Nearest Neighbor Analysis of the Effects of the Rust Fungus *Uromyces scutellatus* on *Euphorbia* spp. in Europe

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Biological control of exotic invasive plants is based on the Enemy Release Hypothesis. In practice, this entails searches within the native range of the invasive for insects or plant pathogens that can damage or cause disease on the "target" plant species. It is increasingly understood in the field of invasive weed biocontrol that a new departure away from a strict reliance on narrow-host range agents (chiefly insects) is needed for control strategies. The prevailing method has come to be known as the "lottery approach" and such an approach is seen as increasing the risk to nontarget species and increasing the hazards of other indirect effects. A consensus is emerging that recommends a focus on fewer, more effective agents. Thus, following tests that show a narrow host range, the magnitude of potential impacts should be assessed prior to field release. In addition to such "prerelease studies" there should be an assessment of impact in the native range. This would be most valuable even prior to prerelease studies. This approach should apply to candidate species that are plant pathogens as well as insects and the method would be useful where stands are irregular in size and occur in small patches. I assessed the effects of the autoecious, microcyclic rust fungus *Uromyces scutellatus* on stand density of *Euphorbia esula/virgata* by comparing population densities among stands with and without symptoms using nearest neighbor spatial analysis. At three of four sites assessed in Hungary and Austria in 2004, symptomless *E. esula virgata* plants were significantly more closely spaced as determined with ANOVA. The stand densities of rusted stands estimated from the distance data were 48-73% of those of neighboring symptomless stands. Thus, it appears that the candidate rust *U. scutellatus* reduces stand density where it occurs at sites in Europe compared to adjacent or nearby stands without rust disease. Additional data will be collected in 2005 at same sites.

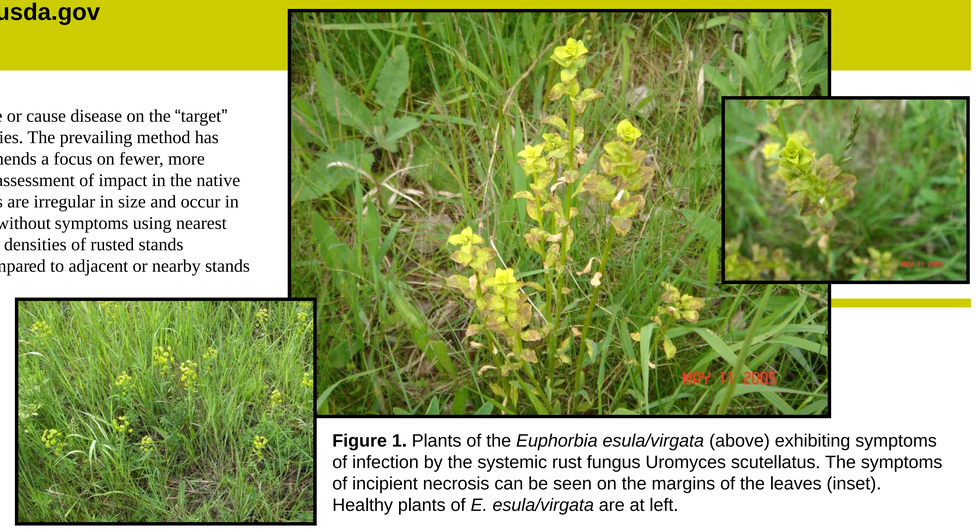


Figure 1. Plants of the *Euphorbia esula/virgata* (above) exhibiting symptoms of infection by the systemic rust fungus Uromyces scutellatus. The symptoms of incipient necrosis can be seen on the margins of the leaves (inset). Healthy plants of *E. esula/virgata* are at left.

Methods

For the biological control of the invasive (in North America) herbaceous perennial *Euphorbia esula/virgata*, the potential of candidate biological agents to cause reductions in population density of this species could best be previewed by assessment of their effects in the native environment. *E. esula/virgata* occurs in irregular stands necessitating the use of "plotless" methods for analyzing effects. Sites in Hungary and Austria with populations infected by the autoecious, microcyclic rust *Uromyces scutellatus* were measured for the distance from 10-15 randomly chosen plants with rust disease symptoms (*Figure 1*) to the nearest 2-3 plants to each. Nearby sites where populations were free of rust disease symptoms were assessed similarly. *E. esula/virgata* plants occur as single individuals (Caesar, unpublished), and are not contagiously distributed. Thus, nearest neighbor methodology is appropriate. The distances were analyzed using one way ANOVA with JMP version 5.1. Density estimates were obtained from nearest neighbor results using the program Density from Distance.

Results

The densities of *E. esula/virgata* plants associated with rust infections at three of four sites were less than half the densities associated with symptomless plants (see table at right). The lower densities were significant as determined with ANOVA and various analyses of mean differences (*Figure* 5.) At a fourth site, while the rusted plants were associated with greater density in 200 4, the density was found to be dramatically less in 2005 (Figures 2, 3). Similar situations have been observed by the author previously.

Comparative stand densities of *E. esula virgata* at four locations in Hungary and Austria where rust disease was present and a nearby stand was disease free.

Symptoms	*Euphorbia* density estimate from nearest neighbor analysis[a]
Gyongyos, Hungary	
Rust	0.9058 / m^2
None	0.6653 / m^2
Mezokovezd/Rt 3, Hungary	
Rust	0.113/ m^2
None	0.678 / m^2
Mayerling, Austria	
Rusted	0.238/ m^2
None	0.492/ m^2
Guntersdorf, Austria	
Rust	0.585/ m^2
None	1.214/ m^2

[a]Plants of *Euphorbia esula/virgata* estimated using the program Density from Distance.

Figure 2. Site near Gyongyos Hungary photographed in 2004 (May 9) showing *E. esula/virgata* plants (indicated with arrows) that Are systemically infected with the rust *Uromyces scutellatus.*

Figure 4. Portion of site shown in Figure 2 beyond the top of that picture showing dense occurrence of chlorotic and spindly stems (arrow) of *E. esula/virgata,* which are systemically infected with the rust *Uromyces scutellatus.*

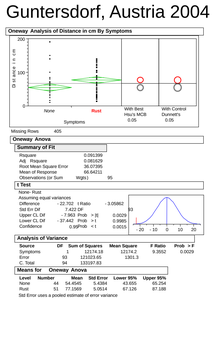
Figure 3. The same site photographed in 2005. Plants of *E. esula/virgata* were nearly absent. Such a rapid decline in density following a heavy rust epidemic has been observed Previously.

Conclusions

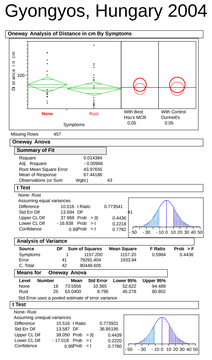
- Analysis of the effects of candidate biological control agents can and should be conducted in the native range of the targeted invasive species. Such "prerelease" or even pre-exploration studies can serve to reduce the hazards of non-target effects due to the "lottery approach" to biological control by providing a preview of what effects the organism causes or can be correlated with.
- The occurrence of *E. esula/virgata* in widely scattered, sparse stands in irregular and/or discontinuous patches lends assessments to spatial methods such as nearest neighbor analysis. This is, to the present authors knowledge, the first known application of spatial analysis to assessing both the density of a herbaceous species and the potential impact of a candidate biological control agent
- Disease within stands of *E. esula/virgata* caused by the autoecious (single host) microcyclic (one spore stage, without secondary spread) rust *Uromyces scutellatus* is associated with at least half the stand densities of adjacent or nearby stands that are rust disease-free (symptomless). Heavy levels of infection incidence one year can result in drastic reductions in population density of *E. esula / virgata* in subsequent years. *Uromyces scutellatus* thus exhibits a high level of impact in its native range and if narrow in host range would be an excellent biological control agent for the invasive perennial leafy spurge.

Figure 5. Results of one-way ANOVA and t-tests of mean stand density differences with graphical plots of results of means comparisons.

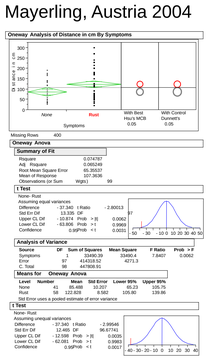
Guntersdorf, Austria 2004



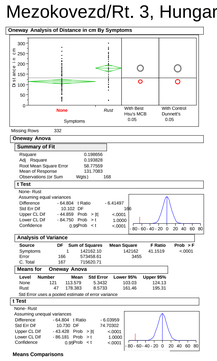
Gyongyos, Hungary 2004



Mayerling, Austria 2004



Mezokovezd/Rt. 3, Hungary 2004



References

Defago, G. Kern, H. and Sedlar, L. 1985. Potential control of weedy spurges by the rust *Uromyces scutellatus. Weed Science* 33, 857-860.

Nakamura, K. Togashi, K. and Takahashi, F. 1997. Distance effect of co-occurring tree species on pine wilt disease incidence in *Pinus densiflora* seedlings inoculated with *Bursaphalenchus xylophilus Ecological Research* 12, 265-275.

Reinhart K O. and Callaway R. M. 2004. Soil biota facilitate exotic *Acer* invasions in Europe and North America. *Ecological Applications* 14(6),1737–1745.

Related studies by the same author:

Caesar, A.J., 1995. Isolation of soilborne fungi associated with damage to roots by insect biological control agents of *Centaurea* species and *Euphorbia esula* from Europe and the U.S. WSSA Abstracts 35, 60.

Caesar, A.J., 2000. Insect–pathogen synergisms are the foundation of weed biocontrol. In: Spencer, N. R. (Ed.), Proceedings of the X International Symposium on Biological Control of Weeds. Montana State University, Bozeman, Montana, USA, pp. 793–798.

Caesar, A.J., Campobasso, G., Terragitti, G., 1998. Identification, pathogenicity and comparative virulence of *Fusarium* spp. associated with diseased *Euphorbia* spp. in Europe. Biocontrol Sci.Technol. 8, 313–319.

Caesar, A.J., Campobasso, G., Terragitti, G., 1999. Effects of European and US strains of *Fusarium* spp. pathogenic to leafy spurge on biomass of native grasses and pathogenicity to Cultivated species in the greenhouse. Biol. Control 14, 130–136.

Caesar, A.J., Campobasso, G., Terragitti, G., 2002. Identification, pathogenicity and comparative virulence of *Fusarium* spp. associated with insect-damaged, diseased *Centaurea* spp. in Europe. BioControl 47, 217–229.

Caesar, A.J., Smidansky, E., Campobasso, G., 1996a. Comparative ecology of *Fusarium* spp. from *Euphorbia* spp. in the US and Europe. Phytopathology 86, S63 (Abstract).

Caesar, A. J. 2003a Synergistic interaction of soilborne plant pathogens and tabstabstroot-attacking insects in classical biological control of an exotic rangeland weed. Biol. Control 28, 144-153.

Caesar, A. J., 2004. Insect-plant pathogen synergisms for the biological control of rangelant weeds In: Cullen, J. M., Briese, D. T., Kriticos, D. J., Lonsdale, W. M., Morin, L. and Scott, J. K. (Eds.), Proceedings of the XI International Symposium on Biological Control of Weeds, CSIRO Entomology, Canberra, Australia, pp. 493-495.

Caesar, A. J. 2005. Melding ecology, classical weed biocontrol, and plant microbial ecology can inform improved practices in controlling invasive plant species. Biol. Control 34, in press