



# APPENDIX A: INVASIVE SPECIES

## INVASIVE SPECIES OF GREATEST ECOLOGICAL CONCERN OCCURRING IN THE LAGUNA DE SANTA ROSA WATERSHED



### NON-NATIVE PLANTS

The species listed here have been identified by the California Invasive Plant Council (Cal-IPC), as non-native plants that are serious threats to wildlands (natural areas that support native ecosystems), or that are state or federally-listed noxious weeds. Cal-IPC designations are based on information submitted by land managers, botanists and researchers, and state and federal designations are based on information collected by agency biologists. Note: the lists are limited here to plants found in the Laguna de Santa Rosa watershed.

*Cal-IPC ranking:* Plants are categorized as High, Moderate or Low threats, based on a combination of their documented impacts, potential for spread, and the range of habitats they tolerate. *These rankings represent statewide impacts.*

- *High:* The most invasive wildland pest plants; documented as aggressive invaders statewide, that displace natives and disrupt natural habitats. These species tend to spread rapidly, and are often widely distributed.  
*Red Alert* – plants with potential to spread explosively, but with small or localized infestations. If found, alert Cal-IPC, the Sonoma County Agricultural Commissioner or the California Department of Food and Agriculture.
- *Moderate:* Wildland pest plants of lesser invasiveness, based on statewide impacts; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; may be widespread or regional.

*California Department of Food and Agriculture Ranking (CDFA):* Noxious weed is a legal or regulatory term for pest plants that are recognized as

“troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate.” In general, noxious weed designations focus on plants with direct economic impacts. Plants cannot be designated as noxious if the designation will be detrimental to agriculture. It is illegal to disseminate the seeds of noxious weeds within the state, and there are a number of other laws and quarantine restrictions that can apply.

CDFR gives listed plants a rating, A, B, C, D, or Q, to reflect the pest’s statewide impacts, the potential for successful control or eradication, and its distribution within the state. The state is also considering a new H rating (standing for ‘temporary hold’), geared toward plants in the nursery industry that are suspected of being potential weed problems.

- *A Rating:* An organism of known economic importance, subject to state enforced action involving eradication, quarantine, containment, rejection, or other holding action.
- *B Rating:* An organism of known economic importance, subject to eradication, containment, control, or other holding action at the discretion of the individual county agricultural commissioner; or subject to state endorsed holding action and eradication when found in a nursery.
- *C Rating:* An organism subject to state enforced action only when found in nurseries; actions to retard spread at the discretion of the commissioner.
- *Q Rating:* A temporary “A” rating pending determination of a permanent rating. The organism is suspected to be of economic importance but its status is uncertain because of incomplete identification or inadequate information.
- *D Rating:* No action; organism is of little or no economic importance.

*USDA noxious weed listing:* It is illegal to import Federal noxious weeds, or to move them between states. These are broadly defined as “any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment.” However, in practice, the Federal noxious weed list is much shorter than those of many states (including California). Federal listing can control interstate commerce of horticulturally-distributed invasive species, and some funding sources can also be more accessible for control of federally-listed noxious plants.

*Need More Information:* Plants for which current information does not adequately describe nature of threat to wildlands, distribution or invasiveness.

*Prioritization:* With non-native species very abundant throughout the Laguna, it is important to prioritize control efforts. Prioritizations are based on several variables, including potential for success; ecological, economic, or health impacts; and control costs. In general, the greatest chance of success at lowest cost is possible when control is initiated early in the invasion. The following prioritization scheme is meant to be a loose guideline for land-managers, based on current Laguna conditions.

- *Priority 1:* Species with high potential for invasion and/or large ecological impacts and infestations are still manageable in size. Immediate attention is required to avoid further spread. Plan to eradicate species entirely.
- *Priority 2:* Invasive is established in habitats with high concentrations of special status species. Plan control measures where habitat value is highest.
- *Priority 3:* Species is established throughout large areas. Remove where infestations are manageable. Prevent further spread.
- *Priority 4:* Keep a watch for movement in the watershed.
- *Priority 5:* Need more research to determine appropriate management action.



Table 5: Most invasive wildland pest plants

Latin Name	Common Name	Cal-IPC/ CDFA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Aegilops triuncialis</i> ‡	Barbed goatgrass	High/B	1	Grasslands, overgrazed pastures; spring lake, pastures near Mark West Creek
<i>Arundo donax</i> + ∅	Giant reed, arundo	High	1	Riparian areas; Santa Rosa Creek, Peterson Creek.
<i>Centaurea solstitialis</i> ‡	Yellow starthistle	High/C	1	Grasslands; found in disturbed areas in Laguna grasslands.
<i>Cortaderia jubata</i> +	Pampas grass, jubatagrass	High	1	Disturbed or exposed sites; Reclamation pond banks, Santa Rosa Creek.
<i>Egeria densa</i> +	Brazilian waterweed	High	4	Streams, ponds, sloughs and Lakes; Fairfield Osborn Preserve
<i>Genista monspessulana</i> ‡	French broom	High/C	1	Oak woodlands, grasslands; Spring Lake and High School Road
<i>Hedera helix</i> +	English ivy	High	3	Riparian; horticultural, found in many yards, serious infestation along High School Road
<i>Hydrilla verticillata</i> *†	Hydrilla	High/A Quarantine	4	Noxious water weed; eradicated from Spring Lake in 1985
<i>Lepidium latifolium</i> *‡	Perennial pepperweed, Tall whitetop	High/B	1	Marshes, riparian areas, wetlands, grasslands; multiple locations in Laguna and tributaries.
<i>Lolium multiflorum</i>	Italian ryegrass	High	3	Grasslands, wetland areas, disturbed vernal pools; very common in agricultural land adjacent to the Laguna
<i>Ludwigia sp.</i>	Water primrose	High	1	Aquatic habitats; Rohnert Park flood control channels, Laguna from Occidental to Guerneville Road
<i>Lythrum salicaria</i> *‡∅	Purple loosestrife	High/B	1	Horticultural weed of wetlands, riparian areas; Blucher Creek near confluence with Laguna and further upstream at Sonoma County Horticultural Nursery

Table 5: Most invasive wildland pest plants

Latin Name	Common Name	Cal-IPC/ CDFA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Myriophyllum aquaticum</i> <sup>★+</sup>	Parrotfeather	High	3	Streams, lakes, ponds; Laguna channel, numerous tributaries, Alpha created wetlands
<i>Rubus discolor</i>	Himalayan blackberry	High	3	Riparian areas, marshes, oak woodlands; widespread through Laguna watershed
<i>Sesbania punicea</i> <sup>★+</sup>	Scarlet wisteria tree	High	1	Horticultural weed of riparian areas; flood control channel near Spring Lake
<i>Taeniatherum caput-medusae</i> <sup>‡</sup>	Medusa-head	High/C	1	Grasslands; serious infestation at Laguna de Santa Rosa Ecological Preserves (Todd Road) and Wright Preservation Bank
<i>Tamarix ramosissima</i>	Saltcedar	High	1	Santa Rosa Creek, Llano Road near Laguna Treatment Plant

★ Red Alert: Species with potential to spread explosively; infestations currently restricted

‡ California Listed Noxious Weed

† Federal Listed Noxious Weed

+ On Draft Cal-PPIPIH list to be phased out of nursery production

∅ Global Invasive Species Database list of 100 of the world's worst invasive species

Table 6: Wildland plants of moderate invasiveness

Latin Name	Common Name	Cal-IPC/ CDFA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Ailanthus altissima</i>	Tree of heaven	Moderate	1	Riparian areas, grasslands, oak woodlands; several locations in Laguna watershed, Santa Rosa Creek.
<i>Avena barbata</i>	Slender wild oat	Moderate	3	Wooded area, waste places, disturbed sites; widespread throughout watershed, heavy infestations on City of Santa Rosa Farms
<i>Avena fatua</i>	Wild oat	Moderate	3	Waste and cultivated places, throughout watershed, Todd Road Preserve
<i>Bellardia trixago</i>	Bellardia	Low	4	Grasslands; Annadel
<i>Brachypodium distachyon</i>	False brome	Not ranked	1	Rincon Valley and Spring Lake
<i>Brassica nigra</i>	Black mustard	Not ranked	4	Grasslands; Todd Road Preserve, Rincon Valley and Spring Lake.
<i>Bromus diandrus</i>	Ripgut brome	Moderate	3	Grasslands; many sites in watershed
<i>Centaurea calcitrapa</i> ‡	Purple starthistle/B	Moderate	3	Grasslands; many pastures where livestock are grazed
<i>Cirsium vulgare</i>	Bull thistle	Moderate	3	Riparian areas, marshes, meadows; widespread throughout Laguna watershed
<i>Conium maculatum</i>	Poison hemlock	Moderate	3	Oak understory, riparian; heavy infestations on City of Santa Rosa Farms, particularly Alpha
<i>Cotoneaster spp.</i> +	Cotoneaster	Moderate	unk.	Horticultural, bird-distributed; found along some Laguna tributaries
<i>Crupina vulgaris</i> ‡	Bearded creeper, common crupina	Not ranked / A Quarantine	1	Aggressively moving into wildlands, especially grasslands; Bennett Valley and Annadel



Table 6: Wildland plants of moderate invasiveness

Latin Name	Common Name	Cal-IPC/ CDFA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Eucalyptus globules</i>	Tasmanian blue gum	Moderate	4	Riparian areas, grasslands, moist slopes; Spring Lake.
<i>Festuca arundinacea</i>	Tall fescue	Moderate	3	Grasslands; widespread through Santa Rosa Plain; Laguna Uplands Preserve
<i>Foeniculum vulgare</i> +	Wild fennel	Moderate	3	Grasslands; found throughout the Santa Rosa Plain.
<i>Hirschfeldia incana</i>	Mediterranean or short-pod mustard	Moderate	unk.	Copeland Creek at Sonoma State University
<i>Hocus lanatus</i>	Velvet grass	Moderate	3	Grasslands, wetlands; widespread throughout Laguna watershed. Laguna Uplands Preserve.
<i>Hypericum perforatum</i> ‡	Klamathweed, St. John's wort	Moderate/C	1	Meadows, woodlands; Hwy 116 near Occidental Road and Annadel
<i>Hypochaeris radicata</i>	Rough cat's-ear	Moderate	unk.	Grasslands, wetlands; many sites west of Santa Rosa in the Laguna drainage
<i>Iris pseudacorus</i>	Yellow water iris	Low	1	Riparian, wetland areas; Sanford Road, Laguna wetland preserve
<i>Mentha pulegium</i> +	Pennyroyal	Moderate	2	Vernal pools, wetlands; throughout the Santa Rosa Plain.
<i>Oxalis pes-caprae</i>	Bermuda buttercup	Moderate	unk.	Invades disturbed sites; many locations in watershed
<i>Pennisetum clandestinum</i> ‡‡	Kikuyu grass	Moderate	unk.	Disturbed sites, roadsides; Spring Lake
<i>Pennisetum setaceum</i> +	Fountain grass	Moderate	4	Grasslands, roadsides; Spring Lake.
<i>Phalaris aquatica</i>	Harding grass	Moderate	3	Grasslands, especially moist soils; multiple locations, especially bad at Kelly marsh, Alpha Farm and Joint Wetlands, spreading at Todd Road Preserve
<i>Piptatherum miliaceum</i>	Smilo grass	Low	unk.	Creeks, canyons; Spring Lake



Table 6: Wildland plants of moderate invasiveness

Latin Name	Common Name	Cal-IPC/ CDEFA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Pyracantha angustifolia</i>	Pyrocantha	Low	unk.	Bird distributed; Santa Rosa Creek
<i>Vinca major</i> +	Periwinkle	Moderate	3	Horticultural escape to riparian and oak woodland; multiple tributaries and drainages to the Laguna

\* Red Alert: Species with potential to spread explosively; infestations currently restricted

‡ California Listed Noxious Weed

† Federal Listed Noxious Weed

+ On Draft Cal-PPIPIH list to be phased out of nursery production

∅ Global Invasive Species Database list of 100 of the world's worst invasive species



Table 7: Need More Information List

Latin Name	Common Name	Cal-IPC/ CDEA Rank	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Eichhornia crassipes</i> *‡†+∅	Water hyacinth	High/B	Monitor	A floating aquatic with showy purple flowers, found in many backyard water gardens, and available for sale at nurseries and Farmer's Markets. Potential for introduction, where it could cover open-water areas.
<i>Glyceria declinata</i>	Silver wattle	Not ranked	Monitor	Found throughout watershed. Multiple trees along Occidental and High School Road near Laguna, also along Llano Road
<i>Parentucellia viscosa</i>		Low	Monitor	Throughout Laguna drainage, Todd Road Preserve
<i>Phyla nodiflora</i>	Mat lippia, fog fruit	Not ranked	Monitor	Wet areas, will grow in vernal pools; Taxonomy unclear; found in moist areas throughout watershed
<i>Prunus cerasifera</i>	Cherry plum	Low	Monitor	Oak woodland, riparian areas; bird distributed; Laguna riparian areas and tributaries
<i>Phalaris arundinacea</i>	Reed Canary grass	Not ranked	Monitor	Grasslands, especially moist soils; Laguna Wetlands Preserve

- \* Red Alert: Species with potential to spread explosively; infestations currently restricted
- ‡ California Listed Noxious Weed
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## NON-NATIVE ANIMALS

There are often conflicting views and values concerning the invasiveness of non-native animals, many of which were intentionally introduced. A number of people have strong ethical objections to capturing or killing animals, even if those animals are contributing to the decline of other species: well-meaning animal lovers feed feral cats and appreciate their presence in the wild. Although there is an emerging recognition of the impacts of feral turkeys and wild boar, these are both managed by the CDFG as game animals. Studies by researchers from Audubon Canyon Ranch have found that grasslands dominated by non-native weeds are also dominated by non-native invertebrates, including European earwigs and slugs. In many cases, much more ecological research is needed to better understand these species, their effects on communities, and possible control options. For these reasons, it is more difficult to find consensus on managing invasive animals, and it is particularly important to have open communication about management options. In general, increasing the health and diversity of native plant and animal populations should increase the resilience of native communities to introduced species. The following table is a partial list of non-native animals that are found in the Laguna wildlands.



Table 8: Non native animals			
Latin Name	Common Name	Control Priority	Habitat of Concern and Locations in the Laguna de Santa Rosa Watershed
<i>Felis catus</i>	Feral cat	3	Widespread throughout watershed. Especially common near urban areas.
<i>Homalodisca coagulata</i>	Glassy-winged sharpshooter	4	Not yet present in Sonoma County, but predicted to be introduced on infected nursery plants. Potential range includes most of Laguna.
<i>Meleagris gallopavo</i>	Wild turkey	2	Widespread throughout watershed. Population appears to be growing exponentially. Regulated by CDFG.
<i>Pacifastacus leniusculus</i>	Signal crayfish	5	Requires permanent stream pools, ponds and creeks with emergent and/or riparian vegetation. Found throughout Laguna wetlands and waterways.
<i>Passer domesticus</i>	House sparrow	5	Widespread throughout the watershed. Cavity nester.
<i>Procambarus clarkii</i>	Louisiana swamp crayfish	5	Requires permanent stream pools, ponds and creeks with emergent and/or riparian vegetation. Found throughout Laguna wetlands and waterways.
<i>Rana catesbeiana</i>	Eastern bullfrog	5	Requires permanent stream pools, ponds and creeks with emergent and/or riparian vegetation.
<i>Sturnus vulgaris</i>	European starling	3	Cavity nester. Common around mature oak trees where they displace native cavity nesters such as blue birds, nuthatches.
<i>Sus scrofa</i>	Wild boar	4	Recently extirpated from Annadel State Park. Found in hills around upper tributaries. Regulated by CDFG.
<i>Vulpes vulpes</i>	Red fox	4	Observed occasionally in the Laguna watershed.

*USEFUL INVASIVE SPECIES WEB SITES*

- California Department of Food and Agriculture's EncycloWeedia: Identification, Biology, and Management of Plants Defined as Noxious Weeds by California Law ([http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia\\_hp.htm](http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm)).
- California Invasive Plant Council (Cal-IPC): provides an inventory of invasive California plants, and other resources for invasive plant management (<http://www.cal-ipc.org/>).
- California Department of Fish and Game: website for invasive, nuisance and exotic species ([http://www.dfg.ca.gov/hcpb/species/nuis\\_exo/nuis\\_exo.shtml](http://www.dfg.ca.gov/hcpb/species/nuis_exo/nuis_exo.shtml)).
- California Department of Pesticide Regulation: The lead agency for regulating pesticide applications. Website has searchable database of commercial pesticide applications by product and county, and data on well monitoring program (<http://www.cdpr.ca.gov/>).
- Extension Toxicology Network: Exttoxnet is an excellent source for toxicology and environmental chemistry information about pesticides, representing a collaborative effort of the University of California, Davis; Oregon State University; Michigan State University; Cornell University; and the University of Idaho (<http://exttoxnet.orst.edu/>).
- Global Invasive Species Database: Lists 100 worst invasive species and links to invasive species research in other countries (<http://www.issg.org/database/welcome/>).
- Habitattitude™: an environmental education campaign, produced through a cooperative effort by the aquarium and pet trade, the USFWS, and NOAA, to stop the release of plants and animals into the wild (<http://www.habitattitude.net/>).
- National Invasive Species Council: has links to the invasive species websites of federal agencies (<http://www.invasivespeciesinfo.gov/>).
- Pesticide Action Network Pesticide Database: a detailed source for information on pesticides, from an organization promoting alternatives to pesticide use (<http://www.pesticideinfo.org/>).
- Sustainable Conservation: an environmental organization, coordinating a statewide effort to reduce horticultural introductions of invasive species (<http://www.suscon.org/>).
- The National Parks Service: website with many links to information on invasive species occurrence and control methods (<http://www.nps.gov/plants/alien/>).

- The Nature Conservancy, Global Invasive Species Initiative: One of the best websites for invasive plant management, with photos, tool reviews, and many other resources (<http://tncweeds.ucdavis.edu>)
- Team Arundo Del Norte: Contains information on Arundo control efforts throughout California. (<http://www.teamarundo.org>).
- University of California Integrated Pest Management Website: Contains the latest pest management information for a variety of plants and animals, as well as other resources (<http://www.ipm.ucdavis.edu/>).
- USDA Plants website: standardized information and distribution maps for both native and non-native plant species. Includes federal noxious weed list (<http://plants.usda.gov/>).
- Weed Workers Handbook: A guide to weed control techniques for a number of the most common weeds in California. Available for free download on line, or order your bound copy off the website. ([http://www.cal-ipc.org/ww\\_handbook/](http://www.cal-ipc.org/ww_handbook/)).



## MANAGEMENT OF SELECTED NON-NATIVE PLANTS

### *AEGILOPS TRIUNCIALIS* (BARBED GOAT GRASS)

Barbed goatgrass is a winter annual species, closely related to wheat. This is an aggressive competitor with native grasses in the uplands of the Santa Rosa Plain. It is a listed noxious weed in California, in part because its barbs can cause severe injury to livestock. Prevention is critical, because once established, barbed goat grass is very difficult to control. Goatgrass spreads by seed dispersal, often carried between fields in the fur of animals or by agricultural equipment. Carefully timed mowing or burning prior to seed maturation can be an effective way of reducing the size of goatgrass infestations, but seeds can be viable in the soil for up to five years. For more information on biology and control methods, see CDFA's *Aegilops* information page: (<http://www.cdfa.ca.gov/phpps/ipc/weed-info/aegilops.htm>). To see a photograph of this species go to The Nature Conservancy's Global Invasive Species Initiative *Aegilops triuncialis* page: (<http://tncweeds.ucdavis.edu/esadocs/aegitriu.html>).

*ARUNDO DONAX* (GIANT REED)

Giant reed is native to India and Middle East, and was first planted in the Russian River watershed for bank stabilization and as a source of clarinet reeds. It is still grown commercially, and sold as an ornamental by garden centers, although it has been included on the Cal-PPIPIH list to be phased out of the nursery industry. Since its initial establishment, it has spread via floodwaters throughout the Russian's riparian areas, forming dense clumps that crowd-out native vegetation. It reproduces asexually, through underground rhizomes. Shoots that become buried by sediment and debris can root at each node, and produce new vertical shoots that grow up through the soil. Thousands of acres of riparian areas in Southern California are now dominated by Arundo, which is the subject of a statewide eradication effort.

Besides reducing native plant diversity and degrading habitat value for birds and animals, Arundo is considered a serious problem for a number of economic and safety reasons. Arundo can cause erosion and block channels when large clumps break off during flood events. In the late 1990s, clumps of Arundo caused repeated bridge failures on the Santa Ana River. Arundo is fire-adapted and highly flammable, even when green. While native species may be slow to recover after a burn, Arundo readily re-sprouts, and quickly dominates burned-over areas. It grows rapidly and uses prodigious amounts of water, competing with fish and human uses.

Local efforts to control Arundo have concentrated on the upper tributaries of the Russian. Because Arundo is spread mostly by stream waters, it is unlikely to re-occur once it has been removed from a drainage. Eradication efforts involve meticulous field surveys, mapping, monitoring and agreements with individual landowners, but appear very successful. Arundo is fairly rare in the Laguna, occurring along Santa Rosa Creek and in backyards and gardens around the Santa Rosa Plain. Eradication efforts at this stage are a high priority to prevent future spread to the Laguna channel.

Control methods target the roots and belowground portions of Arundo. These include combinations of cutting, tarping and herbicide applications, depending on the specific characteristics of the affected site. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative Arundo management summary (<http://tncweeds.ucdavis.edu/esadocs/arundona.html>), or the website of Team Arundo del Norte, a forum of local, state, and federal organizations dedicated to Arundo control in Northern California (<http://ceres.ca.gov/tadn/>).

*CENTAUREA SOLSTITIALIS* (YELLOW STARHISTLE)

Yellow starthistle is an annual broadleaf plant, originally from Eurasia. It was introduced to California as early as 1848, and has spread throughout the state. Yellow starthistle is estimated to cover 14-17 million acres in California. Individuals can produce massive numbers of seeds – as much as 75,000 on a large plant. It is poisonous to horses, and has very unpleasant spines. Although attractive to bees and valued for honey production, it is listed as a noxious weed by the CDFA. At this time yellow starthistle is not widespread in the Laguna, and control efforts should be given high priority. As it has a very short-lived seed bank, yellow starthistle responds fairly well to management techniques that disrupt growth before seed set. Cutting, burning, grazing and herbicide are common control methods. Vigilance is key, and removing all plants prior to seed set for several successive years can bring this species under control with persistent effort. Biological control programs are also underway, with releases of insects imported from Europe; of these the most effective are the hairy weevil (*Eustenopus villosus*) and the false peacock fly (*Chaetorellia succinea*). The Sonoma County Agricultural Commissioner's office has also done experimental releases of a specialized plant rust pathogen. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Centaurea solstitialis* management summary (<http://tncweeds.ucdavis.edu/esadocs/centsoles.html>), or the CDFA's starthistle site: (<http://www.cdfa.ca.gov/phpps/ipc/weedinform/centaurea2.htm>). For distribution and occurrence data see: ([http://www.fs.fed.us/database/feis/plants/forb/censol/distribution\\_and\\_occurrence.html](http://www.fs.fed.us/database/feis/plants/forb/censol/distribution_and_occurrence.html)).

*EICHHORNIA CRASSIPES* (WATER HYACINTH)

Water hyacinth is a particularly controversial species. While it is not known to occur in the wild in the Laguna watershed, water hyacinth has a great potential to be a serious pest if it is introduced to Laguna waterways. Although it is a state and federally-listed noxious weed, it is widely found for sale at farmer's markets, flea markets, and festivals in Sonoma County. This floating aquatic plant reproduces very rapidly, both by seed and by vegetative budding, to form giant mats. It has attractive lavender flowers, and is often introduced to new areas as a naturalized ornamental. Infestations block waterways and deplete dissolve oxygen, and can dramatically reduce biodiversity in aquatic systems. Because of its rapid reproduction and long-lived seed bank, water hyacinth has been extremely difficult to control throughout the state. The California Department of Boating and

Waterways spends more than a million dollars each year on water hyacinth management in the Sacramento Delta, mostly on herbicide treatments.

Water hyacinth also has many proponents, because it is recognized as a bioremediation tool that can take up heavy metals and nutrients from polluted waters. In the 1980s water hyacinth was introduced for this purpose to wastewater treatment ponds in western Sonoma County. The plant spread very rapidly and, because of the density of the vegetation, became difficult to control mosquitoes in these ponds. When the water hyacinth was harvested, it had accumulated so many heavy metals, the material was considered a toxic waste, and had to be trucked to a disposal facility. The plant was only eradicated after extensive treatments with herbicides. In some developing countries, there is research underway examining other uses of water hyacinth, taking advantage of its abundant growth, including as feed for cattle and substrate for mushroom farming; but these kind of economic uses would likely be in direct conflict with managing the Laguna for native biodiversity.

The most important activity for managing this species is environmental education, alerting the public about the risks associated with water hyacinth, as well as enforcement of existing laws to reduce the distribution of this species as an ornamental plant. Citizens wishing to reduce herbicide use in the watershed should be particularly vigilant with water hyacinth prevention. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative management summary for *Eichhornia crassipes* (<http://tncweeds.ucdavis.edu/esadocs/eichcras.html>).

#### *GENISTA MONSPESSULANA* (FRENCH BROOM)

French broom is native to the Mediterranean, and was an early horticultural introduction to California. It has since spread prolifically; especially along roadsides and in upland areas and can form monospecific stands. In the Laguna, it invades oak woodlands and as it is very flammable, can greatly increase fire danger at the wildland-urban interface. This species has a very long-lived seed bank, requiring long-term management commitments.

French broom and its relative Scotch broom are woody perennials. Control methods require a multi-stage approach: first targeting adults, then resprouts and seedlings. Hand-pulling with weed wrenches eliminates resprouts by removing the root. Cutting to ground level will also kill plants if done following seed set and under dry soil conditions. After adults are removed, mowing and mulching are used to suppress seed-





lings. Prescribed burns, grazing, and herbicides have also been used to kill adults and seedlings, but regardless of the method managers have to vigilantly to treat seedlings every year until the seed bank is exhausted. French broom is still sold in nurseries. For photographs, natural history, and more information on specific control methods see *Invasive plants of California's Wildlands*, by Bossard et al. (2000), University of California Press or The Nature Conservancy's Global Invasive Species Initiative *Genista monspessulana* management summary (<http://tncweeds.ucdavis.edu/esadocs/genimons.html>).

#### *HEDERA HELIX* (ENGLISH IVY)

English ivy is a perennial woody vine that favors forested areas, and is common near human settlements because it was historically introduced by gardeners and landscapers. Now birds spread seeds to new infestation sites. English ivy can dominate forest understories, blanketing the ground and growing up tree trunks. Hand removal is thought to be the best method for control, either on its own or in combination with a cut-and-paint application of herbicides. This species has been specifically prohibited for use in vegetative buffers designed to comply with the County of Sonoma's Standard Urban Stormwater Mitigation Plan, but there are many historical plantings in public spaces along roads and parks, that remain. For photographs, natural history, and more information on specific control methods see *Invasive plants of California's Wildlands*, by Bossard et al. (2000), University of California Press or The Nature Conservancy's Global Invasive Species Initiative *Hedera helix* management summary (<http://tncweeds.ucdavis.edu/esadocs/hedeheli.html>).

#### *HYDRILLA VERTICILLATA* (HYDRILLA)

Hydrilla is not currently found in the Laguna watershed, but in 1984, the Sonoma County Agricultural Commissioner's Office spent more than one million dollars to eradicate it from Spring Lake. This project required them to drain and dredge the lake, and though successful, the project was controversial because many fish were killed in the process. Hydrilla is an aquatic plant native to Asia, Africa and Australia and was originally introduced by the aquarium industry. It has very broad habitat tolerances, and has the potential to become widespread throughout the continent. Hydrilla roots in soft sediments, but the majority of the plant floats on the surface of the water, forming dense mats that clog waterways, and deplete dissolved oxygen, degrading the aquatic habitat. As it reproduces

vegetatively from broken roots and stems, Hydrilla is usually spread by fragments attached to boats and equipment; and once established, is extremely difficult to control. The CDFG has an ongoing statewide control program for Hydrilla. Various methods are used depending on site conditions, including mechanical removal, dredging, herbicide, and biological control with grass carp. The best prevention method for Hydrilla and similar floating aquatic plants is to educate boaters to use good hygiene when they move boats between different water bodies. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative Hydrilla *verticillata* management summary (<http://tncweeds.ucdavis.edu/esadocs/hydrvert.html>), or the SFEI's guidebook for the control of invasive aquatic plants (<http://www.sfei.org/nis/hydrilla.html>).

#### *LEPIDIUM LATIFOLIUM* (PERENNIAL PEPPERWEED)

Pepperweed is considered to be one of the worst weeds in California, because of its capacity for explosive spread and the difficulty of control. Native to Eurasia, this tall flowering plant is a member of the mustard family, believed to have been introduced to the United States in the 1930's in a shipment of beet seeds. It has been grown commercially for the cut flower trade, but has little or no forage value, although it is sometimes used medicinally. Pepperweed disperses readily by floodwaters – as seeds, rooting stems and root fragments; and seeds are also distributed in cut hay or in the gut of grazing animals. Perennial root masses can become very large, with long-lasting carbohydrate reserves that allow them to regenerate after long periods without top growth.

Pepperweed is a particularly alarming invader for the Laguna ecosystem because it has the potential for transforming healthy habitats and undermining large, long-term restoration projects. This species favors riparian woodlands, valley oak savannah, and seasonal wetlands – spreading out into adjacent agricultural areas. Its growth pattern is often described as explosive, increasing rapidly across many acres. Researchers at Cosumnes Preserve have found that pepperweed can blanket vernal pools, displacing native wetland plants. Restoration and preservation of native species will have low success in invaded areas, because of pepperweed's large root systems, choking growth pattern and ability to increase soil salinity.

In 2004, staff from the Marin/Sonoma Weed Management Area and the Laguna Foundation surveyed the distribution of pepperweed along most of the Laguna's main channel. Although it is scattered throughout the reach between Stony Point Road and Santa Rosa Creek, it has not yet

reached high densities, and patches are relatively small. It is very important to act quickly to control this invasion, given its potential seriousness, and that it is still relatively limited in spatial scale (and therefore treatable). Pepperweed is a textbook case for the need to do collaborative management, and the need for early detection and rapid response. Failure by one landowner to control pepperweed sharply limits the ability to control the invasion on adjacent properties.

As pepperweed is a problem in other parts of California and many states, there has been considerable research on control methods. In general, strategies involve killing or removing both the above-ground plant parts, preventing seed production, and attempting to kill or remove the below-ground system of roots and rhizomes. These efforts have to be accompanied by long-term monitoring programs to identify and control sources of re-infestation, and restoration to re-establish native plants.

Herbicides are considered the most effective option for pepperweed management in wildland areas. However, there are substantial community concerns about the use of herbicides in floodplains and wetlands, and strong interest in further research on non-chemical control methods. As pepperweed is a rapidly-expanding problem throughout the western states, a number of research programs are already under way. Land managers in some preserves are experimenting with the use of tarps or sheep and goat grazing. Tarps allow managers to reduce or avoid the use of chemicals, but they are best suited to areas where pepperweed grows in small patches in relative monoculture, because tarps unavoidably kill surrounding plants and animals. Sheep and goats provide some level of control, but care must be taken to avoid having seeds carried from infested to non-infested sites in wool or feces. The City of Sebastopol and a citizen volunteer group has initiated a grassroots effort to control pepperweed in the Laguna Wetlands Preserve without using chemicals. Taking the Adopt-a-plot approach, they are experimenting with a range of approaches from hand-pulling to tarping and cutting. Sustained, labor-intensive efforts have been reported to work on small infestations in other areas.

Three different herbicides are widely used for pepperweed control: chlorsulfuron, triclopyr, and glyphosate. All are systemic herbicides, translocated by the plant to the root system. Each has advantages and disadvantages, relating to their effectiveness, their specificity, their persistence and their toxicity. The Pesticide Investigations Unit of the CDFG recommends treating plants in the spring, applied at bud stage. None of these treatments is 100% effective, and the control program must be accompanied with a sustained monitoring and spot-treatment to catch

re-sprouts and new infestations. Where pepperweed is growing alongside sensitive native plants, land managers can use cut-and-paint methods for applying minimal amounts of herbicide directly to the exposed stem.

The key to controlling pepperweed is long-term vigilance, and careful monitoring, regardless of the control method used. As with *Ludwigia*, the pepperweed control program needs support and funding from public agencies and cooperation from private landowners. Weeds know no property boundaries. If funding is limited, control efforts should focus on the small, satellite patches colonizing new areas out from the main infestation site. Research has shown that these patches are most responsible for the spatial spread of the invasion, and as they are generally younger, they have smaller perennial root systems and are easier to kill.

Most of the information above was summarized from the following websites. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Lepidium latifolium* management summary (<http://tnc-weeds.ucdavis.edu/esadocs/lepilati.html>), as well as (<http://www.fs.fed.us/database/feis/plants/forb/leplat/all.html>).

#### *LOLIUM MULTIFLORUM* (ITALIAN RYEGRASS)

Italian ryegrass was originally introduced as a nutritious forage and cover crop. For many years it was planted for post-fire erosion control; however, since it suppresses native seed germination, sites planted with Italian ryegrass tend to have greater susceptibility to erosion over the long-term, and (being quite flammable) increased fire frequency. Italian ryegrass is an annual with a short-lived seed bank, so it can be controlled by fire, grazing, or herbicide treatments applied prior to seed set. This grass tolerates a wide range of soil conditions, but is not tolerant of shading. It is listed by the USDA as a facultative upland species, but is occasionally found in wetlands. For photos and more control information see the California Weed Worker's Handbook section on Italian ryegrass: ([http://www.cal-ipc.org/file\\_library/1965I.pdf](http://www.cal-ipc.org/file_library/1965I.pdf)). For references related to erosion and fire research see: (<http://www.fs.fed.us/database/feis/plants/graminoid/lolmul/all.html>)

#### *LUDWIGIA SP.* (INVASIVE WATER PRIMROSE)

Invasive *Ludwigia* has been the subject of a massive control effort in the Laguna. At least two species have been introduced to Sonoma County from South America: *Ludwigia hexapetala*, and *Ludwigia peploides* ssp.

montevidensis, and taxonomists currently believe that the latter species is most dominant in the Laguna. Several *Ludwigia* species are native to Sonoma County, but these do not appear to co-occur with the invasive types, and may have been displaced. *Ludwigia* species are morphologically plastic, and can be hard to distinguish from one another. For this reason, it is difficult to know how long invasive *Ludwigia* has been present in the watershed. Botanical surveys list *Jussiaea californica* (a synonym of *Ludwigia peploides* ssp. *peploides*) in the Laguna as early as 1990. However, anecdotal accounts from landowners suggest that the current infestation did not become widespread until after 1995.

Recent *Ludwigia* control plans were developed through a consensus process by the Sonoma County *Ludwigia* Task Force, and seek to follow an integrated pest-management (IPM) approach – based on the biology of the plant and on ecosystem-level restoration and management objectives. The integrated approach includes a variety of interim and long-term approaches. Overall, the goal for invasive *Ludwigia* is to sharply reduce its population numbers to alleviate negative impacts on the Laguna ecosystem, and to reduce and stabilize its population growth rate, so that it no longer spreads invasively. Reducing *Ludwigia*'s abundance is the central objective of near-term control plans using glyphosate or triclopyr herbicides and mechanical removal practices. Stabilizing its population growth rate will require lasting changes in Laguna management practices that complement the broader restoration goals for the Laguna ecosystem.

For more information, including the latest revision of the *Ludwigia* management plan and a list of *Ludwigia* Task Force members, please visit the Laguna Foundation's *Ludwigia* Control Project website: <http://www.lagunafoundation.org/RMP/Ludwigia/default.htm>. *Ludwigia* is also a major problem in Europe, as described by the following websites: [http://www.eppo.org/QUARANTINE/Alert\\_List/invasive\\_plants/Ludwigia.htm](http://www.eppo.org/QUARANTINE/Alert_List/invasive_plants/Ludwigia.htm) and <http://www.cemagref.fr/English/ex/hydrosystem/EVJussies/EVjussieex.htm>.

#### *LYTHRUM SALICARIA* (PURPLE LOOSESTRIFE)

Purple loosestrife is a very successful and aggressive invader of freshwater wetlands, and now dominates many marshes in the northeastern states. It is a very attractive and showy perennial species, and was originally a horticultural introduction from Europe. High seed viability and seed production (up to 100,000 per plant!) can build up very large seed banks, allowing explosive population expansion when disturbance – such as

drawdown, siltation, or ditching – opens up germination sites. Once established, it displaces and crowds out native plants.

A small but significant stand of purple loosestrife is established along the lower reaches of Blucher Creek, and at its confluence with the Laguna main channel. Some also occurs along the Russian River. This is a top priority for control, given the small number of individuals and the great potential for spread. It is very easy to map and monitor in summer months, with bright purple flowers growing in large inflorescences on tall vertical stalks. The Nature Conservancy's management summary recommends removing individuals and small satellite populations by hand, being careful to remove all the roots. Purple loosestrife can also be controlled with applications of glyphosate herbicide (aquatic formulations), applied either to the entire plant, or dripped onto cut stems. There is active research underway to find biological control organisms, but these are not yet ready for release in California.

For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Lythrum salicaria* management summary (<http://tncweeds.ucdavis.edu/esadocs/lythsali.html>). See also USGS study on Spread, Impact, and Control of Purple Loosestrife (*Lythrum salicaria*) in North American Wetlands: (<http://www.npwrc.usgs.gov/resource/1999/loosstrf/loosstrf.htm>).

#### *MYRIOPHYLLUM AQUATICUM* (PARROTFEATHER)

Parrotfeather is a mostly-submersed aquatic weed originally from South America, and now found in pockets throughout the Laguna channels, favoring shallow slow-moving waters. Parrotfeather was originally introduced as an aquarium plant, and spreads mainly by fragmentation via floodwaters, water birds, or boats. It forms very dense mats that clog waterways, and can create optimal habitat for mosquito production. Parrotfeather is extremely difficult to control. Harvesters are used in large lakes and flood control channels, but these can further propagate the weeds. Although there is active research to evaluate biological control organisms, it will be some years before they are ready for wide application. Herbicides are also sometimes used, but since much of the plants are submerged, the chemicals often need to be applied to the water column, which has carries risks for non-target environmental impacts. Land managers should begin to map and track parrotfeather infestations as soon as possible, and work to contain its spread. In some areas, the small size of infestations may make it a candidate for hand-removal by volunteers. For



photographs, natural history, and more information on specific control methods see *Invasive plants of California's Wildlands*, by Bossard et al. (2000), University of California Press.

*RUBUS DISCOLOR* (HIMALAYAN BLACKBERRY)

Himalayan blackberry is one of the most widespread invasive weeds in the Laguna watershed, especially in riparian areas. Legend has it that Luther Burbank introduced this species to Sonoma County, and its fruit is still widely enjoyed by county pie-makers. It is often confused with the native California blackberry, but the two can be distinguished by leaflet number (the native has 3 leaflets, the invasive has 5) and other botanical characteristics – most notably, the invasive blackberry has much greater vigor. It has woody, perennial vines or runners that root along nodes where they come in contact with the ground. Blackberry seeds are readily dispersed by birds and other animals.

Himalayan blackberry forms dense thickets in forest understories, and can spread out into abandoned agricultural fields and along roadsides, growing over and excluding native species, and dominating wildland habitats. Himalayan blackberries contribute to flooding problems where they grow into stream beds, trapping debris and displacing floodwaters. By changing water flow patterns they can also lead to increased bank erosion. Himalayan blackberries are a major propagative and systemic host of the *Xylella fastidiosa* bacteria that cause Pierce's disease (a serious disease of grapes and several other crops). This disease is spread by the Blue-green sharpshooter, *Graphocephala atropunctata*, and by Glassy-winged sharpshooter, *Homalodisca coagulata* (not yet in Sonoma County). Researchers have found that vineyardists can control Pierce's disease by removing blackberry and other (mostly non-native) hosts from vineyard boundaries (Pierce's Disease/Riparian Habitat Workgroup 2000). Blackberry control is essential in riparian restoration areas, because young plants can be quickly swamped by vigorous blackberry patches.

Nonetheless, Himalayan blackberry does have some environmental value, especially as habitat for nesting bird species. Land managers must time Himalayan blackberry removals to avoid nesting season, and ideally make provisions for lost habitat by restoring native cover. In some situations, Himalayan blackberry can protect banks against erosion, so removals must be accompanied by bank-stabilization measures.

Blackberry control always requires manual or mechanical removal of runners and vines, and its sharp thorns make this challenging. Roots resprout readily, so removals need vigilant follow-up, as well as surveys to

find new seed-generated plants. Cut-and-paint herbicide applications can be effective for reducing regrowth, and are likely to be the best method in hard to access areas or places where land managers would like to minimize human disturbances. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Rubus discolor* management summary: (<http://tncweeds.ucdavis.edu/esadocs/rubuarmed.html>). For information on Pierce's disease, see Information Manual: Riparian Vegetation Management for Pierce's Disease in North Coast California Vineyards, (2000), by the Pierce's Disease/Riparian Habitat Workgroup, (<http://nature.berkeley.edu/xylella/north/info.htm>).

*TAENIATHERUM CAPUT-MEDUSAE* (MEDUSA-HEAD)

Medusa-head is an annual grass native to the Mediterranean. Its leaves and stems contain high levels of silica, making medusa-head unpalatable to livestock except for early in the season, and slow to decompose so that other grass species have difficulty germinating through its heavy thatch layer. The sharp awns (seed coverings) can harm the mouths and eyes of grazing animals. The DFG's ecological preserve on Todd Road has an expanding infestation of medusa-head, and there are several other sites in the Laguna watershed. Mowing, early-season grazing, and prescribed burns have all been somewhat effective at controlling medusa-head, but it is very difficult to get rid of. The Solano Land Trust commissioned a study on the effects of different grazing regimes on medusa-head. The report on the first year is available at (<http://www.phytosphere.com/publications/Jepsongrazing2005progressI.htm>). For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Taeniatherum caput-medusae* management summary (<http://tncweeds.ucdavis.edu/esadocs/taencap.html>). See also: <http://www.fs.fed.us/database/feis/plants/graminoid/taecap/all.html>

*VINCA MAJOR* (PERIWINKLE)

Vinca is a perennial vine with showy purple-blue flowers and waxy green leaves, still widely used as a groundcover by gardeners. It spreads mostly vegetatively and can form dense carpets in moist or shaded areas, excluding native species. Vinca provides excellent habitat for non-native snails and slugs that feed on native plant seedlings. Vinca also is a major propagative and systemic host of the *Xylella fastidiosa* bacteria that cause Pierce's



disease (a serious disease of grapes and several other crops). This disease is spread by the Blue-green sharpshooter, *Graphocephala atropunctata*, and by Glassy-winged sharpshooter, *Homalodisca coagulata* (not yet in Sonoma County). Researchers have found that vineyardists can control Pierce's disease by removing *Vinca* and other (mostly non-native) hosts from vineyard boundaries.

Hand removal of *Vinca* can be very effective, especially if it is followed-up regularly to remove resprouts. Larger patches have been controlled by mowing or weed whacking, followed by immediate applications of glyphosate herbicides. For photographs, natural history, and more information on specific control methods see The Nature Conservancy's Global Invasive Species Initiative *Vinca* major management summary (<http://tncweeds.ucdavis.edu/esadocs/documnts/vincmaj.html>), or the SFEI's guidebook for the control of invasive wetland plants (<http://www.sfei.org/nis/periwinkle.html>). For information on Pierce's disease, see Information Manual: Riparian Vegetation Management for Pierce's Disease in North Coast California Vineyards, (2000), by the Pierce's Disease/Riparian Habitat Workgroup, (<http://nature.berkeley.edu/xylella/north/info.htm>).



## MANAGEMENT OF SELECTED NON-NATIVE ANIMALS

### *MELEAGRIS GALLOPAVO* (WILD TURKEYS)

Wild Turkeys present a substantial management challenge in the Laguna. This species was intentionally introduced to the area by the CDFG, with the goal of providing recreational hunting opportunities. The introduction has been very successful, in that there are now large numbers of turkeys throughout the state, and data collected by the Audubon Christmas Bird Count suggests that their numbers are increasing exponentially. Most of the lands in the Laguna watershed are not compatible with turkey hunting, and as a consequence, land managers and property owners in the Laguna need to work closely with the CDFG to develop turkey management programs that suit predominate land uses and public interests. Turkey numbers should be kept low in areas where they are likely to have a negative effect on native species and restoration activities, in residential areas where they pose a nuisance, and in agricultural areas where they may damage crops.



Turkeys or turkey-like birds are found in the fossil record of Southern California, but they are not believed to have been native to the northern part of the state (CDFG 2004). The wild turkeys now found in the Laguna are members of a subspecies from Rio Grande, Texas, that were released throughout California between 1959–1988. Since that time, turkey populations have increased rapidly across the state. These population trends, along with turkey’s omnivorous diets and their soil-disturbing feeding behaviors, have caused concern among land managers working to protect indigenous plants and animals, as well as among agriculturists, and homeowners concerned about damage to land and property. There are few large predators (such as coyotes or mountain lions) in the Laguna to provide natural population control, and increased populations of these predators would have additional conflicts with humans. In the CDFG’s 2004 Strategic Plan for Wild Turkey Management (Turkey Management Plan), the Department has attempted to balance the potentially conflicting interests of maintaining large turkey populations in hunting areas while reducing the impacts of turkeys on public and private lands. This strategy requires landowners and managers to clearly articulate their concerns, and to communicate with the Department about how turkeys should be managed on specific properties.

The stated goal of the Turkey Management Plan is to balance the interests of hunters with the need to minimize turkeys’ negative impacts, by aligning site-specific turkey management goals with other land management objectives. The primary way that the CDFG manages turkey populations is through the timing and duration of the hunting season. Spring hunting of males is thought to have the least impact on population growth, although in most parts of the state there is also a short season in November, to coincide with the Thanksgiving holiday. As of 2005, hunters are allowed to take three birds each spring season, and one in autumn (see <http://www.dfg.ca.gov> for up-to-date regulations). Although the goal is for “sustainability,” which implies a stable population size, turkeys appear to be increasing in number in Sonoma County. Turkeys do not recognize property boundaries, and are often in highest abundance – causing the greatest nuisance – on private or public lands where hunting is prohibited. In residential areas they are attracted to backyard ponds and feeders, and can lose their fear of humans and dogs. Males sometimes behave aggressively during the breeding season. However, control options are limited in these areas because hunting is mostly restricted. The CDFG’s policy is to discourage people from feeding turkeys; and in areas where problems are

well documented, to reduce population numbers through trapping and relocation.

Agriculturists, particularly grape-growers, have complained about turkey damage to crops in different regions of California. Responding to these concerns, the state legislature recently enacted laws (Fish and Game Code Section 4181) allowing out-of-season depredation permits to hunt turkeys where there is evidence they have damaged crops or other property. In theory, this takes care of problems where they occur; however, a DFG employee must investigate each request. As this is a new regulation, it will take some time to determine whether this mechanism provides adequate protection for agriculture. A key factor will be the speed at which the department can issue permits, as the season of impact is short (only a few weeks for ripening crops). Homeowners may also obtain depredation permits for damage to residential property. Where the problems are severe, the department has the power to authorize a special hunt to reduce local population numbers (Fish and Game Code Section 4188). Homeowners and agriculturists should document damage as it occurs, and contact the Yountville office of CDFG if they wish to obtain a permit. It may also be possible for the CDFG to arrange to have the turkeys trapped and removed. It is illegal to kill turkeys without a permit, even on private land, and heavy fines may be issued for each violation.

The CDFG's stated goals are to "manage turkey populations across the landscape in ways that best suit predominant land uses and public interests;" to "minimize unwanted turkey populations on public and semi-private lands where they are a conflict with the management goals of those lands;" and to "manage turkey populations to minimize potential impacts to sensitive, native species, based on land management goals." However, at the present time, damage to natural areas does not qualify for turkey depredation permits. Instead, the department will work with managers to trap and remove turkeys where there is evidence that they interfere with management goals. California State Parks, including Annadel, and many of the public lands of the Laguna have goals to enhance native plant and animal populations, and to reduce populations of non-native species. Researchers are studying turkey populations in Annadel and other local State Parks to evaluate which native plants and animals are consumed by turkeys, in what relative proportions. Turkeys consumed a variety of foods, including grass seeds and mast crops such as acorns. There was only one instance where they observed a turkey being taken by a natural predator (a coyote). Based on the results of these studies, researchers estimate that turkeys have the ability to increase five-fold in years when food supplies

are abundant. Research on the ecological impacts of turkeys is also being conducted at Bouverie Preserve, near Sonoma.

A number of specific concerns have been raised about potential environmental impacts from turkeys. These impacts may be subtle and difficult to quantify when turkeys are relatively low in number, but ecological effects and risks to native species are likely increase proportionately with turkey populations. The potential impacts of most concern for the Laguna include effects on oak recruitment, soil disturbance, and damage to sensitive native species. Oak woodlands and oak savanna are a high priority for restoration and enhancement efforts in the Laguna, where oak recruitment has been severely limited. Oaks are the foundation of a diverse ecological community, and are also important for stabilizing hillsides. Many of the mature oaks in the Laguna are reaching the end of their lifespans, and Sudden Oak Death has killed numerous trees in the upper watershed. In some areas, seedling survival appears to be dependent on protection from livestock grazing and mowing, and altering management practices has allowed natural regeneration of oaks. Studies cited in the Turkey Management Plan found that acorns are a major food item, comprising one-fifth of their diet. Acorns are also a preferred food for a number of other birds and animals in the Laguna, and high numbers of turkeys would substantially increase competition for this resource. If turkey flocks become large and widespread, they may become a substantial limiting factor in oak recruitment, and restorationists would have to rely on protected oak plantings rather than natural regeneration processes. More research is needed to quantify the effect of turkey predation on acorn abundance and the success of oak restoration projects.

As turkeys forage for seeds and insects, they scratch and expose the soil. A substantial ecological literature documents that such soil disturbance greatly favors weedy, non-native plant species. An emerging central principle of invasive species management is to reduce the opportunities for invasive species to become established. Early intervention prevents further environmental impacts, has increased success rates, and dramatically lower control costs. Although some studies have shown that small-scale disturbances by burrowing mammals can increase plant species diversity; overall, reducing soil disturbance is believed to be important for minimizing weed management problems. Research at Salt Point State Park has documented increased weediness where soil has been disturbed by feral pigs. Similar research is needed to quantify the effects of turkeys on the distribution of native and non-native plant species.

Grassland areas of the Santa Rosa Plain are habitat for several state and federally listed species, including the California Tiger Salamander and four seasonal wetland plants. While turkeys are generally thought to avoid wetlands, vernal pools dry out in the summer months, and may be visited by turkey flocks foraging in the grasslands. The U.S. Fish and Wildlife Service is working with the Santa Rosa Plain Conservation Strategy Team to develop preserves and other mechanisms to protect these species. Over the next decade, it is likely that large portions of the Plain will be set-aside as Conservation Areas. The overall conservation strategy calls for preserves clustered within each conservation area, with site-specific management and monitoring plans for each preserve. As very little is known about turkey impacts on these protected species, it is very important that turkey population monitoring be included in site-specific management plans.

High numbers of wild turkeys are not likely to be compatible with many of the Laguna's land uses. The watershed is densely populated compared to surrounding drainages, and there are relatively few areas suited to turkey hunting which could thin the flocks. Many of the public lands have native plant and animal protection as a central management goal. The Sonoma County Agricultural Preservation and Open Space District is partnering with other agencies to open lands for public access, which will increase human interactions with turkeys on these properties. Many of the watershed's agricultural operations, notably vineyards and specialty crops, are not compatible with large numbers of wild turkeys. Rural and suburban homeowners will not likely be supportive of large turkey flocks on their properties. As with other non-native species, potential environmental impacts and control costs would be minimized by early action; and active trapping and removal of a small number of birds now would reduce the need for unpopular lethal removals in the future. It is important for landowners and public land managers to begin collecting data on the effects of turkeys on their properties, and to monitor the size of turkey flocks, to provide appropriate evidence for the Department in making management decisions.

Managers writing site-specific plans for natural areas need explicit about their management goals for these properties, and how wild turkeys mesh or conflict with these goals. Plans should also include explicit policy statements about the feasibility of public turkey hunting, and examine different control alternatives. The wild turkey study at Sonoma County State Parks concluded that it was too costly for park staff to control turkeys by hunting, and recommended live trapping.



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