PULL YOUR SHARE

LESSON BREAKDOWN

LESSON FOCUS:

Connecting invasive species education with Montana's relationships to land, culture, and stewardship.

FOR GRADES:

3–12

SUBJECTS:

Science
Social Studies
Montana History
Environmental Education

SOCIAL STUDIES & SCIENCE STANDARDS:

Kindergarten: K-ESS3-3
3rd – 5th Grade: 3-LS4-3, 3-LS4-4, SS.G.4.4, SS.G.5.3
Middle School: MS-LS2-2, MS-LS2-5, MS-ESS3-3, SS.H.6-8.5
High School: SS.G.9-12.5

MT Content Standards

These standards support student understanding of ecosystems, invasive species, human impacts, and stewardship solutions.

LEARNING GOALS:

- Understand what noxious weeds are and why they matter in Montana.
- Recognize the connections between healthy ecosystems, communities, and cultural resources.
- Explore the idea that caring for land is a shared responsibility and instill community service values.
- Identify actions that students can take to protect Montana's landscapes.
- Career exploration through partnerships with natural resource management organizations.

MATERIALS:

The Montana Dept. of Agriculture (MDA) can provide plastic replicas of certain plant species and biocontrol samples for classroom or field presentations. These items are not necessary for teachers doing their own presentations, but can be good learning aids.

Some teachers want their own plastic plant replicas for their classroom. If interested, these can be acquired from MSU's online Extension Store:

MSU Extension Store

MDA also provides gloves and pry tools for classroom demonstrations and for weed pulls. Please contact us before the weed pull to reserve your materials.

CONTACT US:

Give us an email at
agrweeds@mt.gov
to learn more about Pull Your Share and how to include our lesson in your classroom!

PYS Website Contact Page

ADDITIONAL RESOURCES:

Pull Your Share (PYS) focuses the lesson around one primary noxious weed at the site being adopted. This lesson focuses on spotted knapweed.

The PYS website has links to similar presentations focused on different noxious weeds. Check out our website for a variety of lesson plans, presentations, and other resources.

PYS Website & Resources

kNOweeds: Spotted Knapweed

For more information on spotted knapweed identification and/or history, check out the kNOweeds website or the Montana Field Guide.

MT Field Guide

SLIDE 2: LAND ACKNOWLEDGEMENT

READ: LAND ACKNOWLEDGEMENT



ASK: WHAT TRIBES WERE HERE?

Answers depend on your location! Next, read the land acknowledgement

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Today we're going to be talking about several plant species that can be found in Montana. As we learn about plant communities, weeds, and management methods, remember that before colonial influence, Montana was home to many indigenous Tribal Nations. Each indigenous community is unique regarding their practices, cultures, and beliefs, but most practice relationship-based approaches for sustainable land stewardship based on scientific, evidence-based perspectives and observations with the inclusion of culture, ceremony, spirituality, and generational knowledge. These communities practiced their forms of plant management for thousands of years.

Using the map, **ask students which tribal nation(s) were most prominent in their area**.

Read: Today we are learning on the traditional homelands of the (insert above answer) people. We recognize the enduring relationship indigenous peoples have with these lands, waters, plants, and animals. We acknowledge that Tribal Nations continue to be important members of our communities and stewards of these places today. As we learn about invasive species and conservation, we reflect on our shared responsibility to care for the land.

SLIDE 3: WHAT IS A WEED?

ASK: WHAT CHARACTERISTICS MAKE A PLANT A WEED?

- invasive
- reproduces quickly
- overtakes habitat
- harmful/irritating
- non-native

Ask students what characteristics make plants 'weeds'. There are many common characteristics of weedy plants: they tend to spread very easily and quickly (invasive), they often reproduce very quickly, they take habitat from other (particularly native) plants, many are harmful, irritating, or toxic in some capacity, and some are not historically from the region they are overtaking (non-native). These are typical characteristics of weedy plants, but none of these characteristics make a plant a weed.



ASK & RAISE HANDS: IS DANDELION A WEED?

It can be, but not always! A weed is just a plant in a place you don't want it.

Next, **ask students to raise their hands if common dandelion (left) is or is not a weed**. Technically, both are correct: a weed is just a plant in a place you don't want it**.** A weed can be any plant, native or non-native, that is unwanted and/or problematic in an area.

Slide Example (DANDELION):

Common dandelion (*Taraxacum officinale*) is often considered a weed by urban homeowners because it is a very common pest species in yards. Common dandelion is not native, but very adaptable. These plants can produce thousands of seeds every year and can eventually overtake common lawn grasses, like Kentucky Bluegrass (*Poa pratensis*). In a yard, dandelion is rarely eaten or used by other organisms, particularly insects and herbivores, and is generally unwanted. That makes it a weed!

However, in less-managed landscapes like rangeland pastures, dandelions might not be considered weeds. When eaten or otherwise used, dandelions are nutritious early spring forage for a variety of wildlife and livestock. They are also great at fixing nitrogen in the soil for other rangeland plants, particularly grasses, to use. Thus, dandelion is not commonly considered a weed in rangeland areas.

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SLIDE 3: WHAT IS A WEED?



ASK:
CAN YOU NAME THIS PLANT?

This plant is russian olive. Its aggressive root system makes it weedy!

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Finally, **ask students if they can name the plant pictured on the right**. This plant is russian olive, a shrub or small tree native to Europe and western Asia. It was once given out by the state government as a windbreak and has become popular with pheasant hunters, but its aggressive root system makes it a weed for many landowners.

Slide Example (RUSSIAN OLIVE):

Russian olive (*Elaeagnus angustifolia*) is a shrub or small tree that was once distributed throughout Montana as an ornamental and windbreak. It grows well across the state, including in the Hi-Line where many native trees have difficulty growing. It is a pretty, silvery plant that has proven to be good habitat for pheasants and has become popular with hunters and some homeowners.

However, since its distribution, this plant has spread and overtaken riparian habitat from native cottonwoods and willows, which support a wider range of native wildlife. It forms a dense canopy that crowds out other vegetation, and its long thorns can interfere with human, livestock, and wildlife movement. Growth along waterways can also restrict or reduce water flow. Russian Olive has rhizomatous roots, which have nodes from which new stems can grow and allows the plant to spread aggressively, even from cut stumps. Though it is not legally required to remove this plant, it is currently illegal to intentionally sell or spread this plant to new areas.



SLIDE 4: WHAT IS A NOXIOUS WEED?

ASK: HAS ANYONE HEARD THE TERM "NOXIOUS WEED" BEFORE?

- Introduced to MT
- Reduces Crop Yields
- Harm Native Species
- Degrades Recreation
- Toxic/Dangerous

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

EXPLAIN (IF NEEDED)*: NATIVE VS. NON-NATIVE

Native plants are in their historical habitat.

Non-native plants are outside their historical habitat.

Invasive plants spread aggressively and push out other plants.

*The "What are Invasive Species" slide is provided, but not traditionally included in this presentation. This slide is included in the count; hide slide or adjust numbers as needed.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

We're not here to talk about just any weeds, we're here to talk about noxious weeds! **Ask students if they have ever heard the term "noxious weed" before**.

Noxious weeds are non-native plants that have been introduced to the Americas (and Montana) through human actions purposefully and by accident. Due to their aggressive growth and lack of natural controls, these species can be highly destructive, competitive, or difficult to control. They often reduce crop yields, destroy native plant communities, degrade wildlife habitat, damage recreational sites, clog waterways, lower land values, and poison livestock.

NOTE: If necessary, go into detail on the definition of native and non-native. This will be key to understanding the use and success of biocontrol agents. Also, note that invasive plants can be native or non-native.

Native plants originated in the habitat they are found in. Generally, this means that plants were found in their region before European colonization. They are specially adapted to that area through hundreds of thousands of years of ecological interactions and evolution. These systems are fragile and easily damaged: the introduction of non-native plants can have serious consequences.

Non-native plants do not naturally occur in the region they are found in and are often introduced through human activity. Not all non-native plants spread aggressively (are invasive), and some can become naturalized in their non-native range. Some may even provide nutrients or resouces for other wildlife species, but their benefits are not as widespread as those of native plants.

Invasive plants outcompete other species in their area. They can be native or non-native, but they must spread aggressively. There are many invasive native species in Montana, including curlycup gumweed (*Grindelia squarrosa*) and sticky geranium (*Geranium viscosissimum*).

SLIDE 4: WHAT IS A NOXIOUS WEED?

FURTHER BACKGROUND (NOT IN LESSON):

The state of Montana has created a list of 36 specific plant species that are legally designated for management or eradication because they are harmful to Montana's environment, economy, or people. This list is arranged into five different priorities, each with associated management requirements. For example:

Priority 1A weeds are not present or have very limited presence in Montana. These weeds require eradication if detected.

- One Priority 1A weed is dyer's woad (*Isatis tinctoria*). This plant was first reported in Montana in 1934 and was once found in 22 counties. Due to early detection, eradication, and education efforts, dyer's woad is now only found in 6 counties and is contained.
- One unique detection method used to manage dyer's woad in Montana is the Working Dogs for Conservation program. To learn more, visit their website at **www.wd4c.org/dyers-woad**.

Priority 1B weeds have limited presence in Montana. Management of these weeds requires eradication, containment, and education.

Priority 2A weeds are common in isolated areas in Montana. Management requires eradication or containment where less abundant.

Priority 2B weeds are abundant in Montana and widespread in many counties. Management includes eradication where weeds are less abundant, but emphasis is put on containment to prevent further spread.

- The following noxious weeds described in this lesson (spotted knapweed, houndstongue, and leafy spurge) are all Priority 2B weeds.

Priority 3 (Regulated Plants) are NOT noxious weeds. They cannot be intentionally spread or sold and have the potential to have significant impacts, but no containment or eradication is legally required.

- One Priority 3 plant is russian olive. Though management is not legally required, intentional spread is legally prohibited.

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SLIDE 6-7: SPOTTED KNAPWEED BIOLOGY

ASK: CAN ANYONE NAME THIS NOXIOUS WEED?

This plant is called spotted knapweed because its dark "spots" under the flower.

Show the unnamed slides with the weed photos, **hold up the plastic knapweed plant** (if applicable), and **ask students to guess what the pictured weed is called**. Though we will be talking about a few different weed species, the main focus for this presentation is this plant.

This plant is spotted knapweed (*Centaurea stoebe*). Its name comes from the "spotted," dark-tipped bracts seen underneath the flowerhead, which make it distinct from other knapweed species.

CHANGE SLIDE AND CONTINUE

Once students have identified the plant, **click to the next slide** (7), which depicts spotted knapweed with the common and scientific names.

Spotted knapweed, just one noxious weed, covers between 2.6% – 5.4% of the entire state.

There are many reasons why we focus on spotted knapweed. One reason is that it is the most prolific noxious weed and can be found throughout the state. While knapweed is abundant and unwanted in most urban areas, it is primarily an issue in pastures, hayfields, roadsides, and other rangeland areas.

Spotted knapweed covers between 2.5 million and 5 million acres of Montana's total 93 million acres (2.6% – 5.4% of the state), depending on the year's conditions and weed prevention action. This makes it the most widespread and plentiful of all the noxious weeds.

ASK: WHAT DOES IT MEAN FOR A PLANT TO BE BIENNIAL?

It has a 2-year life (or reproductive) cycle. It reproduces through seed, which it only produces its second year of life.

Spotted knapweed's prevalence across Montana is largely due to its biology, particularly its seed production and adaptability.

Ask students if they know what it means for a plant to be a biennial. Spotted knapweed is a biennial, which means it generally follows a two-year life cycle. During its first year of life, spotted knapweed seeds germinate and grow only a rosette, made up of just leaves and the root, to allow plants to concentrate energy on root establishment, photosynthesis, and storing nutrients. During its second year is when knapweed grows its stem, flowers, and seeds. Though it does reproduce like a biennial, spotted knapweed plants often live between five and seven years and reproduce every year except their first.

ASK: HOW MANY SEEDS DO YOU THINK A SMALL PLANT COULD PRODUCE?

1,000 seeds

A BIG PLANT?

10,000 seeds

Like most biennials and annuals, spotted knapweed reproduces only through seed, not through its roots. A small knapweed plant is generally one to two feet in height (roughly the size of the MSU fake plant, if applicable). These small plants can usually produce roughly 1,000 seeds in one growing season.

Knapweed is, however, highly adaptable. When nutrients are readily available, plants can grow to reach five feet in height. These larger plants produce more seeds. Big plants can produce roughly 10,000 seeds in one growing season.

If winters are short or warm, it is possible for spotted knapweed to seed multiple times in one growing season, if conditions stay favorable. That's a lot of seeds!

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SLIDE 7: SPOTTED KNAPWEED BIOLOGY

Spotted knapweed seeds remain viable in the soil for up to 10 years, so we have to monitor sites.

Knapweed not only produces thousands of seeds every year, but these seeds can remain viable in the soil for up to 10 years after being dropped. This means, even if all spotted knapweed was removed from an area, that area would still need to be monitored for at least a decade to make sure the infestation does not return.

ASK:
CAN ANYONE DESCRIBE WHAT A TAPROOT IS?

A simple, carrot-shaped root system.

Again, spotted knapweed reproduces only through seed, not through its root system. Spotted knapweed has what is called a taproot: a thick central root that grows relatively straight down from the plant stem. A common example is a carrot. These root systems might have some lateral roots, but they primarily evolved to grow quickly and reach for deep water. Taproots don't hold soil together well, which can lead to increased erosion, particularly on sloped habitats like streambanks or hillsides. These weeds are often easy to hand-pull.

The roots produce catechin, which inhibits the growth of other species. This helps it make monocultural stands.

Spotted knapweed roots don't produce new stems, but they still help the plant push out other species and create monocultural stands by releasing a toxin called catechin. When stressed, plants produce and release catechin into the soil, suppressing the growth of other plants. This does not affect spotted knapweed because the roots are adapted to not allow catechin to reenter the plant once released into the soil. So, when spotted knapweed seeds fall from the parent plant to the ground, they are able to grow with little to no competition and eventually take over habitat.

Knapweed is desirable to many beekeepers, but has limited forage value for livestock and wildlife.

The ease at which spotted knapweed spreads itself can be problematic on its own, but the big issue with knapweed is that no native wildlife is adapted to use it. Spotted knapweed is not desirable forage for our native wildlife and much of our livestock, especially as winter forage**.** Some animals will graze early rosettes and bolting plants, but when plants dry in the summer, nutrition and palatability are greatly reduced, and animals generally select more palatable, nutritious forage. It has been known to reduce winter forage for economically and socially important wildlife.

Beekeepers sometimes value spotted knapweed because of the flavorful honey that honeybees produce from its nectar. But it is important to note that honey is primarily produced by European honeybee species and does not necessarily support a large range of native bee species. Its monocultural tendencies also mean less flower species and less pollen or nectar available throughout the year.

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SLIDE 7: SPOTTED KNAPWEED & RECREATION

ASK: HOW MANY OF YOU LIKE TO HUNT?

Knapweed drives wildlife out of the state!

FISH?

Knapweed leads to erosion and less fish!

HIKE?

Knapweed takes habitat from our wildflowers!

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Spotted knapweed is the most prolific noxious weed because it's so aggressive! But why should anyone care about this plant? Well, spotted knapweed affects many areas of recreation in Montana. To give examples, ask students what they like to do outdoors and/or **ask students if they like to hunt, fish, and/or hike**.

For those who like to **hunt**, knapweed overtakes habitat from native grasses and shrubs suitable as winter forage for many of our popular hunting species, like goats, elk, moose, and more. If Montana has no suitable forage available, these iconic species will overwinter elsewhere with more reliable forage, leaving less animals available to hunt in-state. Most hunters know, out-of-state tags are more expensive!

For those who like to **fish**, knapweed likes nutrient-rich areas like streambanks. Its taproot doesn't hold together soil well, which leads to increased erosion and stream bank widening. As streams widen, the water level lowers, leaving many native species, game fish, and other aquatic life at risk.

For those who like to **hike**, knapweed takes habitat from our wonderful wildflowers! It also affects other wildlife species, including mammals, birds, and insects, particularly pollinators. The healthiest and most beautiful areas are often the most biodiverse!



SLIDE 8-9: SPOTTED KNAPWEED HISTORY

ASK: WHERE IS KNAPWEED NATIVE?

Southeastern or Central Europe!

Again, all of our noxious weeds are not from Montana, or even North America! Ask students, **where does spotted knapweed come from?** In other words, **where is spotted knapweed native?**

Spotted knapweed is native to southeastern or central Europe and east to central Russia, Caucasia (the Caucasus Mountains), and western Siberia. It has since been introduced to all of Europe, northward towards Sweden.

All of Montana's noxious weeds are native to parts of Europe and Asia, generally around the same latitude as their non-native range in the Americas. These similar latitudes generally have similar climates and temporal trends.

ASK: HOW DID IT GET TO THE AMERICAS?

If spotted knapweed is not from the Americas, **ask students how it crossed the ocean and got over here?**

Allow students to guess, but try to guide their guesses. Transportation methods like wind and water can but rarely transport seeds over open ocean. Birds and other animals also rarely transport seeds across oceans to new continents. If students need additional prompting, ask them to think about what or who started coming from Europe to the Americas in the early 1800s.

CHANGE SLIDE AND CONTINUE

Once students have guessed, **click to the next slide** (9) which should depict alfalfa and link to a Ballast Water Explained video.

EXPLAIN:



It was brought over in alfalfa seed or ship ballast.

Spotted knapweed is thought to have traveled to the Americas on settlers' ships in the early 1880s. When settlers came to the Americas, they didn't just bring themselves. They also brought a variety of animals and animal feed. Knapweed was likely a contaminant of alfalfa, a common livestock forage crop, which also has purple flowers and prefers similar growing conditions.

It is also assumed that spotted knapweed was transported via ship ballast.

Explain ship ballast to students using the video included in the presentation (QR code) or read from the paragraph below:

Video: Ballast Water Explained

When large ships are on the open ocean, they use a substance, typically water or sand, to increase weight and lower themselves in the water. This helps make them more stable on the ocean waves.

Ship ballast is taken on at one port and released/deposited at the next port, often in a different part of the world. Discarded water or sand likely also contained soil or seeds and contributed to the spread of many weed and pest species.

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SLIDE 9: SPOTTED KNAPWEED HISTORY

Spotted knapweed spreads very quickly. It was first reported in British Colombia 1883, and by 1997 it was found in every county in Montana.

We know more about invasive species today, and we take more preventative action!

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Once it got here, spotted knapweed was able to spread very quickly.

Spotted knapweed was first reported in Victoria, British Columbia in 1883. By 1997, only 114 years later, it was found in 14 western states and every county in Idaho, Montana, Washington, and Wyoming. Now, it's found in almost every state and many Canadian provinces.

There are many ways weed seeds have made their way to the Americas. Some plants or their seeds hitched a ride on people or livestock, some were contaminants in other crop seeds, and some were brought over intentionally as food, medicine, decoration, or even to remember home.

Most settlers probably didn't think of these plants as problematic, but today we have a much better understanding of non-native species and their negative impacts. That's why things like imports are regulated today: to prevent more non-native, potentially invasive species from coming in!

SLIDE 10-12: WEED SPREAD IN THE U.S.

ASK: HOW DOES KNAPWEED SPREAD IN THE U.S.?

Different plants have adapted to have different seed dispersal methods. We talked about how knapweed produces thousands of seeds every year, but **how do those seeds spread knapweed throughout the U.S.?**

Allow students to guess.

CHANGE SLIDE AND CONTINUE

When students have given some guesses, **click to the next slide** (11). It should depict some common spreaders of noxious weed seeds, including a water, a bear, and tires.

ANSWER:

- Wind
- Water
- Seed Propulsion
- Animals
- People!

Spotted knapweed has light, fluffy seeds that are easily picked up and spread via wind. Seeds can also be spread via water. Some plants can even forcefully eject (shoot) their seeds away from the parent plant, like leafy spurge (Euphorbia esula), though spotted knapweed cannot do this.

Animals are another spreader of weed seeds. Animals might eat the plant or seed, travel dozens of miles, and deposit the seed in a new area. Many seeds are adapted to survive most animals' digestive tracts. Seeds can also be caught in fur or on feet and carried to new locations.

The biggest spreader of spotted knapweed in the U.S. is people. Many people love to recreate in the backcountry, but when we do so we often transport seeds to and/or throughout our favorite recreation sites. Weeds are often found along trails, where their seeds are easily picked up in shoe or tire treads. Certain seeds, like those of houndstongue (*Cynoglossum officinale*) attach to people or animals and can be carried for miles. Construction equipment or materials have been linked to certain noxious weed outbreaks throughout the state.

CHANGE SLIDE AND CONTINUE

Click to the next slide (12), which should depict a big houndstongue plant alongside two pictures of the seeds, one of a pant leg, one of a dog.

ASK & RAISE HANDS: HOW MANY PEOPLE GET THESE SMALL BURRS IN SUMMER OR FALL?



Knapweed seeds are light and fluffy and can be transported by air, but not all seeds are shaped that way. For example, this plant's seeds are too heavy for wind, but they are covered in barbed hooks that act like velcro and help the seed to stick to most materials.

How a seed looks can often tell you how it usually travels!

Ask students to raise their hand(s) if they have ever seen these small, teardrop-shaped burrs on themselves or their animals in summer or fall.

CONTINUE TO NEXT PAGE

SLIDE 12-13: WEED SPREAD IN THE U.S.

ASK: CAN ANYONE NAME THIS PLANT?

This is houndstongue, another noxious weed! This plant has velcro-like seeds that can be onerous to remove.

Next, ask students if anyone can name this plant.

Many people are not very familiar with houndstongue, the plant, but a lot of us are unfortunately familiar with its seeds! Houndstongue seeds are small, teardrop-shaped burrs that can easily attach to various materials and can be onerous, time-consuming, or even painful to remove.

When removing houndstongue seeds, don't just pick them and flick them! This is how new infestations are made, and these plants can be expensive problems, even in urban yards. To be properly disposed, seeds must be bagged and trashed or incinerated.

CHANGE SLIDE AND CONTINUE

Click to the next slide (13), which should depict a biodiverse field. This slide has a video that will depict how invasive species like knapweed can infest an area and create monocultures over time.

EXPLAIN:

Play the video and read through this script:

This biodiverse field is full of various plants, animals, and insects. These organisms all interact with each other, and changes to one species often impacts several others. For example, let's say a knapweed seed comes into our field. For the first year, knapweed is only a rosette. It doesn't produce any flowers or seeds, but the root is producing catechin and slowly beginning to push out native species and overtake habitat. The second year, knapweed "bolts," meaning it grows a stem, flowers, and seeds. Let's say only three seeds will grow to make new plants.

Those three seeds will all grow only rosette leaves and the root the first year, but in their second year they will all bolt, bloom, and produce seeds. As the knapweed spreads, the catechin pushes out surrounding native plants. Over time, the knapweed takes over habitat more and more quickly because additional plants create more seeds.

Eventually, enough knapweed takes over an area that native species are pushed out. Some generalist species might be able to live or even benefit from living on monocultural knapweed fields, but the biodiversity of the area will be severely impacted. Because knapweed is not good forage, ranchers and livestock would need to rely more on hay, moving their cattle to other fields or limiting their herds.

As the knapweed continues to invade this habitat, more species leave, until we are left with our new, less biodiverse and less healthy ecosystem.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

SLIDE 14-15: FIELD COMPARISON

ASK:
WHAT PERCENTAGE OF THIS FIELD IS SPOTTED KNAPWEED (PURPLE)?

Roughly 40%.

ASK:
WHAT PERCENTAGE OF THIS FIELD IS SPOTTED KNAPWEED (PURPLE)?

Roughly 90%.

ASK:
WHICH FIELD WOULD BE EASIER TO MANAGE? WHY?

The first field! Less herbicide and an established plant community would make weed management easier, faster, and more successful.

ASK:
WHICH FIELD COULD SUPPORT WILDLIFE?

Field A could support other wildlife, as it has some native grasses and shrubs that can still be utilized.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Click to the next slide (14).

Show the first field (Field A) and **ask students what percentage is spotted knapweed** (purple). Answers should be around 40%.

Then **click to the next slide** (15) and **ask students again about the second field** (Field B). Answers should be around 90%.

Finally, **ask students which field would be easier to manage, and why**. Some students might say the Field B due to possible labor cost differences, but the Field A would require less herbicide and has other established plant life to re-colonize the area.

To students who say **Field A**: This field would be much easier to manage. Due to the lower density of knapweed and the presence of other grasses throughout the field, it would be most fitting to do a spot-spray of herbicide. This might increase labor costs compared to Field B, but you'll need less herbicide. This will protect the established plants that can then more easily re-colonize the knapweed-infested areas.

To students who say **Field B**: This field would be much harder to manage for many reasons. It would be fitting to do a broadcast herbicide application in this field, which might keep labor costs below Field A's, but you'll need much more herbicide to cover the entire area. Knapweed releases catechin in the soil, which takes a few months to break down. During that time, you'll need try to recolonize with native plants or crops.

It's not just important to consider cost when managing noxious weeds. As stated before, noxious weeds do not have the nutritional value of native plants, particularly as winter forage. Spotted knapweed can be used by some generalist pollinators and birds, but many native species prefer native plant material. Ungulates like deer, moose, and elk cannot derive sufficient nutrition from this plant; if they were to spend winter in a field full of spotted knapweed, they would starve.

Ask students which field could support wildlife. Field A would be able to support wildlife due to the well-established grasses and shrubs also seen in the picture. Field B would not be adequate forage for native species like deer, moose, and elk. Insect biodiversity would also be reduced in Field B and would impact bird and other mammal species.

SLIDE 16: WEED MANAGEMENT METHODS

ASK:
HOW DO WE KILL WEEDS?

- Herbicide
- Mowing/Cutting
- Burning
- Grazing
- Pulling
- Biocontrol!

The lesson goes into further detail on herbicide, hand-pulling, and biocontrol, so don't worry about going too in-depth with those!

There are many ways to fight weeds! Natural resource managers use a combination of the management methods below to best control weedy areas. **Ask students how they kill weeds**.

Herbicide is often the first management tool that students throw out. Herbicide is an incredibly effective tool, but it is also expensive and labor-intensive. Putting chemicals in the ground, if done improperly, can be dangerous for people or other wildlife. Pests and weeds can also develop resistance to herbicides over prolonged periods. Herbicide is a great weed management tool, but we have to be careful when and how we apply.

Mowing or cutting weeds can also be an effective tool, but it must be used with caution. Weeds that only reproduce via seed can be cut right before seed production, but many weed species are highly adaptable and can adjust to only grow to the height of the mowing blade, just a few inches tall, and still reproduce. Mowers, if used improperly, can contribute to the spread of weed species.

Burning is another good tool that must be used cautiously. Remember, plants across the world evolved with wildfires. Fires are effective at killing off aboveground plant material, but it often leaves root structures untouched. Fire can also encourage weed seeds to germinate.

Grazing can be another weed management tool. Sheep or goats can be trained to eat spotted knapweed and have successfully been used to reduce infestations. Grazing is not always an appropriate management method, as some weeds are toxic to livestock. Stock must also be quarantined to prevent weed spread.

Hand-pulling plants is a great management method for small infestations of weeds. It is important to note that root structure must be considered before pulling. Taprooted plants are easily pulled from the ground, but some weeds have rhizomatous roots, creeping underground root structures that can produce new stems from growing points called nodes. Pulling weeds with rhizomes is not recommended.

Biocontrol is the use of living organisms, particularly bugs and pathogens, to suppress weed populations. Biocontrols are great management methods for large infestations of weeds. Biocontrols are monophagous, meaning they only go after their weed species, but they are not meant to completely eradicate infestations. Their purpose is to weaken existing plants and minimize or stop further population growth.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

SLIDE 17-18: HERBICIDE

GIVE CONTEXT:

Milestone is a common knapweed herbicide.

Let's go into further depth on herbicide. There are many different types of herbicides with different attack methods, strengths, and risks. Spotted knapweed is not particularly resilient against herbicides and does not require strong chemicals that linger in the soil for long periods of time, so spraying is a common control method.

One herbicide commonly used against spotted knapweed is Milestone. A 32 oz container of Milestone can be bought for around $135. Milestone has a suggested application rate of 3–7 oz of Milestone per acre. This means applying Milestone to one acre of spotted knapweed costs approximately $12.66, just for the herbicide.

ASK: HOW MANY ACRES OF SPOTTED KNAPWEED ARE IN MONTANA?

2.5 – 5 million acres (2.6% – 5.4% of MT)

Next, **ask students if they remember how many acres of spotted knapweed are in Montana**. It covers between 2.5 million and 5 million acres of Montana's total 93 million acres (2.6% – 5.4% of the state), depending on the year's conditions and weed prevention action.

ASK: HOW MUCH WOULD IT COST TO APPLY HERBICIDE TO ALL SPOTTED KNAPWEED IN MONTANA?

Between $31.6 and $56.9 million every year.

Ask students how much it would cost to apply herbicide, then **click to the next slide** (18) to show the answers.

If we used the rate of $12.66/acre, it would cost between $31,638,281.25 and $56,948,906.25 to apply herbicide to 2.5 to 5 million acres of spotted knapweed, just one of our 36 noxious weeds! These numbers are in line with real Montana estimates and analyses done in other states.

Herbicides have a lot of restrictions and can lead to resistance, so we try to limit our use of it.

While herbicide is a great tool, it is very expensive, just for the chemical! This doesn't include the cost for water, any additional compatibility agents (other chemicals), or labor. Herbicides have a lot of restrictions: most have short spray windows, some leave chemicals in or on the soil for extended periods, and all require some form(s) of protection (PPE). Extended or excessive use of herbicide can also lead to plants developing resistance.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

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SLIDE 19: HAND-PULLING

Hand-pulling works best on taprooted weeds, not weeds with rhizomatous roots.

ASK: HOW LONG DO YOU THINK THE ROOTS OF THIS NOXIOUS WEED ARE?

The roots of this plant, leafy spurge, can reach 30 feet in any direction! This makes it difficult to kill with just pulling or herbicide, but that's where biocontrol comes in!

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

Herbicide has a lot of restirictions and/or conditions, but other management methods aren't so picky! The main characteristic we look at when pulling weeds is root structure.

Taprooted plants are great candidates for hand-pulling. Their simple, carrot-like root structure usually allows for the majority of the root to be pulled easily from the ground. As long as the puller has gotten the root crown, or the first few inches of the root system, the plant has effectively been killed. Some weed species, however, have much more expansive and aggressive root systems.

Show students the fake leafy spurge (*Euphorbia esula*) plant and **ask if they can name it**. Let them guess, and then tell them that the plant is called leafy spurge.

Next, **ask students to guess how long the spurge root system can get**. Leafy spurge roots have proven to reach lengths of up to 30 feet. These roots do go deep into the soil, but they can also spread horizontally. Small pink nodes along the roots can send up new flowering stems. Damaging the above-ground plants sends signals to the root nodes to begin sending up new plant shoots. What looks to be a patch of leafy spurge plants aboveground might actually just be many stems of the same connected root mass.

Pulling the leafy spurge biomass aboveground will not kill the belowground biomass, but the root system can be starved of nutrients and energy and eventually killed with consistent pulling for several years. Herbicides have difficulty killing plants with such expansive root systems. Fire also won't kill that root system, so how do we kill plants like leafy spurge? This is where biocontrols come in!

SLIDE 20-21: KNAPWEED BIOCONTROL

ASK: DOES ANYONE KNOW WHAT BIOCONTROL IS?

Living organisms used to control weed infestations! They are used for controlling and weakening large infestations, not eradication.

You should be on the slide asking 'What is biocontrol?' The white space should be blank, and fill in with text on the next click.

Ask students if anyone knows what biocontrol is, and let them guess. Then, click once for the definition to appear on the slide.

Biocontrol is the use of living organisms, particularly bugs and pathogens, to suppress pest populations. Biocontrols must be monophagous, meaning they only go after their one weed species. Each biocontrol species goes through rigorous and extensive testing, usually lasting over a decade, to ensure they only attack their target weed species and not any native plants. Biocontrols are great management methods for controlling large infestations of weeds, but they very rarely completely eradicate infestations. Their purpose is to weaken existing plants and minimize or stop further population growth.

CHANGE SLIDE AND CONTINUE

Click to the next slide (21), which should depict three different insect species. These are the three most prominent spotted knapweed biocontrols in Montana.

SPOTTED KNAPWEED BIOCONTROLS

Knapweed has several biocontrols, but the three most-used are these:

The root weevil burrows in the root crown to lay eggs.

The flower weevils eat the seeds at the top of the plant.

The moth's larvae eat the root crown.

There are many biocontrol agents that can be used against spotted knapweed. Which agent is used on a given infestation is dependent on the site's conditions, like temperature and water. Some biocontrols are more effective than others, but almost all are most effective when used in conjunction with other biocontrol species.

The **knapweed root weevil** (*Cyphocleonus achates*) is fairly well dispersed throughout the state. Adult female weevils lay eggs in or on the root crown that, once hatched, will mine into the center of the root to overwinter. The larvae pupate in the root, and mature weevils chew their way out to feed and mate.

The **lesser and blunt knapweed flower weevils** (*Larinus minutus*, *Larinus obtusus*) are widespread throughout the state. Adult females lay eggs within the flower bud, and larvae feed on the seeds. They pupate within the seed head and emerge in late summer to overwinter in the soil.

The **knapweed moth** (*Agapeta zoegana*) is well-established on the western side of the Continental Divide. Adult females lay eggs on the lower stem and leaves, where the larvae can hatch and migrate to the root crown, where they feed. They overwinter in the roots and pupate either in the root or in nearby soil.

The banded knapweed gall fly (*Urophora affinis*) and knapweed seed head fly (*Urophora quadrifasciata*) are also knapweed biocontrols, but are less effective and not as prevalent in Montana. Both species lay eggs in immature flower heads, forming galls in which larvae overwinter and pupate.

CHANGE SLIDE AND CONTINUE TO NEXT PAGE

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SLIDE 22: PREPARING FOR THE PULL

ASK:
WHICH SITE (A, B, C) SHOULD YOU PULL AT FIRST? WHY?

Site C because seeds can spread easily down the river.

Before taking students on the weed pull, it is important to remind them that pulling is intensive, laborious work, and we can only dedicate so much time to any given area. We want to concentrate our efforts so we're doing the most good in the time we have. Give students the river example:

You are a land manager, and one of your sites has three distinct patches of knapweed (A, B, and C). **Which site do you want to pull at or get rid of first? Why?**

Students should choose patch C to pull at because of its location next to the river. Seeds can easily drop into the water and spread further and more easily from that patch, so it should be the first managed.

ASK:
WHY ARE THESE STUDENTS PULLING ALONG THE TRAIL?

Because the knapweed seeds along the trail are more likely to be picked up and carried by any humans or animals on the trail.

These students are pulling knapweed in this image. The knapweed is scattered throughout the hillside (right), but the students are only pulling at the bottom of the hill, next to the trail. **Why might that be?**

The students are pulling next to the trail because seeds will be deposited on the trail and are more likely to be unintentionally picked up and transported by a human or animal using the trail. Though they might not be getting the bulk of that particular knapweed patch, they are preventing the further spread of knapweed to new, uninfested parts of the area.

ASK:
WHEN SHOULD YOU BAG AND TRASH YOUR WEEDS?

Because the knapweed seeds along the trail are more likely to be picked up and carried by any humans or animals on the trail.

Sometimes, spotted knapweed weed pulls require you to bag and trash your weeds, but other times they don't. Why?

Weed pulls early in the spring or summer often don't require bagging and trashing because the plants have not yet formed their seedheads. Spotted knapweed is killed when the root is removed from the soil, so without any seed production, the plants can be left to dry and decompose. Students do generally have more difficulty identifying spotted knapweed without the characteristic dark spotting on the flowerheads, but older plants usually have stems from previous years, with remnants of the dark bracts, to help with identification.

If seed production has started, however, it is best to bag and trash the pulled plants because it is possible some seeds might be or become viable and produce new plants. As a general rule, it is good to bag and trash if the plant as developed a circular or egg-shaped bulb on the top of the stem.

DON'T FORGET!

Dress for working outside! Wear long pants, long sleeves, and close-toed shoes.

If the students will be going on a weed pull, we do try to give them some reminders at the end of the lesson.

Students should wear long sleeves, long pants, and close-toed shoes to a weed pull. Gloves and pry tools will be provided, but students should prepare to work, possibly out in the sun, for a few hours. We recommend students wear or bring sunscreen, hats, bug spray, and extra water.