

CURRENT & POTENTIAL ECONOMIC IMPACTS OF TO INVASIVE WEED SPECIES IN WYOMING

A PILOT STUDY OF AGRICULTURAL LOSSES

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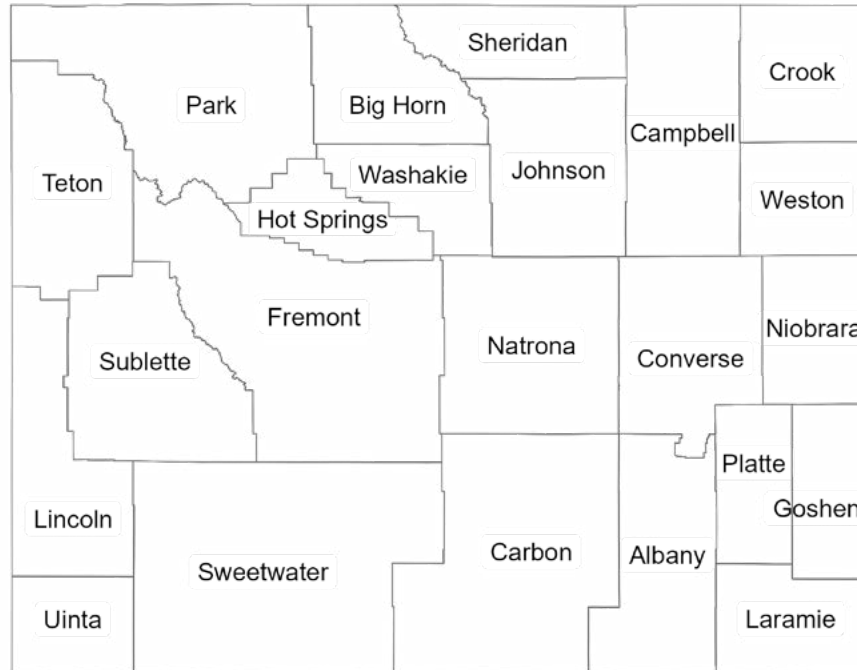


Palmer Amaranth. Photo by Andrew Kniss.

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Figure 1. Wyoming counties.



EXECUTIVE SUMMARY

The widespread and diverse negative impacts of invasive weeds on natural ecosystems of the western U.S. are often discussed in a general sense, but attempts to estimate specific economic impacts are not very common. In response to guidance from a diverse group of Wyoming stakeholders who developed the recommendations in the Governor’s Invasive Species Initiative Report, the Wyoming Weed and Pest Council and the University of Wyoming initiated the pilot study reported here to estimate current and potential future impacts of a subset of 10 invasive weed species on Wyoming’s agricultural sector with a specific focus on impacts to grazing resources.

We consider this report to be a pilot study because of the focus on a single aspect of the economy and because it does not include all of the state’s designated noxious weeds. We used a combination of estimated current acres infested by each weed in each county and the predicted acreage of suitable habitat for each species to estimate 1) current grazing losses and 2) grazing losses if the species were allowed to spread, unmanaged, into all potentially suitable habitat.

While current estimated statewide grazing losses are in the tens of millions of dollars annually, county-level impacts vary widely across the state. Cheatgrass (*Bromus tectorum*) has the highest estimated current and future potential impacts, which may exceed \$110 million annually if left unmanaged into the future. If considered in the broader context of Wyoming’s economy, these numbers are likely a very conservative estimate of impacts because we only accounted for losses due to grazing reductions.

INTRODUCTION

In October 2020, the Wyoming Governor’s Office issued a final report outlining the Governor’s Invasive Species Initiative (OWG 2020). One of the priorities identified in the Governor’s report is to assess the current extent of invasions and how to best use that information. The economic analysis presented in our pilot study provides an additional layer of information about the impacts of weed infestation across Wyoming. Quantifying the agricultural value at risk can aid in prioritizing species for control and provide a basis for comparison over time.

The analyses presented here focus on the agricultural value lost and at risk from 10 weed species in Wyoming at the county and state level. We consider both the current estimated agricultural value reduced by weed infestation in areas with observed weed presence as well as potential risk for future infestation in areas considered suitable habitat for the selected species. These analyses do not consider economic impacts related to recreation, ecosystem services, wildfire, wildlife habitat, or the like.

The report begins with background and justification for this work, then outlines objectives of the analysis, followed by a discussion of the methods used to define agricultural area and value. Next, the report details weed species distribution to estimate the reduction in agricultural value due to weed infestation and associated economic activity at risk. State-wide results are presented, followed by a summary of each individual species. The report concludes with implications and possible opportunities for extended and related analyses.

Table 1. Definition of agricultural land use categories from aggregated National Land Cover Database (NLCD) land class

NLCD land cover class	Acres in Wyoming	Agricultural land class	Acres in Wyoming
Open Water	445,776		
Perennial Snow / Ice	12,743		
Developed, Open Space	297,591		
Developed, Low Intensity	143,146		
Developed, Medium Intensity	81,125		
Developed, High Intensity	19,404		
Barren Land	763,893	Non-agricultural	10,224,998
Deciduous Forest	251,191		
Evergreen Forest	6,928,433		
Mixed Forest	47,118		
Woody Wetlands	460,226		
Emergent Herbaceous Wetlands	774,352		
Shrub / Scrub	35,453,478		
Herbaceous	15,168,762	Rangeland	50,622,241
Hay / Pasture	915,584	Pasture & hay land	915,584
Cultivated Crops	1,095,648	Cultivated cropland	1,095,648
Total	62,858,471		

Source: National Land Cover Database (NLCD) 2019.

BACKGROUND AND JUSTIFICATION

The Wyoming Weed and Pest Council Guiding Principles Committee submitted a proposal to the Wyoming State Allocations Committee to assess the economic impacts of terrestrial invasive weeds in Wyoming. The need to better incorporate economic impacts into planning for invasive weed management in Wyoming was emphasized by Governor Gordon’s Invasive Species Initiative Report (OWG 2020). Other states have produced similar assessments, but state-wide evaluations for Wyoming have not been undertaken.

The Wyoming Weed and Pest Council partnered with the University of Wyoming and other collaborators to develop this pilot assessment for a subset of species of interest in Wyoming in 2021–2022. This pilot assessment is designed to be used as a model that can be expanded in future years.

Of the 30 plants declared as weeds in Wyoming statute 11-5-105(b)(vi), 10 are included in the initial pilot project. The 10 focal species selected for analysis were chosen to provide a cross section of important weedy species, including both widespread and emerging species, a diversity in taxonomic status, and a variety of growth forms (grasses, forbs, trees, annuals, perennials, etc.). These species are:

- Cheatgrass / downy brome (*Bromus tectorum*)
- Hoary cress / whitetop (*Lepidium draba*)
- Leafy spurge (*Euphorbia esula*)
- Medusahead wildrye (*Taeniatherum caput-medusae*)
- Palmer amaranth (*Amaranthus palmeri*)

- Perennial pepperweed (*Lepidium latifolium* L.)
- Russian knapweed (*Acroptilon repens*)
- Russian olive (*Elaeagnus angustifolia*)
- Ventenata (*Ventenata dubia*)
- Yellow starthistle (*Centaurea solstitialis*)

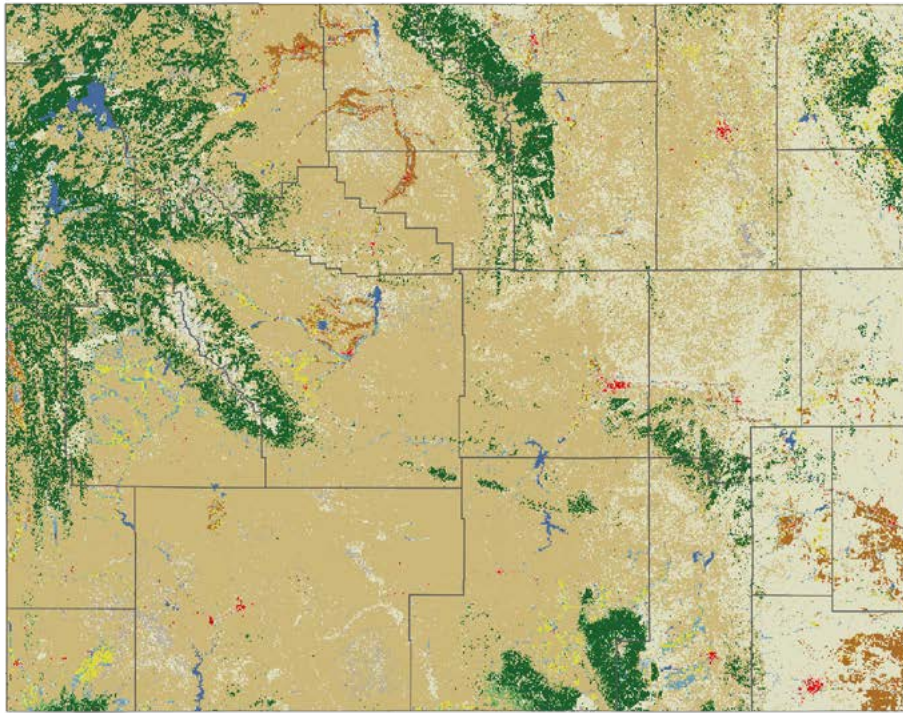
OBJECTIVES

The overarching goals of this pilot study are 1) to accurately estimate current (2022) impacts of invasive weeds to primary sectors of Wyoming’s economy, with a specific focus on agriculture, and 2) to estimate future agricultural value placed at risk if target species were allowed to expand into all suitable habitat. A multidisciplinary team (including weed and plant scientists, agricultural economists, and extension specialists) are collaborators in compiling and analyzing biological and ecological information to inform economic analyses at the state and county scales.

More specifically, objectives of this pilot project are to use best estimates of current spatial extent of infestations for each target species in Wyoming and to compile existing habitat suitability data for these species to estimate direct grazing and crop losses from weed infestations related to current infestation levels and potential future distribution in the absence of continued management.

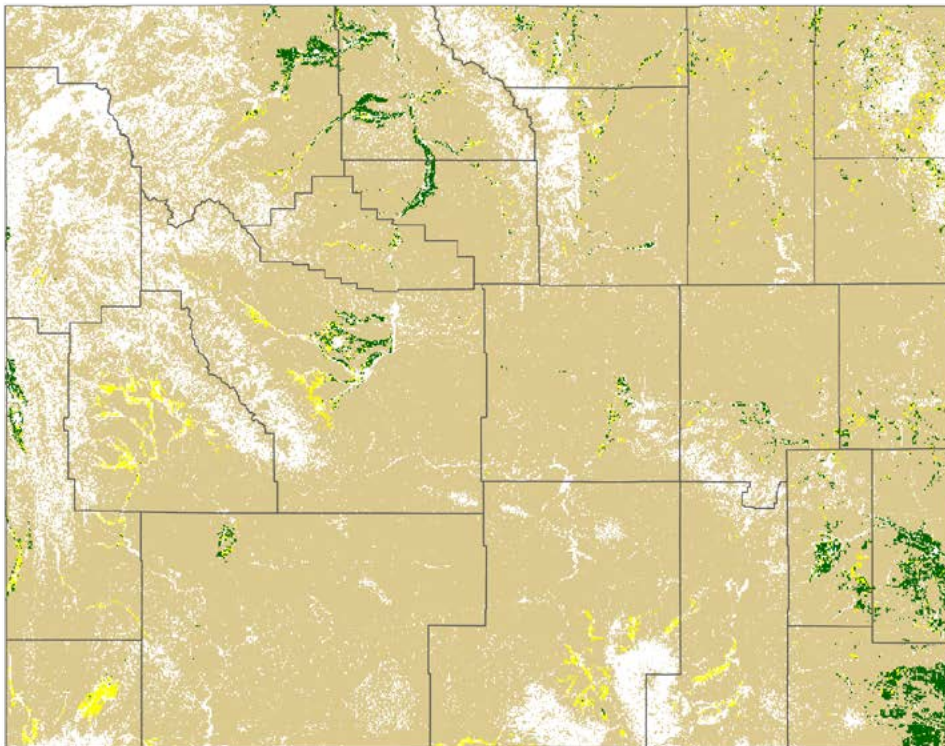
In summary, our approach consisted of estimating economic impacts of invasive weed species across Wyoming by identifying and quantifying agricultural uses and values affected by each identified species, then combining use impact estimates for the extent of infestation of each species

Wyoming National Land Cover Database



- Open Water
- Perennial Snow/Ice
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Herbaceous
- Hay/Pasture
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Wyoming Agricultural Land Cover



- Non-Agricultural
- Rangeland
- Pasture/Hay
- Cultivated Crops

Figure 2. National Land Cover Database showing all land cover categories (above) and selected, aggregated agricultural land cover categories (below) for Wyoming counties.

to quantify direct agricultural costs (cash rent loss due to weed infestation) of infestation for each species at the county and state level. Use impacts are estimated as weed-specific loss in agricultural rents. This valuation method is further applied to all suitable habitat to estimate agricultural value at risk. Economic impact analysis extends loss valuation to consider secondary spending at risk from the loss of potential agricultural income. Total economic activity at risk considers primary loss in agricultural rents (Direct Loss) as well as secondary household spending, which is the portion of foregone household income that would otherwise have been spent and re-spent locally (Induced Loss). Economic impact analysis terms are defined in the “Methods: Total Economic Activity at Risk” section below.

METHODS

Estimating foregone economic value resulting from weed infestations on agricultural land requires 1) a non-impacted baseline economic value of agricultural production; 2) the proportion of areas impacted by weed infestations; and 3) the estimated reduction in production, on a per-acre basis, expressed as reduced grazing and crop production value due to each weed species. The cost of weed presence is estimated as the product of reduced grazing and crop values in each of Wyoming’s 23 counties (Figure 1) for agricultural uses that are impacted by each of the 10 identified weed species. Summing across county estimates provides an estimate of statewide direct effects.

AGRICULTURAL LAND COVER AND VALUE

To estimate county-level cost associated with weed infestations, agricultural land cover combined with respective agricultural production values are used to quantify economic impacts of each weed species.

Land cover is described using the National Land Cover Dataset (NLCD) (Dewitz and USGS 2021) (Figure 2, top). Agricultural land cover is aggregated from NLCD land cover class as rangeland, pasture and hay, and cultivated crop production (described in Table 1). Table 1 includes statewide area totals. The proportion of each of these agricultural land cover categories multiplied by total county area provides a base agricultural use area in each county. The bottom map in Figure 2 shows how these aggregated land cover categories are distributed across the landscape in Wyoming; Table 2 reports agricultural land cover acreage for each category across individual Wyoming counties.

The value of agricultural production associated with livestock and crop land cover categories is estimated using county-level annual cash rent per acre (county estimates of the cash rent paid for different types of agricultural land) reported by the USDA’s National Agricultural Statistics Service (NASS) for 2021 (Table 3). Annual agricultural value

per acre of livestock-related land cover—rangeland and pasture and hay land cover categories—is estimated using annual cash rent for pastureland (NASS 2021a). Weed-infested cropland is considered to be non-irrigated for valuation purposes; agricultural value of cultivated cropland land cover is estimated using 2021 annual cash rent for non-irrigated cropland (NASS 2021b).

Multiplying county land cover acreage for each land use category (Table 2) by respective annual per-acre agricultural rent (Table 3) results in an estimated agricultural value for each county in Wyoming (Table 4). This value, reduced by weed presence and impact areas (described below), is used to calculate county-level and statewide economic loss for each of the 10 invasive weed species considered in this report.

WEED PRESENCE, IMPACTED AREA, AND SUITABLE HABITAT

We consulted Weed and Pest Control District personnel to provide county-specific information for each of the 10 species selected for economic impacts analysis, including two estimates of weed infestation:

- **Presence:** total acreage in a county where a weed is present; and
- **Impacted:** acreage where the estimated canopy cover of that weed species exceeds 20%.

Acreage for weed presence is reported in Table 5; weed-impacted acreages are reported in Table 6 for each county in Wyoming.

Suitable habitat for each weed species (except Palmer amaranth) is estimated as modeled by the USGS Invasive Species Habitat Tool, INHABIT (USGS n.d.; Young et al. 2020), which includes three levels of potential weed distribution: precautionary (more inclusive), balanced (moderate estimate), and targeted (more restrictive).¹ In this report, we use the moderate “balanced” model to estimate potential economic impacts on suitable habitat. For the remainder of this report, “suitable habitat” refers to area defined by the INHABIT moderate model with the following exception. Table 7 reports total county area and area estimated for suitable weed habitat acreage for individual species across the state.

Note that because Palmer amaranth does not currently have suitable habitat modeled by INHABIT, we used a different approach to estimate its potential suitable habitat in Wyoming. After consulting with several weed scientists, we considered all cultivated cropland (Dewitz and USGS 2021) to be suitable habitat for Palmer amaranth.

Each of the 10 weeds selected for economic impact estimation can be classified by its association with a particular agricultural land category or categories, as reported in Table 8.

¹ Targeted estimates use more stringent criteria for ecological characteristics, relative to the balanced model, predicting where each species may be able to exist; precautionary acreage uses a somewhat less stringent criteria than the balanced model and is more inclusive of potential sites, leading to a more liberal estimate of suitable acres.

Table 2. Area (acres) related to agricultural production by Wyoming county

Wyoming county	Rangeland	Pasture & hay	Cropland	Non-ag	Total
Albany	2,244,026 (81%)	32,775 (1%)	0	480,796 (17%)	2,757,597 (100%)
Big Horn	1,535,911 (76%)	21,845 (1%)	116,501 (6%)	347,040 (17%)	2,021,297 (100%)
Campbell	2,827,012 (92%)	76,042 (2%)	20,093 (1%)	152,892 (5%)	3,076,038 (100%)
Carbon	4,179,963 (82%)	91,406 (2%)	949 (<1%)	824,618 (16%)	5,096,936 (100%)
Converse	2,443,335 (90%)	15,066 (1%)	22,647 (1%)	248,586 (9%)	2,729,634 (100%)
Crook	1,291,123 (70%)	96,219 (5%)	39,192 (2%)	407,295 (22%)	1,833,829 (100%)
Fremont	4,782,381 (81%)	81,450 (1%)	71,620 (1%)	994,614 (17%)	5,930,065 (100%)
Goshen	1,168,675 (82%)	17,052 (1%)	184,632 (13%)	58,225 (4%)	1,428,583 (100%)
Hot Springs	1,156,832 (90%)	10,680 (1%)	6,011 (<1%)	110,571 (9%)	1,284,094 (100%)
Johnson	2,199,091 (82%)	25,662 (1%)	14,771 (1%)	432,214 (16%)	2,671,738 (100%)
Laramie	1,367,574 (80%)	13,460 (1%)	246,270 (14%)	92,721 (5%)	1,720,025 (100%)
Lincoln	1,812,968 (69%)	42,644 (2%)	45,256 (2%)	719,686 (27%)	2,620,554 (100%)
Natrona	3,223,706 (94%)	14,234 (<1%)	13,831 (<1%)	188,647 (5%)	3,440,418 (100%)
Niobrara	1,563,821 (93%)	24,438 (1%)	27,873 (2%)	65,752 (4%)	1,681,883 (100%)
Park	2,973,942 (67%)	33,865 (1%)	92,893 (2%)	1,356,992 (30%)	4,457,692 (100%)
Platte	1,120,583 (83%)	32,692 (2%)	78,572 (6%)	119,090 (9%)	1,350,937 (100%)
Sheridan	1,150,186 (71%)	38,127 (2%)	34,226 (2%)	394,383 (24%)	1,616,922 (100%)
Sublette	2,253,986 (71%)	113,180 (4%)	288 (<1%)	791,360 (25%)	3,158,813 (100%)
Sweetwater	6,310,401 (94%)	12,287 (<1%)	12,135 (<1%)	379,511 (6%)	6,714,333 (100%)
Teton	1,166,723 (43%)	6,261 (<1%)	3,235 (<1%)	1,522,822 (56%)	2,699,041 (100%)
Uinta	1,024,563 (77%)	76,944 (6%)	1,632 (<1%)	233,269 (17%)	1,336,407 (100%)
Washakie	1,271,902 (89%)	10,005 (1%)	39,545 (3%)	113,874 (8%)	1,435,326 (100%)
Weston	1,369,101 (89%)	22,780 (1%)	15,225 (1%)	128,906 (8%)	1,536,012 (100%)

Sources: Agricultural Land cover classifications are selected or aggregated from the 2019 National Land Cover Database;
 Total county area from U.S. Census Bureau;
 Area by land use category = land cover proportion × total acres by county.

Agricultural land type classifications for each weed were determined by weed science collaborators based on economic significance. Cheatgrass, medusahead, and ventenata mainly impact Wyoming rangelands used for livestock grazing; hoary cress has potential economic impacts on all agricultural land types; leafy spurge, perennial pepperweed, Russian knapweed, and yellow starthistle infestations have potential economic loss on rangeland and pasture and hay land types; Palmer amaranth is considered a risk to economic loss on cultivated cropland; and Russian olive has potential for economic loss on pasture and hay lands.

AGRICULTURAL VALUE REDUCED BY WEED INFESTATION

In agricultural areas, weeds compete for resources such as water, light, and nutrients, resulting in interference that reduces production values. In order to estimate the direct loss in agricultural value due to each weed species, annual cash rent (Table 3) for relevant agricultural land types (Table 8) is multiplied by

1. a percent loss on agricultural land type acreage where the weed is reported as “present”;
2. a loss estimate on acreage reported as “impacted” (canopy cover of that weed exceeds 20% of each acre);
3. and an average of present and impacted loss estimates on “suitable habitat” acreages.

Loss estimates reported in Table 9 are collected from literature describing agricultural impacts (livestock forage reduction) from infestation. These impacts were interpreted based on biomass reduction resulting from different levels of infestation on relevant agricultural land types for each weed, as interpreted by weed scientist collaborators on this report. Agricultural loss estimates are used statewide.

The highest economic loss estimates on areas where weeds are reported as present are for Palmer amaranth (70%) and medusahead (65%), followed by cheatgrass, Russian knapweed, and ventenata (40%); Russian olive (35%); hoary cress and perennial pepperweed (15%); and leafy spurge (10%). On impacted areas, defined as infestation of more than 20% canopy cover, Palmer amaranth and medusahead again have the highest loss estimates (100% and 95%, respectively); cheatgrass, Russian knapweed, ventenata, hoary cress, and perennial pepperweed each are estimated at 80% loss; Russian olive at 75%; yellow starthistle at 60%; and leafy spurge at 50%. Again, the percentage of potential loss on suitable habitat is estimated as an average of present and impacted percentages.

TOTAL ECONOMIC ACTIVITY AT RISK

Cash rents on agricultural lands, which we used to estimate the direct economic value reduced by weed infestations, enter county and state economies as household income. Households in turn spend a portion of this income

Table 3. Annual per-acre agricultural production values associated with agricultural land cover categories

Wyoming county	2021 Annual cash rent (\$/acre) ¹		
	Rangeland ²	Pasture & hay ²	Cultivated cropland ³
Albany	\$3.10	\$3.10	\$13.00*
Big Horn	\$12.50	\$12.50	\$13.00*
Campbell	\$4.00	\$4.00	\$13.00*
Carbon	\$3.20	\$3.20	\$13.00*
Converse	\$3.10	\$3.10	\$13.00*
Crook	\$6.40	\$6.40	\$12.50
Fremont	\$4.90	\$4.90	\$15.00
Goshen	\$6.20	\$6.20	\$15.00
Hot Springs	\$4.90	\$4.90	\$13.00*
Johnson	\$3.80	\$3.80	\$13.00*
Laramie	\$7.10	\$7.10	\$29.00
Lincoln	\$8.00	\$8.00	\$24.00
Natrona	\$2.80	\$2.80	\$13.00*
Niobrara	\$5.60	\$5.60	\$13.00*
Park	\$3.80*	\$3.80*	\$30.00
Platte	\$4.50	\$4.50	\$12.00
Sheridan	\$7.50	\$7.50	\$13.00*
Sublette	\$6.40	\$6.40	\$13.00*
Sweetwater	\$2.50	\$2.50	\$13.00*
Teton	\$3.80*	\$3.80*	\$13.00*
Uinta	\$6.00	\$6.00	\$13.00*
Washakie	\$3.80*	\$3.80*	\$13.00*
Weston	\$4.60	\$4.60	\$13.00*
Other counties	\$3.80	\$3.80	\$13.00
Statewide	\$4.80	\$4.80	\$17.50

Sources:

¹ Annual cash rent expense reported by the National Agricultural Statistical Service (NASS) 2021

² RENT, CASH, PASTURELAND - EXPENSE, MEASURED IN \$ / ACRE

³ RENT, CASH, CROPLAND, NON-IRRIGATED - EXPENSE, MEASURED IN \$ / ACRE

* Non-disclosed county value replaced by “Other Counties” value.

Table 4. Baseline estimated annual agricultural values by agricultural land cover category for Wyoming counties

Wyoming county	Rangeland	Pasture & hay	Cultivated cropland	Total
Albany	\$6,956,480	\$101,602	\$0	\$7,058,082
Big Horn	\$19,198,889	\$273,065	\$1,514,509	\$20,986,463
Campbell	\$11,308,047	\$304,166	\$261,209	\$11,873,422
Carbon	\$13,375,882	\$292,500	\$12,335	\$13,680,717
Converse	\$7,574,338	\$46,706	\$294,410	\$7,915,454
Crook	\$8,263,187	\$615,803	\$489,905	\$9,368,895
Fremont	\$23,433,667	\$399,106	\$1,074,296	\$24,907,069
Goshen	\$7,245,782	\$105,721	\$2,769,474	\$10,120,978
Hot Springs	\$5,668,477	\$52,331	\$78,144	\$5,798,953
Johnson	\$8,356,546	\$97,514	\$192,025	\$8,646,085
Laramie	\$9,709,774	\$95,563	\$7,141,842	\$16,947,179
Lincoln	\$14,503,745	\$341,151	\$1,086,134	\$15,931,031
Natrona	\$9,026,378	\$39,855	\$179,799	\$9,246,032
Niobrara	\$8,757,395	\$136,851	\$362,351	\$9,256,598
Park	\$11,300,980	\$128,689	\$2,786,776	\$14,216,444
Platte	\$5,042,626	\$147,113	\$942,862	\$6,132,600
Sheridan	\$8,626,397	\$285,949	\$444,937	\$9,357,283
Sublette	\$14,425,508	\$724,350	\$3,741	\$15,153,599
Sweetwater	\$15,776,002	\$30,717	\$157,755	\$15,964,474
Teton	\$4,433,548	\$23,791	\$42,060	\$4,499,398
Uinta	\$6,147,378	\$461,663	\$21,215	\$6,630,256
Washakie	\$4,833,228	\$38,021	\$514,086	\$5,385,335
Weston	\$6,297,866	\$104,789	\$197,925	\$6,600,580
Wyoming total	\$230,262,119	\$4,847,015	\$20,567,792	\$255,676,926

Source: National Land Cover Database (2019) land cover acres related to agricultural production × National Agricultural Statistics Service annual cash rent (2021) for pasture (used for Rangeland and Pasture & hay) or non-irrigated cropland (used for Cultivated cropland).

on goods and services in the local economy, a portion of which is spent locally by the businesses who receive them, and so on. Economic impact analysis aims at quantifying this “ripple effect”—or the portion of each dollar spent by households in the local economy on goods and services.

Lost household income resulting from direct economic loss due to weed infestation has quantifiable ripple effects across the state economy. That is, using the initial direct loss in reduced cash rents, we can estimate secondary losses as a portion of household income that would otherwise have been re-spent locally. In this way, lost income contributes to total economic activity at risk, which includes direct loss plus employment, labor income, value added, and output from foregone household spending, described below.

Economic impact analysis is modeled in IMPLAN using the latest (2021) data. IMPLAN is software that provides economic impact data and modeling to estimate impacts arising from a policy change or event, in this case weed infestation. Agricultural values reduced by each weed are modeled as a “household income event” within the Wyoming economy. Wyoming median household income (in 2021 dollars) was \$65,204 (USCB 2022); therefore, we used the household income specification of \$50,000 to \$70,000 as the relevant IMPLAN parameter.

Following standard economic impact analysis terminology, for this analysis:

Direct Loss is defined as cash agricultural land rent reduced by reduced forage production or crop yield estimated

Table 5. Presence acreage¹ for 10 selected weeds

Wyoming county	Total area (acres) ²	Cheatgrass	Hoary cress / whitetop	Leafy spurge	Medusa-head	Palmer amaranth	Perennial pepperweed	Russian knapweed	Russian olive	Ventenata	Yellow starthistle
Albany	2,735,360	80,000	10,000	1,250	0	0	20,000	8,000	500	500	0
Big Horn	2,007,680	577,405	42,839	13	0	0	6,243	32,583	36,422	0	0
Campbell	3,070,080	2,000,000	3,000	70,000	0	0	0	10,000	1,000	80,000	0
Carbon	5,054,080	475,000	32,620	157,000	0	0	4,706	9,857	5,500	0	0
Converse	2,723,200	1,000,000	500	1,500	5	0	1,000	5,000	500	20	0
Crook	1,829,760	50,000	5,000	250,000	0	0	0	500	1,000	5	0
Fremont	5,877,120	229,000	50,500	26,000	0	1	15,000	50,500	15,000	0	0
Goshen	1,424,000	500,000	2,000	3,000	0	50	2,000	200	10,000	0	0
Hot Springs	1,282,560	321,064	6,644	10	0	0	20	62,592	3,995	0	0
Johnson	2,666,240	900,000	300	10,000	0	0	1	2,000	3,000	80	0
Laramie	1,719,040	170,000	100	17,000	0	0	500	500	0	0	0
Lincoln	2,604,160	1,800,000	10,000	10,000	0	0	50,000	8,000	10	0	0
Natrona	3,417,600	2,000,000	2,500	1,000	0	0	3,000	2,500	500	0	0
Niobrara	1,680,640	900,000	50	40,000	0	0	10	500	150	0	0
Park	4,443,520	1,700,000	375,000	6,500	0	0	10	90,000	45,000	0	0
Platte	1,334,400	900,000	50	8,000	0	0	10	50	5,000	0	0
Sheridan	1,614,720	900,000	11,000	122,286	5,800	0	50	75	42,000	290,000	0
Sublette	3,124,480	85,000	200	844	0	0	3,500	167	0	0	0
Sweetwater	6,672,640	20,000	10,000	600	0	0	40,000	5,000	100	0	0
Teton	2,565,120	7,282	276	214	0	0	149	39	2	0	0
Uinta	1,332,480	24,000	4,000	300	0	0	5,000	500	450	0	1
Washakie	1,433,600	750,000	2,000	5	0	0	200	2,000	5,000	0	0
Weston	1,534,720	50,000	7,000	15,000	0	0	0	5,000	20	0	0
Statewide	62,147,200	15,438,751	575,579	740,522	5,805	51	151,399	295,563	175,149	370,605	1

Sources: ¹Estimated acreage of weed presence reported by Wyoming Weed and Pest supervisors, 2021–2022.

²Total county area from U.S. Census Bureau.

for each weed, modeled as a reduction in landowners’ household income.

Induced Employment Loss represents the number of job years (including part-time, and seasonal jobs adjusted to full-time year-round work) that would potentially be supported by household spending as a result of foregone rent.

Induced Labor Income Loss is foregone employee compensation and proprietor income associated with household spending as a result of rent lost from weed infestation.

Value Added is analogous to Gross Domestic Product for the Wyoming economy—this Gross State Product includes labor income, taxes on production and imports, and other property income. **Induced Value Added Loss** modeled for losses from weed competition is a specific foregone value

generated from reduced household spending as a result of rent reduction.

Output of an industry adds together value created through labor and capital (**Value Added**) plus the cost of goods and services purchased from other industries (**Intermediate Inputs**).

Induced Output Loss is the total lost value, or amount foregone by industries as a result of the reduction in household spending from reduced agricultural land cash rent (Clouse 2022).

Total economic value at risk for Wyoming, including these component parts, is estimated for each listed weed in individual species summaries, and in statewide results below.

Table 6. Impacted acreage¹ for 10 selected weeds

Wyoming county	Total area (acres) ²	Cheatgrass	Hoary cress / whitetop	Leafy spurge	Medusa -head	Palmer amaranth	Perennial pepperweed	Russian knapweed	Russian olive	Ventenata	Yellow starthistle
Albany	2,735,360	40,000	5,000	800	0	0	15,000	6,000	100	200	0
Big Horn	2,007,680	333,760	38,000	0	0	0	2,164	26,175	36,261	0	0
Campbell	3,070,080	1,000,000	1,000	20,000	0	0	0	5,000	100	20,000	0
Carbon	5,054,080	285,000	16,310	31,000	0	0	680	7,393	4,000	0	0
Converse	2,723,200	400,000	100	500	0	0	200	1,000	100	5	0
Crook	1,829,760	2,500	500	40,000	0	0	0	100	0	0	0
Fremont	5,877,120	15,000	5,000	2,600	0	0	300	10,100	750	0	0
Goshen	1,424,000	50,000	100	150	0	0	50	15	300	0	0
Hot Springs	1,282,560	160,532	2,214	1	0	0	5	31,296	2,663	0	0
Johnson	2,666,240	500,000	150	2,500	0	0	0	1,500	2,000	0	0
Laramie	1,719,040	170,000	50	17,000	0	0	250	250	0	0	0
Lincoln	2,604,160	200,000	3,000	2,000	0	0	5,000	3,000	5	0	0
Natrona	3,417,600	500,000	1,500	200	0	0	1,500	1,000	400	0	0
Niobrara	1,680,640	450,000	0	20,000	0	0	0	30	40	0	0
Park	4,443,520	100,000	15,000	200	0	0	1	10,000	10,000	0	0
Platte	1,334,400	800,000	10	4,000	0	0	1	5	20	0	0
Sheridan	1,614,720	400,000	2,000	32,000	1,800	0	0	0	16,000	110,000	0
Sublette	3,124,480	5,000	50	168	0	0	700	16	0	0	0
Sweetwater	6,672,640	10,000	0	0	0	0	30,000	2,500	0	0	0
Teton	2,565,120	5,000	61	81	0	0	16	3	0	0	0
Uinta	1,332,480	16,000	2,500	200	0	0	2,000	150	100	0	0
Washakie	1,433,600	500,000	1,000	0	0	0	30	1,000	3,000	0	0
Weston	1,534,720	5,000	2,000	5,000	0	0	0	200	2	0	0
Statewide	62,147,200	5,947,792	95,545	178,400	1,800	0	57,897	106,733	75,841	130,205	0

Sources: ¹Estimated acreage of weed-impacted area reported by Wyoming Weed and Pest supervisors, 2021–2022.

² Total county area from U.S. Census Bureau.

RESULTS

STATEWIDE DIRECT AND POTENTIAL ECONOMIC LOSSES

Statewide agricultural value reduced by weed infestations observed in 2022, and potential loss estimated on potential habitat, are reported in Table 10. Note that because the loss estimate analyses do not account for overlapping losses from multiple weeds on the same acreage, summing loss estimates over two or more individual weed species is not appropriate.

Considering both direct and potential impacts to agriculture from reduced rents on agricultural land in Wyoming, cheatgrass has the highest loss estimates statewide with \$32 million in direct loss on observed acres and \$110 million in

potential loss from infestation on suitable habitat. Cheatgrass infestation resulted in a 13% reduction in agricultural value across Wyoming in 2021. If cheatgrass were to spread to all potential habitat in the state this loss would grow to a 43% reduction from estimated agricultural value without cheatgrass. Potential future impacts for cheatgrass are notably high in Fremont, Sweetwater, and Big Horn counties; and for ventenata in Big Horn County (Table 10).

Ventenata, another cool-season grass species that is invasive to Wyoming’s rangelands, has the second-highest statewide estimates for direct impacts to agricultural value,

Table 7. Suitable weed habitat acreage¹ for 10 selected weeds by Wyoming county

Wyoming county	Total area (acres) ²	Cheatgrass	Hoary cress / whitetop	Leafy spurge	Medusa-head	Palmer amaranth ³	Perennial pepperweed	Russian knapweed	Russian olive	Ventenata	Yellow starthistle
Albany	2,735,360	2,405,824	1,546,264	85,696	23,228	0	459,621	1,169,251	2,181,614	430,333	1,031
Big Horn	2,007,680	1,627,049	1,522,860	163,415	57,979	116,501	1,051,438	1,440,868	1,539,590	46,469	259
Campbell	3,070,080	2,994,697	2,256,587	347,783	56,149	20,093	367,875	2,104,955	3,057,868	2,307,355	144
Carbon	5,054,080	4,257,820	3,756,976	79,075	29,808	949	1,328,182	3,388,285	2,886,742	181,943	235
Converse	2,723,200	2,593,795	2,049,865	116,917	69,997	22,647	477,228	2,231,472	2,569,388	1,218,301	376
Crook	1,829,760	1,225,475	899,130	124,416	2,899	39,192	276,119	506,383	1,557,141	853,266	0
Fremont	5,877,120	4,611,421	4,129,378	256,821	28,136	71,620	1,890,992	3,904,062	4,007,400	63,483	101
Goshen	1,424,000	1,198,451	1,063,733	257,430	1,259	184,632	420,901	1,316,025	1,385,635	153,541	700
Hot Springs	1,282,560	1,164,546	1,061,896	21,320	112,093	6,011	406,238	974,408	1,145,908	135,502	1,560
Johnson	2,666,240	2,289,214	1,777,728	92,990	49,236	14,771	468,395	1,721,276	2,066,181	869,340	187
Laramie	1,719,040	1,584,504	1,331,179	673,487	4,169	246,270	228,543	1,053,720	1,712,650	729,784	639
Lincoln	2,604,160	1,488,303	1,355,469	136,034	0	45,256	641,653	1,091,238	654,155	86,316	0
Natrona	3,417,600	3,355,635	2,963,400	123,630	90,529	13,831	990,017	2,964,553	2,761,685	305,883	3,734
Niobrara	1,680,640	1,549,547	1,267,550	25,794	228	27,873	321,200	1,449,732	1,675,039	952,572	0
Park	4,443,520	2,071,768	1,497,897	229,155	117,709	92,893	682,232	1,316,228	1,689,094	508,600	4,794
Platte	1,334,400	1,255,984	1,173,978	238,922	78,041	78,572	318,859	1,267,739	1,328,842	688,021	2,276
Sheridan	1,614,720	945,632	1,066,066	245,650	31,138	34,226	365,798	897,073	1,197,426	911,333	0
Sublette	3,124,480	2,100,109	1,565,692	56,314	0	288	1,041,168	1,301,304	43,588	4,589	0
Sweetwater	6,672,640	6,645,545	6,058,401	96,919	12,212	12,135	3,932,114	6,157,226	1,481,711	739	0
Teton	2,565,120	206,163	129,413	73,785	0	3,235	33,512	6,321	53,552	11,210	0
Uinta	1,332,480	1,155,030	1,178,804	165,474	0	1,632	583,829	1,072,434	1,086,927	228,807	0
Washakie	1,433,600	1,360,062	1,250,594	59,784	41,625	39,545	594,048	1,144,371	1,230,492	65,254	316
Weston	1,534,720	1,357,167	1,025,968	58,311	729	15,225	309,319	1,043,131	1,424,222	657,024	0
Statewide	62,147,200	49,443,739	41,928,829	3,729,122	807,165	1,087,396	17,189,278	39,522,056	38,736,849	11,409,665	16,351

Sources: ¹Moderate “balanced” weed habitat estimates modeled by USGS INHABIT, 2022.

²Total county area from U.S. Census Bureau.

³All NLCD-defined cultivated cropland is considered as suitable habitat for Palmer amaranth.

with \$1 million in estimated loss from reduced cash rent on rangelands on observed areas in 2021.

In terms of potential loss on suitable habitat, Russian knapweed and hoary cress are next in line to cheatgrass with \$90 and \$83 million—35% and 32% of non-impacted value—respectively. See individual species summaries for a complete set of county loss estimates.

While other listed weed species have annual statewide direct loss estimates under \$1 million, equating to less than 1% of non-impacted agricultural values statewide, local impacts are relatively high. Hoary cress has an estimated direct loss of \$323,000 in Big Horn County and \$210,000 in

Park County, each accounting for 1.5% of annual non-impacted agricultural value respectively. Leafy spurge has \$199,000 in direct losses in Crook County and \$138,000 in Sheridan County (2.1% and 1.5% respectively). Russian knapweed has direct loss estimates of \$226,000 (1.1%) in Big Horn County and \$167,000 (2.9%) in Hot Springs County. (See below for complete county loss estimates by species.)

Relatively high county-level potential future loss estimates (assuming infestation on all suitable habitat) are notable in the following Wyoming counties for having loss estimates over \$1 million, 10% of non-impacted agricultural value, or both: hoary cress in Fremont County (\$8.2 million, 33%), Big

Horn County (\$7.5 million, 36%), Sweetwater County (\$6.8 million, 43%), and every other Wyoming county except for Teton; leafy spurge in Laramie County (\$1.2 million, 6.8%), perennial pepperweed in Big Horn County (\$4.8 million, 23%), Sweetwater County (\$4.4 million, 28%), Fremont County (\$3.6 million, 14%), and eight other counties; and Russian knapweed in Fremont County (\$9.4 million, 38%), Sweetwater County (\$8.7 million, 54%), and, like hoary cress, every other Wyoming county except for Teton County. County-level potential loss estimates are reported in species summaries below.

TOTAL STATEWIDE ECONOMIC ACTIVITY AT RISK

What secondary impacts ripple across the Wyoming economy as a result of agricultural value reduced by weed infestations? Modeled as a reduction in cash rent on agricultural land, these economic losses reduce landowners' household income. The resulting reduction in induced (household-to-business) spending from these foregone rents can be measured in induced employment, labor income, value added, and output losses reported in Table 11. (See the "Total Economic Activity at Risk" section above for definitions of these economic terms.)

Across the Wyoming economy, cheatgrass infestation resulted in the highest reduced value of agricultural cash rents in 2021, translating to a \$32.1 million direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including 149 annual jobs, \$6.6 million in labor income, \$13.0 million in value added, and \$24.1 million in output. Lost agricultural rents from observed 2021 ventenata infestation (\$1.0 million) resulted in foregone household spending that would have supported 5 full-time annual jobs with \$205,000 in labor income, \$408,000 in value added, and \$754,000 in induced output (Table 11).

SUMMARY OF INDIVIDUAL SPECIES

For each of 10 invasive Wyoming weeds identified for this study, we provide a short description of the species, county-level distribution map of observed presence, and our estimates of direct economic impacts to Wyoming agriculture as well as total economic activity at risk.

Table 8. Agricultural land types impacted by infestation of 10 selected weeds

Invasive weed	Rangeland	Pasture & hay	Cultivated cropland
Cheatgrass	X		
Hoary cress / whitetop	X	X	X
Leafy spurge	X	X	
Medusahead	X		
Palmer amaranth			X
Perennial pepperweed	X	X	
Russian knapweed	X	X	
Russian olive		X	
Ventenata	X		
Yellow starthistle	X	X	

Table 9. Agricultural rent loss estimates on acreage reported as present, impacted (20% or greater incidence), and suitable habitat for 10 invasive weed species in Wyoming.

Invasive weed ¹	Loss on area where present	Loss on area impacted	Potential loss on suitable habitat ²
Cheatgrass	40%	80%	60%
Hoary cress / whitetop	15%	80%	48%
Leafy spurge	10%	50%	30%
Medusahead	65%	95%	80%
Palmer amaranth	70%	100%	85%
Perennial pepperweed	15%	80%	48%
Russian knapweed	40%	80%	60%
Russian olive	35%	75%	55%
Ventenata	40%	80%	60%
Yellow starthistle	20%	60%	40%

Notes:

¹ Refer to species-specific accounts later in the report for details on the derivation of these loss estimates.

² Potential loss on suitable habitat is estimated as the average between loss on area where present and impacted.

Table 10. Statewide direct and potential agricultural loss estimates (% of non-impacted agricultural value)¹ from 10 invasive weed species in Wyoming

Invasive weed	Estimated loss on present and impacted area ²	Potential loss on suitable habitat ³
Cheatgrass / downy brome (<i>Bromus tectorum</i>)	\$32,060,597 (13%)	\$109,841,084 (43%)
Hoary cress / whitetop (<i>Lepidium draba</i>)	\$726,615 (<1%)	\$82,737,008 (32%)
Leafy spurge (<i>Euphorbia esula</i>)	\$577,303 (<1%)	\$5,042,826 (2%)
Medusahead (<i>Taeniatherum caput-medusae</i>)	\$23,003 (<1%)	\$2,446,034 (1%)
Palmer amaranth (<i>Amaranthus palmeri</i>)	\$68 (<1%)	\$1,411,938 (<1%)
Perennial pepperweed (<i>Lepidium latifolium</i> L.)	\$190,643 (<1%)	\$31,690,566 (12%)
Russian knapweed (<i>Acroptilon repens</i>)	\$715,510 (<1%)	\$89,986,377 (35%)
Russian olive (<i>Elaeagnus angustifolia</i>)	\$9,495 (<1%)	\$1,701,662 (1%)
Ventenata (<i>Ventenata dubia</i>)	\$1,001,491 (<1%)	\$27,087,402 (11%)
Yellow starthistle (<i>Centaurea solstitialis</i>)	\$0 (0%)	\$21,799 (<1%)

Notes:

¹ Loss estimate / (all agricultural land area × respective annual cash rent value).

² Weed area reported as present or impacted by Wyoming Weed and Pest supervisors in 2021–2022 × relevant agricultural land type proportion × respective annual cash rent value × relevant present or impacted loss estimate.

³ Suitable habitat area × agricultural land type proportion × respective annual cash rent value × present or impacted loss estimate.

Table 11. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from 10 invasive weed species, 2021

Invasive weed	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Cheatgrass	\$32,060,597	149	\$6,556,448	\$13,048,265	\$24,149,188
Hoary cress / whitetop	\$726,615	3	\$148,594	\$295,723	\$547,312
Leafy spurge	\$577,303	3	\$118,059	\$234,955	\$434,845
Medusahead	\$23,003	0	\$4,704	\$9,362	\$17,327
Palmer amaranth	\$68	0	\$14	\$28	\$51
Perennial pepperweed	\$190,643	1	\$38,987	\$77,589	\$143,599
Russian knapweed	\$715,510	3	\$146,323	\$291,204	\$538,948
Russian olive	\$9,495	0	\$1,942	\$3,864	\$7,152
Ventenata	\$1,001,491	5	\$204,807	\$407,594	\$754,359
Yellow starthistle	\$0	0	\$0	\$0	\$0

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

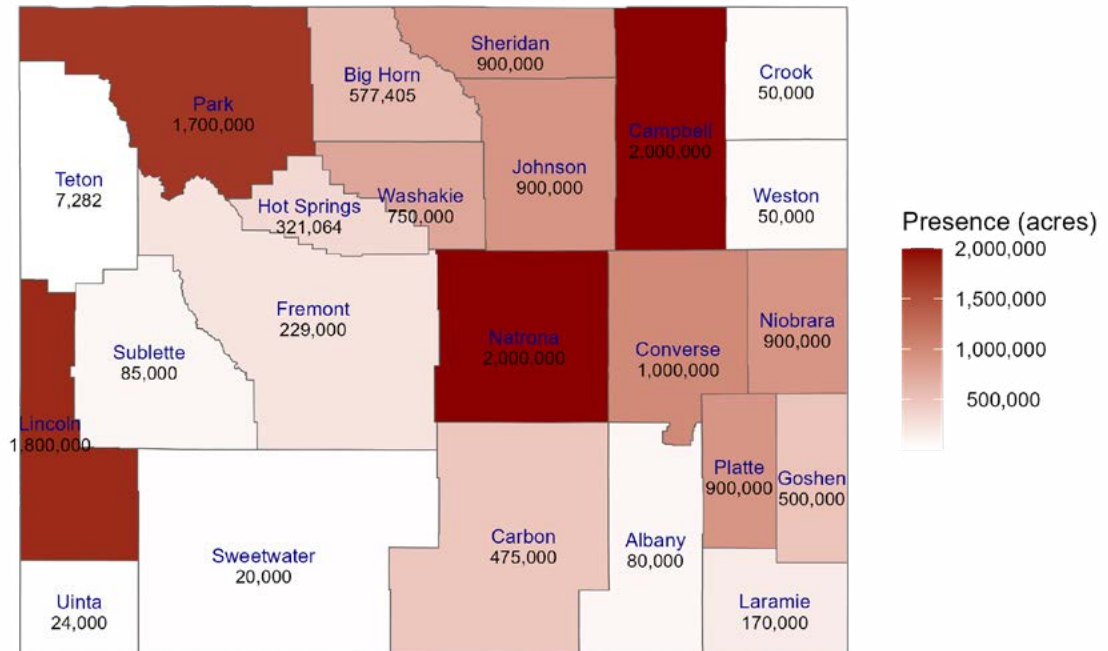
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported by household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 3. County-level cheatgrass / downy brome (*Bromus tectorum*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021–2022.



CHEATGRASS / DOWNY BROME (*BROMUS TECTORUM*)

SPECIES DESCRIPTION

Cheatgrass (*Bromus tectorum*), also known as downy brome, is a tufted, cool-season annual bunchgrass that easily displaces native grasses. Suitable habitat includes degraded or disturbed sites in meadows, grassland, woodland, and riparian communities, generally below 8,500 feet (White 2014). Cheatgrass reduces forage quality, alters wildfire regimes, impacts species diversity, and reduces wildlife habitat (Mealor et al. 2013).

DISTRIBUTION IN WYOMING

On a county level, cheatgrass distribution across Wyoming is concentrated in Campbell, Natrona, and Park counties, as well as much of north-central Wyoming. Statewide, cheatgrass is reported as present on 15.4 million acres (Table 5, Figure 3). Of the acreage where cheatgrass is present, 5.9 million acres (39%) is reported as impacted, that is, accounting for 20% or more of vegetative cover (Table 6).

Suitable cheatgrass habitat is estimated at 49.4 million acres across Wyoming, with significant potential for losses in Sweetwater, Fremont, and Carbon counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Cheatgrass infestations are widespread and primarily impact agricultural production on non-irrigated rangelands in Wyoming. Direct economic loss to agricultural value due to cheatgrass is estimated as a 40% reduction in annual cash rent for rangeland (Table 3 and Table 8) on acres with

reported presence and 80% on impacted areas (Table 9), where cheatgrass cover exceeds 20% of canopy cover. Potential loss on suitable cheatgrass habitat (Table 7) is estimated with 60% loss (Table 9). County non-impacted agricultural values and loss estimates from cheatgrass infestation are reported in Table 12.

Campbell, Lincoln, and Big Horn counties have the highest estimated direct economic impacts to agriculture, with \$4.4, \$3.6, and \$3.5 million in lost annual cash rent on rangelands due to cheatgrass infestation, respectively. Losses in Sheridan, Natrona, and Platte counties are estimated at just under \$3 million each. Total loss to agriculture in Wyoming is estimated at \$30 million (Table 12).

As a percentage of total non-impacted agricultural value, Platte County has the highest loss due to cheatgrass (41%), followed by Campbell (37%) and Washakie (31%) counties. Statewide, cheatgrass infestation reduced total agricultural value by 12.5% (Table 12).

Potential loss from cheatgrass infestation on suitable habitat is greatest in Fremont County, with over \$10.9 million in potential lost agricultural rent; statewide potential annual loss is estimated at nearly \$110 million (Table 12).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, cheatgrass infestation reduced the value of agricultural cash rents by an estimated \$32.1 million in 2021 (Table 12). This translates to a direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including 149 annual jobs, \$6.6 million in labor income, \$13.0 million in value added, and \$24.1 million in output (Table 13).



Cheatgrass. Photo by Beth Fowers.

Table 12. Agricultural value and estimated loss from infestation by cheatgrass / downy brome (*Bromus tectorum*) by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$121,088	1.7%	\$3,641,446
Big Horn	\$20,986,463	\$3,461,808	16.5%	\$9,272,522
Campbell	\$11,873,422	\$4,411,408	37.2%	\$6,605,414
Carbon	\$13,680,717	\$797,787	5.8%	\$6,704,274
Converse	\$7,915,454	\$1,220,936	15.4%	\$4,318,442
Crook	\$9,368,895	\$94,625	1.0%	\$3,313,175
Fremont	\$24,907,069	\$385,683	1.5%	\$10,933,692
Goshen	\$10,120,978	\$1,115,841	11.0%	\$3,647,130
Hot Springs	\$5,798,953	\$850,379	14.7%	\$3,084,447
Johnson	\$8,646,085	\$1,751,544	20.3%	\$4,296,062
Laramie	\$16,947,179	\$767,739	4.5%	\$5,366,845
Lincoln	\$15,931,031	\$3,564,289	22.4%	\$4,942,307
Natrona	\$9,246,032	\$2,623,629	28.4%	\$5,282,364
Niobrara	\$9,256,598	\$1,770,346	19.1%	\$4,841,001
Park	\$14,216,444	\$1,825,318	12.8%	\$3,151,363
Platte	\$6,132,600	\$2,538,228	41.4%	\$2,812,918
Sheridan	\$9,357,283	\$2,774,238	29.6%	\$3,027,009
Sublette	\$15,153,599	\$146,136	1.0%	\$5,754,403
Sweetwater	\$15,964,474	\$28,195	0.2%	\$9,368,626
Teton	\$4,499,398	\$8,070	0.2%	\$203,191
Uinta	\$6,630,256	\$29,440	0.4%	\$3,187,833
Washakie	\$5,385,335	\$1,683,669	31.3%	\$2,747,873
Weston	\$6,600,580	\$90,203	1.4%	\$3,338,746
State total	\$255,676,926	\$32,060,597	12.5%	\$109,841,084

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.4 and 0.8 representing 40% and 80% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.6 representing 60% loss, reported in Table 9).

Table 13. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from cheatgrass

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$32,060,597				
Induced (household spending)		149	\$6,556,448	\$13,048,265	\$24,149,188z

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

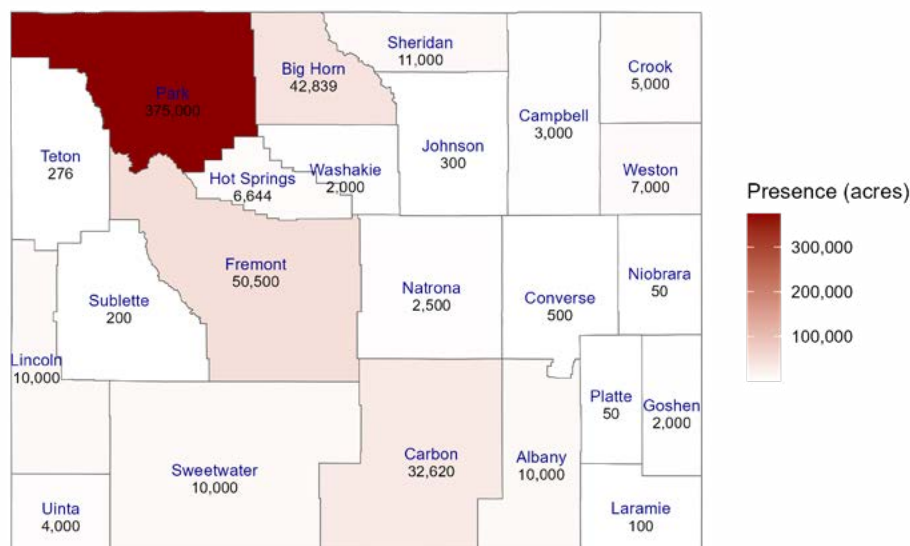
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 4. County-level hoary cress / whitetop (*Lepidium draba*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



HOARY CRESS / WHITETOP (*LEPIDIUM DRABA*)

SPECIES DESCRIPTION

Hoary cress (*Lepidium draba*), also known as whitetop and heart-podded hoary cress, is an annual or perennial herb in the Mustard family with early spring flowers (Whitson et al. 2009). Hoary cress can spread rapidly via seeds, root stock, and creeping roots or rhizomes. Seeds spread by wind and are distributed through livestock manure and agricultural machinery; root fragments can be dispersed through irrigation and tillage (Francis and Warwick 2008). Hoary cress is generally considered a serious weed of numerous economic crops, including corn, small grains, and sugar beets (Weyl 2018), as well as pasture, hay, and forage grasses (Francis and Warwick 2008). It also has potential palatability and toxicity issues for livestock grazing (Wilson, Davison, and Smith 2006).

DISTRIBUTION IN WYOMING

Across Wyoming counties, hoary cress presence is concentrated in Park County, with moderate acreages in Fremont, Carbon, and Big Horn counties, and some reported presence in all other counties. Statewide, hoary cress is reported as present on 575,579 acres; of that, 95,545 acres (17%) is reported as impacted, that is, accounting for over 20% of vegetative cover (Figure 4; Table 6).

Suitable hoary cress habitat is estimated at 41.9 million acres across Wyoming with significant potential for losses in Sweetwater, Fremont, Carbon, and Natrona counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Hoary cress is found in a wide range of habitats and is associated with rangeland, pasture and hay land, and cultivated

crops. Direct economic loss to agricultural value from hoary cress infestation is estimated as a 15% reduction in relevant annual cash rent (reported in Table 3) associated with all agricultural land types (Table 8) on acres with reported presence and 80% reduction on impacted areas (Table 9), where hoary cress cover exceeds 20% of canopy cover. Potential loss on suitable hoary cress habitat (7) is estimated using a 48% loss (Table 9). County non-impacted agricultural values and loss estimates from hoary cress infestation are reported in Table 14.

The highest direct economic impacts to agriculture from hoary cress are estimated in Big Horn and Park counties, at \$323,170 and \$210,487 in lost rents on all agricultural land types, respectively; for all other counties, direct losses are under \$70,000 each. Statewide, losses from hoary cress in 2021 are estimated to be \$726,615 (Table 15).

Losses from hoary cress in both Big Horn and Park counties are 1.5% of total non-impacted agricultural value; statewide, hoary cress infestation reduced total agricultural value by less than 1% (Table 13).

Potential loss from hoary cress infestation on suitable habitat in Wyoming is greatest in Fremont County (\$8.2 million), Big Horn County (\$7.5 million), Sweetwater County (\$6.8 million), and Laramie County (\$6.2 million). Statewide, potential annual loss on all suitable habitat is estimated at \$82.7 million. (Table 13).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, hoary cress infestation reduced the value of agricultural cash rents by an estimated \$727,000 in 2021 (Table 14). This translates to a direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including 3 annual jobs, \$149,000 in labor income, \$296,000 in value added, and \$547,000 in output (Table 15).

Hoary cress / whitetop.
Photo by Tom Whitson.



Table 14. Agricultural value and estimated loss from hoary cress / whitetop (*Lepidium draba*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$12,158	0.2%	\$1,879,893
Big Horn	\$20,928,213	\$323,170	1.5%	\$7,510,395
Campbell	\$11,692,585	\$4,246	0.0%	\$4,137,423
Carbon	\$13,671,418	\$64,543	0.5%	\$4,789,958
Converse	\$7,691,249	\$406	0.0%	\$2,823,516
Crook	\$9,129,822	\$5,492	0.1%	\$2,181,954
Fremont	\$24,183,709	\$45,466	0.2%	\$8,238,373
Goshen	\$8,496,220	\$2,586	0.0%	\$3,579,671
Hot Springs	\$5,750,263	\$11,000	0.2%	\$2,277,866
Johnson	\$8,510,190	\$461	0.0%	\$2,732,654
Laramie	\$11,553,857	\$468	0.0%	\$6,230,069
Lincoln	\$15,206,941	\$11,733	0.1%	\$3,914,119
Natrona	\$9,104,959	\$661	0.0%	\$3,782,928
Niobrara	\$9,050,336	\$41	0.0%	\$3,313,708
Park	\$11,782,660	\$210,487	1.5%	\$2,269,115
Platte	\$5,543,312	\$64	0.0%	\$2,531,414
Sheridan	\$9,169,040	\$17,072	0.2%	\$2,930,477
Sublette	\$15,151,700	\$300	0.0%	\$3,567,729
Sweetwater	\$15,837,056	\$3,567	0.0%	\$6,842,319
Teton	\$4,469,633	\$135	0.0%	\$102,475
Uinta	\$6,618,833	\$5,085	0.1%	\$2,777,964
Washakie	\$5,021,520	\$3,564	0.1%	\$2,228,805
Weston	\$6,472,690	\$3,910	0.1%	\$2,094,184
State total	\$251,684,701	\$726,615	0.3%	\$82,737,008

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.15 and 0.8 representing 15% and 80% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.48 representing 48% loss, reported in Table 9).

Table 15. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from hoary cress / whitetop (*Lepidium draba*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$726,615				
Induced (household spending)		3	\$148,594	\$295,723	\$547,312

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

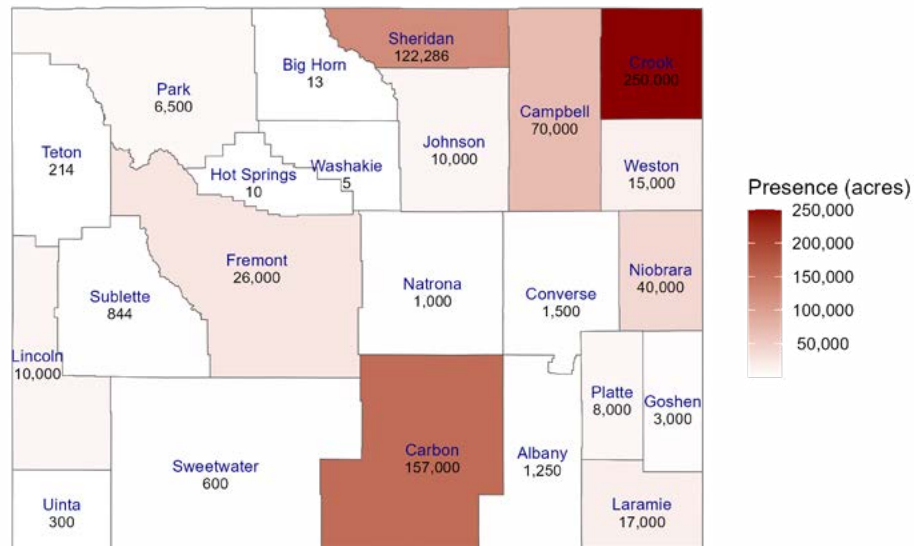
²Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 5. County-level leafy spurge (*Euphorbia esula*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



LEAFY SPURGE (*EUPHORBIA ESULA*)

SPECIES DESCRIPTION

Leafy spurge (*Euphorbia esula*) is a creeping perennial forb with deep spreading roots that can regenerate even after the plant has been pulled, cut, or burned. Its seed capsules can shoot seeds up to 20 feet (MDA 2023). Leafy spurge invades prairies, pastures, and other open areas, displacing native vegetation (Whitson et al. 2009).

Cattle will avoid moderate to high densities of leafy spurge (Lym and Kirby 1987) and infestations result in reduced availability of quality forage (USFS 2014). Leafy spurge has been modeled with an estimate of around 1.25% in loss to grazing lands per 1% infestation (Leitch et al. 1996). On rangeland, leafy spurge has been found to reduce livestock carrying capacity up to 75% (50% yield reduction in rangeland production and 25% loss in utilization from unpalatable leafy spurge mixed with existing grass) (Reilly and Kaufman 1979).

It may be interesting to note that sheep and goat grazing can be effective in reducing leafy spurge on infested rangeland: leafy spurge can comprise between 22% to 66% of the diet of goats when targeted (Seefeldt, Taylor, and Van Vleet 2007; Kirby, Hanson, and Sieg 1994).

DISTRIBUTION IN WYOMING

Notable leafy spurge presence is reported in Crook, Carbon, and Sheridan counties, with some presence in all Wyoming counties, totaling 740,522 acres statewide (Table 5, Figure 5). Of this presence area, 178,400 acres (24%) is reported as impacted (leafy spurge comprises more than 20% of vegetative cover) (Table 6).

Suitable leafy spurge habitat is estimated to be 3.7 million acres across Wyoming, with notable potential for losses in Laramie county (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Direct economic loss to agricultural value from leafy spurge infestation is estimated as a 10% reduction in annual cash rent for rangeland and pasture and hay (Table 3 and Table 8) on acres with reported presence and 50% on impacted areas (Table 9), where leafy spurge exceeds 20% of canopy cover. Potential loss on suitable habitat (Table 7) is estimated using a 30% reduction in cash rent (Table 9). County non-impacted agricultural values and loss estimates from leafy spurge are reported in Table 16.

Crook and Sheridan counties have the highest loss estimates from leafy spurge infestation, with \$198,513 and \$137,956 in reduced agricultural value, respectively. These two counties make up the majority of statewide loss, estimated at \$572,413 (Table 16).

Likewise, as a proportion of non-impacted value, Crook and Sheridan counties are the most heavily impacted by leafy spurge (2.1% and 1.5% of non-impacted value, respectively). Statewide, leafy spurge infestation reduced total agricultural value by less than 1% (Table 16).

However, potential loss to agriculture on land with suitable leafy spurge habitat in Wyoming is notably high in Laramie County, where an estimated \$1.2 million is at risk. Statewide, potential loss from leafy spurge is just over \$5 million (Table 16).

TOTAL ECONOMIC ACTIVITY AT RISK

Leafy spurge reduced agricultural cash rents by an estimated \$577,000 across the Wyoming economy in 2021 (Table 16). This translates to a direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including 3 annual jobs, \$118,000 in labor income, \$235,000 value added, and \$435,000 in state output (Table 17).

Leafy spurge. Photo by Beth Fowers.



Table 16. Agricultural value and estimated loss from leafy spurge (*Euphorbia esula*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$1,139	0.0%	\$65,802
Big Horn	\$20,928,213	\$13	0.0%	\$472,272
Campbell	\$11,692,585	\$56,626	0.5%	\$393,870
Carbon	\$13,671,418	\$75,355	0.6%	\$63,616
Converse	\$7,691,249	\$419	0.0%	\$97,928
Crook	\$9,129,822	\$198,513	2.1%	\$180,718
Fremont	\$24,183,709	\$12,017	0.1%	\$309,647
Goshen	\$8,496,220	\$1,853	0.0%	\$397,421
Hot Springs	\$5,750,263	\$6	0.0%	\$28,495
Johnson	\$8,510,190	\$6,329	0.1%	\$88,273
Laramie	\$11,553,857	\$48,456	0.3%	\$1,151,803
Lincoln	\$15,206,941	\$5,665	0.0%	\$231,181
Natrona	\$9,104,959	\$382	0.0%	\$97,737
Niobrara	\$9,050,336	\$13,221	0.1%	\$40,922
Park	\$11,782,660	\$1,872	0.0%	\$176,268
Platte	\$5,543,312	\$9,220	0.2%	\$275,352
Sheridan	\$9,169,040	\$137,956	1.5%	\$406,201
Sublette	\$15,151,700	\$564	0.0%	\$81,026
Sweetwater	\$15,837,056	\$141	0.0%	\$68,449
Teton	\$4,469,633	\$89	0.0%	\$36,556
Uinta	\$6,618,833	\$173	0.0%	\$245,499
Washakie	\$5,021,520	\$2	0.0%	\$60,869
Weston	\$6,472,690	\$7,295	0.1%	\$72,918
State total	\$251,684,701	\$572,413	0.2%	\$5,042,826

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.1 and 0.5 representing 10% and 50% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.3 representing 30% loss, reported in Table 9).

Table 17. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from leafy spurge (*Euphorbia esula*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$577,303				
Induced (household spending)		3	\$118,059	\$234,955	\$434,845

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

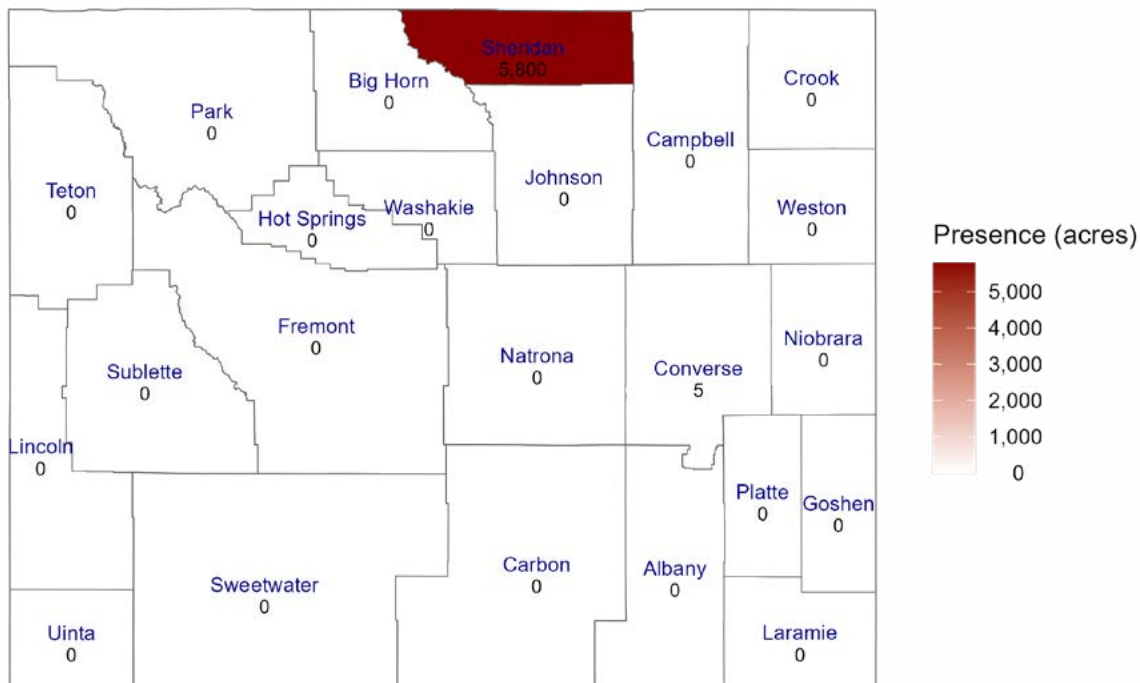
²Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 6. County-level medusahead wildrye (*Taeniatherum caput-medusae*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



MEDUSAHEAD WILDRYE (*TAENIATHERUM CAPUT-MEDUSAE*)

SPECIES DESCRIPTION

Medusahead (*Taeniatherum caput-medusae*), also known as medusahead wildrye, is an invasive winter annual grass that reduces plant diversity and alters ecosystem function, reducing carrying capacities for both livestock and wildlife (Whitson et al. 2009). Medusahead typically colonizes disturbed sites, and may be a higher management concern compared to cheatgrass because of its year-round lack of grazing preference, fast growth, and its ability to replace more palatable annual grasses in some areas (Stannard, Ogle, and St. John 2010). Like cheatgrass, medusahead is a fire-adapted species that threatens western rangelands (Bateman et al. 2020).

DISTRIBUTION IN WYOMING

Nearly all medusahead presence observed by Wyoming Weed and Pest personnel in 2021–2022 (5,800 of 5,805 acres statewide) was in Sheridan County, in north-central Wyoming (Table 5; Figure 6). Of this statewide presence, 1,800 acres (31%) are impacted (medusahead comprises more than 20% of vegetative cover)(Table 6).

While presence as of 2021–2022 was limited, Wyoming has potential for medusahead infestation: suitable habitat is estimated at 807,165 acres across Wyoming, notably in Park, Hot Springs, and Natrona counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Medusahead is primarily associated with rangeland agricultural land cover in Wyoming. Direct economic loss to agricultural value due to medusahead is estimated as a 65% reduction in annual cash rent for rangeland (Table 3 and Table 8) on acres with reported presence and 95% on impacted areas (Table 9), where medusahead cover exceeds 20% of canopy cover. Potential loss on suitable medusahead habitat (Table 7) is calculated using an 80% loss estimate (Table 9). County non-impacted agricultural values and loss estimates from medusahead infestation are reported in Table 18.

Nearly all lost agricultural value from medusahead infestation is in Sheridan County, with \$22,994 (Table 18) accounting for less than 1% of that county’s non-impacted agricultural value; \$23,003 statewide (Table 18).

Potential loss from medusahead on suitable habitat across Wyoming rangelands is more substantial. Top counties in terms of potential loss are Big Horn County (\$441,000) and Hot Springs County (\$396,000), with a statewide total loss estimate of \$2.4 million (Table 18).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, medusahead infestation reduced the value of agricultural cash rents by an estimated \$23,000 in 2021 (Table 18). This translates to a direct reduction in landowners’ household income as well as related induced losses from foregone household-to-business spending, including less than 1 annual job, \$5,000 in labor income, \$9,000 in value added, and \$17,000 in output (Table 19).



Medusahead wildrye. Photo by Beth Fowers.

Table 18. Agricultural value and estimated loss from medusahead wildrye (*Taeniatherum caput-medusae*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$0	0%	\$46,877
Big Horn	\$20,928,213	\$0	0%	\$440,562
Campbell	\$11,692,585	\$0	0%	\$165,131
Carbon	\$13,671,418	\$0	0%	\$62,580
Converse	\$7,691,249	\$9	0%	\$155,385
Crook	\$9,129,822	\$0	0%	\$10,450
Fremont	\$24,183,709	\$0	0%	\$88,947
Goshen	\$8,496,220	\$0	0%	\$5,109
Hot Springs	\$5,750,263	\$0	0%	\$395,857
Johnson	\$8,510,190	\$0	0%	\$123,199
Laramie	\$11,553,857	\$0	0%	\$18,828
Lincoln	\$15,206,941	\$0	0%	\$0
Natrona	\$9,104,959	\$0	0%	\$190,012
Niobrara	\$9,050,336	\$0	0%	\$950
Park	\$11,782,660	\$0	0%	\$238,729
Platte	\$5,543,312	\$0	0%	\$233,042
Sheridan	\$9,169,040	\$22,994	0.2%	\$132,899
Sublette	\$15,151,700	\$0	0%	\$0
Sweetwater	\$15,837,056	\$0	0%	\$22,955
Teton	\$4,469,633	\$0	0%	\$0
Uinta	\$6,618,833	\$0	0%	\$0
Washakie	\$5,021,520	\$0	0%	\$112,132
Weston	\$6,472,690	\$0	0%	\$2,391
State total	\$251,684,701	\$23,003	<0.0%	\$2,446,034

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.65 and 0.95 representing 65% and 95% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.8 representing 80% loss, reported in Table 9).

Table 19. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from medusahead wildrye (*Taeniatherum caput-medusae*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$23,003				
Induced (household spending)		<1	\$4,704	\$9,362	\$17,327

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

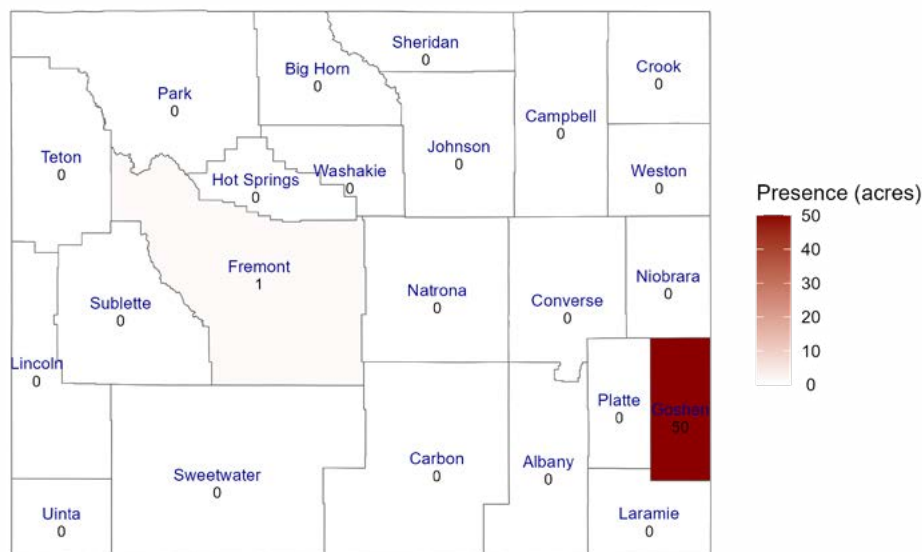
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 7. County-level Palmer amaranth (*Amaranthus palmeri*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



PALMER AMARANTH (*AMARANTHUS PALMERI*)

SPECIES DESCRIPTION

Palmer amaranth (*Amaranthus palmeri*) is a fast-growing broadleaf weed that is also known as Palmer’s pigweed. Infestation leads to significant crop damage, with reported yield losses of up to 91% in corn and 79% in soybeans. Palmer amaranth can also be toxic to animals (NRCS 2017).

Palmer amaranth is associated with agricultural areas of cultivated cropland, with potential for losses for several crops grown in Wyoming, notably corn, soybeans, dry edible beans, and sugar beets. *Amaranthus* species are a current and emerging threat in Wyoming (Coles et al. 2024). Palmer amaranth is aggressive and has evolved resistance to glyphosate herbicides (Coles et al. 2024). A comparative analysis with redroot pigweed (*Amaranthus retroflexus*) using estimated potential future impacts in Wyoming suggests greater expected yield loss in sugar beet and dry bean crops and worse herbicide efficacy from Palmer amaranth infestation (Kniss 2022).

DISTRIBUTION IN WYOMING

Fifty acres of Palmer amaranth presence were reported in Goshen County plus one acre in Fremont County for a statewide total of 51 acres in 2021–2022 (Table 5, Figure 7). Of this area, none was reported as impacted (where more than 20% of land cover is infested)(Table 6).

All 1.1 million acres of NLCD-defined cultivated cropland in Wyoming is considered suitable habitat for Palmer amaranth, with significant acreages in Laramie and Goshen counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Palmer amaranth is considered a threat to all Wyoming cropland (Table 8). Direct economic loss to agricultural value is estimated as a 70% reduction in annual cash rent for cropland (Table 3) on acres where Palmer amaranth is reported as present and 100% on impacted acres (Table 9), where Palmer amaranth exceeds 20% of canopy cover. Potential loss on suitable habitat in Wyoming (Table 7) is estimated using an 85% reduction in rent (Table 9). County non-impacted agricultural values and loss estimates from Palmer amaranth infestation are reported in Table 20.

Nearly all of Wyoming’s reduction in agricultural value in 2021 occurred in Goshen County, where 50 acres of reported presence resulted in an estimated \$68 in lost rent (less than 1% of the county’s non-impacted agricultural value) (Table 20).

More substantial potential loss to agricultural value from Palmer amaranth on suitable habitat is greatest in Laramie County (\$869,000), followed by Goshen County (\$304,000). Across all Wyoming counties, potential loss is estimated at \$1.4 million, or 0.6% of the state’s non-impacted agricultural value (Table 20).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, Palmer amaranth infestation reduced the value of agricultural cash rents by just \$68 in 2021 (Table 20). This translates to a direct reduction in landowners’ household income; related induced losses from foregone household-to-business spending are negligible (Table 21).



Palmer Amaranth. Photo by Andrew Kniss.

Table 20. Agricultural value and estimated loss from Palmer amaranth (*Amaranthus palmeri*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$0	0%	\$0
Big Horn	\$20,928,213	\$0	0%	\$74,197
Campbell	\$11,692,585	\$0	0%	\$1,450
Carbon	\$13,671,418	\$0	0%	\$2
Converse	\$7,691,249	\$0	0%	\$2,076
Crook	\$9,129,822	\$0	0%	\$8,900
Fremont	\$24,183,709	\$0	0%	\$11,028
Goshen	\$8,496,220	\$68	<0.0%	\$304,240
Hot Springs	\$5,750,263	\$0	0%	\$311
Johnson	\$8,510,190	\$0	0%	\$902
Laramie	\$11,553,857	\$0	0%	\$869,174
Lincoln	\$15,206,941	\$0	0%	\$15,943
Natrona	\$9,104,959	\$0	0%	\$614
Niobrara	\$9,050,336	\$0	0%	\$5,104
Park	\$11,782,660	\$0	0%	\$49,362
Platte	\$5,543,312	\$0	0%	\$46,612
Sheridan	\$9,169,040	\$0	0%	\$8,005
Sublette	\$15,151,700	\$0	0%	\$0
Sweetwater	\$15,837,056	\$0	0%	\$242
Teton	\$4,469,633	\$0	0%	\$43
Uinta	\$6,618,833	\$0	0%	\$22
Washakie	\$5,021,520	\$0	0%	\$12,039
Weston	\$6,472,690	\$0	0%	\$1,668
State total	\$251,684,701	\$68	<0.0%	\$1,411,938

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.7 and 1.0 representing 70% and 100% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ NLCD-defined cultivated cropland area × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.85 representing 85% loss, reported in Table 9).

Table 21. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from Palmer amaranth (*Amaranthus palmeri*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$68				
Induced (household spending)		<1	\$14	\$28	\$51

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

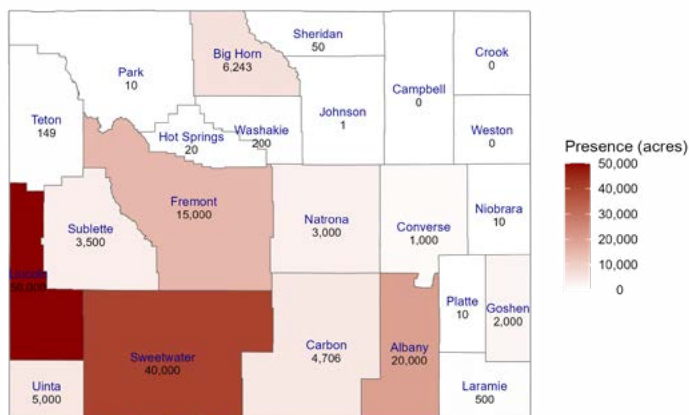
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 8. County-level perennial pepperweed (*Lepidium latifolium* L.) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



PERENNIAL PEPPERWEED (*LEPIDIUM LATIFOLIUM* L.)

SPECIES DESCRIPTION

Perennial pepperweed (*Lepidium latifolium* L.)—also known as broadleaved pepperweed, broad-leaved pepper-grass, and a number of other common names—is a creeping perennial in the Mustard (Brassicaceae) family that invades pasture as well as disturbed and riparian areas (Whitson et al. 2009). The weed has been observed displacing 5% of meadow and 10% of upland grass and shrub vegetation (Francis and Warwick 2008; Young, Turner, and James 1995). Range and pastureland are degraded by perennial pepperweed’s relatively low nutritional quality and digestibility, reducing carrying capacity (Eiswerth et al. 2005); if left un-mowed, dead perennial pepperwood stems can deter grazing (Young, Turner, and James 1995). Further, accumulating litter layers can inhibit other plants and create a monoculture (Renz and DiTomaso 1998). Eiswerth et al. (2005) found that perennial pepperweed can reduce the carrying capacity of grazing lands. They estimate that on land used for pasture and hay, the cumulative benefits exceed cumulative control costs for this weed after 4 to 5 years. As with most mustard and all *Lepidium* species, perennial pepperweed can be toxic to livestock in large quantities (Mackenzie 2004).

DISTRIBUTION IN WYOMING

Perennial pepperweed in Wyoming is concentrated in Sweetwater County, with significant acreages in Albany, Fremont, and Carbon counties (Figure 8). Statewide, reported 2021–2022 presence covered 151,399 acres (Table 5); 57,897 acres of this area (38%), was classified as impacted (observed as more than 20% of vegetative cover)(Table 6).

Suitable perennial pepperweed habitat is estimated at 17.2 million acres across Wyoming with significant potential for losses in Sweetwater and Fremont counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Perennial pepperweed is mainly associated with rangeland and pasture and hay agricultural land types in Wyoming (Table 8). Direct economic loss from perennial pepperweed infestation is estimated as a 15% reduction in annual cash rent for these land types (Table 3) on acres reported as present and 80% on areas reported as impacted (Table 9), where perennial pepperweed exceeds 20% of canopy cover. Potential loss on suitable habitat in Wyoming (Table 7) is estimated using a 48% reduction in rent (Table 9). County non-impacted agricultural values and loss estimates from perennial pepperweed are reported in Table 22.

Perennial pepperweed has the highest direct impacts in Sweetwater County, with an estimated \$60,000 in lost agricultural value. Other counties with relatively high impacts include Lincoln County (\$40,000), Albany County (\$33,000) and Big Horn County (\$23,000). Statewide, direct agricultural value lost due to perennial pepperweed totaled \$190,643 in 2021 (Table 22). Loss estimates account for less than 1% in any county and statewide (Table 22).

Potential impacts from perennial pepperweed on suitable habitat across the state includes nine Wyoming counties with loss estimates of over \$1 million, each of which could see agricultural rent reduced by over 10% of non-impacted values. These nine counties are Big Horn (\$4.8 million, 23% loss), Sweetwater (\$4.4 million, 28% loss), Fremont (\$3.6 million, 14% loss), Sublette (\$2.4 million, 16% loss), Lincoln (\$1.7 million, 11% loss), Carbon (\$1.7 million, 12% loss), Uinta (\$1.4 million, 21% loss), Natrona (\$1.2 million, 13% loss), and Goshen (\$1.0 million, 10% loss). Total potential statewide loss is \$31.7 million (Table 22).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, perennial pepperweed infestation reduced the value of agricultural cash rents by an estimated \$191,000 in 2021 (Table 22). This translates to a direct reduction in landowners’ household income as well as related induced losses from foregone household-to-business spending, including 1 annual job, \$39,000 in labor income, \$78,000 in value added, and \$144,000 in output (Table 23).



Perennial pepperweed. Photo by Tom Whitson.

Table 22. Agricultural value and estimated loss from perennial pepperweed (*Lepidium latifolium* L.) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$32,634	0.5%	\$558,791
Big Horn	\$20,928,213	\$22,572	0.1%	\$4,811,237
Campbell	\$11,692,585	\$0	0%	\$659,656
Carbon	\$13,671,418	\$3,078	0.0%	\$1,691,839
Converse	\$7,691,249	\$558	0.0%	\$632,892
Crook	\$9,129,822	\$0	0%	\$635,031
Fremont	\$24,183,709	\$9,826	0.0%	\$3,609,927
Goshen	\$8,496,220	\$1,711	0.0%	\$1,028,831
Hot Springs	\$5,750,263	\$28	0.0%	\$859,676
Johnson	\$8,510,190	\$0	0%	\$704,008
Laramie	\$11,553,857	\$1,354	<0.0%	\$618,856
Lincoln	\$15,206,941	\$39,597	<0.0%	\$1,726,545
Natrona	\$9,104,959	\$1,120	0.0%	\$1,239,230
Niobrara	\$9,050,336	\$8	<0.0%	\$806,831
Park	\$11,782,660	\$6	<0.0%	\$830,901
Platte	\$5,543,312	\$8	<0.0%	\$581,839
Sheridan	\$9,169,040	\$41	<0.0%	\$957,719
Sublette	\$15,151,700	\$9,688	0.1%	\$2,371,915
Sweetwater	\$15,837,056	\$60,031	0.4%	\$4,397,021
Teton	\$4,469,633	\$54	<0.0%	\$26,288
Uinta	\$6,618,833	\$8,160	0.1%	\$1,371,446
Washakie	\$5,021,520	\$168	<0.0%	\$957,646
Weston	\$6,472,690	\$0	0%	\$612,443
State total	\$251,684,701	\$190,643	0.1%	\$31,690,566

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.15 and 0.8 representing 15% and 80% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.48 representing 48% loss, reported in Table 9).

Table 23. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from perennial pepperweed (*Lepidium latifolium* L.) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$190,643				
Induced (household spending)		1	\$38,987	\$77,589	\$143,599

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

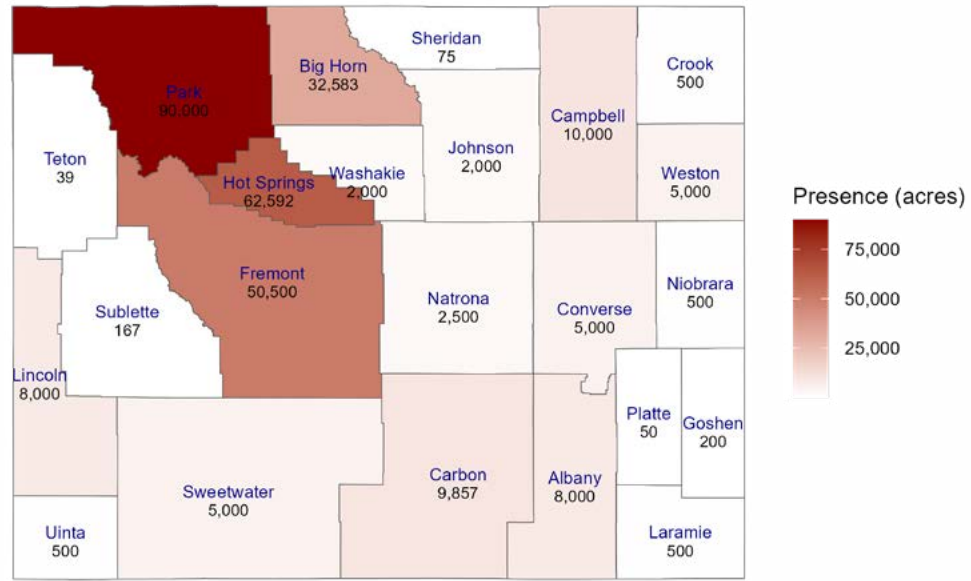
²Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 9. County-level Russian knapweed (*Acroptilon repens*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



RUSSIAN KNAPWEED (*ACROPTILON REPENS*)

SPECIES DESCRIPTION

Russian knapweed (*Acroptilon repens*) is a non-native creeping herbaceous perennial with pink or purple thistle-like flowers, distinguished by brown or black spreading rhizomes (USFS 2015). It is capable of reproducing seed but primarily propagates from vegetative root buds (Beck 2013). In the western U.S., Russian knapweed is found along roadsides and fence lines as well as on rangeland, pasture, and riparian corridors. Dense stands of Russian knapweed reduce livestock and wildlife forage availability; moreover, it is toxic to livestock, especially to horses (USFS 2015).

DISTRIBUTION IN WYOMING

Russian knapweed was observed and reported by Wyoming Weed and Pest supervisors as present on 295,563 acres in 2021–2022 (Table 5), 36% or 106,733 acres of which was classified as impacted (observed as more than 20% of vegetative cover (Table 6)). A swath of northwest-north-central Wyoming has relatively high Russian knapweed presence, including 90,000 acres in Park County, 62,592 acres in Hot Springs, 50,500 acres in Fremont, and 32,583 acres in Big Horn (Table 5, Figure 9).

Suitable Russian knapweed habitat is estimated at 39.5 million acres across Wyoming, with significant potential for losses in Sweetwater County as well as Fremont, Carbon, and Natrona counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

In Wyoming, Russian knapweed is associated with rangeland and pasture and hay agricultural land cover (Table

8). Direct economic loss to agricultural value from Russian knapweed in Wyoming is estimated as a 40% reduction in annual cash rent associated with these land types (Table 3) on areas with reported presence and 80% on impacted areas (Table 9), where Russian knapweed exceeds 20% of canopy cover. Potential loss on suitable Russian knapweed habitat (Table 7) is calculated using a 60% loss estimate (Table 9). County non-impacted agricultural values and loss estimates from Russian knapweed are reported in Table 24.

Big Horn, Hot Springs, and Park counties have the highest estimated direct impacts to agriculture from Russian knapweed infestation, with \$226,000, \$167,000, and \$102,000 in lost annual cash rent in 2021, respectively. Statewide, lost value totaled \$715,510 (Table 24). Loss estimates from Russian knapweed are 2.9 % of non-impacted agricultural value in Hot Springs County, 1.1% in Big Horn County, and less than 1% in all other counties as well as statewide (Table 24).

Potential losses from Russian knapweed on suitable habitat across Wyoming total \$90 million, including \$9.4 million in Fremont County, \$8.7 million in Sweetwater County, and \$8.3 million in Big Horn County (Table 24).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, Russian knapweed infestation reduced the value of agricultural cash rents by an estimated \$716,000 in 2021 (Table 24). This translates to a direct reduction in landowners’ household income as well as related induced losses from foregone household-to-business spending, including 3 annual jobs, \$146,000 in labor income, \$291,000 in value added, and \$539,000 in output (Table 25).



Russian knapweed. Photo by Beth Fowers.

Table 24. Agricultural value and estimated loss from Russian knapweed (*Acroptilon repens*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$14,333	0.2%	\$1,795,622
Big Horn	\$20,928,213	\$226,416	1.1%	\$8,328,272
Campbell	\$11,692,585	\$22,650	0.2%	\$4,767,793
Carbon	\$13,671,418	\$31,927	0.2%	\$5,451,790
Converse	\$7,691,249	\$6,701	0.1%	\$3,738,115
Crook	\$9,129,822	\$1,162	0.0%	\$1,471,076
Fremont	\$24,183,709	\$97,420	0.4%	\$9,414,193
Goshen	\$8,496,220	\$443	0.0%	\$4,063,366
Hot Springs	\$5,750,263	\$167,313	2.9%	\$2,604,669
Johnson	\$8,510,190	\$4,430	0.1%	\$3,267,934
Laramie	\$11,553,857	\$1,710	0.0%	\$3,604,162
Lincoln	\$15,206,941	\$11,783	0.1%	\$3,708,983
Natrona	\$9,104,959	\$3,689	0.0%	\$4,687,337
Niobrara	\$9,050,336	\$1,121	0.0%	\$4,599,942
Park	\$11,782,660	\$102,561	0.7%	\$2,024,911
Platte	\$5,543,312	\$85	0.0%	\$2,922,076
Sheridan	\$9,169,040	\$165	0.0%	\$2,966,757
Sublette	\$15,151,700	\$482	0.0%	\$3,744,679
Sweetwater	\$15,837,056	\$7,063	0.0%	\$8,697,114
Teton	\$4,469,633	\$28	0.0%	\$6,263
Uinta	\$6,618,833	\$1,286	0.0%	\$3,182,155
Washakie	\$5,021,520	\$4,073	0.1%	\$2,330,278
Weston	\$6,472,690	\$8,670	0.1%	\$2,608,889
State total	\$251,684,701	\$715,510	0.3%	\$89,986,377

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.4 and 0.8 representing 40% and 80% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.6 representing 60% loss, reported in Table 9).

Table 25. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from Russian knapweed (*Acroptilon repens*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$715,510				
Induced (household spending)		3	\$146,323	\$291,204	\$538,948

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

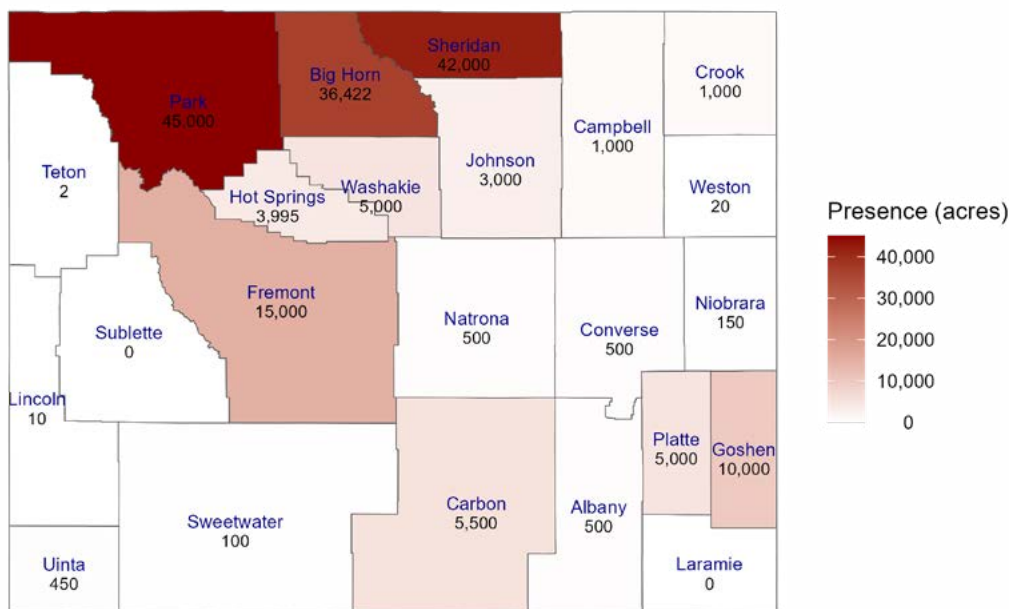
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 10. County-level Russian olive (*Elaeagnus angustifolia*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



RUSSIAN OLIVE (*ELAEGNUS ANGUSTIFOLIA*)

SPECIES DESCRIPTION

Russian olive (*Elaeagnus angustifolia* L.) is a tall shrub or small tree, native to Eurasia and introduced to North America in the early 1900s as a shelterbelt tree. It is now widespread and self-sustaining in riparian areas in the western U.S., where it can replace native cottonwood and willows (Weyl and Pasiecznik 2018). Russian olive can be invasive in irrigated pasture and hay land, interfering with irrigation systems (Pokorny, Mangold, and Noack 2020).

DISTRIBUTION IN WYOMING

Russian olive presence was reported in Wyoming on 175,149 acres in 2021–2022 (Table 5), 75,841 acres (43%) of which was classified as impacted (accounting for more than 20% of vegetative cover (Table 6). Across the state, Park, Sheridan, and Big Horn counties have the highest reported acreages, with moderate areas in Fremont and Goshen counties (Table 5, Figure 10).

Suitable Russian olive habitat is estimated at 38.7 million acres across Wyoming, with notable potential for losses in Fremont and Campbell counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Russian olive is associated with pasture and hay agricultural land cover, often adjacent to riparian areas (Table

8). Direct economic loss from Russian olive infestation is estimated as a 35% reduction in annual cash rent on pasture and hay acres (Table 3 and Table 8) with reported presence and 75% on impacted areas (Table 9), where Russian olive exceeds 20% of canopy cover. Potential loss on suitable habitat (Table 7) is estimated using a 55% reduction in cash rent (Table 9). County non-impacted agricultural values and loss estimates from Russian olive are reported in Table 26.

Big Horn and Sheridan counties have the highest estimated agricultural losses from Russian olive, with \$4,000 each; statewide losses are \$9,495 (Table 26). No county exceeded 1% of non-impacted agricultural value impacted by Russian olive (Table 26).

Potential losses due to Russian olive on suitable habitat across Wyoming total \$1.7 million. The largest potential impacts to agricultural value are in Crook and Uinta counties (Table 26).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, Russian olive infestation reduced the value of agricultural cash rents by an estimated \$9,000 in 2021 (Table 26). This translates to a direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including less than 1 annual job, \$2,000 in labor income, \$4,000 in value added, and \$7,000 in output for the state (Table 27).



Russian olive. Photo by Beth Fowers.

Table 26. Agricultural value and estimated loss from Russian olive (*Elaeagnus angustifolia*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$8	0.0%	\$44,209
Big Horn	\$20,928,213	\$3,682	0.0%	\$114,394
Campbell	\$11,692,585	\$39	0.0%	\$166,303
Carbon	\$13,671,418	\$202	0.0%	\$91,114
Converse	\$7,691,249	\$4	0.0%	\$24,180
Crook	\$9,129,822	\$118	0.0%	\$287,590
Fremont	\$24,183,709	\$374	0.0%	\$148,339
Goshen	\$8,496,220	\$268	0.0%	\$56,399
Hot Springs	\$5,750,263	\$100	0.0%	\$25,685
Johnson	\$8,510,190	\$68	0.0%	\$41,477
Laramie	\$11,553,857	\$0	0%	\$52,334
Lincoln	\$15,206,941	\$1	0%	\$46,838
Natrona	\$9,104,959	\$3	0.0%	\$17,596
Niobrara	\$9,050,336	\$6	0.0%	\$74,962
Park	\$11,782,660	\$570	0.0%	\$26,819
Platte	\$5,543,312	\$191	0.0%	\$79,589
Sheridan	\$9,169,040	\$3,731	0.0%	\$116,469
Sublette	\$15,151,700	\$0	0%	\$5,497
Sweetwater	\$15,837,056	\$0	0%	\$3,728
Teton	\$4,469,633	\$0	0%	\$260
Uinta	\$6,618,833	\$53	0.0%	\$206,514
Washakie	\$5,021,520	\$78	0.0%	\$17,927
Weston	\$6,472,690	\$1	0.0%	\$53,439
State total	\$251,684,701	\$9,495	<0.0%	\$1,701,662

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.35 and 0.75 representing 35% and 75% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.55 representing 55% loss, reported in Table 9).

Table 27. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from Russian olive (*Elaeagnus angustifolia*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$9,495				
Induced (household spending)		<1	\$1,942	\$3,864	\$7,152

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

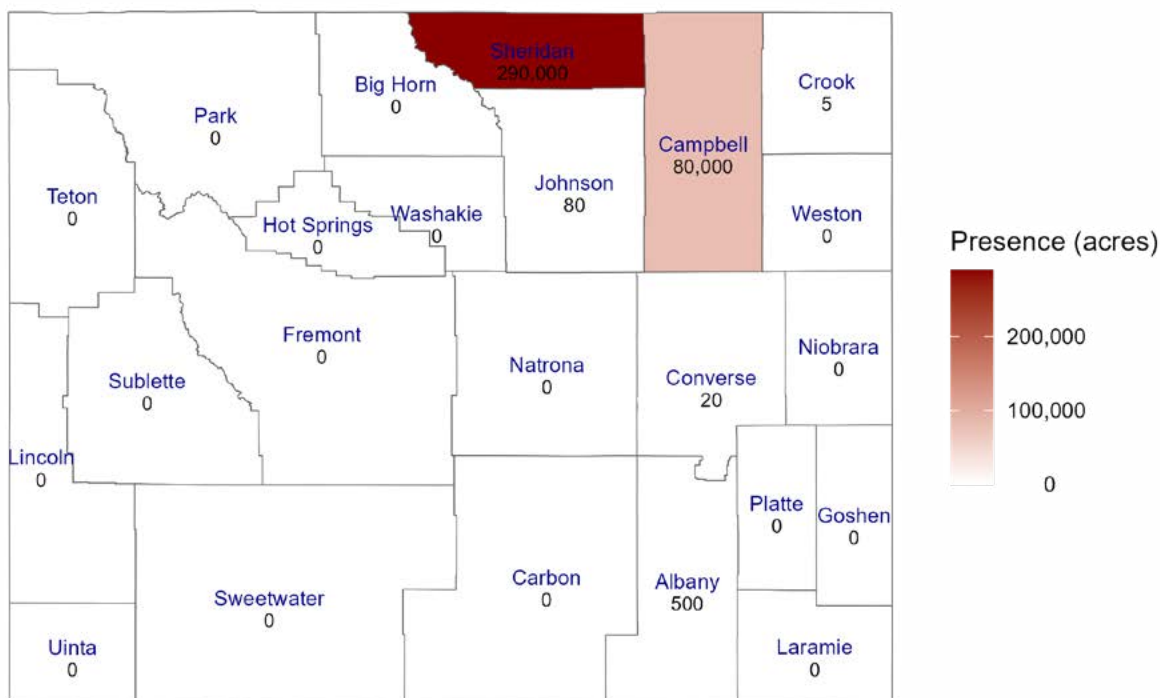
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 11. County-level ventenata (*Ventenata dubia*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



VENTENATA (*VENTENATA DUBIA*)

SPECIES DESCRIPTION

Ventenata (*Ventenata dubia*), also known as African wiregrass, is a non-native cool-season grass species, considered invasive in western North America as it displaces more palatable, nutritious native species and desirable introduced grasses. Ventenata can be invasive in both annual- and perennial-dominated grasslands, including sagebrush-steppe communities (Prather 2015). Ventenata has recently spread to the Great Plains and threatens forage on Wyoming rangelands, with disturbed areas more susceptible to invasion (Hart 2022).

DISTRIBUTION IN WYOMING

Observed occurrences of ventenata in Wyoming are concentrated in Sheridan and Campbell counties with 370,605 acres of ventenata presence reported statewide (Table 5, Figure 11), 35%, or 130,205 acres, of which is classified as impacted (Table 6).

Suitable ventenata habitat is estimated at 11.4 million acres across Wyoming. The highest potential loss area from ventenata is in Campbell County (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

In Wyoming, ventenata is mainly associated with rangeland agricultural land cover (Table 8). Direct economic loss to

agricultural value due to ventenata is estimated as a 40% reduction in annual cash rent for rangeland acres (Table 3 and Table 8) with reported presence and 80% on impacted areas (Table 9), where ventenata exceeds 20% of canopy cover. Potential loss on suitable ventenata habitat (Table 7) is calculated using a 60% loss estimate (Table 9). County non-impacted agricultural values and loss estimates from ventenata infestation are reported in Table 28.

Following observed acres, nearly all lost agricultural value is in Sheridan County (\$853,612), followed by Campbell County (\$147,047); all other counties have negligible or no loss (Table 28). Loss estimates account for 9.1% and 1.2% of non-impacted agricultural value in Sheridan and Campbell counties, respectively, and less than 1% in other counties and statewide (Table 28).

The top county in terms of agricultural value at risk related to ventenata on suitable habitat is Campbell County with \$5.1 million in potential loss. Five other counties (Niobrara, Sheridan, Laramie, Crook, and Converse) have over \$2 million in potential losses on suitable ventenata habitat. Total potential statewide loss is \$27 million. (Table 28).

TOTAL ECONOMIC ACTIVITY AT RISK

Across the Wyoming economy, ventenata infestation reduced the value of agricultural cash rents by an estimated \$1 million in 2021 (Table 28). This translates to a direct reduction in landowners' household income as well as related induced losses from foregone household-to-business spending, including 5 annual jobs, \$205,000 in labor income, \$408,000 in value added, and \$754,000 in output in the state economy (Table 29).



Ventenata. Photo by Beth Fowers.

Table 28. Agricultural value and estimated loss from ventenata (*Ventenata dubia*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$706	0.0%	\$651,350
Big Horn	\$20,928,213	\$0	0%	\$264,826
Campbell	\$11,692,585	\$147,047	1.2%	\$5,089,342
Carbon	\$13,671,418	\$0	0%	\$286,484
Converse	\$7,691,249	\$17	0.0%	\$2,028,365
Crook	\$9,129,822	\$9	0.0%	\$2,306,877
Fremont	\$24,183,709	\$0	0%	\$150,518
Goshen	\$8,496,220	\$0	0%	\$467,256
Hot Springs	\$5,750,263	\$0	0%	\$358,894
Johnson	\$8,510,190	\$100	0.0%	\$1,631,450
Laramie	\$11,553,857	\$0	0%	\$2,471,838
Lincoln	\$15,206,941	\$0	0%	\$286,635
Natrona	\$9,104,959	\$0	0%	\$481,514
Niobrara	\$9,050,336	\$0	0%	\$2,975,968
Park	\$11,782,660	\$0	0%	\$773,631
Platte	\$5,543,312	\$0	0%	\$1,540,901
Sheridan	\$9,169,040	\$853,612	9.1%	\$2,917,217
Sublette	\$15,151,700	\$0	0%	\$12,574
Sweetwater	\$15,837,056	\$0	0%	\$1,042
Teton	\$4,469,633	\$0	0%	\$11,048
Uinta	\$6,618,833	\$0	0%	\$631,497
Washakie	\$5,021,520	\$0	0%	\$131,839
Weston	\$6,472,690	\$0	0%	\$1,616,335
State total	\$251,684,701	\$1,001,491	0.4%	\$27,087,402

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.4 and 0.8 representing 40% and 80% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.6 representing 60% loss, reported in Table 9).

Table 29. Direct loss in agricultural value and related induced economic activity at risk in Wyoming from ventenata (*Ventenata dubia*) infestation, 2021

	Direct Loss ¹	Induced Employment Loss ²	Induced Labor Income Loss ³	Induced Value Added Loss ⁴	Induced Output Loss ⁵
Impact (loss value)	\$1,001,491				
Induced (household spending)		5	\$204,807	\$407,594	\$754,359

Source: IMPLAN model, 2021 data, \$2023.

Notes:

¹ Lost agricultural value, estimated above as a reduction in cash rent on weed-infested agricultural land.

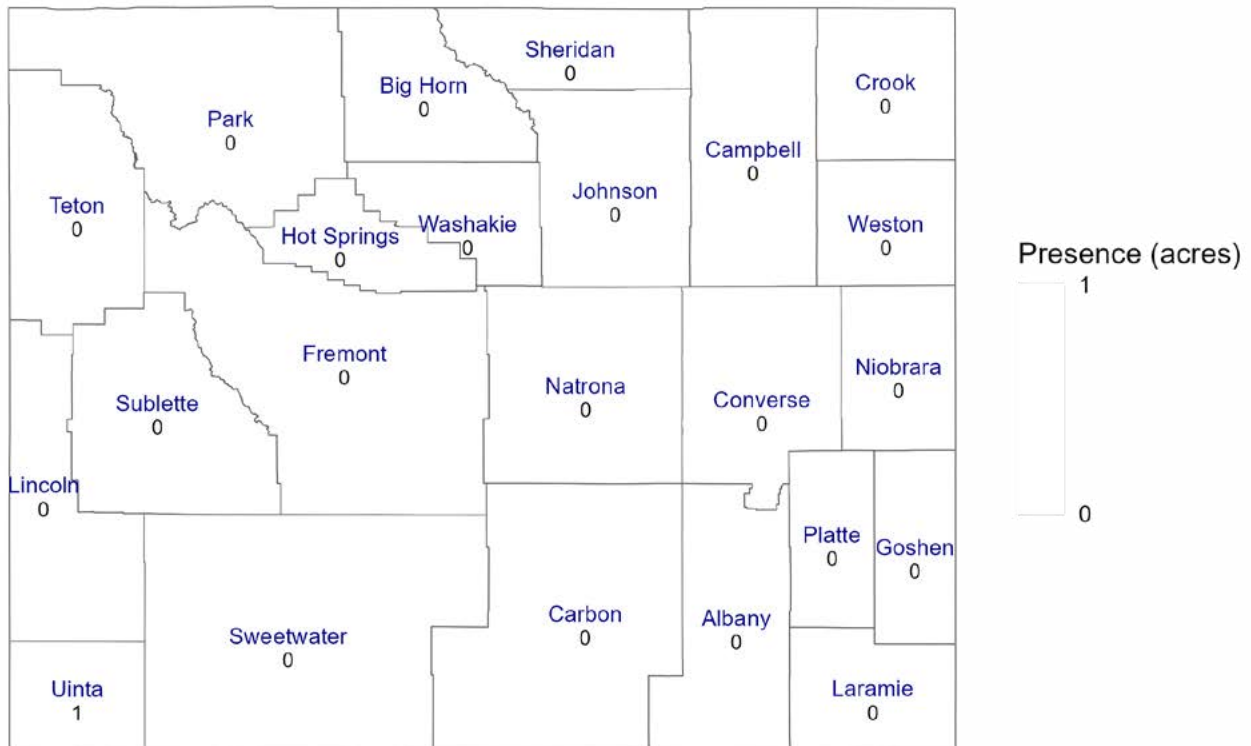
² Number of job years potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

³ Employee compensation and proprietor income potentially supported from household spending in the Wyoming economy if direct agricultural value loss from weed infestation were avoided.

⁴ Value Added is analogous to Gross Domestic Product, and includes labor income, taxes on production and income, and other property income. Loss is Value Added potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

⁵ The total value of production (Value Added plus Intermediate Inputs) potentially supported from household spending in the Wyoming economy if weed infestation were avoided.

Figure 12. County-level yellow starthistle (*Centaurea solstitialis*) presence distribution estimated by Wyoming Weed and Pest supervisors in 2021.



YELLOW STARThISTLE (*CENTAUREA SOLSTITALIS*)

SPECIES DESCRIPTION

Yellow starthistle (*Centaurea solstitialis*) is a tap-rooted annual forb in the sunflower (Asteraceae) family (Whitson et al. 2009). This weed spreads through high rates of seed production and seedbanks that can remain in the soil for 10 years (DiTomaso, Kyser, and Pitcairn 2006). Yellow starthistle can cause serious damage to both rangeland and improved pasture (Eagle et al. 2007), reducing carrying capacity from 10 to 50% (DiTomaso, Kyser, and Pitcairn 2006). The weed can also contaminate dried hay and can be toxic to horses (DiTomaso, Kyser, and Pitcairn 2006).

DISTRIBUTION IN WYOMING

Yellow starthistle had one acre reported of presence and none impacted Wyoming in 2021–2022 (Table 5, Figure 12).

Suitable yellow starthistle habitat is estimated at just 16,351 acres across Wyoming, mainly in Park, Natrona, and Platte counties (Table 7).

DIRECT ECONOMIC IMPACT TO WYOMING AGRICULTURE

Yellow starthistle is associated with rangeland and pasture and hay agricultural land cover (Table 8). Direct economic loss is estimated as a 20% reduction in annual cash rent for

rangeland and pasture and hay (Table 3, Table 8) on acres with reported presence and 60% on impacted areas (Table 9), where yellow starthistle exceeds 20% of canopy cover. Potential loss on suitable habitat (Table 7) is estimated using a 40% reduction in cash rent (Table 9). County non-impacted agricultural values and loss estimates from yellow starthistle infestation are reported in Table 30.

With only a single reported acre of presence, yellow starthistle infestation did not reduce agricultural value in Wyoming in 2021–2022. Fourteen Wyoming counties with suitable yellow starthistle habitat had potential loss. These potential reductions in agricultural rents statewide are estimated at \$22,000, with the highest impacts in Park, Natrona, and Platte counties (Table 30).

TOTAL ECONOMIC ACTIVITY AT RISK

With virtually no present yellow starthistle presence reported for 2021–2022, the value of agricultural cash rents was not reduced and there were no related induced losses from foregone household-to-business spending in Wyoming.



Yellow starthistle. Photo by Tom Whitson.

Table 30. Agricultural value and estimated loss from yellow starthistle (*Centaurea solstitialis*) infestation by Wyoming county

Wyoming county	Total non-impacted agricultural value ¹ (\$/year)	Loss to agricultural value ² (\$/year)	Percent of total agricultural value lost ³	Potential loss on suitable habitat ⁴ (\$/year)
Albany	\$7,058,082	\$0	0%	\$1,056
Big Horn	\$20,928,213	\$0	0%	\$998
Campbell	\$11,692,585	\$0	0%	\$217
Carbon	\$13,671,418	\$0	0%	\$252
Converse	\$7,691,249	\$0	0%	\$420
Crook	\$9,129,822	\$0	0%	\$0
Fremont	\$24,183,709	\$0	0%	\$162
Goshen	\$8,496,220	\$0	0%	\$1,441
Hot Springs	\$5,750,263	\$0	0%	\$2,780
Johnson	\$8,510,190	\$0	0%	\$237
Laramie	\$11,553,857	\$0	0%	\$1,457
Lincoln	\$15,206,941	\$0	0%	\$0
Natrona	\$9,104,959	\$0	0%	\$3,936
Niobrara	\$9,050,336	\$0	0%	\$0
Park	\$11,782,660	\$0	0%	\$4,917
Platte	\$5,543,312	\$0	0%	\$3,497
Sheridan	\$9,169,040	\$0	0%	\$0
Sublette	\$15,151,700	\$0	0%	\$0
Sweetwater	\$15,837,056	\$0	0%	\$0
Teton	\$4,469,633	\$0	0%	\$0
Uinta	\$6,618,833	\$1	0%	\$0
Washakie	\$5,021,520	\$0	0%	\$429
Weston	\$6,472,690	\$1	0%	\$0
State total	\$251,684,701	\$0	0%	\$21,799

Notes:

¹ Total area × proportion of each agricultural land category × its respective annual cash rent value.

² Weed area reported as present and impacted by Wyoming Weed and Pest supervisors in 2021–2022 × each agricultural land category proportion × respective annual cash rent value × respective biomass reduction estimates (0.2 and 0.6 representing 20% and 60% loss, respectively).

³ Annual loss to agricultural value / Total non-impacted agricultural value.

⁴ USGS INHABIT suitable habitat acreage × each agricultural land type proportion × respective annual cash rent value × respective biomass reduction estimate (0.4 representing 40% loss, reported in Table 9).

IMPLICATIONS

Invasive species have substantial economic impacts in Wyoming, as we have demonstrated. Among the species presented, cheatgrass currently has the largest impact on the statewide economy. This species was responsible for \$28.7 million in losses in 2022. In comparison, ventenata, the second most economically damaging species, caused just over \$1 million in losses in 2022. While these numbers may seem relatively small compared to the total economy of the state, they only reflect one level of impact (loss, primarily, of grazing cash rent) that is relatively low in value compared to other ecosystem goods and services. As such, these impact numbers may be very conservative estimates of actual impacts to the state. However, by focusing on agricultural value at risk, this analysis provides valuable information about the impacts of weed infestation across the state to aid in prioritizing species for control and providing a basis for comparison over time.

This report serves as a pilot study, setting out sound methods to estimate the economic impacts of 10 weeds with diverse growth habits, habitat requirements, and potential threats to Wyoming agriculture. Any such estimates are only as good as the area and distribution measures that inform them. The methods used to estimate agricultural value lost to infestation from each selected weed species are a simple reduction in agricultural cash rent for relevant land types (cropland versus pasture and hay or rangeland). Further economic impact analyses serve to illustrate lost value from other types of ecosystem goods and services at risk to impacts from terrestrial invasive plants.

Our results provide a basis to compare costs from lost agricultural value across a subset of invasive species and counties, as well as for ongoing comparisons over time. By including an assessment of potential losses if each species were allowed to spread into all currently suitable habitat, we can estimate the potential proactive reduction in such impacts. While there is much uncertainty regarding habitat suitability, suitable habitat used in this report provides a current best estimate of potential impacts if the weeds were left to spread unchecked.

We must interpret results presented here with appropriate caution. Current impact estimates are based solely upon the acreage estimates from each county Weed and Pest Control District. District personnel are the local experts regarding invasive weeds and are likely the best source for such estimates. However, it is nearly impossible to estimate acreage infested with absolute certainty. Until technology allows us to accurately map weed distribution to the finest scale at very large acreages, local expert knowledge is the best alternative.

Readers must also keep in mind the relationship between realized losses and potential losses due to expansion. It may be tempting to focus on a high-loss species such as cheatgrass in lieu of currently low-loss species (e.g., medusahead). Many of the low-loss species in this analysis are new or not yet widely established in the state, so we may not fully know their impacts. Additionally, preventing further spread of species

with very limited range in Wyoming is a higher-leverage approach than waiting for them to have broad-reaching impacts before implementing a strategic management approach.

These estimates should be considered when planning for invasive plant management—especially when taking regional or statewide approaches. However, the estimates presented here may be considered conservative since we did not include impacts to other ecosystem goods and services such as recreation, wildfire reduction, and wildlife habitat. Non-market ecosystem goods and services can be substantial and even overshadow market goods and services (Epanchin-Niell 2017; Holmes et al. 2009; Rosenberger et al. 2012). Future work should explore additional impacts beyond direct losses to agricultural production capacity.

FURTHER WORK

Work such as that presented in this analysis is limited by lack of empirical data on distribution and severity of weed species across the state. Collection, curation, and sharing of such data in a way that is useful for analyses like this and for decision-makers will strengthen our ability to assess impacts and plan strategically for the future. Additionally, we need more information on the direct losses to other ecosystem goods and services caused by terrestrial invasive weeds. Although general concepts and anecdotal information are commonly seen, it is difficult to find examples of direct impacts across a suite of weed species in our region. Some examples that may be considered for opportunities to improve estimates for future efforts may include the following.

PUBLIC VERSUS PRIVATE RANGELAND SPATIAL AREAS AND VALUES

Available spatial Bureau of Land Management grazing allotment (DOI 2022), U.S. Forest Service Range Management Unit (USFS 2022a), and state and county grazing lease (WOSLI 2020a) data, paired with public grazing lease rates (e.g., BLM 2022b; USFS 2022b; WOSLI 2020b), could be used to more accurately estimate agricultural values on public lands.

PARCEL-LEVEL PRIVATE AGRICULTURAL LAND AREA AND USE

Likewise, Wyoming land parcel polygons (State of Wyoming 2022) and parcel-level county assessment data available from the Wyoming Department of Revenue (WDOR 2022) could be used to better define agricultural land tax status, as well as agricultural production quality and land values associated with spatial locations.

IRRIGATED VERSUS NON-IRRIGATED CROPLAND

Irrigated versus non-irrigated croplands could also be paired with relevant cash rent value. Several spatial datasets defining irrigated cropland are available, including the

U.S. Geological Survey's MODIS dataset (USGS 2019) and Wyoming State Climate Office Water Resources Data System irrigated lands map (WWDO 2007). These data could be paired with NASS-reported cash land rents on irrigated and non-irrigated croplands by Wyoming county (e.g., NASS 2017) and reported as a weighted value (= [irrigated crop rent × proportion irrigated] + [non-irrigated cropland rent × 1 - proportion irrigated]).

IMPROVED SUITABLE HABITAT ESTIMATES

Identifying irrigation status allows for other additional specificity for individual species; for example, cheatgrass impacts could be specified on non-irrigated croplands and Russian olive on irrigated cropland as well as pasture and hay land. Spatial data from more rigorous recent modeling of Russian olive habitat is available from Perry, Jarnevich, and Shafroth (2022). A more focused review of literature for other species might uncover additional sources for suitable habitat estimates.

IMPACTS TO SPECIFIC CROPS

Recent (2021) spatial data for specific crops is available using the USDA Cropland Data Layer (NASS 2022). NASS also reports county-level crop production values. Furthermore, the Weed Science Society of America yield loss committee publishes the economic impact of weed competition in different crops every few years, including crops relevant to Wyoming, such as corn, dry beans, sugar beets, and wheat (WSSA 2023). Combining these at the county level with Wyoming Weed and Pest weed presence and impact observations could be used for more crop-specific loss estimates. Examples of specific crop impacts from weeds identified for analysis in Wyoming include cheatgrass losses associated with winter wheat (Blackshaw and Hamman 1998), winter rye, and other dryland crops (Blackshaw 1993; Schillinger et al. 2006); Palmer amaranth with corn (Massinga et al. 2001), soybeans (Klingaman and Oliver 1994), dry edible beans (Miranda et al. 2022), and sugar beets (Beiermann et al. 2021); and hoary cress infesting corn, small grains, and sugar beets (Weyl 2018).

VALUING LOSSES AND COSTS TO ECOSYSTEM SERVICES

Analysis of the economic impacts related to weed infestation on recreation, ecosystem services, wildfire, wildlife habitat, or similar observations (e.g., Eiswerth et al. 2009, Brunson and Tanaka 2011), is an obvious extension to this pilot study that focuses solely on losses related to agricultural value. Study areas expanded to include non-agricultural wildland areas could capture additional lost economic value. The economic value of wildlife, recreation, and other ecosystem services has also been applied to western rangelands (Maher et al. 2021), though not in Wyoming. Examples of invasive weeds leading to lost ecosystem services value might include medusahead infestation that reduces diversity in

native sagebrush habitat or cheatgrass infestation related to degraded wildlife forage that has a potential to reduce hunting tags available in certain areas (WGFD 2022).

Wildfire suppression costs and benefits impacted by invasive weeds such as cheatgrass may shift Wyoming wildfire regimes (Taylor et al. 2013). This shift can directly impact homes and human lives, but also has indirect effects such as air quality impacts and increased wildfire suppression costs (Jaffe et al. 2020).

FURTHER ECONOMIC IMPACT ANALYSIS

Further economic impact analysis could expand IMPLAN modeling to translate loss and potential loss in agricultural value into potential indirect loss from infestation on suitable habitat.

TOTAL AGGREGATE COST

Summing indirect economic loss estimates over multiple weeds in a given area, for example to calculate the total loss in agricultural value from all selected invasive species in a given county or statewide, requires a process that accounts for the possibility that multiple weeds may be impacting the same observed or suitable area. Developing a total aggregate cost method that accounts for potential overlapping species and species-specific agricultural land types could be valuable as part of further analysis.

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