number, relative growth rate of height (RGRH), and plant survival, and to determine which species, if any, was having more of an effect on the other. For each species, we calculated the mean value per pot for three response variables: biomass, leaf number, and RGRH. Relative growth rate was calculated as in Equation 1:

$$RGRH = \ln\left(height_{final}\right) - \ln\left(height_{initial}\right) / \left(time_{final} - time_{initial}\right) \quad [1]$$

For each response variable (Y), the relation to plant density was described for both garlic mustard and damesrocket (indices A and B, respectively) by nonlinear regression models based on Firbank and Watkinson (1985). For the first species (A), we calculated as shown in Equation 2:

$$Y = y_{\min A} + (w_{mA} - y_{\min A})e^{-b_A(N_A + \alpha N_B)} \quad [2]$$

where $y_{\min}$ is the minimum response, w_m is the mean for an isolated plant, b is the efficiency of resource use by the population (sensu Watkinson 1980, 1984), N is the initial plant density, and α is the competition coefficient for the survival model. If the competition coefficient (α) is < 1, then intraspecific competition is more intense than interspecific competition; if $\alpha = 1$, then both are approximately equal; and if $\alpha > 1$, then interspecific competition is more intense than intraspecific competition. We modified the Firbank and Watkinson (1985) original equations to introduce greater flexibility in the shape of the curves, allowing for a better fit to the empirical data. If the parameter estimate for $y_{\min}$ was not significantly different from zero, it was removed from the equation (Equation 3):

$$Y = w_{mA}e^{-b_A(N_A + \alpha N_B)}. \quad [3]$$

The effect of one plant species on the survival of another was described using the Firbank and Watkinson (1985) nonlinear regression model (Equation 4):

$$N_{FA} = N_A / [1 + m_A(N_A + \gamma N_B)], \quad [4]$$

where N_F is the final plant density, m is the maximum possible density after self-thinning, and γ is the second competition coefficient (in this case for mortality). All data analyses were conducted in R statistical software (R Development Core Team 2009) with nonlinear regression models to estimate the values of the coefficients (function: *nls*). Nonlinear regression results are presented graphically with species response vs. *virtual density*, a variable that represents the combined density of both species accounting for interspecific competition ($N_A + \alpha N_B$; see Leicht et al. 2005, *competitive intensity*). Virtual density was used as a way to visualize the general shape of the nonlinear relations in two dimensions.

Results and Discussion

The two species had similar aboveground biomass when in monoculture (Figure 1A and 1B): approximately 5.73 g plant^{-1} (0.2 oz plant^{-1}) for single plants (virtual density = 1 in Figure 1A and 1B) to 0.48 g plant^{-1} for a density of 16. However, in mixture, when the percentage of garlic mustard plants was greater, biomass of damesrocket was lower, whereas conversely, the biomass of garlic mustard was lower when the percentage of damesrocket was higher (Figure 2A–B). Garlic mustard overall had greater biomass than damesrocket when the plants were mixed at equal densities. For example, at the 16 : 16 ratio, biomass of garlic mustard was 0.34 g plant^{-1}[5.4 g total] vs. 0.13 g plant^{-1} [2.1 g total] for damesrocket. This relationship between the two species is reflected in the competition coefficient that is significantly less than 1 (α = 0.27) for the effect of damesrocket on garlic mustard, and α = 1.92, significantly greater than 1, for the effect of garlic mustard on damesrocket (Table 1). When examining the replacement series diagrams (Figures 2–4), if the species'

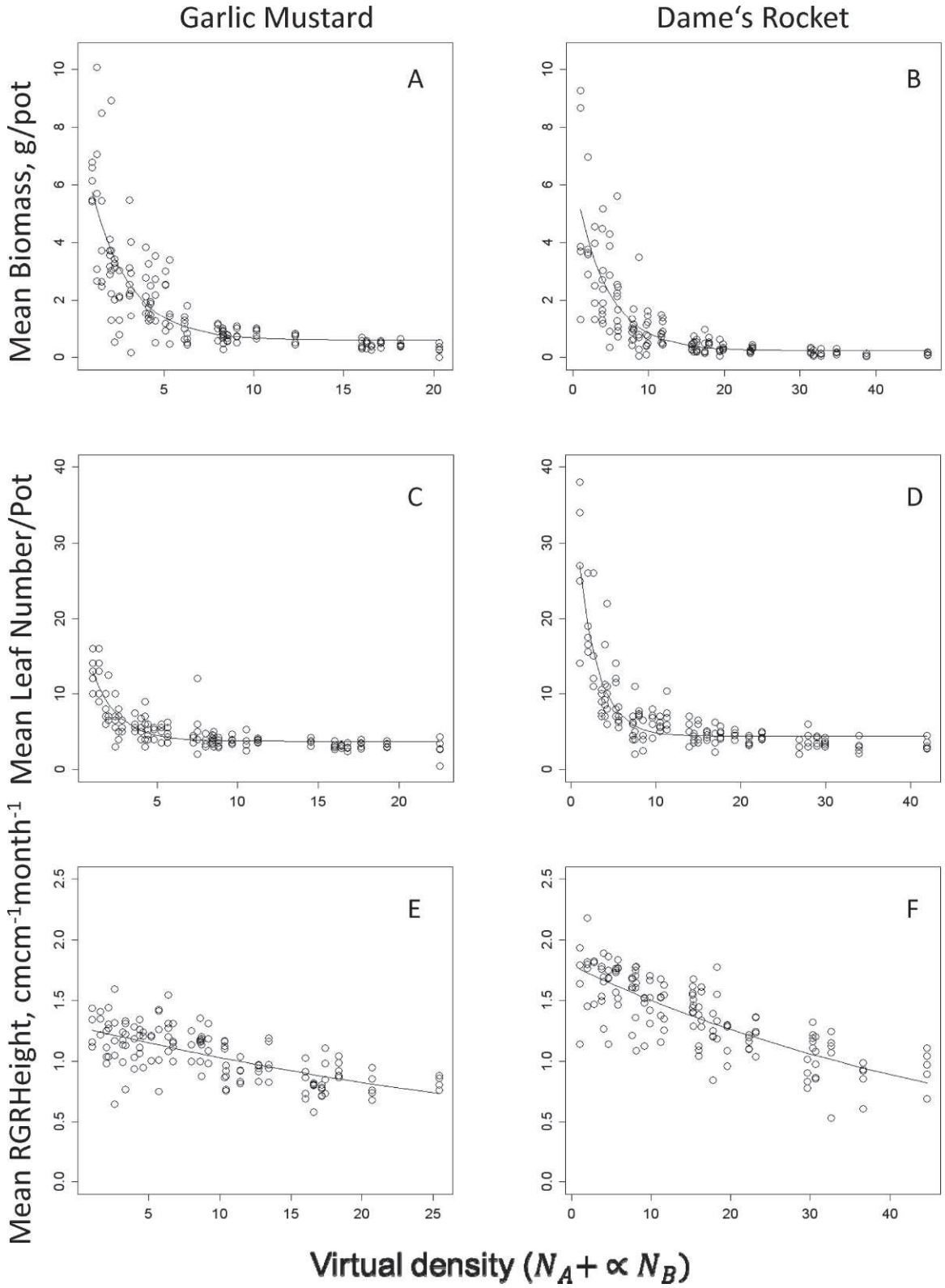

Figure 1. Nonlinear regression models for (A–B) aboveground biomass, (C–D) leaf number, and (E–F) relative growth rate of height (RGRH) for garlic mustard (A, C, E) and for damesrocket (B, D, F). On the x-axis is *virtual density* (competitive intensity), which represents the combined density of both species accounting for interspecific competition (i.e., $N_A + \alpha N_B$). On the y-axis are the mean values for the response variable. General forms of nonlinear regression equations are found in "Materials and Methods," and parameter estimates are in Table 1.

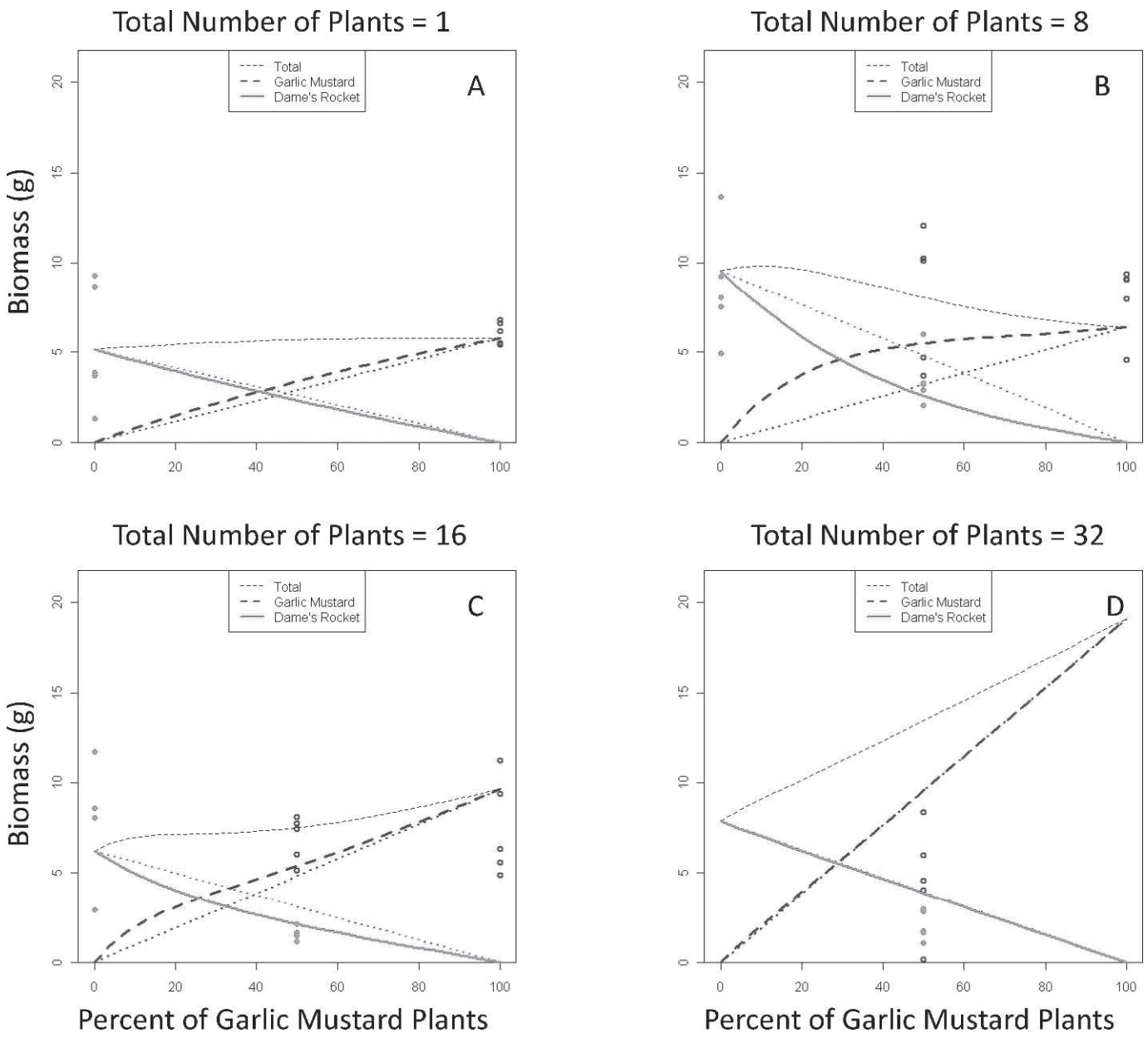

Figure 2. Replacement series diagrams of predicted aboveground biomass following Firbank and Watkinson (1985). On the y-axis are the values for the aboveground biomass of the two plant species. On the x-axis is the percentage of garlic mustard in the mixture. The curvature of dashed and solid lines indicates whether interspecific or intraspecific competition is having more of an influence on plant growth. The thin, straight dotted lines indicates what the relationship would look like when competitors are equal ($\alpha = 1$). Open dots indicate the actual mean values of the aboveground biomass for each of the five replicates for garlic mustard, and solid dots represent those data for damesrocket.

line (garlic mustard or damesrocket) was concave (curving below the straight line), then the response was less than it would be in monoculture; if the curve was convex, then the response was greater than it would be in monoculture.

For total leaf number across all densities, damesrocket on average had more leaves (7.1 ± 1.0) than did garlic mustard (5.2 ± 0.4); however, when grown in mixture with garlic mustard, the number of leaves the damesrocket produced was reduced compared with what it would be if grown in monoculture (Figure 1C–D). As with biomass, the α value for leaf number was greater for the effect of garlic mustard on damesrocket (1.62 vs. 0.41; Table 1); thus, the effect of interspecific competition was greater on damesrocket. For both species, biomass and leaf number (Figure 1A–D) level off after a density of 5 to 10, consistent with the law of final constant yield (Harper 1977; Kira et al. 1953). These plants will grow smaller because of limited resources at higher densities and will

Table 1. Nonlinear regression estimates with standard errors. Responses include aboveground biomass, number of leaves, relative growth rate in height, and survival. Parameters include the minimum response (y_{min}), the mean for an isolated plant (w_m), the efficiency of resource use (b), the maximum possible density after self-thinning (m), and two competition coefficients (α and γ). The competition coefficient (α or γ) listed under each species indicates the effect of the competitor on that species. Thus, a lower competition coefficient indicates that the competitor had a lesser effect. Boldface values indicate where the standard errors do not overlap 1.

		Garlic mustard		Damesrocket	
Response	Parameter	Estimate	SE	Estimate	SE
Biomass	y_{min}	0.60	0.15	0.24	0.12
	w_m	8.83	0.94	6.44	0.58
	b	0.47	0.08	0.23	0.04
	α	**0.27**	0.06	**1.92**	0.40
Leaves	y_{min}	3.73	0.18	4.42	0.30
	w_m	20.93	2.17	39.17	3.08
	b	0.63	0.09	0.43	0.05
	α	**0.41**	0.08	**1.62**	0.25
Height	w_m	1.28	0.03	1.79	0.04
	b	0.02	< 0.01	0.02	< 0.01
	α	**0.59**	0.13	**1.79**	0.28
Survival	m	0.01	< 0.01	< 0.01	< 0.01
	γ	**0.01**	0.33	24.46	45.63

have a higher probability of mortality (Harper 1977). The same pattern was observed for RGRH, with a decrease in the RGRH of damesrocket in the presence of garlic mustard (Figure 3A–D) and greater RGRH for garlic mustard when grown with damesrocket than when grown in monoculture. The relationship between RGRH and density had a linear shape compared with the final biomass or leaf number (Figures 1E and 1F), indicating that, as density increased, RGRH decreased directly.

Neither species showed high rates of mortality (76% was the lowest mean survival rate for garlic mustard at a ratio 16 : 8, with a 90% mean survival rate for damesrocket at several ratios). However, when we examine the replacement series diagrams (Figure 4) in conjunction with the γ values (Table 1), damesrocket γ is not significantly different than 1 for damesrocket; thus, interspecific competition with garlic mustard did not affect the survival of damesrocket more than did intraspecific competition. For garlic mustard, however, γ is significantly less than 1, indicating that intraspecific competition actually had a greater effect than did interspecific competition with damesrocket. Therefore, despite a reduction in biomass, leaf number, and RGRH from interspecific competition, damesrocket mortality damesrocketwas not increased by the presence of garlic mustard.

Other studies on garlic mustard in the field have shown the effects of intraspecific competition in high densities on the survival of garlic mustard. One study by Meekins and McCarthy (2002) reported that garlic mustard plants, followed from rosette to adult stages, exhibited greater mortality in high (80 plants m^{-2} [7.4 plants ft^{-2}]) and medium (40 plants m^{-2}) densities than at low (16 plants m^{-2}) densities. Although their mortality results were similar to those in our greenhouse study, those densities were much lower than were ours (which were around 1,700 plants m^{-2} in the highest treatment). Meekins and McCarthy (2002) found that plants at low densities also exhibited greater biomass and reproductive output than did plants at high densities. In another field study, Anderson et al. (1996) reported that only 7.5% of seedlings survived until maturity at densities similar to our highest-density pots (830 to 1,800 plants m^{-2}) in their second year. Our observed survival (on average, 93% for both species), however, was higher in the greenhouse, compared with the field studies, probably because of the more-protected growing conditions in the greenhouse (i.e., no predators, sufficient light, moisture, etc.). If we had allowed the experiment to run longer, through the overwintering, bolting, and reproductive stages, we might have seen greater levels of mortality from depletion of resources as the plants grew larger. In addition, it is possible that with continued mortality of garlic mustard because of intraspecific competition, the suppressed growth of damesrocket would have recovered at some point in time. Further field studies with both species, however, would be necessary to determine whether that is a valid hypothesis.

The reproductive success of damesrocket has been shown previously to be insensitive to high densities of neighboring plant species. Plants with both high and low numbers of neighbors had the same reproductive output (Mitchell and Ankeny 2001). Thus, although vegetative growth (i.e., biomass) of damesrocket may be negatively affected by

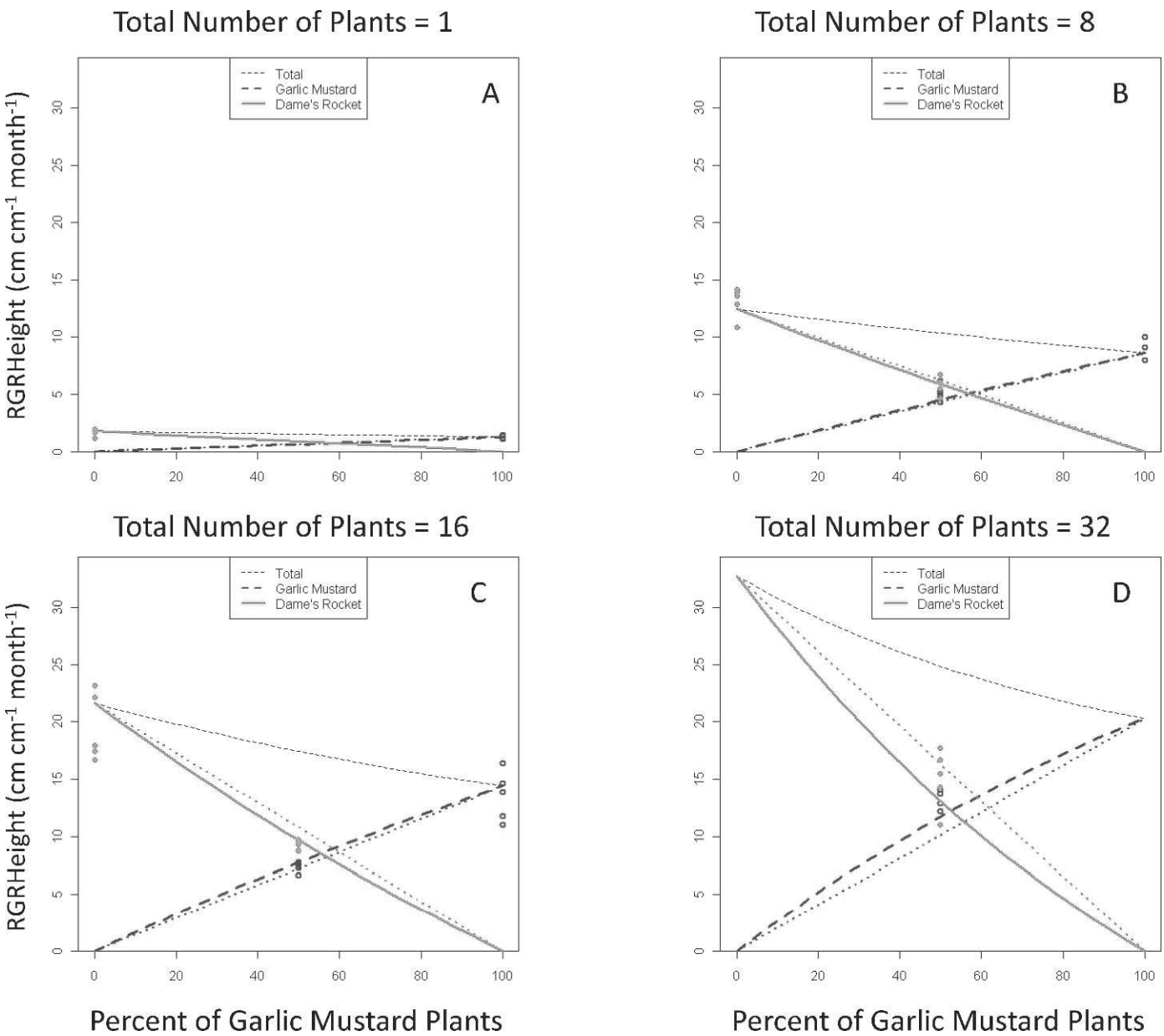

Figure 3. Replacement-series diagrams of relative growth rate of height (RGRH) following Firbank and Watkinson (1985). See Figure 2 for an explanation of the lines.

species like garlic mustard, as in our study, damesrocket seems to be insensitive to competition from neighbors in reproduction and mortality. In contrast, the observed, negative effects of interspecific competition from garlic mustard on vegetative growth measures (i.e., RGRH, biomass, and leaf number) of damesrocket in our study is consistent with Hwang and Lauenroth (2010), who reported aboveground biomass and RGRH of damesrocket were negatively affected by the presence of native neighbors. This species could grow successfully, however, in disturbed situations when pressure from neighbors was reduced (Hwang and Lauenroth 2010).

Interestingly, a greenhouse experiment by Hwang and Lauenroth (2008) revealed that damesrocket was a strong competitor and suppressed the growth of the native species harebell (*Campanula rotundifolia* L.), a long-lived, perennial forb, and mountain muhly [*Muhlenbergia montana* (Nutt.) Hitchc.], a perennial grass, when it grew in higher densities. In addition, a greenhouse study conducted by Meekins and McCarthy (1999) determined that seedlings of some native species were more negatively affected by intraspecific competition than they were by interspecific competition provided by garlic mustard. One of these species was an herbaceous annual, jewelweed (*Impatiens*

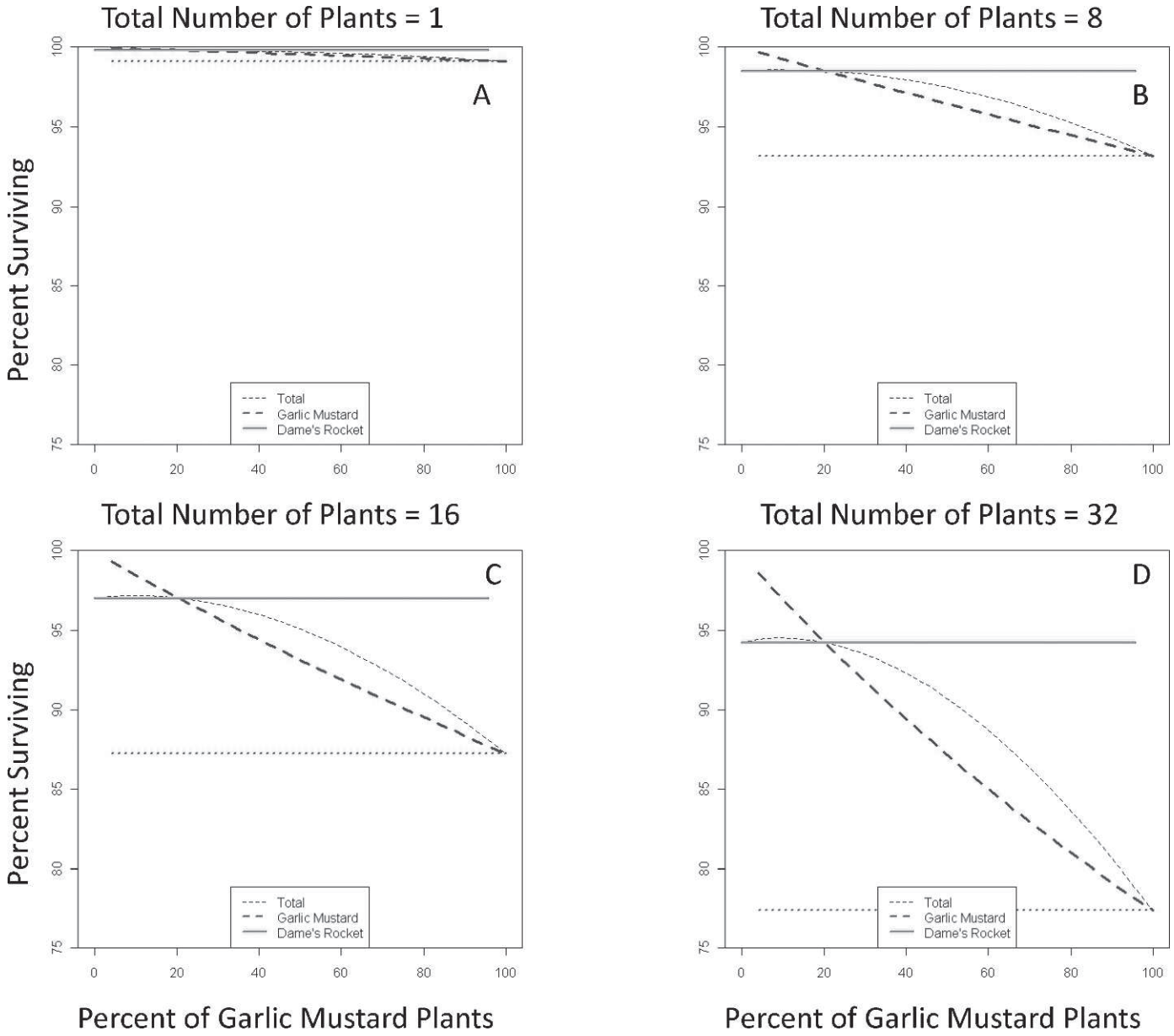

Figure 4. Replacement-series diagrams for the percentage of survival following Firbank and Watkinson (1985). See Figure 2 for explanation of lines; however, in this case, the thin, horizontal, dotted lines indicates survival where $\gamma = 1$. Because, for damesrocket, the γ was not significantly different than 1, it is behind the line showing survival of damesrocket.

capensis Meerb.), and the other was a fast-growing tree, boxelder (*Acer negundo* L.). Chestnut oak (*Quercus prinus* L.), a slower-growing tree, however, showed a negative effect from increasing densities of garlic mustard. Thus, as was the case in our greenhouse study, garlic mustard is not always the clear winner in competition experiments despite its ability to form vast monocultures in the field, to the exclusion of other species.

Other studies of invasive species interactions have shown that the balance of competition can be shifted as resource conditions change (Call and Nilsen 2005). For example, shifting light environments experienced by seedlings of tree-of-heaven [*Ailanthus altissima* (P. Mill.) Swingle] and black locust (*Robinia pseudoacacia* L.) can change which species is more successful, with black locust having an advantage in lower light conditions. In another study by Belote and Weltzin (2006), Mary's-grass [*Microstegium vimineum* (Trin.) A. Camus var. *imberbe* (Nees) Honda] was able to shade out the vine Japanese honeysuckle (*Lonicera japonica* Thunb.). However, the authors point out that if Japanese honeysuckle had supports available for growth, it may have been able to grow above the cover of Mary's-grass and change the competitive interaction (Belote and Weltzin 2006). Differences in greenhouse

conditions and field conditions were shown when Mary's-grass and garlic mustard were equally competitive in a greenhouse setting, but when exposed to actual field conditions, Mary's-grass was able to outcompete garlic mustard (Morrison et al. 2007). Thus, although greenhouse experiments can provide an expectation for competitive outcomes of the two species, field conditions, including changing resources, differing growth habits, or other factors, can shift the balance of competition.

Our research has shown that damesrocket is able to survive in competition with garlic mustard even with suppressed growth. However, the question still arises regarding why garlic mustard is more prominent on the landscape, given that these two species were introduced around the same time and have very similar life histories (Mehrhoff et al. 2003). The answer may be due to the species that shows greater plasticity. Garlic mustard is able to survive and reproduce in a wide range of habitats (Byers and Quinn 1998), whereas that has yet to be determined experimentally for damesrocket. Observations of damesrocket in the field have shown it in habitats ranging from moist, open woodlands, often associated with streams, to along roadsides and railroads (Francis et al. 2009). Garlic mustard is present in those same habitats, although it can also infiltrate low-light, late-successional forests, where damesrocket is not usually found (Nuzzo 1999). Thus, in more-shaded habitats, garlic mustard may have the advantage, whereas in mesic habitats that are more suitable for damesrocket, the balance of competition may be shifted. In the case of our greenhouse experiment, the higher light availability, compared with that of a forest understory habitat, may have benefitted damesrocket.

Besides the possibility of the two species responding differently to the spectrum of resources available, second-year phenology may have differed. Although our main purpose was to examine how these species competed in the establishment phase, the competitive dynamics may change when the second stage of these species' life histories commences with bolting. Both species reach about the same height when bolting occurs (about 1 m [3.3 ft]; Gleason and Cronquist 1991). However, they reach the bolting phase at different times: Garlic mustard bolts and blooms in mid to late April, whereas damesrocket does not bloom until late May in northwestern Indiana. Thus, garlic mustard could shade neighboring damesrocket plants in the early spring. It has also been shown that second-year plants of garlic mustard compete with the first-year rosettes of the same species (Bauer et al. 2010). The population dynamics of the biennial life cycle likely factor into how these species interact on the landscape where they co-occur and may explain the differences in the abundances of these two species that we observe in the field.

In conclusion, we found, in a greenhouse setting, that although interspecific competition with garlic mustard suppressed growth attributes of damesrocket in competition, it did not increase the mortality of damesrocket. Rather, intraspecific competition had a more-negative effect on the survival of garlic mustard at high densities. This study is an important first step in understanding the interactions of these two invasive species on the landscape. Although garlic mustard is generally considered to be the better known and more dominant, invasive species in the northeastern U.S. landscape, it appears that the confamilial damesrocket is able to compete with garlic mustard in a greenhouse experiment. Because these two species overlap in their habitat requirements, these dynamics are relevant to managers of habitats in these areas. To understand the full extent of the interaction of the species, additional field studies need to be conducted. The reality of the disturbed nature of many habitats illustrates the importance of research not only on how invasive species compete with native species but also on how invasive species will interact with each other.

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