Invasive Alien Weeds and Western Cattle Ranching: Lessons Learned from Yellow Starthistle in New Mexico

Jennifer A. Thacher[1 2 3], Janie M. Chermak[4], Kristine M. Grimsrud[5], Kate Krause[1], James I. Price[6]

Introduction

Cattle remain an important feature of the Southwest's economic landscape. Arizona, Colorado, New Mexico, Texas, and Utah produce over 20 million head of cattle while total sales of cattle and dairy products within this region exceed $18 billion annually (U.S. Department of Agriculture, 2007). The majority of cattle in the Southwest are beef cows and consequently spend a substantial portion of their life grazing on rangeland.

Invasive alien weeds (IAW) have the potential to significantly affect the Western cattle industry. IAW alter rangeland vegetation by crowding out native grasses, increasing cattle management costs. Pimentel et al. (2005) estimates that invasive pastureland-weeds cost US agriculture $6 billion annually, consisting of $1 billion in forage losses and $5 billion in control costs.

Addressing the problem of IAW requires both studying the biology of IAW and understanding the economics of IAW management. Efficiently controlling an IAW is a complex management problem: private producers must take into account the trade-off between weed-control costs and future productivity of the land. This trade-off is complicated by interactions with neighboring lands. Even if one rancher efficiently controls the weed on her particular plot, there is the potential for increased weed infestation or re-infestation from neighboring plots. Thus, invasive species control is essentially a tragedy of the commons problem, where individual economic incentives (i.e., profit maximization) conflict with collective goals of land stewardship.

Despite the significant potential impact of IAW on the agricultural industry, limited research has been conducted on management strategy. This paper outlines some issues posed by IAW in the West by looking at the cattle industry in New Mexico (NM) and focusing on one specific IAW, Yellow Starthistle (YST). We briefly review state and federal policy, summarize some of our major findings, and suggest potential policy implications.

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[1] Associate Professor, University of New Mexico.
[2] Corresponding author: Department of Economics, University of New Mexico, MSC05 3060, Albuquerque NM 87131; jthacher@unm.edu; 505-277-1965.
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[4] Full Professor, University of New Mexico.
[5] Assistant Professor, University of New Mexico.
[6] PhD student, University of New Mexico.

Background

Federal and State Responses to IAW

In response to the environmental and economic costs imposed by invasive species, the federal government and several western state governments have drafted regulations to monitor and manage their spread.

Executive order 13112 (1999) specifies the duties of federal agencies concerning invasive species and established the National Invasive Species Council (NISC). NISC provides national leadership regarding invasive species, coordinates federal efforts, promotes action at state and local levels, identifies avenues for international cooperation, and facilitates efforts to monitor invasive species. NISC has identified nine priority areas for addressing invasive species problems: leadership and coordination, prevention, early detection and rapid response, control and management, restoration, international cooperation, research, information management, education and public awareness (National Invasive Species Council, 2001). A key activity in all areas is the coordination of federal, state, and international agencies already engaged with invasive species issues.

In 2005, NISC published a progress report on their management plan (National Invasive Species Council, 2005). Four actions relate directly to IAW. First, NISC encouraged federal, state, and local agencies to develop, and adequately fund, interagency rapid-response strike-teams. These teams were established within the National Park Service, the USDA Forest Service, and the U.S. Fish and Wildlife Service and were responsible for treating over 132,000 acres. Second, NISC called for legislation to provide federal funding for State-level initiatives. In 2004 the Noxious Weed Control and Eradication Act was passed. It requires the Secretary of Agriculture to establish a program for assisting states and other eligible organizations in managing noxious weeds. Third, NISC made recommendations to the Bureau of Land Management (BLM), subsequently adopted, that seeds from the BLM's Seed Warehouse be tested for IAW before being used for restoration purposes. Finally, NISC encouraged federal agencies to improve public awareness of invasive weeds. In response, the BLM expanded its environmental education program to provide IAW brochures and developed a volunteer-based outreach program aimed at educating communities on how to spot new infestations.

In addition to establishing NISC, Congress passed the Plant Protection Act (2000). The act empowers the Secretary of Agriculture to, 'prohibit or restrict the importation, entry, exportation or movement in interstate commerce of any plant, plant product, biological control organism, article, or means of conveyance, if the Secretary determines...it necessary to prevent the introduction...or dissemination of a noxious weed.'

Western states have also passed legislation aimed at reducing the impact of IAW. Colorado, for example, passed the Colorado Noxious Weed Act and developed a Strategic Plan to Stop the Spread of Noxious Weeds (Colorado Noxious Weed Act, 2003). This act makes it illegal to introduce, cultivate, sell, offer for sale, or knowingly allow the growth of any weeds classified as noxious. The act requires landowners to notify authorities when noxious weeds are found, manage the weed in an appropriate manner, and permit government officials to inspect their grounds for noxious weeds. The act empowers county commissioners to reimburse landowners for expenses due to eradication efforts. In 2000, NM passed the Noxious Weed Management Act (2000), which directed the Department of Agriculture to develop a noxious weed list, identify methods of control, and educate the public about noxious weeds. NM also published guidelines for managing noxious weeds (Nellessen, 2000).

Besides legislation, the federal government provides support for IAW research. In 2003 the USDA's Economic Research Service (ERS) launched the Program of Research on the Economics of Invasive Species Management (PREISM). PREISM's aim was to improve IAW management decisions through the funding and dissemination of IAW-related economic research by researchers outside of ERS. These projects included studies in bio-economic modeling, trade and invasive species, resource allocation and decision analysis, program and policy alternatives and design, institutions, and incentives (Blas-Rivera et al., 2009).

IAW and Western Ranching

Future impacts of IAW on western ranching could be substantial. Consider YST, which forms dense stands that displace other vegetation. Livestock avoid grazing in heavily infested areas due to the thorns; thus, the weed can highly increase the cost of managing livestock (DiTomaso, 2006). Cattle forced to feed on this plant can incur injury (Sheley et al, 1999). YST infested pastures also have less crude protein and digestible nutrients than uninfested pastures (Barry (1995) as reported in DiTomaso (2006)). Weed control cannot be accomplished with a single treatment or in a single year. Mowing, hand-pulling, prescribed burning, and the introduction of competitive plant species can be effective; for example, Jetter et al. (2003) found public biological control of YST was effective and had a positive impact on private lands. The most common treatments, however, are chemical.

In California between 1958 and 2002, the spread of YST increased from about one million infested acres to over 15 million acres (Pitcairn et al., 2006), with 85% of counties reporting YST (U.S. Department of Agriculture, 2006). Total losses of livestock forage are estimated at almost $8 million annually with additional out-of-pocket costs for YST control of almost $9.5 million (Eagle et al., 2007). Oregon, Washington and Idaho also have high levels of YST infestations: 72%, 66%, and 62% of counties, respectively, report occurrences. Julía et al. (2007) estimate the total annual economic impact of YST in Idaho to be $12.5 million. Other western states report lower levels of county sightings: Nevada (30%), NM (18%), Wyoming (8%), and Colorado (3%) (U.S. Department of Agriculture, 2006).

While the spread of YST may be slower in other western states than was seen in California, the economic impact could be considerable, making the management choices just as germane. Beef cattle account for over $570 million, or about 35% of the total value of NM livestock and their products sold. The value from this sector is second only to that of the dairy industry. The contribution of beef cattle in other western states is even higher. In Colorado, 77% of the total value of livestock and products sold is attributed to beef cattle, while in Wyoming the figure is 85% (U.S. Department of Agriculture, 2007).

IAW management by ranchers: findings from NM

Our research focuses on an IAW prior to economic impact and asks whether, and under what conditions, ranchers will manage a weed before it causes economic losses. We approach this problem with a series of numerical models, complemented by survey and experimental results.

In Grimsrud et al. (2009) and Chermak et al. (2010), we extend a bioeconomic model for a dispersing weed (developed in Grimsrud et al. 2007) to include strategic interaction between two profit-maximizing ranchers with feedback. These inquiries develop a non-cooperative, dynamic game between the ranchers but consider different synergies between their efforts. Grimsrud et al. (2009) derives a closed form solution with a linear effort-feedback between ranchers, while Chermak et al. (2010) permits non-linear effort-feedbacks and employs simulations to assess the problem. While the approaches are distinctive, the results are consistent. When ranchers are identical with low levels of infestation it is optimal to begin eradication efforts immediately. As the initial infestation levels increase, initial effort levels are lower, due to lower profitability of the land, resulting in a longer required planning horizon to eradicate the weed. When we allow for different initial infestation levels for the ranchers, the model results deviate somewhat. While both models find the high-infestation rancher benefits from being located next to a low-infestation rancher, the impacts on the low-infestation rancher diverge (due to the different dynamics in the two models). Grimsrud et al. (2009) find the low-infestation rancher is minimally affected, while Chermak et al. (2010) find that the impact on the low-infestation rancher is more substantial and requires higher effort levels (relative to the case where both ranchers start with the same initial infestation level) to manage the infestation. In Grimsrud et al. (2009) we also find that larger initial infestation levels can be economically controlled in the case of a longer management horizon. In Chermak et al. (2010) we also compare the noncooperative results to a socially-optimal cooperative-solution and find targeted subsidies to the high-infestation rancher can bring the noncooperative solution in line with the cooperative solution. By providing the incentive for the high-infestation rancher to manage the weed, the low-infestation rancher does not have to exert as high an effort, resulting in higher profits; thus, the low-infestation rancher experiences a positive spillover. The required subsidy depends on the specific characteristics of the problem.

In Krause et al. (2010) we report the results of experiments to investigate rancher-participant response to the level of infestation of IAW and neighbor eradication efforts. Seventy-two ranchers participated in five experiment sessions held in northern and eastern NM, where cattle ranches are prevalent. Our participants chose how much to spend on weed eradication in a multiple-round setting. Current round payoffs decreased by the amount spent on weed eradication, but payoffs in future rounds increased if the weed level fell. The round-to-round increase or decrease in weed level was determined by the participant's and other experiment participants' expenditures.

At each experiment, the initial level of weed infestation was set relatively low, and most neighbor-groups successfully reduced weed density in three to five rounds. In subsequent rounds, with higher levels of initial infestation, experiment participants were less successful. Many participants appeared to recognize the sub-optimality of fighting weeds that had been firmly established and chose to stop spending at all on weed eradication. Some were unable to lower the weed density because they did not spend enough. These results align with the theoretical predictions: early efforts can successfully eradicate IAW. But if a landowner waits until the weed is well-established it can be too late to cost-effectively manage.

Rancher eradication efforts were weakly negatively associated with neighbor efforts in prior rounds, suggesting some tendency to free ride. In other words, when the ranchers saw that significant money was being spent on weed eradication in early rounds, many decided to then reduce their own expenditures and rely on the weed eradication efforts of their neighbors. This is contrary to the reported tendency in the Rancher Survey results (reported in Thacher et al. (2010)), but is consistent with economic theory and Chermak et al. (2010). After the experiment rounds, participants completed an Experiment Survey. Two questions probed participants' planning horizon and preference for immediate relative to future gains. Participants' responses in the Experiment Survey were generally consistent with their experiment behavior: a preference for future gains and a long planning horizon were associated with higher weed-eradication expenditures.

In Thacher et al. (2010) we reports results from a Rancher Survey which focused on understanding and quantifying factors that affect weed-management decisions of ranchers outside of a controlled environment. We use choice-question data from a survey of 712 NM ranchers to examine whether ranchers' weed-management decisions are affected by the management decisions of other ranchers in the community and whether ranchers see light infestations as a management opportunity or a problem to defer. Ranchers chose between managing two types of IAW, managing one, or managing neither. The model estimates the relative importance of participation by other ranchers, the initial level of infestation, the externality impacts of no-management, the impact on carrying capacity, and the cost on weed management decisions.

The setup of the Rancher Survey differs from the theoretical work and experiments in ways that make an explicit comparison of results difficult. For example, in the choice questions, the focus is on the decision of whether or not to manage at all, rather than the level of effort expended on management. In addition, actual communities, composed of families who may have ranched together for generations, may differ fundamentally from experimental 'communities' of people who share an occupation and live in same area but do not share a history. Nonetheless, we consider how the two most striking results from the choice-question data - the timing of management and the importance of community effects - relate to the theoretical and experimental results.

First, while our numerical and experimental results find that early intervention is required for successful management of an IAW, the Rancher Survey results indicate that all else equal, ranchers are more likely to manage an IAW on their own land when local infestation rates are high, rather than when they are low. Note that while the Rancher Survey dealt with the degree of infestation in the area, the theoretical and experimental papers dealt with the degree of infestation on one's own land. However, this result highlights the importance of providing information to ranchers on the need to manage IAW before the infestation is widespread. In the experiments, such information was provided through the payoff matrix. Taken together, the experimental results and Rancher Survey results indicate that targeted information campaigns may, all else equal, lead ranchers to initiate management early on, before an IAW is fully established in an area.

Second, the choice-question data shows that ranchers are more likely to manage when a larger share of other ranchers are managing. This finding does not necessarily imply that ranchers would expend more effort on IAW as others ranchers in the community increase their IAW management. It does suggest, however, that if the goal is to encourage rapid response by ranchers to an initial infestation of an IAW, it may be important to publicize that other ranchers are managing this IAW. This information may help communicate the seriousness of the threat posed by the IAW. Advertising such information can help spread 'best practices'.

Policy Implications

Our results suggest that the effective management of a negative externality, IAW, will require a superior understanding not only of the biologic spread of the species, but also of the strategic economic choices of individual agents and the set of factors that frame the individual agent's choices. At least two policy implications stand out from this work.

First, consider the positive spillover effects of managment, where management by one rancher can reduce a second rancher's infestation level and consequently required management efforts. Because of these positive spillovers, there may be significant benefits for the largest land owner in the West, the federal government, in taking a lead in treating their own land for IAW. Specifically, by having large public landowners attack the IAW's on their land early, significant participation from private ranchers may not be required to contain the problem. This is similar to Jetter et al.'s (2003) findings, which suggest a public biological control program for YST allowed private landowners to focus on other IAW's. Given the size of public western land holdings, governmental agencies may see economies of scale, which would lower average cost to manage IAW, compared to costs of management by individual ranchers.

The existence of positive spillover effects could also suggest a role for incentives to manage. Consistent with Chermak et al. (2010), targeted incentives may be more efficient than a "one-size-fits-all" strategy. Optimal policy-design requires incorporating knowledge of the level of infestation at the time of the policy implementation with knowledge of the biologic spread of the weed and the strategic economic choices of the individual ranchers. While our research did not directly address the types of incentives, they could range from payments to ranchers to assistance with equipment and/or pesticides. Taken together, this raises the interesting policy question of whether increased initial control on public lands or direct federal subsidies for control on private lands is more cost-effective.

Second, while the theoretical work shows the importance of early management of an IAW, in the surveys, most New Mexico ranchers reported that they would not invest in weed management when the infestation level was 'low'. This potentially argues for the role of education or information programs regarding the importance of early treatment. When ranchers are confronted with a multitude of issues - drought, disease, weather, weeds and others - fighting weeds may not be a priority and the opportunity for early management may be lost. But when ranchers focused on the problem of weeds in isolation in an experimental setting, they successfully eradicated. Providing ranchers with clear information about how to identify emerging IAW, the physical and economic harm from spread, and the value of early management could have a large influence on mitigating the impact of IAW's on the Western cattle industry. This could reduce the uncertainty associated with impacts of management, providing ranchers with knowledge with which to make their management decisions.

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