CWSS Research Update and News

Information on Weeds and Weed Control from the California Weed Science Society

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In This Issue

Editor's Note

Since January of 2005, the California Weed Science Society has been publishing a journal twice a year. Many professional societies produce a journal for their members. However, the CWSS Journal was different from those published by other professional societies. Journals typically have scientific articles that are peer reviewed by a panel of reviewers and an editor who together decide whether or not to publish an article. Articles in the CWSS Journal are not peer reviewed and are typically more practical in nature intended for the use and education of our membership, weed science professionals working in the field. Also, the publication we produce often contains news articles and updates. Additionally, the name "Journal" may actually discourage some of our members from reading the publication. **Therefore, the CWSS Board recently decided to change the name of this publication from *CWSS Journal* to *CWSS Research Update and News*.**

This edition addresses off-site movement of herbicides, especially the potential risk of movement into groundwater or surface waters. With the recent attention on agriculture's possible contribution of nitrate to groundwater, it is important that weed science professionals do our best to protect water resources. The announcement of a new book on the control of 350 weeds of natural areas is discussed and includes a couple of example weeds.

Interested CWSS members are encouraged to submit articles or ideas for articles for future editions of this publication. Submit your ideas to Non-conference Education Director Steve Orloff at sborloff@ucdavis.edu.

Off-Site Movement of Herbicides

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The fate of herbicides or other pesticides in the environment can be grouped broadly into "degradation processes" and "transfer processes". *Degradation* implies one or more changes in chemical structure that alters the potency or activity of the compound. Usually this means reduced phytotoxic activity but there are cases where intermediate degradation products also have some level of activity. Generally speaking, all herbicides degrade in the environment but the rate of degradation can vary widely among specific herbicides and environments. *Transfer* processes, on the other hand, refer to changes in the location or availability of the

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herbicide not associated with changes in the chemical structure. There are four primary ways that herbicides can move off-site: volatilization, physical particle movement, water (leaching or runoff), and through uptake and removal in plants or animals. The potential for any type of off-site herbicide movement is greatly affected by the chemistry of the specific herbicide and the environmental conditions.

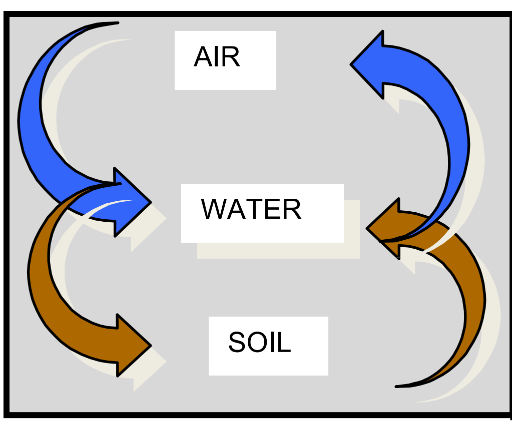
Off-target vs off-site

Two similar sounding terms have very different meanings in the context of herbicide applications. Off-target applications are those that miss the target site or zone. For example, the target of a post emergence herbicide is weed foliage. Thus, a post emergence herbicide that misses the plant and hits the soil technically is "off target". Similarly, a soil-applied herbicide is usually targeted to the surface of the soil or a shallow three dimensional layer of soil to ensure that germinating seedling are exposed to the herbicide. Herbicides incorporated too deeply or not deep enough are not on target. While obviously these are not ideal situations, off target applications usually result simple cases of reduced weed control efficacy and wasted money. Of greater concern for the environments are cases of off-site herbicide movement. Off-site movement refers to herbicides that misses or moves from the treated zone. The intended treatment zone could include whole fields or portions of a field such as blocks, strips, berms, furrows. The intended site could also be defined areas such as road shoulders, fence rows, lawns, or landscape areas or even individual plants. Herbicides that move off site also reduce efficiency and economics of weed control but can also result in non-target plant injury, environmental contamination, legal issues, and negative public perceptions of weed management operations and agriculture in general.

Herbicide Chemistry

The chemical structure and formulation of an herbicide can have a large impact on the potential for off-site herbicide movement and the most likely routes of movement. The chemistry of the herbicide directly impacts the solubility, volatility, stability, and phase equilibrium of the product in the soil and water environment. With any pesticide in a relatively stable environment, the active ingredient will reach an equilibrium (not necessarily equality) among the solid, water, and gas phases of the soil or water environment. There can also be significant interaction between specific herbicides and the environment, especially soil type, texture, pH, organic matter content, and moisture.

Figure: Generalized herbicide partitioning diagram and coefficients.



K_H – Henry's Law Constant
Related to solid:gas phase equilibrium

K_D –Sorption (distribution) coefficient
Related to liquid:solid phase equilibrium

K_{OW} – Octanol:water coefficient
Related to liquid:solid phase equilibrium due to polar:nonpoloar (hydrophilic:hydrophobic) partitioning

K_{OC} – Organic Carbon:Water Partitioning Coefficient
Similar to K_{OW} but normalized for soil organic carbon content

Information on the phase partitioning of many herbicides is available online or in resources such as the WSSA Herbicide Handbook. In general, herbicides with relatively lower Henry's Law Constant (K_H) tend to partition into the liquid or solid phase while higher K_H values are associated with greater partitioning into the gas phase (more vola-

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tile). Compounds with high sorption coefficients (either Kd or Koc) tend to be more tightly bound to soil particles or soil organic matter while products with low sorption are less tightly bound and tend towards the liquid phase. Lipophyllic herbicides (those with high Kow) tend to bind to lipids, especially those in organic matter while low Kow compounds are much more likely to be found in the water phase. It is important to remember that these are "rules of thumb" and behavior of any herbicide depends simultaneously on all these coefficients and other factors.

Volatilization

Movement of volatile herbicides generally is due to herbicide active ingredients that "evaporate" from leaf or soil surfaces after deposition on the intended site. Herbicide movement in the gas phase is somewhat affected by air temperature, wind speed, and soil moisture (e.g. high temp, high wind, and high moisture tend to increase volatilization). However, vapor pressure, which is related to the chemical structure and formulation of the herbicide, is the most important factor affecting potential for off-site movement due to volatilization. In certain cases, formulation technology is used to change the volatility of herbicides. For example, the 2,4-D ester is considerably more volatile than the amine formulation. Relatively speaking, most herbicides are not especially volatile (Table) but we do tend to require incorporation of herbicides that are more volatile than 1×10^{-6} mm Hg to minimize losses due to volatilization. Proper herbicide selection and understanding of factors influencing volatility, and timely incorporation can minimize the potential for off-site movement of volatile herbicides

Table: Vapor pressures for some herbicides and example compounds.

- methyl bromide vp 1640 mm Hg @25C
- rubbing alcohol vp 60
- water vp 20
- EPTC vp 3.4 x 10-2
- clomazone vp 1.4 x 10-4
- trifluralin vp 1.1 x 10-4
- oxyflourfen vp 2.0 x 10-6
- simazine vp 2.2 x 10-8
- glyphosate vp 4.3 x 10-10
- sulfonylureas vp ~ x 10-15

Physical Drift

Herbicide drift generally refers to the off-site movement of herbicide droplets before they are deposited on the target surface. This type of off-site movement is a common cause of problems if sensitive plants are growing near a treated area and is most subject to equipment setup and decisions made by the applicator in the field. Environmental conditions contribute to potential for drift; the effect to high wind speed should be fairly obvious but high temperature and low humidity can also lead to drift conditions because of rapid evaporation of the water droplets – small droplets are lighter and can move off-site more easily than large droplets. Occasionally, temperature inversion conditions can lead to very still air and very slow settling of fine spray droplets; these can also be prone to drift. Equipment setup and application decisions strongly affect the potential for drift. Nozzle type, orifice size, spray pressure, and nozzle orientation can all affect the size distribution of spray droplets. Similarly, boom height (whether ground or aerial) can affect drift because greater distances between nozzle and target allow more time for evaporation and lateral movement due to winds. The consequences of herbicide drift can vary depending on the level of drift, the activity of the herbicide, and the sensitivity of nearby plants. Physical drift can best be managed by setting up equipment to apply fewer fine droplets, leaving appropriate buffers to sensitive areas, and monitoring

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environmental conditions at the applications site. Above all, physical drift potential can be reduced by adequately training sprayer operators and avoiding applications during adverse weather conditions.

Off-site movement on soil particles

Herbicides bound to soil particles can move off site along with soil eroded by wind or water. When significant off site herbicide movement occurs due to wind erosion, it is usually associated with dry soil conditions, very little vegetation cover, and high wind speeds. Injury is more common with herbicides that are persistent and active at very low concentrations and the presence of highly sensitive non target plant species. Herbicides bound to soil particles can also be moved off site with surface water runoff – either irrigation tail waters or heavy rainfall conditions that surpass the infiltration rate of the soil. These herbicides tend to end up in the bottom of water courses or holding areas. Off-site movement of herbicides on soil particles is primarily managed by minimizing soil erosion through water and vegetation management, increasing water infiltration, and decreasing the total amount of surface water leaving the field.

Herbicide leaching or percolation losses

Herbicides that move too deeply in the soil profile to be active on the target weeds are also “off site”. The usual target zone for soil-applied herbicides is the top inch or two of soil where most weed seeds germinate. Herbicides that are poorly soluble in water and strongly absorbed to soil tend to have low potential for leaching. Conversely, water soluble herbicides with weak binding properties can move to a greater extent in soil. Leaching potential is also affected by the timing and amount of irrigation or rainfall that occurs after the herbicide application. Large amounts of water on the soil surface shortly after the herbicide application is more likely to lead to leaching compared to delayed irrigation or precipitation because of time-dependant binding. Soil texture and structure also can affect leaching potential; coarse texture soils, channels, and cracks can lead to greater losses into the profile due to leaching or mass flow. Once herbicide moves beyond the root zone, they tend to be relatively more persistent in the soil environment due to more anerobic conditions, less microbial activity, and greater temperature stability. Leaching is best minimized through proper herbicide selection, effective and timely irrigation management, and soil management that minimizes channeling and cracks.

Plant and animal uptake and removal

Off-site movement of herbicides due to plant or animal uptake and removal from a treated field is usually only a very small portion of the herbicide applied to a site. However, this route of herbicide movement can be economically important due to the potential illegal residues in the harvested commodity which is the primary reason for preharvest intervals (PHI), grazing, and crop residue use restrictions. Specific examples include very specific limitations on when and where certain herbicides can be used because of their persistence in plant tissue (even through the composting process) and potential damage to highly susceptible species.

There are many economic and environmental reasons to minimize off-site movement of herbicides. Increased weed control efficacy, economic efficiency, avoiding legal claims and disputes, stewarding soil and water resources, and protecting the environment. The potential for off-site herbicide movement can be greatly reduced through proper equipment setup, operator training, and weather and environmental monitoring. A basic level of understanding of the chemical, soil, and environmental factors that affect herbicide availability and potential routes of movement can lead to better herbicide recommendations, better applications, and more effective weed control treatments with fewer adverse effects on the environment.

Preventing Pesticide Movement to California Ground Water

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Introduction

Wide-spread detections of the soil fumigants 1,2-dibromo-3-chloropropane (DBCP), 1,2-dichloropropane (1,2-D) and ethylene dibromide (EDB) in California ground water supplies in 1979 and the early 1980's, and a report to the legislature on the vulnerability of California ground water to pesticide contamination (Assembly Office of Research, 1985) prompted the passage of the Pesticide Contamination Prevention Act, 1985 (PCPA). The purpose of the act was to prevent further pesticide pollution of ground water aquifers that may be used for drinking water supplies. As a result of this legislation the California Department of Pesticide Regulation (DPR) developed a ground water program that included sampling from wells located in rural, agricultural areas. In contrast to pesticide sampling activities by the California Department of Public Health, which samples from wells that supply public water connected to 25 or more households, wells sampled by DPR serve mainly individual households, drawing water from relatively shallow ground water aquifers. Generally, these wells are most susceptible to contamination from chemicals applied to the soil surface because they are located near sources of pesticide applications and they draw water from shallow aquifers where pesticide concentrations tend to be highest in ground water.

Prior to the PCPA, the discovery of DBCP in almost 2,500 wells in California, many of which had residue concentrations that threatened human health forced the closure of more than 100 public water supply wells (Assembly Office of Research, 1985). Since the mechanism of residue movement to ground water was poorly understood, there were no known mitigation measures that could be implemented to protect ground water. Eventually it was determined that these pesticides "demonstrated serious uncontrollable adverse effects", which is one of the conditions specified in the California Food and Agricultural Code section 12825 under which the use of pesticides can be immediately suspended. Registration of these soil fumigants was cancelled because of worker safety and general human exposure concerns, and lack of known management practices to prevent further ground water contamination. As DPR's well sampling program expanded, other pesticides were detected in California ground water but at concentrations that did not exceed human health levels. Studies were conducted to determine pathways for movement of residues to ground water and upon identification of the specific pathways additional studies were conducted to determine effective mitigation measures. With the development of mitigation measures, prohibition of use was no longer the only regulatory option and was necessary only when management options were not available.

Geographical information system (GIS) development was initially driven by the desire to develop an efficient monitoring program. Since the goal of the monitoring program was to identify pesticides that were moving to ground water, GIS became useful at characterizing the spatial distribution and intensity of pesticide applications from use reporting data and at helping to select locations for ground water monitoring. There also was the potential for using GIS to associate existing pesticide detections with soil types and depth-to-ground-water information. Through integration of statistical methods with this GIS approach it became possible to identify areas of the state where the ground water is considered most vulnerable to impact by pesticides (Troiano et al., 2000). This approach was incorporated into the update of the ground water regulations enacted in May of 2004 where vulnerable areas, denoted ground water protection areas (GWPAs), are defined by soil properties and depth-to-ground-water.

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Identifying Vulnerable Areas

A result of DPR's ongoing ground water sampling program was the development of a relatively large data set of wells containing pesticide residues that originated from non-point source or agricultural applications. This data set was used as the basis to determining spatial characteristics of the soil in sections of land where the ground water had been impacted by pesticides (Troiano et al., 2000). A section is nominally 1-square mile area of land that is uniquely identifiable throughout the entire state (Davis and Foote, 1966). Soils data were obtained for each section where the ground water had been impacted by pesticides and a statistical clustering method was used to group sections of land that had similar soil properties. Soil texture, which was identified as a combination of permeability and shrink-swell variables, was used to form the main groups. Additional sub-groups were identified based on the presence of a hardpan layer in the soil and on the presence of an annual water table (Troiano et al., 2000). When extensive depth-to-ground-water data became available it also was incorporated into the analysis process identifying sections where the ground water was vulnerable to pesticide contamination. This vulnerability analysis has been used to focus DPR's well sampling activities in areas with the highest probability for pesticide detections. It also formed the basis for changes in DPR's ground water regulations where use of certain management practices are required in vulnerable areas.

Regulation of Pesticide Use Based on Pathways to Ground Water

As pesticides are often used for food production and maintenance of landscapes and rights-of-way, the goal of regulating ground water contaminants is to allow their continued use but under management conditions that will prevent their movement to ground water. Currently, there are seven soil applied herbicides regulated as ground water contaminants that are listed in section 6800(a) of the California Code of Regulations – atrazine, simazine, bromacil, diuron, prometon, bentazon and norflurazon. If a 6800(a) listed pesticide is used in a designated GWPA, the user is required to obtain a permit from the local County Agricultural Commissioner. One objective of the permit is to notify users that the pesticide they are applying has the potential to move to ground water in a vulnerable area. But more importantly, the permit will be conditioned with a mitigation measure that, when adopted by the user, will minimize movement of the pesticide to ground water. These mitigation measures are in the form of a list of management practice options to give users flexibility depending on their treatment needs. Management practice options may be added to the list as additional information is developed by DPR, pesticide user groups, or through industry or university sponsored research. The regulations also allow for the development of additional management practices, especially if the current ones pose a hardship.

The mitigation measures are tailored to the specified pathway for residue movement to ground water where GWPAs are indicated as either having leaching or runoff pathways. Figure 1 illustrates the location of leaching and runoff GWPAs in the San Joaquin Valley, an area where the ground water has been impacted by numerous pesticides and where the density of GWPAs is highest. Studies conducted in coarse-textured soils indicated the importance of managing percolating water, especially during the irrigation season (Troiano et al., 1993). The following list of mitigation options is available in leaching GWPAs where the normal soil-water infiltration process predominates over surface runoff:

Pesticide Leaching GWPA Management Options – Choose one:

1. Do not irrigate for 6 months following pesticide application (usually applicable to noncrop uses);
2. Irrigate so water does not contact pesticide-treated area for 6 months following application;
3. Irrigate efficiently for 6 months following pesticide application applying no more than 133 percent of water at each irrigation required to satisfy evapotranspiration losses;
4. Use a scientifically-based alternative management practice approved by the Director of DPR as specified by an enforcement letter;
5. Apply the pesticide with no use modification if none of the management practices are feasible, and if the requestor submits and DPR approves a protocol for testing a new management practice.

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Runoff GWPAs are typically characterized by soils that contain a hardpan layer located 2-3 feet below the soil surface where movement of residues to sensitive sites has been measured as a result of winter rain runoff (Braun and Hawkins, 1991). When agricultural practices are used that exacerbate compaction of soil, the resulting soil condition is characterized by low soil infiltration rates that favor runoff of water. A study indicated that incorporating herbicide residues by a mechanical method into soil prior to a precipitation event significantly reduced offsite movement of residues through a combination of reducing concentration in runoff water and reducing the amount of runoff water produced (Troiano and Garretson, 1998). The following list of mitigation options is available in runoff GWPAs where surface runoff predominates over the normal soil-water infiltration process:

Pesticide Runoff GWPA Management Options – Choose one:

1. Apply pesticide in a band not to exceed 33% of distance between crop rows, except in citrus where the band can extend to the dripline of the tree;
2. Mechanically disturb soil within 7 days before pesticide application (not an option for bentazon);
3. Incorporate the pesticide on 90% of the treated area within 48 hours after the day of application by mechanical means (disc, harrow, rotary tiller) or by pressurized irrigation (not an option for bentazon);
4. Apply pesticide between April 1 and July 31;
5. Keep runoff water onsite for 6 months. If kept in a storage basin, the basin should have a low percolation rate (<0.2 in/hr) unless the runoff water is recirculated back onto the field within 24 hours;
6. Keep runoff water in an offsite low permeability (<0.2 in/hr) storage basin, under the control of the permittee, for 6 months.
7. Channel runoff water onto an un-irrigated fallow field for 6 months after pesticide application, with full consideration of plant-back restrictions.
8. Allow unchanneled runoff to move to an adjacent area equal in size to the pesticide-treated area as long as the runoff does not move to sensitive sites, such as dry wells, ditches, or permeable retention areas.
9. Use a scientifically-based alternative management practice approved by the Director of DPR as specified by an enforcement letter.
10. Apply the pesticide with no use modification if none of the management practices are feasible, and the requestor submits and DPR approves a protocol for testing a new management practice.

The last two mitigation measures for both leaching and runoff conditions add flexibility to the regulations by allowing development of additional management practices.

In addition to the management practices for uses on agricultural crops, the regulations address use in ground water recharge areas, canals and ditchbanks, roadside use, and wellhead protection. The structure of the management practices is similar to the agricultural practices in that, when feasible, a list of options is available to choose from. Complete information on the regulatory program is available at the DPR website at **http://www.cdpr.ca.gov/docs/gwp/index.htm**.

Summary

California regulations for protecting ground water from pesticide residues were revised in May 2004. At the heart of the regulations was the implementation of a spatial vulnerability assessment that identified areas of the state that are most vulnerable to pesticide contamination. Vulnerable areas are described by soil properties and depth-to-ground-water data. Identification of specific soil properties led to determination of pathways for movement of pesticide residues to ground water and a determination of whether they occur by either leaching or runoff processes. In addition, a list of management options has been developed for each pathway to ground water, providing flexibility for the pesticide user in vulnerable areas while protecting ground water from contamination.

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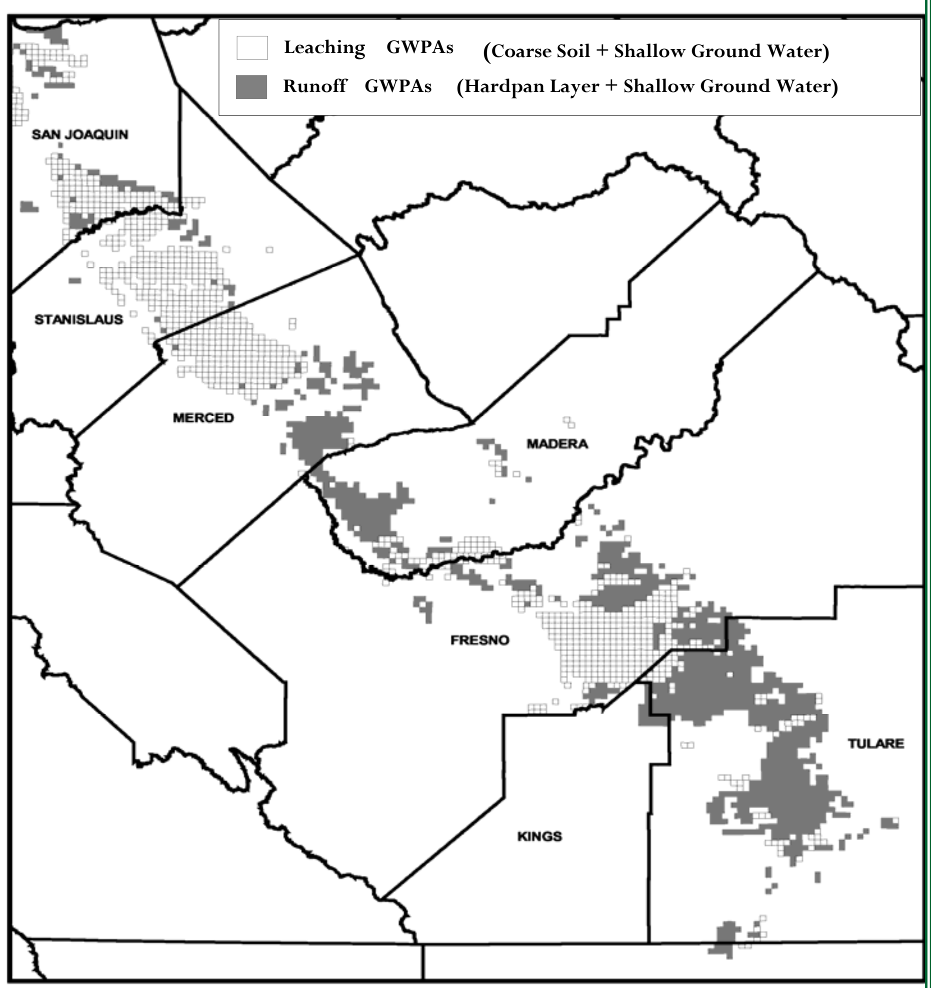

Figure 1. Location of leaching and runoff ground water protection areas (GWPAs) in the San Joaquin Valley.

New Book on Control of 350 Weeds of Natural Areas to be Published in 2012

Examples: Parrotfeather and Common reed

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While there are several publications that provide information on the management of weeds in agricultural systems, there is currently no comprehensive book that provides control options for invasive and weedy species in natural areas. However, in late summer to early fall of 2012, the first such book will be published by the Weed Research and Information Center at the University of California. The book, entitled *Weed Control Handbook for Natural Areas in the Western United States*, will cover about 350 species of weeds that invade or cause problems in wildland and natural areas, rangelands, grasslands, pastures, riparian and aquatic areas. The scope of the book is the 13 western states that include Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. The species chosen were those that were on the state noxious weed lists of the western states, as well as other non-crop weeds that are frequently problematic in natural areas of the western United States. Within the book there are control options, both non-chemical and chemical, provided in full write-ups for nearly 240 species, with a little over 100 additional species included in a susceptibility table only, again both non-chemical and chemical options. Although the vast majority of species are non-native, some native species are included, as they occasionally are problems in certain human use areas, both terrestrial and aquatic.

The bulk of the text is dedicated to providing control options, but it also includes additional information on the variety of control techniques and equipment used in natural areas, as well as safety and environmental considerations, herbicide characteristics, rainfast periods and grazing and haying restrictions for terrestrial herbicides, a list of species with biological control agents either available or under development, and helpful conversion tables. The chemical control options include the recommended rate, timing and any helpful remarks or cautions. There are some instances when the data for control was lacking on the particular species, but through inference with a very closely related species, it includes options the authors feel should be effective. Two examples of write-ups are provided below.

The authors of the book comprise many individuals within California and other western states that conduct research on the control of invasive plants and other non-crop weeds. Though the project was led by Dr. Joe DiTomaso at UC Davis, it also includes Drs. Lars Anderson, Tim Prather from the University of Idaho, Tim Miller from Washington State University, George Beck from Colorado State University, Corey Ransom from Utah State University and several other UC Cooperative Extension experts, including Guy Kyser, Scott Oneto, Steve Orloff, John Roncoroni, Rob Wilson, Steve Wright, Katie Wilson, and Jeremiah Mann. The information in the book comes from a number of sources, including personal experience of the authors, peer-reviewed literature, and non-peer reviewed literature, herbicide labels, and reviews in books. In addition, the authors conducted extensive internet searches for credible websites that contained information on weed and invasive plant control and management. All forms of control, including chemical and non-chemical were included. With this information, the authors summarized what they considered to be the most relevant and practical control options for each weed.

It is the intention of the authors to provide as many options as possible, with the hope that at least a few can achieve the desired objection and be implemented without restrictions. The choice of any option should be weighed against its desirable or undesirable impact on the ecosystem and the desired function of that system.

Finally, because weedy and invasive plants are dynamic with new species appearing each year and new control techniques being developed by researchers and field practitioners around the west, the objective is to update and reprint the handbook about every three years so the information stays current.

Parrotfeather

(*Myriophyllum aquaticum* (Vell. Conc.) Verdc.)

Family: Haloragaceae

Range: Found in New Mexico, Arizona, California, Oregon, Idaho, Montana, and Washington. Also common in the southern and eastern United States.

Habitat: Grows in ponds, lakes, rivers, streams, canals, ditches. Usually in still or slow-moving water, but occasionally found in faster moving water of streams and rivers. Grows best in tropical regions, can survive freezing conditions by becoming dormant. Parrotfeather does not tolerate brackish water and requires high light conditions.

Origin: Introduced from South America as an aquarium plant and pond ornamental in the late 1800s or early 1900s.

Impacts: Parrotfeather can develop colonies that form large sub-surface or surface mats. Mats impede water flow, interfere with boat traffic and recreational activities, create mosquito habitat, and displace native aquatic vegetation.

Western states listed as Noxious Weed: Washington

California Invasive Plant Council (Cal-IPC) **Inventory**: High Alert Invasive

Parrotfeather is a perennial with creeping rhizomes. It has emersed stems and is sometimes semi-terrestrial on mud banks. The total stem length can be up to 16 feet long, though the majority is submerged. Stems fragment easily and root at lower nodes. The submersed leaves are arranged as 3-6-whorled leaves per node, pinnately dissected into linear lobes. The emersed leaves resemble submerged leaves, but are slightly thicker and not as finely dissected. In addition, the emerged leaves are typically light gray-green, mostly 5-6-whorled, 1 to 2 in long, with a flattened midrib that is broader than the lobes.

Flowers are dioecious (male and female flowers develop on separate plants) and inconspicuous in the leaf axils. Most plants in the introduced range are female. Only populations within the native range have been observed to develop seed. Reproduction is only vegetatively by rhizomes, stem fragments, and axillary buds. Stem fragments form new roots and shoots and disperse primarily with water, or by clinging to the feet or feathers of water birds, and with human activities such as boating, mechanical harvesting, and the dumping of unwanted pond or aquarium contents. Mats sometimes detach and float to infest new areas.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, dredging)	Repeated mechanical harvesting can help reduce stem densities, but escaped stem fragments can drift elsewhere and develop into new plants. More effective harvesting systems that remove the biomass and nutrient reserves accumulated in the emergent tissues may be an effective control measure. Removing and destroying stem fragments from recreational equipment, such as boat propellers, docking lines, and fishing gear can help prevent the spread of non-native watermilfoils. Since nearly all spread and reproduction is via shoot and rhizomes, physically removing 6 to 10 inches of infested sediment should eliminate re-growth. For small ponds or small infestations in lakes, this may be a cost-effective approach if it is coupled with stopping any further introductions.
Cultural control	De-watering (draining) can be effective if the exposed sediment is subject to hard freezes. De-watering coupled with excavation to removed sediment-borne roots and rhizomes will also control parrotfeather.
Biological control	Herbivorous insects from Argentina have been investigated and were released for control of parrotfeather in South Africa: *Listronotus marginicollis* (stem-miner), *Lysathia* spp. (leaf-feeder). Neither has been released in the US. The triploid grass carp can provide some suppression, but the fish prefers other submersed plants (native and non-native) and will consume those first if present. Use of grass carp usually requires a permit.

CHEMICAL CONTROL

The following specific use information is based published papers and reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use.

2,4-D *Weedar 64*	**Rate**: For emergent shoots: 0.5 to 1.0 lb a.e./acre with a non-ionic surfactant **Timing**: Spring to early summer is optimal; however mid-summer applications can be effective suppressing growth. **Remarks**: Emergent shoots of parrotfeather are difficult to “wet” due to dense waxy cuticle. The use of a surfactant is highly recommended.
Diquat *Reward*	**Rate**: For spot treatment of emergent shoots: 0.5% v/v solution (2 qt/ 100 gal water) **Timing**: Spring to early summer is optimal. Repeat treatments may be needed in mid-summer. **Remarks**: Use only clean water to mix and spray as diquat is inactivated in turbid water. Since diquat is a contact herbicide, repeat treatment will be necessary at 3 to 5 week intervals.
Bispyribac-sodium *Tradewind*	**Rate**: For foliar treatment to emergent shoots: 1 to 2 oz product/acre (0.8 to 1.6 oz a.i./acre); no more than 4 treatments per year. **Timing**: Apply postemergence to foliage in early spring to early summer (during rapid growth). **Remarks**: Bispyribac-sodium can be tank-mixed with 2,4-D.
Imazamox *Clearcast*	**Rate**: For foliar treatment to emergent shoots: 64 oz product/acre (8 oz a.e./acre); For spot treatment (spray-to-wet): 0.25 to 5% v/v solution. **Timing**: Apply postemergence to foliage in early spring to early summer (rapid growth) **Remarks**: Use an approved surfactant. Aerial application is approved in some states.
Penoxsulam *Galleon*	**Rate**: For foliar treatment to emergent shoots: 2 to 5.6 oz/acre (0.5 to 1.4 oz a.i./acre) with approved surfactant. **Timing**: Early spring to early summer **Remarks**: Provides partial control and suppression. May be tank-mixed with endothall or other herbicides.
Imazapyr *Habitat*	**Rate**: For foliar treatment to emergent shoots: 2 to 4 pt/acre (0.5 to 1 lb a.e./acre). For spot treatment: 1% v/v solution **Timing**: Apply postemergence to foliage in early spring to early summer (when new growth is present). **Remarks**: Imazapyr is a slow-acting systemic herbicide.
Fluridone *Sonar*	**Rate**: For in-water treatment: 10 to 30 ppb **Timing**: Apply to water in early spring to early summer (when new growth is present). **Remarks**: Use various formulations (variable release-rates) or repeated applications to achieve desired concentration for 5 to 7 weeks.

Common reed

(*Phragmites australis* (Cav.) Trin. ex Steud.)

Family: Poaceae

Range: The range of the native endemic lineage of the species is throughout the western United States and adjacent Canada (absent in Alaska and Hawaii and the southeastern US). The Gulf Coast lineage is found from Florida across to southern California, although it is not known if this biotype is native or introduced into the region from Mexico and Central America. The non-native biotype has been found throughout the US and adjacent Canada (absent in Alaska and Hawaii and northern Canada).

Habitat: Grows in wetlands, riparian areas, and shores of lakes and ponds.

Origin: The non-native biotype was introduced from Europe. Apparently accidentally introduced via ships ballast. There are also native biotypes of *Phragmites australis*.

Impacts: Forms dense stands in wetlands and reduces native plant biodiversity. Western states listed as Noxious Weed: Oregon, Washington

Common reed is a rhizomatous perennial grass to 15 feet tall, usually found growing in water or along the shores of streams, ponds, and lakes. The leaves are typical for a grass, but large: up to 1.5 inches wide and from 8 to 16 inches long. The ligule (at the junction of the leaf blade and the stem) is tipped by a fringe of hairs, while the blades and sheaths are smooth. Leaf sheaths of the introduced biotype adhere tightly to the stem as long as they remain through the winter, while in the native biotype the sheaths fall away as the leaves die in the autumn. Stems (or "culms") are sturdy, up to 0.5 inch thick at the base, and slightly ridged or rough to the touch under the leaf sheath.

The inflorescence can be 6 to 16 inches long, and is usually tawny brown or purplish and feathery in appearance. The glumes (the bracts below the flowering spikelet) of common reed are shorter than the lemmas (the bracts at the base of individual florets) and are hairless. Plant reproduce by seeds, rhizome and stem fragments. The florets often have many hairs present, allowing the seed to blow with the wind or in the airstreams of vehicles passing by on the highway, or to float in the water. Common reed rhizomes form a dense network under the colony, with each rhizome capable of growing 10 feet or more in a single growing season. The seeds are short-lived (likely <2 years) under field conditions, and a persistent seedbank does not accumulate.

There are several biotypes of common reed, some native and some introduced. The following table offers a good comparison between the native biotype and the major European biotype. The authors of the table caution that these characters may not distinguish the Gulf Coast type of common reed, which has been introduced into portions of southern California and Arizona in the west.

Summary of Morphological Characters that Distinguish Native and Introduced *Phragmites australis* in the United States.

CHARACTER	NATIVE	INTRODUCED
*Ligule length	>1.0 mm	<1.0 mm
*Lower glume length	3.0 –6.5 mm Most >4.0 mm	2.5 –5.0 mm Most <4.0 mm
*Upper glume length	5.5 –11.0 mm Most >6.0 mm	4.5 –7.5 mm Most <6.0 mm
*Adherence of dead leaf sheaths	Loose, drop off easily	Tight, remain on dead stems
*Growth form (stem density)	Typically in mixed communities, stem density may be low to high, dead stems less likely to persist to the next growing season.	Often grows as a monoculture, stem density is high, dead stems often persist to the next growing season.
Culm texture	Smooth, shiny	Dull or flat color, slightly ridged
Culm color	May be dark red at nodes and internodes, where exposed to UV. May be green as well.	Typically green, occasionally see some red color at the lower nodes
Spots on culms	May be present	Not present, mildew may be present
Leaf color	Lighter, yellow green to dark green	Typically darker green, but may be lighter in saline areas

From: *Phragmites* Field Guide: Distinguishing Native and Exotic Forms of Common Reed (*Phragmites australis*) in the United States, by Jil Swearingen and Kristin Saltonstall (2010). (http://www.nps.gov/plants/alien/fact/pdf/phau1-powerpoint.pdf)

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Digging and removal of common reed is usually not feasible, given its dense root and rhizome system and its tendency to grow on rocky or rough ground or in standing water. If attempted, remove as much root and rhizome as possible, as broken root and rhizome sections will resprout from fragments. Hand pulling is not an effective strategy as it rarely is possible to remove roots and rhizomes without substantial breaking and fragmenting these tissues. Mowing is difficult in wetland sites and unless applied repeatedly, mowing will not generally control this perennial species. Timely mowing can prevent seed production, however. Mulching with plastic or fabric sheets has not been shown to be effective, given that shoots from rhizomes are sharp-tipped as they emerge from the soil.
Cultural control	Dredging and draining of water where common reed is found may reduce the vigor of common reed colonies. However, draining and dredging are not appropriate for use on most wetland preserves where the weed is often found in abundance. Prescribed burning is sometimes used for controlling this species, primarily by removing old growth of common reed and allowing seeds of other species to germinate and perhaps establish. Burning is sometimes used to remove old growth in preparation for herbicide application.
Biological control	There are currently no biological control agents to aid in the control of common reed. Literature and field surveys in the northeastern United States and eastern Canada indicate that at least 26 native herbivores attack common reed in North America. There have been no deliberate releases made of European insects known to feed on the introduced biotype, but at least 21 species have been accidentally introduced to North America.

CHEMICAL CONTROL

The following specific use information is based on published papers or reports by researchers and land managers. Other trade names may be available, and other compounds may also be labeled for this weed. Directions for use may vary between brands; see label before use. Most herbicide applications will require multiple applications to fully control common reed. Because it usually is found growing in or near standing water, only aquatic herbicide formulations are recommended for use. Additionally, most states require specific aquatic endorsements applicators of aquatic herbicides.

Glyphosate *Rodeo, Aquamaster*	**Rate**: For broadcast treatment: 4 to 6 pt product/acre (2 to 3 lb a.e./acre); For spot treatment: 0.75% v/v solution **Timing**: Apply postemergence to plants in full bloom in late summer or autumn. **Remarks**: Use up to 1% non-ionic surfactant approved for aquatic use to improve herbicide uptake. Removal of old stalks and foliage by mowing or burning in the spring may be necessary for the herbicide application to adequately cover the foliage and for the treatment to be effective. Glyphosate will injure or kill other plants growing near treated common reed that are oversprayed or drifted on. Wick application technology can also be a method of glyphosate application to common reed. Glyphosate can be combined with imazapyr for more effective control under some circumstances.
Imazapyr *Habitat*	**Rate**: 4 to 6 pt product/acre (1 to 1.5 lb a.e./acre) **Timing**: Apply postemergence to plants after full foliage is achieved in the summer. **Remarks**: Use up to 1% non-ionic surfactant approved for aquatic use to improve herbicide uptake. Removal of old stalks and foliage by mowing or burning in the spring may be necessary for the herbicide application to adequately cover the foliage and for the treatment to be effective. Imazapyr will injure or kill other plants growing near treated common reed that are oversprayed or drifted on. Imazapyr can be combined with glyphosate for more effective control under some circumstances.

2013 CWSS Photo Contest

Submit your best digital photos

that reflect your experience in the world of weeds!

1st Prize	$100 cash or free registration to The 2014 CWSS Conference in Monterey!
2nd Prize	$75 cash
3rd Prize	$50 cash

Email your best pics to: manager@www.cwss.org

by December 31, 2012. *(Limit 5 pics per entry)*

Winners will be announced at the welcoming evening reception of the 2013 CWSS Conference in Sacramento.

Passing of a Weed Science Legend

 

Bill Fischer 1921-2012

The California Weed Science Society lost one of its most renowned members, Bill Fischer, who passed away earlier this year. Bill made significant contributions to the CWSS and was well known for his polished presentations and unique presentation style where he often used two projectors simultaneously. Bill had a significant impact on the discipline of weed science in California where he developed effective weed management programs for growers. He started working for the University of California Cooperative Extension in Stockton as a field assistant and was transferred to Fresno County in 1957 as a Farm Advisor. Before he retired in 1991, Bill completed 50 volumes of his Fresno County Extension Publication, *"Runcina,"* each one containing detailed summaries of applied research studies written in a "farmer friendly" manner. One of his most significant accomplishments was the development of the *"Grower's Weed Identification Handbook"*, an effort that spanned twenty years; and was one of the highest selling UC publications. Bill loved to help growers in the valley and could be seen driving his pickup on the shoulder of back roads up-and-down Central California surveying orchards, vineyards and field crops.

Born in what was then called Czechoslovakia in 1921, Bill grew up on a village farm and came to the US with his mother and two teenage brothers when he was 18. Bill attended Ohio State University and then the University of California, Davis where he received a Master's degree in Horticulture. He valued time spent during his sabbatical studies in Australia, England, Israel, New Zealand and Central Europe and his work with weed scientists in Argentina, Mexico, China, Japan, Chile, and several African countries. Bill liked to say he had visited every continent except Antarctica. Bill celebrated his 90th birthday in August and died peacefully at home on Monday, January 30, 2012.

Bill Fischer will have a lasting positive impact on weed science in California. Many of us have fond memories of Bill and appreciate the knowledge we gained from our acquaintance. Anyone interested can make donations to the Bill and Jane Fischer Vegetation Management Scholarship Fund, UC Cooperative Extension, 1720 South Maple Avenue, Fresno, CA 93702.

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