INTRODUCTION

Purpose: This handbook is designed as a quick and ready reference of weed control practices used in various cropping systems or sites/situations in Utah, Montana and Wyoming. Because chemical regulation of plant growth is complex and requires considerable knowledge, a large portion of the handbook is devoted to registered uses of herbicides, crop desiccants, and some plant growth regulators. In all cases, authors have made every effort to list only registered herbicides and to ensure that the information conforms with product labels and company recommendations.

Intended Users: The handbook may be useful to producers, company field representatives, commercial spray applicators, consultants, and herbicide dealers. The editor of each section is listed. Feel free to call them or your state weed Extension specialist, if you have questions.

Revision and Availability: The handbook is revised every 2 years and is available from the Bulletin rooms at Montana State University (406-994-3273), Utah State University (435-797-2251) and the University of Wyoming (307-766-2115).

Caution!

The information provided in this handbook is not intended to be a complete guide to herbicide use.

Before using any chemical, you should thoroughly read the label. The recommendation on the manufacturers label, when followed, can prevent many problems arising from incorrect use of a chemical.

This information is supplied with the understanding that no discrimination is intended and no endorsement is implied by the University Cooperative Extension Service. Trade names (brand names) are used in this handbook. The authors have assembled the most reliable information available to them at time of publication. Due to constantly changing laws and regulations, the authors assume no liability for the recommendations. Any use of a pesticide contrary to instructions on the label is not legal or recommended.

Weed Management Suggestions

- **Weed Prevention**

Weed prevention means a land manager prevents the introduction of weed seed or vegetative propagules onto the land. This requires vigilance and the ability to identify weed seeds, seedlings, and mature plants. After a weed is introduced to a piece of land WEED ERADICATION is nearly impossible, and the endless process of WEED MANAGEMENT begins.

One of the most important aspects of weed management is the development of a multi-tactic program to control weeds. This approach, known as **Integrated Weed Management** (IWM), reduces the chances of a weed to adapt to any particular control technique. For example, the increased reliance in herbicides with the same mode of action has resulted in weeds that are resistant to those herbicides (see Section IV. Herbicide Resistant Weeds). Also, the continuous production of certain crops provides weeds a chance to adapt to the particular environment associated with that crop. IWM takes advantage of cultural, mechanical and chemical

weed control strategies in the best possible way with the goal of maintaining weed densities at manageable levels while preventing shifts in weed populations to more difficult-to-control weeds.

Combining as many of the following practices as possible will allow you to design an IWM program:

- Avoid weed establishment; eliminate individual survivors.
- Establish competitive crops that will "choke out" weeds.
- Identify and map weed infestations.
- Keep records over years.
- Recognize and eliminate new weeds before they multiply and establish.
- Control vegetation and seed sources around the field or site.
- Comply with or become involved in establishing county/state weed laws and noxious weed control programs.
- Employ sanitary procedures; prevent weed spread:
    - Clean equipment between sites or infestations.
    - Examine nursery plants, seed, and imported soil or media.
    - Use Certified Seed.
    - Screen irrigation water that comes from surface storage through canals.

Cultural Practices of an IWM Program

Crop Rotation, defined as the alternation of different crops in a systematic sequence on the same land, is one of the most important components of an IWM program. Weeds thrive in crops having similar environmental requirements as their own. Moreover, management practices designed to benefits certain crops may also benefit the growth of specific weeds. For example, winter annual weeds such as downy brome or jointed goatgrass are commonly found in winter wheat fields as they share similar environmental requirements. Crop rotation helps managing weeds because the different environmental conditions created by different crops within a rotation disrupt weed germination and growth cycles. Also, the wide variety of management options associated with each crop (tillage, planting dates, herbicide rotation, etc.) creates multiple stresses on weeds.

Know the weed spectrum in a field then select the crops according to their ability to compete with those weeds. Rotate crops to disrupt weed life cycles or suppress weeds in a competitive crop before planting a less competitive crop.

Plant competitive crops instead of fallowing to improve soils and weed management. Research with Indianhead lentils and other annual legumes appears to be promising fallow substitutes. Also, alfalfa reduces the ability of annual weeds to grow, however it favors growth of perennial weeds. Sudangrass, perennial grasses and tame buckwheat, grown in dense stands, provide intense competition against weeds.

- Consider legumes to supplement soil nitrogen requirements.
- Consider specific varieties of cereals with natural plant toxins (allelopathy); vegetation must remain uniform on the soil surface; either perennial or large-seeded crops can be planted through undisturbed mulch.
- Consider crops such as oats or spring barley that winter kill after vigorous fall growth. This avoids or reduces the need for controls the following spring.

Alter **planting dates** to encourage maximum early crop growth or delay planting until the first flush of weeds is controlled.

Modify **placement and time of application of fertilizer**, especially nitrogen.

- Band or spot fertilizer below crop seed to reduce its availability to surface-germinating weeds.
- Time the application of fertilizer using side-dressing for maximum crop growth or to minimize weed development.

Develop crop canopy to shade weeds and suppress weed germination.

- Select crops or varieties that form a canopy quickly.
- Space plants in equidistant (triangular) arrangements and vary density depending on crop management constraints or harvest requirements.
- Interplant crops in space and time (consider mechanical limitations in commercial plantings).

Manage an appropriate **living mulch** (grass or legume) between perennial crop rows.

Improve **pasture management by reseeding and/or fertilizing** to reduce weed infestation (weeds are usually a symptom of poor management).

Apply Mulch

- Organic mulches such as straw may reduce available N when decomposing, but it could be infested with weed seed.
- Sawdust can be used but you must avoid vertebrate pests by maintaining a mulch-free circle around trees. Also, perennial weeds can become a serious problem under mulch.
- Use bark mulch, black plastic or landscaping fabric which excludes light and therefore controls most annual weeds.
- Avoid clear plastic mulch because it acts like a greenhouse and produces poor weed control.
- There are wavelength-selective plastics that can help in weed and pest management.

Mechanical Weed Control

Mechanical weed control involves the physical destruction of a weed. Techniques involve HAND PULLING or HAND HOEING which are practical for small infestations. MOWING is often used; but by far, the most common practice of mechanical control includes TILLAGE. Advantages of tillage include:

- Elimination of weed debris
- Controll of annual weeds
- Suppression of perennial weeds
- Tillage methods include plowing, rototilling, disking, and harrowing. Weed control implements include sweeps, rolling cultivators, finger weeders, push hoes, rotary hoes, etc.

Other Cultural Methods of Weed Control

Flaming is a technique that can be useful but it requires a physical difference or separation between crops and weeds, or crop protection with a hooded row cover or protein foaming agents.

Proper **water management,** such as the use of drip irrigation or uniform irrigation, can eliminate certain weeds.

Stale seedbeds involve a delay in planting after seedbed preparation to control the first flush of weeds before seeding.

Biological Weed Control

Biological control involves the use of **natural enemies**, such as predators, parasitoids, competitors, or pathogens to control pest insects, weeds, or diseases to levels lower than they would otherwise be. There are three main methods of biological control: conservation, introduction, or augmentation. Human activities can greatly influence the extent to which natural enemies are able to suppress pests. **Conservation Biological Control** is defined as any biological control practice designed to protect and maintain populations of existing natural enemies. This approach is particularly useful in agroecosystems where management practices such as cultivation, pesticide applications, and harvest disrupt the life cycle of the beneficial organisms. **Introduction** or **Classical Biological Control** refers to the importation of foreign natural enemies to control previously introduced, or native, pests. Finally, **Augmentation Biological Control** involves control practices intended to increase the number or effectiveness of existing natural enemies. This approach is commonly used in cases where natural enemies are missing (greenhouses) or late to arrive at new plantings (some row crops), or simply too scarce to provide control.

Many of our worst weeds originated in foreign countries and biological control practices can help us to maintain them below threshold levels. These newly introduced plants, free from the natural enemies found in their homelands, gained a competitive advantage over native plants. Once they are out of control, other methods of weed management are usually not economical or physically possible. The need for a method of weed reduction that was economical, self-sustaining, and environmentally safe provides opportunities for biological control. There are several well-documented successes of biological control: St. Johnswort (Klamathweed in California), tansy ragwort in Oregon, and rush skeletonweed in the Pacific Northwest.

Biological control is a slow process, and its efficacy is highly variable. It usually takes several years for a biological control agent to become established and control a weed. Biological control agents impact weeds in two ways: directly and indirectly. Direct impact destroys vital plant tissues and functions. Indirect impact increases stress on the weeds, which may reduce their ability to compete with desirable plants. Thus, it is very useful to integrate biological control with other weed management practices. For example, once weeds are weakened by Biological Control Agents, competitive plantings may be used to outcompete the weeds.

The goal of a biological control program is not to eradicate a pest, but to maintain it below an acceptable threshold level. When using BCAs, a residual level of the weed populations must be expected since the survival of the agents is dependent on the density of their host weeds. After populations of the host weeds decrease, populations of BCAs will correspondingly decrease. This is a natural cycle and should be expected.

The BCAs released in the U.S. have been thoroughly tested to ensure they are host-specific. This is an expensive and time-consuming task that must be done before the agents are allowed to be introduced. An extensive assessment of BCAs prior to their release secures they will not switch to crops, native flora, and endangered plant species.

Biological control of certain weeds may not work in your area, even though an insect may be very effective in another area. Climate variations such as cold winters, and plant biotype differences may account for some of the failures that have occurred in the past. To ensure maximum success, trained personnel must supervise biological control programs. Biological control agents are living entities and require specific conditions to survive.

As with any other weed management method, biological control has benefits and disadvantages. The benefits include: reduction of herbicide residues in the environment, host specificity on target weeds, long-term self-perpetuating control, low cost per acre, searching ability to locate hosts, synchronization of agents to life cycles of hosts, and unlikelihood that hosts will develop resistance to agents. Some of the disadvantages of biological control include: the limited availability of agents from their native homelands, the dependence of control on plant density, the slow rate at which control occurs, biotype matching, and host specificity when host populations are low.

Table 1. The current status of biological weed control agents released in either Montana, Utah, and/or Wyoming

		Distribution			Infestation			Control			Availability		
Weed	**Agent**	**MT**	**UT**	**WY**	**MT**	**UT**	**WY**	**MT**	**UT**	**WY**	**MT**	**UT**	**WY**
Brown knapweed	*Urophora quadrifasciata*	-	-	-	-	-	-	-	-	-	-	-	-
Bull thistle	*Urophora stylata*	-	-	U	-	-	U	-	-	U	-	-	O
Canada thistle	*Ceutorhynchus litura*	L	L	L	L	L	M	U	U	F	L	O	L
	Orellia ruficauda	-	-	-	-	-	-	-	-	-	-	-	-
	Rhinocyllus conicus	W	W	W	L	L	L	P	F	U	M	L	L
	Urophora cardui	L	F	L	S	-	S	U	-	U	L	-	O
Dalmatian toadflax	*Calophasia lunula*	W	-	U	L	-	U	F	-	U	L	-	O
Diffuse knapweed	*Bangasternus fausti*	L	-	-	U	-	-	U	-	-	O	-	-
	Larinus minutus	L	U	L	U	U	L	U	U	U	O	O	O
	Pterolonche inspersa	L	-	-	U	-	-	U	-	-	O	-	-
	Sphenoptera jugoslavica	L	U	U	U	U	U	U	U	U	L	O	O
	Urophora affinis	W	L	L	M	L	M	G	U	U	M	O	O
	Urophora quadrifasciata	W	L	L	M	M	M	G	U	U	M	O	O
	Agapeta zoegana	U	L	U	U	S	U	U	U	U	O	O	O
Gorse	*Agonopterix nervosa*	-	-	-	-	-	-	-	-	-	-	-	-
	Exapion ulicis	-	-	-	-	-	-	-	-	-	-	-	-
Italian thistle	*Cheilosia corydon*	-	-	-	-	-	-	-	-	-	-	-	-
	Rhinocyllus conicus	-	-	-	-	-	-	-	-	-	-	-	-
Leafy spurge	*Aphthona cyparissiae*	L	L	L	L	S	L	U	U	U	L	O	O
	Aphthona czwalinae	L	U	L	L	U	L	U	U	U	L	O	O
	Aphthona flava	W	L	L	M	S	L	G	U	U	L	O	O
	Aphthona lacertosa	-	U	L	-	U	L	-	U	U	-	O	O
	Aphthona nigriscutis	W	L	W	M	S	H	E	U	U	M	O	M
	Spurgia esulea	L	U	L	L	U	M	U	U	U	L	O	O
Meadow knapweed	*Urophora quadrifasciata*	-	-	-	-	-	-	-	-	-	-	-	-
Mediterranean sage	*Phrydiuchus tau*	-	-	-	-	-	-	-	-	-	-	-	-
Milk thistle	*Rhinocyllus conicus*	-	-	-	-	-	-	-	-	-	-	-	-
Musk thistle	*Cheilosia corydon*	L	-	-	U	-	-	P	-	-	O	-	-
	Rhinocyllus conicus	W	W	W	H	H	H	G	G	G	M	M	M
	Trichosirocalus horridus	L	U	W	S	U	M	U	U	G	L	O	L
Plumeless thistle	*Rhinocyllus conicus*	-	-	-	-	-	-	-	-	-	-	-	-
	Trichosirocalus horridus	-	-	U	-	-	U	-	-	U	-	-	O
Poison hemlock	*Agonopterix alstroemeriana*	-	-	-	-	-	-	-	-	-	-	-	-
Puncturevine	*Microlarinus lareynii*	-	L	F	-	U	-	-	U	-	-	O	-
	Microlarinus lypriformis	-	L	F	-	U	-	-	U	-	-	O	-
Purple loosestrife	*Galerucella calmariensis*	L	U	-	U	U	-	U	U	-	O	O	-
	Galerucella pusilla	L	U	-	U	U	-	U	U	-	O	O	-
	Hylobius transversovittatus	U	-	-	U	-	-	U	-	-	O	-	-
Rush skeletonweed	*Cystiphora schmidti*	-	-	-	-	-	-	-	-	-	-	-	-
	Eriophyes chondrillae	-	-	-	-	-	-	-	-	-	-	-	-
	Puccinia chondrillina	-	-	-	-	-	-	-	-	-	-	-	-
Russian knapweed	*Subanguina picridis*	L	L	L	L	S	S	U	U	U	O	O	O
St. Johnswort	*Agrilus hyperici*	L	-	-	M	-	-	G	-	-	L	-	-
	Aplocera plagiata	L	-	-	U	-	-	U	-	-	O	-	-
	Chrysolina hyperici	W	-	-	M	-	-	G	-	-	L	-	-
	Chrysolina quadrigemina	W	-	L	M	-	M	G	-	U	L	-	O
	Zeuxidiplosis giardi	U	-	-	-	-	-	-	-	-	-	-	-
Scotch broom	*Agonopterix nervosa*	-	-	-	-	-	-	-	-	-	-	-	-
	Apion fuscirostre	-	-	-	-	-	-	-	-	-	-	-	-
	Leucoptera spartifoliella	-	-	-	-	-	-	-	-	-	-	-	-
Slenderflower thistle	*Rhinocyllus conicus*	-	-	-	-	-	-	-	-	-	-	-	-

Table 1. The current status of biological weed control agents released in either Montana, Utah, and/or Wyoming - continued

Weed	Agent	Distribution			Infestation			Control			Availability		
		MT	UT	WY	MT	UT	WY	MT	UT	WY	MT	UT	WY
Spotted knapweed	*Agapeta zoegana*	W	U	L	M	U	U	G	U	U	L	O	O
	Bangasternus fausti	L	-	-	U	-	-	U	-	-	O	-	-
	Chaetorellia acrolophi	L	-	L	U	-	U	U	-	U	O	-	O
	Cyphocleonus achates	W	U	U	M	U	U	G	U	U	L	O	O
	Larinus minutus	U	-	L	U	-	U	U	-	U	O	-	O
	Larinus obtusus	U	-	-	U	-	-	I	-	-	O	-	-
	Metzneria paucipunctella	L	-	-	S	-	-	P	-	-	O	-	-
	Terellia virens	L	-	L	U	-	U	U	-	U	O	-	O
	Urophora affinis	W	U	L	H	U	M	G	U	U	M	O	O
	Urophora quadrifasciata	W	S	L	H	S	M	G	U	U	M	O	O
Squarrose knapweed	*Urophora affinis*	-	L	-	-	S	-	-	U	-	-	O	-
	Urophora quadrifasciata	-	L	-	-	L	-	-	U	-	-	O	-
	Agapeta zoegana	U	U	U	U	U	U	U	U	U	O	O	O
	Bangasternus fausti	U	L	U	U	S	U	U	U	U	O	O	O
	Sphenopter jugoslavica	U	U	U	U	U	U	U	U	U	O	O	O
Tansy ragwort	*Longitarsus jacobaeae*	-	-	-	-	-	-	-	-	-	-	-	-
	Pegohylemyia seneciella	-	-	-	-	-	-	-	-	-	-	-	-
	Tyria jacobaeae	-	-	-	-	-	-	-	-	-	-	-	-
Yellow starthistle	*Bangasternus orientalis*	-	-	-	-	-	-	-	-	-	-	-	-
	Chaetorellia australis	-	-	-	-	-	-	-	-	-	-	-	-
	Eustenopus villosus	-	-	-	-	-	-	-	-	-	-	-	-
	Larinus curtus	-	-	-	-	-	-	-	-	-	-	-	-
	Urophora sirunaseva	-	-	-	-	-	-	-	-	-	-	-	-
Yellow toadflax	*Brachypterolus pulicarius*	-	-	-	-	-	-	-	-	-	-	-	-
	Calophasia lunula	W	-	-	L	-	-	F	-	-	L	-	-
	Gymaetron antirrhini	W	-	U	M	-	U	U	-	U	L	-	O

Distribution within host range: W = widespread, L = limited sites, F = failed to establish, U = unknown status, - not yet released

Infestation of hosts: H = heavy (>70%), M = medium (>30%), L = light (> 10%), S - slight (. 1%), O = none detected, U = unkown status

Ability to control seed production and/or plant density: E = excellent, G = good, F = fair, P = poor, U = undertermined

Availability for redistribution: M = mass collection, *L = limited, O = not collectable at present

* Limited availability indicates agent populations are slow in building or recently introduced. Information concerning these species can be obtained through biological control specialists at the state department of agriculture or state university in your state. Collection and/or transportation of biological control agents may require special permits and procedures.

Table 2. The biological weed control agents released, the general role of each agent, and the type of introduction (C = classical and A = accidental).

Species	Role	Species	Role
Agapeta zoegana	root boring moth C	*Gymnaetron antirrhini*	seed head weevil A
Agonopterix alstroemeriana	defoliating moth A	*Hylobius transversovittatus*	root boring weevil C
Agonotopterix nervosa	shoot tip moth A	*Larinus curtus*	seed head weevil C
Agrilus hyperici	root boring beetle C	*Larinus minutus*	seed head weevil C
Aplocera plagiata	defoliating moth C	*Larinus obtusus*	seed head weevil C
Aphthona cyparissiae	root/defoliating flea beetle C	*Leucoptera spartifoliella*	twig mining moth A
Aphthona czwalinae	root/defoliating flea beelte C	*Longnitarsus jacobaeae*	root/defoliating flea beetle C
Aphthona flava	root/defoliating flea beetle C	*Metzneria paucipunctella*	seed head moth C
Aphthona lacertosa	root/defoliating flea beetle C	*Microlarinus lareynii*	seed weevil C
Aphthona nigriscutis	root/defoliating flea beetle C	*Microlarinus lypriformis*	stem boring weevil C
Apion fuscirostre	seed weevil C	*Orellia ruficauda*	seed head fly A
Bangasternus fausti	seed head weevil C	*Pegohylemyis seneciella*	seed head fly C
Bangasternus orientalis	seed head weevil C	*Phrydiuchus tau*	crown/root weevil C
Brachypterolus pulicarius	flower beetle A	*Pterolonche inspersa*	root boring moth C
Calophasia lunula	defoliating moth C	*Puccinia chondrillina*	rust fungus C
Ceutorhynchus litura	crown/root weevil C	*Rhinocyllus conicus*	seed head weevil C
Chaetorellia acrolophi	seed head fly C	*Sphenoptera jugoslavica*	root boring/gall beetle C
Chaetorellia australis	seed head fly C	*Spurgia esulae*	shoot tip gall midge C
Cheilosia corydon	crown/root fly C	*Subanguina picridis*	stem/leaf gall nematode C
Chysolina hyperici	defoliating beetle C	*Terellia virens*	seed head lly C
Chrysolina quadrigemina	defoliating beetle C	*Trichosirocalus horridus*	root/crown weevil C
Cyphocleonus achates	root boring/gall weevil C	*Tyria jacobaeae*	defoliating moth C
Cytisphora schmidti	stem/leaf gall midge C	*Urophora affinis*	seed head gall fly C
Eriophyes chondrillae	bud gall mite C	*Urophora cardui*	stem gall fly C
Eustenopus villosus	seed head weevil C	*Urophora quadrifasciata*	seed head gall fly A
Exapion ulicis	seed weevil C	*Urophora sirunaseva*	seed head gall fly C
Galerucella calmariensis	leaf beetle C	*Urophora stylata*	seed head gall fly C
Galerucella pusilla	leaf beetle C	*Zeuxidiplosis giardi*	leaf fall midge

Year-Round Weed Management Strategies: A Summary

Weed Prevention

Employ sanitary practices. Prevent new weed infestations. Prevent weed shifts resulting from repeated:

- Cultivation (enhances perennial weeds).
- Mowing (enhances prostrate weeds).
- Herbicides (enhances tolerant weeds, new weed biotypes, new microorganisms that render herbicides inactive).

Identify and Map Your Weeds

- Recognize weeds with identification books (annuals, biennials, perennials).
- Map and record infestations (weed abundance).
- Keep yearly records.

Prioritize Your Weeds by Developing Priorities

- Highly competitive weeds (control them).
- Moderately competitive weeds (suppress them).
- Noncompetitive weeds (don't worry about them).

List the Control Methods Gained from:

- Your experience.
- Local experts.
- Published information.
- Learn the strengths and weaknesses of each control method.

Design a Weed Management Program

Select a field or area with manageable weed problems.

- Consider the environmental aspects.
- Consider the erosion potential.
- Consider surrounding water, high-value vegetation, or urban and/or recreational areas.
- Consider costs, equipment, management skills, precision timing, and other factors needed to achieve results.
- Develop year-round weed management strategies involving combinations of weed control practices.

Evaluate Your Results

- Evaluate weed management programs.
- Continue mapping weeds for future reference.
- Modify practices as weed shifts occur because of repeated practices.