Weed Biocontrol as an Invasion Process

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Biological control programs develop by stages that correspond roughly to those in an invasion process. To investigate three stages (establishment, growth, and spread of control organisms), we combined field observations, experiments, and mathematical models in a case study of two leaf beetle species that were introduced to control purple loosestrife.

Establishment is hampered by factors that put small populations at risk of extinction, including demographic stochasticity, environmental variability, and Allee effects. Simulation models indicated how we might maximize the probability of successful initial establishment given the inherent tradeoff between the size of each release and the number of releases. In most cases, we are unlikely to have estimates of the required parameters for determining the optimum release size (fecundity, survivorship, variance in year to year survivorship, and Allee effect intensity). We develop simple rules of thumb that can tell us whether releases should be “on the large side” or “on the small side” — a significant improvement over the current use of arbitrary release sizes.

Spread of an established organism into a new area is hindered by factors that affect population growth and movement. A scattered colony model incorporating population growth, random diffusion, and long-distance dispersal facilitated our investigation of the interplay between these factors. From knowledge of the mechanism and rate of spread, we refine the optimization of the number, size, and spatial location of secondary releases made to redistribute control organisms.

These approaches illustrate changes in the use of mathematical theory to guide biological control decisions. To take full advantage of these developments, practitioners should replace subjective assessments of the outcomes of releases with quantitative estimates of model parameters. This will create a more reliable basis for comparison, interpolation, and extrapolation.

How to Favour a Rust Fungus to Reduce a Weed Population

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The system management approach of biological weed control was proposed as an alternative to the well established classical and microbial herbicide approaches. Its aim is to shift the competitive weed-crop relationship in favour of the latter, mainly by stimulat-
ing the build-up of a disease epidemic or insect outbreak on the target weed population. Main emphasis is given to native or naturalized antagonists. Plant disease epidemics relate both to the spatial and temporal spread of the disease, and to the increase in disease severity on a given host plant. Constraints on disease development involve: (i) lack of adequate inoculum at the right time, (ii) host resistance, and (iii) environmental deficiencies. We study these factors using the weed-pathogen system Senecio vulgaris-Puccinia lagenophorae as a research model. The plant is considered a weed in most parts of the world, and the rust fungus is the potential control organism, originating most probably from Australia and now naturalized in most parts of Europe. Relating disease epidemics to crop-weed interactions at the population level became the major issue of this research project. The weed-pathogen system is first described. Studies on the population biology of both the plant and the antagonist, on the impact of the rust fungus on plant individuals and populations, and on resistance mechanisms will then be presented. Emphasis will be given to experiments to determine the genetic differentiation and plasticity of S. vulgaris populations, and their relevance for biological control.

Supercooling Capacity of Urophora affinis and U. quadrifasciata (Diptera: Tephritidae): Effect of Site, Time of Season, Differences among Plants, and Gall Density

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The supercooling capacities of Urophora affinis and U. quadrifasciata larvae were evaluated during the 1991-1992 fall/winter time period with respect to differences among sites, fall/winter time periods, differences among plants, and gall densities. Significant differences in supercooling points for U. affinis were found among sites in three out of four fall/winter time periods examined and two of four time periods examined for U. quadrifasciata. Significant differences in supercooling points for U. affinis were found among the four fall/winter time periods in all six sites examined and two of four sites examined for U. quadrifasciata. Only two of six sites and three out of 24 cases examined showed significant differences in supercooling points for U. affinis among plants. Significant differences in supercooling points for U. quadrifasciata among plants were found at two of four sites and four of nine cases examined. No relationship was found between larval supercooling points and gall densities of the respective fly species. Significantly lower supercooling points were found for U. affinis compared to U. quadrifasciata in three out of four fall/winter time periods examined.