Introduction

The management of highly invasive, noxious weeds that became established in North America in the last century has concerned land managers for decades. With the invasion of these species into relatively undisturbed areas, these species became concerns of ecologists, conservation biologists, and environmentalists as well. During the last decade the importance of invasive species attracted the attention of a number of ecologists with training and backgrounds outside the traditional boundaries of weed control or integrated pest management (IPM). The potential contributions of scientists from non-IPM backgrounds, could, in theory, lead to new approaches towards weed management. For this to occur, however, differences in the training and perspectives between ecologists and IPM specialists need to be acknowledged and resolved. Here, the argument is presented that a subset of individuals trained in IPM view successful weed management differently from ecologists. These differences are attributed to several, independent factors, but collectively are suggested to have a negative impact on the effectiveness on current efforts of invasive weed management effort.

A Case Study: Understanding and Controlling Diffuse Knapweed along the Colorado Front Range.

Local governments are responsible for managing over 50,000 ha of public lands in and around the Boulder area of the Colorado Front Range. These lands provide open space, and are used for various combinations of passive recreation, biological conservation, and agriculture. Not surprisingly, these lands require proactive measures for the control of noxious weeds, including species with large regional distributions such as diffuse knapweed (*Centaurea diffusa*). Woodall et al. (2000) documented the social dilemmas faced when conducting relatively controversial management activities such as large-scale herbicide treatment of public lands. As mentioned in that report, aerial spraying for diffuse knapweed was initiated in Boulder County, Colorado in 1996. A lawsuit by citizens opposed to aerial spraying was brought against the County and was dismissed, and the aerial herbicide application was conducted. Regardless of the merits of this activity, the absence of the application of guidelines recommended for conducting scientifically based ecosystem management (Christensen et al. 1996; Noss 1999), was of concern to local ecologists. Aerial application of herbicides was again advocated in 1997 without providing an analysis of 1996 results, and without providing studies of nontarget impacts on plant species in the Boulder area. While the literature indicated that herbicide treatment would provide reductions in the densities of this weed, the wide-spread presence of the weed and its ability to recolonize herbicide-treated areas from either tumbleweed or seed bank sources suggested that the activity was not going to provide a long-term solution (e.g., Beck 1995; Roche and Roche 1999). This information was provided to county commissioners at a 1997 hearing. The result of that activity was that a study area was offered to conduct management alternatives to what had (by default) become the best management practice, broadcast herbicide application.

Field biologists cannot pass up field research opportunities. I and other ecologists proceeded to initiate an ecosystem management approach to attempt control of diffuse knapweed populations.
using both bottom up (plant competition and resource manipulations) and top-down (classical biological control) approaches. The results of these efforts have or are in the process of being published (LeJuene 2002; Seastedt et al. 2003, 2004; Suding et al. in press). The somewhat surprising result – not to be belabored here – was that we found a procedure that at least equaled the efficacy of herbicide treatment that had zero cost to the county and no known nontarget impacts (Seastedt et al. 2003). We reported this to managers and policy makers in 2001, but as of this writing (early 2004), the "best management practice" for treatment of diffuse knapweed in Boulder and in Colorado remains broadcast spraying for knapweed. The question to be pursued here is to ascertain the reasons for the lag time between discovery and implementation of what (from an ecological perspective at least) must be viewed as a superior control program for an invasive species impacting natural areas (e.g., Mack et al. 2000).

1. The bias against classical biological control

Biocontrol insects were not popular in the '90s. Conservation biologists were concerned with nontarget impacts of non-indigenous insect species, and were leery of their use (Simberloff and Stiling 1996; Louda et al. 2003). However, weed managers did not appreciate these insects because of their apparent lack of success. Insects had been released on diffuse knapweed as far back as 1970, but their impact appeared negligible. To quote Carpenter and Murray (1999): "At least nine biological control agents that attack Centaurea diffusa are established in parts of the United States. Unfortunately, it appears that none of these agents, alone or in combination, effectively controls diffuse knapweed populations." I had no reason to be optimistic about their impacts either, but they had never been tested in the Colorado Front Range and there was no literature on the impacts of several of these species. As the unique chemistry of the Centaurea species provided the expectation of few or no nontarget effects (i.e., the insects were specialists), these insects were released at our study site in 1997. Somewhat surprisingly, by 2001 we were forced to move our soil experiments to a new location because the insects consumed many of the knapweed plants adjacent to the insect release site. The insect impacts may or may not be sustainable, but they suppressed knapweed densities for at least as long as the standard herbicide application.

While ample reasons existed in the late '90s to doubt the efficacy of top-down controls for knapweed, this attitude went beyond doubt. “Decades will pass before biological control will make inroads into true weed management” was the prognostication written in early 1999 by a Ph.D. in vegetation management to a local Boulder paper. While we now know this statement to be incorrect, the scientific certainty (i.e., the absence of qualifiers such as "will likely pass" instead of "will pass") with which it was written suggests a bias against classical biological control of invasive weeds. Since insects had not worked to date, they were not going to work in the future.

This bias against biocontrols is reflected at an official web site in Colorado (CWMA 2004). It states, “…biocontrol is not and never will be a cure all or total replacement for judicious herbicide use.” As a generality, there may be some validity in the statement. But, as weed control is a species-specific and a site-specific activity, we know this statement is false for a number of plants in a number of regions. For example, along the Colorado Front Range, the noxious weed St. Johnswort, (Hypericum perforatum), was
introduced along with its biological control agent, the Klamath weed beetle, (*Chrysolinia hyperici*). The result is that this weed has not required proactive management within natural areas beyond that provided by the insect. In this case biological control clearly is a "cure all".

The above web page message tells weed managers that, in general, biocontrols are not sufficient. Has that message been received? While advocating our approach to diffuse knapweed control, I received the following message from a local weed manager: “...I am not opposed to biological control within integrated weed management, …but I am against it as a single tool...”¹ Thus, even when something has zero cost and no known nontarget effects, using it alone is unacceptable? Further, aerial spraying was a clearly being used as a single tool activity for grasslands around Boulder. Single tools may be appropriate for some but not all tools? The bias against classical biological control was again evident.

2. **Leave No Weed Behind: Weed Kill as Weed Management.**

By 2001 our project had demonstrated a substantial local reduction in diffuse knapweed. Site tours were given to managers, and the local papers carried the findings, including skeptical comments from weed managers. There were, after all, still some weeds out there. The continued reduction and control of knapweed increased at our demonstration site in 2002 and 2003, and continued presentations and reports to managers were made. Yet in 2003, the best management practices for diffuse knapweed continued to be broadcast spraying, and such activities continued through 2003. Why spend the money on chemicals when the insects were demonstrated to be effective?

In 1998 I had contacted an author of a book on the management of invasive species, and explained my problems of communication with managers. The response I received proved remarkably insightful. I was given two critical pieces of advice. First, I was told that managers think weed kill is weed management. As long as you’re killing weeds, you’re being successful. The second point was that if you’re against herbicides (therefore against killing weeds), you’re the equivalent of a weed-hugger and will not have credibility with weed managers.

In the case of diffuse knapweed, our limited monitoring data by the end of 1998 indicated that the weed did not monoculture in native areas and therefore was not a short-term threat to native biodiversity. I argued that science studies could therefore be conducted before spending large sums on broadcast spraying of established knapweed populations in these areas. However, this argument was challenged by the same individual quoted above with the comment, "The large scientific gaps in knowledge does not warrant a moratorium on the use of other proven technologies."¹ Herbicides killed weeds and therefore herbicides represented proven technologies. The belief that herbicides function as weed control is another "truth" of IPM programs, yet many ecologists are taught that density independent mortality agents such as herbicides cannot function as true population control mechanisms. An ecological truth is that invasive species with large regional distributions cannot be controlled by herbicides. Temporary reduction of
densities is not control of densities, but this argument has not received public discussion either on the local or national level.

I had presented some findings to the Colorado Weed Management Association in their 2000 meetings. Attendees at the meeting were apparently put on some mailing lists, including those of major herbicide makers. Amongst the literature, I began receiving postcards advertising new chemicals while providing poetry. An example of one of these poems is shown here:

*Herbicide Haiku*

*To have a calm mind*
*You must banish impure thoughts*
*But mostly kill weeds.*

Other poems followed with similar messages. These strongly reinforce what I had been told in 1998. Dead weeds represent good management. The fact that the weeds may simply be coming back or will be replaced by other weeds has not made it into the poetry readings, yet.

Ecologists need to recognize the role that special interests have in weed management. It's the American way to lobby for activities that provide profits to the lobbyists, and herbicide applications to invasive weeds provide millions of dollars annually to companies (Pimentel et al. 2000). A substantial number of individuals also make their living as herbicide applicators and, along with the chemical companies, wish to make the strongest case for their products. Successful alternatives threaten the livelihood of both groups. Biological control interests are represented by a cottage industry that has little or no lobbying abilities. Thus, managers seem to hear very quickly about herbivores that increase the fitness of weeds, and managers seem to learn very quickly about nontarget impacts of biocontrols. And, as evidenced from the poetry, they receive strong, positive feedback about herbicide use. The support for tools that produce instant gratification (dead weeds) are large and exceed the support that is justified based upon the scientific merit of this approach.

Classical biological control demands that weeds be present in order for the insects to be successful. Weeds infested with insects can be little more than sterile insect incubators, yet they remain "noxious weeds" and are treated as such. Flowering stem densities of diffuse knapweed can peak the year before the population crashes (Seastedt et al. 2003). Managers, the public, and policy makers must therefore tolerate the weeds for several years before visual evidence of reduction is produced. I acknowledge that managers must listen to public outcries about “those damn weeds”, but one would think that long-term, low cost, low risk, sustainable solutions would be touted as the sin qua non of management, and that concept is understandable to the public. To reverse the verbiage quoted above, short-term reductions in the abundance of regionally abundant weeds using chemicals should never be viewed as a replacement or cure-all for the management activities that provide top-down or bottom-up controls of weeds in natural areas.
3. Ecologist as Weed-Hugger

The fact that I entered this activity viewed as one opposed to the best management practice (herbicides) clearly is an issue here. My science was suspect. The recognition that the messenger is as important as the message needs emphasis. As stated by Jenkins (2003): “Where environmental experts come from, the nature of their priorities, and how they communicate their knowledge are often as important...as the scientific validity of the knowledge itself.” In other words, when an outcome (no weeds) is produced by someone who is against the best management practice, then the result must be a climatic aberration or spurious result. Ironically, By 2001 similar biocontrol results for diffuse knapweed were reported in Montana (Smith 2004), and those findings supported unpublished accounts from Oregon, Washington, and British Columbia. While I thought the study requested by the county commissioners in 1997 was to become a demonstration project, it instead was apparently something to occupy weed huggers while the real work could be done elsewhere.

The Partnership Between Ecologists and Weed Managers.

Examples and suggestions of successful interactions between scientists and managers of natural areas are now available (e.g., Wilson and Lantz 2000; Byers et al. 2002). In hindsight, my activities should not have been viewed as an "us versus them" activity. First, I should have volunteered in 1997 to assist the County in setting up their aerial application as an ecosystem study, including the installation of a control and documentation of nontarget effects. Not surprisingly, the herbicide-treated sites required re-application, and by 2001, we would have demonstrated the inability of the herbicide to provide sustainable control. Second, the county had released insects elsewhere, and we could have provided documentation of their impacts on those sites (which, ironically, were subsequently treated with herbicides.) The manager and not the 'opposition' could then take credit for developing the sustainable management technique. With that result, I feel that the non-chemical techniques would now be encouraged by weed management association groups. The key is to not be seen as opposed to weed kill, but rather, to measure the effectiveness and impacts of the activity. This emphasis on monitoring cannot be overemphasized. If the managers could quantitatively evaluate the impact of their management four years after the fact, management activities would be more adaptive.

To date, winning the war on weeds has been about as successful as winning the war on drugs. Opinion elicits rebuttal, and I'm sure I'll receive some as a result of this exercise. Among the criticisms will be the comment that the biocontrol effort for diffuse knapweed remains unproven from an absolute sense. I acknowledge that fact, but at the same time I state with high probability that herbicides have failed to have any beneficial, long-term effect on diffuse knapweed, and that nontarget effects of the management activity remain unmeasured. While I welcome open discussion (which has not been abundant in the past seven years), I also do not need to be chastised because I've said negative statements about hard-working, dedicated weed managers. I acknowledge their hard work and
dedication. It is this dedication to weed kill for weeds with large regional distributions that's the issue. I argue that weed managers are operating with a less-than-adequate scientific support system or training system. Right now there's an aura that "all IPM tools are created equal" or that density independent mortality agents such has herbicides have equal standing with density dependent mortality agents provided by top-down and bottom-up ecological controls. Further "best management practices" are treated as cookbook formulas for species that have invaded greatly different habitats and are often out-of-date. As a weed-hugger, however, I'm not the one that can successfully make these arguments to the weed managers. My words have no credibility. The biases identified above must be challenged, reevaluated, and (in many cases) replaced with a more balanced view of positive and negative attributes of tools, and the ability of these tools to function independently. The mantra of IPM, "we use integrated methods" must be replaced with the statement "we use what's necessary, what works, and what has minimal nontarget impacts".

If I could communicate to managers, I would try to explain the scientific basis and logic for emphasis on early detection and removal, even if this means less emphasis on weed kill. Budgets used for chemical applications would go, in part, to high school or college students trained to protect natural areas or to train the public to do this in perpetuity. I would try to explain that budget limitations are not adequate excuses for the lack of monitoring and the lack of proactive restoration activities such as reseeding.

Two endings to this editorial are offered. First is the advice I received in 1998, to leave your science at the door when dealing with weed management issues. Had I done that, I might not have needed to go on blood pressure medication. Yet, besides writing this editorial as a personal catharsis, an optimistic alternative summary is offered. Nothing should succeed like success, but the stakeholders and not special interests must define success. If this is the case, the day will come when weed managers explain to the public that weeds in certain environments provide valuable ecological services, and there exists no compelling ecological or economic argument for their removal in such areas unless a full restoration plan is presented.

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1. Individuals or companies providing these quotes are not identified here. Copies of materials quoted here are available upon request from the author.

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Literature Cited


