Florida Fish and Wildlife
Conservation Commission

Upland Invasive Plant Management Program

Cooperation • Coordination • Collaboration

A comparitive analysis of state programs and funding for terrestrial invasive plant control

Preliminary Report, November 15, 2013

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Introduction

An analysis was conducted of state 'weed control' programs and state funding for invasive species management. Besides Florida, there are few states with a comprehensive invasive plant management program. Where states have a program similar to the 'Uplands Program', in most cases it is part of a larger effort that targets all invasive taxa, and terrestrial plants are a smaller subset. From published reports by the states described below, it appears that where there is funding for terrestrial invasive plant management on natural areas, it is (1) mostly federal pass-through moneys, (2) less than 50% (at best) of total program funding for actual control of species, and (3) spent in-house by public entities (federal, state, and local). There is no clear evidence that any other state spends 90% of its operational budget on direct plant control activies, or has a statewide network of licensed contractors that perform nearly all of the work. Why this may be true was well beyond the scope of this analysis.

Part 1. *THE STATE OF THE STATES*

A common observation across many state reports on invasive plant management is "The intricacies of the federal and state budgeting processes plus a lack of data regarding how much individual entities pay for 'weed control' make obtaining a single dollar figure for weed control in [State] rather elusive." This is equally true in Florida.

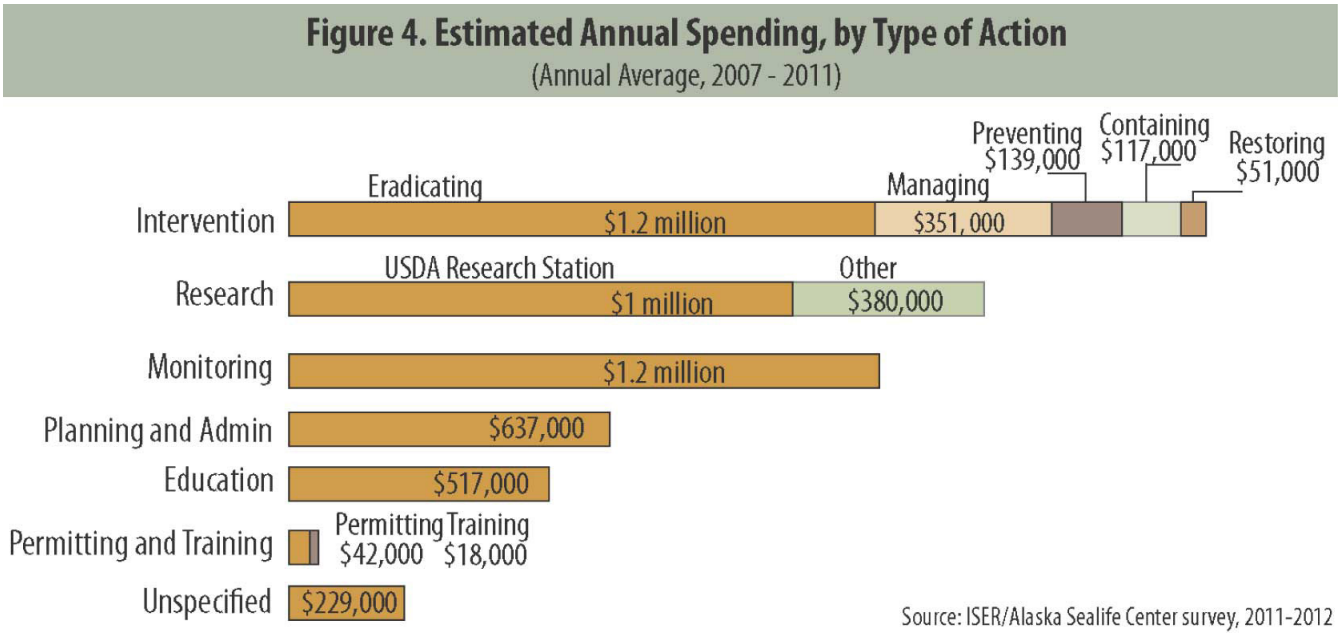
A group of states with legislated invasive species councils, or a similar organizing body, produce reports to state government regarding the costs of invasive species management. A number of these reports were reviewed in an attempt to identify that elusive single dollar figure for weed control. Results were mixed.

The following excerpts from some of the reports have been edited to reflect, as much as possible, the operational budget for invasive plant control for that state. Funds for direct plant management and control activities (versus overhead, administrative costs, etc.) are sometimes identified clearly, but often are not.

ALASKA

Governments, nonprofits, and private donors spent about $29 million to manage invasive species (plant and animal) in Alaska from 2007 through 2011, with an annual average of $5.8 million. The federal government put up the most money—84%. Nonprofits (9%), state (5%) and local governments (2%) supplied almost all the rest.

Figure 4 (in original). Alaska Invasive Species Management Funding by Category



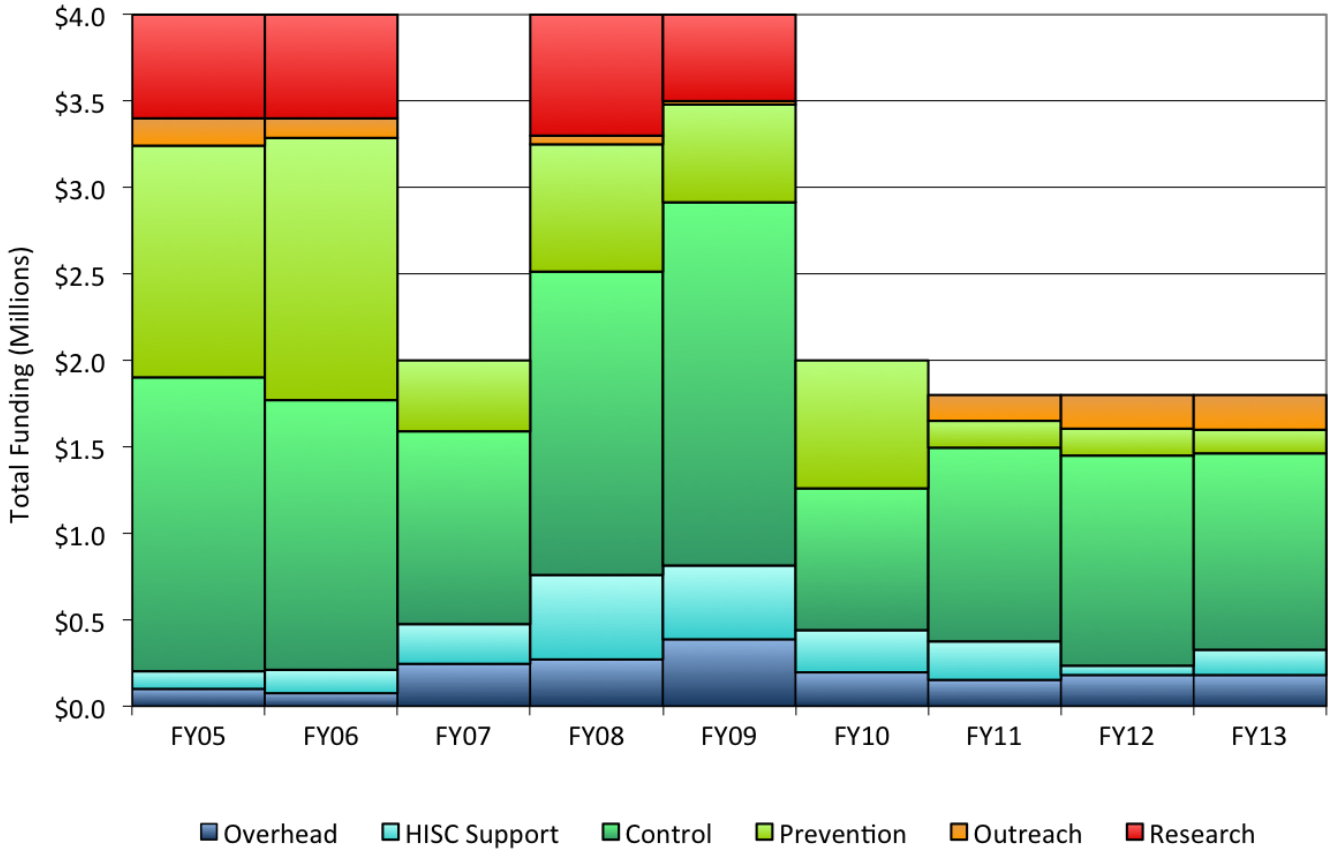
CALIFORNIA

Expenditures on invasive "weed" management by state agencies was estimated as $26 million in 2009 (Cal-IPC). However, agency budgets for weed control have been cut significantly due to state budget crises. Current interviews indicate a total budget of around $15 million. This includes transportation and agriculture funding, aquatic plant management (water-hyacinth and Brazilian elodea; $7M), local Weed Management Areas, and state parks ($4M). The state wildlife agency received a one-time non-recurring appropriation in FY07 for invasive plant control.

HAWAII

Hawaii Invasive Species Council Funding Disbursement History — The amount of funding provided to projects, arranged into the four topical Working Groups of the HISC, has varied greatly by year. In particular, funding to support the Research and Technology Working Group's annual RFP was lost in FY07 (due to general funds for invasive species being provided directly to Hawaii County rather than to the HISC) and after FY09 (due to the economic downturn and subsequent loss in State revenues).

HISC FY14 funding is $2,550,000 total, of which $1,240,900 is designated for "control" operations (plant and animal). Funds are dispersed to other government agencies through a competetive award process.



HISC funding disbursements provided to projects, by year, separated by Working Group to which a given project applied.

IDAHO

Funds for Weed Control - The intricacies of the federal and state budgeting processes plus a lack of data regarding how much individual private landowners pay for weed control make a single dollar figure for weed control in Idaho rather elusive. However, just including the known expenditures establishes a minimum weed management cost in Idaho of approximately $7 - $10 million annually. This amount includes (based on FY 2002 estimates):

- Ø Funds appropriated by the Idaho Legislature to the Department of Agriculture, most of which is given in cost-share grants to individual CWMAs ($336,000)
- Ø Federal grants from the BLM and Forest Service which are added to the ISDA weed cost -share fund ($1,340,000)
- Ø Property tax assessments levied by individual counties to support their own weed departments ($3,594,000)
- Ø Direct payments for weed control work by the Forest Service, BLM, and such state agencies as the Idaho Department of Lands, Idaho Department of Parks and Recreation and the Idaho Department of Fish and Game (approximately $4,400,000)

These are estimates. The difficulty in identifying more specific numbers is largely a function of how agencies account for weed expenditures in their own budgets. Few identify "weed management" as a specific line item, and such expenditures are more likely added into such general budget categories as "land management" that can include the costs of any number of projects clearly not related to weed or other invasive species management.

Cost-share grants include much more than control measures. While nearly half of the ISDA funds granted to the CWMAs went toward on-the-ground control efforts, a significant amount went to education, mapping and inventory, prevention and restoration. In terms of acres, the ISDA estimates that in 2002 cost-share grants resulted in 154,287 acres treated, 675,628 acres mapped and 26,986 restored acres, for a total of 856,901.

The state emphasis on weed treatment contrasts sharply with federal level invasives funding, where the lion's share of funding goes to prevention. Although, federal agencies do their best to protect international borders from unwanted invasions, it is up to states to provide a second line of defense. Although prevention is widely considered to be the least cost strategy to manage invasive species, current spending on prevention measures in Idaho is low relative to overall expenditures and to the need.

Possibly the largest amount of money available to the CWMAs through the participation of the county weed departments is the property tax assessments authorized in the Noxious Weed law. According to the Idaho Tax Commission, all counties made weed control assessments that ranged from less than $0.05 per private acre to over $1.00, with an average of $0.21 per acre. In total, county weed assessments provide the counties with $3.5 million to pay for the county weed superintendent and for control efforts. Coupled with the grants from the ISDA, there is the implication that the individual CWMAs have approximately $5 million or about $156,000 each year. However, there is a great range in the funds available to the individual CWMAs. Those with an urban tax base and a large acreage of private land generally enjoy more funds than those counties with a lot of federal lands. At the low end, some CWMAs have as little as $18,000 per year to conduct their activities.

INDIANA

The Indiana Invasive Species Council was legislatively created in 2009 to coordinate the state's efforts to address the problem of invasive species. A survey by the Invasive Plant Advisory Committee found that Indiana land owners and managers spent $5.85 million last year controlling invasive plants. The committee was created in 2010 to help the Indiana Invasive Species Council work on invasive plant issues in the state. The committee surveyed 116 agencies, land trusts, municipalities, contractors and private land owners throughout the state, representing more than 650,000 acres of managed public and private land in natural areas such as forests, prairies and wetlands. The survey did not include invasive species control in agricultural fields.

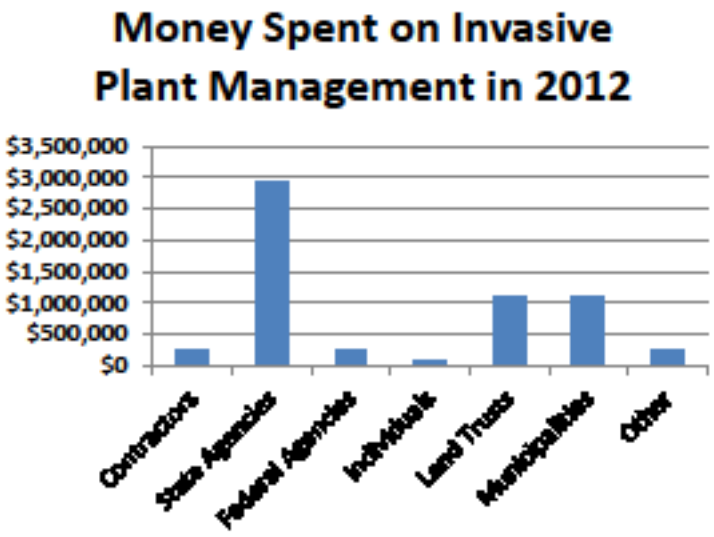
Of the groups surveyed, state agencies spent the most on invasive plant management in 2012 - nearly $3 million. Land trusts and municipalities came in second and third, respectively, each group spending slightly more than $1 million. Private contractors working on private land also responded to the survey.

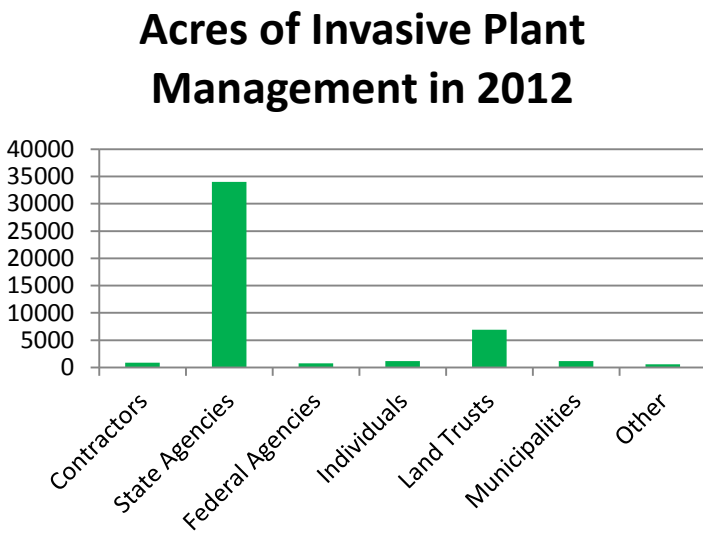
OREGON

State agencies spent a total of $8,292,899 on invasive species in 2008 ($3,906,631 for salaries and benefits, $2,638,094 for operations, and $1,748,174, which they disbursed to other entities). They received a total of $3,122,928 from other entities, thus their total investment in invasive species in Oregon in 2008 was $5,169,971.

The majority of the funds they disbursed to other entities were from the $1,200,000 lottery dollars transferred

Indiana IPM Funding





to the Oregon State Weed Board annually for disbursement to nonprofit organizations and local governments for weed control. The remainder of the $1,748,174 ($548,174) included grants to local governments as well as $74,000 disbursed to three entities—Deschutes County ($16,400), Tri County CWMA ($31,980), and Northwest Weed Management Partnership ($20,500).

State agencies received a total of $3,122,928 from other agencies (primarily federal—BLM, USDA Forest Service, and USDA-APHIS) to supplement invasive species activities.

Operational dollars

Of the $2,635,092 operational dollars expended by state agencies, 77% were spent on management and control [$2,031,332], followed by 8% on monitoring and surveillance,6% on outreach and education, 3% on fundraising, 2% on EDRR, and 1% on effectiveness monitoring, coordination, and policy work.

Salary/benefits

Of the $3,904,629 salary/benefit dollars expended by state agencies, 54% were spent on management and control, followed by 25% on monitoring/surveillance, 6% on coordination, 4% on outreach and education, 3% on EDRR, effectiveness monitoring, and prevention, 2% on policy work, and 1% on research.Total

State agencies spent a total of 63% of their invasive species funds on management and control, followed by 18% on monitoring and surveillance, 5% on outreach and education, 4% on coordination, 3% on EDRR, 2% on effectiveness monitoring, policy work, and prevention, and 1% on fundraising.

Less than half of invasive species management operational funding was directed to upland plant management (Fig.29, in original; see next page).

TEXAS

Funding for invasive species management flows through the Texas A&M Forest Service (TFS), for terrestrial plants, and the Texas Parks and Wildlife Department (TPW), for aquatic plants. The TFS does not receive state funding specifically for invasive species control. However, it developed several programs since 2001 using federal funding from the US Forest Service, Forest Health Protection and the US Animal & Plant Health Inspection Service, the latter for detection surveys for invasive insects not yet known to be in Texas. Federal funding for invasive species averages between $40,000 and $60,000 per year, which includes partnership grants TFS passes through to the Lady Bird Johnson Wildflower Center. The Wildflower Center's funding is primarily for outreach. Federal funding for invasive species has declined markedly in the last couple of years. (i.e., from $75,000 in FY2010 to $25,000 in FY2013 for invasive plants). The TPW 2014 budget for aquatic plant control is about $1.4 million. This is comprised of a mix of state and federal funds.

Oregon IPM Funding Catergories

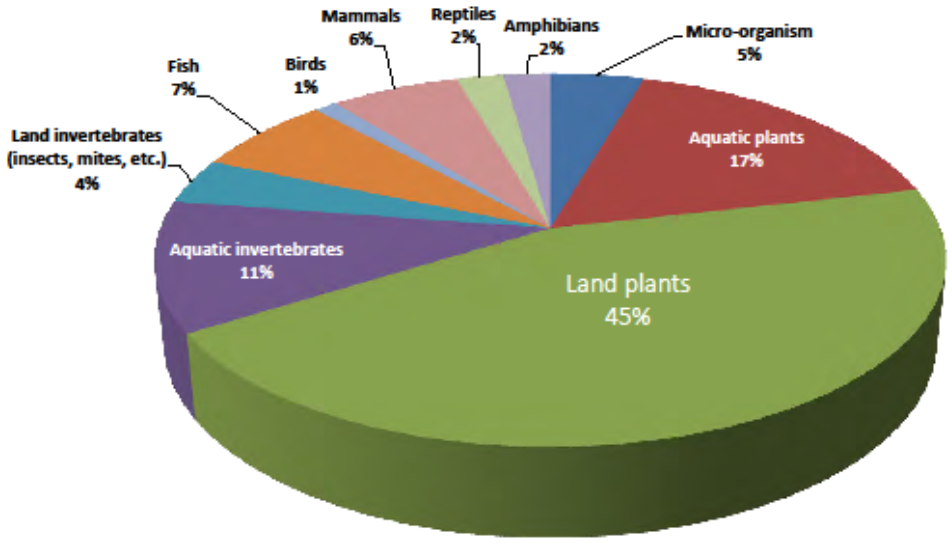


Figure 29. Percentage of invasive species taxa in Oregon for which entities conducted work in 2008.

WASHINGTON

To determine how much money Washington state agencies and universities spend on invasive species management, the state Invasive Species Council drew from a questionnaire sent to key organizations and agencies working on invasive species projects. The survey included questions related to current projects conducted in the state, project budgets, and project purpose (See Table A). Then the council used the State Noxious Weed Funding Report (commissioned by the council) to learn about agencies' noxious weed management activities.

Using data from these sources, the Council grouped project costs into the seven categories listed in Table A. In some cases, respondents were unable to separate out direct and administrative costs. Nevertheless, the spending figures below offer the best information the council has on the statewide budget for invasive species management. According to the information provided, Washington spends an estimated $28.4 million per biennium on invasive species prevention and control measures.

Washington Invasive Species Management, 05-07 Biennium Spending Total: $28,443,962
State Agency Biennial Spending on Invasive Species 33 $21,294,455
Academic Institution Biennial Invasive Species Spending 34 $7,149,507

The council next looked at how the agencies spent their funds. The breakdown of state spending by project purpose is shown in Table A and Figure 1 (see next page). The data indicate that 47 percent of state spending on invasive species is for containment or control efforts, with much less spent on eradication or prevention.

WISCONSIN

The Wisconsin Department of Natural Resources (DNR) spent $7.6 million on invasive species management (plant and animal) in 2011, which increased to $9.3 million in 2012 (based on preliminary spending estimates). Of this investment, about 82% was spent on aquatic invasive species. The source of funds was largely State Segregated Funds, providing 76% of all aquatic invasive species funding for 2011-2012, and 73% of terrestrial invasive species funding.

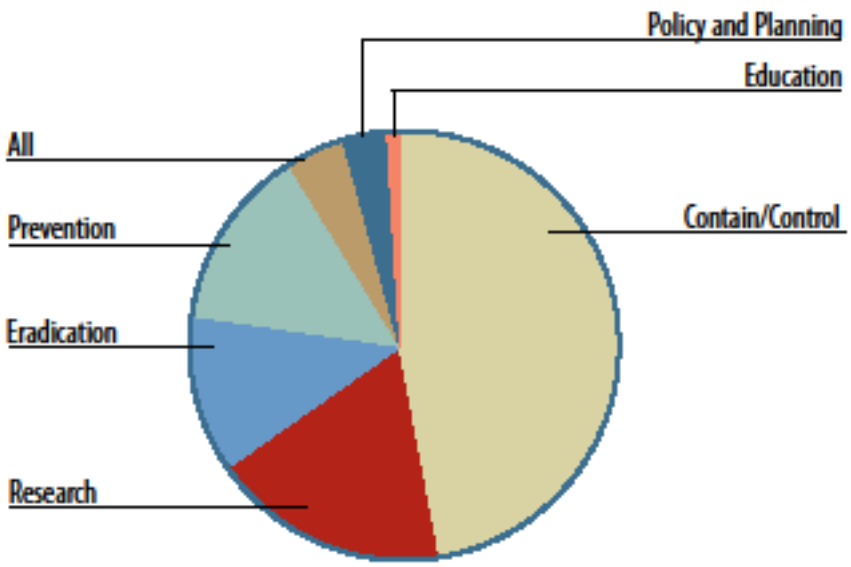
State terrestrial funding of $1,132,189 in 2012 also included invasive animals. In terms of invasive plants on state natural areas, the report states "A small crew of dedicated DNR staff and volunteers manage these precious areas, primarily by controlling the invasive plants that would otherwise eliminate the resources these areas were set aside to protect." Wisconsin's 655 natural areas encompass over 362,000 acres. Separately, the state park system

Washington State Spending on Invasive Species Management

Table A

PROJECT PURPOSE	BUDGET (Biennium)	PERCENT OF TOTAL
Contain/Control	$13,456,174	47.31
Research	$5,483,912	19.28
Eradication	$3,685,500	12.96
Prevention	$3,336,500	11.73
All [36]	$1,260,000	4.43
Policy and Planning	$1,060,764	3.73
Education	$161,112	0.57
TOTAL:	$28,443,962	100.00

Figure 1

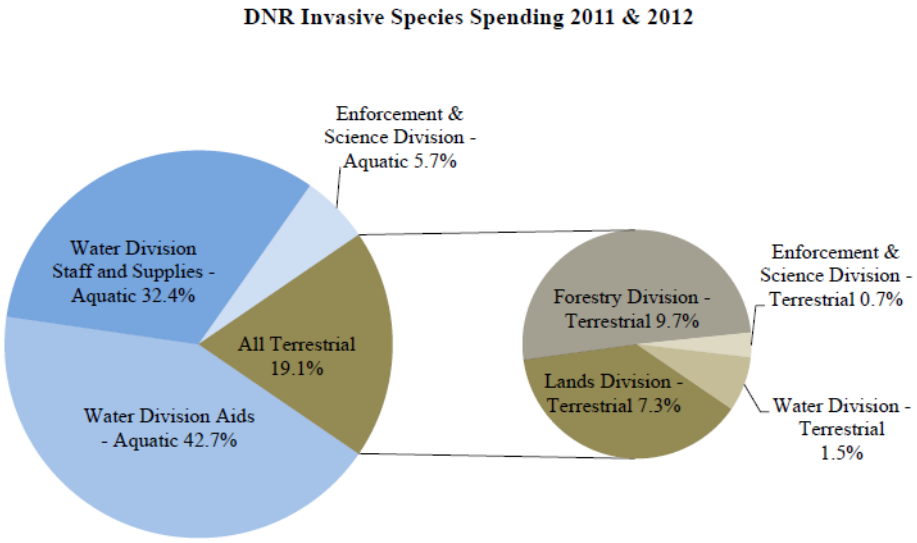


Note: This is preliminary data

[36]"All" describes entities that associated contain, research, eradication, prevention, policy and planning, and education project purposes with their budget figures and could not be broken into individual categories.

includes both state parks and state recreation areas. Wisconsin currently has 66 state park units, covering more than 60,570 acres. The Division of Forestry manages a further 471,329 acres of state forests. Annual funding for invasive plant management (alone) on approximately 900,000 acres of state lands would thus be less than $1 million.

Wisconsin DNR Spending on Invasive Species Management



Part 2. *THE STATE OF FLORIDA*

Upland Invasive Exotic Plant Management Program

The Upland Invasive Exotic Plant Management ("Uplands") Program began as a one-year, one million dollar pilot program. The success of that effort led to creation of an established program with base funding starting at $1 million dollars and rising to $8,686,000 by 2004. The Uplands Program has been recognized nationally for its cooperative model of bottom-up stakeholder involvement in directing program expenditures. The Uplands Program seeks to fund invasive plant control on public conservation lands in an efficient, effective, and cost-saving manner. This is accomplished through 6 steps:

1. Land managers prepare a proposed Scope of Work that is submitted to a Regional Working Group.
2. Each Working Group is composed of land managers and stakeholders, who review and prioritize proposals and then send a ranked list to the Uplands Program.
3. The Uplands Program allocates funding across each of the eleven Working Groups. The number of projects varies with funding, but falls between 55 and 100+ each year.
4. The Uplands Program bids out proposals to private contractors. The lowest quote is accepted.
5. Contractors are required to submit daily work sheets to the site manager, who must sign off on the work completed before an invoice can be submitted.
6. The site manager reviews the work to ensure that the target of 95% control of species over 100% of the treated area has been achieved. The Uplands staff also conduct random compliance reviews.

In addition to Working Group submitted projects, the Uplands Program funds three special projects each year:

1. Florida Natural Areas Inventory (Natural Heritage) Contract - mapping distribution of invasive plants on public conservation lands, assisting land managers, and assisting Cooperative Invasive Species Management Areas (CISMA).
2. Herbicide Bank - provides chemicals at no cost to assist land managers with maintenance of previous Uplands Program projects. In FY12, 46 projects totaling $350,000 were completed on 150,000 acres.
3. Melaleuca Program - $1 million matched with $1 million from the South Florida Water Management District (SFWMD) for control and maintenance operations on *Melaleuca quinquenervia* within the District's boundary.

The Uplands Program also has established contracts with other goverment agencies, including the SFWMD and four counties. These contracts are used when an agency has the ability to do a project themselves on property they manage, but do not have the necessary funding.

Historically, the Uplands Program has completed over 2,000 projects on nearly two million acres at a total cost of $121 million. While an economic analysis of the program has not been conducted, the use of private contractors for nearly every project has created hundreds of permanent and seasonal jobs. Given that 85-90% of a project's cost is in labor, much of the state's funding has been returned through local spending, thus boosting Florida's economy.

Beginning in the 2009-10 state fiscal year, the Uplands Program's base funding was reduced in response to decreased state revenues, resulting from the recession and collapse of the housing market in Florida. With less funding, fewer operational projects were completed (see Table 1). In addition, the program's emphasis shifted from initial control to maintenance control. In the current fiscal year, the program received $11 million in funding, which will allow some progress toward making up for (literally) 'lost ground', assuming this level of funding is sustained in the future.

Table 1. Operational Funding History FY08-FY13

Year	Project $	# Projects	Acres Treated
FY07-08	$12M	142	240K
FY08-09	$13.2M	109	270K
FY09-10	$6.9M	80	200K
FY10-11	$6.2M	81	73K
FY11-12	$5.2M	80	131K
FY12-13	$4.4M	77	162K

The history of the program in treating terrestrial invasive plants on publication conservation land (PCL) is shown in the following two slides (see next page). Expenditures are for operational costs only, not including research, outreach, education, salary, or administrative overhead.

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Note: The Uplands Program is the largest, but not sole, funder of terrestrial invasive plant management in Florida. For public waterbodies, the Aquatic Plant Management Program has a much larger allocation (see Addendum 1), as is typical in other states. However, both the Aquatics and Uplands programs reside in the same agency unit and share a legislative budget appropriation. Other units within the FWC have their own invasive species funding for wildlife habitat management ($1,062,120 average over previous five years), aquatic habitat restoration, and exotic animals. Other state agencies including the Florida Park Service, Florida Forest Service, Florida Department of Agriculture, five regional water management districts, as well as several federal resource agencies, have separate funding for invasive species control on public lands and waters.

Attempts have been made to quantify the total amount of expenditures for invasive species management (all taxa) within Florida, but no single number has resulted (see Part 1). Estimates based upon incomplete data put the total around $90 - $100 million per year.

Additional information about the Upland Invasive Exotic Plant Management Program can be found at:

http://www.myfwc.com/uplandplantmanagement

Additional information about the Cooperative Invasive Species Management Areas can be found at:

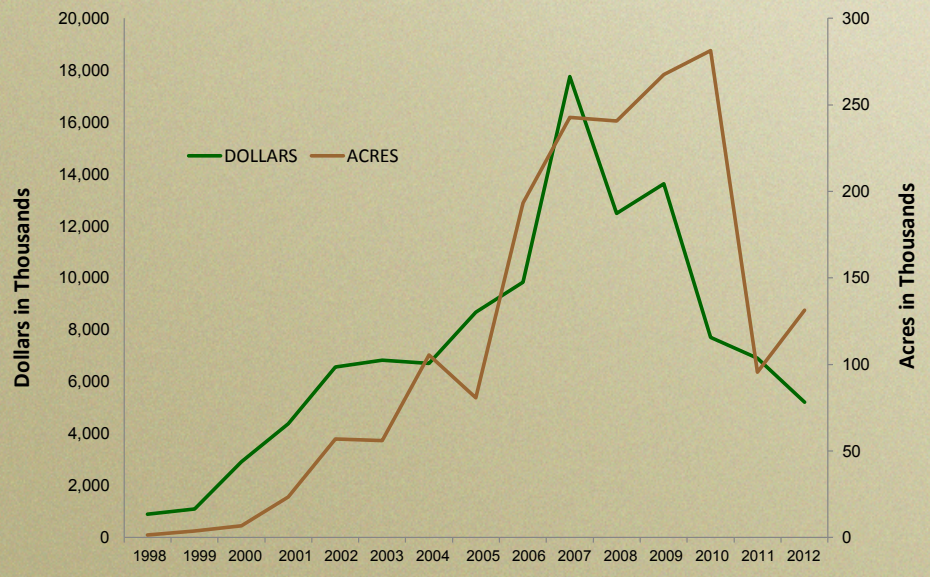
http://www.floridainvasives.org/cismas.html

The Florida Invasive Species Partnership (FISP) is a collaboration of federal, state and local agencies along with non-government organizations, all with a stake in managing invasive non-native species in Florida. FISP increases communication, coordination and the sharing of resources to protect Florida's natural landscape. More information can be found at: http://www.floridainvasives.org/index.html

Upland Invasive Plant Management

16-Year Program Results

FY1998-2012 Totals for Uplands Invasive Plant Control



Does not include FY13 numbers.

Invasive Upland Plants

16-Year Program Results

1997-2013

- **2,035 projects on 617 PCL units**
- **631,000 acres initial control**
- **1,308,000 acres maintenance control**
- **>100 invasive species targeted**
- **$121 million expended**
- **$42 million agency matching funds**

Addendum 1

FWC Aquatic Plant Management Program

Dollars Spent Controlling Aquatic Plants in Florida Public Waters from

Fiscal Year 1988-1989 through Fiscal Year 2011-2012

Fiscal Year	Dollars Spent	Acres Treated
88-89	7,858,001	52,190
89-90	6,531,864	37,840
90-91	6,165,868	42,526
91-92	7,875,983	45,926
92-93	8,855,989	46,463
93-94	7,526,082	38,619
94-95	7,144,324	38,963
95-96	10,672,775	41,317
96-97	15,002,793	47,719
97-98	14,022,966	41,356
98-99	16,962,298	48,708
99-00	17,081,310	41,844
00-01	15,838,267	32,234
01-02	22,321,767	53,078
02-03	24,665,007	64,520
03-04	21,439,952	66,817
04-05	22,506,171	57,795
05-06	21,672,961	64,503
06-07	15,862,891	50,098
07-08	17,766,163	75,727
08-09	18,395,404	59,840
09-10	22,724,112	89,730
10-11	18,926,231	55,192
11-12	19,113,659	68,194
Total	**$366,931,838**	**1,261,199**

Addendum 2

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Addendum 3

An Annotated Bibliography on the Economics of Invasive Plants

by

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April 2004

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[c] Karen Klonsky is a Cooperative Extension Specialist, Department of Agriculture and Resource Economics, University of California, Davis.

Bangsund, Dean A., James F. Baltezore, Jay A. Leitch, and F. Larry Leistritz. 1993. Economic Impacts of Leafy Spurge on Wildlands in Montana, South Dakota, and Wyoming. North Dakota State University, Agricultural Economics Station, Agricultural Economics Report no 304. 49 pages.

This report examines the economic costs of leafy spurge on wildland in Montana, South Dakota, and Wyoming. Wildland is land not used for/classified as agriculture, urban, built-up, or surface water acreage such as rivers and streams. Leafy spurge infestations reduce recreational expenditures, and soil and water conservation benefits. Recreational expenditures include all wildlife consumptive (hiking, hunting, fishing, etc.) and nonconsumptive activities (aesthetic viewing of wildland, benefits provided knowing it exists for future generations, etc.). The authors make use of existing estimates to value the soil and water conservation benefits provided by wildland acreage.

The report finds that wildlife expenditures, and soil and water conservation benefits lost to leafy spurge are $465 thousand a year in Montana, $267 thousand in South Dakota and $71 thousand in Wyoming. The total annual direct and indirect costs of leafy spurge on wildland is $1.041 million in Montana, $728 thousand in South Dakota and $176 thousand in Wyoming for total lost benefits of $1.95 million in all three states.

Bangsund, Dean A. and F. Larry Leistritz. 1991. *Economic Impact of Leaf Spurge in Montana, South Dakota, and Wyoming.* North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 275. 85 pages.

This report estimates the direct and indirect economic impact of leafy spurge on Montana, South Dakota, and Wyoming grazing lands. Grazing land includes private pasture, private ranchland, and federal grazing land. Economic losses attributed to leafy spurge result from reductions in carrying capacity. Carrying capacity reduction models are used to calculate the reduction in carrying capacity resulting from leafy spurge infestations. Direct economic losses are evaluated as changes in payments to land owners and decreased expenditures for livestock inputs. Lost land income is determined by multiplying lost carrying capacity by land rental rates. The decrease in livestock expenditures are extrapolated from developed livestock budgets, one for Montana and Wyoming, and another for South Dakota. The secondary effects of leafy spurge on other related business sectors are estimated using the North Dakota Input-Output model.

Leafy spurge results in direct losses of $5.7 million a year in Montana, $3.8 million for South Dakota, and $0.8 million for Wyoming. The direct and secondary effects of leafy spurge in all three states is $34 million, $13 million in Montana, $8.8 million for South Dakota and $1.8 million in Wyoming. If left untreated, by 1995 leafy spurge losses may rise to $46 million a year in Montana, South Dakota, and Wyoming.

Bangsund, Dean A., F. Larry Leistritz, and Jay A. Leitch. 1997. *Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest.* North Dakota State University, Agricultural Experimental Station Agricultural Economics Report no. 382. 53 pages.

This report estimates the benefits of controlling leafy spurge in the Midwest (Montana, North Dakota, South Dakota, and Wyoming) using a biological control program. The benefits of controlling leafy spurge include increases in: grazing AUMs, wildlife recreational expenditures, and water and soil conservation. This report hypothesizes that by the year 2025, 65% of future infestations or 1.85 million acres of leafy spurge, will be 65% controlled. It assumes grazing land returns to 75% of pre-infestation productivity after treatment, and wildland to 100%.

Total annual grazing benefits are $11.5 million, recreation benefits are $2.6 million, and water and soil benefits are $0.320 million. Adding secondary impacts to these, the report arrives at an annual benefit estimate of $58 million for controlling leafy spurge in the Midwest by the year 2025.

Bangsund, Dean A., F. Larry Leistritz, and Jay A. Leitch. 1999. "Assessing Economic Impacts of Biological Control of Weeds: the Case of Leafy Spurge in Northern Great Plains of the United State." *Journal of Environmental Management* 56. p. 35-53.

In this article, the direct and indirect benefits of controlling leafy spurge using a biological control program are estimated for the Great Plains region (Montana, North Dakota, South Dakota, and Wyoming). Direct benefits of controlling leafy spurge include increases in livestock and wildlife carrying capacity. The indirect benefits from changes in business volume, personal income, retail sales, and other economic activity, are calculated using an input-output analysis.

Direct leafy spurge control benefits are $19.1 million a year. This is allotted as $4.98 million in improved livestock carrying capacity, $11.74 million in increased livestock production expenditures, $1.8 million in wildlife related recreational expenditures, and $0.485 million in water and soil conservation. Adding secondary benefits of $39.3 million results in leafy spurge removal benefits of $58.4 million a year in the Great Plains region by the year 2025.

Bangsund, Dean A., Jay A. Leitch and F. Larry Leistritz. 1996. *Economic Analysis of Herbicide Control of Leafy Spurge in Rangeland.* North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 342. 44 pages.

This report compares the net returns of leafy spurge control under three different treatment options: no treatment, perimeter treatments, and rangeland renovation. The present value of net returns is calculated for a base scenario of a one-acre leafy spurge infestation spreading at 2.00 feet per year, and for variations of the base scenario using a 4% discount rate and a twenty-year period.

Perimeter treatments result in negative net returns regardless of the weed infestation specifics. Rangeland renovation, in contrast, results in positive net returns for infestations of less than half an acre. However, only rarely does rangeland renovation of infestations of larger than fifty aces, or those with carrying capacities higher than 0.65 acres per AUM, result in positive net returns.

Bangsund, Dean A., Dan J. Nudell, Randall S. Sell, and F. Larry Leistritz. 1999. *Economic Analysis of Controlling Leafy Spurge with Sheep*. North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 431. 119 pages.

A benefit/cost analysis of using sheep to reduce leafy spurge in pastures is modeled in this report. The benefits of using sheep arise from their ability to maintain carrying capacity levels that would otherwise be lost due to leafy spurge infestations. The level of carrying capacity that would be lost without sheep grazing, given various leafy spurge levels, is determined using models developed by Bangsund et al (1996). Sheep are obtained either by setting up a sheep enterprise or by renting sheep on a per month basis. Sheep enterprise costs are obtained from budgets. When sheep are rented, the cost is $1to $2 per ewe per month. The base scenario used in this report is a 350-acre ranch, with 50 or 250 acres infested and grazing losses of 17%, 50%, and 100% (increasing 1.5% annually). Initial carrying capacity is 0.20 AUM per acre or 0.90 AUM per acre. The costs of building a fence to confine the sheep, the debt financing system use to obtain the sheep, the initial carrying capacity of the land, the initial infestation size and percentage infested, and sheep performance levels are varied to determine the benefits and costs for different grazing scenarios.

With a sheep enterprise and under best-case scenarios, the present value of net returns per acre ranges from $90 to $180 over a five-year period and $170 to $340 over a fifteen-year period. Under sheep performance levels significantly worse than best-case scenarios, net returns per acre range from –$50 to $80 over five years and –$85 to $80 over fifteen years. For the sheep rental scenario, there are negative net returns when evaluated over a five-year period. Over a ten-year period, the net returns to leasing sheep become positive only with high initial leafy spurge levels and rangeland carrying capacities.

Coombs, Eric M., Hans Radtke, Dennis L. Isaacson, and Stanley Snyder. 1996. "Economic and Regional Benefits from Biological Control of Tansy Ragwort, *Senecio Jacobaea*, in Oregon." In *International Symposium on Biological Control of Weeds*. VC Moran and JH Hoffmann (eds.) University of Cape Town. Stellenbosch, South Africa. p. 489-494.

This report compares ragwort induced economic losses in Oregon with the cost of a ragwort biological control program. Losses from ragwort include livestock poisonings, lost livestock forage, and money spent on ragwort control. Cattle poisonings consumed 2%-10% of herds in 1974 valued at $3.72 million. Horse poisonings cost $29 thousand in 1974. Ragwort losses in Oregon in 1974, after including lost forage and other control expenses, were approximately $5 million.

Under a joint public/private cost-sharing program, the following insects were released throughout Western Oregon: the cinnabar moth, the ragwort flea beetle and the ragwort seed fly. In 1974, contributions to fund the biological control program were $483 thousand from county, state and federal funds, and $849 thousand from private ranch owners. Using a discount rate of 7%, biological control generates a benefit/cost ratio of 15:1. With a 10% discount rate, the benefit/cost ratio becomes 13:1.

Dewit, Marcia. 2001. "Economic Impact of Invasive Weeds." In *Noxious Weeds* 4, no 1. California Interagency Noxious Weed Coordinating Committee. p. 8-11.

This article uses data from Pimentel et al, 2000, to determine the economic impact of invasive weeds in lakes and streams, agriculture, pastures, lawns, golf courses and gardens. Economic losses from weeds include reduced output and the cost of weed control. In addition, it also estimates the effect of weeds on natural services using over 1,000 estimates from published papers. Natural services are any function the ecosystem provides that generates a human benefit.

The article concludes that invasive weeds in lakes and streams, agriculture, pastures, lawns, golf courses and gardens cost the U.S. $34.1 billion a year. Natural services lost to weeds are valued at $33.3 trillion a year.

Hartmans, Martha A., Hongpei Zhang, and Ed L. Michalson. 1997. *Costs of Yellow Starthiste Management*. Agricultural Experimental Station, University of Idaho, Bulletin 793. 12 pages.

The report compares the costs and benefits of treating yellow starthistle in Idaho. The following treatment options are evaluated: no treatment, annual spraying, or a rangeland renovation program involving spraying and reseeding. Slope elevation, project time and program success rates were varied in the analysis. Depending on the slope elevation, spraying and seeding was done with a tractor, an airplane or a helicopter.

The report finds that the internal rate of return (IRR) under a rangeland renovation program is negative for the first three years of the project, regardless of application method. The IRR improves once the benefits of a rangeland renovation program are spread over the full life of the project. Using a tractor for application, the IRR with treatment ranges from 13.9% over ten years to 17.4% over twenty years. When a helicopter is used, the IRR is lower, but remains favorable at 4% over ten years and 9.4% over twenty years. Annual spraying had a negative IRR under all conditions, and using all application methods.

Hirsch, Steven A. and Jay A. Leitch. 1996. *The Impact of Knapweed on Montana's Economy.* North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 355. 43 pages.

This report estimates the impact of knapweed generated economic losses in Montana. Direct losses attributed to knapweed include lost grazing potential, reduced wildlife- related recreation, higher levels of soil erosion and reduced water quality. Secondary losses arise

from reduced employment, income and expenditures in related economic sectors. Annual direct losses from knapweed in Montana are $11.0 million in grazing, $1.2 million in wildlife, and $1.92 million in soil and water conservation. Adding secondary losses of $28 million results in knapweed losses of $42 million a year.

Jetter, Karen M., Joseph M. DiTomaso, Daniel J. Drake, Karen M. Klonsky, Michael J. Pitcairn, and Daniel A. Sumner. 2003. "Biological Control of Yellow Starthistle." Chapter 15 in *Exotic Pests and Diseases: Biology and Economics for Biosecurity*. Daniel A. Sumner (ed.). Iowa State University Press. Ames, Iowa. p.225-241.

This chapter examines the costs and benefits of a ten-year public biological control program for yellow starthistle, and estimates how public biological control programs affect the incentives ranchers have to undertake private rangeland restoration programs. The benefits of a public biological control program are calculated as the increase in the land's asset value. Program costs include the net present value of public expenditures to find, test, import, and release biological control agents. The benefits of private rangeland restoration are due to increases in land values from being able to graze a greater number of animal units on a given amount of land. The costs of the private four-year restoration program include weed treatment, reseeding and lost grazing income. With no biological control, weed treatments are for yellow starthistle and all other weeds. When the public biological control program is successful, the cost to ranchers to control yellow starthistle is equal to zero, and ranchers only treat for all other weeds.

Benefits of a biological control program are estimated to range from $40 million-$1.412 billion. Using a discount rate of 7%, a public biological control program must have at least a 21% probability of success at the lower bound benefit level and a 0.60% probability of success at the upper bound benefit level for the expected benefits to equal the expected costs. The private costs of rangeland restoration are greater than the private benefits, even with a successful public biological control program, thus a policy of public subsidies may be needed to encourage ranchers to restore infested land. A successful public biological control program reduces the subsidies needed to encourage private rangeland restoration from $26-$46/acre to $4-$21/acre.

Leitch Jay A., F. Larry Leistritz, and Dean A. Bangsund. 1994. *Economic Effects of Leafy Spurge in the Upper Great Plains: Methods, Models and Results.* North Dakota State University, Agricultural Experimental Station, Agricultural economics report no. 316. 8 pages

In this report, the methods and models used in the authors' previous studies are updated to estimate costs of leafy spurge infestations in the Upper Great Plains in 1993. Both wildland and rangeland impacts due to leafy spurge infestations are calculated.

This report finds that leafy spurge removal in 1993 would generate annual benefits to the Upper Great Plains of $37.1 million in direct livestock sales, $24.3 million in direct production expenditures, and $119 million in both direct and indirect grazing. Adding wildland benefits to the sum results in total leafy spurge removal benefits of $129.5 million a year.

Pimentel David, Lori Lach, Rodolfo Zuniga, and Doug Morrison. 2000. "Environmental and Economic Costs of Non-indigenous Species in the U.S." *Bioscience* 50, no. 1. p. 53-65.

This article addresses the environmental impacts and economic costs of non-indigenous species in the U.S. This is done using previously published estimates. Damages caused by non-indigenous species are based upon total damages caused by both indigenous and non-indigenous species in the U.S., and the percentage of the total species that is non- indigenous.

The report determines that the U.S. spends $137 billion annually fighting non-indigenous species. This includes non-indigenous plants, mammals, birds, reptiles, fish arthropods, mollusks and microbes. The U.S. spends $100 million treating aquatic non-indigenous weeds and incurs $10 million in additional economic damages. The U.S. also spends $26.4 billion on agricultural weeds; $6 billion on pasture weeds, and $1.5 billion on lawn, garden and golf course weed treatment. This results in $34 billion spent or lost annually in the U.S. to non-indigenous weeds.

Rockwell, William H. 2003. *Summary of a Survey of Literature on the Economic Impact of Aquatic Weeds*. Aquatic Ecosystems Restoration Foundation Report. http://www.aquatics.org/pubs/economic_impact.pdf. Accessed 12/2/2003. 18 pages.

This report estimates the benefits and costs of treating invasive aquatic weeds in the U.S. using two different methods. The first method takes the $25 million in weed control costs in Florida and assumes that Florida accounts for between 5% and 20% of total U.S. weed control expenditures. The second method uses the current costs of treating aquatic weeds in the U.S. with chemicals only, assumes that 10%-75% of aquatic weeds are treated chemically, and that chemical treatment is 0.5 to 2 times as effective as other treatments. Using a benefit/cost ratio of 10:1, the report calculates the benefits of treating aquatic weeds in the U.S. as $10 for every $1 in control costs.

Using the first method, the benefits are $250 million for Florida. When Florida accounts for 5% of aquatic weed treatments, the benefits to the U.S. are $1.0 billion. When Florida accounts for 20%, the U.S. benefits are $10 billion. Using the second method, $150-$400 per acre is spent treating inland water surfaces for weeds with chemicals, resulting in total costs of $50-$100 million a year. Weed treatment benefits for the U.S. range from $500 million when 75% of weeds are treated chemically, and other treatments are half as effective as chemical treatment, to $1 billion when 10% of weeds are treated chemically, and other treatments are twice as effective as chemical treatment.

Smith, H. Arlen, Wayne S. Johnson, J.Scott Shonkwiler, and Sherm R. Swanson. 1999. "Implications of Variable or Constant Expansion Rates in Invasive Weed Infestations." *Weed Science* 47. p. 62-66.

The article compares weed control costs using constant as opposed to variable weed patch growth rates. Using 35 weed patch size observations from different times, they specify a weed patch growth rate function. They then use estimated weed treatment costs ($90/acre for herbicide control with 75% effectiveness) and both a constant and variable weed expansion model to determine how the choice of functional form affects weed treatment cost estimates.

Costs are calculated for immediate control and delayed control assuming initial infestation rates of 10 hectares, 100 hectares and1000 hectares, and time periods from 5 years to10 years. For 10-hectare and 100-hectare infestations, the results show that costs increase when treatments are delayed, and when a variable rate expansion path is used.

Thompson, Flint, Larry Leistritz, and Jay Leitch. 1990. *Economic Impact of Leafy Spurge in North Dakota*. Agricultural Experimental Station, North Dakota State University. 23 pages.

This report examines the consequences of leafy spurge on livestock income and related expenditures in North Dakota. It uses developed models to calculate leafy spurge expansion rates in North Dakota and resulting reductions in carrying capacity and estimates the value of lost carrying capacity and reductions in rancher spending due to lower carrying capacities. Secondary impacts of leafy spurge consist of indirect impacts on regional businesses from reductions in carrying capacity and rancher expenditures.

Leafy spurge infestations on North Dakota cause losses of $8.6 million a year in carrying capacity and $14.4 million a year in potential direct rancher spending. Including secondary impacts, leafy spurge results in economic losses of $75 million a year in North Dakota.

Wallace, Nancy M., Jay A. Leitch, F Larry Leistritz. 1992. *Economic Impact of Leafy Spurge on North Dakota Wildland.* Department of Agricultural Economics, North Dakota State University, Agricultural Economics Report no. 281. 23 pages.

This report examines the benefits of controlling leafy spurge on North Dakota wildland. According to this report, wildland is any land not used for industrial, urban, or agricultural purposes. Removing leafy spurge will increase wildlife-related recreational expenditures, and soil and water conservation benefits. Estimates of water and soil conservation benefits from non-infested wildland are taken from the literature on agriculture conservation preserve programs.

In 1990, $2.95 million in potential direct recreational expenditures and $0.7 million in direct water and soil conservation benefits were lost due to leafy spurge infestations. Adding secondary benefits from changes in business activity of $7.4 million, results in leafy spurge losses of $11.0 million a year in North Dakota.

Washington State Noxious Weed Control Committee. 1996. *Economic Analysis: Noxious Weed Control on State Land*. Presented to the Washington State Legislature. 37 pages.

In this report, the total potential costs of noxious weed treatment on state managed land in Washington are estimated. Weed treatment costs are based upon estimates from state agencies and vary depending on land type, infestation severity and extent, and weed treatment method. Costs are calculated for each activity in a weed treatment program: surveying, prevention, controlling new infestations, controlling established infestations, and monitoring past efforts.

Given an annual weed treatment budget of $5.375 million, the Washington State Noxious Weed Control Board determines that about $2.2 million should be spent controlling existing infestations and $12 million for surveying. Controlling new infestations should receive $875 thousand, prevention $859 thousand and monitoring $250 thousand.

Zavaleta, Erika. 2000. "The Economic Value of Controlling an Invasive Shrub." *Ambio.*29, no. 8. p. 462-467.

This article compares the economic benefits and costs of a tamarisk removal program. Economic losses from tamarisk are estimated as the lost benefits of not having approximately 1.4 billion to 3.0 billion m^3 of water a year available for household use, irrigation agriculture, hydroelectric power generation and flood control. The value of household, agricultural, hydrologic and flood losses was $280-$450 ha^{-1} a year for 22 years.

The tamarisk removal program consists of: planning, removal, revegetation, and monitoring activities. This program costs $7,400 ha^{-1} and between 470 thousand to 650 thousand hectares would be treated. With the annual benefits of tamarisk removal accruing forever, and using discount rates from 0-6%, the article estimates that it will take 17-26 years to recover all eradication costs at a 0% discount rate and 16-50 years at a discount rate of 6%.

Zavaleta, Erika. 2000. "Valuing Ecosystems Services Lost to Tamarisk Invasion in the United States." Chapter 12 in *Invasive Species in a Changing World*. H. A. Mooney, Hobbs, R.J. (eds.). Island Press, Washington D.C. p. 261-300.

This chapter compares the benefits and costs of treating tamarisk infested land in the U.S. Treating tamarisk generates an extra 1.16 million to 2.41 million acre feet of water available for: household use, agriculture, hydrological power generation, flood control, river recreational activities, wildlife, and ecosystem natural services. This generates benefits of $6,300-$9,700 per acre over 55 years.

These benefits are compared with the costs of a tamarisk removal program consisting of: evaluation, plowing, hand-application of herbicide, revegetation, and monitoring. Such a program costs $3,006 per acre and 1.16 million acres of tamarisk are treated. Evaluated over a period of 55 years, and using discount rates of 0-6%, the benefit/cost ratio is 2.10-3.32 for a 0% discount rate and 1.05-1.63 for a 6% discount rate.