Response to Invasion: Managing Spotted Knapweed

by
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Part I – Introduction to Spotted Knapweed

The United States Forest Service (USFS) has found a large spotted knapweed infestation in National Forest in Montana. In Montana, spotted knapweed is listed as a priority 2B noxious weed (Montana Department of Agriculture, 2010). Management goals for priority 2B noxious weeds must include eradication or containment of the weed (Montana Department of Agriculture, 2010). The following strategies have been proposed for controlling this invasive plant: (1) release of biological control insects, (2) seeding with native seed, (3) mowing/grazing, (4) herbicides, or (5) mechanical removal (control methods are summarized in Sheley et al., 1998). Land managers want to design an adaptive management plan so that they can start treating the knapweed monoculture while monitoring the success of their treatment strategies. Based on the results of their treatments, they may revise their plan.

An invasive plant can be a problem when it competes with plants that provide ecosystem services, such as erosion control or pollen-sources for bees. Plants become invasive when the net feedback is positive (Seastedt and Pysek, 2011). Spotted knapweed (*Centaurea stoebe,* hereafter knapweed) is an invasive plant that is both an ecological and economic concern in rangeland management. North American insect herbivores do not grow as well on knapweed as they do on native plants (Schaffner et al., 2011). Thus a contributing factor to knapweed's success could be that it has fewer herbivores than native plants. Untreated knapweed patches can form dense monocultures, reducing species *richness* and *diversity* of native plant communities (Fraser & Carlyle, 2011). Species richness is the number of species found in an area while diversity is the relative contribution of each species to the community. Moreover, knapweed has low nutritional value for domestic cattle and wildlife (Watson & Renney, 1974; Hirsch & Leitch, 1996). When invasive plants replace plants that are palatable to livestock, ranchers cannot raise as many cattle on infested rangeland. Less available forage for livestock and wildlife means less productive rangeland grazing (Watson & Renney, 1974).

Questions

Work in your groups to answer the following questions.

1. Who are stakeholders in this management problem?
2. Create a table to summarize 2–3 possible costs and benefits of each of the proposed management strategies:
   - Biological control insects
   - Seeding with native plants
   - Mowing/grazing
   - Herbicide
   - Mechanical removal
3. Design an adaptive management plan (experimental design) for the USFS to start treating the infestation while determining the best management strategy:
   a. What variables would you manipulate (independent variable)?
   b. What would you measure (dependent variable)?
   c. How long will your study/monitoring last? 1 season? 1 year? 1 decade?

Part II – Show Me the Evidence

Adaptive management requires revising management plans based on evidence. A research assistant has collected additional research on knapweed management strategies and has compiled the results summarized in the figures below. The figures are taken from studies of the effect of plant competition and biological controls on spotted knapweed. Also included are results from studies on the effect of herbicides on plant communities. Use the results presented in the following figures to revise your plan.

Questions

In your group, discuss the independent and dependent variables and the trends displayed in each figure and answer the questions with each figure. After you have examined all the figures, answer the summary questions.

Knapweed and Plant Competition

1. How does plant competition impact knapweed growth?

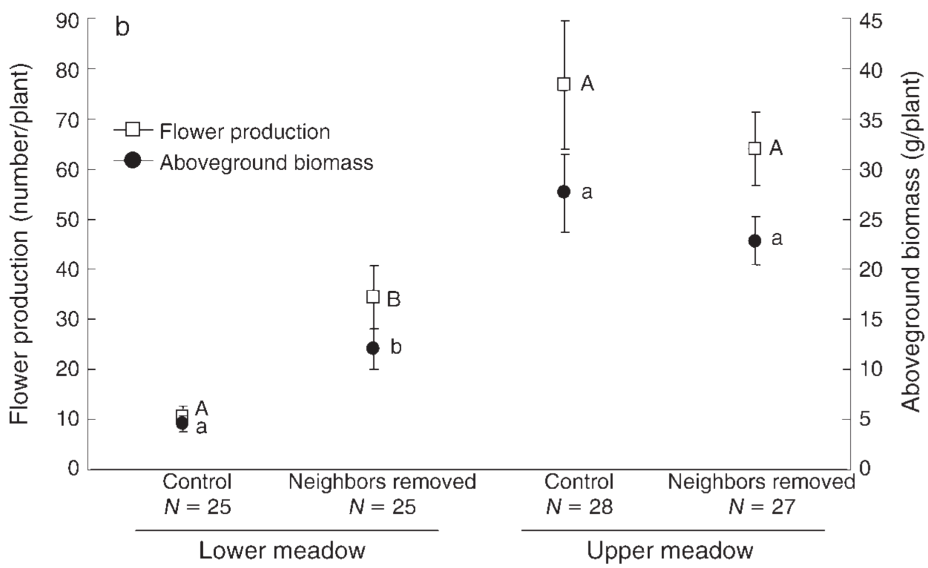

Figure 1. Effect of plant competition (control) on spotted knapweed flower production (squares, uppercase) and overall biomass production (circles, lowercase) at two locations. Different letters indicate statistically significantly different results (comparisons are between plant competition (control) and plant removal at each site). (Excerpt of Figure 2 from Knochel & Seastedt, 2010, used with permission from the Ecological Society of America.)

Biological Control Insects: Knapweed Specialist Herbivore Weevils

2. How do the introduced biological controls—root weevil *C. achates* and seed head weevil *L. minutus* (pictured above)—affect spotted knapweed?

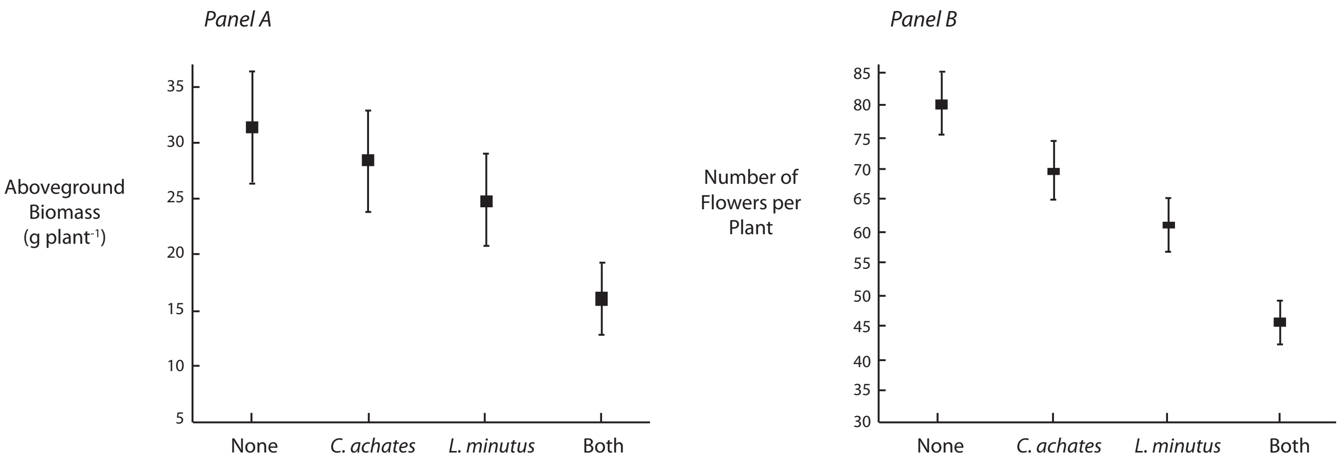

Figure 2. Effect of knapweed specialist root weevil *Cyphocleonus achates* and seed head weevil *Larinus minutus* on plant biomass production (Panel A) and number of flowers produced per spotted knapweed plant (Panel B). Non-overlapping error bars indicate statistically different values. (Redrawn after Figure 3 from Knochel et al., 2010.)

3. What is the timeframe for treatment with biological controls? *Note:* 2B noxious weeds must be eradicated or contained in Montana. How does this influence your determination of treatment timeframe?

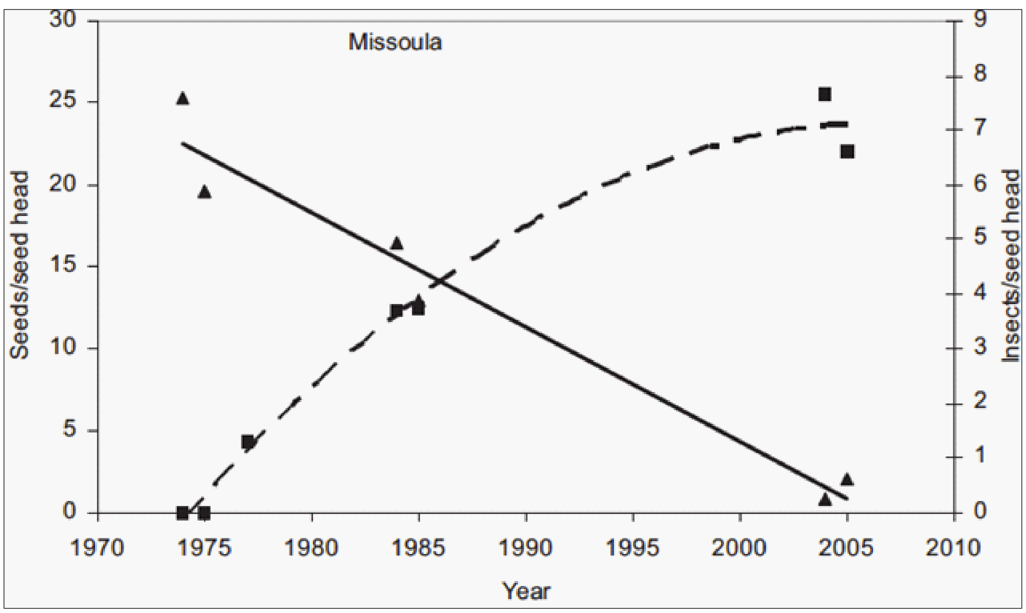

Figure 3. Larinus minutus seed head weevil density (dashed line/ squares) and seeds per seed head (solid line/ triangles) over time. Absence of points equal years without recorded values. These results are from a field site in Missoula, MT where biological controls were released in 1974. Regression values for seeds is $R^2 = 0.96$, $p < 0.001$ and for insects is $R^2 = 0.99$, $p < 0.0001$. (Excerpt of Figure 2 from Story et al., 2008. Used with permission from the Entomological Society of America.)

Herbicides

4. How does herbicide application impact species richness (the number of plant species present) if: herbicide is only applied once (striped bars)? What about if herbicide is applied twice (shaded bars)? (*Hint:* Compare untreated bar (white/starred) to striped and shaded bars.)

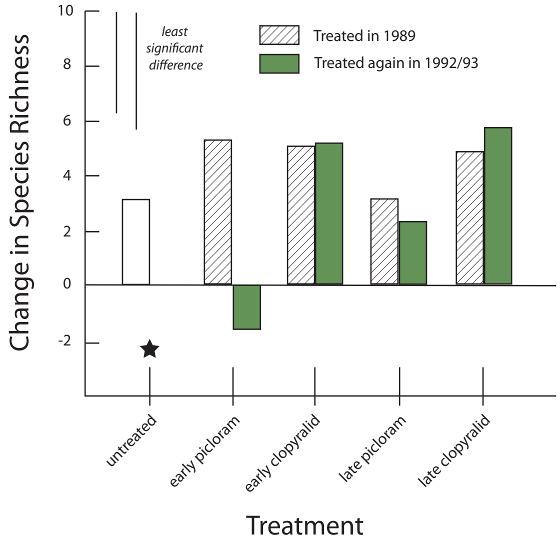

Figure 4. Difference in species richness from the initial species richness prior to treatment to the final species richness (final – initial). A negative value indicates a decrease in species richness and a positive value indicates a increase in species richness. Also, the two lines in the upper left corner indicate the least significant difference. The left one is to compare the control with the treatments and the right one is to compare the two treatments to each other. (Redrawn after Figure 4 from Rice et al., 1997.)

5. How does herbicide application impact relative abundance of native vs. exotic forbs in the community (Yr16)? What perspective does a long-term study add (4 vs. 16)?

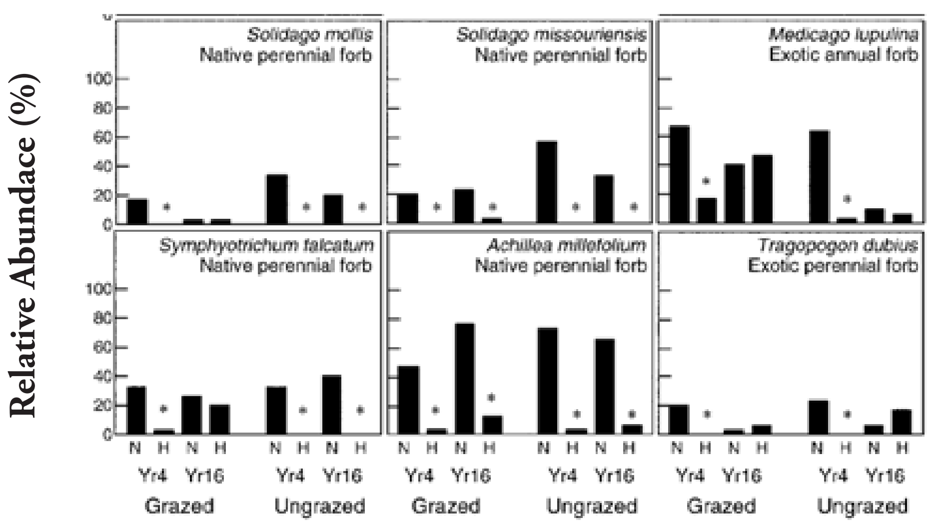

Figure 5. The y-axis is relative abundance (percent of area covered by each species). The x-axis is herbicide application (H = herbicide and N = No herbicide) in grazed or ungrazed plots. Plots were treated with picloram (herbicide) once and results were recorded 4 and 16 years after herbicide application. Asterisks represent significantly different values from bar on left. (Excerpt of figure from Rinella et al., 2009, used with permission of the Ecological Society of America.)

6. Compare and contrast the information presented in figures 4 and 5. (*Hint:* Diversity measures are a combination of species richness and abundance.)

Summary Questions

Answer the following summary questions based on the above results.

7. Do the measured (dependent) variables compare to the variables in your design? Were any of the measured variables surprising? Why might these criteria have been chosen? Explain.
8. After evaluating these results, how would you adjust your cost/benefit analysis in Part I?
9. Based on these results, what management strategy would you propose? Be sure to support your plan with evidence from the above experimental results.

Part III – New Details and Conclusions

The USFS is ready to implement your plan, but concerned citizens have raised some issues at a meeting to organize the knapweed eradication effort. Their concerns will need to be addressed before your plan can move forward.

The patch of spotted knapweed that the USFS is going to treat is on a watershed, which directly feeds a nearby town's water supply. One study found that some herbicides (such as 2,4-D + clopyralid and clopyralid) are gone from the soil 30 days following treatment; however, low levels of picloram were detected in the soil up to 2 years following treatment (Rice et al., 1997).

Nearby beekeepers are concerned about the eradication of spotted knapweed. The taste of the honey that bees produce depends on the plant(s) from which they collect their pollen. This is why honey from different locations tastes different. Montana beekeepers have learned from colleagues in Michigan that bees make great tasting honey made from spotted knapweed. They are concerned that an eradication program will result in a reduction in the value of the honey that their bees produce. Note that their concern is not the production of honey, but the flavor of the honey that is produced. Baskett et al. (2011) demonstrated that when spotted knapweed is removed, pollinators return to other plants.

Questions

Answer the following questions in your group. Be ready to share your plan with the class.

1. How does this information impact your management plan? What else might you need to know to answer these concerns?
2. Will your plan eradicate spotted knapweed? If so, what is the estimated time for treatment to be effective? How long do the results need to be monitored?
3. Defend your plan to the stakeholders based on ability to control or eradicate the invasive plant and impacts to stakeholders. Be sure to support your claims with evidence from the study results (Part II).

Part IV – Writing Assignment

Write a 2–3 page description and defense of your management plan.

Your description should include: (1) a description of your experimental design, (2) justification of your design including evidence from Part II, and (3) explanation of how this plan might affect 2–3 stakeholders.

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