WEEDS

WEEDS

Better adapted to thriving in disturbed environments, weeds compete with cultivated crops, often causing yield losses, if not total crop failure. Some species are also detrimental to wildlife since they provide poor habitat and out-compete native plants. Weeds also have some benefits, such as protecting soil from erosion. Certain species can indicate soil-nutrient status and structure (e.g., pH and moisture levels, the presence of a hard pan layer, or other areas of poor drainage).[1] Weeds also increase plant diversity; some provide good wildlife habitat because many weed species are native and adapted to specific microclimates and local conditions. Beneficial insects, such as green lacewings and parasitic wasps, depend to a large extent on non-crop species for nectar and pollen particularly early in the season. Weeds can, therefore, increase opportunities for biological control of crop pests. Understanding why and how weeds grow, how farming practices affect them, and which species are present in a field are key to weed management.

PRINCIPLES OF WEED MANAGEMENT

WEED COMPETITION

Weeds are pests because they compete for nutrients, water, and light. However, the degree of competition is closely related to the life cycle of the crop. Keeping annual crops weed-free during the first third of their life cycle is critical, since that is the period when weed competition is the most damaging. Competition that occurs later in the crop life cycle usually results in minimal yield loss, although seeds from late-season weed infestations can become a problem in subsequent crops. Competition is keener when crops and weeds emerge about the same time. Therefore, practices that can give the crop a head start on the weeds can help to reduce competition.[2]

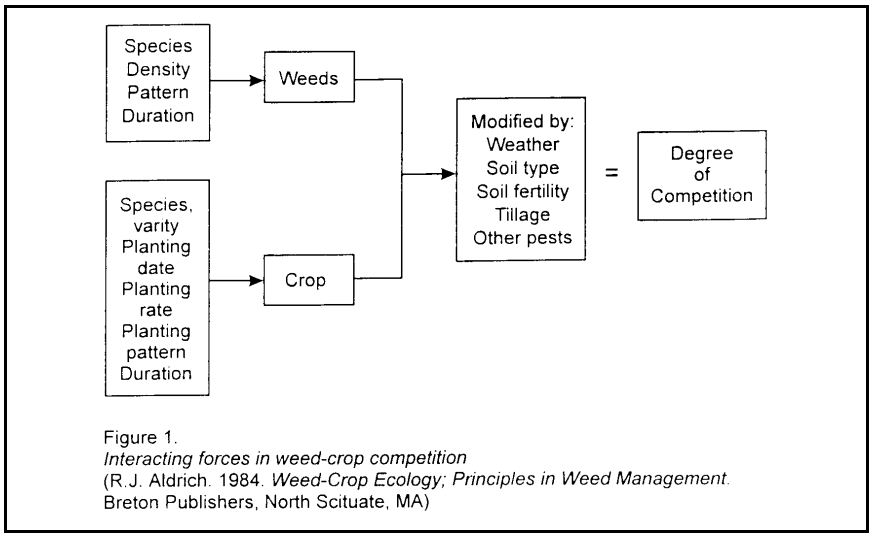

Figure 1.
Interacting forces in weed-crop competition
(R.J. Aldrich. 1984. *Weed-Crop Ecology; Principles in Weed Management.* Breton Publishers, North Scituate, MA)

WEED IDENTIFICATION

Weed identification and record keeping is essential in planning a successful control strategy. Each weed species has its own unique life cycle and competitive abilities. Knowing what type of weeds are in the field, and learning about their survival mechanisms enables the grower to select the most effective management strategy. It is important to identify whether or not the weed is a grass or a broadleaved plant, whether it is an annual, biennial or perennial, and during which seasons the weed seeds will germinate.[3]

It is also important to know if the weeds present are classified as noxious by the state or federal government, since this classification may dictate control actions. *Appendix Weeds-1* provides state definitions of noxious weeds and the rating for common Refuge weed species.

The *Growers Weed Identification Handbook*[4] and *Weeds of the West*[5] contain excellent life cycle information and photographs useful for weed seedling identification.

WEED SEED SURVIVAL AND GERMINATION

Soil contains millions of weed seeds per acre. Although many of these seeds germinate each year, others remain dormant. Survival of weed seeds varies greatly from species to species. Since annual weeds depend on the production of a large number of seeds to survive, preventing seed production reduces weed-seed density in the soil.

To germinate, seeds require oxygen, moisture, and an appropriate temperature range. Most weed seedlings emerge from the top 2 inches of the soil—an area where conditions necessary for germination exist.[2] Depending on the species, other factors required to trigger germination

may include further ripening, chilling, light, or the correct degree of alternation between daytime and night-time temperatures. Without these factors, seeds lie dormant, often surviving for long periods of time, until proper conditions occur. For example, dormant field bindweed seeds can live up to 30 years.[6] Proper identification of weeds in the field can indicate how long the seeds can survive in soil, and can help determine the best management strategy.

Table 1.
Emergence dates for common weeds in Klamath Basin.[7]

April	May	June
Lambsquarters London Rocket Mustards Pigweeds Quackgrass Shepherdpurse Wild Oats	Barnyardgrass Canada Thistle Cocklebur Field Bindweed Foxtails Mallow Nightshades Sowthistle	Dodder Kochia Purslane Russian Thistle

VEGETATIVE REGENERATION

Perennial weeds often have vegetative parts that can sprout and grow even if the parent plant is killed. These weeds survive by resprouting from underground roots, stems, bulbs, tubers and other plant tissues.

Nutrient reserves in a vegetative part determine the ability to resprout and grow into a new plant. There is usually a period of days immediately following the spring growth flush when a perennial is most easily destroyed by tillage.[2] Therefore, tillage must be carefully timed to suppress perennial weeds at their most vulnerable stage. If tilled at the wrong time, weeds that are capable of resprouting can be moved around in the field, resulting in an even bigger problem than before the tillage.

CONTROLLING WEEDS BY MANAGING THEIR ENVIRONMENT

Cultural control practices make the environment less favorable to weeds. Cultural controls for weeds include exclusion, crop rotations, seedbed preparation and cover crops. To be successful, cultural controls require skillful management. They also require growers to consider prevention as well as control, and to optimally combine practices to achieve the best results.

EXCLUSION TO PREVENT WEEDS

The best, and sometimes the only economical method of weed control is prevention. This includes avoidance of weed seed introduction. Machinery, seed-contaminated irrigation water, weedy field margins, or contaminated crop seed can all be sources of infestation. Weed infestations along the berms are of considerable concern. Until weeds are controlled along the berms, they will continue to serve as a seed source in the fields (see Berm Management Plan). Growers have noted a higher number of weeds near sprinklers, suggesting that seeds may be sucked from water in irrigation canals and introduced to the field via sprinklers. Growers and researchers may wish to investigate this further. If true, finer filtration of irrigation water may be desirable.

CROP ROTATIONS

Field history will influence weed problems. Intensive cultivation of annual crops favors short-life-cycle annual weeds, whereas maintaining land in perennial crops like alfalfa or grasslands tends to encourage perennial weed species. Rotations from one system to another—or example from a row crop to alfalfa—are useful because they reduce the weed species that were previously causing problems. Rotations also benefit soil fertility and reduce insect and disease problems. Some weed species (e.g., field bindweed) are well adapted to a wide range of conditions, and rotation is less useful for their control.

COVER CROPS AND GREEN MANURES

Cover crops compete with weeds for light, water, and nutrients and are useful in several ways for controlling weeds. For instance, when included in a crop rotation plan, cover crops serve to disrupt the life cycle of many weeds that are adapted to an annual production system. Cover crops also can be used to shade out, or “smother,” hard-to-control perennials such as quackgrass. Some cover crops, such as rye, actively suppress weeds through chemicals associated with living or dead plant parts. Maintaining a strip of cover crop (known as a “living mulch”) between plant rows is another unique way of using cover crops to control weeds. In addition to controlling weeds, cover crops also reduce soil erosion and improve soil structure, biological activity, and fertility.

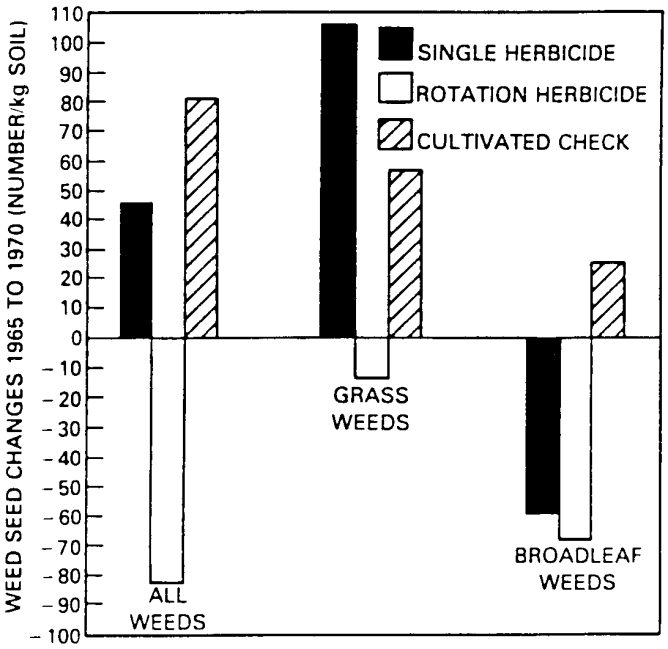

Figure 2.
Effect of crop rotation and weed control type on weed seed numbers in soil after 6 years
(R.J. Aldrich. 1984. *Weed-Crop Ecology; Principles in Weed Management.* Breton Publishers, North Scituate, MA)

PRE-PLANT TILLAGE

Tillage operations can be timed to reduce the number of weed seeds in the soil. The strategy is to till, wait for the weed seeds to germinate, then till again. For this technique to work, it is important to allow enough time between successive cultivations for the weed seeds to germinate.

The type of implement used for pre-plant tillage will influence the results. Cultivation with shallow implements, such as spring-tined cultivators, leaves weed seeds near the surface where they will germinate. This strategy is especially good for controlling species with long-lived seeds. The seeds are brought up to the surface and encouraged to germinate instead of staying deeply buried and remaining dormant. Deep tillage, such as plowing, buries weed seeds. This strategy helps to eliminate short-lived seeds, since they die while still deeply buried. Understanding the life cycle of the weed and using a range of cultivation techniques, both deep and shallow, can ensure that tillage does not selectively encourage individual weed species.

PRIORITY WEEDS ON REFUGE LEASED LANDS

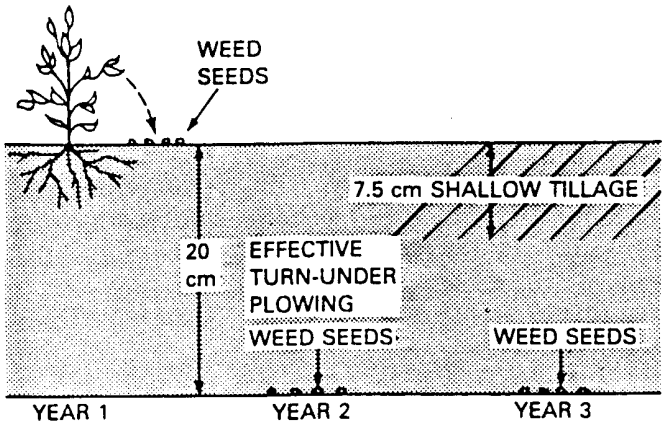

Figure 3.
Use of tillage to minimize weed emergence following production of a large number of weed seeds
(R. J. Aldrich. 1984. *Weed-Crop Ecology; Principles in in Weed Management.* Breton Publishers, North Scituate, MA)

The following weeds were identified as priority pests by crop by the growers. (Priority weed species were identified by a combination of how often the weed was identified as a problem and how frequently it was controlled, according to grower, agency, researcher and pest control advisor interviews.)

Table 2 .
Pest status of weed species on the Refuges

Weed species	Alfalfa	Potatoes	Grains	Onions	Sugar-beets	Berms	Remarks
Broadleaved annuals							
five-hook Bassia	+	+	+	+	+	+	Kochia and five-hook Bassia are often confused; Kochia is by far the most prevalent of the species.
netseed lambsquarter	+	+		+	+	+	May be host to *Verticillium* spp.
pigweed	+	+		+	+		
redroot pigweed		+		+	+		Host of potato leaf roll virus.

Weed species	Alfalfa	Potatoes	Grains	Onions	Sugar-beets	Berms	Remarks
Kochia		+	+	+	+		Two to three Kochia plants per square foot can reduce wheat yields 30%: Kochia infestations can also cause problems at harvest.
common purslane							
tumble mustard					+		Aphid host.
wild mustard	+			+	+		Green peach aphid and beet leafhopper host. Aphids and beet leafhoppers transmit sugarbeet viruses. Wild oats and wild mustard are very competitive with wheat and onions. Left unchecked, 10 wild oats or wild mustard plants per square foot will reduce wheat yields 10-20 bushels per acre or 35%
hairy nightshade					+		Host of green peach aphid and potato aphid, and possible reservoir for potato leaf roll virus and sugarbeet viruses. Also host for *Rhizoctonia* spp.
Annual Grasses							

Weed species	Alfalfa	Potatoes	Grains	Onions	Sugar-beets	Berms	Remarks
wild oats	+	+	+	+	+		Wild oats and wild mustard are very competitive with wheat and onions. Wireworm populations build in wild oats.

Perennials and Biennials

Canada thistle		+		+		+	Canada thistle patches often reduce wheat yields by 60%. Beet leafhopper host.
perennial pepperweed				+		+	
Russian thistle	+						Beet leafhopper host.
cheatgrass	+						
quackgrass			+				
field bindweed (morning glory)			+				
poison hemlock							

Source: [8] [9]

WEED CONTROL BY CROP

SUGARBEETS

Overview, Seasonal Development

Broadleaved weeds and grasses are important pests of sugarbeets since this crop is highly susceptible to yield reduction as a result of weed competition. Uncontrolled weeds can reduce sugarbeet yields by over 90 percent.[10]

Annual broadleaved weeds and some grasses mentioned by Refuge growers as being the worst pests are Bassia, netseed lambsquarter, pigweed, redroot pigweed, wild mustard, Kochia, hairy nightshade, tumble mustard (Jim Hill mustard), and wild oats. Summer annual broadleaved weeds are problematic in sugarbeets because they are present when the crop is most vulnerable to competition. Summer annuals begin to germinate in the late spring (April to May) and continue through summer, whenever soil moisture is adequate.

Short and Long-term Management Guidelines

Cultural

- Till or use cover crops (such as Sudangrass or rapeseed) off-season to control weeds and prevent the production and dispersal of additional weed seed in the field. Avoid introducing weed rhizomes, stolons, and seeds into fields on farm equipment or in contaminated seed or irrigation water.

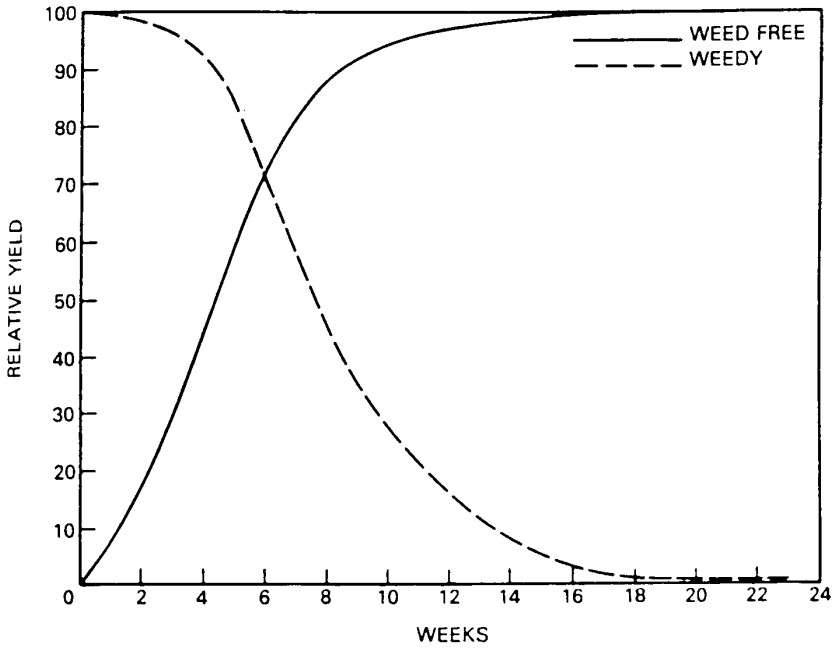

Figure 4.
Effects of weed-free period and weedy period on yields on sugarbeets
(R.J. Aldrich. 1984. *Weed-Crop Ecology; Prinicples in Weed Management.* Breton Publishers, North Scituate, MA)

- Crop rotation (required in lease agreements and sugarbeet contracts) helps suppress weed species that are associated with sugarbeets.

- Mechanical and cultural weed control practices currently used for Refuge-grown sugarbeets include preirrigation to germinate weed seeds followed by spring tillage.[8][9]

This two-step technique germinates and kills a large number of weeds while minimizing the number of new seeds brought to the surface.

- Once well established, fast growing cultivars can out-grow weeds.[8] However, early season weed control is critical to stand establishment.

▶ *Biological*

- Biological control of weeds in berm areas is a possibility (see Berm Management Plan), and would have secondary benefits for row crops like sugarbeets since the number of weed seeds coming into the field would diminish. There are no effective biological weed control options to recommend for use within sugarbeet fields during the cropping season.

▶ *Herbicides*

- Aerial and band applications of herbicides combined with between row cultivation are typical weed control methods used on the Refuge. Roundup is PUP-approved for use on direct seeded, pre-formed beds to kill weeds prior to crop emergence. Flaming the seedbed prior to sugarbeet seedling emergence is a potential alternative to Roundup, and is discussed in detail under the Field Trial Recommendations.

- Postplant band applications of Betamix Progress are PUP-approved for broadleaved weed control. Poast is PUP-approved for grass control. Preplant-incorporated herbicides are not used since they are ineffective on the high-organic-matter soils of the Refuge lands.[8]

ONIONS

Overview, Seasonal Development

Broadleaved weeds and grasses are important onion pests. Onions are poor competitors with weeds due to their slow growth, shallow, fibrous root systems, and lack of an aerial canopy to shade out other vegetation. Additionally, the long growing season allows for several "flushes" of weeds to arise. Because of these factors, and given a choice, onions should be planted in the most weed-free fields available.

Onion growers on the Refuge report significant competition from a wide variety of annual broadleaved weeds. Among wild grasses, wild oats is the major problem. Perennial weed problems do not appear widespread, though some concerns about Canada thistle and quackgrass have been raised.[9]

Short- and Long-term Management Guidelines

▶ *Monitoring*

- Record crop growth stage and weed types and locations each week throughout the monitoring period. Such knowledge assists in determining optimum crop rotations, selection and timing of herbicides, and evaluating possible alternatives to herbicides.

▶ *Cultural*

- Weed problems can be reduced in onions by means of a number of preventive measures. Till or use off-season cover crops (such as Sudangrass or rapeseed) to control weeds and prevent the production and dispersal of additional weed seed in the field. Avoid introducing weed rhizomes, stolons, and seeds into fields on farm equipment or in contaminated seed or irrigation water.

- Crop rotation (required in lease agreements) helps suppress weed species associated with onions.

- Mechanical and cultural weed control practices currently used for Refuge-grown onions include preirrigation to germinate weed seeds followed by spring tillage. This two-step technique germinates and kills a large number of weeds while minimizing the number of new seeds brought to the surface.[11]

- Onions are provided with some competitive advantage through the use of nitrogenous fertilizers, such as ammonium nitrate, ammonium thiosulfate, or mixtures of urea and sulfuric acid. Applied when the onions reach one true leaf, the crop is stimulated while many broadleaved weeds are "burned back" by the fertilizer.

▶ *Biological*

- Biological control of weeds in berm areas (see Berm Management Plan), would have secondary benefits for onions since the number of weed seeds coming into the field would diminish. There are no effective biological weed control options to recommend for use within onion fields during the cropping season.

▶ *Herbicides*

- Following seedbed preparation, weeds in leased-land onion fields are controlled primarily by herbicides, and supplemented with between-row cultivation and limited hand hoeing. Roundup is PUP-approved for use on direct-seeded pre-formed beds to kill weeds prior to onion seedling emergence. Postemergent herbicide applications of Goal 1.6E—for broadleaved weeds and Fusilade for wild oats—are PUP approved. Aerial and ground applications are approved for Fusilade; and ground and chemigation applications are approved for Goal.[8]

- Buctril (bromoxynil), a postemergent broadleaved herbicide, sometimes used in conjunction with Goal, is not used on the Refuge due to its high toxicity to fish and wildlife. Preplant- incorporated herbicides like Dacthal (chlorthal dimethyl) are not used since they perform poorly on high-organic-matter soils.[8]

POTATOES

Overview, Seasonal Development

Potatoes are generally good competitors with weeds because they are able to draw upon the reserves in the seed piece for sustained growth early in the planting season. However, if weeds are not controlled during the initial phases of crop growth, severe crop losses sometimes can result. Once the plants are grown, and especially once rows are “closed,” few weeds can compete with the dense, viney growth of potatoes.

Most annual broadleaved weeds that affect potato production are species common to any arable land and can be controlled by a combination of cultivation and herbicide use. If herbicides are used, weeds are best controlled before they reach the second-true-leaf stage.[12]

Perennial weeds are more difficult to control because of their generally extensive root reserves. The best control is prevention.

Several weeds have been identified by local growers and researchers as important pests every year in potatoes (see *Table 2*).

Short- and Long-term Management Guidelines

▶ *Monitoring*

Scouting and recording weed species and their first appearance is important to an effective weed management program. Such knowledge assists the grower in determining optimum crop rotations, selection and timing of herbicides, and evaluating possible alternatives to chemical control.

▶ *Cultural*

- Crop rotations are an important aspect of weed management. Because crop rotations change the management of a field every year, no single weed species or weed type (e.g., warm-season annual grasses) is favored. Rotations also provide the opportunity to manage especially troublesome species at various times in the rotation.

- Irrigation in late summer or early fall following harvest of a rotational crop will encourage weeds to germinate that can then be destroyed by late fall or early spring herbicide applications, tillage, or winter freezing.[12] In Klamath Basin, preirrigation is generally timed for the early spring to allow emerging weeds to be destroyed during tillage and bed preparation.

- Cover crops and some green manures show much promise as weed management tools for potatoes in addition to their soil conservation and microclimate enhancement benefits to the crop. These are discussed further in Field Trial Recommendations.

▶ *Biological*

- There are no effective biological weed control options to recommend for use within potato fields during the cropping season.

▶ *Herbicides*

- There are a variety of PUP-approved herbicides available to growers for weed control in potatoes. Sencor DF, Lexone DF (both with metribuzin as active ingredient), and Roundup are broad spectrum herbicides effective on both annual grasses and broadleaved weeds. Applications of metribuzin are restricted to no more than two per season and are not to exceed 1.33 lbs per season. Roundup is restricted to one application per season. In addition to these broad-spectrum herbicides, Eptam (EPTC) is available for control of grasses such as annual ryegrass, wild oats and foxtails.[8]

- Matrix is a broad-spectrum herbicide which may be ground applied no more than two times per season, with the total application not to exceed 2 oz. per season per acre. Aerial application of Matrix is not PUP-approved. Poast is specific to grasses and is used as a postemergent weed treatment. It may be applied no more than two times per season and may be both ground or aerially applied.[13]

SMALL GRAINS

Overview, Seasonal Development

As in most crops, weed control in small grains is especially important early in the cropping season. Weeds established prior to the mid-tillering phase of the crop cause the greatest yield reductions. Weeds emerging after mid-tillering usually have little effect on yield unless

the stand is poor. Vigorous stands are the best protection against weed emergence and seed development after mid-tillering. Weed control in small grains prevents yield loss, weed reseeding, and reduces dockage in the crop.

In Klamath Basin, the main weed competitors are quackgrass, wild oats, and various mustard family weeds.[14] Local growers identified Bassia and Kochia as important weeds and netseed lambsquarter, pigweed, and redroot pigweed as problem weeds (see *Table 2*).

Weed control in small grains on the leased lands might fall into two categories because of the different climate and management of the Tule Lake and Lower Klamath Refuges. Crop rotations are required on the Tule Lake leased lands. The soils are generally better and the climate just a bit warmer than the Lower Klamath area. On Tule Lake, grains can be rotated with potatoes, alfalfa, sugarbeets and onions. Weed management can then be accomplished in an integrated, rotation-wide management scheme. However, crop rotation is not generally used on the Lower Klamath leased lands. The cooler temperatures make growing row crops more risky. In spite of this, the potential for some crop rotation exists if markets for rotation crops, such as canola, can be found.

Short- and Long-term Management Recommendations

Cultural

- ***Tule Lake leased lands.*** Cultural control of weeds is done by a combination of crop rotation and tillage. Fall irrigation by sprinklers and preirrigation by flooding may be used by some growers to germinate weeds, subsequently controlled by tillage or herbicides. Irrigation water may be a source of weed seeds if water is not sufficiently screened.

- ***Lower Klamath leased lands.*** Cultural control of weeds is accomplished with a combination of flooding, plowing, and disking. In some fields, the stubble is burned in the late fall. Flooding floats many weed seeds off the soil, but may deposit them in another location within the same field, or carry them to a new field. Crop rotations to a broadleaved crop on this land would be especially helpful for control of grass weeds.

- Sanitation is important in preventing weed seeds from entering the field. Use of certified seed will prevent weed seeds from coming in with the grain seed. Use of non-certified seed can create weed problems for years to come. To prevent the spread of a particularly difficult-to-control weed, growers need to be especially careful to clean equipment.

Biological

- Biological control of weeds in berm areas (see Berm Management Plan) would have secondary benefits for potatoes since the number of weed seeds coming into the field would diminish. There are no effective biological weed control options to recommend for use within potato fields during the cropping season.

Herbicides

- To maintain profitability for small grains, herbicide applications should be kept to a minimum, well-timed for maximum effectiveness, and coordinated with cultivations for weed control. Most growers combine tillage and seed bed preparation (both of which control weeds) with one application of herbicides for weed control. Below are listed the PUP-approved chemicals, target weeds, and some remarks.[8]

Table 3.
Pup-approved chemicals and target weeds

PUP-approved herbicide	Weeds controlled	Remarks
Roundup	quackgrass, Canada thistle, perennial peppercress, wild oats	This is a broad-spectrum herbicide and can be ground or aerially applied.
Amine 4, Weedar 64, MCP-4 Amine	five-hooked Bassia, Kochia, pigweed, lambsquarters, wild mustard, sowthistle, shepherd's purse, white top, morning glory	These three herbicides are formulations of 2,4 D manufactured by different companies. They control broadleaved weeds and can be ground or aerially applied.
Avenge	wild oats	For use on barley or wheat only (not oats). Specific to wild oats and can be ground or aerially applied.
Banvel	five-hooked Bassia, Kochia	This product is tank-mixed with 2,4 D to provide better control of Bassia and Kochia and is used individually on some badly infested field borders. It can be ground or aerially applied.

ALFALFA

Overview, Seasonal Development

Weeds are pests of alfalfa primarily because they compete for nutrients, water, and light. They also can lower hay quality by reducing its feed value. Some weeds are toxic or spiny, and contaminated hay may be unfit for livestock consumption. Foxtails and cheatgrass may injure livestock mouths, and some weeds such as fiddleneck and yellow starthistle are poisonous. Others, such as summer grasses, may make baling impossible. Weeds are especially problematic during new stand establishment.

Alfalfa weed problems can be grouped into three basic categories:

- stand establishment weeds;
- dormant period weeds; and
- summer weeds.

Stand establishment. Alfalfa is the most vulnerable to weed competition in the seedling phase, and uncontrolled weed growth then can result in complete stand loss. Planting season is critical to providing the crop with a competitive edge. However, recent research indicates a window of opportunity for planting occurs in late summer. This is the time when summer annual weeds decline in number and vigor and before most winter annual weeds emerge.[32] Therefore, plant during this window, when moderate temperatures favor alfalfa growth over the weeds. Depending on weed pressure on the new stand, use of post-emergence herbicide applications may be needed.

Dormant period weeds in established stands. Established alfalfa stands may be invaded in the fall and during the dormant period by winter annual weeds. Winter weeds germinate in the fall through the early spring (October through March). They grow rapidly in the spring and are usually a problem only in the first cutting.[15] Wild mustard, shepherdspurse, wild oats, and cheatgrass are particularly troublesome winter annuals in both seedling and established alfalfa fields on Refuge lands.

Summer weeds. Summer weeds germinate as temperatures rise beginning in late spring (April to May) and continuing through the summer. They are mostly a problem in second and subsequent cuttings, and in older, depleted stands. Five-hook Bassia, netseed lambsquarters, pigweed, and Russian thistle are especially problematic broadleaved summer weeds for Refuge-grown alfalfa.

Short and Long-term Management Guidelines

Monitoring

- Winter annual weeds germinate in the fall through early spring (October to March). Summer annual weeds germinate as temperatures rise in the late spring (April to May).[15] Scout for perennials such as Canada thistle and quackgrass by looking for their vegetative reproductive structures, such as stolons or rhizomes.

- Check for weeds just after alfalfa is cut. For newly seeded fields, scout when the alfalfa crop emerges.[16]

Cultural

- ***Prevention through proper stand management.*** The best, and sometimes the only economical method of weed control in alfalfa is prevention. Healthy, vigorously growing stands of alfalfa are very competitive and resist invasion by most weed species. A weakened stand grows more slowly and is more sparse, reducing its ability to compete with weeds. Planting dates, fertilization, irrigation, and harvest practices all influence the degree of weed problems in alfalfa.

- ***Exclusion.*** Avoidance of weed seed introduction is another important prevention strategy. Machinery, irrigation water, weedy field margins, or contaminated crop seed can all be sources of infestation. Avoid planting alfalfa to a field with a history of weeds known to be difficult to control in this crop.

- ***Harvest frequency and timing.*** If harvest is done too frequently the plants are unable to store enough food reserves in the roots between cuttings. Without the food they need, they weaken and are vulnerable to weed invasion. If harvest is delayed too long, the

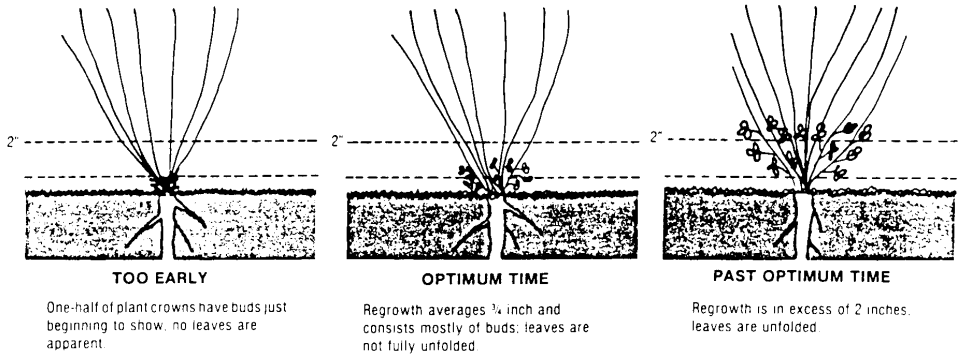

Figure 5.
Proper time for harvest as indicated by re-growth bud development
(Summers, C.G., D. Gilchrist, R. Norris [technical coordinators]. 1985. *Integrated Pest Management fo Alfalfa Hay*. U.C. Statewide IPM Project, Division of Agriculture and Natural Resources, Oakland, CA)

feed value of the hay suffers. To avoid these problems, alfalfa should be harvested only when a sample of crowns shows that 60 percent of them have regrowth buds averaging 0.75 inches tall.[17] Longer harvest intervals may suppress summer annual grasses and broadleaved weeds by depriving them of light. Physical damage to the crowns during harvest indirectly provides an advantage to weeds, so field traffic should be kept to a minimum.

- ***Weevil control.*** Fields with high weevil populations at harvest are more vulnerable to weed invasion if the hay is left in windrows more than a few days after cutting. Weevil feeding is concentrated under the windrows, creating bare spaces susceptible to seedling weeds. U.C. IPM recommendations suggest using an under-the-windrow treatment with Malathion if 10 to 15 larvae are present per sweep at harvest, to both reduce weevil damage to the regrowth and to prevent weed invasion.[18]

- ***Irrigation management.*** Irrigation management affects weed problems too. Overwatering can lead to disease problems, causing areas of plants to die and opening space for invading weeds. Timing of irrigation is also important; too soon after cutting, and summer grasses will get enough light and water to grow. Irrigation is best done as close to the initiation of harvest as possible, but with enough time allowed for soil drying to prevent compaction problems.

- ***Pre-plant tillage.*** Preplant irrigation to germinate weed seedlings, followed by one or two shallow cultivations, is recommended prior to establishing a new alfalfa field.

▶ *Biological*

- There are no effective biological weed control options to recommend for use within alfalfa fields during the cropping season. Alfalfa fields may provide habitat for beneficials that control weeds.

▶ *Herbicides*

- The need for herbicide use in a particular alfalfa field depends on the species present, their competitiveness and/or toxicity to livestock, potential market value of the hay, and the time of year. Stand vigor is another consideration, since a vigorously growing field will

compete better with weeds. To be economical, the value of increased forage must be worth more than the cost of the herbicide application. Also, the stand density must be high enough to benefit from reduced competition. Herbicide applications to sparse, severely weed-infested fields may increase forage quality, but probably not total yield. Alfalfa does not spread into open areas, so sparse areas left after a herbicide treatment are vulnerable to weed reinfestation.[15]

The market for the hay also effects the economics of herbicide use. Hay intended for cattle or livestock feed can contain a higher number of weeds before it is cost-effective to treat the field. If the market is for dairy or feed stores, or for export, few weeds are tolerated.

- ***Stand establishment phase.*** A pre-emergence herbicide application may be warranted, depending on field history and anticipated weed problems. Currently, there no PUP-approved pre-emergence or postemergence herbicides that may be used during the establishment of Refuge-grown alfalfa.

- ***Dormant season phase.*** Sencor DF or Lexone DF are PUP-approved for dormant season herbicide treatments of winter annual grasses and broadleaved weeds in established alfalfa stands.[8] Consideration should be given to organic content of the soil when determining herbicide rates. Land managers should identify weed species and review past infestation histories to forecast potential problems prior to making a decision to use herbicides in established fields.

- ***Summer weeds.*** Herbicides generally are not warranted for summer annual weed control.[15] There are no PUP-approved herbicides for summer weed control on Refuge lands.

FIELD TRIAL RECOMMENDATIONS

Trials are prioritized, with the most important trial listed first. Particularly important field trials are noted with the symbol:

☞

The trials suggested below are given to help develop new information about weed control options. Most of these trials can be done by any grower interested in experimenting with the idea. Results of most of these trials also can be quantified by the grower, such as changes in yields or quality of the harvest. To develop a more detailed picture of what is happening in the field, it is recommended that the grower notify local researchers and the IPM coordinator to inform them of upcoming field trials. In this way, useful trial information may be communicated to others and/or refined and investigated further. Some trials are appropriate for a number of Refuge-grown crops, and others are only appropriate for one crop.

☞ **1. Ridge tillage for potatoes and sugarbeets**. Every time a field is tilled, new weed seeds are brought near the surface to germinate. No-tilling or strip-tilling potatoes or sugarbeets into grain may reduce or eliminate this problem.

North Dakota-Minnesota teams of researchers and farmers conducted on-farm studies over a period of 5 years that concluded ridge till in sugarbeets reduced soil erosion by increasing crop residue approximately 70 percent over conventional tillage, provided better soil moisture during seed germination, reduced fuel needs for tillage by up to 42 percent, reduced labor needs by up to 18 percent, and reduced populations of several key weeds significantly (e.g., over 50 percent reduction in redroot pigweed.[19][20]

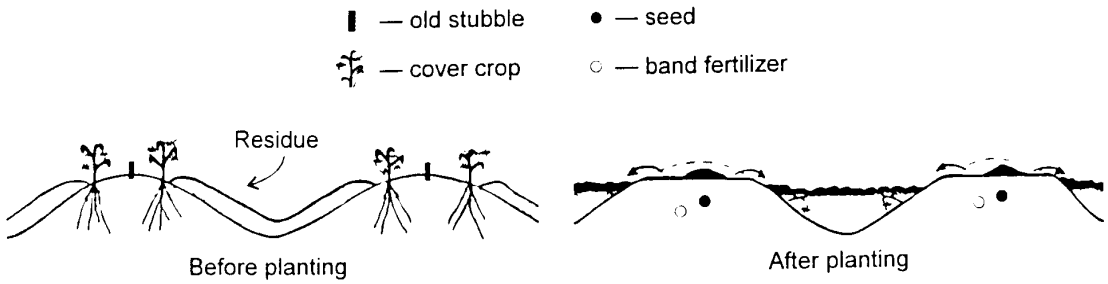

Figure 6.
Ridge-till: ridges before and after planting
(adapted from: Exner, Rick. 1992. *Practical Farmers of Iowa Reducing Weed Pressure in Ridge-till.* Iowa State University, Ames, IA)

In one 3-year study, yields achieved in 2 of the 3 years (including recoverable sugars) were statistically equal between conventional and ridge till systems. In the other year, ridge till outperformed conventional tillage by 1.14 tons/acre yield, 0.49 percent increase in sugar, 507 lbs. of recoverable sugar per acre, 12 lbs. of recoverable sugar per ton, and a net profit of $74 per acre.[20]

In a separate 2-year study, ridge till provided better residue and soil moisture, provided better yields (i.e., tonnage, percent recoverable sugars, nitrate grade), reduced the number of tillage operations for seedbed preparation and weeding, reduced weed populations, reduced soil erosion, and increased profits per acre.[20]

Research[1] in Willamette Valley [21] showed that snap beans planted into a fall-planted barley cover crop eliminated the need for spring tillage and reduced early season weed emergence by 87 percent. Flailing the barley cover increased crop emergence and yield, but also increased weed emergence.

What is ridge till? Dickey[22] describes ridge till as a one-pass, tillage and planting method. Seed is planted in 4 to 6 inch high ridges formed during cultivation of the previous crop (in the fall or late summer). Two cultivations are used for ridge building, one to loosen soil and the other to create the ridge. *Ten percent of leased-land acreage can be fall tilled to implement an IPM practice.*

At spring planting, sweeps or other row cleaning devices mounted in front of the planters, shave off the top 1 to 2 inches of ridges and push clods and residue between rows. This results in a cleanly tilled seedbed with strips of residue between the rows that reduce erosion.

Ridges dry out and warm up faster in spring compared to non-ridged sites. Most often a band of herbicide is applied during planting and crop cultivation is used for weed control between the rows.

Since planting is done into a ridge that may have loose soil on top and more compact soil on the sides, achieving a uniform planting depth may be difficult for growers new to the system. Some producers chop residue or perform shallow tillage to smooth ridge tops and reduce equipment malfunctions caused by excessive crop residue. Proper ridge shape and annual maintenance are the keys to making the system work. Care must be taken not to damage or destroy the ridges by wheel traffic.

Equipment necessary for ridge till could include rotary tillers, mulch shredders, tandem disks or harrows, furrowing wings, and sweeps.

☞ **2. Strip tillage for potatoes and sugarbeets.** Strip till is similar to ridge till except that just before planting, rather than shaving off the top of the ridge, a 7-inch-wide band is tilled there. Beds or ridges are 24 inches apart. After tilling, beets are planted using a conventional planter. Bill Iversen, a beet grower in northeastern Montana, pioneered this method.[23] His off crop is grain, which he treats as a row crop. He claims reduced erosion and ground preparation costs.

☞ **3. Flame weeding**. Flaming the seedbed after weed emergence but prior to crop emergence has potential for reducing herbicide use in potatoes, sugarbeets, and onions. Pre-plant, pre-emergent and postemergent applications have been successfully applied in various crops.

Preplant flaming has been referred to as the stale seedbed technique. This method is similar to using Roundup, only the weeds are seared after emergence with a flame weeder instead of with an herbicide. Flaming could replace pre-emergent applications of Roundup, except where perennial weeds are a problem.

[1]This same study showed that planting snap beans into a fall-planted barley cover reduced the incidence of white mold on snap beans to a level comparable to the conventional plot treated with Ronilan. Planting snap beans in flailed (threshed) barley was more effective in decreasing white mold compared to planting in unflailed barley.

Figure 7.
Flame cultivator for the burning of stubble and other crop residues for organic control of weeds, pests and diseases
(*New Farmer & Grower*, Autumn 1995, No. 48)

For preplant flaming, seedbed tillage is completed and weed seeds (mostly in the upper 2 inches of soil) are allowed to sprout. Assuming adequate moisture and a minimum soil temperature of 50 degrees F (to a depth of 2 inches.), weed germination should occur within

2 weeks. A fine-to-slightly compacted seedbed will germinate a much larger number of weeds. The weeds are then "seared" with a flamer, preferably when the population is most susceptible: between the first and sixth true leaf stages. The crop should be sown as soon as possible, and with minimal soil disturbance to avoid bringing new seed to the surface. For the same reason, subsequent cultivations should be shallow (less than 2 inches deep).[24] Pre-emergent flaming may also be done after seeding and prior to crop emergence.

Searing the weed is much more successful than charring. Excessive burning of the weeds often stimulates the roots and encourages regrowth in addition to using more fuel. Flaming has generally proven most successful on young, broadleaved weeds. It is reportedly less successful on grasses, as the seedlings develop a protective sheath around the growing tip when they are about 1 inch tall.[25][26][27][28]

Pre-emergent flaming may also be done after seeding and prior to crop emergence. Careful monitoring is required to make sure the flaming is done early enough to avoid damaging emerging seedlings.

Research in Europe on postemergent flame weeding in onions indicates that it has potential, but is rather exacting. Though onions become fairly heat resistant when they reach the four-

leaf stage, they do remain sensitive to excess heat. Uniform seedbed preparation, consistent ground speed, and minimal wind during postemergent flaming are critical to successful use of this method in onions.[26][27][29]

See Useful Contacts and Resources for a list of cultivation equipment manufactures and suppliers.

4. Trials with various cultivation tools. There are a variety of innovative cultivation tools that can be used during the season to control weeds such as rolling cultivators, basket weeders, steerage hoes, spring-toothed weeders, spring-hoe weeders and finger weeders. Trials to see how well some of these cultivators work in leased-land crops should be considered.

Rolling cultivators are versatile, ground-driven cultivation systems. Cultivating tines are mounted on toolbars and are either overlapped so they will cultivate wide areas, or are set to weed between rows. The tines can be positioned to either move soil toward or away from the row.

The Buddingh "basket weeder" is a high-speed cultivation device designed for very early cultivation. Since the weeder does not throw soil onto the row, it can be used right after planting without burying emerging plants.

Steerage hoes, developed in Europe, are mounted behind the tractor onto the three-point hitch. While one operator drives the tractor, another sits in back and steers the hoe. This enables cultivation to be done very close to the crop.

Spring-toothed weeders have narrow, flexible, curved tines that are mounted to a toolbar. The tines vibrate as they are pulled along the soil surface, and they break up the crust and control small weeds that are still in the white-tipped stage.

Bezzerides Brothers have engineered implements that can precision-cultivate between rows as well as between plants in the row. Their "spring hoe weeders" travel just below the soil surface along either side of the crop. The vibrating action of the spring hoes disturbs the soil just enough to uproot weed seedlings within the row without harming the crop plants. "Spyder tines" are used in conjunction with the spring hoes and replace the discs on a traditional cultivator. Unlike conventional discs, spyder tines do not leave a hard band of soil next to the crop row (where weed seedlings can survive), nor do they cut crop roots.

The Buddingh "finger weeder" uses flexible teeth and rolling tines to kick out seedling weeds from between plants within the row without disturbing the more deeply rooted crop species. This weeder provides excellent control for young crops (up to 4 inches in height) and should be adaptable to use in a number of row crops.

See Useful Contacts and Resources for a list of cultivation equipment manufactures and suppliers.

5. Flooding. Flooding acts to control weeds primarily through oxygen deprivation. It is known to be highly effective in controlling established perennial weeds, such as quackgrass. It has also shown some promise in suppressing certain annual weeds by reducing weed seed populations. Among the species that flooding is expected to suppress are common lambsquarter, redroot pigweed, Kochia, hairy nightshade, and wild oats.[30] Flooding is a weed control practice that might benefit all crops grown on leased lands.

6. Test covercrops as weed management tools. Cover crops and green manures also can be effective tools to manage weeds. Studies in Washington State found that fall-seeded Jupiter rapeseed grown as a green manure crop decreased weed biomass from 50 to 96 percent. Combining the rapeseed cover crop with one cultivation may eliminate the need for herbicide applications in many situations, while maintaining potato yields.[31]

USEFUL CONTACTS AND RESOURCES

Books

- Rees, N.E., P.C. Quimby, Jr., G.L. Piper, E.M. Coombs, C.E. Turner, N.R. Spencer, and L.V. Knutson (eds). 1996. *Biological Control of Weeds in the West*. Western Society of Weed Science in cooperation with WSDA-ARS, Montana Department of Agriculture and Montana State University. (Western Society of Weed Science, P.O. Box 10342, Helena, MT 59604; $20 plus $5.00 shipping/handling; (406)444-3140)

- Whitson, T., Ed. 1991. *Weeds of the West*. University Wyoming, Laramie. (Cooperative Extension, Bulletin Room, University of Wyoming, P.O. Box 3313, Laramie, WY 82071-3313 $19.50, includes postage; (306)766-4233)

Sugarbeet ridge till trials

- Nick Sinner, 60 Meadowlark Lane, Fargo, ND 58102; (701)347-4855

  Sugarbeet grower, his farm was the site of a modified ridge till system trial for sugarbeet weed control.

- Norman Cattanach, Research Specialist, 249 Walster Hall, Soil Sciance Department, North Dakota State University, Fargo, ND 58105; (701)231-8184

- Joseph Giles, Associate Professor, 133 Walster Hall, Soil Science Department, North Dakota State University, Fargo, ND 58105; (701)231-8596

  Research and trials with modified ridge-till systems for sugarbeet production.

- Allan W. Cattanach, Extension Sugarbeet Specialist, 227 Walster Hall, Soil Science Department, North Dakota State University, Fargo, ND 58105; (701)231-7858

Sources of cultivation equipment

- Bezzerides Brothers, 14142 Ave. 416, Orosi, CA 93647; (209) 528-3011. Contact: David Vradenburg

  Manufacturer of in-row cultivation tools such as spring-hoe and spyder weeders.

- Buddingh Weeders, 7015 Hammond, Dutton, MI 49316; (616) 698-8613

  Manufacturer of basket weeders, custom-built to grower specifications

- Lely Agricultural Implements—USA, P.O. Box 961, Albany, OR 97321; (541) 926-7753

  American supplier of the Lely finger weeder and other specialized cultivation equipment.

Sources for flame weeding equipment and information

- Flame Engineering, Inc., P.O. Box 577, LaCrosse, KS 67548; (800) 255-2469

- Flame Systems, 3403 Hwy. 93, Eau Claire, WI 54701; (715) 839-7242 or (715) 839-8087. Contact: John Quast

- Peaceful Valley Farm Supply, P.O. Box 2209, Grass Valley, CA 95945; (530) 272-4769

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APPENDIX WEEDS-1

State Noxious Weed Ratings and Definitions†

(None of the following weeds were federally rated.)

Weed species	Oregon noxious-weed rating	California noxious-weed rating
Annual Broadleaved		
Five-hook bassia *Bassia hyssopifolia*		
Netseed lambsquarter *Chenopodium berlandieri*		
Pigweed *Amaranthus* spp.		
Wild mustard *Brassica berlandieri*		
Kochia *Kochia scoparia*	B	
Common purslane *Portulaca oleracea*		
Black nightshade *Solanum nodiflorum*		
Tumble mustard *Sisymbrium altissimum*		
Annual Grasses		
Wild oats *Avena fatua*		
Perennials and Biennials		
Canada thistle *Cirsium arvense*	B*	B
Perennial pepperweed *Lepidium latifolium*	B	B
Russian thistle *Solsola Kali* L. var. *tenuifolia*		
Cheatgrass *Bromus secalinus*		
Quackgrass *Elytrigia repens*		B
Field bindweed (morning glory) *Convolvulus arvensis*	B	C
Poison hemlock *Conium maculatum*	B*	

† Oregon and California noxious weed control rating systems
(See next page.)

Oregon Noxious Weed Control Rating System

"A" designated weed— a weed of known economic importance which occurs in the state in small enough infestations to make eradication/containment possible: or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent.
Recommended action: Infestations are subject to intensive control when and where found.

"B" designated weed—a weed of economic importance which is regionally abundant, but which may have limited distribution in some counties. Where implementation of a fully-integrated statewide management plan is infeasible, biological control shall be the main control approach ("B" weeds for which biological control agents are available are identified with an asterisk.
Recommended action: Limited to intensive control at the state or county level as determined on a case-by-case basis.

California Noxious Weed Control Rating System

"A" designated weed—Eradication, containment, rejection, or other holding action at the state-county level. Quarantine interceptions to be rejected or treated at any point in the state.

"B" designated weed—Eradication, containment, control, or other holding action at the discretion of the commissioner.

"C" designated weed—State endorsed holding action and eradication only when found in a nursery; action to retard spread outside of nurseries at the discretion of the commissioner; reject only when found in a crop seed for planting or at the discretion of the commissioner.

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