Economic Assessment of Noxious Weeds in Montezuma County

Written by: Bonnie Loving

Montezuma County Noxious Weed Department Director

970-565-0580

bloving@co.monteuzma.co.us

Date: 8-2-2022

Disclaimer:

Bonnie Loving is not an economist, however she felt it was important an economic assessment was done in Montezuma County to show the impacts of noxious weeds. There are many variables that can still be taken into account.

These are all reserved numbers based off MCNWD inventory data, USDA Land Type, CSU, Parks and Wildlife, along with dozens of studies. A full report of this assessment, including sources and the steps taken to calculate these numbers, can be found at: www.montezumacounty.org/noxious-weed-program.

Variables that have not been analyzed by Bonnie are impacts on recreation, wildlife, aesthetics, land value, infrastructure (road, irrigation canal, waterway damage, etc...), and species that can increase frequency and intensity of wildland fires.

Index:

Executive Summary:

Noxious weeds have a substantial impact on the economy in Montezuma County. It was only until recently that Montezuma County Noxious Weed Department (MCNWD) had enough inventory data to conduct an economic assessment from the impact of noxious weeds. The inventory data shows that Montezuma County has 51,407 acres infested with designated noxious weeds. In order to know where weed management should be prioritized it is important to understand the economic impact noxious weeds have on different land types.

Much research and analysis of data was done in this assessment to grasp the impact of noxious weeds. The results show an economic loss of $157,361 in wheat crops, $1,621,589 in alfalfa crops, $1,799,662 in grass hay, $40,226 in corn, $91,351 in other crops, $131,448 in rangeland grazing loss, $97,206.47 loss in hunting revenue, and $1,163,651 lost due to water consumption of Russian olives and saltcedars. The results show that the priority of Montezuma County should be in restoring land from non-native phreatophytes such as Russian olives and saltcedars. The second biggest economic impact from noxious weeds is on alfalfa, which should also be a priority.

By completing this assessment, Bonnie Loving, hopes land managers and the public will get a better understanding of the impact noxious weeds have on our land. These silent invaders are very underestimated by most, and if they are not managed the economic losses will only increase over time.

Introduction:

The Department of Agriculture defines noxious weeds as; "*any non-native plant that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment.*" Most noxious weeds have been introduced into the United States by ignorance or mismanagement. Typically, these species grow aggressively, multiply quickly without natural controls, and easily outcompete native species.

The purpose of this economic assessment is to shed light on the current noxious weed situation in Montezuma County and the corresponding impacts the local economy. Bonnie hopes this assessment will help show the public the problem we are facing with noxious weeds and inspire them to take action and help restore the land to native/desirable species.

Noxious Weed Species Assessed:

In Montezuma County, there are 37 known species of noxious weeds. Of these 37 species, nine species have populations under one acre, and 13 species have populations under 150 acres; therefore, they will not be included in this assessment. Of the 37 known noxious weed species, seven species have not been thoroughly mapped. There will be nine species used in this assessment which all have populations over 150 acres and have been thoroughly mapped. These species are Canada thistle, Dalmatian toadflax, downy brome, hoary cress, musk thistle, Russian knapweed, Russian olive, saltcedar, and jointed goatgrass.

Data Source:

Our Montezuma County Geographic Information System (GIS) team took the 2019 crop type data from USDA and converted the raster data into a polygon shapefile that Bonnie could use. Spatial algorithms created this crop type data by the color of the land given the local geographic aspects such as elevation and climate. By using the crop type

data, Bonnie can overlay their noxious weed inventory data to see how many acres of each crop type is infested with noxious weeds. From there, Bonnie assessed crop yield losses and associated economic impacts.

Crop types include agricultural crop products and designated land as riparian, barren, developed, rangeland, and forest. By using this data, Bonnie can then calculate infested acreages within each land type and then assess the impacts.

The Montezuma County Noxious Weed Department (MCNWD) updates the noxious weed inventory data annually throughout the county (private and public). Infestations are mapped from the public right-of-way and off private properties when the landowner gives permission. MCNWD uses contemporary AgTerra software to map noxious weed populations without walking the entire boundary of the infestation.

For this assessment, the weed inventory will be used from data that has been compiled over a five-year period (2015-2020). The inventory data used is comprised of data collected by MCNWD, the Bureau of Land Management (BLM) data, and the United States Forest Service (USFS) data. Data will be adjusted for known gaps in inventory per species, as well as for overlapping population data.

Adjustment of Noxious Weed Inventory Data:

As was mentioned in the data source section, MCNWD maps noxious weeds mainly on public right-of-ways, which means there is a lack of data for the private properties viewable from public right-of-way. There is also a lack of inventory data from public land managers because of the lack of resources and funding to conduct inventory over such large areas of public land. Due to these two known gaps in data, there has been an adjustment on the 2015-2020 compiled inventory data. Bonnie has made these adjustments based on professional experience and local knowledge of the area. The following narrative discusses adjustment needs for each of the nine noxious weed species that is being assessed.

Saltcedar and Russian Olive Data:

Saltcedar and Russian olive data was mapped in 2019 using satellite imagery; estimated accuracy is 95% for all populations within Montezuma County. These species are very distinctive from other native vegetation; therefore, satellite imagery is accurate. Saltcedar and Russian olive data required no adjustments because of the presumed accuracy.

Dalmatian Toadflax Data:

There are several locations of Dalmatian toadflax populations that have been reported to BONNIE through credible sources that have not been mapped yet. These populations are estimated to be about 100 acres in total. Bonnie will therefore increase the mapped inventory of Dalmatian toadflax by 10% to account for the populations that have not been mapped yet.

Canada and Musk Thistle Data:

Canada and musk thistle populations are generally found on disturbed land, whether that be from overgrazing, development, right of ways, or farming. MCNWD has good inventory off right of ways and in developed areas. Areas that are grazed by cattle are not easily seen off public right of ways, especially within forested areas. MCNWD has good data from farmland, typically the sections of land are uniform in management. Therefore, if the sections of field that MCNWD can see, from public right of way, consists of 10% of noxious weeds, it is safe to presume the entire field, past what BONNIE can see, will be consistent with 10% of noxious weeds.

Given the knowledge of the area and where MCNWD has good data and where the data is likely to be lacking, the inventory numbers will be adjusted by 15%.

Hoary Cress Data:

A majority of hoary cress populations occur on developed land, right of ways, or irrigated land. It is very rare to see hoary cress survive on dryland areas. A majority of the populations are found on private lands that have water. BONNIE has an accurate inventory of hoary cress because most populations are visible from the public right of ways. Hoary cress tends to stick out from other vegetation therefore it is easy to spot a mile away.

Bonnie estimates 95% of hoary cress populations have been mapped, therefore no adjustment of the inventory data is needed.

Downy Brome Data:

Downy brome is very widespread throughout the county, the only areas that it tends to not dominate the vegetation are within USFS land. Farmland / vacant land is easy to map downy brome because the land is generally flat with not trees, therefore it is easy to see long distances. Right of ways are generally not mapped with noxious weed infestations because they are constantly being treated, meaning the noxious weed populations are not stable.

The challenging areas to map Downy brome are in pinion pine / juniper stands, which dominates most of the BLM land, and some private land. BLM occupies 15% of Montezuma County, putting it at 194,000 acres. From what Bonnie has seen as far as downy brome populations within pinion pine and juniper stands, it is estimated that 20% of BLM land has downy brome. Bonnie also estimates there is at least 500 to 1,000 acres infested within private lands that have not been mapped. Therefore, the downy brome population numbers will be increased by 35% to accommodate these unmapped areas.

Jointed Goatgrass Data:

Jointed goatgrass is a very problematic species for local wheat farmers, and mapped data is currently lacking. Jointed goatgrass is a species that requires onsite personal inventory. Jointed goatgrass cannot be accurately identified and mapped from afar.

Nine major wheat producing counties of western Nebraska researched jointed goatgrass between 1990 and 1992. Nearly 1,300 grain samples were collected from trucks delivering newly harvested wheat to grain elevators. Of the samples, 25 percent contained jointed goatgrass spikelets (joints), each spikelet containing one to four seeds. In Kimball, Cheyenne, Deuel, Keith, and Perkins counties more than 40 percent of the samples contained jointed goatgrass spikelets.

According to the 2019 USDA data, Montezuma County has about 6,500 acres of winter wheat. If 25% of Montezuma County's wheat is contaminated, that puts the population at about 1,625 acres. Currently, BONNIE has mapped jointed goatgrass on 100 acres of the public right-of-way, which is estimated to be 70% of the overall jointed goatgrass populations within the public right-of-way. Therefore, in total, it is estimated Montezuma County has about 1,800 acres of jointed goatgrass.

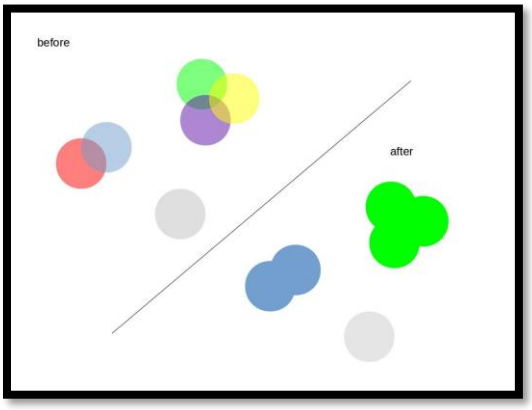
Russian knapweed Data:

Russian knapweed is one of Montezuma County's most widespread and problematic species. MCWD mapped a total of about 11,000 acres of Russian knapweed from 2015 to 2020. (dissolved acreage removing any overlapping polygons). MCWND knows this is not all of the knapweed within the county; the BLM has many populations not accounted for and private lands not inventoried. It is likely that there is another 25% of Russian knapweed unmapped. However, to be more conservative, the knapweed inventory will only be increased by 15%.

Overlapping Data Adjustment:

When adjusting overlapping data within a GIS system, the technical term is dissolving. When dissolving data, multiple overlapping polygons are combined or "dissolved" into one polygon. To map a noxious weed population, MCNWD draws a polygon around the perimeter of the infestation. Then the Polygons are categorized under which species are growing within that polygon, or multiple species (depending on what is growing there that year). The problem with only using this raw data is that there will be many overlapping polygons after five years of mapping. Then when calculating the total acreage of these polygons, it will be highly inaccurate. Thus overlapping polygons must be dissolved to improve accuracy.

Table 1: Dissolving Polygons Visual



Individual species populations have been dissolved to delete any overlapping polygons mapped on different dates between 2015 and 2020. This gives an accurate acreage of each species. The same process of dissolving will then be done based off land type. Multiple noxious weed species can and do occur in the same area, which results in overlapping polygons of different species occupying the same land type. Noxious weed populations will be dissolved to give an accurate acreage for each land type.

Noxious Weed Inventory Relative to Land Type Data:

The primary land cover types in Montezuma County are wheat, other crops, barren/fallow, rangeland, corn, alfalfa, grass hay, riparian/waterway, developed, and forest. The two predominate land cover types are rangeland and forest, which occupy about 89.3% of Montezuma County. The data shows 27,011 acres of the forest and rangeland are infested with noxious weeds. The four most predominant species found in the forest are Canada thistle, downy brome, musk thistle, and Russian knapweed. The most predominant species found in rangeland are downy brome, Russian knapweed, and musk thistle.

Alfalfa is the third largest land type in Montezuma County, consisting of 42,659 acres. Of this acreage, 3.3% is infested with noxious weeds. Alfalfa is a challenging crop type to not damage while managing for noxious weeds. Once broadleaf noxious weeds are established in alfalfa fields, the farmer will most likely plant the field into a grass species in order to eradicate the noxious weed species. Canada thistle, musk thistle, and Russian knapweed are the most common species found in alfalfa fields according to the data.

Grass hay fields and wheat fields both have high infestations of Canada thistle and downy brome. Wheat fields' most problematic noxious weed problem is found with jointed goatgrass, which infests about 1,800 acres of wheat

fields. Jointed goatgrass populations within wheat fields will be a difficult problem to solve because of the seed contamination problem.

Riparian and waterway areas have high infestations of Russian olives and saltcedars. These two species are very aggressive and have dominated a majority of waterways in Montezuma County. Their ability to utilize both ground water and water from the aquafers give them a competitive advantage to the native vegetation. Saltcedar also has a competitive advantage by pumping salt from deep into the soil and depositing it on the soil surface, which most native plants cannot tolerate.

Corn and other crops have about 8% of their acreage contaminated with noxious weeds. The prominent noxious weed species that grows in these areas is Canada thistle. Once again, most of these crops are broadleaf crops which makes it very challenging to manage a broadleaf weed in without injuring the crop. The farmers in Montezuma County are moving more towards round-up ready crops, which significantly reduces noxious weed problems.

Barren and fallow land has about 2,700 acres infested by noxious weeds. The two most prominent noxious weed species are downy brome and Canada thistle. Lastly, the developed acreage has about 3,800 acres infested with noxious weeds, predominately Canada thistle and musk thistle.

Table 2: Noxious Weed Species Relative to Land Type (Adjusted and Dissolved)

	2015-2020 Adjusted Acreage	Wheat Acreage Infested	Other Crops Acreage Infested	Barren / Fallow Acreage Infested	Rangeland Acreage Infested	Corn Acreage Infested	Alfalfa Acreage Infested	Grass Hay Acreage Infested	Riparian/ Waterway Acreage Infested	Developed Acreage Infested	Forest Acreage Infested
Canada thistle	14,611	1,457	399	668	3,299	338	3,747	2,022	393	775	1,512
dalmatian toadflax	1,394	20	1	17	1,234	-	32	-	-	70	20
downy brome	18,430	1,033	105	1,500	11,274	99	911	1,933	240	188	1,148
hoary cress	1,630	23	0	8	1,040	3	155	85	11	247	58
musk thistle	12,621	599	190	397	5,169	33	2,634	1,268	255	636	1,440
Russian knapweed	12,826	178	60	125	8,388	10	1,218	714	325	704	1,103
Russian olive	5,825	8	0	-	2,236	11	551	211	2,076	212	520
salt cedar	6,021	6	3	9	1,999	13	355	110	2,607	198	721
jointed goatgrass	3,325	1,769	0	46	578	-	81		28	748	75
Totals	**76,683**	**5,093**	**758**	**2,770**	**35,218**	**507**	**9,683**	**6,344**	**5,936**	**3,778**	**6,596**

Table 3: Infested Land Types Relative to Total County Acreage

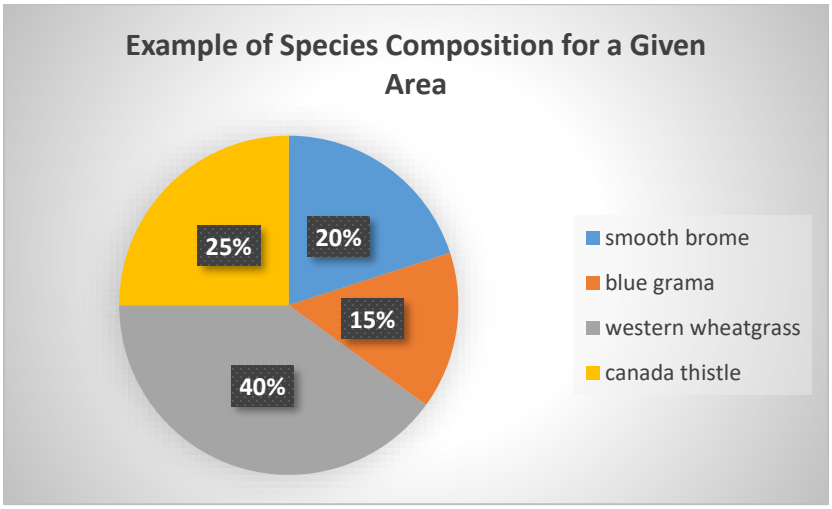
	2015-2020 Noxious Weed Acreage	Total Acreage in Montezuma County	% of Noxious Weed Coverage	Percent of Land Each Land Type Occupies in Montezuma County
Wheat	3786	13547	27.9%	1.0%
Other Crops	468	6214	7.5%	0.5%
Barren / Fallow	2162	15058	14.4%	1.2%
Rangeland	22870	641280	3.6%	49.3%
Corn	278	3348	8.3%	0.3%
Alfalfa	5705	42659	13.4%	3.3%
Grass Hay	4218	14259	29.6%	1.1%
Riparian / Waterway	5375	25538	21.0%	2.0%
Developed	2404	18648	12.9%	1.4%
Forest	4141	519335	0.8%	40.0%

Noxious Weed Species Impact on Crop Yield:

There are two main ways noxious weeds impacts agriculture; they outcompete the crops and reduce crop quality. Economically, this affects producers through crop yield losses and product value. Calculating these economic impacts requires research on crop yield losses, relative to the crop type, as well as average production and product values.

One of the biggest challenges for getting accurate calculations is accounting for variations in data for weed densities. The inventory data used in this assessment only consists of noxious weed populations consisting of 15% or more of the species composition in a given area. This is done because weed populations under 15% of a given area are most likely not established populations capable of causing significant damage to the other species present in that area.

Below is a visual example of the minimum threshold of species composition that is being used in this assessment.



Research studies that have been conducted to determine crop yield losses are typically done using sites consisting of 10% or more noxious weed species composition. Therefore, the inventory data that is being used in this assessment is in line with study data that will be used to determine the average crop yield loss.

The average production per acre and the average cost will be based off of the 2020 State Agriculture Overview of Colorado, done by the USDA. The units of production are either in bushels (BU) per acre or tons per acre.

Wheat Yield Losses:

Weeds compete for nutrients, space, light, and can be allelopathic which leads to chemical intolerances for wheat. In Montezuma County, the most common weeds to found in wheat fields are Canada thistle, jointed goatgrass, and downy brome. Of these three species, jointed goatgrass is the most problematic weed species for farmers to mitigate because it germinates the same time winter wheat does, and the seeds cannot be filtered out of the winter wheat seeds. The issue of contaminated wheat also leads to a decreased product value.

According to the National Jointed Goatgrass Research Program, *Best Management Practices for the Control of Jointed Goatgrass*, (Schmale 2008), typical discounts are 4 cents per bushel at 1% dockage, 11 cents per bushel at 2% dockage, and 18 cents per bushel at 3% dockage. If grain from a field contains 3% jointed goatgrass, it is estimated that the field suffered a 15% yield loss. The price of wheat at the time when these dockage prices were in place was $4 per bushel. For this assessment we will inflate the dockage costs in relation to the wheat price in 2020.

Below are different studies and their concluded wheat yield losses caused by weeds. The average yield loss will be calculated and used in the economic impact section.

- According to the Weed Science Society of America, *Perspectives on Wheat Yield Losses Due to Weeds in North America*; (Flessner, Dille, Sikkema, Burke, Everman, and Gessel 2021), on average, weeds cause 22.4% yield loss in winter wheat.
- In an article published by the Extension Dryland Cropping Systems*, Controlling Jointed Goatgrass (*Lyon and Klein 2007), researchers concluded that weeds will reduce wheat yields 28% at densities of 15 plants per square yard.
- Other researchers, *Management of Dryland Wheat* (Anderson and Impiglia 2002), found that weeds can produce severe reductions in yield even at low densities. The yield loss with grass weeds from 50 plants/m2 to 150 plants/m2 ranges from 17-42% yield loss (average 29.5%).

The average crop yield loss that sets the baseline in this assessment is the average from all the above studies: 22.4%, 28, 29.5 = 26.63%. Using this average yield loss of 27%, the average dockage percent is 5.4% leading to a 35-cent decrease in price. According to 2020 State Agriculture Overview, the average cost of wheat prices in 2020 was 4.62 per bushel, which would put a 5.4% dockage decrease of .40 cents per bushel.

Alfalfa Yield Losses:

According to the USDA's 2018 chart of yield per harvested acre by county, Montezuma County has about 15% of its alfalfa dryland (or non-irrigated) and the remaining 85% irrigated. In 2020, the USDA's state agriculture overview shows Colorado as having an average alfalfa crop yield of 3.4 tons per acre. This average, is averaging irrigated crop yield with dryland crop yield, therefore the calculations in this assessment will not be separated for dryland versus irrigated.

The yield really will not change due to weeds, because the weeds and the alfalfa will be bailed together. If the weed biomass is taken out from the alfalfa there are yield losses from 20-30% (Norris, 2021) (Renz, 2020). The economic impact of weeds on alfalfa comes from the feeding value. For example, in one study, protein content was as low as 9 percent in hay that contained 80% weeds. When weeds were controlled with herbicides, the protein content rose to over 20 percent (*Orloff, 2007).*

Weeds affect quality because most weeds are less palatable and less nutritious than alfalfa. The loss feeding value from weed infestation can be due to physical, chemical, or toxic factors. Forage quality of alfalfa with about 5-15% weed composition decreases in value by 38%, while alfalfa with more than 15% weed composition will decrease by 52% (USDA, 2021).

Corn Yield Losses:

Weeds affect corn yields primarily by competing with the crop for light, water, and nutrients. At the start of the growing season the requirements for these resources is small enough that both the corn and weeds can co-exist without significantly affecting each other's growth. As the growing season progresses and plant sizes increases, the weeds will begin to compete with the crop for the resources. Once weeds begin to deprive the crop of these resources, the corn yield potential can be negatively impacted.

Below are different studies and their concluded corn yield losses caused by weeds. The average yield loss will be calculated and used in the economic impact section.

- Research by the South Dakota State University found an average crop loss of 26% from weeds. (SDSU Rosenberg, 2013).
- The Department of Plant, Soil and Microbial Sciences, from Michigan State University Extension, observed a 6% yield loss if weeds were not controlled prior to reaching 6 inches tall and 27% yield loss if weeds were not controlled prior to the corn reaching 12 inches tall. *(*Burns, 2021*).* Montezuma County Noxious Weed Department typically maps noxious weeds between June and November of each year, and only maps thistle species as they are flowering, which is an indication the landowner has not managed them. Due to the weed inventory timelines noxious weed species are not mapped in corn fields until they start flowering later in the summer, meaning the corn will have reached 12 inches in height by the time of the inventory. The 27% yield loss will therefore be the most relevant number to the data being used in this assessment.

  The average crop yield loss baseline used in this assessment is the average from all the above studies: 26%, 27%: 26.5%.

Grass Hay Yield Losses:

Similar concept as discussed in the alfalfa section, the weeds will be baled with the grass hay which will result in a lower than expected yield loss. A majority of all the listed noxious weeds will produce less biomass per square foot than grass hay species such as timothy and wheatgrass, therefore there will be an overall yield loss. However, the main economic impact noxious weeds have on hay is the feeding value / quality. When the hay is virtually weed free, the quality is high, designating it as premium hay which will result in a higher cost. Hay that contains a significant amount of weeds may be ranked as good or fair (depending on the percentage of weeds and which species of weeds is present), which can drop the price down 34% (USDA Colorado Direct Hay Report).

Below are different studies and their concluded grass hay yield losses caused by weeds. The average yield loss will be calculated and used in the economic impact section.

- A report from the Utah State University Extension, data showed a yield loss of 11% in hay due to weeds. (Dewey, 2010).
- In a report explicitly focused on Canada thistle, observers reported yield loss of 13% in grass biomass caused by Canada thistle. (Barker, 2007).

The average crop yield loss baseline used in this assessment is the average from all the above studies: 11%, 13% = 12%.

Other Crop Yield Losses:

The main type of 'other crops' that are grown in Montezuma County are dryland beans. Below are different studies and their concluded grass hay yield losses caused by weeds. The average yield loss will be calculated and used in the economic impact section.

Below are different studies and their concluded dryland bean yield losses caused by weeds. The average yield loss will be calculated and used in the economic impact section.

- Dryland bean yields decreased by up to 60% (Ghamari, 2011).
- Dry bean yield loss due to uncontrolled weeds is about 50% in Idaho (Soltani et al., 2018).
- A research study reported pinto bean yield losses, in Colorado, averaged 62 and 27% (44.5% average), with some fields as high as 89 and 66% (Harveson, Smith, Stroup, 2005).

The average crop yield loss baseline used in this assessment is the average from all the above studies: 60%, 50%, 44.5%: 51.5%

Table 4: Economic Impact of Noxious Weeds on Agriculture

	MC Acreage Infested	Average (Unit) Per Acre	Units / acre	Average Cost per Unit	Average Loss in Yield	Reduced Price From Lower Quality	Total Revenue if no Noxious Weed Species	Total Revenue With Weed Species	Yearly Economic Loss Due to Weeds
Winter Wheat	3,786	27.0	BU	$ 4.62	0.27	4.22	$ 472,265.64	$ 314,905.09	$ 157,360.55
Alfalfa	5,705	3.4	tons	$ 209.00	-	125.40	$ 4,053,973.00	$ 2,432,383.80	$1,621,589.20
Grass Hay	4,218	2.4	tons	$ 212.00	0.12	139.90	$ 2,146,118.40	$ 1,246,287.40	$1799662.00 for 2 cuttings
Corn	278	116.0	BU	$ 4.62	0.27	-	$ 148,985.76	$ 108,759.60	$ 40,226.16
Other Crops	468	82.5	BU	$ 4.55	0.52	-	$ 175,675.50	$ 84,324.24	$ 91,351.26
Total Loss									$3,710,189.16

Economic Impacts of Noxious Weeds on Rangeland:

AUM's determine the appropriate level of grazing on a given pasture. By definition, the AUM is the amount of forage needed by an "animal unit" (AU) grazing for one month. A cow's metabolic weight determines the amount of forage required for optimal production. Animal unit is defined as one mature 1,000 pound cow and her suckling calf. A cow nursing her calf will consume approximately 26 pounds of dry matter (DM) of forage per day (20 lbs. for the cow and 6 lbs. for the calf).

Other livestock stock is also assigned AUM equivalents based on size and consumption. For example, a mature bull is the equivalent of 1.3 AU, a yearling steer or heifer is 0.67 AU and, a weaned calf is 0.5 AU. These are equivalents established by various agencies specializing in range management.

Bonnie used the Livestock and Range App, developed by Colorado State University (CSU), to calculate average AUM allowances over the noxious weed-infested portions of Montezuma County. The CSU App calculated that the average AUM per acre was .2045 if the land was healthy. If the land was in poor health, the App calculated the average AUM per acre was .12393. The poor health calculation was used for the acreage infested with noxious weeds. The loss in AUM's due to land health is .08 per acre.

With noxious weeds infesting 22,870 acres of rangeland in Montezuma County there is a loss of 1,842.64 AUMs. Correlating this number with the AUM needs of a cow/calf pair for 185 days, we are losing the ability to support 236 cow/calf pairs due to noxious weeds decreasing the health of the land.

Bonnie used the cost of hay required to support the 236 cow/calf pairs as the loss in revenue. Each cow/calf pair needs 7,400 pounds of hay for 185 days, which costs about $555.00 (Based on USDA Data). The total loss in revenue resulting from having to pay for hay for the cows that cannot be supported on the land due to weeds, comes to $131,447.68 per year.

Table 5: Data of Economic Impact of Noxious weeds on Rangeland:

Rangeland Acres	Average Forage Production Level AUM per acre	AUM per acre Decreased From Weeds	Total Loss of AUM due to Weeds	AUM for Cow/Calf 185 days	Loss in Cows Supported	Pounds of Hay Needed for a Cow/Calf for 185 Days	Cost of 7,400 lbs of Cow Hay	Cost of Hay Needed for Loss in Cows
22,870	0.2045	0.12	1842.64	7.78	236.84	7400.00	550	$ 131,447.68

Economic Impact on Wildlife within Forested Acreage:

Bonnie used the same CSU App for seeing how much grass/forb vegetation Montezuma County's forested land can support when it is healthy versus not healthy. Using the average health, because Montezuma County is in a drought, the average palatable pounds of vegetation per acre per year comes to 385. When the land condition is adjusted on the application to reflect poor land health, because of noxious weeds, the pounds of vegetation drops to 220. Deer will eat 1,725 pounds of vegetation per year; therefore, there will be a loss of forage to support 396 deer.

There is economic data from hunting in Colorado, updated in 2021, by Hunting Works for Colorado. This data shows $465 million is spent annually in Colorado for hunting. Each year 259,000 people hunt in Colorado, and about 44% are out-of-staters. The hunters spend $221 million on trip-related expenditures and $185 million on hunting equipment. Then there is a $763 million ripple effect from hunting. This ripple effect is the business that hunters bring to local communities by shopping, eating out, purchasing supplies, processing meat, etc.

To calculate how many hunters are not able to get tags for deer a lot of statistics are needed. By using the Parks and Wildlife data for years 2016, 2017, 2018, 2019, and 2020 the average deer populations and number of hunters was calculated. The ratio between the number of hunters and deer population was then calculated. This percentage of hunters to deer population was used to calculate how many hunters there would have been if 396 deer were added to the average population. The loss of hunters would then be multiplied to the average revenue each hunter brings in.

The percentage of hunters to deer population was calculated at 14%. When multiplying 14% by a deer population of 7,333 there is an additional 54 hunters, meaning due to weeds there are 54 less hunters. The loss in revenue comes to $97,206.47 per year.

Table 6: Data of Economic Impact of Noxious weeds on Forest:

Forest Acres	Palatable lbs/acre/year	PalatableVeg With Weeds lbs/acre/year	Deer Annual Intake (pounds)	Deer Supported With No Weeds	Deer Supported With Weeds	Loss of Deer Due to Weeds
4,141	385	220	1725	924.22	528.13	396.10

Year	Deer Population Pre Hunt	# of Hunters	# of Deer Harvested	Ratio of Deer Harvested to Population #	Ratio of Hunters to Deer Population
2020	8180	1031	530	6.48%	13%
2019	7506	1076	546	7.27%	14%
2018	7027	931	547	7.78%	13%
2017	6886	987	596	8.66%	14%
2016	7066	988	606	8.58%	14%
Average	**7333**	**1002.6**	**565**	**8%**	**14%**

Loss of Deer Due to Weeds	Average Herd Size + Deer Loss	# of Hunters With Additional Deer	Difference in Hunter #'s	Average Revenue Per Hunter	Loss In Revenue
396	7729	1057	54	1795.37	$97,206.47

Economic Impact from Water Loss Due to Russian Olives and Saltcedars:

Both Russian olives and saltcedars are described as facultative phreatophytes, meaning they can use water from the ground surface to the water table / aquifer. This facultative phreatophyte designation means that these species can occur in wetlands and non-wetlands. Several studies have attempted to estimate the groundwater consumption of these species, but it proved to be very complex.

In 2007, the U.S. Geological Survey reported that tamarisk consume about 32 gallons a day. The average tamarisk being 2-4" in diameter. Using this data the average diameter is 3", which will consume 10 gallons per inch in diameter per day. The University of Arizona College of Agriculture and Life Sciences states that trees will use 3 to 5 times as much water during the summer than winter. For BONNIE's potential water savings, they will use the U.S. Geological Survey reported consumption for a 30-week period (summer months), and will decrease that amount by 80% for the remaining 22 weeks.

In order to determine phreatophyte water consumption in Montezuma County, MCNWD uses the documentation from their Phreatophyte Removal Project to determine how many trees were removed, relative to their diameter, per acre. MCNWD then uses an equation to calculate how much each tree, that was removed, was consuming per year. The total gallons that was calculated was then divided by the number of acres that was managed, to give gallons per acre consumed. Bonnie then simplified it into acre-feet. One acre-foot equals 326,000 gallons. Compiling and averaging the data documented in three year, MCNWD is losing 1.48 acre feet of water, per acre, per year.

The next component to deriving a potential economic impact from the water usage of these non-native phreatophytes is trying to understand the salvageable water component. Even though these two species consume large amounts of water, that doesn't mean we can take that water and use it elsewhere.

The range of water savings depends on site ecology, hydrology, and the species of replacement vegetation. The ability to salvage water requires the replacement of tamarisk and Russian olives with species that require less water. The sites of which these non-native phreatophytes occupy vary significantly in elevation, topography, and native vegetation type. Some of the areas have an established grass understory, whereas others are completely void of any other vegetation which will result in total reclamation needs.

The sites that already have grasses will result in a higher salvageable water because those grasses were already consuming the water they needed to survive, therefore once the non-native phreatophytes are removed the grasses will not necessarily need more water. The sites that will require total recall will result in a lower salvageable water amount because the water saved from not being consumed by the non-native phreatophytes will be used to establish new vegetation.

It is impossible for studies to be done to measure these salvageable amounts of water because of the significant variances in vegetation types per location, as well as the variables the must remain the same while getting accurate measurements, such as the weather, ground water levels, and waterway / ditch levels.

For what it is worth, I want to at least get some kind of idea on what economic loss we might be suffering from because of these water robbers. If we were able to salvage 20% of the water Montezuma County is losing to non-native phreatophytes that puts it at 2,308.8 acre-feet of water that we can use per year.

This can then get very complex; what will the water be used for, and what are the economic impacts of those uses. For simplicity and just trying to grasp some kind of number, each share of water sold will vary in price because they are private sales. Montezuma Valley Irrigation Company (MVIC) sold a share at an auction in March 2022 for $7,500. Once you own the share, you are then charged $310 per account + $33/share of water, each year. Each share of water consists of 4 acre feet per year when MVIC has all the water they need. Since we are in an extended drought, in 2022 each share of water is worth 3 acre feet per.

If Montezuma County is able to salvage the 20% of water consumed by non-native phreatophytes, there will be 770 shares of water available. The initial economic impact may be the creation of additional shares at about $7,500 per share. Alternatively, since we are currently in a drought they may use that extra water to give the current shares a larger amount of water. The more realistic result would be increased water for existing shareholders. This would then result in increased crop yields or increased grazing capacity for livestock.

For this assessment, Bonnie calculated cost benefits of turning rangeland into hay production. In doing so there will need to be the purchase of irrigation equipment plus the costs of hay operations. Initial costs of transforming rangeland into irrigated hay will be significant and unknown. For this assessment, we will not be assessing those initial costs of infrastructure. Bonnie did put an expense percentage of 50% to cover labor of irrigating and harvesting the hay.

Table : Data of Estimated Worth of Water for Irrigation:

Average profit per acre of rangeland for grazing	**Average profit from grass hay - 2 cuttings per season**	**Acreage that Could be Irrigated From Water Savings**	**Farming Expenses 50% of income**	**Profit from additional water**
$ 5.73	$ 1,017.60	2300.00	$ 1,150.00	$ 1,163,651.46

Concluding Summary of Economic Losses from Noxious Weed Species:

Noxious weeds have a severe impact on Montezuma County's economy. The calculated total yearly loss is $5,102,524.78. There were not economic values determined for aesthetic, land values, infrastructure damage, and the cost that is already going into noxious weed management.

Table 12: Revenue Loss per Year Due to Noxious Weeds in Montezuma County:

	2015-2020 Noxious Weed Acreage	Total Acreage in Montezuma County	Loss of Revenue due to weeds
Wheat	3,786	13,547	$ 157,360.55
Other Crops	468	6,214	$ 91,351.26
Rangeland	22,870	641,280	$ 131,477.68
Corn	278	3,348	$ 40,226.16
Alfalfa	5,705	42,659	$ 1,621,589.20
Grass Hay	4,218	14,259	$ 1,799,662.00
Forest	4,141	519,335	$ 97,206.47
Water	7,800	N/A	$ 1,163,651.46
Total			**$ 5,102,524.78**

Sources:

Bruce Barker 2007. Integrated Canada thistle control on pastures.

Doug Schmale 2008. Best Management Practices for the Control of Jointed Goatgrass.

Drew Lyon and Robert Klein 2007. Controlling Jointed Goatgrass.

Erin Burns, Christy Sprague 2021. Protecting crop yields starts with early season weed control.

F.C. Oad, M.H. Siddiqui and U.A. Buriro 2007. Growth and Yield Losses in Wheat Due to Different Weed Densities.

Hossein Ghamari and Goudarz Ahmadvand 2011. Weed Interference Affects Dry Bean Yield and Growth.

Hunting Works for CO 2021. Economic Data.

J. Anita Dille, Peter H. Sikkema, Wesley J. Everman, Vince M. Davis, and Ian C. Burke 2014. Perspectives on corn yield losses due to weeds in North America.

J. Anita Dille, Phillip W. Stahlman, Curtis R. Thompson, Brent W. Bean, Nader Soltani and Peter H. Sikkema 2020. Potential yield loss in grain sorghum (Sorghum bicolor) with weed interference in the United States.

K. Neil Harker 2000. Survey of yield losses due to weeds in central Alberta.

Mark Renz 2020. Weed management in Alfalfa.

Michael L Flessner, J Anita Dille, Peter H Sikkema, Ian C Burke, Wesley J Everman, and Mark J VanGessel 2021. Perspectives on Wheat Yield Losses Due to Weeds in North America.

Mick Canevari, Ron N. Vargas, and Steve B. Orloff 2007. Weed Management in Alfalfa.

Nader Soltani, J. Anita Dille, Ian C. Burke, Wesley J. Everman, Mark J. VanGessel, Vince M. Davis and Peter H. Sikkema 2017. Potential Corn Yield Losses from Weeds in North America.

Parks and Wildlife. Colorado Deer Harvest Estimates.

Parks and Wildlife. Colorado Big Game Population Status and Management Summary.

Reid Hensen 2021. Rangeland Carrying Capacity App.

R.E. Whitesides and S.A. Dewey 2010. Identification and Control of Noxious & Poisonous Range Weeds.

Rezaul Karim 1998. Relative yields of crops and crop losses due to weed competition in Bangladesh.

R.M. Harveson, J.A. Smith, and W.W. Stroup 2005. Improving Root Health and Yield of Dry Beans in the Nebraska Panhandle with a New Technique for Reducing Soil Compaction.

Robert F. Norris 2007. Season-Long Yield Losses from Weeds in Seedling Stands.

Sally Colby 2014. Managing weeds in hay fields.

Sarah Lancaster 2020. World of Weeds: Downy Brome.

Soltani, N., J.A. Dille, R.H. Gulden, C.L. Sprague, R.K. Zollinger, D.W. Morishita, N.C. Lawrence, G.M. Sbatella, A.R. Kniss, P. Jha, and P.H. Sikkema. 2018. Potential yield loss in dry bean crops due to weeds in the United States and Canada. Weed Technology 32: 342–46. doi: 10.1017/wet.2017.116.

South Dakota State University Rosenberg 2013. Weed Competition Can Decrease Corn Yield.

United States Department of Agriculture 2021. 2020 State Agricultural Overview Colorado.

USDA AMS Livestock, Poultry & Grain Market News 2021. USDA Colorado Direct Hay Report.

Walter, Nick 2020. CAP System Loss: 3 facts of CAP efficiency: seepage and evaporation.

W.K. Anderson and A. Imiglia 2022. Management of dryland wheat.