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Nevada's Priority Agricultural Weeds: Hoary Cress

Brad Schultz, Extension Educator, Humboldt County, Winnemucca, Nevada
Stephen Foster, Extension Educator, Pershing County, Lovelock, Nevada

INTRODUCTION

Plants commonly referred to as hoary cress (*Cardaria sp.),* or short whitetop, are one of three different but closely related perennial forbs: hoary cress (*Cardaria = Lepidium draba*), lens podded whitetop (*Cardaria = Lepidium chalepensis*), and hairy whitetop (*Cardaria = Lepidium pubescens*). All three species are non-native to the United States and all of North America. They originated largely from Central Asia, the Middle East and/or Southern Europe.

The *Cardaria* species are widespread across all eleven Western states, including every county in Nevada, Utah and Wyoming, and nearly every county in Idaho, Montana and Colorado. The total area infested has not been well quantified recently. Historical estimates from 20+ years ago for California and Colorado identified over 30,000 acres in each state. Over the past two decades, those infestations have increased. Although speculative, it is quite likely that hoary cress inhabits a similar amount of acreage in Nevada.

A 2008 survey of all of Nevada's agricultural producers found that 42% identified hoary cress as a problematic weed. An even greater percent of public land managers (53%) reached this conclusion. At the county level, over half (55%) of agricultural producers in Elko County rated hoary cress as problematic, while in Clark and Lincoln Counties 11% of producers rated hoary cress problematic. In all other counties, at least 30% of producers rated the weed as problematic.

All hoary cress species are well adapted to growing in moist areas, including native grass hay meadows, irrigated pastures, riparian areas and irrigation ditches. Upland areas with deeper soils (i.e., greater water-holding capacity) sometimes become invaded. Hoary cress also inhabits roadsides and other areas that often receive run-on moisture and have few competitive plants present. Many of these roads are near meadows and other high-value areas, and often have direct links to those habitats via drainages, seasonal and/or perennial streams, and/or animal movements (wild and domestic). Irrigated cropland, including alfalfa and small grain, is highly susceptible to invasion, particularly if the water source for irrigation passes through established populations and viable seed disperses downstream. Upland areas with deep soils that store a large amount of soil moisture can have large populations. The soils of many infestations often, but not always, are alkaline.

A common trait across many infestations, especially large ones, is a disturbed plant community (physical or ecological). The invaded sites typically have few deep-rooted perennial herbaceous species compared to the site's potential. The lack of deep-rooted herbaceous species creates "open space" with abundant available resources (water, soil nutrients, sunlight, etc.). When hoary cress (and other weeds) establish in these open plant communities, the plants readily use the available resources to establish dense populations. Hoary cress is problematic for several reasons: 1) it reduces the production of desired forage species and crops; 2) it

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is difficult to effectively control; and 3) it is widespread across Nevada, and the size of populations is increasing.

PLANT BIOLOGY

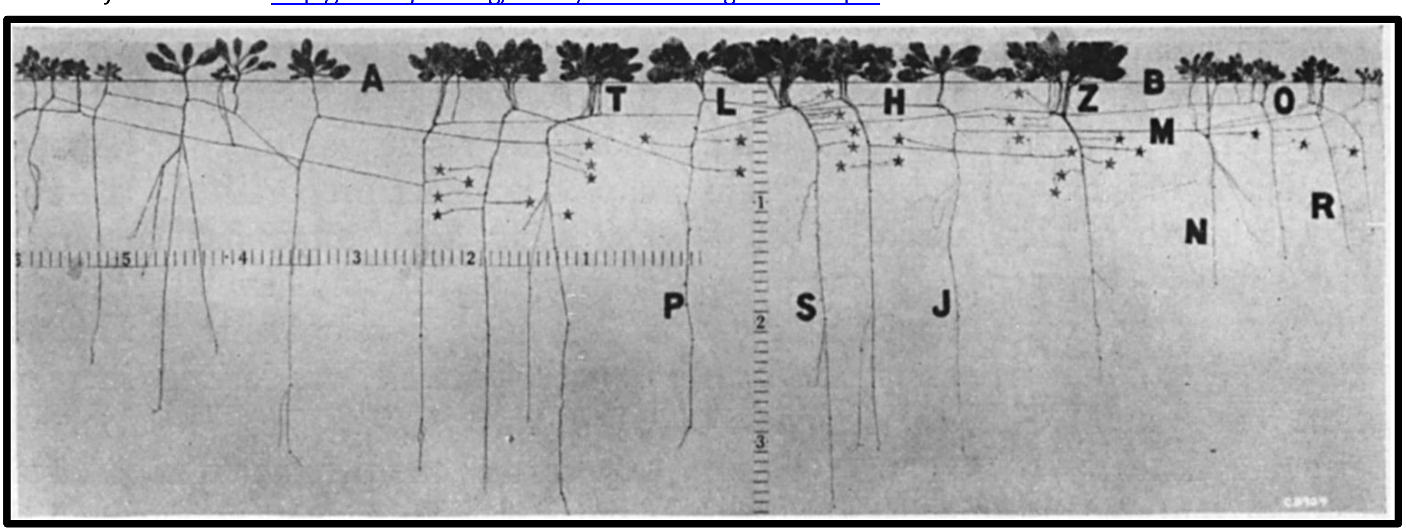
Hoary cress is a relatively short-statured, erect species. Individual plants can live for at least eight years, while clonal patches can persist for decades. Plants usually range from several to 24 inches tall, with increasing plant height reflecting better quality growing conditions. New hoary cress plants can develop from either seed or vegetative reproduction. Vegetative reproduction typically is the primary method for the expansion of an existing population. A single plant may produce up to 4,800 seeds, most of which do not survive in the soil seed bank for longer than three years.

Seedlings initially develop a taproot that typically reaches a depth of 30 inches. The initial taproot develops one or more lateral roots from which new shoots arise (**Figure 1**). These lateral roots may reach lengths of up to 30 feet within three years, and eventually turn down and form additional vertical roots. These secondary vertical roots may reach depths greater than the original taproot. Where soils are deep, the roots of mature hoary cress may reach depths of 5 to 8 feet. There is some research-based evidence that hoary cress's roots may contain chemicals that reduce seed germination and root growth of numerous desired species.

At about three weeks of age, hoary cress plants begin to develop buds on the vertical taproot. As the lateral roots grow, they also develop an extensive network of buds. These buds are the structures that allow hoary cress to overwinter and regrow every spring. When a physical disturbance breaks the roots into small pieces, the buds on each root fragment can initiate growth and develop into new plants. Research has found that root segments as short as 2 inches can routinely produce one or two new plants when buried at depths up to at least 5 inches. The greatest depth from which small root fragments can produce new plants is unknown, but likely deeper than 5 inches. The amount of energy

Figure 1: Approximately 60% of growth attained by one plant of hoary cress about six and a half months after the seedlings emerged. The arrangement of the stems and roots shows the relationship among plant parts as they were found in the soil. The stars indicate points from which additional lateral roots were removed to improve overall clarity. The letters **A** and **B** represent the soil surface. Lateral roots to the left of primary vertical developed under sloping ground line, which causes them to appear to grow upward from point of origin when arranged along a horizontal ground line. **P**, primary vertical root; **L**, permanent lateral of first order; **S,** secondary vertical of first order; **H**, permanent lateral of second order; **J**, secondary vertical of second order; **M**, permanent lateral of third order; **N**, secondary vertical of third order; **0**, permanent lateral of fourth order; **R,** secondary vertical of fourth order. Scale in feet and inches.

From: J.C. Frazier. 1943. Nature and Rate of Development of Root System of Lepidium draba. Botanical Gazette. 105:2:244-250. Accessed from JSTOR at: http://www.jstor.org/stable/2472207?origin=JSTOR-pdf.



reserves (soluble carbohydrates) in the root fragment determines from how deep a new stem can emerge.

The large root system of hoary cress can contribute up to 75% of the plant's total biomass. The carbohydrates that form the roots are of two general types: structural carbohydrates and soluble or stored energy reserves. Hoary cress uses the stored energy reserves (created during the previous year/growing season) to keep the buds alive during dormant periods and to initiate growth when dormancy breaks in the spring (or in the fall if sufficient precipitation occurs). The first few leaves that emerge develop from energy stored during the previous growing season.

Hoary cress's stored energy reserves decline when growth starts and the first leaves develop and enlarge. The energy reserves in the roots tend to be smallest in early to mid-spring, during the vegetative growth phase. During the vegetative growth phase, most of the carbohydrates produced by photosynthesis remain aboveground to form additional leaves and stems. Stored energy in the roots starts to increase during the bolting growth stage, and continues to increase through the bud, flowering and seed production growth phases. Carbohydrate movement to the roots is greatest during the flowering growth stage, followed next by the bud stage. These two growth phases can occur quite rapidly, with the plants becoming summer-dormant shortly after flowering and seed production. Once the plant starts to enter summer dormancy, there are few carbohydrates directed to the root system and associated buds.

Short hairs (called trichomes) usually cover both the stems and leaf blades of hoary cress. These hairs can intercept the spray droplets that carry an herbicide directed toward the leaf's surface, potentially reducing the amount of the chemical that reaches the leaf surface. The leaf surface is where uptake occurs, through the cuticle or stomata. Small droplets, as compared with large droplets, are more likely to be intercepted by and stick to the leaf hairs, and not reach the leaf surface. Large droplets typically "shatter" easier than fine spray droplets, when they contact the leaf hairs. Some of the small "shattered" droplets ultimately pass through the leaf hairs and reach the leaf surface. The leaf surface typically develops waxes or other difficult to penetrate surfaces as the plant matures.

Hoary cress plants in Nevada typically enter the flowering growth stage from April to June, with annual and/or regional variation based upon soil moisture and temperature. Many clonal patches exhibit wide variation in growth stage among individual flowering stems. When some are at the flowering growth stage, others are either in late-vegetative or post-flowering growth phases. The presence of several different growth stages may affect herbicide effectiveness because peak movement of carbohydrates to the roots occurs during bud-flowering period, a relatively brief period of time. Also, not all herbicides are equally effective at the same growth stage.

CONTROL METHODS

Nonchemical Control

Mechanical Tillage

Tillage will control seedlings before they become perennial, but does not work as a stand-alone, one-time treatment for mature stands. Once the roots develop buds, tillage creates many root segments, each of which usually has viable buds capable of producing a new plant.

For tillage to control mature plants, the mechanical treatment must occur every couple of weeks for two to four years. Each tillage event breaks apart the large roots within the tilled zone (depth), creating many smaller fragments. These fragments use stored energy to produce new plants, and the new plants must be killed before they become perennial. Thus, tillage must occur frequently. Finally, tillage treatments typically do not affect the deeper roots, below the tilled depth. These roots also have many buds and a large amount of stored energy. The deeper depth of these roots does not prevent the formation of new plants when tillage separates the deep roots from their stems and associated shallow roots. It only delays their eventual emergence. Several feet or more of root length can provide a substantial amount of stored energy for regrowth.

In reality, few producers (organic may be an exception) have sufficient financial resources to effectively use this multi-year approach at a large scale. Also, frequent tillage is likely to degrade soil quality, structure and overall health.

Mowing

The intent of mowing hoary cress is to reduce leaf area, to reduce carbohydrate production and their subsequent movement to the roots. This prevents the replenishment of energy reserves used to initiate new leaves and stems. Those reserves are smallest at the bolting to bud growth stage, and removal of leaf area at this time should weaken the plants. Mowing mature stands of hoary cress, however, is an ineffective, stand-alone control treatment. The mower blade often cannot be set low enough to remove sufficient leaf material (from the relatively short plants) to dramatically reduce leaf area and carbohydrate production. Fields with an uneven microtopography exacerbate this problem, as the blades must be set even higher to prevent them from repeatedly clipping the soil surface and damaging the equipment.

On flat cropland that has no rocks, a flail mower can scalp the plants to ground level without damaging the blades, but multiple treatments are needed due to hoary cress's regrowth potential. Small infestations may be mowed quite effectively with a hand-held weed trimmer, but repeated treatment is necessary.

When hoary cress plants grow tall enough, mowing the plants when the flowers emerge may reduce seed production that year. The outcome depends on soil moisture and the potential for the plants to regrow. When the soil has good moisture levels from irrigation, abundant spring rainfall, or a high-water table, the plants can easily regrow, flower and produce seed. Mowed plants on dry sites may enter summer dormancy without producing any seed. Preventing seed production will not control an existing infestation since most reproduction is vegetative from root buds, but can reduce the amount of seed available for movement off site. This can help reduce the spread of hoary cress to areas not currently infested.

Repeated mowing treatments may reduce leaf area to some degree, but an important question becomes at what cost to desired plants on the site. Frequent and/or intense mowing may adversely affect the desired plants more than it harms hoary cress. This is not a desired outcome, especially if the area cannot successfully be reseeded. In some situations, a mowing treatment may improve access to hoary cress plants for a subsequent herbicide treatment, and potentially increase its effectiveness.

Fire

Fire is unlikely to be a successful stand-alone treatment for mature plants. Targeted flaming can effectively control young seedlings. Mature, green hoary cress is difficult to burn, and fire does not kill the buds on the root system. Regrowth will occur either the year of the fire treatment, provided soil moisture is adequate, or the following year. In some situations, fire is an appropriate tool when combined with other treatments, particularly an herbicide. Fire can remove old, decadent, dead and/or taller vegetation that would reduce the amount of an herbicide reaching the leaves of hoary cress plants. Also, fire may stimulate buds on the roots to produce additional stems and leaves, potentially increasing leaf surface area, which can result in greater herbicide uptake. Any use of fire must consider potential adverse effects to any desired residual species on the site.

Grazing

Targeted grazing may suppress hoary cress in some situations, particularly if grazing occurs with sheep or goats. These two herbivores, compared to cattle, typically select broadleaf plants as forage over grasses. When properly managed, sheep or goats can defoliate hoary cress both frequently and intensely, when defoliation is most likely to reduce root biomass and energy reserves. Those stages are the late-vegetative to early bolting periods, as carbohydrate movement to the roots is greatest during flowering, followed by the bud and seed-production phases.

Cattle are not as well suited for grazing hoary cress. They typically select grasses, and most perennial grasses are desired species that a producer wants to increase following weed control. Also, cattle do not graze as close to the ground (leaving more leaf area for photosynthesis) as sheep and goats, unless left on site for too long a period and no other forage exists.

There is some evidence that hoary cress produces glucosinolates, which can be toxic to cattle when present in large amounts. Proper management must consider how grazing may affect the residual desired species on the site. Grazing strategies should limit adverse effects. The principles of foraging behavior and how to train livestock to consume plants they normally do not select should be reviewed prior to implementing a grazing program to control weeds.

Cultural Techniques

Long-term flooding of hoary cress populations is a potential cultural control technique. Standing water that completely covers hoary cress plants for several months can result in complete mortality. This approach, however, is feasible only when water is available much of the spring and early summer (i.e., the typical growth period), and water depth can be easily and regularly controlled. When considering a flooding treatment, always evaluate the probable effects on desired species and weigh that outcome against the impact on hoary cress.

Another factor to consider is the potential for leaching important soil nutrients out of the root zone or their movement off-site in moving flood waters. After flooding, fertilization may be needed. The effect of flooding on the seed bank is not well known. For perennial pepperweed, a genetically related species that occurs in similar environmental settings, seed can survive one to two years underwater quite well.

Hoary cress seedlings often occur shortly after the floodwaters recede, or the following year. Monitoring for seedlings should occur after flood events, with rapid treatment when seedlings appear. As previously emphasized, young seedlings are much easier to kill than plants with roots with buds.

Biological Control

There are no readily available biological control agents for hoary cress at this time. Animal & Plant Health Inspection Service (APHIS) approved the gall mite, *Aceria draba*, for release in 2018, but knowledge gaps exist. Work in Montana is trying to improve our understanding of how to develop persistent nurseries for this insect and how it disperses and persists across the landscape. This gall mite appears to be very specific to hoary cress and may reduce seed production by up to 98%. It remains unclear how well *Aceria draba* can establish viable populations across the Western states, including Nevada. Widespread use probably is several years or more away.

Chemical Control

Effective chemical control of hoary cress requires the use of a systemic herbicide. Systemic herbicides are those that are absorbed in one part of the plant (typically leaves or roots) and subsequently moved through the plant's vascular system to another location to kill the plant's growing points. For a foliar-applied herbicide to be effective, the chemical must move past the leaf hairs and reach the surface of the leaf. Once at the surface of the leaf, the herbicide must enter the leaf, which typically occurs through the open stomata (structures that release water and oxygen from the plant and absorb carbon dioxide) or the cuticle, which can have a waxy barrier. After the herbicide enters the leaf, the plant must transport the chemical to the "sites of action." The "sites of action" are the specific locations in the plant where the active ingredient disrupts an important growth process, which results in death to the weed. The "sites" in hoary cress where the herbicide acts on the plant are typically buds on the roots, which can be many feet from herbicide uptake on the small leaf area. Numerous characteristics of hoary cress make herbicide uptake and translocation difficult, which can reduce herbicide effectiveness.

To control and eventually reduce hoary cress, an herbicide treatment must eliminate or greatly reduce the large population of buds on the extensive root system. Think of these buds as a large bank account from which the plant withdraws periodically to survive. The plant dies when the account reaches zero.

The movement of a foliar-applied herbicide to and then through the large root system largely follows the movement of carbohydrates (photosynthate) from the leaves to the roots. Growing conditions that promote the production and movement of carbohydrates from the leaves to the far reaches of the root system, at the time of herbicide application, and probably for a week or so afterwards, improve the success of an herbicide treatment.

For hoary cress, the plant moves more carbohydrates to the roots from the bud through the flowering period, with peak movement at flowering, then dropping rapidly and reaching the smallest level at seed set. Several factors, however, make it hard to maximize herbicide placement on the appropriate leaf surface at the flowering growth stage.

First, the flowers reside directly above the leaves, and any herbicide sprayed onto the plants from directly above will land largely on the flowers, not the leaves (especially the lower leaves), which reduces potential uptake (**Figure 2**). Herbicide application when most buds have formed may often be the best time for treatment to maximize chemical placement on the leaves.

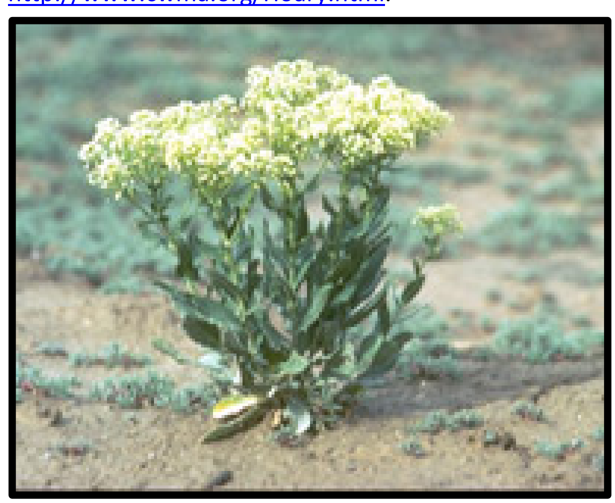
Second, the leaf hairs (see earlier discussion) often intercept the water droplets that carry the herbicide, keeping the herbicide from reaching the leaf's surface and stomata. Inclusion of a surfactant (product labels provide herbicide-specific recommendations) in the spray mix and the use of nozzles that project larger droplets can partially overcome the leaf hair barrier or waxy surfaces on the leaf.

Third, in many plants, the upper leaves send most of the carbohydrates they produce to the flowers and seeds, while the lower leaves send most of the carbohydrates they create toward the root system. Placing more of the herbicide mix onto the lower leaves increases the potential to move more of the herbicide's active ingredient to the roots, and possibly deeper into the root system. This can be difficult because the upper leaves, flowers and possibly other vegetation often reside directly above hoary cress's lower leaves. For spot treatments where the applicator can easily control the angle of the application equipment, placing the herbicide on the lower leaves should be much easier.

Fourth, a systemic herbicide must be translocated into and throughout the large root system to affect as many buds as possible. Long-distance transport takes time; thus, the applicator must consider the probable growing conditions for a week or so after treatment. Movement of herbicides out of the leaves to the roots occurs within a few hours, but

Figure 2: Hoary cress at the optimal time for herbicide application. The leaves, the location of maximum herbicide uptake reside directly below the dense layer of flowers.

Photo from Colorado Weed Management Association at: http://www.cwma.org/Hoary.html.



movement throughout the entire root system takes longer. When plants reduce or stop photosynthesis shortly after an herbicide application, due to cold weather, excessively dry or saturated soil, or some other factor, there is an increased risk that only a small amount of the active ingredient will be moved to the roots furthest from the leaves. This outcome allows many buds to survive and develop new plants the next growing season. Treatment at the bud stage may reduce the risk of poor movement through the plant due to drying soils at or just after peak flowering.

Fifth, the plants that compose a stand of hoary cress often are not at the same phenological stage of growth. Some stand patches may be at the vegetative stage, while others are at the bud stage, and still others may be flowering or producing seed. An herbicide applied only once is likely to occur at the optimal time for control of plants that are flowering, but suboptimal for those that have not bolted and started to develop buds. Effective treatment of large infestations often requires multiple applications to achieve optimal timing of the chemical treatment. When possible, treatments should occur in the same growing season. Postponing follow up treatment until the following year, when surviving plants are at the bud growth stage, will allow substantial growth of their root systems and new stems to emerge, perhaps negating much of the previous year's effort (and cost).

In Nevada, when adequate precipitation (or run-on moisture) occurs in September or October, hoary cress plants can develop new rosettes. Rosettes do not occur every fall and in some places are very infrequent. When present, treatment of fall rosettes can be quite effective. The presence of fall rosettes is unpredictable in most areas of Nevada; thus, fall treatment of hoary cress should be considered an opportunistic action to pursue when it occurs and not part of a planned annual control program. It just may not be possible most years.

Active ingredients routinely used to treat hoary cress are listed in **Table 1**. For each active ingredient, there may be several commercial products available. Those listed are only some of the more common or well-known products. No single active ingredient or product is the best chemical for all weed-control situations. Every situation is unique, and the choice of an herbicide depends upon many short- and long-term factors. Some factors to consider are: 1) do you need an herbicide that is selective and will not adversely affect the desired species on the site?; 2) are your short- and mid-term management objectives compatible with a chemical that leaves a residual of the active ingredient in the soil?; 3) what will hoary cress's growth stage(s) be when you apply an herbicide treatment; and, 4) can you make the commitment for needed follow-up treatments, and if not, develop a second-best strategy that fits within your constraints?

Glyphosate and 2,4-D herbicides typically result in less long-term control than the other active ingredients listed in **Table 1**. Triasulfuron effectively controls seedlings but only suppresses mature plants. Treatment of hoary cress with these three chemicals, more than likely, will need more follow-up applications and usually sooner than with the other herbicides listed in **Table 1**.

Even the most effective treatment results in a few survivors. Ask yourself, are you likely to make the commitment to frequent retreatment? If not, would a different herbicide be more appropriate, and if so, which herbicide is more likely to only require periodic (less time-consuming) spot treatments?

When considering any herbicide, consider whether the active ingredient has a soil residual for control of new seedlings for the next growing season or two. Other factors to consider are: how long the active ingredient may preclude the plantback of other species; potential movement through the soil into the water table; the potential for windblown soil to carry the active ingredient off-site; and how the soil's pH may affect the active ingredients' longevity. The active ingredient in sulfonylureas can persist much longer in soil with high pH, compared to soil that is neutral (pH = 7) or acidic (pH<7).

INTEGRATED WEED MANAGEMENT

Weeds are complex organisms, and they establish and grow across complex landscapes. Very seldom does a single type of treatment or management address this complexity. The result is that using only one treatment action, even multiple times within or across years, eventually fails, and weeds persist.

Any weed management program for hoary cress (or any weed) should develop a long-term integrated management approach. An integrated management strategy uses two or more methods of weed control across a series of years, while also deploying strategies to prevent weeds from establishing in areas not infested.

Figure 3a illustrates that an integrated weed management program uses both proactive strategies and reactive approaches. Where hoary cress (or any weed) is not present, management should focus on preventing its establishment. This may occur through management actions that prevent seed from being introduced on the site, controlling seed banks if viable seed has been introduced or remains after an effective treatment, or managing the crop or vegetation to competitively exclude the weed.

When weed prevention fails and one or more populations inhabit the area, the next proactive strategy is to identify all locations inhabited by the weeds, and document the scope and context of the infestation. Pairing this information with the biology of the weeds allows one to make decisions about which direct control methods to use for the specific situation being addressed. Prevention, however, should still be emphasized on areas that remain uninfested, as well as areas with successful treatments.

The best direct weed control actions are going to be infestation specific, and should identify which mechanical, cultural, biological and/or chemical approaches overlap and complement one another (**Figure 3b**). The application of multiple control methods, based on the weed's biology and ecology, that reinforce one another are likely to be more effective across a longer timeframe, than any single approach applied only once or even annually.

For hoary cress, elimination of root buds is needed to reduce the population to a manageable level that permits one to meet production goals and objectives for the farm or ranch. The strategy also should include management actions that limit the spread of seed or root fragments onto the site, and that reduce the potential for seed to germinate and/or seedlings to establish should viable seed disseminate onto your property.

All treatment and management approaches, except the purposeful maintenance of bare ground, must consider how to increase, and in some cases establish (seed), a high density of desired species on the infested area. A dense, vigorous stand of desired herbaceous species provides the least risk for reinfestation of a site. For rangelands, meadows and pastures, deep-rooted perennial grasses that occupy most of the soil surface and root zone are the best option for preventing large-scale seed germination and subsequent seedling survival of hoary cress and other weed species.

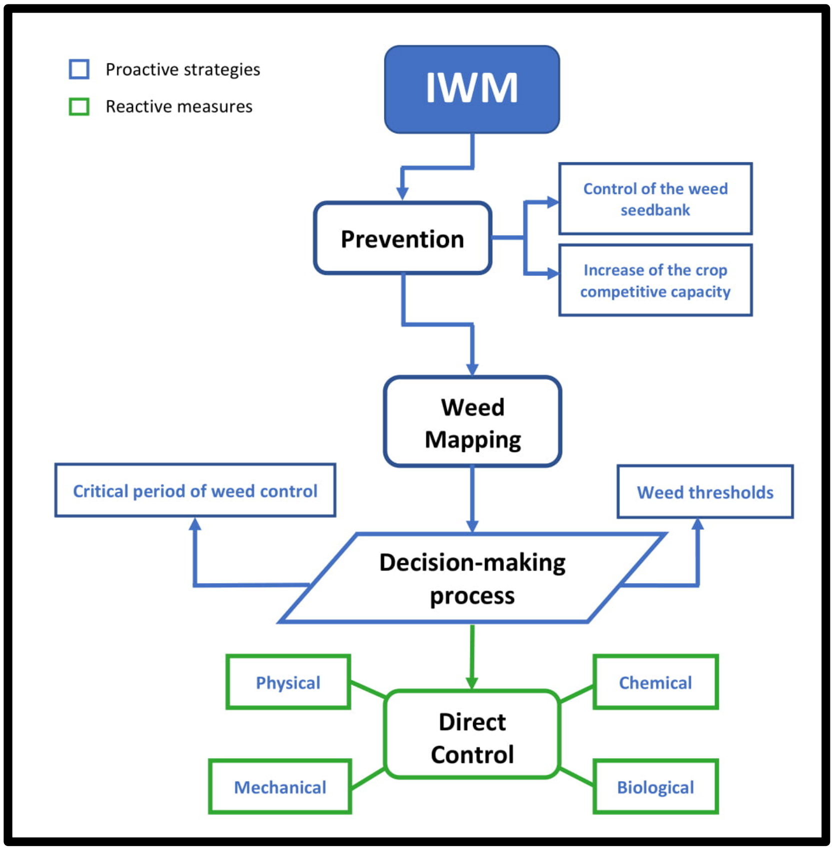


Figure 3a. Conceptual approaches to integrated weed management from prevention of new infestations or reinfestation of successfully treated areas. There are both proactive strategies to reduce the risk of infestation and reactive actions once an infestation occurs. Direct control measures should complement one another, and strengthen the effectiveness of the overall treatment program.

Diagram from Scavo and Mauromicale (2020: 3a) and Mark VanGessel (Ed: 2019 rev; 3b).

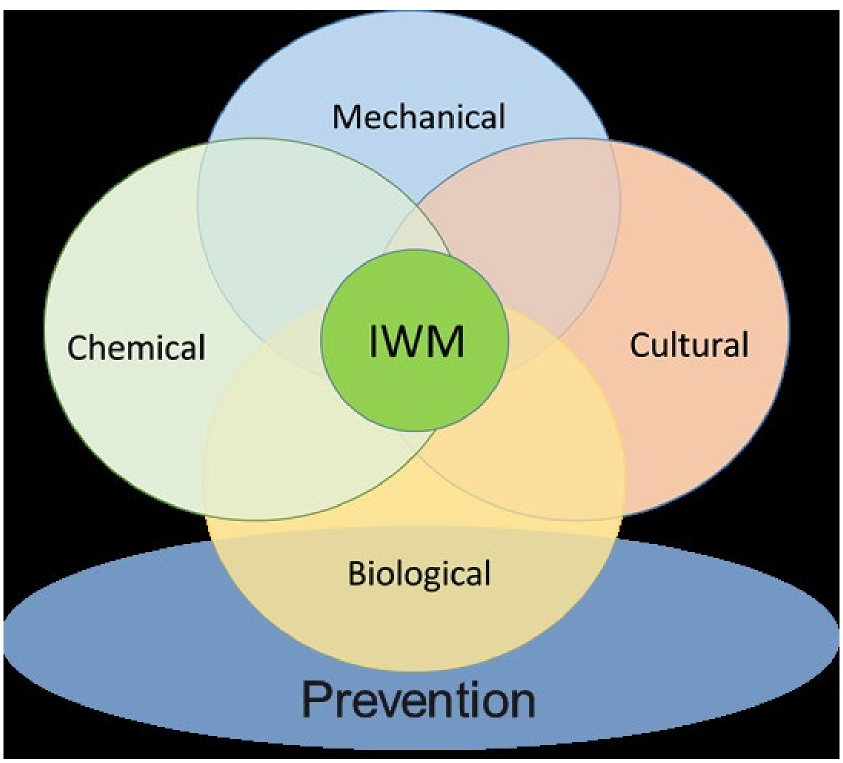


Figure 3b. Prevention is always an ongoing strategy, as there almost always are some areas that remain weed-free, and management should try to keep these areas weed-free. Prevention strategies also should occur on successfully treated areas to preclude the need for repeated direct control approaches.

Diagram from Scavo and Mauromicale (2020: 3a) and Mark VanGessel (Ed: 2019 rev; 3b).

Table 1. The list below identifies the active ingredients and many of representative products known to control hoary cress in the general sites or crops for which the active ingredient is labeled. Use the information in this table to determine potential products for use based upon your specific needs. Product selection should occur only after applicators have read all current product labels and identified the appropriate products for their specific situation. Always consider potential effects to nontarget plants at the time of application. Many of the active ingredients listed in this table are available in premixed formulations with other active ingredients. These premixed packages (products) are not listed in this table. A complete list of all active ingredients and products labeled to control hoary cress can be searched for at the Crop Data Management Systems website http://www.cdms.net/LabelsMsds/LMDefault.aspx?pd=7607&t=. The order of chemicals below does not reflect any preference or efficacy. Across the spectrum of available products, some may only suppress hoary cress (generally means no seed production).

Active Ingredient	Representative Products	Range and Pasture	Noncrop	Fallow	Bare Ground	Small Grains	Corn	Alfalfa	Mint	Potatoes	Selective	Soil Residual	Growth Stage
2,4-D	Many	x	x	x	x	x	x				Yes	One to four weeks	Pre-bud and fall rosettes
MCPA dimethylamine	Many	x	x			x		x			Yes	≤ one month in moist soil; six months dry	Postemergence to small actively growing plants
Chlorsulfuron	Telar XP	x	x								Yes	Yes, especially in high pH soils	Postemergence from flower bud to full flowering, or on fall rosettes
Glyphosate	Accord, Roundup and many others	x	x	x		x	x	x	x	x	No	No	Postemergence to rapidly growing plants at the late-bud to flower-growth stage
Imazamox	Imox, Raptor		x								Yes	Yes	Actively growing plants, bud to early flowering
Imazapic	Imazapic 2SL, Panoramic, Plateau	x	x								Yes	Yes	Postemergence bud through flowering, or fall rosettes. Variable results if applied after completely dormant
Imazapyr	Arsenal, Habitat, Polaris	x	x		x						No	Yes	Postemergence in the spring during flowering or to fall rosettes. Can be a soil sterilant
Metsulfuron-methyl	Escort, Manor Selective, MSM 60, Tide MSM 60 Patriot	x	x			x					Yes	Moderate, but long in soils with high pH	Postemergence from flower bud to full flowering, or on fall rosettes
Sulfometuron-methyl	Oust, Spyder, or as a prepackage mix with other herbicides (e.g., Landmark)	x	x								Yes	Yes, especially high pH soils	Pre-emergence or early postemergence before or during the rainy season when weeds are actively germinating or growing
Triasulfuron[1]	Amber	x		x		x					Yes	Yes	Pre-emergence in fall before extended freezing period, or postemergence to actively growing weeds less than 2 inches tall or wide

1-Controls seedlings but only suppresses mature plants

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