Testimony for Dr. K. George Beck

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House Natural Resources Committee
Subcommittee on Public Lands and Environmental Regulations
Oversight Hearing on Invasive Species Management on Federal Lands

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Chairman Bishop, Ranking Member Grijalva, members of the subcommittee, thank you for the opportunity to testify before you today. My name is Dr. George Beck and I am a professor of weed science at Colorado State University. I am appearing before you today representing the Healthy Habitats Coalition, a diverse coalition of land managers, conservation organizations, private companies, and academics such as myself, focused on how local management is the best practice for natural resources management including invasive species. I would like to walk you through the growing problem related to invasive species as well as some of the research HHC has conducted on dollars spent to control and manage invasive species.

Invasive species overview and situation to date

Invasive species is an insidious and occasionally sinister economic and environmental issue – it is not new. Canada thistle, for example, was first declared noxious in the United States in 1795 in Vermont. A little overgrazing by one user, in this instance, opened the door for invasion of the common area by Canada thistle, which in turn decreased everyone else's ability to raise the sustenance needed to survive. It was the tragedy of the commons where one person's use of the environment influenced the next person's use and invasive species continue to plague us in this fashion to this day.

In the 1980s, many western states public and private land managers were highly dissatisfied with how Federal land management agencies were managing noxious and invasive weeds. The Intermountain Noxious Weed Advisory Council (INWAC) was formed in 1987. INWAC was a grass roots organization whose goal was to educate Federal Agency decision makers and Congress about the problems associated with noxious and invasive weeds and the need for much enhanced management by Federal Agencies in particular. In 1990, INWAC helped write and secure passage of Section 2814 of the Federal Noxious Weed Act, which requires all Federal Agencies to manage noxious weeds in cooperation with state and local governments. Furthermore, the law specifically requires that any National Environmental Policy Act (NEPA) assessment that must be produced be completed within one year and Section 2814 presently remains the law of the land. Some Federal Agencies have not yet complied with Section 2814.

In 1996, INWAC along with several noted invasive species scientists from across the U.S. met with President Bill Clinton's Science Advisors to voice their dissatisfaction with the management of invasive species by Federal Agencies. The Administration at that time disagreed but a letter of protest about invasive species management in the U.S signed by 500 scientists was an outcome of that meeting and found its way to the highest Administrative offices. As a result, Executive Order 13112 was issued by President Clinton in 1999. The National Invasive Species Council (NISC) was formed, which was comprised of eight of the President's Cabinet Secretaries and co-chaired by the Secretaries of Agriculture, Commerce, and Interior. E.O.

13112 created the Invasive Species Advisory Committee (ISAC) which along with NISC staff created all the National Invasive Species Management Plans over the past 13 years. ISAC also wrote and published a guidance paper for all Federal Agencies clearly defining what constitutes an invasive species – i.e., what is, and just as importantly, what is not an invasive species (see Addendum).

The National Invasive Weed Awareness week in Washington D.C. started in 2001 and evolved recently into the National Invasive Species Awareness Week. The goal was to heighten the awareness about invasive species among Federal Agency decision makers and members of Congress. We were successful and our elected leaders in particular understand that invasive species indeed is an insidious issue albeit, a competing priority that has fallen short of the action that is clearly needed.

Current status and necessary steps to take:

In spite almost three decades of work with the federal government to control and manage invasive species, little progress has been made and what progress that has occurred is grossly insufficient on a national scale. A multitude of taxa require our immediate management attention; zebra and quagga mussels, New Zealand mudsnails, Burmese pythons, feral hogs, emerald ash borers, gypsy moths, Asian carp, snakehead fish—the list of invasive species is long but manageable. The Healthy Habitat Coalition's collective experience, however, is with invasive weeds and we will focus on the continued growth of various weed species and the need for better control and management measures on lands and waterways throughout the country. The data in Table 1 outline the amount of infested acres, the amount of acres treated, and the increase of infested acres for the six major Federal Agencies who have jurisdiction over invasive species.

AGENCY (Big 6)	Infested Acres	Treated & restored acres	Percent T&R	New Acres Annually **	Total Net Infested Acres
BLM	35,000,000	375,000	1.1%	4,155,000	38,780,555
USFS	7,000,000	390,000	5.6%	793,200	7,403,200
NPS	2,600,000	66,000	2.5%	304,080	2,838,080
DOD*	2,500,000	200,000	8%	276,000	2,576,000
APHIS	81,709	27,805	34%	6,469	60,372
FWS	2,300,000	345,000	15%	234,600	2,189,600
Others	Not available	200,000	Not available	Not available	-
Totals	49,481,709	1,603,805	3.2%	5,769,349	53,847,807

Table 1. Magnitude of Federal Agency invasive weed management FY09; above data provided to Healthy Habitats Coalition directly from Federal Agencies.

These data clearly show that only 3.2 percent of existing acres infested with invasive weeds were treated and restored in 2009. Weed scientists indicate that a typical rate of spread for weeds is 12 to 16 percent annually (Duncan and Clark 2005). Treating and restoring only 3.2 percent of infested acres annually coupled with a 12 percent increase indicates that the FY09 infested acres on Federally managed lands will double by 2017 and will surpass 100 million acres by 2018 (Table 2). Because the rate of invasive weed spread apparently is not recognized or at least accounted for, Federal Agencies are acquiring 3.5 times more acres of invasive weeds annually than they are treating and restoring. This is a plan that decidedly will never be successful and will continuously produce more and more infested acres thus, preventing realization of land management goals and objectives. Just as importantly, these ever-expanding acres of invasive weeds on federally managed lands will serve as a constant source of propagules to disperse to neighboring lands and those distant to the infested site! HHC recommends that Federal Agencies treat and restore at least 15 percent of their infested acres annually to successfully decrease acres of invasive weeds on lands they manage on behalf of the American public. Additionally, our nation must create a borderless collaboration among Federal Agencies, states and their land management agencies, private enterprise, and private land owners and land managers for invasive species management. Invasive species do not recognize political borders and we must overcome the barriers that prevent borderless collaboration to be successful.

Year	Elapsed Years	Beginning Infested Acres	Acres Treated & Restored (3.2% of Begin)	Infested Acres After Treatment	12% Annual increase	Year End Infested Acres
2009	1	49.48	- 1.60	= 47.88	+ 5.75	= 53.63
2010	2	53.63	- 1.74	= 51.89	+ 6.23	= 58.12
2011	3	58.12	- 1.89	= 56.23	+ 6.75	= 62.98
2012	4	62.98	- 2.04	= 60.94	+ 7.31	= 68.25
2013	5	68.25	- 2.21	= 66.04	+ 7.92	= 73.96
2014	6	73.96	- 2.40	= 71.56	+ 8.59	= 80.15
2015	7	80.15	- 2.60	= 77.55	+ 9.31	= 86.86
2016	8	86.86	- 2.81	= 84.05	+ 10.09	= 94.14
2017	9	94.14	- 3.05	= 91.09	+ 10.93	= 102.02
2018	10	102.02	- 3.31	= 98.71	+ 11.85	= 110.56

Table 2. Performance assessment of invasive weed management by Federal Agencies over a 10-year period.

FY09 NISC budget:

The National Invasive Species Council staff assembled an annual “invasive species budget” by collecting data from Federal Agencies and placing that information into one of seven categories that are associated with the National Invasive Species Management Plan. In FY09, the federal government spent $1.563 billion (Figure 1) on invasive species stating that $642 million was spent on control and management, which is one of the NISC budget categories. HHC members have years of experience helping to design weed management strategies and systems and our calculations differ substantially from the federal data. From Table 1, Federal Agencies indicate they treated and restored 1,603,805 acres infested with invasive weeds in FY09. Our calculations suggest the following when Early Detection and Rapid Response (EDRR) is budgeted at $1000/acre, restoration at $300/acre, and control with a herbicide at $100/acre:

$291,000,000 spent on EDRR ÷ $1000/acre = 291,000 acres EDRR treated;

$50,520,000 spent on restoration ÷ $300/acre = 168,400 acres restored;

1,603,805 acres – 291,000 EDRR treated-acres – 168,400 acres restored = 1,143,505 acres remaining for direct weed control. Calculating at $100/acre to control invasive weeds with a herbicide equates to $114,350,500 spent by Federal Agencies to decrease their population abundance, which is the first logical step in any weed management system. Based on HHC calculations, far less appears to have been spent on control and management than the data stated by the Federal Agencies (Figure 2).

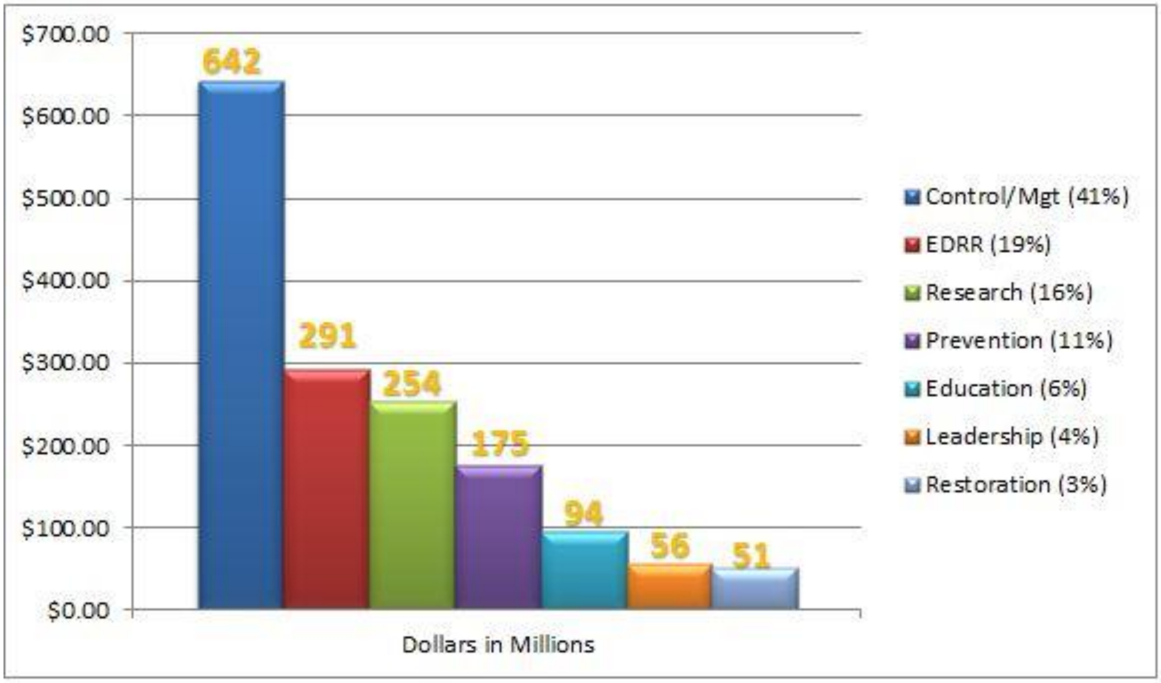

Figure 1. NISC FY09 invasive species budget.

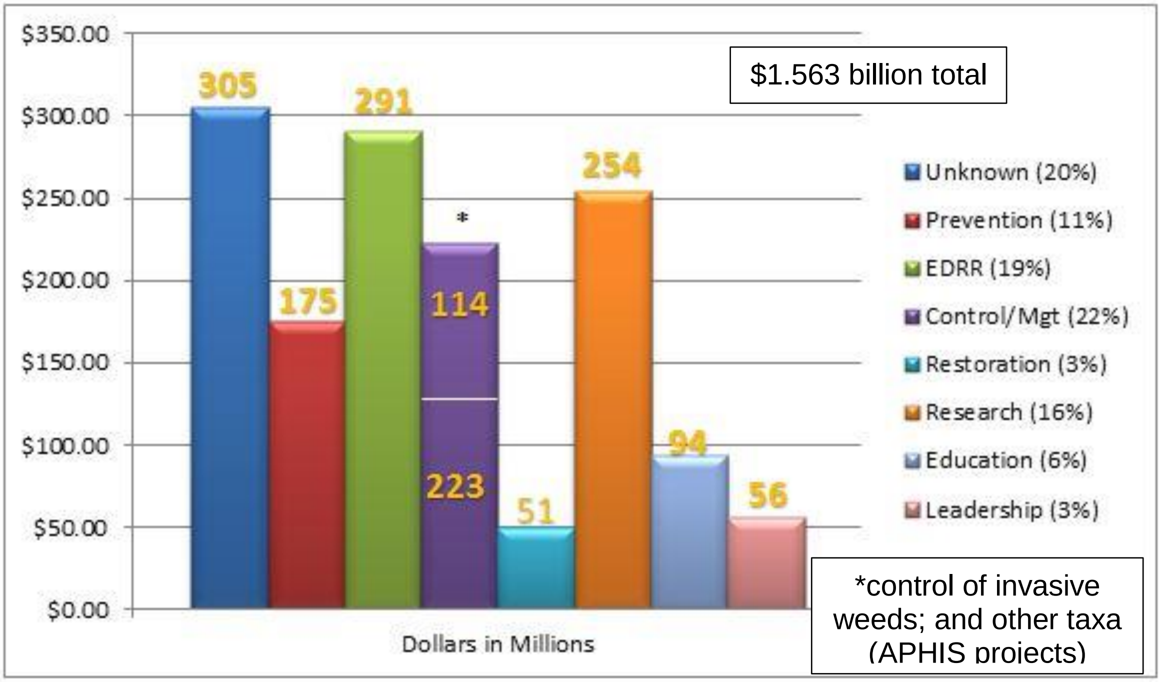

Figure 2. HHC's recalculated NISC budget impacts based on average cost analysis.

APHIS projects to control invasive insects and taxa other than invasive weeds comprise about two-thirds of the control and management budget categories. There remains about $305 million that cannot be readily placed into one of the NISC budget categories and it is highly likely that Federal Agencies are spending more per acre to control invasive weeds than is necessary because they are not using the most cost-efficient tools and have high labor expenses.

Solution to Federal Agency performance managing invasive weeds:

Year	Elapsed Years	Beginning Infested Acres	Acres Treated & Restored (15% of Begin)	Infested Acres after treatment	12% Annual increase	Year End Infested Acres
2009	1	49.48	- 7.42	= 42.06	+ 5.1	= 47.16
2010	2	47.16	- 7.07	= 40.09	+ 4.81	= 44.90
2011	3	44.90	- 6.73	= 38.17	+ 4.57	= 42.74
2012	4	42.74	- 6.40	= 36.34	+ 4.35	= 40.69
2013	5	40.69	- 6.10	= 34.59	+ 4.15	= 38.74
2014	6	38.74	- 5.80	= 32.94	+ 3.95	= 36.89
2015	7	36.89	- 5.53	= 31.36	+ 3.76	= 35.12
2016	8	35.12	- 5.26	= 29.86	+ 3.58	= 33.44
2017	9	33.44	- 5.01	= 28.42	+ 3.41	= 31.83
2018	10	31.83	- 4.77	= 27.06	+ 3.25	= 30.30

Table 3. A positive outcome if Federal Agencies treat and restore at least 15 percent of acres infested with invasive weeds annually.

Federal Agencies must treat and restore at least 15 percent of existing infested acres in any given year to overcome their management deficit to date (Table 3). Table 3 is similar to Table 2 but is based upon treating and restoring 15 percent of infested acres annually. Within 10 years, 19.2 million acres would be treated and restored, which represents a 39 percent decrease of acres infested with invasive weeds on federally managed lands as opposed to their current thrust where over 100 million new acres would be infested (Table 2) over the same time period! In addition to treating and restoring many more acres annually than Federal Agencies currently do, they also must be more efficient and effective with taxpayer dollars. A paper addressing this issue is included in the addendum.

Invasive species management by Federal Agencies:

It is abundantly clear that the management of invasive species by Federal Agenciesis not sufficient to slow the growing problem. The very nature of invasive species is to increase their populations in their new home seemingly without bounds until habitats are saturated (Figure 3). Invasive species management is not an option.

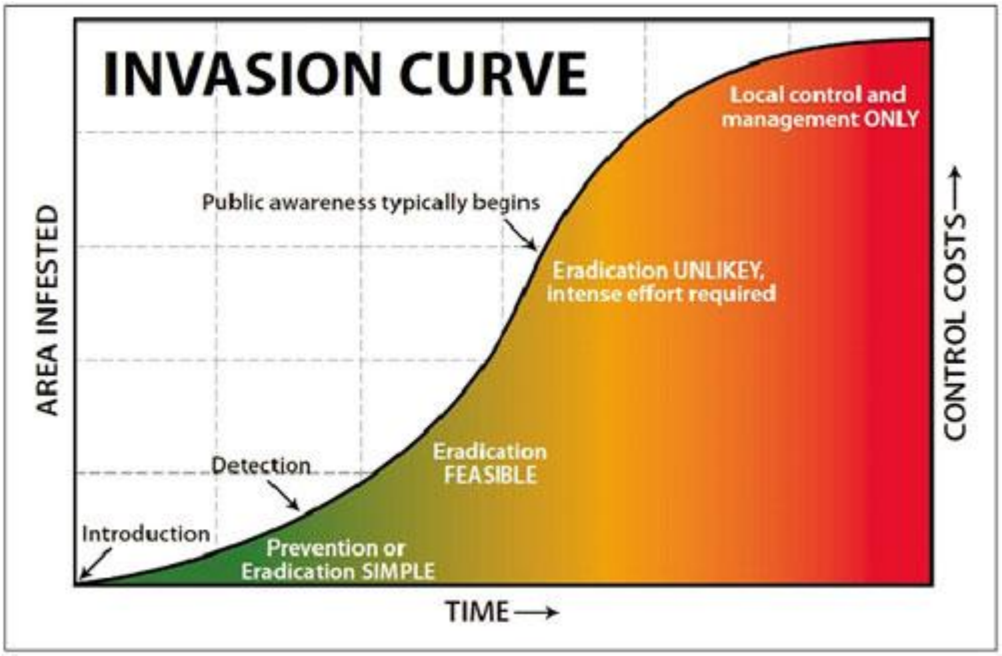

Figure 3. Typical population growth curve for invasive species.

Many university professors with extension appointments have spent considerable time over the past 25 years educating and training the federal land management workforce about invasive weeds and their management. To be sure, there are some shinning lights within the federal system with regard to invasive species management. For example, The US Fish and Wildlife Service spent about 42 percent of their FY09 “invasive species budget” to control and manage invasive species and the National Park Service spent 100 percent of their FY09 “invasive species budget” on control and management, and the majority of these monies were spent on invasive weeds. So it is clear that if an Agency or Department desires to manage all taxa associated with this insidious problem, they can do so! The Healthy Habitats Coalition has a proposed solution to our national invasive species problem, but it will take Congress, the States, local governments, Federal land managers, private enterprise, and private landowners working together to implement a solution. The time for action is upon us—we must stop kicking this can down the road!

Chairman Bishop, Ranking Member Grijalva, thank you again for the opportunity to testify at today’s hearing and present the facts related to invasive species. I am happy to answer any questions.

FY09 National Invasive Species Council invasive species expenditures compilation.

Economics of Invasive Weed Control: Chemical, Manual/Physical/fire,
Biological, Doing Nothing
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Financial costs/acre and impacts to budgets

Regardless of whether working for private enterprise or government, land management personnel must stretch limited budgets yet be effective simultaneously. Labor most often is the most expensive portion of any weed management project. It is incumbent upon land managers to use methods that minimize labor costs and this is especially so with public land managers because they are dependent upon tax dollars to execute their programs.

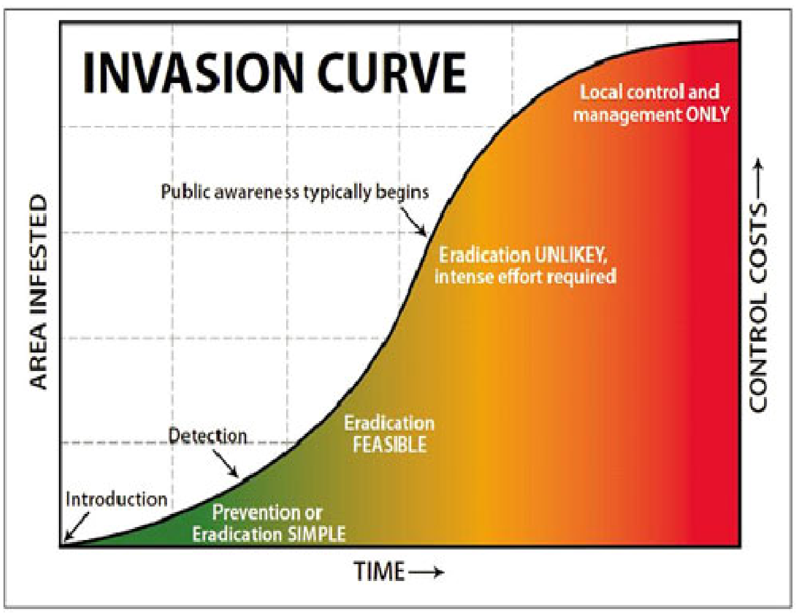
Using herbicides or biological control agents to decrease the population abundance of a target invasive weed represent those approaches that utilize the least labor to effect initial/continued reduction of targets species. Biocontrol is developed with public funds and this is the primary reason that it seems inexpensive to the end user, including Federal Agencies. Biocontrol is a very attractive and highly useful approach to control invasive weed species but success has been inconsistent in space and time. There are numerous successful biocontrol endeavors and the literature has many examples. The Fire Effects Information System website managed by USDA-Forest Service is one of the best and most complete information sources for the biology and management of many invasive weed species (http://www.fs.fed.us/database/feis/). Another outstanding source of information on managing invasive weeds recently became available – Weed Control in Natural Areas in the Western United States by Joseph DiTomaso et al. 2013. It too describes where and upon what species biocontrol has been successful and extensively outlines all management options. If biocontrol is the method of choice, land managers must carefully research choices for their effectiveness. The spatial and temporal variation associated with biocontrol performance can be due to many genetic and environmental reasons from habitat preference by the biocontrol agent to the production of new genotypes from previously geographically separated genotypes now growing in proximity to one another, and many as yet to be discovered reasons.

Fire too can be a good tool to decrease populations (DiTomaso et al. 2006) of some invasive weeds, most notably annual grasses and forbs such as cheatgrass (*Bromus tectorum*) or medusahead (*Taeniatherum caput-medusae*) and yellow starthistle (*Centaurea solstitialis*). As with other integrated management systems for weeds, use of fire to manage invasive weeds must be integrated with other tools such as seeding to provide competition to ward off recovering weed species and allow completion of land management goals and objectives. Burning mixed brush-cheatgrass stands destroys some to many weed seeds and allows for about one season to establish desirable vegetation before cheatgrass re-establishes and dominates the site again (Evans and Young 1978; Young and Evans 1978; Young 2000). Establishing competitive perennial grass species may successfully keep cheatgrass from re-establishing. If, however, the system is left alone after burning, cheatgrass or medusahead will re-invade. Burning stands of yellow starthistle also will provide excellent population control if combined with herbicide treatment and seeding (DiTomaso et al. 2006b). Burning stands of perennial weeds such as Canada thistle, leafy spurge, Russian and other knapweeds, or tamarisk rarely is effective because of the plants' capability to re-grow from its root system and dominate a site again. These and other similar invasive weeds may recover soon enough after a prescribed burn to preclude establishment of seeded species. If fire is used to control perennial forbs or grasses, herbicides likely will have to be integrated into the management system to allow sufficient suppression of the target weed for a long enough time to give seeded species the opportunity to establish.

Of all the methods used to decrease weed population abundance, herbicides are the most researched and arguably the best understood. In the course of their development, consistent performance in space and time is an extremely important consideration for a product to reach the consumer. Because of known performance developed from extensive research and the decreased labor associated with their use, herbicides often represent the most cost-effective means to use taxpayer dollars to decrease invasive weed populations so land restoration or rehabilitation may proceed.

The decision to do nothing seems inexpensive and harmless on the surface but nothing could be farther from reality. The problem with invasive species is their populations always seem to expand and cause harm, albeit, a species can be problematic in one location or setting and not another (Beck et al. 2008). Most invasive species and certainly invasive weed populations develop in a sigmoid curve pattern and after a lag time following introduction, their populations increase exponentially until site saturation when their populations are limited by resource availability (Figure 1).

Figure 1.



The problem is one never knows where on the curve the population at any given population lies. Even with cheatgrass, the invaded location/site might be new and at the bottom of the curve when population control is most easily obtained or it could be at beginning of the exponential phase but it is difficult at best to make such a determination. The best response is to ***NEVER DO NOTHING*** because doing nothing can be the most expensive decision one can make due to the subsequent population growth by the invasive weed and the resulting havoc it wreaks upon the native plant community and the animals it supports! Doing nothing simply yields the site to the invasive species.

Importance of prevention, early detection and rapid response/eradication

Prevention often is thought of as the most powerful form of weed management and indeed, the least expensive weed to control is the one that is not present – however, prevention is not free. The perception that prevention is simply steps taken to keep stuff out that currently does not exist in a particular location is accurate for certain and possibly represents the greatest cost savings to taxpayers. Cleaning equipment between uses and locations seems a logical prevention approach along with using certified weed seed-free hay, forage, mulch or gravel, and careful screening of ornamental and agricultural introductions can be of tremendous benefit in the battle against invasive species. Prevention, however, can be expensive when it arbitrarily impedes trade and benefit: risk assessment is an important if not an essential component to screening programs so decisions that impact trade are transparent, logical, and acceptable.

Prevention also means decreasing population abundance of existing weed infestations so they are not a source for new ones to develop some distance – close or far – from the infested site. It is quite appropriate to think of extending prevention as a management strategy to efforts that decrease target populations in an infestation that is part of a project area. In fact, this may be the best "first light" under which to examine prevention efforts; i.e., how to keep current infestations from serving as sources for others. The silo or stovepipe approach to any weed management project is dangerous and invasive species management always should be thought of as a continuum among the strategies and methods used to manage such species. All this must be kept in mind because prevention and EDRR are the first lines of defense against invasive species.

Economics and pest expansion models can help set program priorities

Almost every person recognizes that it is much simpler to pull a single, newly found noxious weed than let it go and try to eradicate the large infestation that undoubtedly will occur over time. It is puzzling then that people tend to wait because "that weed is not causing me a problem … now" knowing well that it inevitably will do so. The sooner an incipient patch of an invasive weed is controlled, regardless of proximity to the source, the less expensive it is to control, the greater the success will be, and most likely one will have eradicated a new or small, dispersed population. Data in Table 1 shows the increasing control cost associated with waiting in a hypothetical example of a newly found patch of spotted knapweed. The data also compare the decision to control manually v using an herbicide and both include seeding costs.

Table 1. Cost comparison of controlling spotted or diffuse knapweed physically or chemically, demonstrating the importance of early detection and rapid response.

Initial patch size	Herbicide cost[a]	Application cost[a]	Time for handpull or dig[a]	Handpull or dig cost	Seed cost	Total cost herbicide + seeding	Total cost handpull/dig + seeding
10 ft^2[b]	$0.003	$0.20	0.25 h	$3.00	$0	$0.20	$3.00
100 ft^2	$0.03	$0.40	0.5 h	$6.00	$0.46	$0.89	$6.46
1 acre	$14	$20	145 h	$1,742	$200	$218	$1,742
10 acres	$140	$200	1,450 h	$17,420	$2000	$2,340	$19,420
100	$1,400	$2,000			$20,000	$23,400	

acres

[a]Cost comparisons based upon: Milestone herbicide $300/gal; $20/A application cost; labor $12/h; seed cost $200/A.
[b]For 10 and 100 ft^2 initial patch size, application method spot spray; only labor calculated.

These data clearly show that the decision to wait to respond to a new weed infestation can be very costly. Regardless of the method, the cost of management increases several thousand times but the cost of manual control exceeds the cost of using an herbicide by 800 to 1500 percent! This example shows the value of monitoring to find incipient invasive weed populations so they can be effectively controlled or eradiated at a fraction of the expense compared to waiting for impact and havoc to occur. These data also show the dramatic fiscal savings associated with using an herbicide compared to handpulling or similar manual methods of control. The decisions to act quickly when new or small infestations are found and to use an herbicide to affect target weed population decrease represent efficient and responsible use of taxpayer dollars and the stretching of limited budgets.

While this example is hypothetical, Tables 2 and 3 present data comparing the costs (late 90s) associated with different methods to decrease target weed populations on Colorado and Montana rangeland. Diffuse knapweed (*Centaurea diffusa*) was targeted in Colorado where handpulling twice annually was compared to mowing three times annually, to mowing twice followed by herbicide in fall, to herbicide application alone. Control of diffuse knapweed rosettes and bolted plants was best 1 year after treatments were exerted where a herbicide was

Table 2. Cost of different control methods for diffuse knapweed on Colorado rangeland in 1997 and subsequent control 1 year after original treatments were applied (Sebastian and Beck 1999).

Treatment	Rate	percent Control rosettes[1]	percent Control bolted[1]	Hours	Rate/hr or acre[2]	Cost/acre	Total cost/acre
Handpull	2 times/ year	0 c	0 d	8.2	$9/Hr	$2,643	$2,643
Mow	3 times/ year	0 c	0 d	1.6	$50/A	$150	$150
Mow + Tordon	2 times + 1 pt/A	84 a	100 a	1.1+0.4	$50 + 31/A	$100+31	$131
Mow + Transline	2 times	43 b	100 a	1.1+0.4	$50 + 22/A	$100 + 22	$122

	+ ***1 pt***						
Tordon	1 pt	74 a	96 b	0.4	$31/A	$31	$31
Transline	***1.3 pt***	8 c	94 bc	0.4	$23/A	$23	$23
Banvel+2,4-D	1+2 pt	0 c	89 c	0.4	$22/A	$22	$22
Control	0	0	0	0	0	$0	$0

[1]Compare means within a column; means followed by the same letter are similar (α=0.05).
[2]Rates/costs based upon the following: $9/hr labor; mowing $50/A; Tordon $86/gal; Transline $31/gal; Banvel + 2,4-D $90/gal; $20/acre all ground herbicide applications (each plot 300 ft^2, 4 reps=1200 ft^2 total/treatment).

used alone or in combination with mowing compared to mowing alone or handpulling. Herbicides alone were about 1 percent of the total cost of handpulling and the latter was completely ineffective.

The second experiment (Table 3) was conducted in Montana on spotted knapweed and was similar to the Colorado experiment except biocontrol also was evaluated and the treatments were exerted for 2 years and data collected shortly (1 to 2 months) thereafter. Handpulling kept 100 percent of plants from going to seed (bolted plants were targeted for pulling), but controlled only about one-half of spotted knapweed plants. Herbicides alone kept 93 to 100 percent of plants from going to seed and controlled 79 to 100 percent of spotted knapweed plants. Mowing in combination with herbicides or handpulling combined with herbicide use produced similar results to herbicides alone. Biocontrol was ineffective but insufficient time had passed to allow their successful establishment much less spotted knapweed population decrease. As with the Colorado study, the use of herbicides alone was less than 1 percent of the cost associated with handpulling and controlled almost twice as much knapweed.

Both of these experiments show the strong monetary and weed control advantages associated with using herbicides to decrease target weed populations. All government land managers, regardless of the level of government, must demonstrate fiscal responsibility to taxpayers and that not only translates into total dollars spent but also what benefit or return was realized from the expenditures.

Table 3. Cost of different control methods invoked for 2 consecutive years for spotted knapweed in Montana and subsequent control 1 year after initial treatments applied and 1 month after final treatments (Brown et al. 1999).

Treatment	Rate	Plant growth stage	Application 1997	Dates 1998	8/4/98[1] percent decrease in flowering	8/4/98[1] percent control of plants	Cost/acre[2] for 2 years
Handpull (bolted plants)	Twice	Early & late bud	6/20 & 7/20	6/20 & 7/22	100 a	56 d	$13,900.00
Tordon + handpull (rosettes + mature)	0.5 pt + once	Bolt late bud	6/2	--- & 7/21	100 a	98 ab	$97.50
Mow	Twice	Early & late bud	6/20 & 7/20	6/19 & 7/17	99 a	0 f	$200.00
Mow + Tordon	Once +	Late bud Fall	7/20	---	100 a	100 a	$75.37

	0.5 pt	regrowth	9/29	---			
Mow + Curtail	Once + 1 qt	Late bud Fall regrowth	7/16 9/29	--- ---	100 a	93 a	$77.67
Tordon	0.5 pt	Fall regrowth	9/29	---	100 a	96 ab	$25.37
Curtail	1 qt	Fall regrowth	9/29	---	100 a	79 c	$27.67
Tordon	1 pt	Bolting	6/2	---	99 a	98 ab	$30.75
Curtail	2 qt	Bolting	6/2	---	93 b	93 b	$35.37
Cyphocleonus achates	30/plot	Flowering	8/27	---	0 d	0 d	$90.00
Tordon + *Cyphocleonus achates*	0.5 pt + 30/plot	Bolt Flowering	6/2 8/27	--- ---	46 c	46 e	$113.58
Untreated					0 d	0 d	$0.00

[1]Compare means within a column; means followed by the same letter are similar (p=0.05).
[2]Costs based upon the following: handpulling $9.00/hr; *Cyphocleonus achates* $1.00/weevil; mowing $50/acre; Tordon $86/gal; Curtail $30.70/gal; ground application $20.00/acre.

Control risks v harm caused by invasive weeds

Duncan and Clark (2005) cite numerous examples of the environmental and economic impacts caused by invasive weeds. Pimentel et al. (2005) calculated that invasive species impact the U.S. economy by more than $120 billion annually and $36 billion of this was caused by invasive weeds. The problems associated with invasive weeds are very clear and very expensive. The harm, real or potential, from invasive species is always a much greater risk than the tools used to control any invasive taxa but especially invasive weeds. If this was not the case, the species in question would not be considered invasive. Invasive species alter evolved relationships among organisms that share a habitat or ecosystem, which is highly significant biologically, ecologically, and economically!

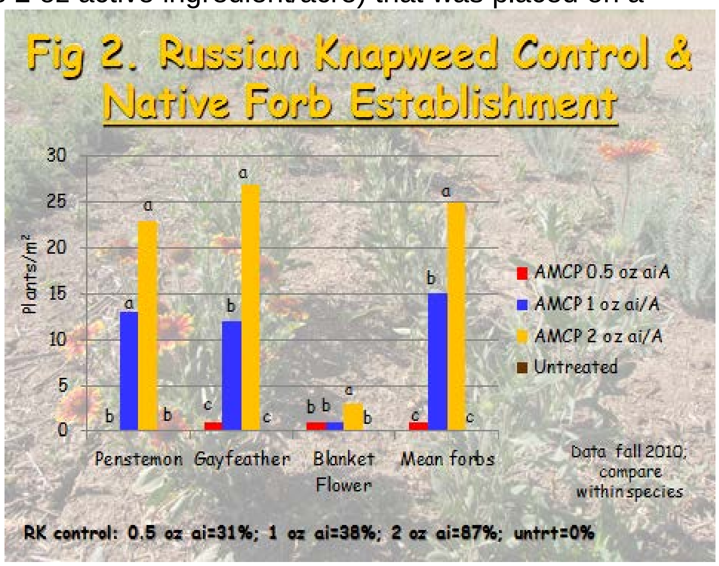
Herbicides are the most efficacious, most economical, and most consistent means of decreasing the population abundance of invasive weeds. A common theme is readily apparent when attempting to recover an infested habitat; i.e., a land manager must first decrease the population of the invasive weed before beginning any seeding operation or the latter effort will fail. Other site characteristics also may be in need of attention to fully realize restoration and these too should be addressed before expecting establishment of seeded species. Many of these characteristics could be very expensive to repair and thus, all the more reason to use the most economically viable tool to decrease invasive weed populations to use taxpayer dollars to the greatest extent possible.

One serious concern about using herbicides to decrease target invasive weed populations is their effect on native plants, especially native forbs and shrubs. Many people believe that using an herbicide that will control invasive weedy forbs will strongly select for grasses and eliminate native forbs and shrubs, which are essential components of any native plant community. This is in fact not the case and the weed research community is developing databases to define the injury to native grasses, forbs, and shrubs caused by herbicides used to control invasive weeds. Erickson et al. (2006) sprayed Paramount (quinclorac) or Plateau (imazapic) directly onto the western fringed prairie orchid (*Platanthera praeclara*) in fall when it was senescing to mimic when these herbicides would be used to control leafy spurge (*Euphorbia esula*) and data were collected on orchid survival and fecundity 10 and 22 months after treatments (MAT) were applied. Neither herbicide influenced orchid survival. Plateau decreased orchid height by 43 percent at 10 MAT but this effect was no longer apparent at 22 MAT. Plateau also decreased raceme length by 58 percent and flower number by 70 percent 22 MAT. Quinclorac, however, had no such effects on the orchid and the researchers concluded that it was safe to use Paramount to control leafy spurge in the presence of the western fringed prairie orchid and while Plateau caused temporary stunting and decreased fecundity of the orchid, most of these symptoms disappeared the second year following treatment.

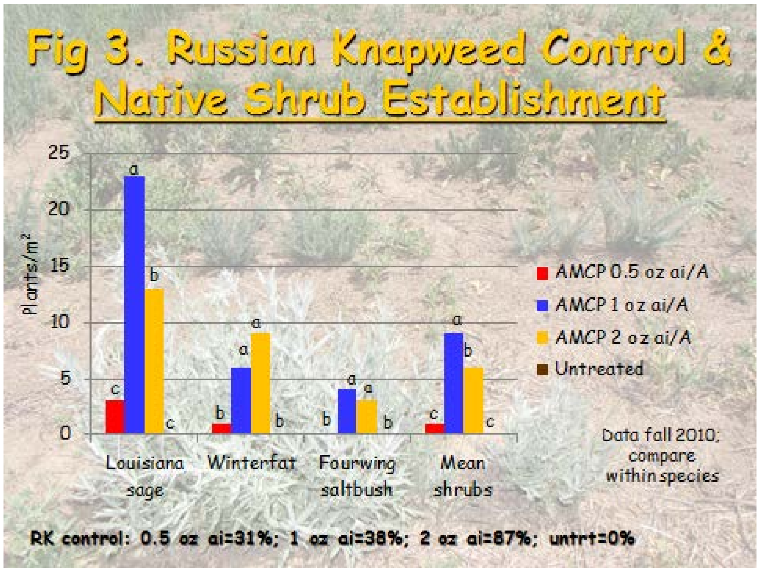
Rice et al. (1997) studied the effects of plant growth regulator herbicides (picloram, clopyralid, and clopyralid + 2,4-D) on native grasses, forbs, and shrubs applied to control spotted knapweed (*Centaurea maculosa*; *C. stoebe*) in Montana over an 8-year period at four sites. Herbicides were applied once in either spring or fall to control spotted knapweed in 1989 and re-treated again in 1992 to control the recovering invasive weed. Plant community data were collected annually over the 8-year period and compared back to the floristic composition of each study site determined before initiation of the experiments. Herbicides controlled spotted knapweed very well (98-99 percent control) and shifted the plant community to dominance by grasses but the depression on plant community diversity was small and transient. By the end of the third year after initial treatment, there were no differences in species diversity among treatments and some herbicide-treated plots began to surpass untreated plots in plant community diversity measurements. They also found that late-season herbicide application after forbs had entered summer-drought induced dormancy minimized the impact on plant community diversity. The effects of the pyridine herbicides (picloram and clopyralid) on the native plant community diversity were small and temporary and minimal compared to the reported impacts caused by spotted knapweed on the plant community (Tyser and Key 1988; Tyser 1992).

University researchers worked with Dow AgroSciences to test a new pyridine herbicide, Milestone (aminopyralid), effects on native grasses, forbs and shrubs (http://techlinenews.com/ForbShrubTolerancetoMilestone.pdf) at 14 locations throughout the western U.S. Individual tolerance rankings were established for 90 native forb and 19 native shrub species to Milestone applied at 5 or 7 fl oz/acre in spring, late summer, or fall. Of the 90 forb species studied in this experiment, 23, 14, 19, and 34 were ranked as susceptible (more than 75 percent stand reduction), moderately susceptible (51-75 percent stand reduction), moderately tolerant (15-50 percent stand reduction), and tolerant (less than 15 percent stand reduction) 1 year following application. Many of these forbs recovered by the end of the second year following application and only 19 of the 90 forbs were ranked either as moderately susceptible or susceptible at that time. Interestingly, shrubs generally were more tolerant of Milestone than were forbs. Of the 19 shrubs in the study, 74 percent were ranked as moderately tolerant or tolerant 2 years after herbicides were applied and Rosaceae shrubs were generally the most susceptible species. These data also demonstrate the transitory nature of injury to native forbs and shrubs caused by herbicides used to decrease the populations of invasive weeds.

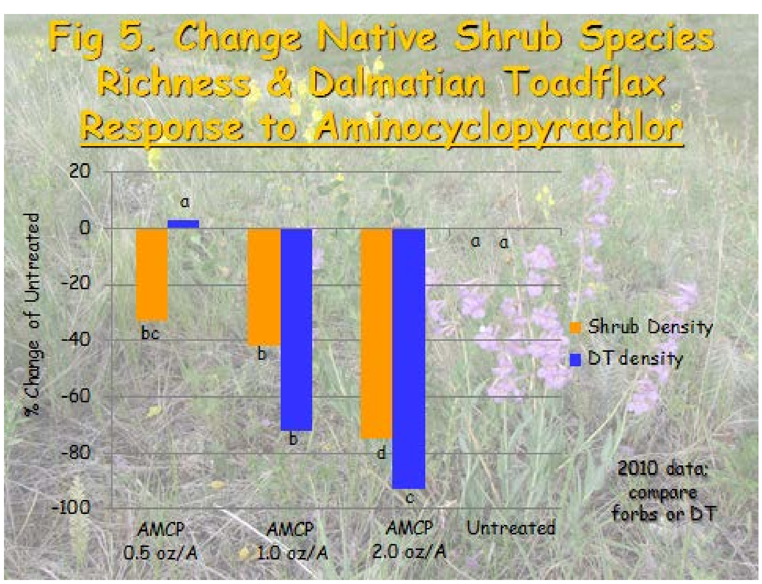
Aminocyclopyrachlor is a new herbicide developed by DuPont and can be used to control susceptible invasive weedy forbs and woody species. It is a reduced-rate herbicide (typical maximum rate for selective weed control is 2 oz active ingredient/acre) that was placed on a fast-track registration by US-EPA. An experiment was conducted on a rangeland site north of Denver, CO (Sebastian et al. 2011) to assess the establishment of native forbs and shrubs after using aminocyclopyrachlor (AMCP) to decrease the population abundance of Russian knapweed (*Acroptilon repens*). The herbicide was applied at 0.0, 0.5, 1.0, and 2.0 a.i./a on May 14, 2009 and 10 native forbs, 4 native shrubs, and 2 native, cool-season perennial grass species were drill-seeded in April 2010 and data were collected in fall 2010. Data for a penstemon species, gayfeather (*Liatris punctata*), and blanketflower (*Gaillardia pulchella*) showed the highest establishment at the highest herbicide rate where Russian knapweed control was greatest (Figure 2) and the same effect was observed for the average of all forbs; blanketflower, however, appeared more susceptible to the herbicide residue than did the penstemon species and gayfeather. Shrubs in general seemed to be more susceptible than forbs to AMCP soil residues (Figure 3). Greatest establishment of all seeded shrubs was realized at the 1 oz ai/a rate of AMCP. Louisiana sage (*Artemisia ludoviciana*) established best at the 1 oz rate of AMCP but winterfat (*Krascheninnikovia lanata*) and fourwing saltbush (*Atriplex canescens*) established similarly at the 1 and 2 oz rates of AMCP and all three species established better than in plots where the Russian knapweed was not controlled. The latter is a



key response and our research results are very clear regardless of the target species and herbicides used to decrease its populations – the target weed species populations must be decreased to give seeded species the opportunity to establish or failure of the latter will ensue! Overall summary of this experiment showed that 50 percent of grasses, 8 percent of forbs, and no shrubs established in the untreated controls whereas 100 percent of grasses, 93 percent of forbs, and 88 percent of shrubs established in plots treated with 2 oz ai/a of aminocyclopyrachlor where Russian knapweed control was maximized.



A similar studied was conducted at a foothills location west of Longmont, CO but on an established plant community (Sebastian et al. 2012). It is a harsh site with thin topsoils and a very robust native plant community that was invaded by Dalmatian toadflax (*Linaria dalmatica*). Aminocyclopyrachlor was applied at 0.0, 0.5, 1.0, and 2.0 oz ai/a in May 2009 and data were collected in fall 2010. Dalmatian toadflax adults were controlled well at 1.0 and 2.0 oz/a (Figures 4 and 5) but a flush of toadflax seedlings was apparent suggesting that the herbicide residue was insufficient to control these germinants (data not shown). The mean density of all native forbs (Figure 4) decreased 22, 18, and 40 percent at the 0.5, 1.0, and 2.0 oz/a AMCP rates, respectively. Native shrubs appeared more sensitive to Aminocyclopyrachlor than forbs; mean shrub densities decreased 33, 42, and 75 percent at the 0.5, 1.0, and 2.0 oz/a rates (Figure 5). Overall, native forb richness by species decreased 22-44 percent and shrubs decreased 33-75 percent but neither native functional group was eliminated by Aminocyclopyrachlor. Warm season grass abundance increased 227 percent (data not shown) over the course of the experiment likely in response to increased summer precipitation that occurred in 2010. The harsh conditions at this site, i.e., thin soils and typically dry climatic conditions replaced by abundant summer precipitation – appeared to have influenced results and this experiment is currently being repeated at three additional sites nearby and we will continue to monitor changes at all four sites for at least 4 years following herbicide application to detect temporary and permanent shifts in the native plant community.



Continual monitoring for incipient patches or introductions is of critical importance for successful invasive species management. Bear in mind that invasive species have earned such declaration and their populations almost always increase and often exponentially so. New ecological relationships vary drastically from their points of origin – there are over 20 hypotheses associated with invasion success but they all share the common theme that the invasive species populations, regardless of species, increase dramatically in new homes. Invasive weed populations throughout the United States should be managed assertively by all land managers but especially by public land managers that are managing large tracts of land for the benefit of the American public. Management systems developed to help restore or reclaim infested habitats should be effective and efficient and one of the most important aspects associated with being effective and efficient is the decrease in the population abundance of invasive weeds that must occur before seeded species can successfully establish. Herbicides represent the most effective and fiscally efficient means to decrease target invasive weed populations. Databases are under development that carefully define the injury to native grasses, forbs, and shrubs caused by herbicides used to control invasive weeds to provide all land managers with the appropriate information to design ecologically-based, IPM systems that include herbicides yet allow recovery of productive native plant communities so land management goals and objectives can be realized.

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