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Cladonia uncialis lichen and *Polytrichum communue* moss in NJ Pinelands

Can lichens protect against *Teesdalia nudicaulis* invasions and their after-effects?

INTRODUCTION

Lichen-dominated patches of ground are a common and intriguing feature of the sandy soils of the Eastern United States. But what ecological patterns do they influence that might justify more concerted efforts at preservation of these areas? Previous studies (Thomas, et al. 2007) and our preliminary data suggest lichens may prevent invasion by a non-native mustard, *Teesdalia nudicaulis*, and thereby prevent declines in other native species.

Lichen patches are lovely spots that occur in both shaded protected forests, such as the Manumuskin River Preserve (NJ) and the Hofwyl-Broadfield Plantation Historic Site (GA), and in more open areas, including the former railroad right-of-way at the Crossley Preserve (NJ) and in the Parker Preserve (NJ) where they grow on the dike roads that separate abandoned cranberry bogs. The NJ Conservation Foundation's Parker Preserve in Chatsworth NJ has very few invasive plants because the acidic sandy soils have too little nutrients and water for most of them to survive. However, the dike roads in the Parker Preserve have been invaded recently by *Teesdalia nudicaulis*, a European member of the Brassicaceae family that thrives in dry, sandy soils. Thomas et al. (2007) described a successional pattern from Poland in which moss-lichen mats were broken by the growth of junipers, and in the opened cracks, *T. nudicaulis* began to appear. Our questions are: (1) are areas without robust lichen-moss mats in the US northeast more susceptible to *T. nudicaulis* invasion? (2) Does *T. nudicaulis* reduce diversity of native plant communities? (3) Where *T. nudicaulis* is present, does it reduce the mycorrhizal associations of native plants?

T. nudicaulis prevention may have important implications for other plants in the system. Our preliminary studies on the dike roads in the Parker Preserve have found that some plants (particularly in the Poaceae family), when growing near *T. nudicaulis*, exhibit less mycorrhizal colonization in their roots than plants growing without *T. nudicaulis* nearby (unpublished data). This is not surprising since many Brassicaceae are non-mycorrhizal, and one way the *T. nudicaulis* might have a competitive advantage is by interfering with the mycorrhizal associations; another member of the Brassicaceae, *Alliaria petiolata*, does just that (Roberts and Anderson, 2001). This trend is very important because mycorrhizae serve critical functions in water and nutrient acquisition for most plants, so plants more weakly associated with mycorrhizae may exhibit reduced growth and reproduction.

METHODS

For our study, we chose 3 sites that had considerable populations of T. *nudicaulis*. At the Parker Preserve in Chatsworth NJ, we chose one road where a dike had been breached so the road is no longer in service (Parker – Dike). We also chose sand road at the Parker Preserve that is still in use (Parker – Road). Our third site was in a field at the Caumsett State Historic Park in Huntington, NY (Caumsett – Field), where *T. nudicaulis* had been reported before (Greller, 2005). We also investigated 2 more sites with *T. nudicaulis* reports. On one of these sites on Turkey Point Rd., in Port Norris, NJ, the *T. nudicaulis* had disappeared, and Gerry Moore, who had reported the siting (Moore, 2004), suggested that in the intervening decade, succession had made the conditions impossible for *T. nudicaulis* to continue to grow. This was an important hint to us that perhaps *T. nudicaulis* is not a persistent threat in this habitat .An old field, near 5913 Bennett's Mill Rd, in Vineland, NJ, had remnants of many *T. nudicaulis*, but we did not find this site until June 1st, and *T. nudicaulis*'s peak blooming season in this area is in early May, so we were not able to collect reliable data from that site. This was also a valuable find since *T. nudicaulis* was only present at this site in a formerly plowed field, not in the intact forest habitat, suggesting to us that *T. nudicaulis* does not spread rampantly where the soil has not been disturbed.

At each of the 3 sites, we established 10 plots along a 50-m transect (5m apart). Each plot was 2x1m wide, to cover most of the top surface of the road. We recorded percent cover of each species present in each plot for our study of the effects of *T. nudicaulis* on community composition. We used linear regression to model the effects of *T. nudicaulis* on native plant cover, and used multidimensional scaling to display differences in community composition.

To understand whether *T. nudicaulis* could negatively influence native plants by interfering with mycorrhizal colonization of the roots, we compared the roots of plants in *T. nudicaulis* patches and outside of *T. nudicaulis* patches. We expected roots near *T. nudicaulis* patches to have fewer mycorrhizae than roots far from *T. nudicaulis* patches. We used 3 common arbuscular mycorrhizal plants in the area, (2 grasses and 1 aster), and had 3 replicates of each species. To observe the mycorrhizae, we washed the roots, cleared them in potassium hydroxide, stained them w/ Trypan Blue, washed them with acidified glycerol solution, and prepared slides about 10 cm of root. This process stains fungal structures blue so they're easier to see in the root. We observed 50 views of each root, and recorded the presence of arbuscules, hyphae, or no fungi. We use used these values to represent percent colonization of the root. The arbuscules are the knotty or tree-like structures the fungus forms to have more surface area to exchange sugars and nutrients with the plant cell. The more arbuscules the plant has, the more effectively it can transfer material between it and the fungus.

With these data we were able to determine (1) that lichen-moss presence is not associated with reduced invasion of *T. nudicaulis*; (2) that the presence of *T. nudicaulis* is rarely associated with significant changes in the rest of the plant community and; (3) that *T. nudicaulis* presence does not interfere with mycorrhizal colonization of roots of nearby plants. Taken together, these findings demonstrate that lichens don't stop *T. nudicaulis* from spreading, but that spread of *T. nudicaulis* seems to pose little threat to intact Pinelands ecosystems.

RESULTS and DISCUSSION

Table 1 and Figure 4 display some of our results of the community survey. Figure 4 is a non-metric multidimensional scaling ordination; in this graph, each point is positioned so that the similarity of the plant community at any two points is proportional to the distance between them. The points are color coded by the sites, and one striking feature of this pattern is that the sites are all very different from each other in terms of plant community. The pictures hint at the obvious dissimilarity between the mowed lawn at Caumsett, the used road at the Parker preserve, and overgrown Parker Preserve dike. At the Parker – Dike site, the most common plants were: *Panicum sp.*, *T. nudicaulis* and *Digitaria ischaemum.* At the Parker – Road site, the most common species were: *D. ischaemum, Minuartia Canadensis,* and the moss*, Polytrichum commune.* At the Caumsett – Field site, the most common plants were *T. nudicaulis, Rumex acetosella,* and an immature grass (we will ID those early grasses this season). The two sites at Parker Preserve are more similar to each other than they are to the Caumsett site; the Parker Preserve sites have more moss and lichen cover and more native plant cover than the Caumsett site.

			% cover		
	Scientific Name	Code	Dike	Road	Field
	bare	BARE	27.87	59.68	19.58
Grasses, Sedges and Rushes	Anthoxznthum odoratum	ANOD	0.00	0.00	8.57
	Carex pensylvanicus	CAPE	1.08	0.25	0.00
	Carex sp.	CASP	0.00	0.18	0.00
	Cyperus sp.	CYSP	0.03	0.00	0.00
	Digitaria ischaemum	DIIS	12.05	13.38	0.00
	Grass1	GRA1	0.00	0.00	7.81
	Grass2	GRA2	0.00	0.00	0.42
	Grass3	GRA3	0.00	0.00	19.20
	Juncus dichotomous	JUDI	1.57	0.00	0.00
	Juncus sp.	JUSP	0.00	0.05	0.00
	Panicum sp.	PASP	16.06	0.06	0.00
	Schizacharium scoparium	SCSC	9.04	2.75	4.02
Forbs	Asteraceae1	ASSP	0.00	0.00	2.30
	Daucus carota	DACA	0.69	0.00	0.00

Table 1 (left). Average % cover of species found at 3 sites surveyed. These data are displayed graphically in Figure 1, with the species codes stand for the species as listed.

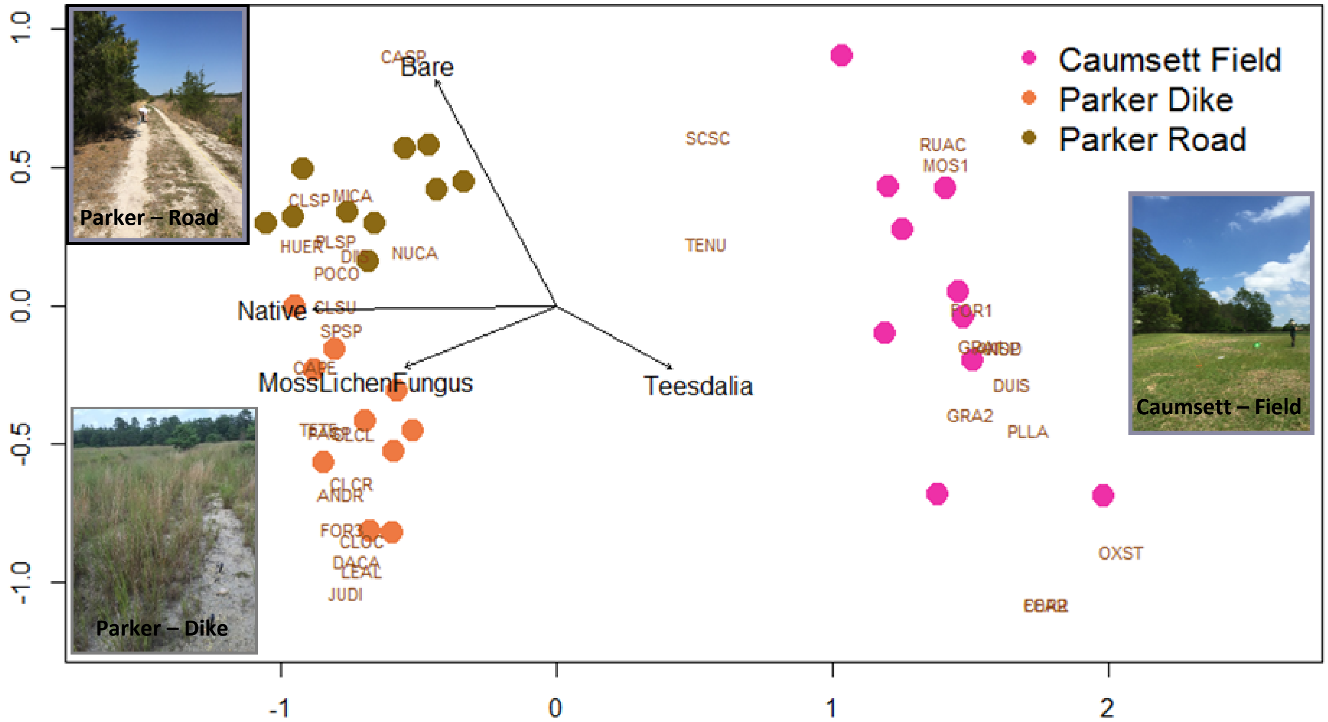
Figure 1. *Teesdalia nudicaulis* rosette

	Forb2	FOR2	0.00	0.00	0.16
	Forb3	FOR3	2.13	0.00	0.00
	Forb4	FOR4	0.06	0.00	0.00
	Forb5	FOR5	0.02	0.00	0.00
	Nutallanthus canadensis	NUCA	0.18	0.22	0.01
	Oxalis stricta	OXST	0.00	0.00	0.11
	Plantago lanceolata	PLLA	0.00	0.00	3.17
	Rumex acetocella	RUAC	0.00	0.00	9.99
	Spergularia rubra	SPRU	0.02	0.00	0.00
	Spurgula morisonii	SPSP	0.19	0.06	0.00
	Stellaria media	STME	0.00	0.00	0.62
	Teesdalia nudicaulis	TENU	13.60	1.63	19.98
	Viola sp.	VISP	0.00	0.00	0.83
	Waldsteinia fragaroides	WAFR	0.00	0.00	0.38
Woody	Hudsonia ericoides	HUER	2.00	2.49	0.00
	Quercus sp.	QUSP	0.00	0.00	0.01
	Rubus hispidus	RUHI	0.00	0.05	0.00
Lichens, Mosses, Fungi	Cladonia atlantica	CLAT	0.03	0.00	0.00
	Cladonia chlorophaea	CLCL	0.37	0.16	0.00
	Cladonia cristatella	CLCR	1.03	0.03	0.00
	Cladonia occrochlora	CLOC	0.32	0.00	0.00
	Cladonia sp.	CLSP	0.00	0.09	0.00
	Cladonia subtenuis	CLSU	0.08	0.04	0.00
	Placynthiella sp.	PLSP	1.36	1.58	0.00
	Leucobryum album	LEAL	0.19	0.00	0.00
	Minuartia canadensis	MICA	3.53	13.39	0.00
	Moss1	MOS1	0.00	0.00	2.84
	Polytrichum commune	POCO	6.19	3.89	0.00
	Telephora terrestris	TETE	0.31	0.02	0.00

Figure 2. *Teesdalia nudicaulis* flowers.

Figure 3. *Polytrichum commune* (moss) w/ *Cladonia chlorophaea* (cup lichen) and *Cladonia cristatella* (British solider)

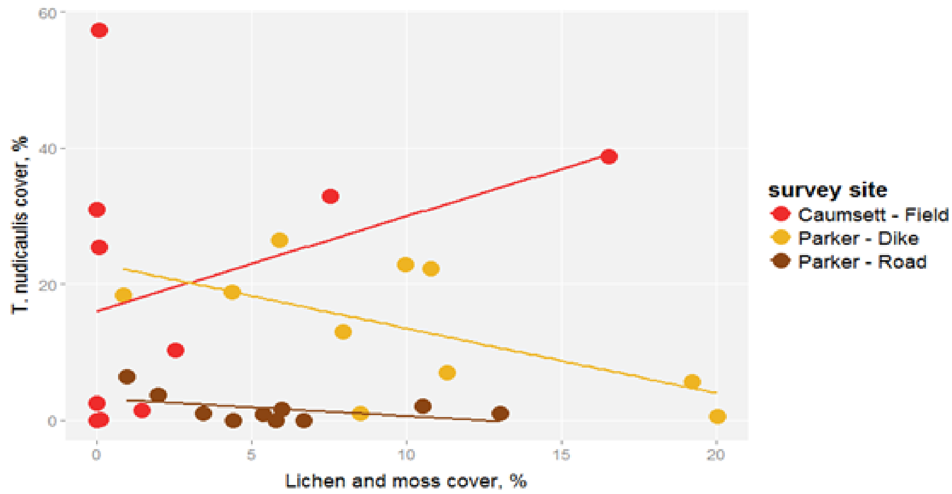
Fig 4: Ordination of communities where *T. nudicaulis* occurs. Each point represents a quadrat in which we measured percent cover of each species, and sites that are closer together on the graph have more similar plant communities. Sites are distinguished by color (pink = Caumsett field; orange = Parker dike; brown = Parker road) with pictures of each site near cluster representing that site. The ordination also includes codes for species present at each site. The arrows representing increasing % cover values for the groups shown.



In order to determine whether lichens prevented *T. nudicaulis* establishment, we compared *T. nudicaulis* cover with lichen cover. If sites with high lichen cover had low *T. nudicaulis* cover, and sites with high cover of *T. nudicaulis* areas had low lichen cover, the organisms might be negatively influencing each other. But since we found that *T. nudicaulis* cover had no trend associated with lichen cover, (Figure 5) we do not think that lichens are preventing *T. nudicaulis* expansion.

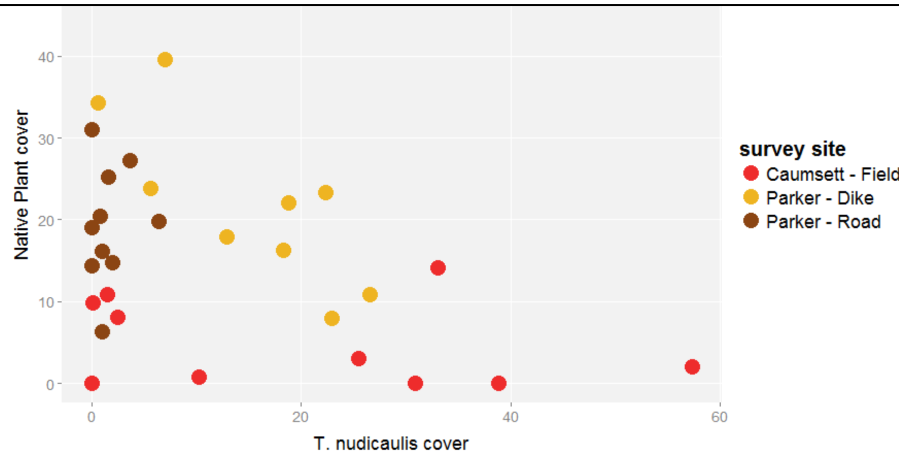
However, since we chose these sites by the presence of *T. nudicaulis* only, we excluded areas with high lichen cover where no *T. nudicaulis* was present. It appears that the two groups, lichens/mosses, occupy areas with different disturbance intensity. The lichens are present at high levels where there is low disturbance (like banks on the sides of roads), and *T. nudicaulis* thrives in areas of intermediate disturbance, like the mowed areas at Caumsett and the abandoned Dike at Parker preserve. Mosses appear to be the highest disturbance tolerators in this system, displaying some cover even in the used road tracks where *T. nudicaulis* and lichens were sparse. In order to directly test whether lichens exclude *T. nudicaulis*, we should do a greenhouse esperiment, trying to grow *T. nudicaulis* in pots with and without lichen cover. But the results presented here demonstrate that lichens habitat and *T. nudicaulis* habitat have little natural overlap, so that greenhouse experiment would not have analogs taking place often in field.

Figure 5. % cover of *T. nudicaulis* is compared with the cover of mosses and lichens; this comparison suggests that there is no significant relationship between *T. nudicaulis* cover and lichen and moss cover.



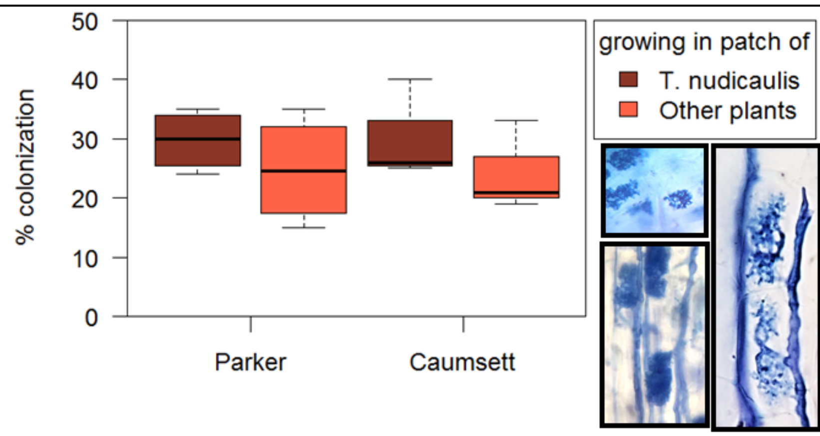
Of the 3 sites that we tested, only the Parker – Dike had parts with high native plant cover and high *T. nudicaulis* cover. At that site, there is a significant negative relationship between native plant cover and *T. nudicaulis* cover (fig. 6). On the Caumsett – Field site, there was very little native plant cover, as is common for mowed sites, so changes in *T. nudicaulis* cover did not influence the small cover of native plants. On the Parker – Road site, there was very little *T. nudicaulis* cover, so native plant richness did not change with the small increases in *T. nudicaulis* cover we found at that site.

Figure 6. *T. nudicaulis* is associated w/ lower native plant cover at the Parker – Dike site.



For all plants pooled, there was no difference in mycorrhizal colonization whether or not there was *T. nudicaulis* present (Figure 7). These findings suggest that if the presence of *T. nudicaulis* does decrease native plant cover, it is not through the mechanism of interfering with the mycorrhizal associations of native plants.

Figure 7. *T. nudicaulis* has no influence on mycorrhizae in roots, since there is no significant difference in the arbuscule formation when plants are growing in or out of a patch of T. nudicaulis. The blue pictures are microscope views of arbuscules in the stained roots.



CONCLUSIONS

From the findings on these sites, we have found that generally, T*. nudicaulis* is exploiting open habitats (judged by the high % bare ground at all sites), and does not pose a threat to intact habitat in the NJ pinelands.

Our first finding is that lichen and moss mats on these sites are not negatively correlated w/ *T. nudicaulis* populations, though we did not investigate sites with very high lichen cover for this study. One of us (Natalie) has surveyed many lichen mats across the NJ Pinelands, and has never *found T. nudicaulis* in them, reinforcing the idea that *T. nudicaulis* only colonizes exposed habitat. *T. nudicaulis* is probably growing in places that are too disturbed (former roads, mowed areas, plowed fields) for lichens to thrive, which may explain the low lichen cover we found on our sites.

Our third finding is that the presence of *T. nudicaulis* does not stop normal mycorrhizal colonization of plants, which is great because it means that the plant is less likely to negatively impact the plant community. This should not be too surprising, because the family Brassicaceae is very large, and few members have documented negative impacts.

Our second finding is more ambiguous; high *T. nudicaulis* cover may be associated with low native plant cover. Is this because it is just growing on disturbed sites, conditions in which the native plants grow thinly, or because *T. nudicaulis,* reduces growth of native plants some other way besides mycorrhizal interference? Since *T. nudicaulis* was associated with decreased native plant cover in one of 3 sites (Parker – Dike) , we are interested in exploring two more *T. nudicaulis* covered sites next summer so our community dataset is more robust and has more explanatory power. To really understand whether *T. nudicaulis* causes reduced native plant growth, we would have to do a greenhouse study of germination and growth of native plants in pots with and without *T. nudicaulis* seeds and seedlings present, which could be a worthwhile follow-up study if our field work next summer demonstrates convincingly that *T. nudicaulis* cover is associated with decreased native plant cover.

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References:

Greller, A. M., Lotowycz, G. E., Moore, G., Lamont, E., Binger, H., Conolly, B. and Hoar, J. (2005). Vascular Flora of Caumsett State Historic Park , Lloyd Neck , Long Island , New York , with Notes on the Vegetation. *Journal of the Torrey Botanical Society*, 132(1), 149–168.

Moore, G. (2004). Field Trip Reports. *Journal of the Torrey Botanical Society*, 131(4), 403–419.

Roberts, K. J., & Anderson, R. C. (2001). Effect of Garlic Mustard [Alliaria petiolata (Beib. Cavara & Grande)] Extracts on Plants and Arbuscular Mycorrhizal (AM) Fungi. *The American Midland Naturalist*, 146(1), 146–152.

Thomas, P. a., El-Barghathi, M., & Polwart, a. (2007). Biological Flora of the British Isles: Juniperus communis L. *Journal of Ecology*, 95(6), 1404–1440.