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CALIFORNIA EXOTIC PEST PLANT COUNCIL

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CALIFORNIA EXOTIC PEST PLANT COUNCIL

2000 Presentation Abstracts

A Survey in South Africa for Insects with Potential as Biological Control Agents for Cape Ivy (*Delairea Odorata* Lemaire)

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Introduction

Cape ivy, *Delairea odorata* Lemaire (Asteraceae), formerly *Senecio mikanioides* Otto ex Harv. is now one of the most invasive weeds in California, and also known to be invasive in Australia, New Zealand, Hawaii and Spain. Indigenous to Lesotho and the following provinces in South Africa: Western Cape, Eastern Cape, Mpumalanga, and KwaZulu-Natal, Cape ivy populations there are localized and show no invasive tendencies. In southern Africa, Cape ivy is both a creeper and climber on the fringes of indigenous forests, often on the southern slopes of mountainsides and hills.

In it's native home, Cape ivy is an uncommon plant, and the insects associated with it have never been studied. Between April 1998 and April 1999, we conducted the first survey for phytophagous insects on Cape ivy. After locating Cape ivy, we obtained permission from the land owners to collect it. Since most of the sites were on public lands, this entailed obtaining numerous permits from the appropriate agencies [see Acknowledgements section]. Our survey covered most of this vine's geographic distribution in South Africa, as well as its various seasonal growth forms. Collecting included visual inspection, hand picking, beating and sweeping techniques, followed by the rearing of immature insects. Specimens were identified by appropriate specialists in South Africa, as well as in other countries [see Acknowledgements section].

Our results revealed a large insect fauna of over 120 families in 12 orders, comprising more than 400 species, either directly or indirectly associated with *D. odorata*. Phytophagous guilds causing the most damage comprised leaf-feeders (Coleoptera, Diptera, Lepidoptera, Thysanoptera), stem-borers (Diptera, Lepidoptera), gall-formers (Diptera), leaf-rollers and leaf-tiers (Diptera, Lepidoptera), flower- and seed-feeders (Coleoptera, Diptera, Lepidoptera) and sap-suckers (Hemiptera).

After completeing the first year's of surveys, between April 1999 and April 2000, we conducted another extensive survey, this time collecting not only from Cape ivy, but also from12 species of carefully selected, closely-related and ecologically homologous plants growing in the vicinity. These included members of the genera *Senecio* (8 species), *Cineraria* (2 species), *Mikaniopsis* (1 species) and *Mikania* (1 species). All are climbers or sprawling plants, usually with at least semi-succulent leaves or stems, occurring in or on the edges of forest patches where Cape ivy also occurs. The objective of this second survey was to see if five of the insect natural enemies of Cape ivy, considered to have the highest potential as possible biological control agents, were restricted to Cape ivy under natural field conditions, or if some of them fed on any of the above mentioned relatives of Cape ivy as well.

Phytophages associated with Cape ivy

The following two tables list the phytophagous and presumably phytophagous insects associated with Cape ivy that we found during two years of surveys. Table One lists the insect species that we feel may be useful as potential biological control candidates have been marked ("*"). A variety of other diverse insects, damaging the plant but which are known, or likely, to have a variety of other hosts, are not marked. Very rare species, even if host specific to Cape ivy, are likely to prove extremely difficult to develop as biological control agents. Thus, some insect species found only in low numbers, such as some of the stem-boring

species and a root-feeder, have not been marked as possible biological control agents. Parasitoids, emerging from promising biological control agents, are included on our list, as the degree of parasitism may affect the eventual choice of an agent. Most of the parasitoids were wasps in the families Eulophidae, Braconidae and Ichneumonidae, and members of the latter two have only been identified to family level.

Table 1. List of potential biological control agents for Cape ivy collected during our surveys (1998-2000)

i) Gall-formers

Diptera

* **Tephritidae:** (Fruit flies)
* *Parafreutreta regalis* Munro
  (Year 1: 33 adults, 13 maggots, 5 galls, 4 puparia, 21 collections at 16 sites)
  (Year 2: 35 adults, more than 2 maggots, 12 collections at 7 sites)
* The galls formed by this fly appear to stunt growth of young shoots, and may also act as nutrient sinks.
  Possible parasitoids of *P. regalis*, which emerged from galls collected in the field, include: Braconidae; Pteromalidae (cf. *Trichomalopsis* sp., nr. *Sphegigaster* sp., *Pteromalus* sp.); and Eurytomidae (*Eurytoma* sp.).

ii) Leaf-feeders

a) Coleoptera

* **Chrysomelidae:**
  * cf. *Abrarius* species 1 indet. (Alticinae (Flea beetles)) (5 adults, possibly 4 larvae, 1 collection at 1site)
  * *Sphaeroderma* sp. (Alticinae) (15 larvae, 1 collection at 1 site)
    * During the first year of surveying, larval leaf mines destroying most of the leaf blade were found on Cape ivy. Despite attempts to rear larvae in the laboratory, no adults were obtained. It was speculated that they may be the larvae of a cf. *Abrarius* sp. Leaf-mining larvae were also found during the second year of surveying. Similar larvae were observed in the leaves of *Senecio deltoideus*. Attempts made to rear the latter were successful. The adult is a small spherical alticine that also feeds on the leaves, removing the lower leaf surface create a lace-like pattern.
  * cf. *Ageniosa* sp. (Chrysomelinae) (6 adults, 1 larva, 1 collection at 1 site)
    * Many larvae were collected feeding on the leaves of Cape ivy but only a few were reared to maturity during the second year of surveying. Final instar larvae pupated in loose soil from which the adults emerged.
  * *Ageniosa* cf. *badenii* (Vogel) (Chrysomelinae)
    * Adults and larvae of this species were collected from *D. odorata* plants in the Ngele Forest (a site we visited briefly during winter of the first year of surveying) by C. A. Rolando. She was a MSc student at the Botany Department of the University of Natal, Pietermaritzburg, in 1999, working on the breeding system and natural predators of *D. odorata.*
  * Genus et species 1 indet. (Galerucinae)
    (Year 1: 80 adults, 7 collections at 6 sites)
    (Year 2: 26 adults, 2 collections at 2 sites)
    * Adult beetles feed voraciously on leaves and the larvae may be shown to be root-feeders. Adults of this species were found only at two localities during the second year of surveying, in late November and early December. Significant damage to leaves was observed in the field.
  * Genus et species 2 indet. (Galerucinae) (80 adult specimens collected, 6 collections at 6 sites)
    * As for species 1 above.

b) Diptera

Agromyzidae:

* Genus et species 3 indet.
  (Year 1: 5 adults, 1 puparium, 1 pupal case specimens collected, 5 collections at 3 sites)
  (Year 2: 1 adult, 1 collection, 1 site)
  * Larvae mine extensively in the leaves.
    Possible parasitoids: Eulophidae (*Meruana* sp., *Chrysocharis* sp., *Chrysonotomyia* sp.).

c) Lepidoptera

* **Arctiidae:**
  * *Diota rostrata* (Wallengren) (Arctiinae)
    (Year 1: 116 adults and many more than 12 larvae, 16 collections at 13 sites)
    (Year 2: 25 adults, 1 pupa, 7 collections, 6 sites)

* A widespread and relatively common, hairy caterpillar which effectively defoliates plants. Possible parasitoids: Braconidae; Ichneumonidae; Tachinidae (*Carcelia* sp., *Linnaemya* sp., Genus et species 3 indet.).

iii) Leaf-rollers

Diptera

* **Cecidomyiidae:** (Gall midges)
* Genus et species 1 indet. (16 adults, more than 110 maggots, 1 pupa, 3 pupal cases, 27 collections at 22 sites)
* Cecidomyiidae maggots cause leaf-curling and stunt growth.

iv) Root-feeders

Coleoptera

Curculionidae:
One larva was found amongst stems of *D. odorata* in the leaf litter layer, the specimen was not preserved and this finding could not be confirmed by subsequent findings.

v) Stem-borers

a) Diptera

* **Agromyzidae:**
  * Genus et species 1 indet.
    (Year 1: 247 adults, more than 5 pupae, 2 pupal cases, more than 2 maggots, 32 collections at 25 sites)
    (Year 2: 97 adults, 1 maggot, few puparia, 19 collections, 10 sites)
  * Stem-boring fly maggots. Young emergent stems with a few leaves were collected although they appeared very healthy in the field. Flies emerged, indicating that there was obviously sufficient food and moisture for even very young maggots to develop to maturity. Possible parasitoids include: Pteromalidae (*Sphegigaster* species 1 and 2 indet.) and Braconidae.

b) Lepidoptera

* **Acrolepidae:**
  * *Acrolepia* sp.
    (Year 1: 260 adults, 4 cocoons, 4 pupae, 29 larvae, 32 collections at 26 sites)
    (Year 2: 81 adults, 7 larvae, number of pupal cases and cocoons, 23 collections, 13 sites)
  * Potentially a very destructive moth species, which can cause the death of flowering and prostrate stems and damage leaves. During the second year of surveying very young emergent shoots with some leaves, were collected. Although the material appeared very healthy in the field, moths emerged. As these young stems contain much moisture, there was obviously sufficient food for even very young larvae to develop to maturity. A larva was also found mining extensively in a leaf. Possible parasitoids: Ichneumonidae and Braconidae.

vi) Flower- and seed-feeders

a) Coleoptera

* **Melyridae:** (Soft-winged flower beetles)
  * *Pagurodactylus* cf. *rostralis* Champion (Dasytinae) (107 adults and many larvae, 9 collections at 9 sites)
  * *Pagurodactylus* species 1 to 4 indet. (Dasytinae) (12 adults and a number of larvae, 8 collections at 8 sites)
  * *Melyris* cf. *interstitialis* Champion (Melyrinae) (22 adults and more than 7 larvae, 6 collections at 6 sites)
  * *Melyris* species 2 indet. (Melyrinae) (81 adults and more than 14 larvae, 5 collections at 5 sites)
  * A variety of beetle larvae were found developing in unripe seeds in flower-heads and may be of use should inhibition of seeding be required. It was noted in the report after the first year of surveying that larvae had yet to be reared to confirm their specific identity. The larvae listed above were presumed to be those of the *Parurodactylus* and *Melyris* species, as they resembled larval morphology in the family Melyridae and large numbers of adult beetles were also found at the same sites. During the second year of surveying some of these larvae burrowed into soil, from which adult Phalacridae later emerged. Larvae listed above may therefore not all belong to the genera *Parurodactylus* and *Melyris* but also to the family Phalacridae. Therefore, adult phalacrid beetles collected have also been included in this section

* **Phalacridae:** (Shining flower beetles)
  * Genus et species 1 to 4 indet. (55 adults, 16 collections at 15 sites)
  * Phalacridae are known to develop in flower heads of Asteraceae and some coleopterists regard them as specialised seed-eaters. See comments above under Melyridae.

b) Diptera

* **Cecidomyiidae:** (Gall midges)
  * Genus et species 3 indet. (4 adults and many maggots, 8 collections at 8 sites)
    * A variety of midge maggots were found developing in unripe seeds in flower-heads and may be of use should inhibition of seeding be required.

c) Lepidoptera

Geometridae:

Chloroclystis muscosa tumefacta Prout (Larentiinae) (4 adults, 4 collections at 4 sites)
Eupithecia hypophasma Prout (Larentiinae) Prout (5 adults, 4 collections at 4 sites)
Eupithecia infelix Prout (Larentiinae) (2 adults, 2 collections at 2 sites)

Table 2. List of other phytophagous and presumably phytophagous insects that probably have little potential as biological control agents for Cape ivy

i) Flower- and seed-feeders

a) Coleoptera

Anthribidae:

Urodontus planicollis Louw (Urodontinae) (2 adults, 2 collections at 2 sites)

Bruchidae: (Seed and bean weevils)

Spermophagus sp. (Amblycerinae) (2 adults, 1 collection at 1 site)

Curculionidae: (Weevils)

Derelomus species (Curculioninae, Derelomini) (8 adults, 4 collections at 4 sites)
Mecysolobus species (Curculioninae, Molytini) (1 adult, 1 collection at 1 site)
Sibinia species 1 to 3 indet. (Curculioninae, Tychiini) (3 adults, 3 collections at 3 sites)

b) Diptera

Tephritidae: (Fruit flies)

Cryptophorellia peringueyi (Bezzi) (3 adults, 2 collections at 2 sites)
Telaletes ochracea (Loew) (10 adults, 2 collections at 2 sites)

c) Hemiptera

Lygaeidae:

Dieuches expandens Eyles (1 adult, 1 collection at 1 site)
Probably *Dieuches* sp. nymphs (4 nymphs, 2 collections at 2 sites)
Nysius binotatus (Germar) (27 adults, more than 4 nymphs, 6 collections at 5 sites)
Nysius natalensis Evans (22 adults, 9 collections at 9 sites)
Nysius pallidus Evans (114 adults, 8 collections at 7 sites)
Nysius stali Evans (22 adults, 7 collections at 7 sites)

d) Thysanoptera

Phlaeothripidae:

Haplothrips gowdeyi (Franklin) (1 flower sample, 1 collection at 1 sites)
Haplothrips nigricornis (Bagnall) (4 flower samples, 4 collections at 4 sites)
Haplothrips species 3 indet. (1 flower sample, 1 collection at 1 site)

Thripidae:

Thrips tenellus Trybom (6 flower samples, 6 collections at 6 sites)

ii) Leaf-feeders

a) Coleoptera

Attelabidae:

Probably *Auletobius* species (Rhynchitinae, Auletini) (1 adult, 1 collection at 1 site)

Brentidae:

Apion species 1 indet. (Apioninae, Apionini) (1 adult, 1 collection at 1 site)
Apion species 2 indet. (Apioninae, Apionini) (4 adults collected, 1 collection at 1 site)
cf. *Conapion* species 1 indet. (1 adult, 1 collections at 1 site)
cf. *Piezotrachelus* species 1 indet. or *Conapion* species 1 indet. (1 adult, 1 collection at 1 site)
cf. *Piezotrachelus* species 2 indet. or *Conapion* species 2 indet. (1 adult, 1 collection at 1 site)

Acrolepia larva

Acrolepia damage

Acrolepia live

Acrolepia mines

Acrolepia pinned

Agromyzidae adult

Agromyzidae puparium

Diota larvae

Diota adult live

Diota larva full

Diota female

Diota male

DODO fly & gall

Luperodes adult

DODO gall

Luperodes adult

Luperodes damage

Luperodes feeding

cf. *Piezotrachelus* species 3 indet. or cf. *Conapion* species 3 indet. (1 adult, 1 collection at 1 site)

Chrysomelidae:

Afrorestia acuminata (Jacoby) (Alticinae (Flea beetles)) (3 adults, 3 collections at 3 sites)
Altica species 1 indet. (Alticinae) (4 adults, 2 collections at 2 sites)
Epitrix sp. cf. *integricollis* Jacoby (Alticinae) (7 adults, 1collecting at 1 site)
Epitrix species 2 indet. (Alticinae) (1 adult, 1 collection at 1site)
Hespera intermedia Jacoby (Alticinae) (1 adult, 1 collection at 1 site)
Longitarsus basutoensis Bechyné (Alticinae) (6 adults, 5 collections at 4 sites)
Longitarsus species 2 indet. (Alticinae) (1 adult, 1 collection at 1 site)
Podagrica oneili (Jacoby) (Alticinae) (1 adult, 1 collection at 1 site)
Genus et species 10 indet. (Alticinae) (1 adult, 1 collection at 1 sites)
Aspidimorpha confinis (Klug) (Cassidinae (Tortoise beetles)) (1 adult, 1 pupal case, 1 collection at 1 sites)
Aspidimorpha tecta Boheman (Cassidinae) (8 adults, 3 collections at 3 sites)
Cassida dorsovittata Boheman (Cassidinae) (8 adults, 3 collections at 3 sites)
Cassida lacrymosa Boheman (Cassidinae) (1 adult, 1 collection at 1 site)
Cassida litigiosa Boheman (Cassidinae) (6 adults, 3 collections at 3 sites)
Cassida melanophthalma Boheman (Cassidinae) (2 adults, 1 collection at 1 sites)
Laccoptera ruginosa Boheman (Cassidinae) (1 adult, 1 collection at 1 site)
Genus et species 8 indet. (Cassidinae) (1 pupa, 1 collection at 1 site)
Genus et species 1 indet. (Chlamysinae/Cryptocephalinae) (many case-bearing larvae, 1 collection at 1 site)
Genus et species 1 indet. (Chrysomelinae) (2 adults, 2 collections at 1 site)
Cryptocephalus characterus Suffrian (Cryptocephalinae) (2 adult, 1 larval and 1 pupal case, 2 collections at 2 sites)
Cryptocephalus species 2 indet. (Cryptocephalinae) (1 adult, 1 collection at 1 site)
Colasposoma sp. (Eumolpinae) (1 adult, 1 collection at 1 site)
Macrocoma sp. (Eumolpinae) (1 adult, 1 collection at 1site)
Scelodonta sp. (Eumolpinae) (3 adults, 2 collec-

tions at 2 sites)
Genus et species 4 indet. (Eumolpinae) (1 adult, 1 collection at 1site)

Curculionidae: (Weevils)
Embrithes cirricollis (Boheman) (Brachycerinae, Embrithini) (1 adult, 1 collection at 1 site)
cf. *Lalagetes* species (Brachycerinae, Embrithini) (1 adult, 1 collection at 1 site)
Sciobius bistrigicollis Boheman (Brachycerinae, Otiorhynchini) (5 adults, 2 collections at 2 sites)
Sciobius pullus (Sparrman) (Brachycerinae, Otiorhynchini) (1 adult, 1 collection at 1site)
Sciobius tottus (Sparrman) (Brachycerinae, Otiorhynchini) (2 adults, 1 collection at 1 site)
Sciobius species 4 indet. (Brachycerinae, Otiorhynchini) (1 adult, 1 collection at 1 site)
Sciobius species 5 indet. (Brachycerinae, Otiorhynchini) (3 adults, 1collecting at 1site)
Sciobius species 6 indet. (Brachycerinae, Otiorhynchini) (1 adult, 1 collection at 1 site)
Sitona discoideus Gyllenhal (Brachycerinae, Sitonini) (1 adult, 1 collection at 1 site)
Tanymecus probably *makkaliensis* Fåhraeus (Brachycerinae, Tanymecini) (1 adult, 1 collection at 1site)
Eremnus probably new species, near *Eremnus horticola* Marshall (Brachycerinae, Tanyrhynchini) (6 adults, 3 collections at 3 sites)
Eremnus segnis Marshall or species near (Brachycerinae, Tanyrhynchini) (14 adults, 2 collections at 2 sites)
Eremnus probably new species, near *E. murinus* Boheman (Brachycerinae, Tanyrhynchini) (5 adults, 2 collections at 2 sites)
Eremnus aciculaticollis Boheman or species near, #1 (Brachycerinae, Tanyrhynchini) (5 adults, 2 collections at 2 sites)
Eremnus aciculaticollis Boheman or species near, #2 (Brachycerinae, Tanyrhynchini) (2 adults, 1 collection at 1 site)
Baris species (Curculioninae, Baridini) (2 adults, 1 collection at 1 site)
Genus et species 1 indet. (probably *Ceutorhynchus* sp.) (Curculioninae, Ceutorhynchini) (12 adults, 6 collections at 5 sites)
Genus et species 2 indet. (Curculioninae, Ceutorhynchini) (1 adult, 1 collection at 1 site)
Genus et species 3 indet. (Curculioninae, Ceutorhynchini) (1 adult, 1 collection at 1 site)

b) Lepidoptera

Arctiidae:
Galtara purata Walker (2 adults and 2 larvae, 3 collections at 3 sites)

Geometridae: (Loopers)
Oedicentra albipennis Warren (Ennominae) (1 adult, 1 collection at 1site)
Comostolopsis stillata (Felder & Rogenhofer) (Geometrinae) (1 adult , 1 collection at 1site)
Eupithecia infelix Prout (Larentiinae) (5 adults, 4 collections at 4 sites)
Eupithecia nigribasis (Warren) (Larentiinae) (1 adult, 1 collection at 1 site)
Possible parasitoids: Braconidae.

Lasiocampidae:
Bombycopsis cf. *bipars* (Walker, 1855) (Lasiocampinae) (1 adult, 1collection at 1 site)
Probably *Bombycopsis* cf. *bipars* (Walker, 1855) (Lasiocampinae) (1 larva, 1 collection at 1 site)

Noctuidae:
Agrapha limbirena (Gueneé) (Plusiinae) (5 adults, 4 collections at 4 sites)
Possible parasitoid: Encyrtidae (*Copidosoma* sp.)
Trichoplusia orichalcea (Fabricius) (Plusiinae) (1 adult, 1 collection at 1 site)

Psychidae:
Genus et species indet. (Psychinae) (1 adult, 1 collection at 1 site)

Pyralidae:
Larva, genus et species indet. (1 larva, 1 collection at 1 site)
cf. *Ancylosis* (*Heterographis*) sp. (Phycitinae) (1 adult, 1 collection at 1 site)
Udea ferrugalis (Hübner) (Pyraustinae) (23 adults, 13 collections at 12 sites)

Tortricidae:
Lobesia (Polychrosis) stericta (Meyrick) (Olethreutinae) (3 adults, 2 collections at 2 sites)
cf. *Cydia* species (Olethreutinae) (1 adult, 1 collection at 1site)
Similar to '*Epichorista*' *perversa* Meyrick (Species 2 indet.) (Tortricinae) (15 adults, 1 pupa, 1 larva, 10 collections at 9 sites)
Probably near *Procrica* or *Niphothixa* (Species 1 indet.) (Tortricinae) (17 adults, 8 collections at 8 sites)
Possible parasitoids: Braconidae & Ichneumonidae.

c) Orthoptera

Caelifera:

Acrididae: (Grasshoppers, locusts)

Genus et species 1 indet. (16 nymphs, 1 collection at 1 site)

Genus et species 2 indet. (14 nymphs, 3 collections at 3 sites)

Genus et species 3 indet. (1 nymph, 1 collection at 1 site)

Genus et species 4 indet. (1 nymph, 1 collection at 1 site)

Genus et species 5 indet. (3 nymphs, 3 collections at 3 sites)

Genus et species 6 indet. (large number of nymphs, 1 collection at 1 site)

Tetrigidae: ('grouse-locusts' 'pygmy grasshoppers')

Genus et species indet. (1 adult, 1 collection at 1 site)

Ensifera: (Crickets, bush crickets, katydids)

Gryllidae: (Crickets)

Genus et species indet. (1 adult, 2 nymphs, 1 collection at 1site)

Tettigoniidae: (katydids, bush crickets, long-horned grasshoppers)

Genus et species indet. (2 nymphs, 2 collections at 2 sites)

d) Thysanoptera

Thripidae:

Anaphothrips cf. *tamaricis* (Priesner) (1 sample, 1 collection at 1 site)

Frankliniella occidentalis (Pergande) (2 samples, 2 collections at 2 sites)

Heliothrips haemorrhoidalis (Bouché) (1 sample, 1 collection at 1 site)

Heliothrips sylvanus Faure (1 sample, 1 collection at 1 site)

Hercinothrips bicinctus (Bagnall) (4 samples including 15 adults, 4 collections at 3 sites)

Hercinothrips jansei Faure (1 sample, 1 collection at 1 site)

Hercinothrips cf. *jansei* Faure (2 adults and 1 larva, 1 collection at 1 site)

Scirtothrips aurtantii Faure (2 samples, 2 collections at 2 sites)

Taeniothrips gowdeyi Bagnall (5 samples, 5 collections at 5 sites)

Thrips tabaci Lindeman (2 samples, 2 collections at 2 sites)

Thrips (Athrips) brevisetosus Trybom (3 samples, 3 collections at 3 sites)

Thrips sp. (5 samples including 8 adults and larvae, 5 collections at 5 sites)

ii) Root-feeders

Coleoptera

Chrysomelidae:

Larvae of the Eumolpinae are probably root feeders.

Colasposoma sp. (Eumolpinae) (1 adult, 1 collection at 1 site)

Macrocoma sp. (Eumolpinae) (1 adult, 1 collection at 1 site)

Scelodonta sp. (Eumolpinae) (3 adults, 2 collections at 2 sites)

Genus et species 4 indet. (Eumolpinae) (1 adult, 1collecting at 1 site)

iii) Sap-suckers

Hemiptera

Auchenorrhyncha (Cicadas, spittle bugs, leafhoppers, planthoppers)

Acanaloniidae:

Genus et species indet. (25 adults, 7 nymphs, 7 collections at 7 sites)

Achilidae:

Genus et species 1 and 2 indet. (2 adults, 2 collections at 2 sites)

Aphrophoridae:

Poophilus sp. (31 adults and 26 nymphs, 17 collections at 16 sites)

Cercopidae: (Spittle bugs)

Locris sanguinipes Walker (8 adults, 2 collections at 2 sites)

Sepulia sp. (2 adults, 1 collections at 1 sites)

Cicadellidae: (Leafhoppers)

Napotrephes africanus Stål (Agalliinae) (1 adult, 1 collection at 1 site)

cf. *Peragallia* sp. (Agalliinae) (10 adults, 1 nymph, 5 collections at 4 sites)

Mileewa adrastus Linnavuori (Cicadellinae) (1 adult, 1 collection at 1 site)

Mileewa signoreti (Stål) (Cicadellinae) (1 adult, 1 collection at 1 site)

Mileewa sp. (Cicadellinae) (1 adult, 1 collection at 1 site)1

Poecilocarda minuscula Linnavuori (Cicadellinae) (2 adults, 2 collections at 1 site)
Equeefa tsitsi Theron (Deltocephalinae) (1adult, 1 collection at 1 site)
Afrosteles distans (Linnavuori) (Deltocephalinae) (number of adults and nymphs, 2 collections at 2 sites)
Afrosus unimaculatus (Naudé) (Deltocephalinae) (1 adult, 1 collection at 1 site)
Balclutha sp. (Deltocephalinae) (1 adult, 1 collection at 1 site)
Exitianus capicola (Stål) (Deltocephalinae) (1 adult, 1 collection at 1 site)
Nesoclutha erythrocephala (Ferrari) (Deltocephalinae) (2 adults, 2 collections at 2 sites)
Recilia sp. (Deltocephalinae) (4 adults, 2 collections at 2 sites)
Tetartostylus brevistylus Theron (Deltocephalinae) (1 adult, 1 collection at 1 site)
Genus et species 8 indet. (Deltocephalinae) (3 adults, 5 nymphs, 3 collections at 3 sites)
Iassomorphus drakensteini (Naudé) (Iassinae) (1 adult, 1 collection at 1 site)
Narecho tecomariae Theron (Nirvaninae) (2 adults, 2 collections at 2 sites)
Penthimiola bella (Stål) (Penthimiinae) (5 adults, 1 nymph, 1 collection at 1 site)
Genus et species 1 indet. (Selenocephalinae) (1 adult, 1 collection at 1 site)
Genus et species 2 indet. (Selenocephalinae) (2 adults, 2 collections at 2 sites)
Genus et species 3 indet. (Selenocephalinae, Ianeirini) (many more than 14 adults, many more than 10 nymphs, 9 collections at 8 sites)
Accacidia sp. (Typhlocybinae) (4 adults, 1 collection at 1 site)
Empoasca barbistyla Poali (Typhlocybinae) (many more than 27 adults, many more than 5 nymphs, 13 collections at 12 sites)
Epignoma natalensis Dworakowska (Typhlocybinae) (many more than 26 adults, many nymphs, 11 collections at 9 sites)
Tzitzikamaia sp. (Typhlocybinae) (1 adult, 1 collection at 1 site)
Genus et species 5 to 8 indet. (Typhlocybinae) (many more than 10 adults, many nymphs, 7 collections at 7 sites)
Nymphs, genus et species indet. (Typhlocybinae) (3 nymphs, 1 collection at 1 site)
Coloborrhis corticina Germar (Ulopinae) (2 adults, 1 collection at 1 site)

Cixiidae:
Achaemenes entabeniensis Synave (1 adult, 1 collection at 1 site)

Delphacidae:
Embolophora britmusei Asche (1 adult, 1 collection at 1 site)
Sogatella vibix (Haupt) (2 adults, 1 collection at 1 site)
Sogatella sp. (1 adult, 1 collection at 1 site)
Thriamus sp. (1 adult, 1 collection at 1 site)

Dictyopharidae:
Genus et species indet. (1 nymph, 1 collection at 1 site)

Flatidae:
Dalapax postica (Spinola) (7 adults, 3 collections at 3 sites)

Issidae:
Genus et species indet. (8 adults, 6 collections at 6 sites)

Membracidae: (Treehoppers)
Nymphs, genus et species indet. (3 nymphs, 2 collections at 2 sites)

Tettigometridae:
Hilda patruelis (Stål) (1 adult, 1 collection at 1 site)

Hemiptera: Heteroptera

Coreidae: (Squash bugs)
Cletus sp. (1 adult, 1 collection at 1 site)
Coreidae nymphs, genus et species indet. (2 nymphs, 2 collections at 2 sites)

Lygaeidae:
Caenocoris nerii (Germar) (1 adult, 1 collection at 1 site)
Lasiosomus enervis (Herrich-Schaeffer) (14 adults, 8 collections at 8 sites)
Oncopeltus famelicus (Fabricius) (1 adult, 1 collection at 1 site)

Miridae:
Genus et species 1 indet. (47 adults, 5 nymphs, 13 collections at 12 sites)
Genus et species 2 indet. (5 adults, 5 collections at 5 sites)
Genus et species 3 indet. (3 adults, 2 collections at 2 sites)
Genus et species 4 indet. (3 adults, 2 collections at 2 sites)
Genus et species 5 indet. (1 adult, 1 collection at 1

site)
Genus et species 6 indet. (3 adult, 2 collections at 2 sites)
Genus et species 7 indet. (9 adults, 8 nymphs, 7 collections at 6 sites)
Genus et species 8 indet. (1 adult, 1 collection at 1 site)

Pentatomidae: (Shield bugs)
Bagrada hilaris Burmeister (1 adult, 1 collection at 1 site)
Boerias maculata Distant (3 adults, 2 collections at 2 sites)
Carbula sp. (1 adult, 1 collection at 1 site)
Caura rufiventris Germar (1 adult, 1 collection at 1 site)
Eysarcoris inconspicuus Herrich-Schaeffer (3 adults, 2 collections at 2 sites)
Halydicoris sp. (1 adult, 1 collection at 1 site)
Nezara prunasis Dallas (1 adult, 1 collection at 1 site)
Nezara viridula (Linnaeus) (5 adults, 5 collections at 5 sites)
Genus et species indet. (4 nymphs, 4 collections at 4 sites)

Plataspidae:
Brachyplatys sp. (2 adults, 1 collection at 1 site)

Pyrrhocoridae: (Cotton stainers)
Cenaeus carnifex (Fabricius) (4 adults, 1 nymph, 2 collections at 2 sites)
Dermatinus sp. (4 adults, 3 collections at 3 sites)
Scantius sp. (1 adult, 1 collection at 1 site)

Rhopalidae:
Leptocoris sp. (2 adults, 3 nymphs, 2 collections at 1 site)

Tingidae: (Lace bugs)
Genus et species indet. (1 adult, 1 collection at 1 site)

Hemiptera: Sternorrhyncha

Aleyrodidae: (Whiteflies)
Aleyrodes proletella (Linnaeus) (Cabbage whitefly) (many adults and nymphs, 13 collections at 10 sites)
Possible parasitoids: Aphelinidae (*Encarsia* sp.)

Aphididae: (Aphids)
Aulacorthum circumflexum (Buckton) (Mottled Arum aphid) (sample with adults and nymphs, 1 collection at 1 site)
Brachycaudus helichrysi (Kaltenbach) (Leaf-curling plum aphid) (large sample, 1 collection at 1 site)
Macrosiphum euphorbiae (Thomas) (Potato aphid) (sample with adults and nymphs, 1 collection at 1 site)
Possible parasitoids: Braconidae (many genera et species indet.) and Braconidae: Aphidiinae.

Diaspididae: (Armoured scales)
Aspidiotus nerii Bouché (Oleander scale) (5 samples, 5 collections at 5 sites)
Genus et species indet. (2 samples, 2 collections at 2 sites)
Possible parasitoids: Aphelinidae (*Encarsia* sp., *Aphytis* sp.)

Margarodidae: (Giant coccids and ground pearls)
cf. *Icerya* sp. (1 nymph, 1 collection at 1site)
Genus et species indet. (2 nymphs, 1 collection at 1 site)

Pseudococcidae: (Mealybugs)
Genus et species indet. (1 specimen, 1 collection at 1 site)

Psyllidae: (Jumping plant lice)
Genus et species indet. (3 adults, 2 collections at 2 sites)

v) Stem-borers

a) Coleoptera

Cerambycidae: (Long-horned beetles)
Promeces longipes Olivier (Cerambycinae) (3 adults, 2 collections at 2 sites)
Zosterius laetus Thomson (Cerambycinae) (3 adults, 1 collection at 1 site)
Sophronica sp. (Lamiinae) (1 adult, 1 collection at 1 site)

Chrysomelidae: (Leaf beetles)
Subfamily, genus et species indet. (stem-borer/gall former) (2 larvae, 2 collections at 2 sites)

Curculionidae:
Gasteroclisus species (Curculioninae, Lixini) (2 adults, 2 collections at 1 site)
Lixus species (Curculioninae, Lixini) (1 adult, 1 collection at 1 site)
Mecysolobus species (Curculioninae, Molytini) (1 adult, 1 collection at 1 site)
Genus et species 3 indet. (Curculioninae) (1 adult, 1 collection, at 1 site)
Genus et species.1 to 4 indet. (Scolytinae) (5 adults, 4 collections at 4 sites)

Curculionidae of unknown affinity:
One weevil larva was collected from a “cell”

(possibly a gall) in a stem (1 site)
Stem-borers among the Curculionidae are mostly Molytini and Lixini of which a small number were collected during this survey. However, this larva seems to be too large for the species collected from these groups (pers. comm., R.G. Oberprieler). Rearing this larva to adulthood will allow identification.

Languriidae: (Lizard beetles)
Genus et species 1 to 2 indet. (4 adults, 2 collections at 2 sites)

b) Lepidoptera

Tineidae:
Opogona omoscopa (Meyrick) (1 adult, 1 collection, 1 site)

Conclusion following two years of surveying

Tests with potential biological control candidates, on alternative food plants under artificial conditions, are usually expensive and more so if done in quarantine in the new country. Results may be misleading and lead to unnecessary and premature rejection of good candidates. Information on the occurrence of such insects, on closely related and similar plants in their native habitat, could reduce the possibility of wasting time and resources on candidates that may later prove unacceptable. Conversely, proof of their absence on such plants but abundance on the targeted weed in the field, would support the notion of co-evolution with, or restriction to, one or a few closely-related plants, and possibly even host-specificity (monophagy). In practice these results could aid greatly in designing meaningful tests to be done under controlled conditions and with correct selection of test plants from the proposed new environment.

The second year of surveying in the field revealed significant data:

- ***Acrolepia* sp., the leaf- and stem-mining moth, was entirely restricted to Cape ivy.** Ecologically homologous moth species occurred on seven of the other 12 plant species.
- **Defoliating larvae of the moth *D. rostrata*, were found on only one other host in the field, namely *Senecio angulatus*.** This plant is also known to be a host where grown in gardens. Similar, ecologically homologous moth larvae were found on two of the other plants surveyed.
- ***Parafreutreta regalis*, the stem-galling fly, was only reared from Cape ivy.** Ecologically homologous flies were reared from stem galls on five of the other plants surveyed.
- **Damage by adults of the of the unidentified leaf-feeding beetles, Chrysomelidae: Galerucinae, was found to be limited to Cape ivy**, also suggesting a restricted host range. The site for larval development on the plant still has to be determined for these beetles.
- **Maggots of flies in the family Agromyzidae were found to develop in stems of Cape ivy and of nine of the plant species studied.** Until identification, or at least expert comparison of the reared adult flies has been done, it is not possible to determine if one or more species of fly may be involved.

These results, exceptionally narrow host ranges amongst the likely alternative plants, suggest that further, more definitive work on at least four of the five insects previously selected, seems warranted. Also that some, if not all, may prove to be safe and most valuable for use as biological control agents in California and elsewhere.

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The Role of Fire in Promoting Plant Invasions

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The abundance of invasive plants in a landscape typically increases after large scale disturbances such as fire. Examples of where fire has promoted the dominance of invasive non-native species include giant reed grass and tamarisk in riparian habitats; brooms and gorse species in Northern California, highway iceplant in coastal chaparral; and invasive grasses and forbs in many other habitats, especially in arid and semi-arid regions of the western USA. Invasive exotic plants often become established before fire, but then become dominant components of plant communities after fire. The mechanisms by which fire promotes the dominance of invasive plants appear to be related to increased availability of soil nutrients and light and reduced competition from native species after fire.

The effect of fire on resource availability depends on fire intensity. Soil nutrient availability can increase after fire, particularly in habitats with naturally low nutrient levels such as deserts, serpentine outcrops, and some low elevation coniferous forests. Very cool fires have no effect and very hot fires decrease soil nutrient availability, but most fires include significant areas of moderate intensity that lead to increased nutrient levels. Increased soil nutrient levels are often more effectively exploited by invasive than native plants, due to their high relative growth rates and ability to quickly disperse into burned areas.

Light levels can increase after fires where levels are naturally low due to high plant cover. High plant cover prevents light from reaching the soil surface, which suppresses seed germination. When this impediment is removed after fire, seeds germinate profusely from the seedbank. In habitats such as chaparral where native plants have evolved adaptations to recover from fire, native shrubs often reestablish continuous cover within a few decades and suppress seed germination until the next disturbance event. However, an individual fire can allow invasive species to establish a foothold in new areas, although they may only be present as dormant seeds in the soil seedbank during later stages of chaparral succession. Following the next fire, invasive species can reach maximum cover more rapidly because they are already present on the burned site.

The use of limiting resources or maintenance of light limitation by native perennial plants typically decreases or is interrupted by fire due to the combustion and loss of photosynthetic biomass. This in turn may facilitate the establishment of previously suppressed exotic species in the postfire landscape. As invasive species become dominant, and reduce levels of soil water and mineral nutrients, they hinder the reestablishment of native shrub and bunchgrass seedlings. This has been observed in Great Basin, Mojave Desert, and coastal sage scrub habitats in California.

Many invasive plants are highly flammable, and can increase fire frequency to the point where native plant communities cannot recover. High fire frequency promotes high light and soil nutrient availability and reduced competition from native perennial plants, all factors that promote dominance by invasive species. Frequent fires can maintain high light availability and reduce competition from native species that cannot tolerate recurrent fire, creating ideal conditions for invasive plants. Even in habitats that evolved with fire such as chaparral, return intervals shorter than 15-20 years can convert native shrubland to invasive alien grassland.

The interrelationships between fire and plant invasions have only recently received significant attention from land managers and research scientists. Accordingly, much of what we describe here is based on studies focused on either fire or invasive plants, but not on their interrelationships. Some integrated studies are in progress, but much more of this type of research is needed. Land managers need to understand how fire and invasive plants are interrelated to avoid the often conflicting results that occur when fire and natural resource plans are not well integrated.

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Fire Regimes Changed By Exotic Plants

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Fire is one of severai important disturbance factors promoting plant invasions of natural ecosystems. This can occur even in vegetation generally regarded as "fire adapted" because species are fine-tuned to a particular fire regime. Plant invasions can occur when the natural fire regime is altered and the subsequent invasive plants often modify the fuel structure in ways that further upset ecosystem functioning. High fire frequency favors herbaceous growth forms over woody growth forms and enhances the competitive displacement of native species with non-natives. Type conversion of shrublands to grasslands alters the natural fire regime by reducing fire intensity and increasing fire frequency. The latter results from 1) increased fine fuels with greater ignitability, 2) increased seasonal window of opportunity for fires and 3) enhanced fire spread characteristics of herbaceous fuels, which spread fire both horizontally through the stand and vertically into the shrubs with very little wind.

Ecological Effects of Exotic-Altered Fire Regimes

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The frequency and intensity of disturbance in systems dominated by exotic vegetation can differ greatly from the previous regime that shaped the native vegetation community prior to conversion. Consequently, the effects on habitats and dependent animals can be magnified or changed in systems altered by exotic vegetation. The Snake River Birds of Prey National Conservation Area, which covers approximately 200,000 ha in southwestern Idaho, represents an extreme example of low-elevation shrubsteppe habitats that are in transition to a new state dominated by exotic annuaI vegetation. Over one-half of the shrubland communities existing in 1979 have been converted into extensive grasslands dominated by cheatgrass (*Bromus tectorum*). The average retum interval between fires decreased to 27.5 years between 1980 and 1994 compared to 80.5 years between 1950 to 1979. Although wildfires were the primary and immediate cause of habitat conversion, areas of greatest landcover change also had been grazed by livestock or used for military training, Using computer models to simulate spatial and temporal dynamics of vegetation, we determined that shrublands would be virtually absent from the study area within 25 years if the current fire regime were maintained. In contrast, shrublands could be restored when large fires were eliminated or suppressed. However, the lack of available seed sources for shrub restoration limited natural recovery in regions dominated by extensive grasslands; the largest grassIands still had not recovered to a shrubland state after 100 years in the simulation. Increases in dominance by cheatgrass increased the rate at which shrublands were lost as well as decreased the percent cover of shrublands in the landscape primarily by increasing fire frequency and size. Numbers of blacktailed jackrabbits (*Lepus californicus*) reflected the loss of shrublands and were successively lower during population peaks (1971, 1979-1982, 1990-1992. Total numbers of golden eagles (*Aquila chrysaelos*), which prey on jackrabbits, also have declined between 1971 and 1994. The reiationship behveen habitat change and numbers of Paiute ground squirrels (*Spermophilus mollis*) and prairie falcons (*Falco mexicanus*) was more complex

and less predictable than the golden eagle and jackrabbit response. Exotic annual grasslands had higher densities of ground squirrels in nondrought years compared to shrublands or habitats containing perennial However, ground squirrel populations in grasslands were more susceptible to environmental fluctuations compared to populations in habitats having a more drought-resistant component of perennial shrub vegetation. Although numbers of prairie falcons have declined from 1976-1997, their decline was not directly linked to either changes in ground squirrel populations or to habitat changes. Many shrubsteppe systems, particularly low elevation sagebrush steppe, may be irreversibly altered or eliminated unless current rates of fragmentation and loss of shrublands are reduced. Land managers now face the difficult conundrum of controlling the destructive component of a disturbance at the same time as they attempt to restore shrubland systems that include essential maintenance processes. In addition, simply restoring shrubland components may not have the anticipated result because responses by raptors and their primary prey to habitat changes were not always correlated.

The Use of Fire to Control Exotic Plants

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Fire has a long association with vegetation management of both wildland and cropland environments. The application of fire in these two environments may differ. In cropland environments, interest in weed flaming (ignited gas or liquid fuels from one or more nozzles directed at the weeds or the soil) has increased as farmers look for non-herbicide weed control techniques. In wildland environments, prescribed fire is the common fire-related weed control technique. Prescribed fires generally use the litter or standing-dead plants as fuel for the fire. Both approaches will be discussed and examples of current and proposed uses of weed naming in wildland environments will be presented. As with any tool for.plant control, the effectiveness of fire in weed control will depend the timing of the application reiative to the life cycle of the plant. Depending on the plant species and on the timing of the fire, fire may be used to kill young plants, mature plants or seeds or to prevent seed production for a season. However, some plants are adapted to fires and thus are able to tolerate or resist being burnt. I will relate plant morphology, life history and community associations to the success or failure of fire-induced plant control. I will use two examples to demonstrate each extreme. The Bureau of Land Management in Oregon is using prescribed fire as an initial control treatment in an integrated weed management plan in a location infested with medusahead, *Taeniatherum caput-medusae*. They follow the initial fire with spot treatments with herbicide and with revegetation of a diverse mixture of perennial grasses, forbs and shrubs. The USGS and the US Fish & Wildlife Service used fire as one of 16 treatmenes examined for the control of perennial pepperweed, *Lepidium latifolium*. The fires were difficult to burn and had no effect on the weed because the perennating buds of this species are below ground. When fire does reduce plant populations, a single fire application alone is generally not sufficient for prolonged plant control. Therefore, integrating fire into a larger ecologically based control plan that incIudes techniques for restoring or enhancing the desired vegetation on the site may be necessary.

Postfire Restoration Strategies to Minimize Aliens

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The postfire environment is ideal for the growth of many invasive non-native plant species: lots of light, bare mineral soil, little or no competition from other plants, and readily available nutrients deposited in the ash. Activities associated with emergency postfire watershed rehabilitation and forest restoration can also bring seeds of invasive species into a burned area. Preventing alien plant invasion involves a three part attack: 1) Eliminate or minimize inadvertent introductions from rehabilitation/restoration actions; 2) Prevent establishment of nonnative species that do get into the area; 3) Control established plants while the infestation is small. Emergency postfire watershed rehabiiitation on steep slopes often involves the application of mulch or seed to provide quick soil stabilization and to reduce the chances for flooding. Both techniques can introduce weed seeds. Use of rice straw for mulch in dry upland areas reduces the chances that any weeds that germinate could survive.

If available, weed-free straw from native species can be used for mulch; it will introduce herbaceous plant seeds, but not invasive species. Grass seed used for emergency seeding should be from native species or short$ived, non-invasive non-natives. Use of cereal grains has gained popularity, but the seed source should be checked carefully for weed seed content. If possible, germination tests should be run ahead of seed application. To prevent introduction of invasive plants from equipment used for rehabilitation projects, the tires and other soil-collecting structures on vehicles and equipment can be washed prior to entering a burned area or when moving from areas of known pest plant infestation to cleaner areas. Planted nursery stock should be carefuIly inspected to make sure no weeds are lurking in the potting medium or clinging to bare-root seedlings. Preventing establishment of invasives includes minimizing ground disturbance in the burned area to reduce the chances for successful germination. Seeding with a non-persistent grass species to crowd out non-native weeds has been suggested, but data on the effectiveness of this practjce are scarce. Regular monitoring of the burned area to detect early establishment of invasive species is critical to keep small infestations from growing. Hand or chemical methods can then be used to eliminate genninated weeds. Enlisting an enthusiastic cadre of "weed warriors" to battle invaders will greatly increase the percentage of a burn that can be monitored (just make sure the "warriors" take precautions not to introduce weed seeds during their monitoring efforts!). Priority areas for monitoring include roadsides and areas nearest to existing stands of non-native plants. Invasive species with wind- or animal-dispersed seeds are more likely to appear the second and subsequent years after Fire, rather than the first, thus continued vigilance is necessary.

Seed Biology and Control of Jubatagrass

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Jubatagrass (*Cortaderia jubata*) is an introduced perennial grass, native to the Andes of South America. In California, it invades disturbed areas along the coast from the Oregon boarder to San Diego. Jubatagrass establishes dense populations that reduce conifer seedling recruitment and displace native plant species. Because jubatagrass primarily spreads by seed, successfuI management of jubatagrass must be based on both the study of seed biology and control methods. Laboratory, greenhouse and field studies revealed that jubatagrass is able to produce an average of 80,000 seed per inflorescence, of which 30% are germinable. Seed germination is not limited by temperature, but is significantly reduced in the dark and if buried in the soil at depths greater than 2 cm. Juatagrass does not persist in the soil for more than 4 months and contains no seed dormancy mechanisms. Thus management of a soil seed bank is not necessary to controlling jubatagrass. Attention should be paid to controlling mature plants in order to reduce seed groduction.

Control methods for jubatagrass has traditionally been limited to mechanical removal and high volume ("spray-to-wet" equivalent to 200-250 GPA) spot applications of glyphosate. In order to develop alternative economical control options for jubatagrass in sensitive coastaI habitats, several herbicides, rates, treatment times, formulations, and application methods were evaluated for jubatagrass control at Vandenberg Air Force Base in Santa Barbara County, California. Glyphosate at 1.4% low volume (90 GPA) resulted in approximately 80% jubatagrass control. Regrowth did occur the following summer. Rates below this did not provide acceptable controI. Low volume fall application of fluazifop at 0.5% and imazapyr at 0.5% and 1.1 % gave approximately 95% jubatagrass control with no regrowth the following year. The cost of application with these alternative treatments was comparable to a conventional high volume glyphosate application. In some coastal habitats, jubatagrass coexists with sensitive endemic broadleaf forbs and shrubs such as *Arctostaphylos* and *Ceanothus*. Under these conditjons, the graminicide fluazifop provides a safer option than non-selective herbicide treatments.

Jubatagrass vs Pampasgrass: A growth analysis and comparison of invasive potential

Alison Tschohl, University of California, Davis

Two species of *Cortaderia* are widely distributed weed problems in California. Introduced through the nursery trade to Santa Barbara in the mid 1800s, both

species escaped cultivation and spread rapidly throughout the state. Jubatagrass (*C. jubata*) is the dominant species in Northern CA wlhile pampasgrass is most prevalent south of Santa Barbara. Jubatagrass occupies a narrow band along the entire coast, restricted to the influence of coastal fog. The distribution of pampasgrass (*C. selloana*) overlaps heavily with jubatagrass in the central coast but the species has also escaped to inland regions, especially riparian zones in Sacramento and San Bernardino counties. Once estabiished, both specjes are strong competitors.

We hypothesizedl that differences in environmental tolerances in the seedling stage of both species may play a role in their geographic distribution. Seedlings of *C. jubata* and *C. selloana* were grown in the greenhouse at four different light intensities and in a controlled environment across a range of seven temperatures. A variety of growth parameters were measured and compared for both species.

The data indicate that *C. selloana* is a much more vigorous species. Plant height and root mass are ecologically relevant growth parameters that are important in colonizing bare ground. Under optimal conditions of ample light, water, and moderate temperature, pampasgrass grows significantly faster and taller then *C. jubata*. At full sun, *C. selloana* had four times greater root mass. This declined to two and half times more roots at 60% sun. When light is limited (30, 15% sun) the difference disappears and the species become nearly indistinguishable.

In the temperature experiment, optimal growth for both species was 20C (68F). At 37C (98F) *C. jubata* had significantly greater mortality. Taken together with the light data, this may partially explain the failure of *C. jubata* to establish in inland. Both species do equally well in the cool, foggy coast, but *C. selloana* appears to thrive in the wanm, high light interior.

Differences in reproductive strategy may also piay a role in the geographic distribution. Populatians of *C. jubata* consist of entirely female plants which produce genetically identical seed through an asexual process called apomixis. This selfing strategy is advantageous in establishing founding populations when colonizing new areas, but there is little opportunity for adaptation to new environments through genetic recombination. In contrast, *C. selloana* populations have separate male and female p]ants that reproduce sexually. Outbreeding species have the ability to react to selective pressures and it may be that *C. selloana* is slowly adapting to interior climates. One possjble explanation for the current geographic distribution is that *C. jubata* has saturated its climatic range on the coast, but *C. selloana* is still in an expansion phase, poised to expand throughout the central part of California.

Hand Control of Cortaderia in Remote Mountain Sites

Ken Moore, Wildlands Restoration Team

The Wildlands Restoration Team is a program using hand removal by volunteers to control several invasive plant species on over 50,000 acres of state park lands In the Santa Cruz mountains. *Cortadera* removal has been one of our major tasks, consuming over 10,000 hours over the last 9 years on 104 separate work sites. Many of these sites are in extremely remote places, requiring miIes of off-trail hiking on steep slopes to access.

Specialized tools and techniques were developed to accomplish this task, some requiring rope work on near vertical cliff faces. Since transporting and applying herbicides on this terrain would be dangerous as well as infeasible, hand removai was the only control option. Despite the logistic difficulties involved, *Cortaderia* removal has been one of the outstanding successes of our program. Most of the sites have been completely cleared of *Cortaderia*, currently requiring little or no follow up work.

Pampas Grass Control in Goleta Slough, California

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Santa Barbara Audubon received a CalEPPC grant for a Pampas grass control demonstration project in the 2250-acre Goleta Slough Management Area in April 1998. While there is still Pampas grass in this area, we now have hundreds of acres nearly clear of Pamgas grass. With volunteers and contractors, Audubon has removed major infestations and scattered plants. The tools of restoration have been backhoe, sharpshooter shovel, climbing gear to scale ocean bluffs, RoundUp and Rodeo, pulaski, and chainsaw. We have educated the public, regulatory agencies, and landowners, with varying responsiveness, on the invasive character and poor wildlife habitat value of Pampas grass, and the need of coordinated control efforts.

Does Sawdust Addition Reduce Soil Ammonium Levels and Promote Native Grass Growth in Competition with Exotic Grasses?

Jeffrey D. Corbin and Carla M. D'Antonio, Univ. of Calif., Berkeley

The maintenance of native grass biodiversity in California grasslands in the face of invasion by Eurasian annual and perennial grasses has proven to be a formidable challenge. Whereas perennial grasses such as *Nassella pulchra*, *Festuca rubra*, and *Agrostis oregonensis* were thought to dominate coastal grasslands prior to European settlement, introduced annual and perennial grasses are dominant even in stands where some native bunchgrasses have persisted. Evidence that the exotics are capable of higher rates of growth than the natives suggests that the exotics may rely on relatively high nitrogen availability to fuel growth. We tested whether experimental addition of sawdust reduces plant-available nitrogen in the soil, and whether native grasses fare better in competition with exotic grasses under these reduced-nitrogen conditions. In 1998 we established a series of plots in which three native perennial bunchgrass species were grown alone and in combination with three exotic annual grass species. In the first growing season, above-ground production of all three native species was reduced by sawdust addition and by competition with exotic annual species. However, when in competition with the exotics, two of the three native grass species experienced greater growth with sawdust addition than without sawdust addition. In the second growing season (1999-2000), we detected significantly slower rates of N mineralization in sawdust-amended plots, though there was no benefit of sawdust addition on native growth. By the end of the second year, any positive impact of sawdust addition from the first season was no longer detectable. We hypothesize that the perennial native grasses were sufficiently competitive with the exotic annual grasses in the second year that sawdust addition no longer disproportionately impacted the exotics.

Role of Mycorrhizae in *Centaurea* invasions

Marilyn J. Marler and Ragan M. Callaway, Div. of BiologicaI Sciences, Univ. of Montana

We have found that mycorrhizal fungi are important mediators of plant competition during *Centaurea* invasion of grasslands in Montana and California. In Montana grasslands, the invader *Centaurea maculosa* has higher levels of colonization by mycorrhizal fungi than dominant native bunchgrasses, and in the presence of mycorrhizal fungi *C. maculosa* has a greater competitive effect on native bunchgrasses than when no fungi were present.

This effect of mycorrhizae on interspecific competition may be due to carbon translocation from native plants to *C. maculosa*. Stable isotope analysis indicates that up to 15% of aboveground biomass of *C. maculosa* can be attributed to neighboring plants. However the tendency of carbon to move from native "donors" to *C. maculosa* "recipients" is species specific.

We found similar relationships among mycorrhizal fungi, *C. melitensis*, and California grasses. In greenhouse studies, *C. melitensis* biomass was significantly greater in the absence of mycorrhizal fungi when no neighbors were present, yet significantly greater in the presence of mycorrhizal fungi with *Nassela pulchra* as a neighbor. Again, the trend is species specific since the presence of mycorrhizal fungi had no effect on *C. melitensis* biomass when *Avena fatua* was the neighbor.

It appears that AM fungi facilitate *Centaurea* invasions into perennial grasslands. These interactions have implications for biological control programs and revegetation strategies.

Soil consequences of *Bromus tectorum* invasion

Jayne Belnap, USGS-BRD, Moab, UT

Cheatgrass (*Bromus tectorum*) and other introduced annual grasses have become frequent members of many plant communities. However, distribution of these annual grasses is often patchy, both on a local and landscape scale. Recent research characterizing environments where cheatgrass does and does not occur showed that soil texture and chemistry can enhance or prevent cheatgrass invasion, regardless of past or ongoing disturbance. Cheatgrass was shown to have

high root cation-exchange-capacities (CEC) when compared to native shrubs and grasses. In fine-textured soils with high CECs, cheatgrass was found to dominate the herbaceous plant layers. In sandy soils with much lower CEC, however, cheatgrass distribution was found to be much more patchy, and highly correlated with soil K/Mg ratios. Extrapolation of these findings may enable us to better predict soils susceptible to cheatgrass invasion, as well as aid in native plant community restoration. A *Bromus* invasion into an ungrazed, undisturbed native perennial bunchgrass community has allowed us to investigate the influence of *Bromus* on native plants and soils independent of disturbance. In only 3 years, *Bromus* dramatically altered plant species cover, composition and litter cover; biological soil crust composition and nitrogen fixing capabilities; soil food webs; and soil chemistry. Most native annuals have been eliminated. *Hilaria jamesii*, a perennial native grass species, shows declines in above-ground biomass, although no individuals are dying. In contrast, mortality of *Oryzopsis hymendoides* has been noted. Plant litter cover has increased dramaticaily. Soil lichens are being replaced by mosses and liverworts, probably a result of shading from increased plant and plant litter cover. As soil lichens are an important source of nitrogen for this ecosystem, nitrogen inputs are decreasing. Changes in plant productivity and biological soil crust composition are altering C inputs. Soil food webs are changing. Bacterial and fungal active and total biomass is increasing; however, the fungi are increasing more rapidly than the bacteria. Microarthropod populations are significantly reduced, and population structure altered. These changes are expected to alter decomposition rates and therefore affect soil nutrient availability in the invaded soils.

Killing Weeds With Computers

Steve Schoenig, California Department of Food & Agriculture

Information Technology (IT) is thc science of collecting, organizing, visualizing and analyzing data in ways that benefit the understanding and management of systems. What this means for invasive species is new ways to collect, use and share weed data. This science has made major strides with the development of high-speed desktop computers, the Internet, GIS and modern programming languages. Major areas of weed science that involve IT are:

- GPS and remote sensing for weed inventory;
- GIS and databases for the storage, display and analysis of weed data;
- Expert systems for “smart” plant identification;
- The Internet for sharing and obtaining data;
- Spatial modeling for predictive analysis;
- DigitalCameras;
- Objective scoring systems for weed ranking.

Remote Sensing for Invasive Species Detection and Mapping

Susan L. Ustin, Center for Spatial Technologies and Remote Sensing, Univ. of California, Davis

Managers charged with controlling the introduction and spread of invasive weeds need new tools to map their location and assess the threat to the environment. Remote sensing is the only practical method to acquire spatially detailed data over a large area. Because images can be acquired multiple times it provides a way to directly assess changes (location, density) over time. A large and growing number of aerial and satellite platforms are available for use that have a wide range of spectral, spatial and temporal resolutions. Digital remote sensing images offer many advantages over photography including convenience in computer-aided data analysis and display and entry into GIS databases. Yet it is not always easy to interpret this information in a form suitable for management decisions. To use remote sensing information accurately and effectively to map weeds, we need to understand the environmental properties that affect the spectral measurement. I will summarize the characteristics of the main categories of remote sensing instruments and what types of information they can provide. The deveiopment of a remotely sensed map of leafy spurge will be used to illustrate the potential for mapping weeds basea on their unique spectral signatures.

Using Volunteers in Regional Mapping Programs

Hal Romanowitz, Tehatchapi Resource Conservation District (TRCD).

The Tehatcapi RCD has undertaken the ambitious goal of eradicating yellow starthistle(YST) from the Tehatchapi valley and surrounding areas. To accomplish this goal, many partners have been enlisted. One of the most successful components is the use of high school students, retired realtors, and others to map YST throughout the region on assessor parcel maps. These maps are then used to launch a homeowner contact program and cooperative control program. This program aims for permanent results and is a long term commitment to keeping YST out of the valley once it is eradicated.

The Californiaa Database

Ann Dennis and Tony Morosco, CalFlora Database

CalFlora already.serves as a repository and clearinghouse for plant information from a wide variety of sources. CalFlora provides species accounts occurrence data, and photos for all California vascular plants, both native and introduced, that are recognized as naturalized in California. Through an initiative cosponsored by Caltrans, we are currently focusing on expanding occurrence data and photo holdings for invasive exotics, and developing tools for accepting occurrence observations in real-time from observers from across the state. We are also creating online query, display and download tools tailored to needs of users interested in weed management, mapping, and GIS analysis.

Weed Bio-informatics: Sharing Weed Data

Jim Quinn, UC Davis

Management of invasive species can frequently benefit from data from other programs, locations, or countries. A number of inter-related programs are beginning to develop strategies for sharing data on locations, properties, experts, and management strategies, based on standardized data exchange standards and controlled vocabularies. Some of the efforts now being coordinated include programs in the National Biological Information Infrastructure (NBII), the U.S. Invasive Species Council initiative, the North American Biodiversity Information Network (NAFTA), the Inter-American Biodiversity Information Network (Summit of the Americas), and the Global Invasive Species Programme (TUCN, UNEP, and others). Data shared includes species of concern to different organization, experts, control projects, identification materials, and location maps. These data can be used to semi-automatically produce analyses useful to managers, including early warnings (Global Invasive Species Program and Federal Interagency Committee for the Management Noxious and Exotic Weeds) and models of likely spread of new invaders (Species Analyst).

SE.SSION VII: Concurrent I

Assessing Cape-ivy Control in Two California National Parks

Ellen E. Hamingson and Maria E. Alvarez, Golden Gate Nat'l Recreation Area, Sausalito, CA

Given the current rate and scale of biological invasions, knowledge about effective control methods linked with well planned invasive plant control programs are critical to effectively protect and manage ecosystems. Since complete eradication of most invasive species is usually not possible, control programs that target control in areas where invasive species are having the greatest impact, use a variety of methods, assess the efficacy of these methods and conduct long-term follow-up should demonstrate the greatest success. Two National Parks in northern Califomia, the Golden Gate National Recreation area and the Point Reyes National Seashore are midway through a three-year cape-ivy (*Delairea odorata*), control grogram. In natural areas cape-ivy forms large patches up to several acres in size and creates a dense groundcover cover, smothering herbs and large shrubs and climbing trees to 6m in height. Cape-ivy spreads primarily by vegetative reproduction of stolons and is difficult to remove. Much cape-ivy containment and removal has been accomplished and learned during the last eighteen months. This information will assist resource

managers in understanding the variety of strategies, crew types, control methods and logistics involved in controlling a highly invasive vine throughout a variety of different habitats; including willow riparian, alder riparian, coastal scrub, seasonal wetlands and springs, grassland, dunes, and exotic shrub and forest habitats.

A Virtual Toolbox Tour for Control of Invasives in Fort Ord PubIic Lands

Laura Lee Lienk, Service Learning lnstitute, California State Univ. Monterey Bay, CA

This weed education/outreach presentation will highlight tbe tools and resources that have been assembled to form the Return the Natives - WeedEd curriculum. The curriculum provides both web-based and print based resources for educators and outreach The presentation will emphasize the “recognize, remove, restore, return” approach to restoration education being tested on the Ft. Ord Public Lands and in Monterey Area Schools. Images of students engaging in the WeedEd activities will serve to reinforce the necessity of a restoration approach to invasive plant education.

The Presence of Fennel Affects the Distribution of Lizards on Santa Cruz Island

Jennifer K. Gibson, National Park Service, Whiskeytown NR4, Whiskeytown, CA

Fennel (*Foeniculum vulgare*) is an invasive noranative herb that has become dominant in Santa Cruz Island's grassland communities. This study examined the effects of removing fennel on two lizard species, Sideblotched (Uta stansburiama) and Southem Alligator lizards (Elgaria multicarinata). The data demonstrate that the impacts of fennel on lizard distribution and abundance are related to structural changes that favor one species (Southern Alligator Lizard) and selects against another (Side-blotched Lizard). The reduction of fennel through prescribed burning and the application of a relatively light concentration of triclopyr (Garlon 3A) increased the abundance of Sideblotched lizards while at the same time reduced the abundance of Southern Alligator lizards. These methods of reducing fennel are successful in that the treated fennel plots resembled grassland control plots in the distribution and abundance of lizards the year following treatment. This study is significant because rarely has there been a study on the impact of removing a non-native species from an ecosystem.

SESSION IX: Concurrent 2

Nature of the Invasive Species *Prosopis juliflora* in Sri Lanka

Dr. lndrani Seveneratne, Botany Dept. Univ. of Colombo, Sri Lanka

Prosopis juliflora (*Fabaceae*) is a species native to Central and Northern South America. It was introduced to Humbantota in early 1950s to improve the salt affected soils and the cover in this area. It has now become invasive and a serious threat to the Bundala National Park, the only wetland in Sri Lanka listed under Ramsar Convention.

Main objectives of this research study were to find the distribution, impacts on native flora and human factors contributing towards invasiveness and possible control methods. So far the distribution of *P. juliflora* is limited to the two arid areas in Sri Lanka, Hambantota and Puttalam districts. Study has shown that within the Bundala National Park it affects all types of plant vegetation except the sand dunes. Among the identified indigenous flora within Hambantota area, the most affected native tree species is *Salvadora persica*, one of the few species which shows affinities of Sri Lankan flora with that of African flora. The aggressive growth of this invasive species along the road side has become a problem to humans. It is preferred as a fuel wood but at present it is used on a small scale.

Control of Barbed Goatgrass Using Prescribed Burning

Joseph M. DiTomaso, UC Davis; Adina Merenlender and Kerry Hiese, UC Berkeley, Hopland Research and Extension Center, Hopland CA

Barbed goatgrass and other undesirable annual grasses are outcompeting all other grasses, leading to a homogenization of many grassland ecosystems. These non-indigenous species are causing detrimental impacts to native biodiversity including threatened and sensitive

plants all of that influences the natural ecosystem process of northcoast watersheds. The primary objectives of this project are to 1) reduce the levels of barbed goatgrass and other noxious annual grass infestations, 2) improve forage quality of these grasslands by restoring both desirable annual forage species and native California perennial grasses, and 3) increase total plant diversity in this California grassland ecosystem.

In two separate gastures (South and Little Buck) treatments consisted of a mid-May burn in 1997 and a July burn in 1998. Line transects and quadrat analyzes were conducted to estimate cover of all species present and soil cores were collected to determine the effect of the treatment on goatgrass seedbanks. after two years of treatment, complete control of barbed goatgrass was achieved in the Little Buck pasture. Prescribed burning aiso significantly increased total grass cover in Little Buck pasture. Native perennial grasses increased from 1% prior to the burn to 15% after 2 consecutive years of buming. Native forbs also increased from 3 to 12% after 2 years of burning in Little Buck pasture. In the South pasture, two soil types were present, including a moist lower section of the pasture and a higher, drier serpentine section. Consequently, we burned and measured various parameters in these two regions and compared this with an unbumed control site. One year of burning reduced barbed goatgrass by 84% in the upper burn site and ~5% in the lower burn site. In the second year, there was not enough vegetation to provide a complete burn in either of these two sites. Ninety-two percent of the upper site was burned and only 44% of the lower site was burned. This corresponded to 98% control in the upper site and 75% control in the lowersite. These results indicate that prescribed burning is a very effective tool for barbed goatgrass control. In addition, it has been shown to enhance the population of native species, particularly perennial grasses and legumes.

Factors affecting successful control of French and Scotch broom and restoration of native communities in coastal California grasslands

J. M. F. Alexander and C. M. D'Antonio, University of California, Berkeley

French broom (*Genista monspessulana*) and Scotch broom (*Cytisus scoparius*) are aggressive, invasive, nitrogen-fixing shrubs from Europe that are now abundant in California. Once established, broom plants form dense, practically monotypic stands and spread into areas dominated by native plants. In an effort to restore native plant communities, land managers control broom through cutting, pulling, and prescribed burning. We surveyed the community composition of areas that had received different numbers and types of management treatments to assess which environmental factors are important in effectively controlling broom and restoring native plants. We measured soil characteristics, including moisture, depth, and total carbon and nitrogen, and environmental variables such as slope, aspect, rainfall, and elevation, as well as site history variables. Using a canonical correspondence analysis, we found soil carbon and nitrogen, and number of burn treatments were useful in separating species groupings on the first axis, and time since last burn was important in further separating groups on the second axis. Repeated burning did reduce broom abundance aboveground, but the plant community replacing broom was composed largely of exotic herbaceous species.

Factors controlling the relative abundance of two thistle species: evaluating non-exclusive hypotheses for success of an introduced invader

Daniel A. Gluesenkamp, Dept. Integrative Biology, Univ. of Calif., Berkeley

A number of hypotheses have been proposed to explain the success of invasive alien species, but few studies simultaneously evaluate likely mechanisms. This study evaluates the degree to which herbivory, competition, and seed bank dynalnics shape relative abundance a native biennial thistle (*Cirsium brevistylum*) and its more abundant alien congener (*C. vulgare*). I quantified the importance of these factors in 37 sites in northern California. I measured effect of herbivores by excluding insects from plants and quantified effect of competition with background vegetation by sowing seeds of each species into plots with vegetation intact versus clipped; germinating seeds were marked and monitored to quantify survivorship and fecundity. Finatly, I measured size of, and recruitment from, the soil seed bank.

The two thistles displayed very different patterns of abundance. Population size of the native *C. brevistylum* is large following a patch-initiating disturbance, but the alien *C. vulgare* is better able to persist as patches undergo succession and so is more abundant on the scale of the entire forest. While both species were limited by competition and herbivory, differences in plant population density and in rates of population persistence were best explained by differences in size of soil seed banks and in the survival of seedlings that germinate when the seed bank is exposed by soii disturbance. These results emphasize the importance of understanding the unique biology of individual species and show that small differences among very similar species can lead to important differences in patterns of management actions.

2000 Poster Titles and Abstracts

lnfluence of Environmental Conditions on Shoot Emergence from Arundo Donax Rhizomes

D.F. Spencer and G. G. Ksander, USDA-ARS Exotic & Invasive Weeds Research Unit, Davis, CA

The ability to predict initiation of growth is central to developing integrated management approaches for weedy plant species. Giant reed (*Arundo donax*) is an important weed in California riparian zones. Once established, it spreads by clonal expansion which is dependent on the production of new shoots from rhizomes. Little is known about the environmental cues which regulate initiation of shoot production although temperature and moisture appear to be important. As an initial step toward understanding the timing of shoot emergence, we performed two experiments. In the first, Arundo rhizome sections and stem cuttings were maintained for 12 weeks at either 7, 14, or 20 C. New shoots emerged and survived at 14 and 20 C. A single shoot emerged at 7 C from a stem cutting but died shortly thereafter. No shoots emerged from rhizome sections at 7 C. Shoots emerged sooner at 20 C and thus were taller than those at 14 C at the end ofthe experiment. In another experiment, rhizome sections were exposed at 8 or 16 C for 14 weeks with various levels of added nitrate (0, 0.3, 0.6,1.2, 2.4, 3.6, 4.8, 6.0 mg/l nitrate) in the weekly watering solution. New shoots emerged at 1CS C, but not 8 C. Neither time to shoot emergence nor the number of shoots were influenced by nitrate level in the watering solution. Shoot emergence was monitored during 1999 for for rhizomes planted outdoors in February at Davis, Califomia. Shoots first emerged March 26 when the average weekly temperature was 11.5 C. New shoots continued to emerge until November 4 when the mean temperature for the preceding week was 15.6 C. These studies indicate that the threshold for shoot emergence was between 8 and 12 C. They also indicate that shoot emergence was not in response to exposure to nitrate.

War on Weeds — Invasive Weed Education and Outreach Program

Emily Briscoe, Bureau of Land Management, and Thor Anderson, Jon Detka, Return of the Natives

The “War on Weeds” at Bureau of Land Management (BLM) Fort Ord Public Lands, Monterey County, CA, focuses on two important facets of Weed Education and Outreach.

First is the “Recognize”, “Remove,” “Restore” sequence. The “Recognize” category highlights the importance of recognizing the six most invasive weeds on Fort Ord: Jubata grass (*Cortaderia jubata*), Yellow Starthistle (*Centaurea solstitialis*), Ice Plant (*Carpobrotus edulis*), Italian thistle (*Carduus pycnocephalus*), French broom (*Genista monspessulana*), and Cut-leaf Fireweed (*Erechtites glomerata*). The “Remove” category describes several working techniques for effective weed removal. The “Restore” category details the major steps involved in habitat restoration, and tells of our Return of the Natives program which involves local school children, eleven public school greenhouses, and music in the restoration process.

Second is the participation of Fort Ord's Weed Warrior team in volunteer events, classroom presentations, public school field trips, and symposia. The Weed Warrior team consists of three CSUMB (Cal State Univ Monterey Bay) college interns and two SCA (Student Conservation Association) interns who have devoted the last 11 months to weed education, outreach and eradication. They have hosted dozens of volunteer events, informed thousands of local school children, and participated in several symposia and conference events. The Weed Warrior team is funded by BLM (through the National Fish and Wildlife Foundation),

non-federal matching donors. Funding is applied for and administered by local CSUMB Retum of the Native's and BLM staff.

Beer Creek Watershed Restoration Program

Craig D. Thomsen, Dept. Agronomy and Range Science, Univ. of Calif., Davis, CA 95616

The Bear Creek watershed is an ecologically significant landscape that comprises 65,000 acres in California's Inner Coast Range. A wealth of native plant communities are found within the watershed providing home to a rich array of wildlife. Over 25 special plants and animals have been documented, 14 of which are species of concern. Herds of tule elk are found on BLM land and Caltrans has designated a right-of-way as a State Botanical Management Area. The 24 mile Bear Creek drainage is a rare aquatic ecosystem, supporting native fishes, northwestern pond turtles, and yellow legged frogs. Geo-thermal springs provide habitat for three endemic insects. The most critical restoration need is to manage invasive plants, including yellow starthistle, tamarisk, perennial peppenveed, medusahead, barb goatgrass, and giant reed. Together they are undermining the ecological integrity of native communities, transforming many areas to weed-dominated landscapes. To address this, cooperative partnerships have been formed to conduct an integrated, watershed-level weed control program, using a combination of mowing, prescribed burning, controlled livestock grazing, cutting, herbicide applications, and manual measures. With funding from the National Fish and Wildlife Foundation, American Land Conservancy, UC Davis, and Caltrans, we are moving forward with a long-term program to protect biological diversity, sustain ranching, demonstrate land management methods, and enhance recreation.

Mayten: an Outbreak Averted?

Ed Leong, Charlice W. Danielsen, and Noah Booker

In 1997, Ed Leong and Charlice Danielsen identified several thousand maytens, *Maytenus boaria*, growing in Gwin Canyon, a part of Claremont Canyon Regional Preserve in the Berkeley-Oakland Hills. Native to Chile, the tree has been used horticulturally in the Berkeley area since the 1890s. Although gardeners have complained about its tendency to spread vegetatively, it has not been considered a pest plant in the wild until recently. Wildfire burned most of Gwin Callyon in 1991 and very likely contributed to the species' spread.

The East Bay Regional Park District and the California Native Plant Society East Bay Chapter's Native Plant Restoration Team began control efforts in 1998. Attempts were made at pulling and grubbing the plant out by the roots, but many resprouted. Cut stump and low-volume basal bark applications of Triciopyr-based herbicides gave excellent control.

The restoration team is in the grocess of surveying the plant cover of the canyon slope, and plans to supplement the work ofPark District staff. This collaboration will draw from the strengths of both groups to reach mutual management goals.

Efforts will be made to educate landscape landscape designers and land managers about mayten’s potential for escape, inventory, and collect data on populations and individual plants known or discovered in the wild, research the natural history of the plant in its native habitat, and plan for and do future controlwork. With concerted effort, it may be possible to contain this escapee before it becomes a widespread problem.

The Use of Native Yellow Lupines for Controlling Ripgut Brome and Radish

Kristy L. Uschyk and Peter Slattery, Moss Landing Marine Laboratory

In the process of rehabilitating native plant communities at a seven acre coastal dune site, we found yellow bush lupine (*Lupinus arboreus*) to be an effective control on limiting reseeding, and regrowth of ripgut brome (*Bromus diandrus*) and wild radish (*Raphanus sativus*). Following an initial application of chemical herbicide (Roundup) we planted 12" tall yellow lupines, propagated from seeds collected at the site, at a 24" spacing.

Within six months yellow lupines where completely dominant, shading out the ripgut and radish. The yellow lupine also deposited a dense leaflitter that further limited regrowth of the preexisting ripgut and radish seed base. After two to three years the lupine plants were killed by ghost moths, allowing for the develop-

ment of longer-lived native species. Ripgut and radish at this point could be controlled with simple hand weeding. By using this native plant, we effectively controlled invasive weeds, we significantly reduced the need for chemical herbicides, and the yellow lupines provided new habitat for a wide variety of other species including birds not previously seen at this site, the sensitive California legless lizard, and native annual and perennial plants previously precluded by ripgut.

Biological Control of Yellow Starthistle

Lincoln Smith, Joe Balciunas USDA-ARS, Albany, CA, Michael Pitcairn, California Dept. Food and Agriculture Sacramento, CA

Yellow starthistle (*Centaurea solstitialis*) (YST) is an alien plant that probably originated from the eastern Mediterranean. It was first collected in Califomia in 1869, and now infests 42% ofthe state's townships. It interferes with land use such as grazing and recreation, displaces native species, and is toxic to horses. This weed is much less invasive in its land of origin, which suggests that natural enemies, such as insects, plant diseases, herbivorous animals or competing plants help to keep it under natural control. So far, six species of insect bioiogical control agents, have been introduced to control yellow starthistle. The most promising of these agents is the YST hairy weevil (*Eustenopus villosus*). The YST bud weevil (*Bangasternus orientalis*) and YST gall fly (*Urophora sirunaseva*) are widely established in CA, but do not occur in high numbers. The YST flower weevil (*Larinus curtus*) is established at a few sites in CA, but also in low numbers. The YST peacock fly (*Chaetorellia australis*) prefers bachelor button, and the gall fly (*Urophora jaculata*) never established. The yellow starthistle false peacock fly (*Chaetorellia succinea*) was accidentally introduced into the USA in 1991. Subsequent tests indicate that this insect is fairly specific to yellow starthistle. It is now widely established in CA and OR, and is spreading into WA, ID and NV. All these agents attack the seedhead. We are now looking for additional insects and pathogens that attack young plants in Greece, Turkey and southern Russia. Prospective agents will be tested for efficacy and host specificity to make sure they do not attack other plants. After evaluation and approvaf by state and federal agencies, these agents will be released to help reestablish the natural control that occurs in the land of origin.

Cooperative Yellow Starthistle Leading Edge Mapping Project

Rosie Yacoub, California Dept. of Food and Agriculture, Sacramento, CA 95814

The California Department of Food and Agriculture and CALTRANS, with support from the County Agricultural Commissioners, members of the California Interagency Noxious Weed Coordinating Committee and local Weed Management Areas, initiated a cooperative yellow starthistle mapping and assessment project. This project involves the mapping of yellow starthistie (*Centaurea solstitialis* or YST) by a few hundred resource management professionals, qualified amateurs and landowners. Mapping is being carried out at a fairly high level of resolution and the collation of this information is being put into a Geographic Infonnation System. Primary areas of focus will include pubIic lands and roadway easements.

An eastern boundary of YST spread will be established. To the best of everyone's knowledge, YST will not be known to occur east of this boundary. Immediately west of this boundary, a containment zone will be determined and key eastward outlier populations (EOPs) will be identified. Yellow starthistle in the containment zone and EOPs will be targeted as having high eradication and control priorities. When feasible, the containment zone could be a “knock-back zone” where concerted efforts are made to move the eastern boundary westward through local eradication. As part of the assessment phase, potentially "infestable" areas (where YST can biologically survive) will be biologically determined and mapped to focus detection and emphasize the importance of the prevention efforts.

To date, much of the data has been collected and put together in a single GIS layer. Work to follow includes working with Weed Management Areas to decide the containment zone in their area as a function of the distribution of YST, and their capacity to control it. Further analysis can be performed to try to identify biological limitations of YST, which can help to focus both further survey work and control work. The goal of the cooperative mapping project is to help focus management of yellow starthistle in the Siena Nevada. If successful, this project will serve as a pilot for similar YST and invasive weed control mapping/assessment projects throughout the state.

Alameda-Contra Costa Weed Management Area

The Alameda-Contra Costa Weed Management Area (WMA) has developed a display panel for use at county fairs and other public and stakeholder meetings. The display depicts: the problems created by exotic invasive weeds, the mission of their WMA (stopping the introduction and spread ofweeds), and highlights of some of their region's weed control programs. The display was partially funded by the USDA, NRCS (EQIP).

Non-native Plant Control on the Watershed Level: Role of the Santa Margarita and San Luis Rey Watersheds Weed Management Area

Jesse Giessow, Jason Giessow, Judy Mitchell

To effectively control invasive plants within a watershed the effort must be carried out using a watershed wide approach. This is particularly important for *Arundo donax* (giant reed) because it spreads vegetatively during flood events by the dispersal of broken off rhizome and stem fragments which then grow into new individuals. If control is not carried out working from the top to the bottom ofthe watershed, areas that have been cleared will be re-infected with new propagules from upstream. The need to carry out invasive plant control on such a large scale necessitates a unified approach involving all landowners within the watershed. The Santa Margarita and San Luis Rey Watersheds Weed Management Area (WMA) was formed in March 2000 to provide the organizational framework necessary for a coordinated watershed

The two watersheds are at different stages in the exotic plant control process. On the Santa Margarita watershed the goal of the WMA is to ensure that the scattered remaining *Arundo* (mostly in the uppermost portions of the watershed) is mapped and then treated to ensure that long-term control is achieved. A large effort in the lower watershed has already controlled hundreds of acres of Arundo and the WMA wants to protect this work. On the San Luis Rey watershed there has been almost no exotic plant control despite the concern of many different entities and private citizens on the increasing growth and threat of exotic species like Arundo. The goal of the WMA in the San Luis Rey watershed is to bring together all stakeholders and initiate a coordinated exotic plant control effort working from the top of the watershed towards the bottom. The main efforts of the WMA fall into four categories: 1) mapping plant distributions, 2) creating and maintaining a website information center, 3) carrying out and coordinating exotic plant control projects, and 4) developing new controlprojects. Mapping of target exotic plant distributions is necessary to know how much is present and exactly where it is located. This information is used in planning control projects in an organized and logical manner and has been an important element in applying for grants. Plant distribution data is available as CIS coverages and JPEG images at the WMA website (http://smslnvma. org). The website is the infonnation celiter ofthe WMA - providing information on the activities ofthe WlMA to all participants, but also providing information on the identification, biology and control of target exotic plants. Downloadable identification posters have been created for some species. In Fall 2000 the WMA is both canying out and coordinating/managing Arundo control projects in both watersheds. The WMA is also applying for funding and working together with different agencies, groups and communities to develop new control projects.

The WMA will be an important organizational force in carrying out coordinated exotic plant control on the Santa Margarita and San Luis Rey watersheds. The WMA will ensure that exotic plant control occurs on a watershed level, and it will function as a data repository and 'watchdog' by creating a database of all control projects within the watersheds and monitoring their success over the long-term.

Mapping Distribution and Acreage of an Exotic Plant Using Orthocorrected lmagery & Field Mapping to Produce GIS Coverages

Jason Giessow

The Santa Margarita and San Luis Rey Watersheds Weed Management Area needed to map the distribution and acreage of *Arundo donax* (giant reed) within the 359,000 acre San Luis Rey watershed for under $10,000. The mapping needed to be spatially accurate, give the acreage of infestation, cover riparian and upland areas, and include all small, scattered infestations

high in the watershed. Other mapping methods that were considered (remote sensing and presence/absence within riparian reaches) would not have provided accurate acreages or included the small infestations. The WMA has been pleased with the mapping data produced using the methodology described below. The mapping has allowed for effective planning of Arundo control projects, used in grant applications, and will aid in long-term monitoring ofArundo within the San Luis Rey watershed .

The mapping procedure used can be divided into nine main steps:

Step 1 Acquire imagery: One meter resolution imagery (orthocorrected) for the entire watershed was acquired from SANDAG/San Diego State University.

Step 2 Print maps for field surveying: 30 Dsize maps (22' x 34") covering 2.4 by 3,3 miles each and 4 E-size maps (3B x 44") were printed. The larger E-size maps were used for the upper watershed where there was a very scattered Arundo distribution.

Step 3 Map exotic plants in the field. Arundo was mapped at two densities (50-80% and 80-100% cover) and other exotic plants were mapped as encountered.

Step 4 Transfer data from field map to clean sheet: Arundo polygons were traced onto tracing paper/acetate with reference points (such road intersections, buildings etc.).

Step 5 Scan traced images and convert into polygon coverages (using GIS software such as TNT Mips by MicroLmages) .

Step 6 Georeference each polygon coverage using reference points

Step 7 Merge coverages and clean up: Merge individual polygon coverages into one coverage and delete reference markers using GIS software (such as ArcView by ESRI).

Step 8 Proof final coverage: Compare final coverage to field survey maps

Step 9 Distribute data: The final GIS coverage and maps created from the coverage are available to the public at http://smslrwma.org.

The final Arundo coverage is thought to be accurate to ± 20% of the actual acreage at this time. If a more accurate acreage is required (e.g. for mitigation projects) then ground-based GPSing can be carried out during the actual treatment effort. This ground-based mapping is much more expensive and time consuming than the method described here and is generally not warranted for large-scale mapping projects. The mapping method described here is a good balance between accuracy and cost of implementation. Project budgets can be developed based on mapped acreages and projects can be canied out with confidence that unknown upstream sources will not re-infect current project sites.

Team Arundo del Norte: Collaborative Approach to Exotic Pest Plant Control

Deanne Dipietro, Team Arundo Del Norte Team

Arundo del Norte is a forum of organizations dedicated to the control of *Arundo donax* (giant reed), where it threatens the health and biodiversity of riparian and wetland ecosystems in Central and Northern Califomia. Members include researchers, landowners, and representatives from local, state, and federal govemment agencies and watershed groups.

The Team, founded in 1993 following the example of Team Arundo of Southern California, emphasizes information exchange and partnerships in order to support the many local efforts to eradicate this harmful weed. A website at httt://ceres.ca.gov/tadn provides the means to share contact information, control methods, educational opportunities, and outreach materials. Members communicate regularly via an email listserv on a wide array ofrelevant topics and experiences, from permitting issues and policy to research findings and remote sensing techniques. This ongoing cooperation has created a context for a regional strategy for addressing the problem of Arundo, and has fostered partnerships that have resulted in much-needed research and the development of education materials that benefit all Arundo control efforts.

Arundo donax Eradication and Coordination Project: Coordinating eradication projects in the Bay-Delta region

Mark Newhouser, Team Arundo Del Norte

The project, funded by CALFED (US Fish and Wildlife Sewice) is a regional effort inspired by the collaboration achieved by Team Arundo delNorte (TAdN). The premise ofthe CALFED proposal is to

bring multipie projects under one umbrella to increase efficiency, pool resources and standardize Protocols.

The Project includes eradication partners from around the San Francisco Bay and the Sacramento River Delta. Six partners are funded for Arundo eradication projects, including Big Chico Creek, Napa River, Putah Creek, San Francisquito Creek, Sonoma Creek and Walnut Creek. All partners will be reporting results to the Project Administrator, the Sonoma Ecology Center. The Project Coordinator will see that all the informational, financial and shared resource needs of the partners are met. An Information Coordinator will create the database for all monitoring and eradication data.

Eradication partners will be working independently using their site specific eradication plans and methods. However, partners will be using the same mapping, monitoring and reporting protocols. A steering committee comprised of TAdN members will help develop and standardize needed protocols and oversee the project.

An important goal ofthis project is to identify more partners throughout the region and provide them information and access to resources. When these new partners initiate projects, they will be sharing in a functional network. Ultimately, the Bay/Delta region will have all watersheds with Arundo infestations participating and succeeding in a truly collaborative effort.

The Plant Community Effects of a Burn and Two Herbicide Sprays on a Fennel-lnfested Grassland in the Central Valley of Santa Cruz Island, California

Jennifer Erskine, UC Davis

Foeniculum vulgare has had an environmentally prolonged lag effect on Santa Cruz Island, CA, for nearly 150 years before becoming an invasive weed. The removal of cattle and feral sheep from The Nature Conservancy portion of the island in 1986 induced habitat modifications which allowed a large cohort of *Foeniculum vulgare* to invade the Central Valley (CV) of Santa Cruz Island. Uncontrolled, this cohort aggressively formed monospecific stands, replacing populations of native species, and invading many different communities throughout Santa Cruz Island. A multitrophic experiment evaluating the effects of fennel eradication on species diversity began in 1997 with an autumn controlled burn and two subsequent spring sprays (May 1998, 1999) with the broad-leaf herbicide, Garlon 3A. The burn and spray regime has significantly decreased fennel in the Central Valley of Santa Cruz island. Canonical Correspondence Analysis (CCA) has shown herbicide induced succession in the Central Valley of Santa Cruz Island with those plots treated becoming less similar to untreated fennel plots, and more similar to untreated grassland plots in which fennel has not invaded. Species diversity has increased with the removal of fennel.

Lassen County Special Weed Action Team

Carolyn Gibbs and Debbie Falkowski

The Lassen Cownty Special Weed Action Team (SWAT) has developed multiple strategies for attacking our county's weed problems. We have developed an aggressive educational campaign to help area residents identify noxious weeds and understand their effect on both natural ecosystems and agricultural lands. We have passed out literature, held seminars, promoted an annual weed week and community weed pull day. Our display "Pulling Together Against Noxious Weeds" illustrates the importance and effectiveness of involving the community in the "War on Weeds." As part of our campaign, we are developing an "Adopt--A-Site" program that will directly involve classrooms, youth groups, and clubs in our weed eradication efforts. Through service learning projects, the youth in our community will leam about invasive species as a global problem with a local solution, (Think globally, act locally.) Students will assist local agencies and land owners in removing perenial pepperweed along the Susan River and in restoring; important riparian habitats. The studv of noxious weeds will be an important component of environmental education in our schools. Representatives of our weed group will be attending this year's "Ag in the Classroom" Conference to help raise teacher awareness about the threat of noxious weeds in Califomia and how students can assist in the "War on Weeds." For more information about our educationai campaign contact Debbie Falkowski at (530) 251-2362 or Carolyn Gibbs at the BLM (530) 257-0456. Also, check out our website at cdfa.ca.gov/wma.

Nonnative Plants in Two Biological Communities in the Tirari Desert of South Australia

Steven Blaha, EIyn V. Owen, and Dr. CarIa C. Bossard, St. Mary 's College of California

We examined two communities of the South Australian Tirari Desert, on the Etadunna Dune and surrounding the dry Lake Palenkarinna, both areas with less than seven inches average annual precipitation. Cattle grazing has been extensive on the dune community but rare in the Lake Palenkarinna area. Species were identified, all plants were mapped and species morphological and physiological features were examined. The species list shows the same six non-native species exist in both the Lake Palenkarinna and the Etadunna Dune communities. Nonnative species do not occur in the highly saline area within 33.5 m ofthe dry lake bed. One species, *Salsola kali* (Russian thistle) becomes the dominant vegetation in a small band that ranges between 210 m and 265 m from the dry lake edge. The percent cover of non-natives in the lake community is 20.2% of the total vegetative cover. The dune community in the foredune and dune swale areas have 66 and 68% vegetative cover, respectively, in non-native species. Moreover, these dominant non-native species (and what native species still occur there) all have either mechanical protection from herbivores or high levels of alkaloids in their tissues. Species not self-protected from herbivores were found only in the dune swale, beneath low-growing Acaciais which likely protected them from herbivory. While the Lake Palenkarinna community appears to be maintaining its biodiversity and is not significantly impacted by nonnative plants except in one zone, the composition and condition ofthe dune community indicates it has been severely altered, most probably as a result of the stocking rate for cattle being too high.

Cooperative Weed Management Areas

Jennifer Drewitz and Steve Schoenig, Calif. Dept. of Food and Agriculture

Weed Management Areas (WMAs) are local organizations that bring together landowners and managers (private, city, county, State, and Federal) in a county, multi-county, or other geographical area for the purpose of coordinating and combining action and expertise in combating common invasive weed species. The WMA functions under the authority of a mutually developed memorandum of understanding (MOU) and is subject to statutory and regulatory weed control requirements. A WMA may be voluntarily govened by a chairperson or a steering committee. To date, groups in Califomia have been initiated by either the leadership ofthe County Agricultural Commissioner's Office or a Federal Agency employee. WMAs are unique because they attempt to address agricultural (regulatory) weeds and “wildland” weeds under one local umbrella of organization. It is hoped that participation will extend from all agencies and private organizations. WMAs have: printed weed LD./control brochures, organized weed education events, written and obtained grants, coordinated demonstration plots, instituted joint eradication and mapping projects as well as many other creative and effective outreach and weed management projects.

Update: As of September 7, 2000 Senate Bill 1740 passed appropriating $5,000,000 to the Noxious Weed Management Account. This bill modifies Assembly Bill 1168 — the noxious weed control bill that passed in 1999 and will fund Weed Management Areas and agricultural commissioners to implement integrated weed management plans throughout the state.

For further information about WMAs, see the California WMA website at http://www.cdfa.ca. gov/wma.

Noxious Times Newsletter

California Dept. of Food and Agriculture

The Noxious Times is a quarterly newsletter sponsored by the California Interagency Noxious Weed Coordinating Committee (CINWCC). This publication provides agencies and local staff with relevant information on noxious weed control throughout California. By providing news, policy information, and program reports from specific agencies, the Noxious Times serves as a resource for those interested in sharing information and coordinating efforts against noxious weeds. Look us up on the web at: www.cdfa.ca.gov/noxioustimes

Preventing the Purple Plague from Taking Over California's Waterways

Carri Benefield, Calif. Dept. of Food and Agriculture

The California Department of Food and Agriculture (CDFA) was recently awarded a grant by the CALFED Bay-Delta Program to conduct a purple loosestrife prevention, detection, and control program. Purple Loosestrife is a showy ornamental that has escaped home gardens and nurseries and moved extensively throughout the we~tlands of the United States causing immense ecological destruction. Loosestrife is listed by the CDFA as a "B" rated noxious weed and as a "species with potential to spread explosively" by the California Exotic Pest Plant Council. Based on historic records, the distribution of purple loosestrife is currently in multiple, mostly small and scattered populations, in the Sacramento-San Joaquin Delta system and nearby hydrological units. However, infestations of purple loosestrife often follow a pattem of establishment, maintenance at low numbers, and then dramatic population increase when conditions are optimal.

Purple loosestrife, which spreads primarily by copious production of seed the size of groundpepper, threatens to become established and forms dense stands that crowd out native wetland vegetation and associated wildlife, thus threatening the overall biodiversity of aquatic, wetland, and riparian areas. The complex interface between farm Iand and water in the Bay-Delta estuary also provides rich and varied habitat for wildlife, particularly waterfowl. The displacement of valued flora and fauna and the diminishment of critical fish and wildlife habitats has been well documented throughout the United States.

Primary program objectives will be to conduct: (1) a broad education and training campaign, (2) extensive surveying and mapping, (3) a collaborative assessment meeting of cooperators to develop site specific adaptive management plans, resulting in (4) comprehensive local management, control, and eradication efforts, and (5) monitoring. The geographical focus will be on the SacramentoSan joaquin Delta watershed where there are a number of threatened and declining species due to a multitude of environmental stressors. The project will be an extensive collaborative effort with: CDFA Integrated Pest Control Branch District Biologists, County Agricultural Commissioners, local Weed Management Areas, CA Department of Boating and Waterways, the CA Department of Fish and Game, U.S. Fish and Wildlife Service, USDA ARS Resource Conservation Dlstricts, and local watershed groups, amongst others.

Purple Starthistle Seed Germination

James A. Young and Charlie D. Clements, USDA-ARS, Reno, NV and Michael J. Pitcairn, California Dept. of Food and Agriculture, Sacramento CA 95832

The genus *Centaurea* (Asteraceae) is estimated to contain about 500 species native to Asia and North Africa. Several species have been introduced to North America as ornamentals and some have become highly invasive and often noxious weeds. Yellow starthistle (*C. solstitialis* L.) is extremely widely distributed in Califomia as well as portions of Oregon, Washington, Idaho, and Nevada. Purple starthistle (*C. calitrapa* L.) was probably first introduced in Solano County, Califomia and now occurs in high densities in Napa, Marin, Mendocino, and Contra Costs Counties. It is also found in several other western states. Purple starthistle tends to grow sympatric with or adjacent to infestations ofthe much more widely distributed yellow star thistle. The Califomia Department ofFood and Agriculture has recently released several insects that attack spotted knapweed (*C. maculosa*), diffuse knapweed, (*C. diffusa*), and squarrose knapweed (*C. squarrosa*) (all closely related to purple starthistle), to determine if the insects will attack purple starthistle in the field. Postrelease surveys include examining seed heads for damage and have provided a source of seed for germination studies.

Seeds (achenes) were collected in Lagoon Valley, Solano County, and Gordon Valley, Napa County, California in 1998 and bulked for germination testing. In 1999, seeds were again collected at these sites and at Lucas Valley, Marin County, California. In 1999 all three locations were tested separately. In all experiments 4 replications of 25 seeds each were used in a randomized block design. Seeds were placed on top of non-toxic commercial germination paper in closed Petri dishes and kept wet with tap water. Germination trials were conducted in the dark. Seeds were considered germinated when the radical emerged 1 mm. Germination counts were made after 1, 2, and 4 weeks incubation. Constant incubation temperatures were 0,

2, and 5 C and at 5 degree increments through 40 C. In addition, altemating regimes included 16 hr at each constant temperature, plus 8 hr at each possible higher temperature per 24 hr. For example, 35 C alternated with 40 C only, while O C altemated with 2, 5, 10, 15, 20, 25, 30, 35, and 40 C. This made a total of 55 constant and alternating temperature regimes.

The germination responses ofthe accessions ofpurple star thistle were compared using the seedbed temperature definitions:

a. Very cold: 0/0 (constant O C), 0/2 (O C for 16 hr and 2 C for 8 hr in each 24 hr), 0/5 and 2/2 C.
b. Cold: 0/10, 0/15, 2/5, 2/10, 2/15, S/5, and 5/10 C.
c. Cold fluctuating: 0/20,through 0/40C and 2/20 through 2/40 C.
d. Fluctuating: 5/30 through 5/40 C, 10/35, 10/40, and 15/40 C.
e. Moderate: 5/15 through 5/25, 10/10 through 10/30 C,15/15 through 15/35 C, 20/20 through 30/35 C, and 25/35 C.
f. Warm: 20/40, 25/35, and 25/40 C, 30/30 through 30/40 C, 35/35, 35/40, and 40/40 C.

The categories of seedbed temperatures reflect germination environments of field seedbeds based on several years of monitoring in the Great Basin.

Data from each base temperature and its altemating temperature regimes were used to generate a quadratic response surface with estimated means and confidence intervals at the I% level of probability. Several germination parameters were synthesized from the quadratic response surfaces.

Results show that seeds ofpurple star thistle will readily germinate at a wide range of incubation temperatures. Some germination occurred at from 75 to 93% ofthe 55 temperatures tested. This is a very important germination parameter for an invasive weed. If the species produces an abundance of seed, even very limited germination at adverse seedbed temperatures is often sufficient to perpetuate and enlarge infestations.

The germination response for the seeds collected in 1998 (composite accession) and the 1999 accession from Lagoon Valley were very similar. Germination for the Lucas and Gordon Valley accessions tended to be low for most categories.

In comparison to categories of seedbed temperatures, the accessions had no or very limited germination at very cold temperatures. There was a very large jump in germination at cold seedbed temperatures. The cold category corresponds to seedbeds where the surface soil would freeze at night and thaw during the day. This would probably be exceptionally cold for the areas in California where the seeds were collected. Germination dropped at warmer seedbed temperatures, especially for the Lucas and Gordon Valley accessions. Highest germination occurred at moderate seedbed temperatures which includes 36% of the 55 temperature regimes tested.

The maximum germination observed was 90% or higher for all accessions. Optimum germination, defined as those means not lower than the maximum observed minus one half its confidence interval at the 0.01 level of probability, ranged from 88 to 96%.

The frequency that temperature regimes support optimum germination provides an index of what seedbed temperature is ideally adapted for species. For purple star thistle seeds, 17 temperature regimes supported optimum germination, but only 15/25 ºC (15ºC for a 16 hour cold period and 25ºC for 8 hour warm period in each 24 hours) always supported optimum germination.

Proceedings

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CALIFORNIA EXOTIC PEST PLANT COUNCIL

Joint Workshop of The United States Geological Survey & The California Exotic Pest Plant Council

Presentation Abstracts

Session I

Introduction and Overview of Invasive Species in the Southwest

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Deserts are among the least invaded ecosystems worldwide. However, the relatively few species that have successfully invaded deserts have had dramatic ecological effects. Saltcedar (*Tamarix* spp.) guzzles precious water and changes fire regimes in riparian systems, and annual and perennial grasses compete with native plants for soil nutrients and change fire regimes in both riparian and upland systems. As deserts become urbanized, dispersal rates of invasive plant propagules will increase and environmental conditions may become more suitable for the establishment of new invasives as irrigation runoff and atmospheric pollution increase levels of soil water and nitrogen.

Some native species can be considered invasive in some cases, and critical components of native diversity in other cases within the same desert bioregion. For example, creosote bush (*Larrea tridentata*) and honey mesquite (*Prosopis glandulosa*) are considered invasive along the ecotone between native grasslands and shrublands in the eastern Sonoran Desert and northern Chihuahuan Desert, and important keystone species in shrub communities of adjacent hot desert regions. Sagebrush (*Artemisia* spp.) is considered to be invasive in the rangelands of Arizona and New Mexico, yet it is a high priority for conservation in the Great Basin, where it is threatened by two other native species, Juniper (*Juniperus* spp.) and pinyon pine (*Pinus edulis*), invading from adjacent woodlands. Disagreement on management strategies for these species complicates integration among regional weed management programs.

Most past research on invasive plants has been conducted by biologists, who have rarely collaborated with physical scientists. To be most effective, future research will need to be multidisciplinary, especially in arid regions where physical and chemical soil properties and climate appear to have such strong effects on habitat invasibility. This session on multidisciplinary invasive plant research will present examples of potentially beneficial collaborations between scientists who are studying invasive species and scientists studying physical processes that potentially control plant invasions.

Role of Environmental Heterogeneity and Climate Variability in Plant Invasions: Insights from the Fossil Record

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Natural migrations provide model systems for understanding biotic responses to global change and invasions of non-native species. Here, we draw from the fossil record of plant migration of western North America to highlight the influence of environmental heterogeneity in dictating patterns of establishment and spread, and of climatic variability in pacing migration. We have purposefully selected ongoing natural migrations that are now being modulated by contemporary land use. Current theory of biotic invasions emphasizes population processes of dispersal, establishment, and expansion, where environmental heterogeneity is typically treated as a binary classification of favorable and unfavorable sites, and climatic variation as stochastic variation about a mean. Favorable sites, however, may range from places that can be occupied only with continual immigration to those where populations can per-

sist independently despite environmental variability. In heterogeneous landscapes, the most favorable sites may occur far from the advancing front, and migration can thus follow unexpected pathways. Climate variability may set the tempo, with unfavorable climate imposing a prolonged colonization phase, and periods of rapid population spread reflecting episodes of favorable climate rather than attainment of population "critical mass." To some extent, the record of non-native species invasions mimics the fossil record. Most introductions of non-native species appear to fail multiple times before they eventually succeed. Both multiple failures and eventual successes are generally attributed to some combination of demographic and environmental stochasticity. A key distinction between past and contemporary invasions is the increasing probabilities of long-distance dispersal associated with the frenzy of universal air and ground travel.

Interrelationships Between Geomorphology, Soils, and Plant Invasions

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The region over which an exotic species spreads is usually similar in climate to that of the plant's native range. In arid and semi-arid environments where water strongly limits plant development, soil conditions may further influence where certain kinds of exotic plants may spread or predominate. In the southwestern United States, understanding relationships between soils, soil hydrological behaviors, and plant responses is essential for understanding many vegetation responses, including those caused by various human uses of the land, climate change, and spread of undesirable introduced species.

In arid and semi-arid environments, three variable characteristics of the spatial and temporal distributions of soil moisture strongly affect plants: (1) vertical (=depth) distribution of soil moisture (2) localized evenness vs. patchiness in the horizontal distribution of moisture, and (3) temporal persistence of soil moisture. The manner in which water is extracted from the soil by different kinds of plants in arid and semi-arid environments can be arranged along a continuum ranging from intensive to extensive exploitation. Various spatial and temporal distributions of soil moisture availability often foster the predominance of plant species that differ in their modes of soil moisture acquisition.

Variation in vegetation composition and types of undesirable vegetation changes that have historically occurred in the Southwest illustrate the effects of contrasting soil hydrologies. It is also possible that future behaviors of some exotic species in drylands could be better predicted with more detailed knowledge of these plants' water use requirements coupled with a better understanding of geomorphology, soils, and soil hydrology.

How Will a Hotter, Drier, and More Variable Climate Affect Invasives in the Mojave Desert?

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Predicting invasive species responses to a hotter, drier and more variable environment requires a synthesis of climate change and plant migration research. Based on climatic variation observed over the past century in combination with fossil records it is predicted that hotter and drier conditions may dominate the southwestern United States for a period of decades. We use the invasive annual grass, red brome (*Bromus madritensis*), as a model species. Predictions depend on the rate and magnitude of climate change in relation to biological feedbacks and changes in disturbance regimes. Because it is already established across the entire region, red brome will likely respond to climate change in a rapid-active phase of population response unlike the slow-quiescent phase observed during many new invasions. Predicting red brome responses to climate change may be complicated by large inter-annual differences in seed banks coupled with local variation in response to environmental conditions. We speculate about the invasion of red brome based on 40 years of observations at the Beatley study plots, Nevada Test Site and the pattern of fires across the Mojave Desert for the past 20 years. We developed three conceptual models of how red brome responds to climate change: 1) regional declines across the current range due to poor seed dormancy mechanisms and reduced germination; 2) a brief population decline followed by rapid

re-invasion due to inherent amplitude of beneficial characteristics, genetic variability, or genetic plasticity; 3) red brome becomes much reduced in desertscrub and shrub steppe but maintains numerical dominance in mixed conifer woodlands setting in motion elevational or latitudinal migrations that could reshuffle plant communities when coupled with fires. The outcome of these scenarios will be tied closely to disturbances such as fire and vegetation losses due to drought. Our understanding of weed responses to climate change in deserts may benefit by incorporating seed bank ecology and considering interactions with granivorous vertebrates and invertebrates.

Effects of Increased CO_2 and Nitrogen Deposition on Desert Invasive Plants

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Arid regions may be particularly responsive to elevated atmospheric CO2 and to nitrogen deposition, as may invasive plants, suggesting that invasive plant problems in dryland regions could be exacerbated by global change. In 1997, we initiated the Nevada Desert FACE (Free-Air CO2 Enrichment) Facility (NDFF), an ecosystem manipulation experiment in which an intact Mojave Desert ecosystem is continuously exposed to elevated CO2. Although we have observed increased plant production at elevated CO2 in all life forms, particularly in wet years, we have observed the highest increase in density and production to be that of an invasive annual grass, *Bromus madritensis* ssp. *rubens*. This species exhibited a 2.3-fold increase in primary production and 3-fold increase in seed rain in the wet El Niño year of 1998; these increases were even more pronounced in 'fertile island' microsites beneath shrubs. In contrast, native annuals exhibited 20-30% increases in primary production and seed rain. Photosynthetic carbon assimilation was only 20% higher in *Bromus* at elevated CO2, but these plants had much lower construction cost than at ambient CO2, a result that did not occur for the native grass *Vulpia octoflora*. We have also observed *Bromus* to construct smaller, lower quality seeds at elevated CO2, whereas *Vulpia* does not. Therefore, these invasive and native species react very differently to elevated CO2 and nitrogen. We will continue to assess the response of these two species at the NDFF and at a new N-deposition/crust removal site in the Mojave Desert.

Interactive Effects of Roads, Soils, and Exposure on Invasion of Calif. Grasslands

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The idea that roadless habitats act as refuges for native plant diversity against exotic plant invasion has seldom been tested. We examined the effect of isolation from roads on native and exotic plant diversity in a Calif. foothill grassland landscape. We measured native and exotic plant diversity and cover in sites stratified by distance from roads (10 m, 100 m, and > 1000 m), soil type (serpentine and non-serpentine), and exposure (cool, warm, and neutral). In non-serpentine grasslands, native cover was greatest in sites > 1000 m from roads (22%) and least in sites 10 m from roads (8%), and habitats > 1000 m from roads contained a significantly greater percent of native species (44%) than those 10 m (29%) or 100 m (35%) from roads. In serpentine grasslands, the percent of native species and native grass and forb diversity were greatest in isolated sites. Two exotic species that have recently been observed to be spreading (*Aegilops triuncialis* and *Centaurea solstitialis*) were least prevalent, and one native bunchgrass (*Nassella pulchra*) was most prevalent, in isolated sites. Native species were generally most prevalent on infertile sites on both soil types, and were most prevalent on cool, ungrazed slopes on nonserpentine soils. Roadless areas are significant refuges for native species, but careful management is important to protect these habitats from continued invasion

Multidisciplinary Research Needs for Invasive Plants in Southwestern North America

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Land managers need to be able to predict which species will likely invade, which types of habitats they will invade, and what the effects of these invasions will be. They also need to understand how various land use activities will affect invasive plants, and what these changes will mean within the broader context of ecosystem integrity. Multidisciplinary research approaches have the greatest promise for providing this information. Relationships should be studied between the life history characteristics of invasive species and the geomorphological and hydrological characteristics of landscapes. Temporal variations in these relationships should be evaluated in response to future shifts in climate, air pollution, and disturbance regimes. It is my hope that multidisciplinary collaborations among scientist, and improved communications between and among scientists and land managers, will lead to a greater capacity to manage invasive plants and minimize their negative ecological impacts.

Session II

10 Years of CalEPPC

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The Calif. Exotic Pest Plant Council (CalEPPC) was formed at a conference on wildland weeds in Moro Bay, Calif. in 1992. The conference was organized by scientists, academic researchers, conservation activists and land managers inspired by the example of the Florida Exotic Pest Plant Council. A Board of Directors is elected by the membership to serve staggered two-year terms, while officers are elected annually. Membership is open both to individuals and organizations. CalEPPC is incorporated as a 501 (c) (3) non-profit.

The group's mission is to protect California's biodiversity — its diverse plants and wildlife — from the threat posed by invasive exotic pest plants in the state's natural areas. This focus on biodiversity makes the organization's mission distinct from that of other organizations that fight weeds such as those focused on agriculture, water ways and rangelands. In many cases the missions overlap as the same weeds may be encountered and strategic alliances or coalitions formed.

The organization's membership is deliberately broad. It was decided by its early organizers to have a "broad tent" — that anyone who was interested in fighting invasive weeds would be welcome to join. It was a deliberate decision that membership would not be limited to organizations or agencies.

CalEPPC carries out this mission through education, research, policy advocacy, and coalition building. Education includes a quarterly newsletter, a web site that is constantly adding content, annual symposiums such as this one, regional workshops — often on a single weed or group of weeds such as *Arundo*, *Saltcedar* or the brooms, Proceedings of papers and posters presented at the symposia, authoring the new *Invasive Plants of California's Wildlands*, and helping to develop a K-12 curriculum and materials on invasive weeds.

CalEPPC promotes research into invasive weeds on several levels. With a grant from a private foundation for over $250,000 CalEPPC financed a series of projects on the *Cortaderias*, pampas and jubata grasses. CalEPPC, in partnership with the Calif. Native Plant Society, has raised almost $250,000 in four years to support Cape ivy biocontrol research by the U.S. Dept. of Agriculture (USDA) and its Agricultural Research Service (ARS). CalEPPC is now supporting the International Broom Initiative, seeking biocontrol agents for a variety of brooms and gorse.

From the beginning, CalEPPC has had a strong strategic alliance with the Calif. Native Plant Society (CNPS) and The Nature Conservancy. Over the years other alliances or partnerships developed with the Cattlemens Association, the Calif. Dept. of Parks and Recreation, the Calif. Dept. of Food and Agriculture, the USDA-ARS, and others. CalEPPC promotes and participates in coalitions such as the Team Arundos or the new Weed Management Areas. Nationally, it is a member of the National Association of EPPCs (NAEPPCs), an organization that includes other groups with different names, but similar missions. Nationally, a goal is to influence the broader policy making taking place with respect to invasive weeds such as the Invasive Species Council.

In the future, CalEPPC expects to actively support the newly developing Weed Policy Steering Committee to author and influence weed legislation and funding in California. The intention is to be able to participate more intensely on state, regional and local weed policy issues such as the raging controversy over the new water quality pesticide discharge requirements or the effort by some groups to ban the use of all pesticides in individual countys within the state.

As a conservation group CalEPPC can potentially have an important voice in such public debates that the Agricultural groups can't duplicate. Strenthening the NAEPPCs and expanding their role in national policy making is another goal. But, the CalEPPC Board of Directors recognized two years ago that CalEPPC has reached the limits that an all volunteer effort can accomplish and therefore an important organizational goal is to develop a professional paid staff, beginning with an Executive Director to be hired in late 2001. Watch the web site for the job description. A major focus of the future professional staff will be fundraising to support a much higher level of research for current and future priorities such as the Cape ivy biocontrol program. CalEPPc also wants to fund graduate student research projects.

And of special interest at this 10th Anniversary Symposium is the role CalEPPC can play in promoting invasive weed organizing in the desert southwest. We come into this discussion with no preconception as to its outcome. The CalEPPC Board decided it would be premature to assume that an umbrella organization such as Southeast EPPC, with a number of state chapters under its charter, would be the way to go. Or that a Desert EPPC, independent of CalEPPC, should be the goal. Or a regional coalition made up of the existing invasive weed groups. The Board felt it important to first get to know the on-the-ground organizations that are already active in the North American Southwest, their missions, projects and who makes up their memberships. Is there a need to work together? Most certainly, These invasive weeds seem to have little respect for political boundaries and require a coordinated effort to meet the challenges they pose. But the organizational form that coordination should take is the topic to be explored in this afternoon's session. Let's engage the discussion.

History and Function of Exotic Pest Plant Councils

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The first Exotic Pest Plant Council was founded in Florida in 1984 to bring scientists, land managers, and concerned citizens together to identify and address harmful invasive plant problems in a unified manner. By the late 1980s several people here in Calif. had learned about this group and its accomplishments and they soon began efforts to organize a similar group here leading to the formal organization of CalEPPC in 1992. Shortly afterwards, EPPCs were founded in the Pacific Northwest and Tennessee. Tennessee EPPC later spearheaded a move to create a regional Southeastern EPPC with chapters in at least 5 more states (GA, KY, MS, NC, SC plus FL and TN). By the late 1990s a Mid-Atlantic EPPC with members from Virginia to New Jersey began forming. In recent years several other organizations with similar missions and goals formed in other parts of the U.S. under different names. These include the Invasive Plant Council of New York State (founded 1999), New England Invasive Plant Group (1999) and the Invasive Plant Association of Wisconsin (2001).

Accomplishments of these EPPCs and similar groups include increasing awareness of invasive plant problems though annual conferences, workshops, the publication of newsletters, brochures and books, and the creation of websites; funding research and development of biocontrol for high priority invaders; funding other research and control projects; developing authoritative lists of the most severe invasive plant pests and lists of non-invasive substitute species.

Since meeting and signing an MOU in 1995, the various EPPCs and similar groups have banded together in a loose coalition known as the National Association of EPPCs (NAEEPC). This Association ensures regular communication between the groups and facilitates cooperative action on common goals. The 2001 annual NAEPPC meeting of representatives of member groups will take place in Florida just a day before the 2001 CalEPPC Symposium. I will attend that meeting and report back any new developments.

Southwest Vegetation Management Association

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The history of SWVMA mirrors that of CalEPPC in its humble beginnings to meet a need perceived by people working at the field level for information that could be shared. The organization began in 1997 with a half dozen people concerned that no one was meeting the needs of people working at the field level in vegetation management in Arizona. They organized a group based on the New Mexico Short Weed Course and created a non-profit organization based on education of scientific principle with leadership provided by four officers and an advisory board of directors, with various committees created as needed to fulfill special roles. The mission statement chosen was, **"**to conserve and protect natural resources by providing leadership, education, regulatory direction, and professional and environmental awareness by promoting integrated vegetation management."

Accomplishments to date include holding the fourth annual conference this year in November, publication of a noxious weed handbook for the state of Arizona and a state noxious weed calendar. An electronic newsletter was started this past year. Plans for the future include creation of a web-page to allow better access to information and link the organization to other special interests. A federal grant proposal was drafted this spring for creation of WMA's in New Mexico and Arizona to control invasive species. Work is currently being done to draft a state noxious weed plan to be submitted to the state legislature.

Southwest Exotic Plant Information Clearinghouse

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Management of invasive species requires action and timely information to guide those actions. Since 1997 the USGS in Arizona has been working with land managers to develop a system for sharing information on the location and size of exotic plant species infestations. The Southwest Exotic Plant Mapping Program (SWEMP) has resulted in the development of a regional database that is updated yearly with the submitted field observations of federal, tribal, state and private. Maps of species distribution are developed yearly and displayed interactively on the web. The database currently includes 7500 records, contributed through the fall of 2000, representing over 50 species. In order to provide more comprehensive information on problematic exotic plants in the southwest, SWEMP has joined in a partnership to publish an updated web site, the Southwest Exotic Plant Information Clearinghouse (SW-EPIC), which includes the NPS developed Alien Plant Ranking System. As local weed management areas become more organized it has become easier for the regional database and web based information clearinghouse to identify and develop their role in the collective efforts to manage exotic plant species. SW-EPIC and SWEMP are now poised to provide data collection and distribution services that gives important information to concerned parties for action at the local level, vision across administrative boundaries at the regional level, and data for policy and strategy development at the national level.

The Nature Conservancy

Jon Hall

Invasive Species in Northern Mexico

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In the past, researchers assumed that arid areas were not susceptible to invasions by non-native plant species. In the Sonoran Desert, there are 233 non-native plant species. Not all of these are problematic, but there are some species that are starting to change the ecological relationships and impact species diversity in Northern Mexico and Southern Arizona. Three species that are problematic are bufflegrass (*Pennisetum ciliare*), tamarisk (*Tamarix ramosissima*) and crystal iceplant (*Mesembryanthemum crystallinum*). The perennial, African Bufflegrass is altering the ecological regime of desert areas by introducing fire to the ecosystem. Tamarisk is a species that can withstand drought and cause drying of the few springs that are present in arid areas. The arid adapted crystal iceplant is especially problematic in coastal areas and on islands in Northwest Mexico. Although individuals and organizations working on monitoring and controlling pest plants as part of their programs, there is no organization or group of organizations that are working to coordinate the effort to decrease impacts of non-native species on native vegetation. Border areas, like Organpipe Cactus National Monument, are in need coordinated binational efforts in order to be effective.

Interagency Weed Action Groups: An Effective Weapon in the War on Invasive Weeds?

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Interagency Weed Action Groups (IWAGs) are proving to be quite effective in "getting things done" to address invasive weeds issues in both New Mexico and Arizona. The New Mexico IWAG was organized first in May 1999 as a Federal Weed Action Group, and later expanded to bring in State agency weed staff as well, acquiring the name "IWAG" at that time. So far the New Mexico group has accomplished two major tasks: They prepared a template for an MOU for control of invasive plants on State highway corridors through Federal (and possibly State) lands; and they held a Symposium on Invasive Weeds on June 19-20, 2001, for executives of Federal and State agencies in New Mexico. The Arizona IWAG just got off the ground in March of this year, and has held only two meetings.. Nevertheless, through the IWAG, the Sweet Resinbush Task Force has acquired donations of herbicides and some equipment for control of the spread of a sweet resinbush infestation in the Safford area.

IWAGs are ad-hoc groups that operate without charter, without time-consuming paperwork, but with considerable personal commitment. They have been established as action groups, with participation limited to Federal and Stage agency weed folks in order to remain small enough to work efficiently and effectively together to address concerns and issues the agencies have in common. The participants decide what issues they want to address, identify actions needed, and then focus attention primarily on those issues.

New Mexico Weed Management Areas

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New Mexico has a relatively young noxious weed program. The noxious weed management act was passed in 1998. Unlike many other western states, New Mexico's law specifies that private landowner compliance is strictly voluntary. This has made public awareness and private citizen involvement even more critical than usual. Unlike more northern states, but typical to the southwestern states, there is no formal or uniform political structure in place for managing weeds at the local level. Instead, the state relies on the formation of cooperative weed management areas (CWMA), which are usually led by the local soil and water conservation district or the county extension agent. Currently, there are 12 counties with active CWMAs, and approximately 11 counties in the process of organizing a CWMA, out of the 33 counties in New Mexico.

The lack of a political framework allows flexibility in the structure of CWMAs, but also produces a lack of uniformity that further complicates coordination. Given the voluntary nature of the CWMAs, it is a struggle to balance the need for education and coordination opportunities with a finite schedule for actual weed management. There is a yearly noxious weed summit

to provide coordination between the CWMAs, and to chart the coming year's priorities for weed management. A strategic plan has been developed to help guide the weed management program, and there is an Interagency Weed Action Group to provide coordination on specific issues affecting state and federal agencies involved in weed management. The New Mexico Vegetation Management Association is a non-profit organization whose mission is to provide education related to all types of vegetation management, including noxious weeds. New Mexico holds a yearly noxious weed shortcourse produced through a joint effort of Univ. of Arizona and New Mexico State University. Other organizations, like the New Mexico Association of Conservation Districts and Southwest Strategy, have also incorporated noxious weeds as one of the issues they work on.

Another serious problem is the lack of information on effective control methods for species affecting desert environments. The results from the limited research that have been done are difficult to find and not widely available to land managers. The strategic plan calls for the formation of a technical advisory group, but such a group has not been formalized.

If a southwestern exotic plant pest council is going to be formed, it is critical that it fills a need and not duplicate or compete with existing organizations. Everyone is in agreement the last thing anyone needs is one more meeting to attend. The most obvious void is in the area of technology transfer. The discussion around the formation of an EPPC needs to focus on how it will meet this need, or others which may be identified, without just adding another layer to the organizations already addressing invasive species.

Invasive Plant Species Management in Arizona

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The mission of Arizona's Noxious Weed Program is to prevent, control, or contain non-native pest plant invasions. Arizona noxious weed statutes authorize the Director of Arizona Dept. of Agriculture to designate plants that are "...detrimental or destructive and difficult to control or eradicate..." as regulated pests. Arizona Administrative Code regulations establish a noxious weed list divided into three regulatory categories of (1) prohibited, (2) restricted or (3) regulated botanical pests. Landowners are responsible for controlling regulated weeds on their property and complying with abatement orders issued by the Department. Enforcement of noxious weed regulations is one responsibility of inspectors employed by the Department's Plant Services Division. Identifying noxious weeds, documenting/mapping infestations, developing public awareness, and advising landowners is a cooperative effort among the Dept. and volunteer non-governmental weed management organizations, Univ. of Arizona, non-profit organizations, private citizens, and numerous local/state/federal government agencies. The Dept. has initiated the process to list four Sonoran Desert invasive plants: buffelgrass (*Pennisetum ciliare*), fountain grass (*Pennisetum setaceum*), Sahara mustard (*Brassica tournefortii*), and Malta starthistle (*Centaurea melitensis*).

The Noxious Weed Program in Nevada: Where it Started and Where it's Going.

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The Nevada noxious weed program is a little over one year old. The legislature created a weed specialist position for the Dept. of Agriculture in 1999 and the position was filled in May 2000. Currently there are two state weed groups: The Nevada Weed Management Association and The Nevada Weed Action Committee. These groups were both formed in 1995 and have been instrumental in forming alliances and cooperative efforts.

Nevada is a unique western state in its relatively low occurrence of noxious weeds, relative that is to adjacent states. Because of it's large size and low population, Nevada until recently has not had sufficient traffic to introduce and move invasive plants extensively. But this is changing rapidly as we are now one of the fastest growing states in the nation. As such, a good deal of our focus is on exclusion of new introductions.

Educating the residents in the southern part of the state has been a recent priority. With the discovery of tall whitetop in the Las Vegas washes, noxious and inva-

sive weeds have caught the attention of this urban community. The majority of weed related activities in the past seemed to focus on the northern end of the state. Efforts are underway to integrate both south and north regions and create a coordinated, unified program.

Calif. Weed Management Areas

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County-level weed management areas, and other statewide coordination groups have brought invasive plant prevention and control to a higher level of sophistication and effectiveness in California. As of 2001 all but 4 of the 58 counties in the state are participating in a WMA. But much more can be done to tie together work within the state. To date, groups in Calif. have been initiated by either the leadership of the County Agricultural Commissioner's Office or a Federal Agency employee. WMA's are unique because they attempt to address agricultural (noxious) weeds and "wildland" weeds under one local umbrella of organization WMA's have printed weed I.D./control brochures, organized weed education events, written and obtained grants, coordinated demonstration plots, instituted joint eradication and mapping projects, as well as, many other creative and effective outreach and weed management projects. The Calif. Dept. of Food and Agriculture runs a support program which allocates $1.3 million dollars per year in cost share support for county-level WMAs. CDFA also puts on coordination workshops and other training in GPS, GIS, and strategic planning.

Session IV

Invasive Species, Coming to America. New Strategies for Biological Protection through Prescreening, Early Warning, and Rapid Response.

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Introduction. During the 18th and 19th century, when global trade and travel were minimal, foreign pests that threatened crop and livestock production, were major concerns. However, at that time, there was little concern about the thousands of plant and animals that were being imported to the U.S. for utilitarian purposes such as soil erosion [kudzu (*Pueraria montana*)], windbreaks [Russian olive (*Eleagnus angustifolia*)], medicinal use (purple loosestrife (*Lythrum salicaria*)], and for ornamental use [salt cedar (*Tamarix chinensis*)]. While many of these introductions remain beneficial today, some of them have become invasive and pose a serious threat to our remaining natural and conservation areas.

Prohibited Lists – The Heart of the Current U.S. Crop Protection System. The current U.S. federal/state crop protection system was developed in the late 1800s and early 1900s in response to outbreaks of plants and animal pests such as foot and mouth disease and Mediterranean fruitfly (*Ceratitis capitata*). The system includes programs that form two lines of defense against invasion through **exclusion of foreign agricultural pests** (production of pest free commodities; preclearance at ports of export; inspection and clearance at ports of entry); **early warning and rapid response to incipient infestations** (early detection, rapid assessment, rapid response).

For decades, alien pests of concern have been assessed for invasiveness and prohibited introduction into the U.S. under a menagerie of federal plant and animals quarantine laws. In 2000, these laws were superseded by the omnibus Federal Plant Protection Act. *While the new law provides equal authority for regulation of all types of invasive species,*

including invasive plants, *the decision to assess a candidate species to determine whether it should be regulated is still optional in most cases*. As a result, most species that are imported into the United States are still not being assessed for invasiveness – in general, the system does not require it (proposed new fruits and vegetables must be assessed for invasiveness under Quarantine 56 for invasiveness). The current system generally works fine to protect monocultural agricultural production systems from *known* foreign pests. However, in order for the nation to effectively meet the challenge it faces with invasive species in all types of environments, scientific evidence is persuasive that new approaches for preventing introduction, establishment, and spread of invasive species are needed.

Prescreening – A Regulatory Yield Sign Needed to Slow the Global Movement of Invasive Species. In theory and practice, there is nothing inherently wrong with the assessment tools being used in the current federal prohibited list system. However, in order to identify all potential new invaders that are being imported, all proposed species should be assessed for invasiveness and to determine whether they should be regulated – not just known agricultural pests. The very successful Australian Weed Risk Assessment System has demonstrated the viability of this approach, and could serve as a model in developing a similar system in the United States.

For continuity with the current U.S. plant regulatory system, the proposed prescreening system could continue to focus on 'prohibited' species. However, unlike the present federal system, which only assesses a small percentage of proposed species for invasiveness, the new system would assess all proposed species to determine whether they should be **prohibited entry** (invasive species with no known commercial benefit, e.g., zebra mussel), **regulated entry** (invasive species with some commercial benefit), **permitted entry** (pending other regulatory issues), or placed on a **National Invasive Plant Watch List** (species already too widespread to officially regulate).

New Approaches for Early Warning and Rapid Response to New Invasive Plants.

Under the current crop protection system, federal and state plant regulatory agencies work to protect the nation from economically important plant and animal pests and diseases. However, due to a lack of resources and organized constituencies, new invasive plants are seldom addressed on public or private land until populations become widespread and prevention / eradication becomes impractical. With this in mind, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) hosted a workshop in Ft. Collins, Colorado, in June, 2000, on creating a **National Early Warning and Rapid Response System for Invasive Plants**. During 2001, an Early Warning/Rapid Response Action Plan was developed that closely follows major recommendations that were developed at the workshop, as well as relevant recommendations under the National Invasive Species Management Plan, which was approved by the National Invasive Species Council in January 2001.

The overall purpose of the National Early Warning and Rapid Response System would be to provide a coordinated framework of public and private partners at the local, state, regional, and national levels to more effectively address new invasive plants through **early detection** and **reporting** of suspected new plants, **ID** and **vouchering** of specimens, **verification** of suspected new records, **archival** of new records **in appropriate databases**, **rapid assessment** of new records, and **rapid response** as appropriate. Once fully implemented across the nation, the proposed system would provide an effective second line of defense against invasive plants, and would work in concert with federal efforts to prevent unwanted introductions at the ports of entry (the first line of defense). With both systems in place, the nation would be better able to defend against future economic and environmental losses due to "plants out of place".

Conclusions. In order to effectively address new environmental invaders that have no obvious political constituency, we need to develop a science

based **Biological Protection System** for more effectively preventing the introduction, establishment and spread of invasive species in natural and managed areas of the United States. To accomplish this, we need to:

A. Prescreen all new plants and animals proposed for importation into the United States, to determine if they should be regulated at the federal and/or state level.

B. Develop a National Early Warning and Rapid Response System for Invasive Species.

C. Create new local, state, and regional interagency partnerships to rapidly assess and respond to new invaders.

Killer Algae, the rapid response to *Caulerpa taxifolia*, a case study in a multi-agency project

Rachel Woodfield, Merkle & Assoc.

Anonas spp. (fieldrest harrow): rapid response to the first known U.S. infestation

Richard Little, Agricultural Biologist, San Luis Obispo Agriculture Dept.

Session V

Endangered Species & Invasive Weeds: Use by, Impacts on, and Control/ Regulatory Issues

Managing Endangered Species to Remove Constraints Against Invasive Weed Control

Dick Zembal, Orange County Water Dept. & Team Arundo

Regulatory Issues in Controlling Invasive Weeds — Session Chair, Joel Trumbo, Calif. Dept. Fish & Game

Objectives of this panel discussion:

- To gain understanding of the objectives/ priorities of the involved regulatory agencies;
- To discover potential areas of compromise and cooperation;

Format:

- Each participant will be given a set amount of time to explain their agencies authority/ role.
- Pre-arranged Q&A with prepared questions from moderator;
- Open forum Q&A from audience;
- Wrap-up, closing comments from panel members.

Aquatic Herbicides and NPDES Permits — Larry Nash, State Water Resources Control Board and Pete Michael, San Diego Regional Water Quality Control Board

Threatened and Endangered Species Protection — Tamara Spears, Calif. Dept. of Fish & Game and Daniel Brown, U.S. Fish & Wildlife Service

Session VIII: Concurrent Sessions

Emergence and Development of *Cynara Cardunculus*: Developing Seedling Removal Strategies for an Invasive Weed

Virginia A. White and Jodie S. Holt. Dept of Botany and Plant Sciences, Univ. of California, Riverside, CA

Cynara cardunculus, artichoke thistle, occupies thousands of acres of California's grasslands. Understanding the conditions necessary for germination and establishment is critical to formulating successful management plans for such invasive species. Soil cores collected seasonally from infested areas indicate that *C. cardunculus* has a transient seed bank with field-collected seeds exhibiting no dormancy in laboratory experiments. Trials on a temperature gradient bar showed that germination occurred fastest from 13 to 29 degrees C. Daytime temperatures at a field site (Crystal

Cove State Park, Laguna Beach, CA) were within this range, indicating ideal germination temperatures occurred as early as January and continued through May. A greenhouse experiment was undertaken to determine how surface conditions and planting depth affect emergence and development of *C. cardunculus*. Surface condition treatments included covering the surface with artichoke thistle thatch, *Bromus* spp. thatch, or no thatch (bare soil); planting depths were 0 or 1 cm. Germination percentage was greatly reduced in the bare soil treatment with seeds planted on the soil surface. Regardless of planting depth, both thatch treatments resulted in shoot apices elevated in the soil profile with respect to the bare soil treatment. The information from these experiments can be utilized in a management plan for simultaneously promoting germination to exhaust the seed bank and elevating the shoot apex, leaving it exposed and vulnerable to removal.

Terrestrial Fauna Community Composition of *Arundo Donax* (*Poaceae*) Root Masses

Robert E. Lovich, Edward L. Ervin, and Robert N. Fisher, Wildlife Management, AC/S Environmental Security, Marine Corps Base, Camp Pendleton, CA Dept. of Biology, San Diego State Univ., San Diego, California, U.S. Geological Survey, Western Ecological Research Center, San Diego Field Station, CA

The giant reed, *Arundo donax*, is an exotic invasive plant that has become widely established along riparian corridors in the southwestern United States. It is widely known to form dense thickets and negatively affect riparian systems in many ways, however little is known about the faunal communities associated with this plant. In this study, faunal composition from root masses of the giant reed, *Arundo donax* was analyzed from the Santa Margarita River at Marine Corps Base Camp Pendleton, San Diego County,

California. A total of 41 root ball masses were analyzed in this study. No sensitive species and almost no vertebrates were found in association with *Arundo donax*. A total of 2590 macroinvertebrates were collected and identified, and represented 64 species from 7 classes. Three exotic invertebrate species made up 41% of the total number of captured invertebrates, and only 31% of the sampled invertebrates could be confirmed as native species. Those species that were confirmed as native (n=901, 29 species) had a diversity of 1.03, and an evenness of 71% (1.46), while confirmed exotic species (n=1201, 8 species) had a diversity measure of 0.62, and 68% evenness (0.90). The native versus exotic species Shannon Weaver diversity indices were significantly different ($t = 10.51$, $df = 996.0$, $p < 0.001$), with native species diversity being significantly greater than exotic species diversity. This study demonstrates that A. donax root masses are suitable habitat for some native macroinvertebrate species, but are dominated by a greater abundance of few exotic species. Our results also suggest that in localized and ruderal stands of *A. donax*, removal by means of heavy equipment may not compromise sensitive species in southern Calif. riparian systems.

Tamarix aphylla: An invasive threat in the Desert Southwest

Pamela Barnes, Elizabeth Powell, and Lawrence Walker. Univ. of Nevada, Las Vegas and National Park Service, NV

In the Southwestern United States, the athel pine (*Tamarix aphylla*) has been considered to be an innocuous introduction. However, at the Lake Mead National Recreation Area, populations of the tree have spread beyond their original boundaries, forming monospecific stands and creating a threat to native flora and fauna. *Tamarix aphylla* has been thought to be sterile and unable to reproduce by seed in this area. We examined the germinability of *T. aphylla* under laboratory conditions and found that the trees in this area do produce viable seeds. While some trees produced no viable seeds, other trees produced seed sets with eighty-eight percent germination. With estimated seed production of large trees over a season of up to 250,000 seeds, the Lake Mead population of *T. aphylla* is producing millions of viable seeds. On examination of areas surrounding our study sites, we found seedlings of *T. aphylla*. This suggests that if favorable environmental factors exist, seedling establishment is probable for *T. aphylla*. The possibility of sexual reproduction of this exotic species, combined with rapid vegetative reproduction, makes *T. aphylla* an invasive threat along the shores of Lake Mead and other mesic areas in the southwestern deserts.

The Impacts of a Riparian Invader, Salt Cedar (Tamarix Ramosissima), on a Stream Food Web

Theodore Kennedy, Dept. of Ecology, Evolution, and Behavior, Univ. of Minnesota, Saint Paul, MN

Although biological invasions are increasingly recognized as an important aspect of global change, the impacts of specific invaders are often poorly understood. By experimental manipulation of salt cedar (*Tamarix ramosissima*) density along a desert stream (Jackrabbit Spring, Nevada), I documented changes in organic-matter dynamics and concomitant changes in aquatic communities due to invasion by exotic salt cedar. Dense stands of salt cedar along Jackrabbit Spring reduce autochthonous production by 56-67% and emergent macrophyte biomass by 71-95%, and increase allochthonous litter inputs 1100-4300%. Salt cedar reaches are dominated by introduced mosquitofish (*Gambusia affinis*) and crayfish (*Procambarus clarkii*) and support significantly fewer endangered speckled dace (*Rhinichthys osculus nevadensis*) and pupfish (*Cyprinodon nevadensis mionectes*) than native riparian vegetation or salt cedar removal reaches. This research demonstrates that a riparian invader, salt cedar, can alter in-stream dynamics and is having a negative impact on the endangered fish of Ash Meadows.

Experimental Revegetation Strategies and Technologies for Restoration of Native Shrub/grass on Salt Cedar Infestation Sites

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Critical knowledge gaps exist regarding vegetative recovery in xeric, monotypic saltcedar (*Tamarix* spp.; TAARA) stands with no (desirable) understory. On sites not subject to seasonal flooding, shallow water table or irrigation, recovery of desirable vegetation may be the most limiting factor for site restoration. Vegetative recovery of sites impacted by saltcedar invasion (and subsequent control) presents technical and conceptual challenges. Formulation of revegetation strategies that provide site stabilization, resistance to further saltcedar and weed infestation, and acceptable habitat values for affected wildlife species becomes particularly problematic in monotypic saltcedar stands under biological control scenarios. Amount and density of standing biomass (live and dead) remaining after control poses limitations in relation to seeding and planting techniques, seed interception in aerial (broadcast) applications, and seedbed preparation methods. Undisturbed soil surfaces impacted by saltcedar leaf litter accumulation, salinity, hummocky micro-relief, and nutrient limitations restrict potential for successful revegetation. Long duration of saltcedar occupation may produce depletion of needed microbial communities, particularly arbuscular mycorrhizae (AM) symbiotic and host-specific to native revegetation species. Increased emphasis is needed on development of revegetation techniques for sites where potential for natural vegetation recovery following saltcedar control is limited. Innovative revegetation strategies and technological approaches will be discussed in view of ongoing, interagency research on biological control and restoration of saltcedar infestations funded by a grant from the Cooperative State Research and Extension Service and the Initiative for Future Agriculture and Food Systems. These approaches include evaluation of seedbed preparation methods, seeding/planting techniques, mycorrhizal inoculation, nitrogen dynamics, and sequential seeding technologies.

Successful Removal of Cape Ivy and Recovery of Riparian Vegetation on Two Acres along Redwood Creek, Marin County: Changes in Cover Three Years after Removal

Carolyn Shoulders, Natural Resource Specialist, National Park Service, Golden Gate National Recreation Area, San Francisco, CA

Redwood Creek, which drains from Mt. Tamalpais to Muir Beach in Marin County, retains numerous elements of a naturally functioning riparian system, but its riparian corridor became engulfed by the highly noxious *Delairea odorata* (cape ivy) in the past decade. The National Park Service initiated a project in 1998 to remove cape ivy on two acres of creekside habitat and has documented the recovery through the use of permanent transects in the removal area and a control area. Cover data shows that the NPS removal method was successful in virtually eliminating cape ivy, which dropped from about a 40% absolute cover to a 0% cover in the first year. Numerous native species rebounded quickly and now have a significantly

higher rate of cover than before cape ivy removal, including *Rubus ursinus* (native blackberry), *Rubus parviflorus* (thimbleberry), *Stachys chamissonis* (hedge nettle), and *Sambucus racemosa* (elderberry). Some species appeared which had not been observed at all before removal, such as *Smilacina racemosa* (false Solomon's seal) and *Trilium ovatum* (wake robin). The only element of concern in the recovery process has been the increasing rate of cover by non-native species other than cape ivy, particularly *Holcus lanatus* (velvet grass). NPS used only mechanical removal methods for this project. All above-ground herbaceous vegetation was cut and raked up. Roots of native perennial species remained, allowing for quick reestablishment. Roots of cape ivy were grubbed out by hand in the following months, mostly by large groups of volunteers.

San Francisco Peaks Weed Management Area

Laura P. Moser, San Francisco Peaks Weed Management Area, Coconino National Forest, Flagstaff, AZ

This spring the Coconino NF (AZ) Weed Control ll Project (#00-002-003), under the Pulling Together Initiative, has added to the many accomplishments of the year. We expanded the weed management area, hired an Inventory Control and Management Crew, treated over 13,640 acres of invasive weeds (including ADOT's road treatment program), encouraged and developed invasive species research projects, expanded educational projects and resources with new partners. We continue to work towards the SFPWMA long-term goals of eradicating recently introduced invasive weeds and restoring native vegetation to protect wildlife, national parks, forest service lands, and private lands from being overrun by invasive exotic plants. By June 30, 2001 in Project II, the project partners have spent more than our total match goal on invasive plant education, surveys, mapping, control actions, monitoring and re-vegetation. The City, County and Forest Service have been able to establish baseline surveys in areas never surveyed before and treat many high-risk populations before seed dispersal. We've created a two level training program: 'Weed Species Identification' for all field/road personnel and 'Planning for Weeds' for all project managers, planners, and NEPA personnel. I will summarize our WMA development, accomplishments and training program.

Managing annual weeds in Coastal Sage Scrub: What works?

Robert Cox and Edith B. Allen. Dept of Botany and Plant Sciences, Univ. of Calif., Riverside, CA

Research was begun in 1999 to determine suitable methods of weed control and restoration in coastal sage scrub (CSS) at the Shipley Reserve, Riverside Co, California. Historical grazing and cultivation of the lowlands has depleted the native seedbank. Weed control treatments included application of the grass specific herbicide Fusiladetm (fluazifop), thatch removal, and mowing. Plots were raked, and species native to CSS in this area were broadcast in 2001 to allow comparisons between unseeded and seeded areas and to evaluate the success of the various treatments at allowing native seedlings to emerge and establish. Application of herbicide for two consecutive years provided control of exotic grasses into the third year. Exotic forbs, however, increased under the same treatment. Native forbs emerged best from experimental units in which thatch was removed and herbicide was applied. Mowing provided some control over exotic grasses but not exotic forbs. Native forbs did not emerge well from the mowing treatment. Native shrubs did not emerge in any treatment.

Integrated management of yellow starthistle and medusahead using prescribed burning and clopyralid

Joseph M. DiTomaso, Guy B. Kyser, Steve Orloff, Sergio Garcia, Glenn Nader, and Richard Smith, Univ. of Calif., CA

Recent research efforts have led to the development of effective control methods for yellow starthistle (*Centaurea solstitialis*), particularly prescribed burning and the herbicide clopyralid (Transline). However, repeated use of burning can be impractical and continuous clopyralid treatments can result in suppression of desirable legume species or selection for other undesirable species, particularly exotic annual grasses. Although the solution to these potential problems is the development of effective integrated weed management strategies, no studies have yet focused on the impact of integrating prescribed burning and herbicides on yellow starthistle management and rangeland health and vigor. In this study, we treated 0.25 to 0.5 acre plots with one of five

possible treatments; 1) untreated control, 2) two consecutive years of clopyralid (4 oz product/A), 3) two consecutive years of prescribed summer burning, 4) first year clopyralid followed by second year prescribed burning, and 5) first year prescribed burning followed by second year clopyralid. Treatments were made in 1999 and 2000. The study was conducted in San Benito, Yuba, and Siskiyou counties. In 2001, vegetative cover was evaluated in all treated plots. In Siskiyou County the lack of rainfall resulting in the absence of yellow starthistle cover even in the untreated plots. In the other two counties, however, results demonstrate that two consecutive years of clopyralid reduced yellow starthistle cover in the following year by more than 90%. However, in Yuba County, this treatment resulted in an increase in medusahead (*Taeniatherum caput-medusae*) cover from 12 to 19%. Two consecutive years of prescribed burning reduced both medusahead and yellow starthistle in Yuba County, but did not reduce yellow starthistle in San Benito County because of the incompleteness of the burn. Clopyralid treatment the first year followed by prescribed burning in the second year did not significantly reduce starthistle in either site. The best combination for yellow starthistle control was a first prescribed burn followed by a second year clopyralid treatment. In both sites, yellow starthistle was reduced to less than 1% cover. In addition, this combination also greatly reduced medusahead cover in Yuba County. It is hypothesized that prescribed burning results in a stimulation in yellow starthistle germination the following winter, thus rapidly reducing the starthistle seedbank. A subsequent clopyralid treatment in the second year can provide effective control of these germinated seedlings.

Large-scale integrated management of yellow starthistle (*Centaurea solstitialis*) at Fort Hunter Liggett, Monterey County, California

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Yellow starthistle, *Centaurea solstitialis* L. (Asteraceae), is a noxious annual that has spread throughout the western United States since the mid-1800s. Within California, yellow starthistle has invaded 10 to 15 million acres, where it can produce large stands that serve as continuous seed reservoirs. Thus, control efforts focus on reducing seedbanks or destroying plants before they produce seeds. Recent studies suggest that integrating two or more management techniques (e.g., mowing, herbicide application, burning, reseeding, grazing) over several years provide successful control. Landscape-scale integration of prescribed burning and broadcast herbicide application of Transline® (clopyralid) is being studied at Fort Hunter Liggett (FHL) military installation in Monterey County. Three habitat types are being managed, including a military-use grassland, an oak woodland, and a grassland with rare species (*Chlorogalum purpureum* ssp. *purpureum*). The military-use and oak woodland sites were burned during summer 1999, aerially treated with Transline in April 2000, and treated with Transline in February 2001(military-use site) or burned (oak woodland site) in July 2001. The rare plant grassland was burned during autumn of 2000. At each site, yellow starthistle cover, density, biomass, and overall species richness were evaluated. First and second year treatments resulted in up to 94% and 96% reduction in yellow starthistle cover, respectively, at the military-use and oak woodland sites. Less control was achieved in the rare plant grassland site. We have concluded that integration of properly timed prescribed burning and Transline application can significantly reduce starthistle infestations while having little impact on total species richness in treated areas.

Posters 2001

Evaluation of Chipped Arundo Biomass as Mulch

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Introduction

Arundo donax can produce huge volumes, up to 45 kg/m^2, of biomass (A.H.B.M. Wijte, pers. comm.). In many cases the plants are foliar sprayed and the material is left standing or it is chopped in place. There are times when for other reasons, such as reducing the amount of dead biomass introduced into a riparian system, that the choice is made to remove the material. This can be costly and difficult to manage and so we evaluated its use as mulch for restoration and erosion control.

Approximately 80,000 yards of chipped *Arundo donax* were generated as a result of *Arundo* eradication efforts on Camp Pendleton. The material consists of stem and root fragments ranging from $^1/_2$ inch to 6 inches in size (Fig. 1). This material has the potential to resprout under ideal laboratory conditions from pieces as small as $^1/_4$ inch (Claude Boehm, pers.comm). However, other than the potential for *Arundo* resprouts the material contains very few weeds, making it potentially useful for restoration. Also expected are additional benefits associated with stabilizing the soil and hindering wind and water erosion. Our question was to find out how much *Arundo* resprouting actually occurs under actual field conditions to evaluate the viability of using *Arundo* as mulch throughout the Base.

Methods

During calendar year 2000 approximately 20,000 cubic yards were spread on five sites (Fig. 2). The purpose of the first study was to get an idea of the quantity of resprouting *Arundo* in order to determine the practicality of using this product for restoration and erosion control. In 2001, approximately 400 cubic yards of *Arundo* mulch was incorporated in a coastal sage scrub restoration project (Rusev et. al). The purpose of the second study is to evaluate *Arundo* mulch against Oceanside landfill orchard mulch in terms of soil moisture retention and non-native plant invasion.

The *Arundo* was removed from the soil with a grapple and ground using a stationary tub grinder between October 1999 and January 2000 (Fig. 3). Between the months of February and April approximately 450 truckloads of *Arundo* mulch was spread 6 to 10 inches deep at five sites (Figs 4 – 11).

The sites were visited on February 15 and June 16, 2000 to evaluate resprouting.

Results

On June 16, 2000, after approximately four months post-application, sites 1-4 were examined for *Arundo* resprouts (Table 1). Site # 5 was examined on August 8, 2000. These sites had received about 7.8 inches of rainfall. The total number of resprouts across all lay down sites was relatively small. The area with the greatest amount of resprouting was the woodlot containing the source pile that still was fairly deep (approximately 36 inches).

Table 1. Number of resprouts at each site.

Site*	#1	#2	#3	#4	#5
# of Resprouts	10	2	10	1	12

#1 Vacant Lot; #2 Firebreak; #3 Pistol Range & Parking Lot; #4 Parking Lot; #5 Military Training Facility

At the coastal sage scrub restoration site in 2001 14 resprouts were found.

Discussion

In the 2000 study the *Arundo* resprouts seemed to share two traits. They all grew from large rhizomes that 1) apparently remained fairly intact through the mulching operation, and 2) were buried rather deeply in the substrate under deeper layers of mulch (Fig. 12). Mulch that was spread

thinly and evenly, like over most of Site #3 and at the parking area at Site #4, had fewer resprouts. Site #1 was different in that resprouts appeared to be more uniformly distributed across the site and not necessarily tied to deeper mulch than at the other sites. However, since this was the only site where the mulch was tilled into the soil, resprouting may still have been accelerated by deeper mulch in the subsurface soil. The woodlot had the most resprouting and the deepest pile of mulch of all sites investigated here.

In the 2001 study four of the fourteen resprouts had no detectable rhizome or stem fragment at the base of the plant while the remainder grew from pieces ranging from 6 to 29 cm in length. At this time both the Arundo mulch and Oceanside Landfill Orchard Mulch have resulted in increased moisture retention and slower non-native plant invasion than bare ground (Rusev et.al, 2001).

Conclusions

1. While very small stem and root fragments can germinate under laboratory conditions, in the field very few actually do.
2. The numbers of resprouts are so few and small that pesticides are not needed for their control and they can easily be collected by hand.
3. Even though resprouts are few, they do occur and so arundo mulch is only recommended on sites where follow-up monitoring is planned.

Literature Cited

Rusev, A., T. Zink and M. F. Allen. 2001. Annual Report for the Restoration of Coastal Sage Scrub Habitat as Mitigation for the Santa Margarita River Flood Control and Basilone Bridge Replacement Project. Prepared for Southwest Division Naval Facilities Engineering Command, San Diego, California.

Acknowledgements

We would like to thank the staff of the Environmental Security Office at Camp Pendleton, especially Chris Bandy, Wildlife Biologist and Rich Riddle, Range Conservationist for their participation in and support of this project.

Figure 1. The *Arundo* mulch consists of stem and root fragments ranging from 1/2 inch to 6 inches in size.

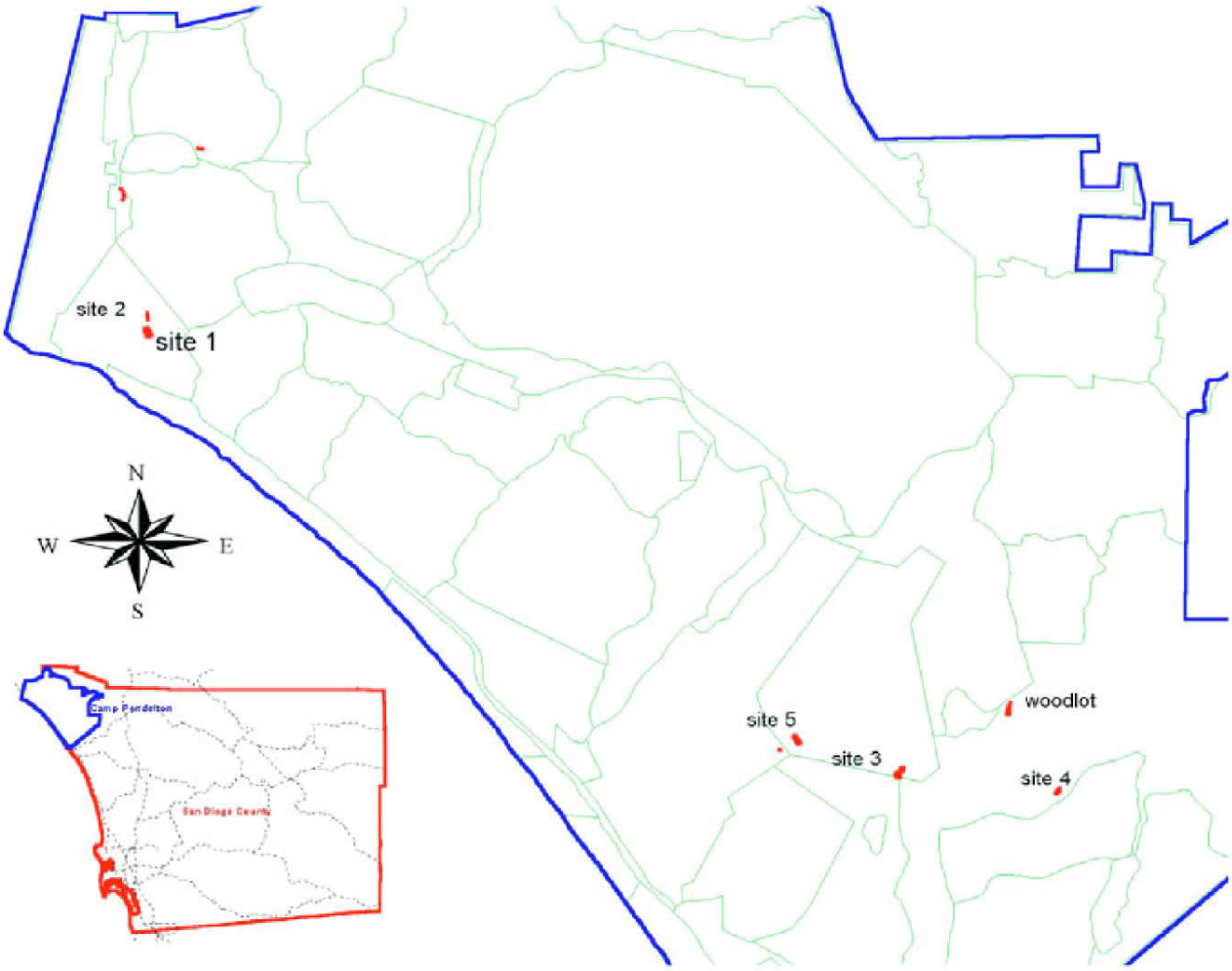

Figure 2. *Arundo* mulch was distributed from the woodlot to sites within Camp Pendleton for soil stabilization and to hinder erosion.

Figure 3. *Arundo* was removed from riparian areas using a grapple. Large clumps of *Arundo* were pulled and placed in trucks and carried to a stationary Tub Grinder for processing.

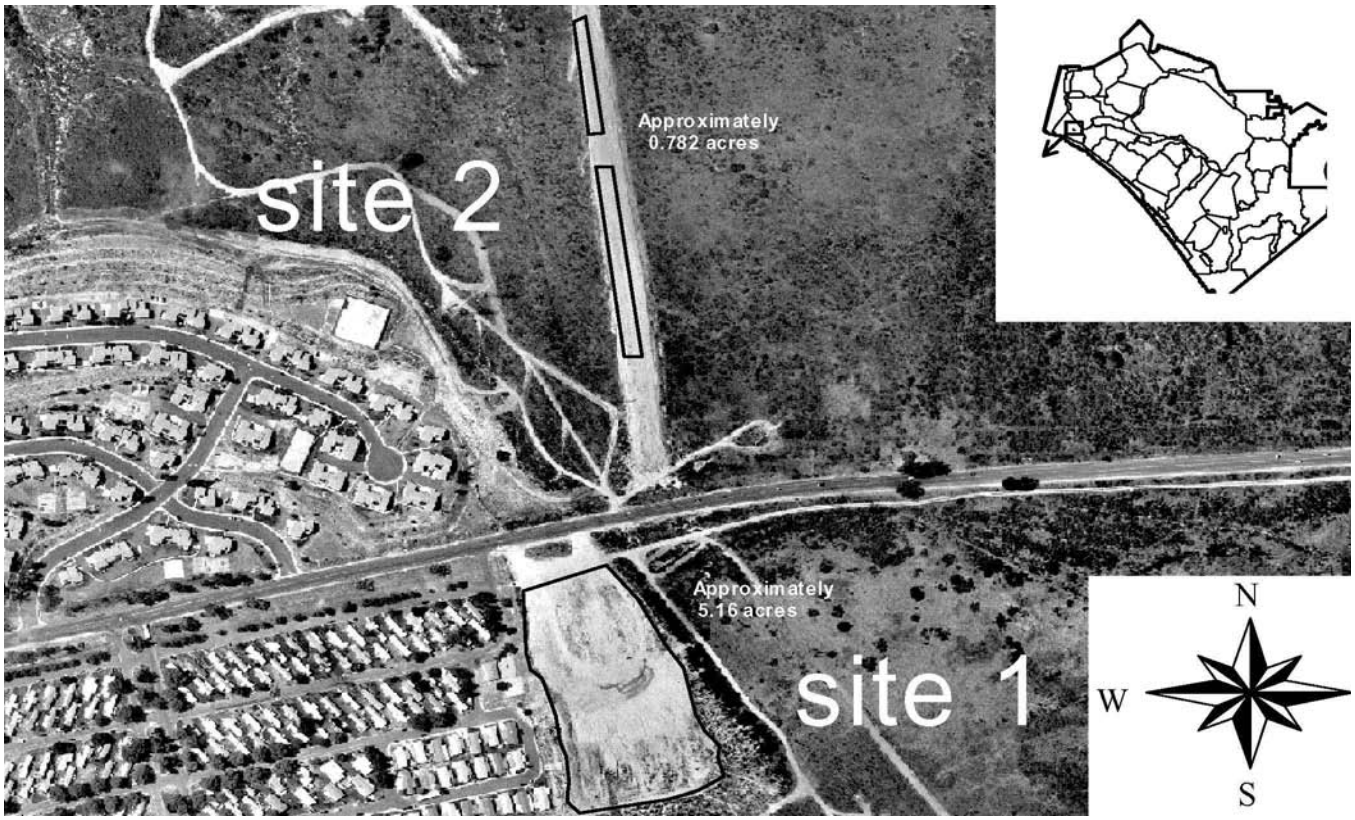

Figure $. Site #1 and Site #2.

Figure 5. Site #1 (foreground), a vacant lot about 5.1 acres where 7000 cubic yards of mulch was applied. The soil was tilled after application of the mulch. Site #2 is a firebreak across the road from Site #1 where approximately 940 cubic yards of mulch was spread over a bout 0.78 acres.

Figure 6. Site #3, Range 102, is a pistol range. *Arundo* mulch was spread over the range and its associated parking area. The mulch covered about 4.7 acres (4600 cubic yards of mulch).

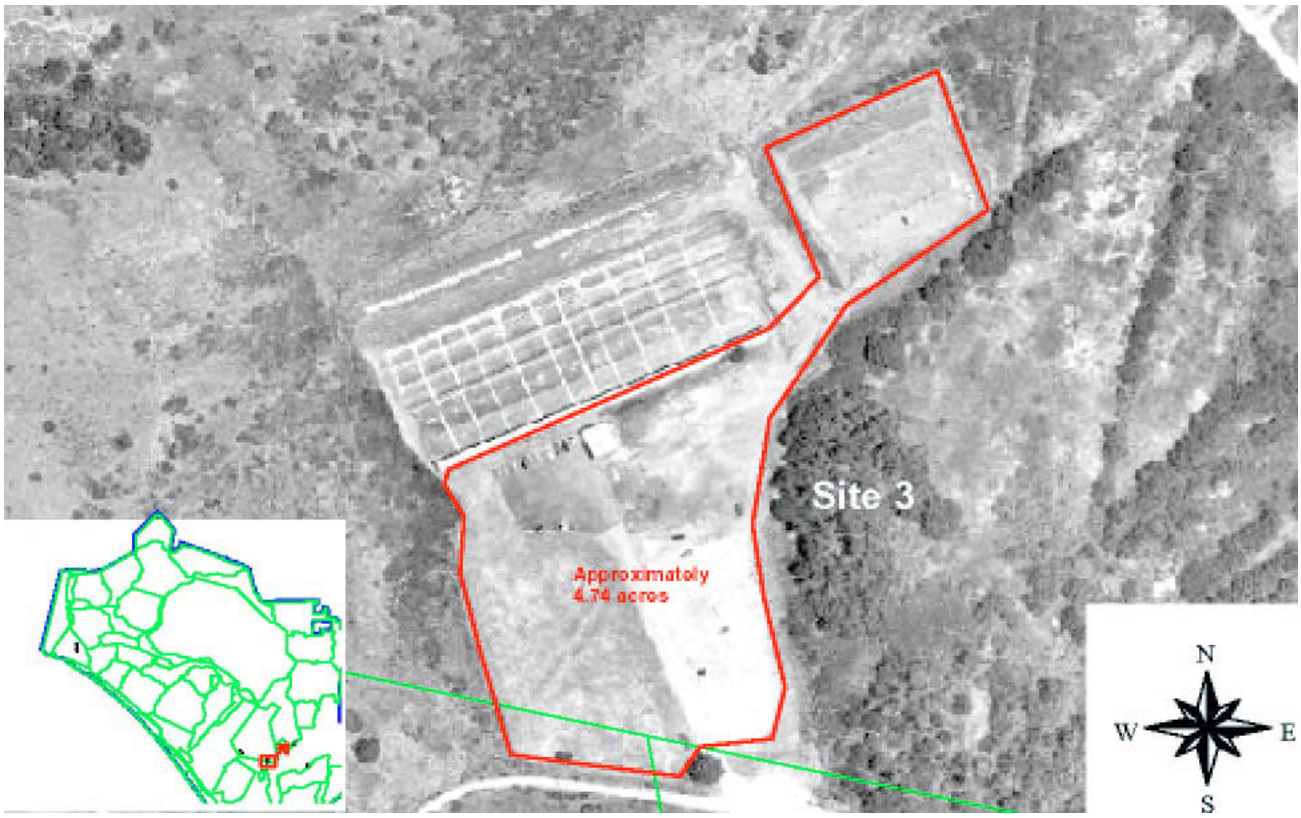

Figure 7. Site #3: Range 102 and parking lot.

Figure 8. Site #4 is the unpaved portion of a parking lot. Approximately 1100 cubic yards of mulch was spread on one acre.

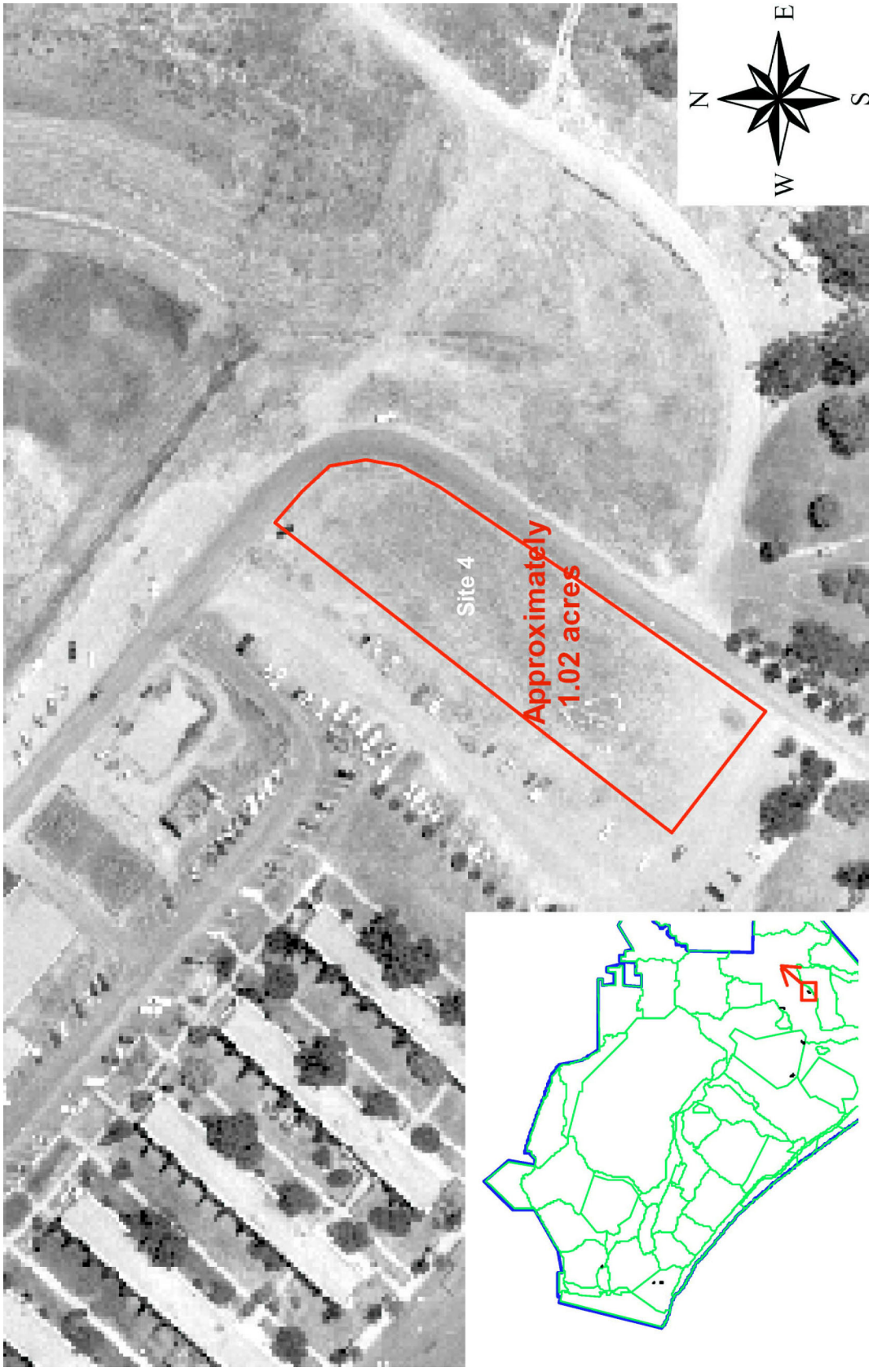

Figure 9. Site #4: Overflow

Figure 10. Site #5 is a military training facility where approximately 5800 cubic yards of mulch was spread. The circle marks an *Arundo* r resprout. *Arundo* mulch was spread in a deep layer on the mounds and between mounds.

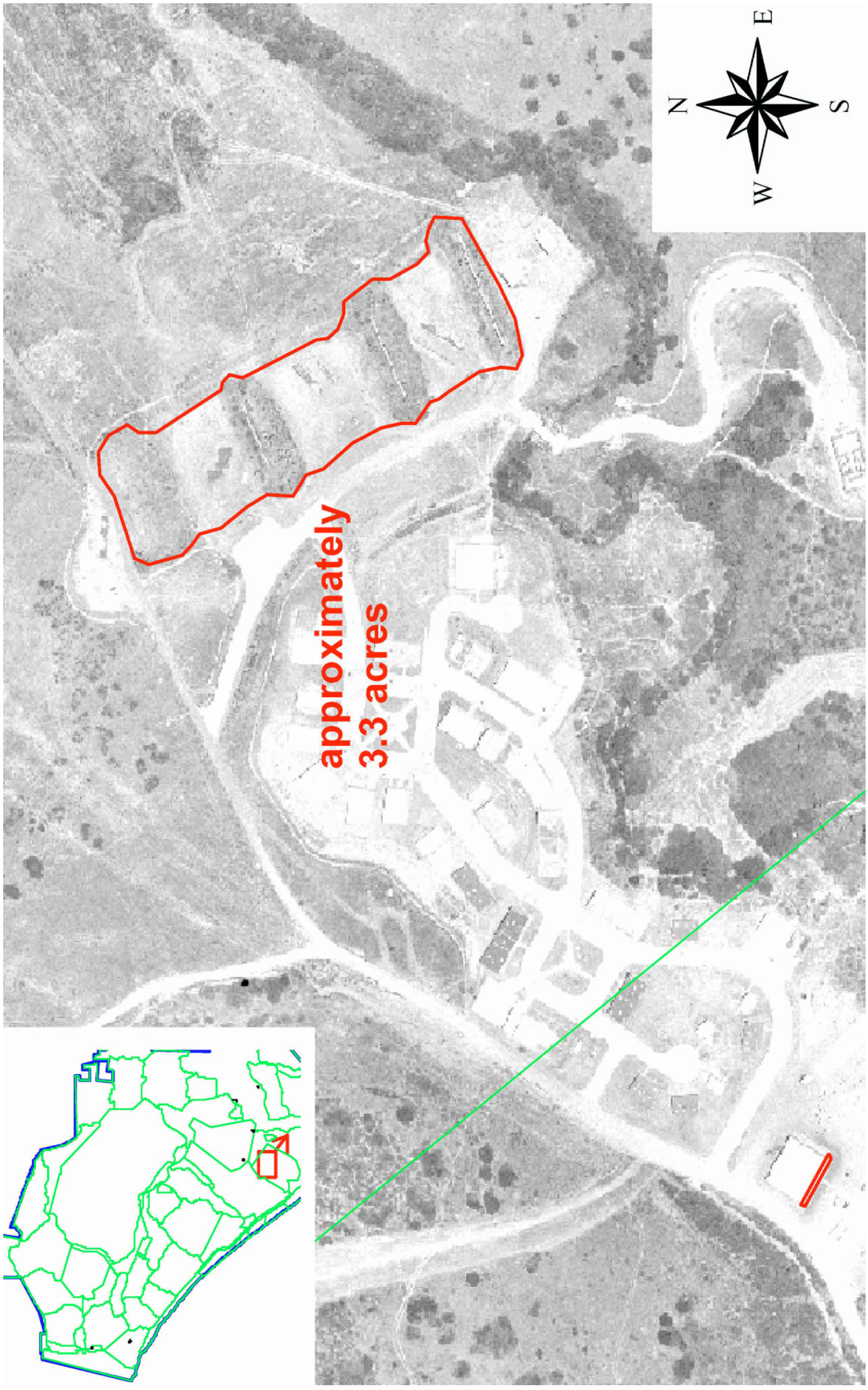

Figure 11. Site #5 training facility.

Figure 12. *Arundo* resprouts from site #5 demonstrate the range of rhizome fragment that resprouted. The larger rhizome is 14 inches and was buried over 6 inches.

Distributions of Arundo Donax in Coastal Watersheds of Southern California

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Introduction

A regional map showing distributions of Arundo donax (giant reed) in southern California's coastal watersheds has been posted at the website of the Santa Margarita and San Luis Rey Weed Management Area, <www.smslrwma.org>. Map coverage extends from the Santa Ynez River in Santa Barbara County to the Mexican border.

The Arundo distribution map is based on visual inspection of riparian corridors, viewed from public roads, bridges and roadside overlooks where possible, and to a lesser degree from bike paths and foot trails. In numerous places, Arundo control proponents with knowledge of local areas provided maps or verbal reports of Arundo distributions that were incorporated into the regional map.

The Arundo survey adopted the reconnaissance mapping protocol developed by Team Arundo del Norte, whereby the abundance of Arundo is classified according to the average number of clumps per mile in a relatively narrow riparian corridor, or the average distance between clumps in a broad floodplain. Most of the survey was conducted during the second half of 1999 and first half of 2000. The baseline map shows areas cleared of Arundo before January 2000. Also posted is an updated version that displays project sites treated by January 2002.

Survey Protocol

Lengths of riparian corridor that contain Arundo are divided according to abundance into four classes on the regional map:

Isolated: 1 to 5 clumps per mile; >1000 ft average spacing between clumps Scattered: 6 to 20 clumps per mile; 250-1000 ft average spacing

Abundant: 20 to 200 clumps per mile; 25-250 ft average spacing

Dominant: Amalgamated clumps, continuous in places

This classification of Arundo abundance was adopted from the "windshield" survey protocol of Team Arundo del Norte, posted at <ceres.ca.gov/tadn>. Note that the term "Dominant" refers to areal abundance, not structural prominance, and can describe a shaded understory of Arundo beneath a canopy of taller native trees or eucalyptus.

Arundo is mapped as "Absent" when not observed along distances of one mile or more of riparian corridor, or is inferred to be absent between accessible locations.

River and stream channels are mapped as "Non-riparian" where trees and other riparian vegetation are sparse or absent, due to water diversion or flood control management or natural causes. Such channels may be lined with rock or concrete, or periodically mowed or graded, or landscaped, or nearly barren of vegetation due to limited water supply or natural flood scour. "Non-riparian" channels generally lack Arundo, but those that contain minor amounts are not distinquished on the regional map; the absence of riparian habitat is the primary consideration.

Channels labelled as containing "Abundant tamarisk" denote degraded riparian habitat that lacks Arundo but is too dry to support trees other than tamarisk, generally owing to upstream water diversions.

Areas cleared of Arundo by restoration projects are depicted on the regional map only if they encompass the full width of a riparian corridor and a half-mile or more of its length.

In terms of areal cover, Arundo populations assigned to the "scattered" category occupy not more than one percent of the riparian corridor vegetated area, and the division between "abundant" and "dominant" categories is equivalent to areal coverage of about ten percent.

Arundo Dispersal Patterns

Typically along riparian corridors the upstream end of an Arundo population is sharply defined and is the site of initial introduction. These sites usually are resi-

dential yards or other developed property where Arundo was planted adjacent to the stream channel. In several watersheds Arundo was introduced to remote locations by plantings near hot springs; examples include Hot Spring Creek near Montecito in Santa Barbara County, Arrowhead Springs near San Bernardino, and San Juan Hot Springs northeast of San Juan Capistrano in Orange County.

In the simplest cases, the introduction site is marked by the largest Arundo clump in a watershed. Owing to flood transport of vegetative propagules, derivative clumps extend for miles downstream, becoming smaller and less abundant with increasing distance from the parent source. Dulzura Creek in southern San Diego County is an example of a simple dispersal pattern: the largest clump is located next to the creek at the town center; in the upstream direction, Arundo clumps have been planted at several locations but not are not present along the stream channel; in the downstream direction, Arundo abundances are mapped as "abundant" over the first mile from the parent clump, as "scattered" over the second mile, and as small "isolated" clumps over the next 5 miles, ending near Lower Otay Lake. Other streams showing the downstream-thinning pattern of early invasion include the San Jacinto River east of Hemet in Riverside County; the upper portion of San Juan Creek in Orange County; and in San Diego County, the San Luis Rey River east of I-15, Escondido Creek, the Harbison Creek tributary of the Sweetwater River, and Cottonwood and Potrero Creeks near their confluence.

More complicated dispersal patterns result where, following the initial introduction, (1) Arundo has been transplanted upstream of the parent clump either intentionally or accidently; or where (2) Arundo has been planted independently on several tributaries of the main channel; or where (3) channel constrictions, barriers and excavations have caused propagules to accumulate irregularly.

Examples of complex dispersal patterns cited above include (1) Matilija Creek in Ventura County, where "scattered" clump density is mapped upstream of "abundant" clump density; (2) the San Luis Rey River west of I-15 in northern San Diego County, where Arundo was planted on three tributaries (Keys Creek, Live Oak Creek, Ostrich Creek) and on the main channel above the confluence of the tributaries; (3) the Santa Ana River in Riverside County where the Prado Basin and Prado Dam mark a sharp discontinuity in Arundo clump density.

Additionally, in watersheds where introduced many decades ago, Arundo does not diminish in abundance downstream but instead becomes the dominant vegetation. In these systems Arundo appears able to spread into all flood-prone areas, not limited by factors such as lack of perennial moisture or rocky substrate or dense shade. Examples include the lower portions of rivers such as the Ventura, Santa Clara, Santa Ana, Santa Margarita, San Luis Rey and San Diego Rivers.

The mapped distribution patterns are consistent with earlier recognition that Arundo is spread to new sites by floods or human-assisted transport of plant fragments, rather than by seed dispersal because viable seed has not been reported in California (Bell 1993, Else 1996). Both rhizomes (root) and stem fragments can grow into new clumps of Arundo, with rhizomes considered to be the more common source of new plants (Else 1996). Arundo is highly adapted to the flood regime characteristic of southern California riparian systems. Periodic high flow events "re-set' the riparian system, removing mature stands of vegetation and depositing new substrate of sand and gravel. Native vegetation can re-seed these depositional bars and sprout from plant fragments. Similarly, floods dislodge and break up clumps of Arundo and spread them downstream, with each plant fragment growing to a new Arundo clump or stand. Urbanization has altered flow regimes for many systems, either directly by channelization or elimination of floodplains or indirectly by reducing water retention of uplands through development. This has resulted in 'flashier' flood regimes that may promote the spread of Arundo. Additionally many seasonal streams and creeks have been turned into perennial systems fed by agricultural and urban run-off.

In coastal watersheds Arundo is not confined to riparian areas with high water tables, but is able to survive on rainfall at upland sites. Consequently, isolated clumps can be found growing on hillsides and next to roads where rhizome fragments have been transported by road construction or soil dumping. Compared to those nourished by riparian groundwater, Arundo clumps at mesic locations have shorter growing seasons, and are shorter and less robust -- with stalks generally less than 15 ft tall. These upland clumps expand slowly and do not spread without assistance to riparian areas.

One general observation is that Arundo is relatively rare in the national forests of southern California. In most occurrences Arundo has been introduced at private

inholdings within several miles upstream of the national forest boundary. Exceptions are limited to Angeles National Forest, where Arundo was introduced along roads that traverse the National Forest (San Francisquito Canyon and Bouquet Canyon) and at a mine located high in the watershed of Big Tujunga Canyon.

WATERSHED SUMMARIES

1. Southern Santa Barbara County

1.1 Santa Ynez Valley: Arundo is rare in the Santa Ynez watershed and only 4 clumps are known along the main stem of Santa Ynez River from Juncal Dam to Vandenburg Air Force Base, separated by an air distance of about 55 miles.

In the upper portion of the watershed, Arundo is not present at Big Caliente and Little Caliente Hot Springs northeast of Gibraltar Reservoir, nor is it evident from Paradise Road between Gibraltar Reservoir and Lake Cachuma. In the middle portion of the watershed, starting in 1994, county flood control staff cleared scattered, mostly small Arundo clumps along a 4-mile reach of Alamo Pintado Creek between Los Olivos and Solvang.

Near the river channel 6 miles west of Buellton, in 2001 county staff discovered populations of 1 and 3 clumps adjacent to vineyards accessed from Santa Rosa Road. In the Lompoc area, several Arundo clumps are present at Mission La Purissima Concepcion and one grows in a rural yard at the lower end of San Miguelito Canyon, but adjacent tributaries are not invaded.

1.2 Coastal canyons near Santa Barbara: An Arundo infestation extends down Hot Springs Canyon and Montecito Creek, starting at abandoned gardens near ruins of Hot Springs Hotel, initially constructed in the 1880's and burned in 1920 and 1964. In other canyons near Santa Barbara, Arundo appears to be absent in Los Padres National Forest and rarely present in urbanized areas, with the exception of the lower portions of Arroyo Burro and Mission Creek in the City of Santa Barbara. West of Goleta, the lower 1.2 miles of Refugio Canyon harbors dense Arundo on private land below the National Forest boundary.

2. Ventura River and tributaries:

On Matilija Creek above Matilija Dam, Arundo presumably was first planted behind vacation cabins or along the access road, then later was transplanted upstream to the highest inholding in the national forest. Two miles below Matilija Dam, the abundance of Arundo in the Ventura River channel drops sharply where water is diverted to Lake Casitas. The town of Ojai was another early introduction site, from where abundant Arundo extends down San Antonio Creek and then down the Ventura River to the ocean. Removal efforts are limited currently to a demonstration project on the Ventura River near the San Antonio Creek confluence, sponsored by the Ventura Co. Flood Control District and Ventura Co. Resource Conservation District.

3. Tributaries of Santa Clara River:

3.1 Sespe Creek: Arundo appears to be absent from Sespe Creek except near the outlet in Fillmore.

3.2 Piru Creek: The entire watershed is probably Arundo-free, judging from its absence in the rural communities of Gorman and Lockwood Valley, and at widely spaced vantage points elsewhere along Piru Creek.

3.3 San Francisquito Creek: Arundo was introduced along the Los Angeles Aqueduct right-of-way with highest -- in elevation -- but not densest occurrances at Power Plant No. 1. Angeles National Forest started a removal program in 1995, employing Pestmaster Services (Bishop) to operate a tractor-size hammer-flail mower. The program was expanded in 1999 to include Los Angeles Dept. Water & Power property.

During 2000-2001, Pestmaster Services mowed and treated Arundo along the lowest 2 miles of San Francisquito Creek as a mitigation project for Valencia Co. bridge construction (?).

3.4 Soledad Canyon: The riparian corridor is free of Arundo through Acton and downstream for a distance of 7 miles, although Arundo is present in some of Acton's residential yards. In Soledad Canyon the primary introduction site is a rural residence next to the stream channel, 1 mile west of the conservation camp. Below the introduction site, Angeles National Forest hired Pestmaster Services to clear a one-mile length of the channel starting in 1996 (?).

4. Calleguas Creek watershed:

Calleguas Creek and its tributaries are mostly channelized but in places Arroyo Canejo, Arroyo Simi and Arroyo Las Posas retain riparian character. Affecting Arroyo Canejo, Arundo probably was introduced to the Thousand Oaks area before urbanization. Below Simi Valley, Arundo density increases downstream in Arroyo Simi, so the history of introduction is not appar-

ent. Removal work has been limited to Arroyo Las Posas downstream of Moorpark, when in 1998 the Ventura Co. Flood Control District hired a contractor to clear two-thirds of a mile to mitigate bank stabilization elsewhere.

5. Santa Monica Mountains:

5.1 Malibu Creek: Isolated Arundo clumps are present below Lake Malibu through Malibu Creek State Park. Below Tapia Park, before treatment, Arundo clumps became abundant at the filled reservoir and extended below the dam to the ocean. In the lower canyon below Piuma Road, more than 200 Arundo clumps on park land were foliar sprayed in late 2000 by a contractor crew from Agri Chemical & Supply (Oceanside), funded by state and federal grants to the Mountains Restoration Trust.

5.2 Topanga Canyon: The highest occurrences of Arundo are in oak woodlands and residential yards in the community of Glenview, above the zone of typical riparian vegetation. Where the riparian corridor starts, Arundo is present and extends to the ocean.

6. Los Angeles River watershed.

6.1 San Fernando Valley: Upstream of paved storm drains that cross the valley floor, in canyons of hills bordering San Fernando Valley, Arundo is present in the following approximate amounts: Dry Canyon/ Arroyo Calabasas -- 0.6 acre; Devil/Brown's Canyons -- 0.7 acre; Limekiln Canyon -- none; Aliso Canyon -- 3 clumps.

6.2 Sepulveda Basin: During Fall 2001, Army Corps of Engineers contractor Reyes & Sons used bulldozers to clear 10-15 acres of Arundo from 1.4 miles of Los Angeles River channel between Balboa and Burbank Blvds., with debris trucked to landfills. Less than an acre remains in the soft-bottom channel west of Balboa.

6.3 Pacoima Canyon: Isolated Arundo clumps are present downstream of the bridge crossing southeast of Bear Divide and presumably down to Pacoima Reservoir; above the bridge crossing, none are visible on private land for a distance of one-quarter mile.

6.4 Little Tujunga Canyon: The highest occurrence of Arundo is a half-mile downstream of Gold Creek Road, near the boundary between Angeles National Forest and private inholdings; approximately 12 net acres are present above Hansen Dam basin.

6.5 Big Tujunga Canyon: Within Angeles National Forest, Arundo initially propagated downstream from the Stonyvale settlement of vacation cabins. Higher in the watershed, Arundo was later introduced near 4200 ft. elevation at a mine on Iron Mountain, from which Arundo spread downstream about one mile along Monte Cristo Creek and Mill Creek.

6.6 Big Tujunga Wash: Outside Angeles National Forest, below the canyon mouth near Sunland, the Los Angeles Co. Dept. of Public Works implemented the Big Tujunga Wash mitigation bank in late 2000 to offset county-wide flood control impacts, employing Chambers Group and Natures Image (Orange County) to clear 30 acres of Arundo below Interstate 210 using a hammer-flail mower and chainsaw crews. Also, in 2001 the California Environmental Project secured grant funding to start removal work between the Forest Service boundary and Oro Vista Ave.

6.7 Arroyo Seco: Arundo is limited to several clumps, starting at a City of Pasadena water diversion facility a quarter-mile upstream from the canyon mouth.

6.8 Glendale Narrows: On a soft-bottom, non-concrete-lined portion of the Los Angeles River, North East Trees manually cleared Arundo from a half-mile length of the channel in 1998, downstream from Los Feliz Blvd.

6.9 Eaton Canyon: After introduction at the Forest Service's Henninger Flat station, Arundo spread somehow along the Mt. Wilson Toll Road and down Eaton Canyon. A one-mile reach of abundant Arundo stands below the toll road crossing was cleared mainly by excavation of continuous stands and cut & spray of more isolated clumps, in 1996 as off-site mitigation for housing construction.

6.10 Rio Hondo: In the Whittier Narrows Flood Control Basin, the Mountains Recreation & Conservation Authority sponsored excavation of a 250-ft-long Arundo stand in 1997 at the Bosque del Rio Hondo park; and in 2000 the San Gabriel Mountains Regional Conservancy initiated work north of the Pomona Freeway, employing the L.A. Conservation Corps for chainsaw removal and Agri Chemical & Supply for foliar spraying.

7.1 San Gabriel River:

Within Angeles National Forest, Arundo occupies several isolated upland locations but has not become established along the upper tributaries.

Along the 3-mile length of San Gabriel Canyon between Morris Dam and Roberts Creek, scattered Arundo clumps were partly removed during 1999-2000 by Forest Service and CA Environmental Project

(CEP) chainsaw crews, funded by Los Angeles Co. Dept. of Public Works (DPW).

Along the one-mile channel length between Roberts Creek and the Azusa Rock/Vulcan Materials conveyor belt crossing, scattered Arundo clumps were mostly removed during 2000-2001 by a CEP crew and Riparian Repairs, funded by a grant from the Center for Natural Lands Management to the San Gabriel Mountains Regional Conservancy.

Along the nearly 2-mile channel length from a conveyor belt crossing to Foothill Blvd., abundant to semi-continuous Arundo stands were cleared during 2000 by chainsaw crews from Fairfield Landscaping Service (Pasadena), funded by Azusa Rock/Vulcan Materials to mitigate construction of the conveyor belt crossing.

Along the half-mile channel length from Foothill Blvd. to Interstate 210, Arundo was removed during 1999-2000 by Los Angeles County, with work performed by the Dept. of Forestry and funded by DPW.

Above the Whittier Narrows flood control basin, about 22 acres of dense Arundo was removed from a 2-mile reach between Walnut Creek and San Jose Creek in 1997-98 by Los Angeles Co. DPW for the purpose of flood channel maintenance.

During Fall 2001, Army Corps of Engineers contractor Reyes & Sons used bulldozers to cleared about 30-40 acres of Arundo from 1.2 miles of the San Gabriel River channel below San Jose Creek, with debris trucked to landfills. Another mile of dense Arundo remains in the channel upstream of Whittier Narrows Dam.

7.2 Eastern tributaries of San Gabriel River: In Big Dalton, Little Dalton and San Dimas Canyons, Arundo became established in the vicinity of water retention and debris basins near the canyon outlets, and has been removed by a cooperative program managed by Angeles National Forest and funded by Los Angeles Co. Dept. of Public Works. Starting in 1997 above the debris basin dams, Forest Service crews and the CA Environmental Project cleared one mile of scattered clumps in Big Dalton Canyon and half-mile of large stands in Little Dalton Canyon. Above San Dimas Canyon Reservoir, in 1998 Forest Service crews cleared scattered Arundo from half-mile sections in two canyons; and in 2000 Forest Service and CEP crews started work below the reservoir on continuous Arundo stands between the dam and golf course. Below these canyon areas the stream courses are channelized.

8. Santa Ana River watershed:

Upper tributaries are being cleared of Arundo by the Santa Ana Watershed Association (SAWA) of Resource Conservation Districts, funded by the SAWA mitigation trust fund. Similarly, with separate mitigation banks, the Riverside County Regional Parks and Open Space District is responsible for the river's main channel from Riverside to Norco, and the Orange County Public Facilities and Resources Dept. (PFRD) is responsible for restoration of Santa Ana Canyon below Prado Dam. Future state bond funding to these organizations will be administered by the Santa Ana Watershed Project Authority (SAWPA).

8.1 Cajon Wash: Starting below Highway 38, abundant Arundo clumps grading downstream to mostly scattered densities were cut and treated during 1999-2000 by crews from Washburn Grove Mgmt. (Hemet) contracted by the Inland Empire West RCD. Also a large Arundo stand at Lost Lake was removed.

8.2 San Bernardino area: The Arrowhead Springs resort was the introduction site for continuous stands of Arundo in the lower parts of Waterman Canyon, Hot Springs Creek and East Twin Creek. Along City Creek, Arundo is absent in the National Forest down to Highland Blvd., below which scattered clumps are present.

8.3 San Timoteo Canyon: Starting near Highway 60 below Beaumont, contractors (Washburn Grove Mgmt., Pestmaster Services) employed by the East Valley RCD cleared about 6 miles of riparian corridor during 1996-99 and another 5 miles during 2000 to the natural channel's terminus below Allesandro Road, as well as most of Live Oak Canyon through Yucaipa.

8.4 Riverside area: Starting in 1993, Riverside Co. Parks staff cleared Arundo along a one-mile length of the Santa Ana River near the Van Buren bridge, funded mainly by a mitigation bank. Using a variety of methods, contractors employed by the Riverside-Corona RCD cleared Sycamore Canyon during 1997-98, Fairmont Park during 1998-99, Alessandro Arroyo during 1999-2000, the Castle View drainage during 2000-01 (Agri Chemical & Supply, Pestmaster Services, Washburn Grove Mgmt., Natures Image).

8.5 San Jacinto River: Arundo appears to be absent from the Idyllwild community and National Forest land, and the highest mapped location is a private inholding 3 miles upstream from the Forest Service's Cranston Station. In the San Jacinto Valley below the Saboba Reservation, San Jacinto Basin RCD staff cleared scattered amounts of Arundo east of Highway 79 during 1998-99, and Washburn Grove Mgmt. crews

cleared tamarisk and isolated Arundo clumps from Bridge St. to Davis St. during 1999 and between Sanderson Ave. and Bridge Street during 2001. Below Canyon Lake, Arundo is absent from Railroad Canyon above Interstate 15 and present downstream from the freeway.

8.6 Temescal Canyon: Downstream from Lake Elsinore, Walker Canyon adjacent to Interstate 15 is Arundo-free, and although Arundo is planted near Lake Street, it has not yet invaded the stream channel. Downstream, Arundo becomes established below Lake Corona and semi-continuous near El Cerrito. Starting in 1997-98, a quarter-mile reach of dense Arundo near El Cerrito has been cleared and revegetated by Glenn Lukos Associates and Canyon Landscaping as mitigation for 3M Co. quarry operations; initial clearance by Estill's Windbreak Trimming Inc. (Ojai) employed a hammer-flail mower.

8.7 Prado Basin: Along the Santa Ana River northwest of Corona, the Riverside-Corona RCD employed Pestmaster Services and Washburn Grove Mgmt. (?) to remove 30 acres of Arundo during 1997-98 to reduce flood hazard above the River Road bridge.

8.8 Santa Ana Canyon: On the south side of Featherly Regional Park, between the Santa Ana River and Riverside Freeway, county staff treated Arundo resprouts with herbicide during 1989 following an accidental brush fire east of Gypsum Canyon. On the north side, chainsaw clearance of a 2-mile strip totalling 60 acres downstream from the Gypsum Canyon bridge was started in 1992 but conducted mainly during 1994-98, by county staff and the Orange Co. Conservation Corps, mainly for off-site mitigation of county flood control projects. In 2000 mechanical excavation of stalks and roots using a front-loader tractor was initiated on the north side east of Gypsum Canyon. Continuous stands of Arundo remain in the central part of the flood channel.

8.9 Carbon Canyon: Arundo forms continuous stands along Carbon Creek below the settlements of Olinda Village and Sleepy Hollow, yet in Chino Hills State Park undeveloped Telegraph Canyon is Arundo-free. This is one of few examples in southern California where converging tributaries exhibit maximal differences in Arundo density. During 2000 Chino Hills State Park staff and CDF fire crews initiated Arundo removal on about 2 acres along Carbon Creek.

8.10 Santiago Creek: In response to forecasts of El Nino flooding in early 1998, during 1997 residents of Silvarado Canyon cleared Arundo from 2 miles of private property along Silvarado Creek, with herbicide applications conducted by county staff. In Modjeska Canyon Arundo is established in the rural developed area below the Cleveland National Forest boundary.

9. Southern Orange County:

9.1 Aliso Creek: In the late 1990's two sections of Aliso Creek were cleared of Arundo by Orange Co. employees for off-site mitigation: Whiting Ranch Park near the top of the drainage, and between Trabuco Road and Jeronimo Road.

9.2 Arroyo Trabuco: The highest occurrence of Arundo is near cabins in Holy Jim Canyon, about 2 miles upstream from the Cleveland National Forest boundary. During the winter of 2000-01, the upper 2 miles in O'Neill Regional Park was cleared by county staff and prison crews.(?)

9.3 San Juan Creek: Arundo spread downstream from early plantings at San Juan Hot Springs and nearby cabins outside the Cleveland National Forest boundary. The hot springs area in Caspers Regional Park was cleared of Arundo during 1997-98 by county staff and prison crews as mitigation for downstream bridge construction. In San Juan Capistrano, Arundo clearance during 1995 between La Novia Ave. and Interstate 5 was not maintained so Arundo reinvaded.

10. Orange/San Diego County Line

10.1 San Mateo Creek: Scattered to abundant Arundo was present on lower portion of San Mateo Creek within Marine Corps Base Camp Pendleton. The Base and the Navy funded treatment by foliar spraying from the Base entrance gate to Interstate 5 in 1998, and upstream of this area in fall 2001. West of I-5 in San Onofre State Beach, starting in January 2001 California State Parks contracted Innovative Inclosures (Fallbrook) to excavate 1.5 acres of Arundo from the beach near the creek outlet.

10.2 San Onofre Creek: Previously Arundo was present in scattered and abundant densities along the lower 5 miles of river length. Marine Corps Base Camp Pendleton treated these areas in 1996.

11. Santa Margarita River watershed:

Primary upstream introduction sites were the towns of Temecula and Rainbow. Arundo did not become established along the primary tributaries in Riverside County -- Murrieta Creek upstream of Temecula, and Temecula Creek draining the north side of Palomar Mountain.

On Tucalota Creek above Lake Skinner, at least 3

Arundo clumps are established in the channel in the community of Sage, but have not yet spread downstream.

In 1995 the Mission Resource Conservation District in Fallbrook initiated clearance work in Santa Margarita Canyon between Rainbow Creek and Sandia Creek, with mitigation funding from Camp Pendleton. Treatments of the lower portions of the river were initiated in 1997 by Camp Pendleton. Approximately 12 of the 18 river miles have been treated (350 of 500 acres of Arundo). Arundo stands on the Base are dense and mature, forming monotypic stands over 200 meters wide and up to 1000 meters long. The Arundo removal work has been a mixture of foliar application of herbicides (Agri Chemical & Supply, Oceanside) and mechanical extraction (Innovative Inclosures, Fallbrook).

With the formation of the Santa Margarita and San Luis Rey Weed Management Area (SMSLRWMA) in 2000, control work has expanded to include the entire main channel downstream from Interstate 15, tributaries in Fallbrook and Sandia Creek. This work has been funded by a grant from the National Fish and Wildlife Foundation and an Army Corps of Engineers In-Lieu-Fee Mitigation Bank set up for the watershed. All applications are foliar herbicide application with limited biomass removal at some locations after the Arundo has died. Work has been performed by a variety of contractors (AgriChemical & Supply, Kelly & Associates, Pestmaster Services).

12. San Luis Rey River watershed:

12.1 East of Interstate 15: Along the river's main stem, Arundo was introduced on private land upstream of Wilderness Gardens County Park east of Pala. Higher segments of the river appear to be Arundo-free, including the heavily wooded portion from Lake Henshaw down to the Escondido Canal intake, and the dry, sparsely vegetated channel through Rincon Springs and Pauma, despite the presence of Arundo clumps planted at upland sites in Rincon Springs.

When mapped in 1999, Arundo densities decreased from "abundant" at Wilderness Gardens to "scattered" near Pala to "isolated" above the Couser Creek confluence. During 2000-01 the SMSLRWMA program cleared Arundo from 5 miles of riparian corridor from Wilderness Gardens to Pala Reservation (Agri Chemical & Supply). Two small tributaries between Pala and I-15, Rice Canyon and Double Canyon, remain to be treated.

12.2 Keys Creek: North of Valley Center, Keys Creek is Arundo-free at Cole Grade Road, but two miles west, above Lilac Road, Arundo continuously fills the understory space beneath a tall canopy of native trees. The introduction site is on inaccessible private property about midway between the two county roads. About 40 acres of Arundo are present from the introduction site to a treated half-mile length of lower Keys Creek near the confluence with the San Luis Rey River Interstate 15. Arundo in this area was mechanically removed in 1996 using a slope mower (Fire Prevention Services, Alpine CA) followed by herbicide treatments (San Diego Co. Dept. of Agriculture staff) as mitigation for bridge repairs.

12.3 West of Interstate 15: Within two miles below the Keys Creek confluence, Arundo densities in the San Luis Rey floodplain decrease sharply to levels mapped as "scattered". Some of these areas have been treated by CalTrans. Continuing downstream, at the confluence of Live Oak Creek, Arundo densities return to levels mapped as "abundant", presumably owing to propagules from the two heavily infested tributaries of Live Oak Creek (24 acres of Arundo) and Ostrich Creek (25 acres of Arundo). The remaining 14 miles of the San Luis Rey River from Ostrich Creek to the ocean is mapped as "abundant" or "dominant", with 340 acres of Arundo, often forming dense 200-meter-wide monotypic stands.

13. Escondido Creek:

In San Elijo Canyon below Escondido, Arundo dominates the understory beneath eucalyptus. In the late 1990's a quarter-mile length in the Elfin Reserve was cleared of both non-native species by the Olivenhain Water District, with physical work performed by the CA Conservation Corps, as mitigation for construction of a water storage reservoir. Along the lower part of Escondido Creek near Olivenhain, Arundo is present as isolated clumps although other invasive exotics are plentiful.

14. San Dieguito River/Santa Ysabel Creek:

Arundo is not evident near Santa Ysabel Mission, nor below the Lake Sutherland Dam to Pamo Valley, nor between the confluences of Boden and Clevenger Canyons. The highest occurrence is about 1/2 mile downstream from Clevenger Canyon, where the proximity of State Highway 78 is the only unusual feature compared to upstream areas. Control work in the watershed has been limited to CNPS volunteer projects around Lake Hodges.

15. San Diego River:

15.1 Above San Vicente Reservoir: Along the West Fork of San Vicente Creek, Arundo starts abruptly in the community of Fernwood and extends downstream 2 miles to the reservoir. Along San Vicente Creek, Arundo is present as isolated, dispersed clumps of uncertain derivation in rural San Vicente Valley; further downstream, the remote portion between Klondike Creek and the reservoir was not surveyed. Along Barona Creek, arundo is absent on the Barona Indian Reservation.

15.2 Above El Capitan Reservoir: Arundo is not observed at tributary crossings and in ranchette yards along the Boulder Creek Road between Descanso and Julian. Arundo clumps reported along the reservoir shore may have originated from the community of Alpine at the reservoir's south end.

15.3 Lakeside area: Below El Capitan Dam, the San Diego River channel has riparian foliage for approximately one mile, then is abnormally dry with abundant tamarisk but no Arundo nor native trees (except in adjacent yards) for a distance of 6 miles to the San Vicente Creek confluence. Below San Vicente Dam, the channel of San Vicente Creek supports both abundant Arundo and tamarisk and is the apparent source of Arundo in the San Diego River channel below Lakeside.

15.4 San Diego area: As reported by Mike Kelly in the Spring 2000 CalEPPC News, during the 1990's Arundo was removed from 3 miles of riparian corridor in Mission Trails Regional Park and 2.5 miles from the lower river between Highway 163 and Interstate 5 (AgriChemical & Supply, Kelly & Associates).

16. Sweetwater River:

Arundo was not observed in Cuyamaca Rancho State Park, nor in the vicinity of Descanso, nor at the Interstate 8 crossing, nor above or below Palo Verde Lake southeast of Alpine. Above Loveland Reservoir, small abundant clumps of unknown derivation extend less than 1 mile upstream of Japatul Road. Around the Loveland Reservoir shore and below the dam are larger clumps that probably were introduced earlier than those below Palo Verde Lake.

The community of Harrison Canyon on a small tributary (Harrison Creek) harbors the densest and presumably oldest Arundo infestation in the upper Sweetwater River watershed. Below the junction of Harrison Creek and the Sweetwater River, Arundo is present mostly in scattered densities where the river channel has not been converted to golf courses.

Continuing downstream on the Sweetwater River, since the early 1990's staff of the Sweetwater Authority have partly cleared Arundo and tamarisk at the upper end of Sweetwater Reservoir. Sizeable patches of both Arundo and tamarisk intermixed with native riparian habitat still remain on the reservoir property and upstream areas of the National Wildlife Refuge. Below the dam in Sweetwater Regional Park, volunteers and County Agricultural Commissioner staff removed 3 to 5 acres of Arundo along the river near Chula Vista from 1996 to 1998 (Kelly 1999).

17. Otay River:

As reported above, on Dulzura Creek Arundo starts in the community of Dulzura and clumps diminish in size and abundance downstream. The riparian corridor is abnormally watered by water captured at Barrett Lake. On drier Jamul Creek, a 1-acre stand was cleared by Kelly & Associates for a Wildlands Inc. commercial mitigation bank. Below Lower Otay Lake, the Otay River channel is dry and nearly barren below the dam, then supports abundant tamarisk and Arundo which outnumber native trees approaching I-805.

18. Cottonwood Creek:

Arundo is absent along tributaries above Barrett Lake and Lake Morena, although one clump was observed in Morena Village. Water from the upper watershed would naturally drain to the Rio Tijuana, but is diverted at the Barrett Lake dam by pipeline to the top of Dulzura Creek which flows to Lower Otay Lake. On the relatively dry part of Cottonwood Creek below the dam, Arundo starts at a trailer park one mile upstream of Barrett Junction. On Potrero Creek, Arundo is absent in the community of Potrero but starts at an isolated private residence below the turnoff to Tecate. Downstream of Barrett Junction, the density of Arundo appears to diminish toward the Mexican border.

19. Tijuana River:

Arundo is thought to be present in light to heavy densities on the Mexican side of the boarder and is present on the U.S. side of the border when the river crosses back into the U.S. Two miles of river ending at the ocean have been treated on Imperial Beach Naval Air Station and Imperial Slough National Wildlife Refuge.

Acknowledgements

Contributors of information about Arundo distributions and

removal project histories include, in north to south order: Larry Fausett, Santa Barbara Co. Flood Control & Water Consv. District; David Chang, Santa Barbara Co. Agricultural Commissioner's Office; Dennis Kanthack, Ventura Co. Flood Control District; Paul Nicholson, Hill Canyon Conservancy; Shawna Bautista & Nancy Mahaffie & Karen Fortus, Angeles National Forest; Jeff Van Diepen & Bob Carney, Pestmaster Services; Jo Kitz, Mountains Restoration Trust; Patricia Wood & Jason Pereira, Los Angeles Co. Dept. Public Works; John Caruana, Natures Image; Chuck Arnold, North East Trees; Mickey Long, Eaton Canyon Nature Center; Paul Edelman, Santa Monica Mountains Conservancy; Jennifer Ares, East Valley Resource Conservation District; Kerwin Russell, Riverside-Corona RCD; Jim Gilmore, San Jacinto Basin RCD; David Washburn, Washburn Grove Mgmt.; Greg Everett, Glenn Lukos Associates; Dave Matias, Canyon Landscaping; Paul Frandsen, Riverside Co. Park & Open Space District; Bill Tidwell & Chris Kubasek, Orange Co. Public Facilities & Resources Dept; Tom Hummel & David Pryor, California State Parks; Adrian Wolf, Harmsworth Associates; Rick Fox, City of San Diego Water Dept.; Kirsten Winter, Cleveland National Forest; Mike Kelly, California Exotic Pest Plant Council; Pete Famolaro, Sweetwater Authority.

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Planning *Arundo donax* removal: A review of methods for control and biomass removal

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The restoration of riparian areas often involves the removal of invasive non-native plants, such as *Arundo donax* (giant reed), a bamboo-like grass that can grow into thick dense stands. Several options exist for killing *Arundo* and dealing with the biomass. The most appropriate method of *Arundo* control for a specific site depends on many factors: presence of sensitive wildlife species, permitting regulations, site access, presence of native vegetation, size and distribution of *Arundo* stands, ability to retreat the site and whether the *Arundo* is dormant.

There are two widely used methods for treating *Arundo*: application of herbicide and mechanical extraction. Herbicide application may be done on the standing plant (foliar spray), to cut stems after removal of *Arundo* cane (cut and spray), or to resprouts after it is cut (cut and spray resprouts). Positive and negative aspects of each treatment method are examined. Depending on the amount of *Arundo*, the potential fire/flood hazard, and the future replanting plans for the site, the *Arundo* biomass (either dead material after foliar application or green cut biomass) may need to be mulched on site or removed. Biomass may be chipped using a drum chipper or a mowing/mulching device such as a SEPE. This material can be left on site to suppress ruderal weeds, and native woody vegetation can be planted through it.

When planning an *Arundo* control program many elements must be considered in determining the most appropriate and cost-effective treatments for a particular site and care must be taken to avoid negative impacts to native wildlife.

Role of the Santa Margarita and San Luis Rey Watersheds Weed Management Area in Watershed Based Exotic Plant Control and Restoration in northern San Diego County

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The Santa Margarita and San Luis Rey Watersheds Weed Management Area (WMA) was formed in March 2000 with the goal of organizing and carrying out watershed based invasive exotic plant control in the two watersheds, and increasing awareness of invasive plant issues.

On both watersheds the main exotic plant of concern is *Arundo donax* (giant reed). On the Santa Margarita watershed most of the *Arundo* has already been controlled and the WMA's goal is to ensure that any remaining scattered infestations are treated and that long-term re-treatment occurs in all areas. The WMA has mapped the remaining *Arundo* stands, mostly in the upper watershed and small tributaries, and is carrying out initial control of these infestations in 2001.

On the San Luis Rey (SLR) watershed the *Arundo* control effort is just beginning. Due to the large number of property owners, control efforts on the SLR watershed require large amount of effort and organization. The WMA has mapped the *Arundo* in the watershed, has initiated control on the uppermost portion of the SLR River and a heavily infested tributary, and is dividing up remaining areas into manageable projects and applying for grants, working from the top to the bottom of the watershed.

The WMA has found the mapping of invasive plant distributions vital in planning control projects and applying for grants. Plant distribution data is available as GIS coverages and JPEG images at the WMA website (http://smslrwma.org). The website is the information and education center of the WMA - providing information on the activities of the WMA to all participants, as well as information on the identification, biology and control of target exotic plants.

Noxious Times Newsletter

Integrated Pest Control Branch
California Dept. of Food and Agriculture, 1220 N. St., Room A-357, Sacramento CA 95814

The Noxious Times is a quarterly newsletter sponsored lby the California Interagency Noxious Weed Coodinating Committee. This publication provides agencies and local staff with relevant information on noxious weed control throughout California. By providing news, policy information, and program reports from specific agencies, the Noxious Times serves as a resource for those interested in sharing information and coordinating efforts against noxious weeds.

Look us up on the web at:
www.cdfa.ca.gov/noxioustimes

Sign-up today, Add a friend! There are three ways to add a colleague or neighbor to the mailing list:

(1) Write to 1220 N. St., Room A-357, Sacramento, CA 95814, (2) Requests by e-mail to noxtimes@cdfa.ca.gov or (3) Calls to (916) 654-0768.

Watershed Based Eradication of *Arundo donax* (giant reed): from pulling together to mapping to treating to re-planting

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Arundo donax

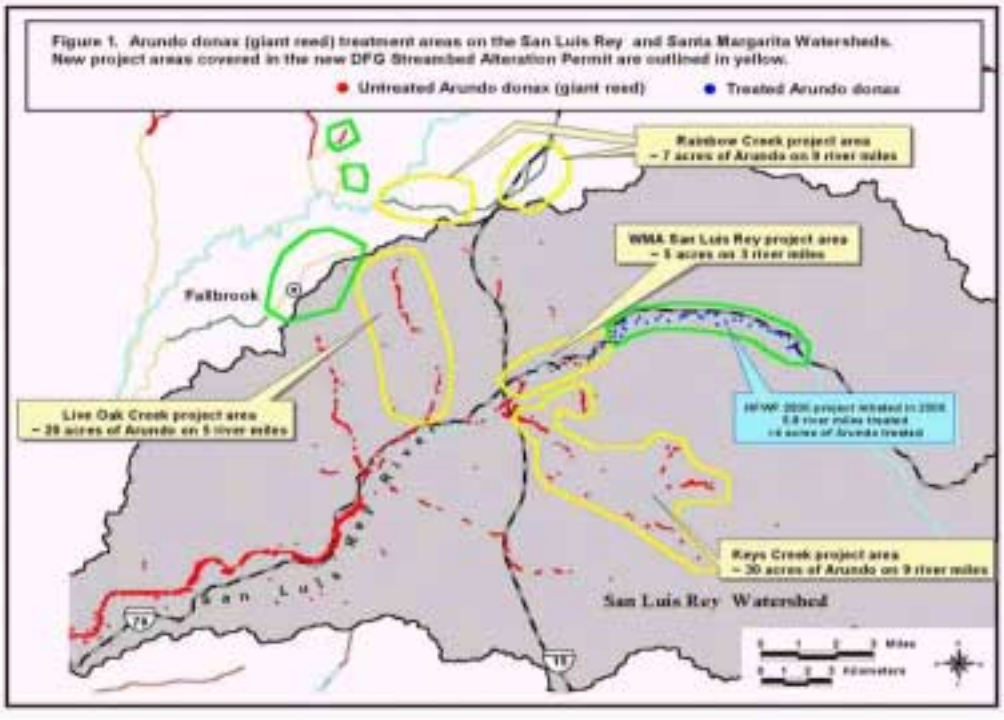
- **Non-native grass**
- **Highly invasive**
- **Spreads only asexually**
- **Low habitat value**
- **Flood/Fire risk**

Step 1: Pull together group

- Watershed based control
- WMA/RCD/other lead..
- NFWF PTI Grant
- Apply for $
- Long term management and monitoring

Step 2: Map infestation

- Scale of infestation
- Property ownership
- Budget
- Plan, track projects
- Map cheaply!



How to map cheaply

STEP 1

Acquire imagery:
1 meter resolution imagery (orthocorrected) for the entire watershed from SANDAG/SDSU.

STEP 2

Print maps for field surveying:
30 D-size maps (22"x34") each covering 2.4 miles x 3.3 miles.
4 E-size maps (34"x44") for upper watershed areas with scattered *Arundo* distribution.

STEP 3

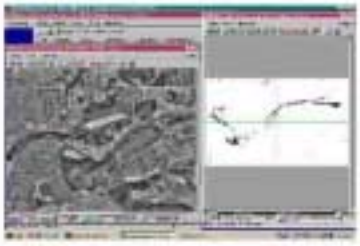
Map exotic plant in the field:
Arundo was mapped at two densities (80-100% & 50-80% cover). Other exotics were mapped as encountered.

STEP 4

Transfer from map to clean sheet:
Traced *Arundo* polygons onto tracing paper/acetate with reference points (such as road intersections).

STEP 5

Scan traced images and convert into polygon coverages (using GIS software such as TNT Mips by MicroImages)



STEP 6

Georeference each image using GIS software

STEP 7

Merge coverages and cleanup:
Deleted reference markers using GIS software (such as ArcView by ESRI).

STEP 8

Proof final coverage:
Compared to field survey maps.

- Driving 10 days
- Office 10 days
- Printing materials

Total cost under $10,000
350,000 acre area

Step 3: Project planning & funding

- Use mapping to develop project costs
- Select project sites
- Match sites with grants based on ownership, site conditions
- Apply for grants (Prop 12/13, Urban stream, WRP, WC Board, etc..)

Step 4: Obtain permits for projects

DFG: 1600

ACOE: 404

RGP:41?

CEQA: Exemption?

FWS Consultation

- Streamline permitting
- Obtain "Blanket Permits" covering multiple projects under one permit (same method, same group)
- Apply as group (cohesive management, accountability, long term management)
- Cater methods to permitting issues (avoid nesting season)
- Avoid triggering 404, CEQA

Step 5: Select control methods for project areas

- Site conditions (access, native cover, topography, etc.)
- Cost
- Time of activity
- Number of repeated visits over time
- Flood/fire risk of treated stands
- Succession of vegetation after control
- Permitting issues

The three most used methods

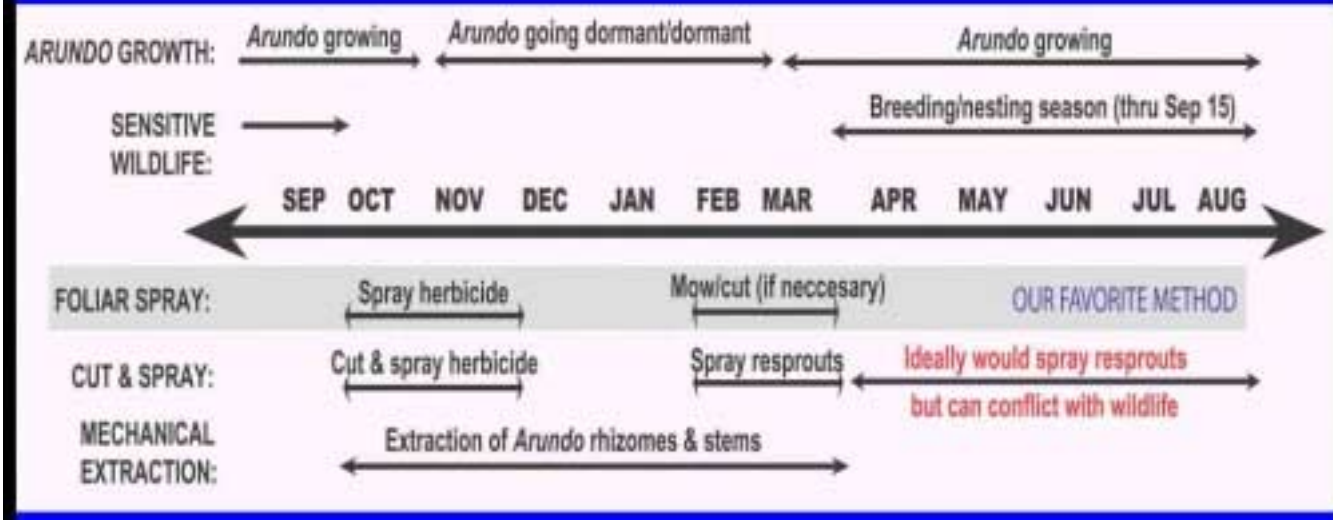
1) Foliar spray stand in fall: then leave, cut or mow; ~$4,000 - 10,000 for 3 year effort

2) Cut or mow and spray regrowth multiple times; ~$8,000 - 20,000 for 3 year effort

3) Mechanical extraction and spray regrowth; ~$15,000 - $30,000 (?) for 3 year effort

Key to controlling costs

- Avoid hand work (sawing, hauling, etc…)
- Avoid moving, handling, grinding, chipping biomass
- Use effective initial herbicide treatments (reduce re-treatment efforts)



Cut/Mow and then application of herbicide

- **Moderate to fairly effective**
  - **50-100% Rodeo on cut stem surface**
  - **multiple high intensity retreatments required (5-10% Rodeo or Roundup)**
- **Retreatments can conflict with nesting, complicating permitting**
- **Biomass is greatly reduced, but does "regrow"**
- **Some skip initial cut stem treatment**
- **Higher cost ($10,000 to $20,000+ per acre)**
- **Reduces fire risk and flood damage**

1) Cut then treat stump (some skip stump application)

2) Regrow

3) Respray

Mechanical control

- Effective: but retreatment of regrowth for several years
- Too many steps: pull, haul, pile, move, grind, move, spread, then retreat site……
- Permitting more complicated, retreatment nesting conflict
- Higher cost (>$15,000 per acre)
- Good access required
- Removes biomass
- Good for thick stands, not small or intermixed

Hammer-flail mower

Mowing: lower biomass

- Great for lowering biomass (lower fire/flood risk)
- Aids replanting by providing mulch
- Each mower can do 1 to 3 acres a day
- Limited ability to work on complex topography/wet areas
- Low cost (~$1,700 day) compared to hand work

Hand cut then chip/mow piles

- Lowers biomass at site (reduces fire/flood risk)
- Use to "clean" site (in channel/by trees) i.e. sensitive areas
- Use where there is no mower access
- Use drum chipper or pile and then mow
- High cost ($10,000+ per acre)

Succession of vegetation in an area depends on:

- Hydrologically functional site?
- Distance to water table
- Soil texture
- Rainfall
- Native/exotic seed in soil
- *Arundo* patch size (proximity of natives)

Succession after foliar or cut & spray

Foliar sprayed areas

1 year later

2 years later

Mechanical areas 1 year later

Succession after mechanical

Our typical treatment cycle

1: "Prep" *Arundo* stand for spraying in fall (fold *Arundo* onto self & trim native vegetation)

2: Spray site (fall)

- **Backpack sprayers**
- **Power sprayers**
- **GOOD COVERAGE**

3: Mow site & trim excess with hand crews in early spring

<u>Mow site & trim excess with hand crews</u>

Pre-sprayed photo

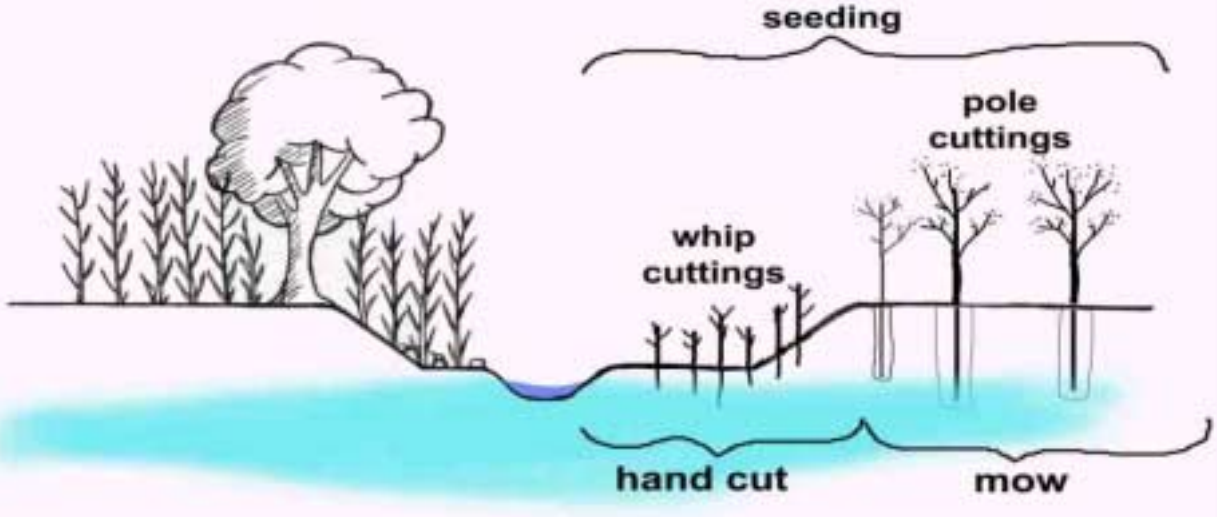
Post-spraying, mowing and cleaning

Auguring

Pole cuttings

4: Re-planting (if kick start is needed)

- Incised creek
- Poor hydrology
- Remote shelf
- No irrigation
- High density low effort
- Find water table
- Salvage material



2 year old cuttings

Species that work well from cuttings: mulefat, cottonwood, willows, elderberry and alder

The Invasive marine alga, *Caulerpa taxifolia* in Southern California

Southern California *Caulerpa* Action Team
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In the summer of 2000, the highly invasive nonnative marine alga, *Caulerpa taxifolia* was identified for the first time along the Pacific Coast in two separate coastal embayments. *C. taxifolia* is a bright green alga that grows along the seafloor and is native to tropical areas. Since its discovery in the Mediterranean Sea in the 1980s, the alga has rapidly spread along the coast and has dramatically altered and displaced native plant and animal communities. Eradication was not attempted early on in the Mediterranean, and governments are now unable to control its spread.

Due to its fast-growing, hardy nature and attractive appearance, *Caulerpa taxifolia* became popular as a decorative marine aquarium plant in the 1980s. The most likely source of infestations in nonnative areas, including the Mediterranean, Australia, and California, is through release from aquariums. Once introduced, *C. taxifolia* spreads mainly by fragmentation, and even a small, broken-off fragment can form a new plant. While the sale of *C. taxifolia* is currently legal in California, pending legislation (Assembly Bill 1334) would prohibit its sale, transport, and possession throughout the State.

The devastating ecological and economic consequences that have resulted from the spread of *C. taxifolia* throughout the Mediterranean has raised great concern from scientists about its impacts in California should it become established along the Pacific Coast. A plan for eradication and associated surveillance is currently underway at the sites of both infestations under the direction of the Souther California *Caulerpa* Action Team (SCCAT). Scientists are cautious, but hopeful that over time complete eradication will be achieved.

Clopyralid Drift Following Aerial Application at Fort Hunter Liggett

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Drift was monitored from an aerial application of clopyralid into adjacent buffered vernal pool and stream sites at Fort Hunter Liggett. For all areas the buffer zone was 30 m from the water source, except the Vernal Pool with California Tiger Salamander (200 m buffer). On the day of application, March 19 2001, wind conditions were light (~5 mph) and in the direction of the treated area to the stream. Water sample from the creek were taken 1, 2, 3, 4, 5, 10, and 15 min after application. Vernal pool water samples were taken 1 hr after application. All samples were analyzed by capillary gas chromatography using electron capture detection with a detection limit of 0.05 ppb for water samples and 1.25 ng for filter paper samples. Clopyralid was undetectable in all samples taken in Stoney Creek at all monitoring times (1, 2, 3, 4, 5, 10 and 15 min after application). Within the treatment zone the average concentration of clopyralid detected on the filter paper was 7.8 mg. At 10 m away from the border of the treatment area the concentration of clopyralid had dropped to 8% of the treated area concentration, and at the stream edge (30 m from the treatment zone) the concentration of clopyralid was only 0.6% of that found in the treatment zone. Little, if any clopyralid, was undetected in the vernal pools. In conclusion, drift potential for clopyralid was minimal even with aerial application and a slight downwind breeze. Buffers of 30 m provided adequate drift safety. Nevertheless, it is important to minimize application error, particularly accidental encroachment into the buffer zones, to ensure that movement of herbicide to water sources are minimized.

Tamarisk (*Tamarix* spp.) Control and Management at Anza-Borrego Desert State Park®, California

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Staff and volunteers at Anza-Borrego Desert State Park® (ABDSP) and California State Parks' Colorado Desert District have waged a 30-year battle to control and eradicate tamarisk/salt cedar (*Tamarix* spp.) from riparian habitats, springs and cienegas in California's largest state park. These wetland habitats are of critical importance to wildlife, including a number of state and federally-listed endangered or threatened species, along the western edge of California's Colorado Desert. During this time period tamarisk infestations have occupied over 130 linear miles (210 kilometers) of such habitat, or approximately 5,000 acres (2,000 hectares), within ABDSP. Tamarisk infestations have resulted in decreased surface water availability, loss of wildlife habitat, and loss of riparian plant species diversity throughout 12 of the Park's major drainage systems. Early attempts at control of this invasive non-native shrub relied heavily on mechanical means and volunteer labor. During the past decade, the California State Parks System has provided funding from a variety of sources for staff and materials to work on a systematic eradication/control program using mechanical and chemical means, along with prescribed fire. Sustained control efforts have resulted in the near-eradication of tamarisk/salt cedar from the Coyote Creek, Borrego Palm Canyon, Borrego Badlands, Carrizo Badlands, Sentenac Canyon and Fish Creek drainages, and allowed for natural revegetation of these areas. Significant battles remain to be waged in the San Felipe Creek/Sentenac Cienega region, in the Carrizo Creek drainage, and at Carrizo Marsh.

Integrated Strategies for *Phalaris arundinacea* L. (Reed Canarygrass) Control in Oregon

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Biodiversity of native wetland habitats throughout the United States, especially in the Pacific Northwest, is threatened by *Phalaris arundinacea* (reed canarygrass), an invasive exotic species. Reed canarygrass is an especially pernicious perennial weed because it is fast-growing, tolerant of a variety of soil conditions, and difficult to manage using conventional methods. It often forms dense stands that outcompete native plants, are of little use to wildlife, and alter surface hydrology and encourage erosion.

Our principal objective is to evaluate the treatment combinations that achieve the highest reductions in reed canarygrass abundance and encourage the reestablishment of native plant communities, while reducing the overall need for long-term herbicide use. Currently, there is little consistent understanding of how best to control reed canarygrass in wildlands without severely impacting the surrounding habitat (such as by tilling or disking). Despite the serious threat posed by this species, there has been little research into the effectiveness of integrated control techniques for natural areas.

The Nature Conservancy, in partnership with the U.S. Army Corps and Portland Metro Regional Parks and Greenspaces, has initiated a three-year study that will determine the effects of integrated control strategies for the management of reed canarygrass in western Oregon. We will implement and then evaluate the results of 18 different combinations of mowing, burning, shading and herbicide applications, with special emphasis placed on varying the timing of the mowing and herbicide treatments. In the second year following treatment, restoration will be implemented via the seeding of native plant species.

Invasion into Four Plant Communities by Artichoke Thistle, *Cynara cardunculus*

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Cynara cardunculus, artichoke thistle, is an invasive perennial herb that has spread to occupy thousands of acres in California. Understanding which plant communities are most vulnerable to invasion will help to focus management efforts. Experiments were begun at a field site (Crystal Cove State Park in Laguna Beach, CA) to determine the risk of invasion by artichoke thistle into four plant community types: coastal sage scrub, annual grass, mustard, and artichoke thistle dominated communities. In each community type, 12 plots (2m by 2m) were established. Six plots were monitored to determine resident seed bank size while the remaining six plots were seeded with 25 seeds each. Emergence and leaf number were monitored in all plots. In three unseeded plots in each community type, soil moisture and air temperature were also monitored. All plots were located on north facing slopes with the exception of the coastal sage scrub plots, which were split between north and south facing slopes. Although no resident seeds germinated in the south facing shrub community, it had the largest emergence percentage and final leaf number of planted seeds. The artichoke thistle community was the only one in which resident seeds germinated and it also had the second highest emergence percentage of planted seeds. These two community types were the wettest and among the warmest during the early growing season. The three remaining communities had extremely low emergence percentages from planted seeds. From this information, it appears that dispersal distance of artichoke thistle seeds is very low. However, coastal sage scrub can be an ideal location for germination once seeds arrive. This information can help land managers identify the vulnerable communities on their land and focus their control efforts accordingly.

Volunteers Pay Money to Remove Invasive Weeds

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The Catalina Island Conservancy (CIC) manages and owns 88% of Catalina Island. The removal of invasive weeds is a major part of the CIC's mission to restore Catalina to a natural state. Starting in 1999 the Volunteer Department of the CIC successfully started Volunteer Vacations, in which individual volunteers from the mainland work together as a group and pay to assist in restoration projects on Catalina. Many of these projects involve the removal of invasive weeds. Currently volunteers pay $135 for their efforts to restore the island. The program is ultimately managed by volunteers for volunteers, with two local volunteers comprising approximately 80% of the program's management and the remaining 20% by CIC staff.

The impetus for the program was the niche for volunteer groups to fill during a normal business week. The Volunteer Department received a constant flow of requests by individuals from the mainland who would like to volunteer; however, this option was too costly with the coordination, training, supervision and resources that it would require to use an individual volunteer to remove weeds. The result was the founding of Volunteer Vacations- where people pay money to remove weeds. All volunteer groups are housed at the Volunteer Camp. Operating from a very small budget, the Volunteer Department constructed the camp with approximately 90% volunteer labor, and has many amenities including a kitchen, showers and toilets. In 2001 Volunteer Vacations had a net gain of $1500, and with 465 hours donated to weed removal during its three year operation.

Results of Basal Bark Application of Garlon4 on *Ailanthus altissima* (Tree of Heaven)

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Ailanthus altissima (Tree of Heaven) is a highly invasive tree in riparian areas of California. Through abundant root sprouts and allelopathy it produces thickets that outcomes and displaces native vegetation (Hunter 2000) . The tree is listed as an A-2 by the Calif. Exotic Pest Plant Council (Most Invasive Willard Pest Plants; Regional. 1999. CalEPPC in Exotic Pest Plants of Greatest Ecological Concern in California). Land managers have found it difficult to control this species with traditional methods such as the cut stump method where the tree is cut down with a chain saw and the stump painted with an herbicide such as RoundUp or Gallon4 (Kit 1997). Resprouting and numerous retreatment are commonly required (Hunter 2000).

In April and June 2001 Kelly & Associates tested a basal bark application of Gallon4 herbicide in an oil base (paraffin hydrocarbons) at a rate of 1:3 (25% Gallon4® to 75% basal oil) on *Ailanthus altissima* (Tree of Heaven). On each of the two occasions, approximately 400 stems of this invasive tree were treated. An attempt was made to treat every stem, small or large, within the colonial structure typical of the plant. The herbicide mix, inspired by similar successful treatments on saltcellar (Bill Neil pers. comma.), was applied to the entire circumference of each stem as low to the ground (close to the roots) as possible. The spray pattern around the stem varied from about 15 cm (6 inches) on smaller diameter stems to 30 cm (12 inches) on large trunks in height. Since Gallon4 is known to volatilize above 86º F it's important to make the application during cooler weather or a cooler part of the day, to give the herbicide time to be absorbed into the tree.

The tests were conducted on the Rancho Jamul Ecological Reserve, a new reserve bought by the California Dept. of Fish & Game. Within two weeks of the respective applications, the trees were showing obvious signs of distress including browning leaves and curling growth tips. A survey in mid-september 2001 found greater than a 98% kill on the sprayed stems. No new stems were observed which might indicate root resprouting. Additional untreated trees will be treated before the tree goes dormant for the year. A revisit will be made to the treatment area in Spring 2002 to inspect for new seedlings from the seed bank or resprouting stems. An important consideration is whether site conditions permit leaving the standing dead trees which they did in this case.

Basal bark treatment thus appears to be a more effective treatment of killing Tree of Heaven than other techniques such as a cut stump or girdling method.

Hunter, J. 2000. Ailanthus altissima (Miller) Swindle. In: Board, C. et al. *Invasive Plants of California's Wildlands.* U.C. Press.

Kitz, J. 1997. A Working Paper on Ailanthus. CalEPPC News Summer 1997, Vol. 5 No. 3.

Drilling as a Technique for Controlling *Eucalyptus*, Palms & Other Exotic Trees

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The Friends of Los Peñasquitos Canyon Preserve, a San Diego conservation group, have included drilling as one of their techniques for eradicating invasive trees, especially Eucalyptus. The technique has also been successfully used on Fan palms (*Washingtonia robustus*), Canary Island Date Palms (*Phoenix canariensis*), and Brazilian peppers (*Schinus terebinthifolius*). Drilling appears on some herbicide labels such as RoundUp under injection. Injection is a technique common to silvaculture control of unwanted tree species in managed tree plantations.

Using drilling to kill *Eucalyptus* spp. such as the Red Gum (*E. camaldulensis*), the most commonly found invasive *Eucalyptus* in southern California was suggested to this author by Judith Railings of Bushmasters, an Australian habitat restoration company at a California Exotic Pest Plant Council Symposium.

The technique involves drilling holes every 6 cm (2.4inches) or closer around the entire circumference of the tree with a portable drill and a 5/16" (or larger) drill bit at a downward angle through the bark and into the cambium layer. Each hole is filled with a concentrated (undiluted from the 41% concentrate) dose of glyphosate (RoundUp Pro) and refilled on the bigger trees. Spacing of the holes should vary with the sea-

son. In July and August, hot weather drilling produced a kill on *Eucalyptus* spp. in 2-3 weeks. Colder weather applications (February – March) took longer and from experience, applicators learned to space holes as close as 3 cm (about 1 inch). Trees as large as 60 – 90 cm (2 – 3') diameter were successful killed. A caveat, however. Coastal San Diego, where these treatments occurred, rarely suffers from deep, killing frosts common to inland areas or other parts of the state — hence many non-deciduous tree species in San Diego actively grow during winter months. Drilling is likely not to work in areas where trees go dormant. Brazilian peppers were similarly treated with successful results. On some trees, due to the contortions of the trunk or the splitting into multiple trunks some part of the tree may not be killed, evidenced by the healthy looking green leaves. Trace the green branches down the trunk and rebill this section of the tree for a complete kill.

Drilling palm trees requires a variation on the technique used with *Eucalyptus* spp. It is necessary to purchase specialty drill bits of 18 – 48 inches in length. The diameter can remain the same and they will chuck up in the same portable drill and are surprisingly stable when drilling. Longer drill bits can be found in specialty tool stores. The longer drill bit is necessary to reach the vascular transport system within palms. Unlike *Eucalyptus* spp. where this transport system is in the cambium layer just under the bark at the outer circumference of the trunk, in palms it is to be found in the center of the trunk where the heartwood or palm heart is to be found. The Friends typically drill three holes at different heights, but usually from waist to chest height on the palm. Each hole is drilled at a slight downward angle into the heart of the trunk in order to promote gravity transport of the herbicide into the center. The number of holes is arbitrary. The applicators have not tried 1 or 2 holes, which would make for a good experiment in the future.

Delivering the herbicide, the same concentrated dosage of RoundUp used on *Eucalyptus* spp. is tricky. The Friends have chosen to use plastic laboratory bottles with the extra long, curved necks to squeeze the herbicide into the holes. (As with any herbicide container, label the bottle with the contents, EPEE #, warning word and applicator information to prevent accidents.) However, with this method, some herbicide is wasted in space between the layers of palm frond husks built up around the trunk when the lab bottle neck is not long enough to penetrate past these layers. Another applicator designed a long metal nozzle for the Friends, about 18" long, to fit over the original nozzle of an herbicide spray gun to help deliver the herbicide deeper into the plant. In this case it's necessary to drill the hole with a bigger bit or use the existing 5-16" bit to widen the hole to permit entry of the specialty nozzle. A stiff plastic tube would probably work for delivering herbicide into the heartwood.

Actively growing Fan palms will often show die-off within 2–3 weeks. Death is obvious with Fan palms, since they the fronds turn brown. With the Canary island date palms, however, the fronds remain green for as long as 2 years! The only way the Friends found to be sure they had died was to cut a "ladder" to the terminal bundle of fronds, the growth point. When you find it, pull on it. If the palm is dying, it easily pulls out as a separate, decaying bundle. It appears that the herbicide is acting on the active growth part of the palm, but not killing the entire root zone, which continues to support green fronds. No resprouting has been observed with either of these species. Any reader of this paper that knows more about palm physiology and what may be happening internally in these palms is encouraged to share this information with the author.

Caution: The Canary island palms have extremely long spines and are quite dangerous to work around.

When drill?

When to use drilling as opposed to the traditional cut stump method depends on the restoration goals and other limiting factors. In many situations in which the Friends find themselves it is desirable to leave standing dead trees or palms. They provide raptor perches and in the case of the palms, nesting opportunities among the fronds. If they occur next to roads or trails or open streams where their falling could possibly injure a person or block a stream, these "widow-makers" eventually have to be taken down. Dead trees weigh a lot less than live ones and will do less damage in falling if cut down after dessication. Drilling takes a lot less time than cutting down a big tree and bucking it up. Drilling is also a quiet method, useful when the noise of a chainsaw might startle passing equestrians, a common occurrence in Peñasquitos Canyon Preserve, or disturb the nature experience many hikers are there to enjoy. Just as construction activity is prohibited before 7 a.m. in San Diego so as to avoid waking residents from their sleep, drilling can be used when a chainsaw might wake canyon rim dwellers. A thick grove of dead trees of any kind may also inhibit recruitment of natives to the area, possibly another reason for taking

down some or all of the trees. Most of the Friends' drilling has been on scattered trees where this is not an issue.

Purple Loosestrife Under Siege in California

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In 1999, the California Dept. of Food and Agriculture (CDFA) was awarded a grant by the CALFED Bay-Delt Program to conduct a purple loosestrife prevention, detection, and control program. Purple loosestrife (*Lythrum salicaria*) is a showy ornamental that has escaped home gardens and nurseries and moved extensively throughout the wetlands of the United States causing immense ecological destruction. Purple loosestrife is listed by the CDFA as a "B" rated noxious weed and as a "species with potential to spread explosively" by the California Exotic Pest Control Council. Based on historic records and recent surveys, the distribution of purple loosestrife in California is currently in multiple, mostly small, and scattered populations. Primary program objectives have included: (1) a broad education and training campaign, (2) extensive surveying and mapping, (3) collaborative assessment meetings of regional cooperators to develop site specific adaptive management plans, resulting in (4) comprehensive local management, control, and eradication efforts, and (5) monitoring. The geographical focus is on the Sacramento-San Joaquin Delta watershed where there are a number of threatened and declining species due to a multitude of environmental stressors. The project is an extensive collaborative effort with State and Federal Agencies, County Agricultural Commissioner's Offices, watershed groups, and local Weed Management Areas. In 2002, the project will enter its second season of control (mechanical, chemical, and biological control) with many, local eradications possible and widespread control and containment achievable.

Cooperative Weed Management Areas

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Weed Management Areas (WMAs) are local organizations that bring together landowners and managers (private, city, county, State, and Federal) in a county, multi-county, or other geographical area for the purpose of coordinating and combining action and expertise in combating common invasive weed species. The WMA functions under the authority of a mutually developed memorandum of understanding and state and local weed control authority. A WMA may be voluntarily governed by a chairperson or a steering committee. To date, groups have been initiated by either the leadership of the County Agricultural Commissioner's Office or other interested parties. WMAs are unique because they attempt to address agricultural (regulatory) weeds and "wildweeds" weeds under one local umbrella organization. It is hoped that participation will extend from all agencies and private organizations. It is hoped that participation will extend from all agencies and private organizations. WMAs have printed weed I.D./control brochures, organized weed education events, written and obtained grants, coordinated demonstration plots, instituted joint eradication and mapping projects as well as many other creative and effective outreach and weed management projects.

In 2000, Senate Bill 1740 passed appropriating $5,000,000 to the Noxious Weed Management Account. This bill modifies Assembly Bill 1168, the noxious weed control bill that passed in 1999 and will fund WMAs and agricultural commissioners to implement integrated weed management plans through the state.

For turther information aout WMAs in general, see the California WMA website at http://www.cdfa.ca.gov/wma or contact Steve Schoenig at the California Dept. of Food and Agriculture, sschoenig@cdfa.ca.gov.

Review of the Impact of Invasive Weeds on Two Endangered Plant Species: *Acanthomintha ilicifolia* (San Diego Thornmint) and *Monardella linoides* ssp. *viminea* (Willowly monardella)

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Acanthomintha ilicifolia (San Diego thornmint) and *Monardella linoides* ssp. *viminea* (Willowly monardella), both Federally and State listed Endangered Species, face severe threats from a variety of invasive weeds. These weeds include, but are not limited to, *Cynara cardunculus* (Artichoke thistle), *Avena* ssp. (wild oats), *Centaurea melitensis* (Tocalote), *Brassica nigra* (black mustard), and *Erodium* ssp. (filaree). Experiments by Dr. Ellen Bauder (SDSU) have demonstrated a direct negative by tocalote on the Thornmint. Control methods are discussed.

Sierra Club Volunteers Eradicate *Tamarix ramosissima* (tamarisk, saltcedar) in Sensitive Habitats in Anza Borrego State Park

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For more than 4 years now the San Diego Chapter of the Sierra Club has been organizing volunteers to travel to various sensitive areas of Anza Borrego State Park in California to control the highly invasive *Tamarix ramosissima* (tamarisk, saltcedar). There they use a cut stump method of control, using loppers, handsaws, and chainsaws to cut down the tamarisk, then apply an herbicide to the cut stump. Their team focuses on ephemeral water sources that can be drastically drawn down by heavy infestations of the saltcedar. These water sources are scarce in the desert and vital to the wildlife, including the Federally listed Peninsular Bighorn Sheep. The team has witnessed dramatic changes in water flow after removal of the invasive shrub.

The Lassen County Special Weed Action Team (SWAT)

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The Lassen County Special Weed Action Team (SWAT) 2001 display addresses the noxious weed activities undertaken by some of the signatories of the Memorandum of Understanding (MOU) for our weed management area (WMA). We have 27 groups or agencies participating in a coordinated effort to fight the invasive species infestations in Lassen County. We wanted to show how working together can improve the health of our natural community. We wanted to show that some of our activities would not have been accomplished without the coordinated effort. an example of this is the education projects that have been made possible only through our combined efforts. Together we have also had many successes in eradication of infestations. The Lassen SWAT has been effective in many areas of invasive species control and hope that this display will aid others in finding opportunities to fight noxious weeds.

Introduced *Spartina* in San Francisco Bay: 2000-2001 Survey and Findings

San Francisco Estuary Invasive *Spartina* Project
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The San Francisco Estuary Invasive *Spartina* Project, established in 2000, conducted an extensive survey of four species of aggressively spreading *Spartina*, or cordgrass, in the South Bay, Central Bay and portions of the North Bay. The loss of native tidal marsh, channel, and mudflat habitat, probable local extinction of native *Spartina foliosa*, as well as the elimination and marginalization of endangered species habitat due to the invasion of non-native *Spartina* is a growing concern to resource managers and the public. Significant alteration of both marsh composition and

structure due to the spread of introduced *Spartina* species can be observed around the Bay. Future marsh restoration in the Bay is likely to be affected. Survey data is being analyzed to assess the feasibility of eradicating the populations and to develop a regionally coordinated control strategy.

The 2000-2001 survey assesses the current distribution of introduced *Spartina* species, and quantifies net acreage for each of the four species (*S. alterniflora* and its hybrids were mapped as one unit, using molecular tests to confirm field identification). The mapping project was a field-based effort, utilizing GPS (Global Positioning System) units to collect location and ecological data for each found population of invasive *Spartina*. In addition to detailed field mapping, aerial photos and ground truthing were utilized to assign cover classes to highly infested marshes. All collected data and photos have been integrated into a GIS system for analysis.

The Invasive *Spartina* Project is funded by Calfed Bay-Delta Ecosystem Restoration Program, California Coastal Conservancy, National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service Coastal Program.

Proceedings

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Risk Assessments and the Ecological and Economic Impacts of Invasive Weeds

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CALIFORNIA EXOTIC PEST PLANT COUNCIL

2002 Presentation Abstracts

Session 1

Regulatory Compliance at the County Level

Peggy Rose, Ventura County Resource Conservation District

Local concerns and constraints can and do effect permit issues and the ability to do Arundo removal projects. The Ventura County Resource Conservation District is the lead agency for the Ventura County Arundo Task Force. Working with the local Flood Control District and other partners, they have encountered ordinances, circumstances, and points of view that affect their ability to move forward with projects and which shape the details of the projects that are undertaken. Ms. Rose will share local perspective on these issues.

Session 2

Developing Alternatives to Invasive Landscaping Plants

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Horticultural stock is a significant source of known and potentially invasive plants. For example, nurseries in California have propagated 53%, or 41 of the 78 plants listed on the California Exotic Pest Plant Council's (CalEPPC) lists of "Pest Plants of Greatest Ecological Concern." Only a small fraction of these wildland invaders are regulated (occurring on the state or federal noxious weed lists) and no mechanism exists in the current regulatory frameworks at the state or federal level for controlling the propagation, distribution, and sale of unlisted species with known invasive tendencies. The current climate of inadequate government infrastructure and funding for invasive species insures that any attempts to regulate the industry will fail. With cash receipts of over 13 billion in 2001, the horticulture industry is a powerful force in the U.S. economy that strongly opposes outright bans on specific plant sales. We must therefore address the problems associated with invasive horticultural stock through rigorous education campaigns. Work has begun on a project to develop non-invasive landscaping alternatives. A preliminary workshop was held at the UC Berkeley Botanic Gardens in June 2002 to develop a list of target invaders. In developing the list of targets, the workshop participants considered such criteria as availability in nurseries, regions or habitats invaded, and the realized or potential impacts of a plant. For each target, we then considered all the attributes that might make the plant a desirable ornamental; a particular growth habit, flowering time, or color, its hardiness, cultivation requirements, or if the plant had a specific landscaping use like a windbreak, wildlife attractant, or functioned as a focal point in a garden. In selecting suitable alternatives we tried to match plants that shared as many similar attributes as possible. This criteria-based approach may be an effective educational tool that will stimulate people to think about why we choose the plants we do. The larger goal of the project is simply to raise both public and industry awareness of the problem of invasive species and to offer a positive solution that benefits all stakeholders. Increased research on alternatives to invasive species may offer an additional benefit to the horticulture industry as it may lead to new non-invasive cultivars and breeding techniques that could actually increase numbers of new plants and diversify nursery stock.

CalEPPC's Risk Assessment Process for Classifying Invasive Non-native Plants

Peter J. Warner, California Dept. of Parks and Recreation, California Exotic Pest Plant Council

The impetus for a risk assessment process to support CalEPPC's "Exotic Pest Plants of Greatest Ecological Concern in California" (aka, the "weed list") developed largely due to the popularity and widespread use of the "list," first published in 1996. The first two vesions of the list (1996 and 1999) were developed based on the professional opinion of weed scientists and managers

statewide, and was primarily intended as a quickly referenced educational resource. In recent years, the list has assumed "quasi-regulatory" status, cited statewide as an authoritative document for planning and management purposes. Seeing that the list had outgrown its tidy, well-tended CalEPPC garden and bolted into the dense underbrush of a more regulatory-influenced climate, the Board of Directors recognized the need to publish a set of repeatable criteria describing the process for ranking species on the list and excluding species from the list. . In 2000, CalEPPC's weed list committee morphed into a criteria development project with a primary goal to assemble "transparent" and scientifically supported protocols through which to rank the state's non-native plant species.

The committee's work began with a delineation of primary goals, which include the development of the criteria, a revision of the weed list, and compilation of supporting documentation. We reviewed similar criteria-based weed-ranking systems, especially the protocols devised by The Nature Conservancy (Randall et al. 2001), from which the still-evolving criteria have been adapted. Into our cauldron of debate and deliberation, we've welcomed the participation of the Southwest Vegetation Management Association and the University of Nevada Cooperative Extension, with the hope that these organizations will use the same criteria to develop wildland weed lists in Arizona and Nevada. Currently, we are near completion of a finished draft of the criteria.

One essential consideration throughout this process is that the criteria clarify the decision-making process for the placement and ranking of species on the list. We are attempting to provide clear definitions, and to articulate appropriate uses of the system. However, we also acknowledge that the criteria and this process will have limitations – another specimen within the rich human heritage of efforts to classify and organize. As practically as possible, we've aimed for simplicity: only ecological and biological impacts and mechanisms are assessed – economic impacts are not under consideration. Likewise, we discarded evaluations of management feasibility (i.e. is it easy or hard to eradicate or control), choosing to pursue that task as a worthwhile future endeavor. The scoring system, we accept, will be scrutinized extensively, despite our efforts to summarize complex information objectively.

In the near future, we intend that the criteria will be published and available for review on the CalEPPC website. The committee will employ these criteria during its pending revision of the current weed list, and this document will also be published and internet-accessible. We plan to develop complementary databases on species-specific references and management information, and to promote the compilation of weed lists for different ecoregions within California. To the extent possible, we will provide links to other useful resources, and provide information as comprehensive as our resources allow. In the spirit of disclosure and education, CalEPPC welcomes constructive assessments of the criteria that will promote its evolution as a scientifically sound process for ranking invasive species.

Using Climatic Models to Predict the Potential Range of Invasive Plants.

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Prediction is a key element to preventing a plant invasion. One of the more promising predictive tools is the climatic matching simulation, CLIMEX. If a species cannot tolerate the climate of a new location, it will not survive regardless of other factors that might limit its success. CLIMEX combines species response to temperature, moisture, and photoperiod with the observed temperature, moisture and photoperiod of a location that might be invaded. Specifically, the model determines an overall climatic suitability index for a species at a location. I have developed a protocol to parameterize CLIMEX for any invasive plant species. It begins by acquiring biological information for a species from the literature or through experimentation. Acquiring a species' native range is also important for this initial parameterization. The biological information is plugged into a built-in template and tailored to predict native distribution. The model is then applied to the potentially invaded range to determine climatic suitability of that new habitat. CLIMEX comes with meteorological data for 14 California locations. We have formatted a National Oceanic and Atmospheric Administration (NOAA) database adding a total of 321 locations for California thus enhancing the resolution of prediction immensely for California. The protocol was followed to develop a model to predict gorse (*Ulex europaea* L.) distribution in California. The EI for gorse is high (1.0) only in northern California along

the coast and tapers to zero (not suitable) south of Monterey. Therefore, gorse should be considered of minor invasive potential south of San Luis Obispo County and east of the coastal range. The results from predictive climatic matching models such as CLIMEX should be used as tools to aid in further studies. A high EI indicates that climate is not likely to limit a species success, but does not preclude the significance of other abiotic or biotic factors in limiting its spread. CLIMEX has many additional tools that are useful for invasive species, such as the ability to predict the simultaneous climatic suitability of an invasive plant species and a potential biological control agent. It also allows for predictions under assumptions of global climate change.

Session 3

The Importance of Quantifying Economic Impacts of Invasive Weeds

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Invasive plants have spread extensively through California's natural and managed ecosystems. The total impact from these pest plants in our state, while generally acknowledged to be great, has not been comprehensively cataloged or systematically studied. Impacts are often dichotomized into either economic or biological terms but there is overlap when considering the valuation of ecosystem benefits or "nature's services" to society and the market economy.

There is a great need to increase public awareness of, and funding for, invasive weeds. While the biological impacts alone are sufficient to motivate those with a conservation interest, economic impacts are very compelling to legislators, policy makers and administrators. Invasive weed control, as a 'cause', must compete with poverty, health, education, road maintenance, fire risk, chemical pollution, homeland security and a host of other societal maladies. There is now the California Invasive Weed Awareness Coalition (CalEPPC is a founding member) to try and take weed awareness to a much higher level of intensity – however we are missing some of the critical information to communicate the massive economic impacts that invasive weeds have.

Figuring out impacts to agriculture, road maintenance, horticulture, recreation industry, real estate values is somewhat straightforward yet time intensive. We in the weed control business can total up all of our cost and extrapolate them to forecasted needs and expansion. However, since CalEPPC is focused on wildland weeds we need to look further into how invasive induced changes in the "natural environment" may impact market economies. Recent work by Gretchen Dailey of Stanford and resource economists around the country is starting to provide dollar impacts to impaired ecosystem function. These functions (which can be valued) include: soil stabilization, CO_2 sequestration, water infiltration and availability, local species diversity, genetic diversity within species (hence biochemical diversity), natural pest control, wildlife habitat, fire protection. It is crucial that we all try to start thinking about how invasive weeds affect our economic heath and begin to package this information to influence public policy.

Analyzing Economic Impacts of Leafy Spurge in the Northern Great Plains

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Leafy spurge (*Euphorbia esula* L.), a perennial weed native to Europe and Asia, has become a serious problem for ranchers and land managers in the Northern Great Plains region. This invasive weed is used to illustrate an approach to assessing economic impacts of other invasive species. Estimating the economic impacts of leafy spurge required a model that related the biophysical impacts of leafy spurge infestations to economic outcomes. The first step in model development was to identify the biophysical impacts of leafy spurge infestations. Key relationships in the model were developed to relate changes in levels of leafy spurge infestation to changes in land output (e.g., carrying capacity for grazing livestock, wildlife habitat value). The two key components of the bioeconomic model are (1) estimating rangeland (grazing land) impacts and (2) estimating wildland impacts. Rangeland impacts were developed by assessing the effects of leafy spurge on livestock carrying capacity (grazing potential) and then estimating the economic effects on both livestock producers (direct effects) and the regional economy. Wildland impacts were developed by esti-

mating the effect of leafy spurge on outdoor recreation activities and changes in soil and water conservation benefits. Direct economic impacts from leafy spurge infestation on wildland include (1) changes in wildlife-associated recreationist expenditures that impact local businesses and (2) changes in user expenditures to mitigate damages from runoff and soil erosion. Regional economic impacts were estimated using input-output analysis. The input-output model provides estimates of the secondary impacts that result from the direct effects via the multiplier process. The input-output results reflect the total (direct plus secondary) effects on each of 17 sectors of the regional economy.

Session 5

Influences of Arundo donax Invasion on Riparian Biodiversity

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California's wetlands and riparian areas provide habitat for approximately half of the protected species in the state, and replacement of native vegetation by *Arundo* has the potential for substantial impacts to these communities. *Arundo* permanently alters the structure and function of these ecosystems by outcompeting mature plants under a variety of environmental conditions, inhibiting establishment of native woody plants and understory species, and through streambank armoring prevents the resetting of succession brought about by seasonal scouring and meandering of the stream. While it is widely agreed that the effect of replacement of native riparian communities by monocultures of *Arundo* is detrimental to species depending upon these systems, this consensus is largely based on "common sense" and is difficult to support without scientific documentation. This talk will give an overview of research done to quantify the presence of native life forms and their success in reproduction within *Arundo*-invaded areas. For example, it has been found that terrestrial arthropod diversity and abundance in these stands are half that found within native vegetation, especially in the spring when these resources are of greatest importance for migrating and nesting songbirds. *Arundo* litter is a poor quality resource for aquatic insects, as evidenced by caddisfly growth rates and final biomass shown to be about 30% lower when fed *Arundo* vs. native plant leaves. Salmon, steelhead, and other fish depend upon aquatic insects throughout the region affected by *Arundo* invasion. *Arundo* is thought to provide poor structure for successful nesting of some birds, and to reduce the amount of shade over waterways, effecting water temperature and therefore conditions required for fish spawning and rearing. Sensitive species such as the arroyo toad have been found to be completely absent among *Arundo* roots. In these ways sensitive species are potentially affected directly and indirectly, through alteration of food web regimes and habitat for breeding and cover.

Management of Rare Native Species Amidst Exotic Plant Competition: Insights from Santa Cruz County's Endemic Sandhills Community

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Throughout California, communities associated with unique soils support numerous endemic species, rendering the California floristic province high on the list of global biodiversity hotspots. Despite theory suggesting that the inimical soil conditions should render these communities resistant to biological invasion, exotic plant species have successfully invaded most of California's endemic plant communities. Their presence makes management of native biodiversity difficult, as strategies for facilitating rare plants can similarly enhance exotic plant species that compete with native plant populations.

My research examines the conundrum of managing rare plants amidst the threat of exotic species in the unique sandhills plant community in Santa Cruz County, central coastal California. By removing dominant plant species and freeing up resources, natural disturbances in the sandhills including fire and soil disturbances facilitate native plants including two endangered species, *Chorizanthe pungens* var. *hartwegiana* (Polygonaceae), and *Erysimum teretifolium* (Brassicaceae). However, European annual grasses and forbs including *Vulpia myuros* and *Hypochaeris glabra*, which are widespread and patchily abundant in the sandhills, compete with the native plants and may themselves be facilitated by disturbances.

Using small-scale experiments, I examined the effects of reintroducing fire and managing soil disturbances in the sandhills amidst exotic plant species. I found that fire facilitated native plant cover and the population growth of the two endangered plants directly by removing accumulated litter that inhibits plant establishment and survivorship. Rather than enhancing exotic plants, however, fire also disproportionately reduced exotic plant species and, in doing so, indirectly facilitated endangered plant performance. Small-scale soil disturbances including slides, trails, and gopher mounds enhanced native plant species both directly and indirectly by these same mechanisms.

Results of these experiments indicated that exotic plants compete with the endangered plants for soil moisture that is scarce in the droughty soil of the sandhills. I examined the direct and indirect effects of availability of soil moisture on the endangered plants through experimental manipulations of rainfall. I found that increased spring rainfall enhanced endangered plant performance both directly and indirectly by decreasing the competitive effects of exotic plants.

Habitat Alteration and the Decline of a Rare Endemic Plant on Santa Cruz Island, California

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Dudleya nesiotica is an endangered endemic plant that occurs only in a 200 h area on Fraser Point, the western tip of Santa Cruz Island, California. Monitoring of *D. nesiotica* and other species was conducted from 1991 – 1998 in three strata based on initial density of *D. nesiotica*. The density of *D. nesiotica* in the high abundance stratum initially increased from 53 stems/m^2 in 1991 to 80 stems/m^2 in 1993, then declined steadily to 10 stems/m^2 by 1998. Density in the medium abundance strata declined from 10 stems/m^2 to 0.2 stems/m^2 between 1992 and 1998. Density in the low abundance stratum increased from 0.3 stems/m^2 in 1991 to 9 stems/m^2 in 1993, then declined to 1.4 stems/m^2 by 1998. The decline of *D. nesiotica* in the high abundance stratum was correlated with an increase in cover of non-native grass and a subsequent buildup of organic litter. The density of *D. nesiotica* had a negative correlation with organic litter in the medium abundance stratum, and with non-native grass and forb cover in the low abundance stratum. Besides reduction in density of *D. nesiotica*, there was also an overall decrease in species richness and cover of other native forb species in the high abundance stratum. The increase in cover of non-native herbaceous species was most likely an indirect result of the eradication of feral sheep from Santa Cruz in the 1980's. Non-native grasses and forbs had occurred on the island for > 150 years, so the habitat alteration was not due to invasion *per se* but proliferation of non-native species which already occurred at Fraser Point. Although this is one of the few studies that has directly correlated the decrease in abundance of a rare or endemic plant species with an increase in abundance of non-native plant species, the mechanism underlying the negative relationship between *D. nesiotica* and non-native herbaceous species is unknown. The most likely explanation for the decline in abundance of *D. nesiotica* was diffuse competition for light and water with the alien species, and future research should focus on this interaction so that an effective long-term recovery plan for *D. nesiotica* can be developed.

The Creeping Loss of California's once Widespread Shrublands to Pampasgrass and other Aliens

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California's Mediterranean-type shrublands have resisted invasion by alien plants. Several processes, however, are gradually eroding this resistance: (1) Urbanization is fragmenting once contiguous shrublands into a more vulnerable network of patches. (2) An increasing flood of alien propagules is inundating shrublands. (3) The ecological properties of some alien species are changing. The invasion dynamics of two introduced species of *Cortaderia* exemplify these processes. On Vandenberg Air Force Base, *C. jubata* is converting endemic Burton Mesa chaparral into a perennial grassland. Although several characteristics of Burton Mesa chaparral make it resistant to invasion, moderate disturbances opened an invasion window. Once established, founding populations catalyzed further invasion by swamping the adjacent un-disturbed

chaparral with a prodigious rain of seed. Elsewhere in California, *C. selloana* is invading endemic shrublands as well as other restricted plant communities. This condition is relatively recent, however. Both the morphology and the relative invasiveness of *C. selloana* populations have changed over the past 150 years, suggesting that they are gradually adapting to the California environment. These examples illustrate that even widespread and relatively resistant plant communities can be threatened by the persistent pressures of fragmentation, swamping by alien genes or propagules, and the adaptation of alien species. These erosive properties gradually change how aliens invade and impact native communities. To be effective, management practices will have to adapt to these changing dynamics.

Session 8

More Bang for your Buck: Comparative Benefits of Using Volunteers in Weed Management

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Loath to organize a volunteer program around an invasive plant removal project? Yes, it does require staff planning and time. Yes, you will need to focus on recruitment and retention of volunteers. And yes, it can make a huge difference in the amount of work your program accomplishes on a weekly or monthly basis. Since 1985, the National Park Service has been utilizing community members to manage weeds in the Golden Gate National Recreation Area. For a current operating budget of only $732,000 our natural resources division has managed to log nearly 170,000 hours of invasive plant removal. The bulk of this work has all been done by volunteers: interns and community service workers, corporate groups and organizations, school programs, and regular volunteer work days. The result is an effective project, as well as a budding community of restorationists and park advocates. Is it worth your time and money? Analyzing different types of volunteers and the nuts and bolts framework needed to accommodate them will help you decide.

Eradicating, Educating, and Enticing: Having Fun With the War on Weeds

Laura Lee Lienk, Monterey Weed Warrior

An avowed "native plant planter," the presenter was dragged "kicking and screaming" into the battle against invasive weeds in the Monterey Bay region. This case study presentation will highlight some of the programs that the Watershed Institute of CSU Monterey Bay, has developed to entice agency partners, homeowners, school teachers and children into the "War on Weeds." Featured will be the Iceplant Olympics, the Cycle of Restoration, the Weed Alert Card, the Genista-Free Yellow Ribbon Award, and more.

Session 9

Effects of the Exotic Prosopis juliflora Shrub on Native Flora and Soil Characters of the United Arab Emirates

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The effects of the invasive exotic *Prosopis juliflora* shrubs on the natural plant communities were assessed in three regions in the United Arab Emirates (Sharja, Ras Al-Khima and Khor Fakan). These regions represented the natural range of the species in the country. Three sites were selected subjectively in each of Sharja and Khor Fakan and two in Ras Al-Khima to cover the prevailing substrates and different densities and sizes of *P. juliflora* populations. The effect of the *P. juliflora* shrubs on the associated annual and perennial plants was studied in a number of quadrates distributed under, at the boarder and outside the crown of a shrub located in the center of each of 20-30 stands in each site. The absolute density, frequency and species diversity were estimated in each quadrate for both annual and perennial plant species. Soil samples were collected from under and outside the crown of each site and their physical and chemical analyses are analyzed. Age structure of *P. juliflora* shrubs was estimated in each site, through the calculation of the size index, which is

the average heights and diameters. The results indicate that the effect of *P. juliflora* on the associated species depends significantly on the density and age of their individuals. Larger individuals and greater densities have significantly adverse effect on associated species. Old and dense sites of *P. juliflora* in the three studied regions attained significantly lower density, frequency and diversity. All of the studied community attributes were significantly lower in the quadrates under the *P. juliflora* crown, compared to those outside it. This was true for most of the studied species, so a reverse trend was observed in some other. The analysis of age structure of the different regions showed that most of the populations are rapidly growing. It is interesting to note that the *P. juliflora* individuals improved most of the examined soil characters and able to grow in highly saline habitats indicating the potentiality of this species to be used in the afforestation of the salty habitats and its reclamation.

Spread of Exotic Cordgrasses and Hybrids (*Spartina* sp.) in the Tidal Marshes of San Francisco Bay

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Four species of exotic cordgrass occur in the San Francisco estuary in addition to the California native *S. foliosa*. Our goal was to map the location and extent of all non-native *Spartina* in the estuary. We characterized the appearance of *S. foliosa*, *S. alterniflora,* and *S. alterniflora* x *foliosa* hybrid plants, genetically evaluated by RAPDs, to enable visual identification of these entities in the field. Hybrids of *S. alterniflora* and *S. foliosa* are by far the most numerous exotic and are spreading rapidly. Radiating from sites of deliberate introduction, *Spartina alterniflora* and hybrids now cover ca 190 ha, mainly in the South and Central Bay. Hybrids or one of the alien cordgrass species have colonized each subregion of the Bay; the total coverage of 195 ha is slightly less than 1% of the Bay's tidal mudflats and marshes. *Spartina anglica* has not spread beyond its original 1970's introduction site. *Spartina densiflora* has spread to cover over 5 ha at 3 sites in the Central Bay. *Spartina patens* has expanded from 2 plants in 1970 to 42 plants at one site in Suisun Bay. Seed which floats on the tide has the potential to export this invasion throughout the San Francisco estuary, and to estuaries outside of the Golden Gate. We found isolated plants of *S. alterniflora* and *S. densiflora* in outer coast estuaries north of the Bay demonstrating the likelihood for the San Francisco Bay populations to found others on the Pacific coast.

Eating Exotics for Lunch: Does Cattle Grazing in Vernal Pool Grasslands Increase Diversity of Native Plant Species by Reducing the Abundance of Exotics?

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Much of California's vernal pool grassland habitat has been spared from agricultural and residential development because it has been used as range for cattle. As this rangeland is acquired for conservation purposes, the ecological implications of cattle grazing are generally examined. Unfortunately, scientific information regarding the impacts of grazing on vernal pools is limited to anecdotal information and unreplicated studies. This study is designed to quantify the community-level changes that occur when cattle grazing is removed from vernal pools. Four grazing removal treatments are being tested: (1) continuously grazed (control = grazed October – May), (2) wet-season grazed (December – March), (3) dry-season grazed (March – June), and (4) ungrazed. These treatments are replicated six times at the site across two soil types and a range of vernal pool sizes. We are measuring plant species richness and cover inside permanent plots at three zones in the vernal pool grassland matrix: the pool center, pool edge, and upland. After two years of treatment, grazing significantly decreased the cover of exotic plants, particularly exotic annual grasses, in all three vernal pool zones. The relative cover of native species (cover of natives/total plant cover) in all three zones was significantly higher in the continuously grazed treatment than the wet-season grazed or ungrazed treatments due to the reduction of

exotic species cover in those treatments. This effect was greatest in the pool center and upland. Native species richness was significantly higher in the continuously grazed and dry-season grazed treatments than the wet-season grazed and ungrazed treatments. This effect was detectable in all three pool zones. The preliminary results of this study suggest that grazing significantly reduces the cover of exotic plants and promotes native species richness and cover in vernal pool grasslands.

Effect of Competition on Artichoke Thistle, *Cynara cardunculus*

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Determining effects of root competition and shoot competition can give insight into the competitive ability of a plant species and direct land management strategies. In this study, the target species, *Cynara cardunculus*, was subjected to competition with four species: *Bromus diandrus*, *Nassella pulchra*, *Brassica nigra*, and itself. Target *C. cardunculus* plants were grown in full competition, shoot competition, or no competition. The shoot competition treatment isolated the root system of the target plant from those of the competitors. Each target was surrounded with four competitors of the same species. In two trials, all plants were planted on the same date. In two additional trials, competitors were planted one month prior to the targets. Measurements of height, diameter, and leaf number were taken every three days for the duration of the six-week experiment. Shoot dry weight was also recorded after plants were dried for at least one week. Significant differences among treatments were detected in target plant diameter, number of leaves, and shoot dry weight. Compared to the control, the target plants were smaller when grown in full competition with *Bromus*, *Brassica*, and *Cynara* in all trials. These same growth measurements differed in the trials with staggered planting dates for targets grown in full competition with *Nassella*. There were no significant differences in any of the shoot competition treatments. These results suggest that *C. cardunculus* is particularly sensitive to root competition, and that by carefully selecting re-vegetation material for a restoration project, re-invasions can be suppressed.

Invasion Ecology of the Japanese Alga *Undaria pinnatifida* in California

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The invasive kelp *Undaria pinnatifida* has recently become established at several locations in California coastal waters. *Undaria* is native to Japan, but in recent decades it has spread via either purposeful or accidental introductions to numerous other coastal areas worldwide. Both *Undaria's* population dynamics, and its effects upon native communities, have been found to vary greatly among invaded areas. Thus, the potential effects of *Undaria* upon California's marine communities cannot be predicted from previous studies. In this study, we tracked the timing and magnitude of *Undaria* recruitment, growth, and subsequent reproductive onset, in the Santa Barbara, California harbor following the discovery of a dense, reproductive population in April 2001. From July to September 2001, there was limited recruitment of new *Undaria* sporophytes. Although these individuals reached maturity and produced viable offspring, they were much smaller than the spring 2001 cohort. However, a much larger recruitment pulse was observed during January to March 2002, followed by rapid growth of individuals. This recruitment pulse is correlated with a drop in ocean temperature, and ongoing laboratory culture experiments are exploring the effects of different water temperatures on the growth of microscopic stages of *Undaria*. This research provides insight into the potential for the spread and relative impact of *Undaria* to previously unoccupied habitats along the California coast, as well as information for the timing of subsequent eradication efforts.

Session 10

A Brief Overview of the California Dept. of Food and Agriculture's A-rated Noxious Weed Education and Eradication Program

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The California Dept. of Food and Agriculture (CDFA) supports several noxious weed control and eradication programs. These are the A-rated Noxious Weed Education and Eradication program, the Biological Control program, and the Weed Management Area programs. These programs have many common goals and are mutually reinforcing. (A-rated noxious weeds are those noxious weeds of limited distribution in the State of California, as determined by a multi-agency board chaired by the CDFA). The objectives of the A-rated noxious weed eradication program are to educate the public about A-rated noxious weeds, to locate and map A-rated noxious weed infestations in California, and to eradicate A-rated noxious weeds by the most environmentally compatible means available. A-rated noxious weeds of particular concern to the Program are the aquatic weeds hydrilla (*Hydrilla verticillata*), and alligatorweed (*Alternanthera philoxeroides*); and terrestrial weeds such as spotted knapweed (*Centaurea maculosa*), and Scotch thistle (*Onopordum acanthium*). The backbone of the A-rated Program is the District Biologists and the Agricultural Pest Control Supervisor. They work closely with the County Agricultural Commissioners, the County Biologists, and the Weed Management Areas, and other public and private partners. Each District Biologist tailors the survey and detection efforts, the control and eradication efforts, the efficacy and environmental monitoring, and education and public outreach to their district's needs. Each District Biologist also uses a variety of weed eradication methods and tailors these methods to the characteristics of the infested site. Each site then requires an appropriate strategy to most efficiently prioritize eradication efforts.

Salmon River Cooperative Noxious Weed Program

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Since 1994 the Salmon River Restoration Council, a community based 501-c-(3)non-profit, has worked with various partners (agencies, tribes, landowners, schools, resource users) to control several prioritized species of noxious weeds throughout the almost half million acre Salmon River watershed. Although we've received approximately $60,000 from various sources, we've relied largely on volunteer support, provided predominantly by members of our small community of 250 residents. The SRRC has coordinated over 10,000 volunteer hours to aggressively control hundreds of populations of invasive plants in this wildland ecosystem using manual techniques. We're managing several species, but are primarily focusing on eradicating *Centaurea maculosa* and *Centaurea diffusa* from the Salmon River, which is 98.7 % National Forest lands. These two species are the only known state listed "Class A" species present in our watershed. The Salmon River is identified as having the second largest infestation of *Centaurea maculosa* in California. A protocol for determining eradication effectiveness was developed by the US Forest Service and is being applied annually. The SRRC has completed a draft management plan that includes 13 Goals: Cooperation/ Coordination; Planning; Education; Prevention; Inventory; Tracking; Groundwork; Adaptive Management/ Research; Revegetation; Monitoring; Evaluation; Reporting; and Support/Funding. To expand our Program, we're formalizing a Weed Management Group specifically for the Salmon River. The SRRC is a member of the Siskiyou County Weed Management Area and is promoting similar volunteer efforts elsewhere in neighboring watersheds.

Biological Control Programs for Yellow Starthistle and Russian Thistle

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Several new candidates have been identified for biological control of yellow starthistle and Russian thistle. Six insects that attack yellow starthistle have become established in California, but only two species are very abundant, and only the seedheads are attacked. Recent foreign exploration in Turkey, Greece, Italy and southern Russia resulted in discovery of a root crown weevil (*Ceratapion basicorne*), a stem-boring beetle *(Psylliodes* sp. nr. *chalcomera*), a mite (*Aceria* sp.), and a lace plant bug (*Tingis grisea*). These agents are being tested to determine host plant specificity. A rust pathogen (*Puccinia jaceae*) is in the final stage of approval for release in California. Two Russian thistle agents were introduced in the 1970s, but they have not become abundant enough to affect the weed. New agents discovered in France, Greece, Turkey and Uzbekistan include: a blister mite (*Aceria salsolae*), a gall midge (*Desertovelum stackelbergi*), a seed-feeding caterpillar (*Gymnancyla canella*), a root weevil (*Bothinoderus* [=*Chrysoderes*] *declivis*), a stem weevil (*Baris soricinae*), a flea beetle (*Chaetocnema breviuscula*) and two fungi (*Uromyces salsolae, Colletotrichum gloeosporioides*). Many of these agents are being further evaluated for safety and potential efficacy. The plant bug (*Piesma salsolae*) and a weevil (*Lixus incanescens* [=*salsolae*]) developed on some nontarget plants, and may be eliminated as candidates.

Monitoring Carduus pycnocephalus (Italian Thistle) on Grasslands in Coastal Central California

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Many areas of California are being invaded by the noxious weed *Carduus pycnocephalus* (Italian Thistle). This invasive plant not only disrupts local ecosystems, but is also a danger to livestock, as well as a financial drain upon limited state resources in the form of annual weed control and eradication programs. Are current plant control methods effective? In order to study the effects of various control techniques, a study was created using current GIS/GPS technologies to document existing areas of infestation. Located on 1600 km^2 of the BLM grasslands of the former Fort Ord near Monterey, California, this study was designed as a baseline for further Italian Thistle monitoring. Currently, control efforts are limited to mowing, grazing, as well as herbicides and hand pulling. Data collection and mapping were completed in June 2002. Although some areas of disturbance had strong colonization of Italian Thistle, no overall pattern could be observed. Italian Thistle was present in fields, hillsides, in sun and in shade. Age and maturity of seeds varied from area to area, with some just flowering, and others seeded and dead. This factor brings into concern the timing of any mowing or grazing, as spreading seeds would be a major concern. Overall, this project serves the purpose of creating a data set for further monitoring. With mowing and or grazing being the best and easiest technique available for control, simple mapping such as this allows for the yearly monitoring of any changes that may occur.

Alternative Bedding Sites for Grazing Sheep on Ft. Ord

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On Ft. Ord, invasive weeds have become a serious problem and the Bureau of Land Management (BLM) has taken action to battle the invasive weeds. There are a number of different methods or tools for dealing with invasive weeds. One tool for battling invasive weeds is the use of grazing. When the sheep graze, they need a place to sleep as well, this is where the sheep bed. Bedding sites are sites that experience the most intense grazing which could lead to further infestations of invasive weeds. This project found alternative bedding sites for the grazing sheep on Ft. Ord grasslands so that the sheep are not bedding in the same sites

throughout the grazing period. This was accomplished using existing bedding data, and finding commonalties between bedding sites using Geographic Information Systems (GIS). This allowed me to determine where similar, alternate sites would be located. New bedding sites were overlaid on top of current invasive weed sites to find which of the new bedding sites are close to or on top of invasive weed sites. There were originally 17 bedding sites and 17 new and alternate bedding sites were created. The information that I have obtained has been given to Ft. Ord BLM to help them make better land management decisions on where the sheep will bed in the future and where they will have the greatest impact on stopping the spread of non-native invasive weeds.

Poster Abstracts

Introduced *Spartina* in San Francisco Bay: 2000-2001 Survey and Findings, San Francisco Estuary Invasive Spartina Project

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The San Francisco Estuary Invasive Spartina Project (ISP) conducted a survey of four species of aggressively spreading *Spartina*, or cordgrass, in the San Francisco Bay Estuary. Invasion impacts include the loss of native tidal marsh, channel, and mudflat habitat, clogged flood control channels, invaded restoration sites, probable local extinction of native *S. foliosa*, and the elimination and marginalization of endangered species habitat due to the invasion of non-native *Spartina*. The 2000-2001 survey mapped the distribution of introduced Spartina species, and quantified net acreage for each of the four non-native species: *S. anglica, S. densiflora, S. patens*, and *S. alterniflora* and its hybrids with the native. The mapping project was a field-based effort, utilizing GPS (Global Positioning System) units to collect location and ecological data for each found population of invasive *Spartina*. All collected data was integrated into a GIS system for analysis. *S. alterniflora* /hybrids were the most widespread *Spartina* species in the Estuary, totaling 470 net acres. Populations were also found in the outer coast marshes of Point Reyes National Seashore, Tomales Bay, and Bolinas Lagoon. Research, outreach, and monitoring will be continued to prevent further invasion within the Bay, outer coast marshes, and restoration sites. Using the 2000-2001 survey data, ISP will develop a regionally coordinated *Spartina* control plan using integrated vegetation management. Possible treatment methods include physical, mechanical, and chemical. ISP will continue to support research on the biology of the *Spartina* sp. invasion and on the development of new control methods, using the most recent science available for the management of the invasion.

The Invasive Spartina Project is funded by Calfed Bay-Delta Ecosystem Restoration Program, California Coastal Conservancy, National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service Coastal Program.

Arundo donax Physiology, Shoot, and Root Growth Under two Nutrient Regimes

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Arundo donax (giant reed) is a pervasive invader of riparian systems, and therefore a potentially good candidate for bio-control. As a part of an on-going study of *A. donax* herbivory response, we investigated growth of 12 individuals grown from 4 x 3 cm rhizomes over a 5 month period (2/02-7/02). These plants were grown in 125cm x 125cm x 125cm containers with mini-rhizotrons at 30 cm intervals, filled with felt sand. Plants received either de-ionized or well (high N) water via drip irrigation daily. For two months, (5-6/02) plants also received weak solutions (2x for high nutrient treatment) of a micro and macro nutrient fertilizer on a weekly basis. We measured growth weekly; above ground growth was measured with a 3-D digitizer, and below ground growth was measured by analyzing root pictures taken with a mini-rhizotron camera. Physiology was measured using a LI-6400. Above and below ground growth, photosynthetic rate, and water use efficiency rates varied widely among in-

dividuals and did not consistently differ between treatments. However, all 12 plants had roots >1m deep within 4 1/2 months. *A. donax* in the field and in our pots reached photosynthetic saturation around 1000 PAR, but it closed stomata and stopped photosynthesizing between 29-31^0 C. However, they are not CO_2 limited, typical of a C-3 grass. These preliminary results suggest that *A. donax* has been successful because it has high enough photosynthetic rates to compensate for its heat sensitivity, and deep root systems to access water during the dry season.

Manual Removal of Cape Ivy in Volunteer Canyon – Bolinas Lagoon Preserve, Audubon Canyon Ranch, Stinson Beach, California

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Audubon Canyon Ranch manages a system of nature preserves in Marin and Sonoma counties. Seasonally-flooded red alder-dominated riparian forest is an important component of ACR's Bolinas Lagoon Preserve. During the period 1950-1995 Cape Ivy (CI), *[Delairea odorata]* invaded 6.3 acres of a flood plain, forming large continuous stands of CI and causing serious degradation of a rich riparian habitat. A restoration project was begun in 1995, with the goals of total removal of Cape Ivy and restoration of healthy riparian habitat. The strategy included surveying, mapping and marking of the riparian CI infestation, along with numerous satellite plots. Following removal of the satellites the contiguous growth was attacked from the perimeter inward, and from upstream proceeding down. A modified scorched earth policy allowed for saving many native shrubs such as the ferns and coffeeberry. Removed biomass was composted on site. Manual removal of CI by volunteers using simple hand tools was the preferred method, supplemented by a trial of goat grazing and periodic paid workers.

We judge the project a qualified success. Up to 1000 person hours per year were expended. Efficiency varied with terrain and substrate, with clearance rates between 5 and 10 sq. meter per person hour. Native flora replenished itself from the seed bank and opportunistic invasions (mainly *Conium maculatum* and several non-native thistle species) were managed on an *ad hoc* basis. The transformation in many areas has been inspiring. Manual removal works, but can succeed only with dedicated long-term follow up effort.

Predicting *Arundo donax* Shoot Emergence Using Degree-Day Based Equations

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Invasive plant species significantly alter ecosystem structure and function. *Arundo donax* is an invasive weed of California riparian zones. Once established, it spreads by clonal expansion, which is dependent on the production of new shoots from rhizomes. We performed experiments to test the hypotheses that temperature (7, 8, 14, 16, or 20 C) and nitrate concentration (0, 0.3, 0.6,1.2, 2.4, 3.6, 4.8, 6.0 mg/l nitrate) regulated the initiation of shoot production. No shoots emerged from rhizome sections at 7 C or 8 C, but shoots emerged at 14 C, 16 C, and 20 C. Neither time to shoot emergence nor the number of shoots that emerged was influenced by nitrate level in the watering solution. We used the above results in combination with shoot emergence data from rhizomes planted outdoors at Davis, California to develop degree-day equations for three separate cohorts of shoots. When compared to shoot emergence from different plants in a different year, there was very good agreement between predicted and actual shoot emergence indicating that these equations provide a realistic representation of processes involved in shoot emergence. This is an important step in developing integrated management plans for this invasive plant species.

Invasive Weed Control at Fort Ord

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The Bureau of Land Management's Project Office at Fort Ord has conducted an Integrated Pest Management Weed Program at Fort Ord since 1995. This program includes the use of 1500 domestic sheep 6 months each year, chemical (RoundupPro), manual, and mechanical (tractor mowers) means for spot treatments of approximately 20 invasive weed species. BLM's display at the 2002 CALEPPC Symposium will highlight the various abatement techniques used on Fort Ord and trends in declining abundance of invasive weeds treated on Fort Ord.

Focusing Foreign Exploration for Biocontrol Agents of *Arundo donax* using CLIMEX, Distribution Records, Genetics and Laboratory Rearing

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Arundo donax, Giant Reed, is a widespread invasive weed of watercourses in California, present in all continents with a natural range from the Canaries, through the Mediterranean basin, all of India and parts of Nepal to northern Myanmar. It was selected as a biocontrol target because of its intransigence to cultural and chemical control resulting displacement of native plants and disastrous impact on the local ecology; changing water levels, obstructing waterways leading to destructive flooding and sustaining wild fires in dry stands. It is thought to originate from the eastern Indian subcontinent. Based on this hypothesis foreign exploration was made in Nepal and India but revealed a nondescript insect fauna and no signs of natural control. Similar collections made around the Mediterranean resulted in 3 Hymenoptera, 5 Diptera, 1 Homopterous species causing stunting of shoots, tip rot and death of dormant buds underground. In addition several plant diseases were found attacking the rhizome, and shoots. Using CLIMEX to compare infested areas of California and its natural range no part of India seems a close match whereas parts of the Mediterranean basin are excellent matches. These results plus the diverse and often abundant presence of phytophagous insects and pathogens on *Arundo* from the Mediterranean area suggests that it or as yet unexplored areas nearby (Morocco and Canaries) are more likely to be near to the center of origin and therefore the most profitable areas to explore for natural enemies. *Arundo* samples have been taken from Europe, Africa, Asia, North America and Australia for genetic characterization and may provide clues as to the actual center of origin of *Arundo.*

Weed Watch: a Guide for Gardeners

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The Watershed Institute of the California State University Monterey Bay has created the "Weed Watch A Guide for Gardeners" card. The wallet sized card lists the Monterey Area's Most Invasive Species and Best Native Alternatives. Designed to be carried around by gardeners and landscapers the card's educational message subtle yet powerful.

Determining the Effectiveness of Eradicating *Centaurea maculosa* from the Salmon River Wildland Ecosystem

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Determining effectiveness for successfully eradicating noxious weeds has been performed utilizing various techniques and occurring at various scales in various areas of California. Currently there are qualitative and quantitative analysis techniques used at both the site level (a single population) and the program

level (the entire Salmon River Basin) for eradicating *Centaurea maculosa*. Through the Salmon River Cooperative Noxious Weed Management Program (Program) an assessment of density and occurrence has been developed in cooperation with the Ag-Extension of Davis Univ., Klamath National Forest, and Siskiyou County Dept. of Agriculture. The results from work accomplished in years 2001 and 2002 are displayed on the poster. In addition, other criteria for evaluation of activities such as: containment, work force, prevention, education planning and vector assessment have been performed and are presented. The Siskiyou County Weed Management Area partakes in the Programs review. The Salmon River Restoration Council is particularly interested in developing unbiased effectiveness monitoring techniques for eradication at the Program level in a wildland ecosystem that are consistent across the region. Conference participants and others are encouraged to provide a critique and suggestions.

Yellow Starthistle Control Using Native Grassland Restoration

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Three types of native grassland communities were grown in 4 m x 4 m plots with and without yellow starthistle (Centaurea solstitialis). We wished to learn which types of native species best compete with yellow starthistle. Restoring native communities that reduce yellow starthistle may be a valuable part of a long-term integrative starthistle control strategy. We gathered plant abundance data to learn whether late season species, early season species, or a combination of late and early species were most effective at reducing starthistle cover. We measured soil moisture at six depths down to 1.8 m and available light below the canopy to learn the mechanisms of competition. Late season (summer active, mostly perennial) species most effectively reduced soil moisture and yellow starthistle cover. In early spring, all communities showed nearly 100% cover. By summer, early season species had died off, allowing more light to penetrate their communities. Late season communities provided more consistent cover and allowed less light penetration over time.

Recently-Introduced Shrub *Hypericum canariense* (Canary Island St. Johnswort)

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Knowledge of a species' genetic diversity is becoming increasingly important in our efforts to both predict and control invaders. As the raw material for adaptation to novel environments and communities, genetic diversity may be crucial to initial establishment, expansion into new habitats, and resistance to control efforts. While the question of how much genetic diversity invaders typically bring from their native range is an old one, relatively few studies have tackled genetic comparisons between an invader's native and introduced ranges, and fewer still have examined genetic diversity in the life history traits that determine the survival and spread of a population (e.g. growth, seed production). I am examining both molecular (DNA marker) and ecological (life history trait) diversity in the native and introduced ranges of the shrub *Hypericum canariense* L. (Hypericaceae). An endemic of the Canary Islands (Spain), *H. canariense* is vigorously out-competing both native and exotic vegetation in areas of California, Hawai'i and Western Australia. This recent and ongoing invasion provides and excellent opportunity to examine how the genetic diversity in an initial introduction contributes to the success of an invader over time. I am also exploring the interplay between diversity and potential modes of reproduction via investigations of inbreeding depression and clonal propagation in *H. canariense*.

Weed Free Forage and Mulch in California

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Hay, raw feeds, and straw can contain germinable weed seeds if grown in fields where weeds are allowed to produces seeds, or rhizomes. These weeds can be spread into new areas by domesticated animals and mulches used for erosion control. Verifying that animal

feed and mulch is weed free before it is used in an area can prevent the spread of weeds. Prevention programs are much simpler and cheaper than detection, control, or eradication programs for weeds that are already established.

After the final approval of the Sierra Nevada Framework, lands under the jurisdiction of the Forest Service will close to those not using Certified Weed Free Forage; and it is expected that Bureau of Land Management, and National Park Service will follow suit. The closure has a three-year timeline: the first season (tentatively 2000) there will be implementation of a certification and education about what the closure means for land users. The second year, enforcement will be limited to warnings to those not in compliance. The third year, total enforcement will occur.

The California Agricultural Commissioners and Sealers Association (CACASA) formed a Weed Free Forage Committee California to develop and implement a weed free certification program that will comply with Weed Free Forage requirements on Federal Lands in the Sierra Nevada. Materials included in this program are: hay, grains, straw, and mulch. The committee has to date adopted procedures for certifying forage as "weed-free". They are currently working on documentation procedures. Finalizing the certification program should happen at the Spring Conference of the California Agricultural Commissioners.

Montana started its Noxious Seed Free Forage Program in 1972. Since then, the idea has spread, and now almost all the Western States have or are working on Weed Free Forage certification programs. Several states also have closures to non-certified forage applied on Federal lands. Colorado has additionally closed lands managed by its Dept. of Wildlife to non-certified forage.

For more information contact Karl Bishop (510) 283-6365 or Joanna Clines (559) 294-4938

Trial of Several Herbicides and Application Techniques for Control of *Ailanthus altissima*, Upper Putah Creek, Yolo County

Joe DiTomaso and Guy Kyser, Weed Science Program, Univ. of Calif., Davis, in cooperation with Calif. Dept. of Fish and Game

During October 2001 we tested several treatment methods using three herbicides for control of *Ailanthus altissima* along Putah Creek in Yolo County, California. Herbicides tested were Chopper® (imazapyr), Garlon 4® (triclopyr ester), and Roundup Pro® (glyphosate). Methods included cut stump, hack and squirt, cut and hack, and basal bark applications. Cut-tree treatments were applied at several time intervals after cutting. We evaluated canopy reduction and stump sprouting in August 2002. *Cut stump:* There were no differences among times of application from 0 to 1 hr after cutting. 30.0% of stumps treated with Roundup Pro resprouted, compared with 0% of stumps treated with Chopper and 20.7% of stumps treated with Garlon 4. Cut stump applications using Chopper would be a useful treatment in situations where immediate tree removal was desired. *Hack and squirt:* Hack and squirt treatments using Roundup Pro, Chopper, and Garlon 4 reduced standing tree canopy by a mean of 82.3%, 99.9%, and 66.7% respectively. *Cut and hack:* Trees were cut and a hack and squirt treatment applied to stumps. Stumps treated with Roundup Pro, Chopper, and Garlon 4 resprouted in proportions of 85.7%, 35.7%, and 60.7%, respectively, with no differences among times of 0 to 1 week after cutting. *Basal bark:* Almost all basal bark treatments with Chopper or Garlon 4 (20% each in Hasten) resulted in 100% canopy reduction. This was a successful technique requiring minimal equipment. Because of the possibility of Chopper being washed off the trunk or released by tree roots, Garlon 4 may be preferable in sensitive areas.

Long-term, Large-scale, Integrated Management of Yellow Starthistle (*Centaurea solsitialis*) at Fort Hunter Liggett, Monterey County, California: Lower Cost Follow-up Maintenance is Vital for Successful Control Program.

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A long-term, large-scale management program was implemented to reduce yellow starthistle (*Centaurea solstitialis*) populations at Fort Hunter Liggett in Monterey County, California. Treatments integrated the use of spring herbicide applications, early summer and fall prescribed burns, and biocontrol agents. A series of 2- to 3-year initial intensive management plans were prescribed to four sites: 1) a highly-disturbed grassland (military-use grassland); 2) a 250-acre oak woodland (Training Area (TA) 27); 3) a grassland with rare plants; and 4) a smaller 30-acre oak woodland site (TA 16). The treatments, integrating prescribed fire, herbicide application, and biocontrol, were based upon resource management objectives established at each site.

Results varied depending upon treatments administered at each site. In particular, the military use grassland achieved the greatest success after three years (first year prescribed burn, second and third year aerial clopyralid applications). After the first and second year of treatments, there was a 96.3% reduction in yellow starthistle cover. After the third year of treatment, yellow starthistle was reduced by 100%. During the fourth year, after which no large-scale treatment was administered, yellow starthistle populations began to rebound. As part of a follow-up maintenance program for this site, approximately 82 plants per acre were hand-pulled. Based on successful initial intensive treatment, follow-up costs were estimated at approximately $4.00/acre for hand-pulling. However, in areas where initial treatments were ineffective, as seen in TA 27, follow-up costs were estimated to exceed initial treatment costs.

A follow-up management program should be instigated once initial treatment has been completed for effective long-term, large-scale control of yellow starthistle. Although two to three years of intensive treatment can potentially reduce yellow starthistle cover by 100%, the persistent nature of the yellow starthistle seedbank allows for populations to rebound. Assuming the initial treatments were both properly-timed and effective, the cost of a follow-up plan should decrease from year to year as yellow starthistle populations dwindle.

Preventing the Purple Plague From Taking Over California's Wetlands

David Butler and Steve Schoenig, Integrated Pest Control Branch, Calif. Dept. of Food and Agriculture, 1220 N Street, Room A-357, Sacramento, CA 95814

The California Dept. of Food and Agriculture (CDFA) was recently awarded a grant by the CALFED Bay-Delta Program to conduct a purple loosestrife prevention, detection, and control program. Purple loosestrife is a showy ornamental that has escaped home gardens and nurseries and moved extensively throughout the wetlands of the United States causing immense ecological destruction. Loosestrife is listed by the CDFA as a “B” rated noxious weed and as a “species with potential to spread explosively” by the California Exotic Pest Plant Council. Based on historic records, the distribution of purple loosestrife is currently in multiple, mostly small and scattered populations, in the Sacramento-San Joaquin Delta system and nearby hydrological units. However, infestations of purple loosestrife often follow a pattern of establishment, maintenance at low numbers, and then dramatic population increase when conditions are optimal.

Purple loosestrife, which spreads primarily by copious production of seed the size of ground-pepper, threatens to become established and forms dense stands that crowd out native wetland vegetation and associated wildlife, thus threatening the overall biodiversity of aquatic, wetland, and riparian areas. The complex interface between farm land and water in the Bay-Delta estuary also provides rich and varied habitat for wildlife, particularly waterfowl. The displacement of valued flora and fauna and the diminishment of critical fish and wildlife habitats by purple loosestrife infestations has been well documented throughout the United States.

Primary program objectives will be to conduct: (1) a broad education and training campaign, (2) extensive surveying and mapping, (3) a collaborative assessment meeting of cooperators to develop site specific adaptive management plans, resulting in (4) comprehensive local management, control, and eradication efforts, and (5) monitoring. The geographical focus will be on the Sacramento-San Joaquin Delta watershed where there are a number of threatened and declining species due to a multitude of environmental stressors. The project will be an extensive collaborative effort with: CDFA Integrated Pest Control Branch District Biologists, County Agricultural Commissioners, local Weed Management Areas, CA Dept. of Boating and Waterways, the CA Dept. of Fish and Game, CA Parks and Recreation, U.S. Fish and Wildlife Service, USDA-ARS Resource Conservation Districts, and local watershed groups, amongst others.

For more information please contact David Butler, Purple loosestrife Project Coordinator, (916) 654-0768, dbutler@cdfa.ca.gov

Noxious Times Newsletter

Steve Schoenig, Matt Caldwell, and Susan Monheit. Integrated Pest Control Branch, California Dept. of Food and Agriculture, 1220 N Street, Room A-357
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The Noxious Times is a quarterly newsletter sponsored by the California Interagency Noxious Weed Coordinating Committee (CINWCC). This publication provides agencies and local staff with relevant information on noxious weed control throughout California. By providing news, policy information, and program reports from specific agencies, the Noxious Times serves as a resource for those interested in sharing information and coordinating efforts against noxious weeds. Look us up on the web at: www.cdfa.ca.gov/noxioustimes.

Sign-up today, Add a friend! There are three ways to add a colleague or neighbor to the mailing list: (1) Write to 1220 N Street, Room A-357, Sacramento CA 95814, (2) Requests by e-mail to www.cdfa.ca.gov/noxioustimes or (3) Calls to (916) 654-0768.

Cooperative Weed Management Areas

Steve Schoenig, Integrated Pest Control Branch, Calif. Dept. of Food and Agriculture, 1220 N Street, Room A-357, Sacramento, CA 95814

Weed Management Areas (WMAs) are local organizations that bring together landowners and managers (private, city, county, State, and Federal) in a county, multi-county, or other geographical area for the purpose of coordinating and combining action and expertise in combating common invasive weed species. The WMA functions under the authority of a mutually developed memorandum of understanding and state and local weed control authority. A WMA may be voluntarily governed by a chairperson or a steering committee. To date, groups have been initiated by either the leadership of the County Agricultural Commissioner's Office or other interested parties. WMAs are unique because they attempt to address agricultural (regulatory) weeds and "wildland" weeds under one local umbrella of organization. It is hoped that participation will extend from all agencies and private organizations. WMAs have printed weed I.D./control brochures, organized weed education events, written and obtained grants, coordinated demonstrations plots, instituted joint eradication and mapping projects as well as many other creative and effective outreach and weed management projects.

In 2000, Senate Bill 1740 passed appropriating $5,000,000 to the Noxious Weed Management Account. This bill modifies Assembly Bill 1168, the noxious weed control bill that passed in 1999 and will fund WMAs and agricultural commissioners to implement integrated weed management plans through the state.

For further information about WMAs in general, see the California WMA website at www.cdfa.ca.gov/wma or contact Steve Schoenig at the California Dept. of Food and Agriculture, sschoenig@cdfa.ca.gov.

2002 Red Alert! New Introductions and Recent Expansions in California

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A vital component of successful invasive species management is the prevention, early detection of, and rapid response to new invaders. The annual CalEPPC Red Alert! seeks to inform land managers of invasive species that have just recently been detected in California (not listed in the Jepson Manual or in CalFlora) and which have the potential to become widely invasive in the state. The Red Alert is also intended to provide updates on already-established non-native plant species that have recently been reported extending their range(s) within the state. This 2002 edition of the Red Alert! includes two species not previously reported as established in California and updates on range extensions of five already-established species. Additional reports of new non-native species can also be seen in CalEPPC News, The Noteworthy Collections section of the journal Madroño and on The Nature Conservancy's Invasives-on-the-Web Homepage (http://tncweeds.ucdavis.edu). If you know of any new invasives or know of range expansions, please contact TNC's Wildland Invasive Species Team for inclusion in next year's CalEPPC Red Alert!

Newly Detected Species with the Potential to be Invasive in California:

Undaria pinnatifida (Japanese kelp, wakame, Asian seaweed), an annual seaweed native to eastern Asia, is popular in several Asian cuisines. *U. pinnatifida* is already documented as invasive off the coasts of Australia, New Zealand, South America, and Europe, where it has invaded harbors and artificial substrates, and may be impacting native kelp populations and their associated invertebrate and fish communities. In California, *Undaria* has been reported from at least 6 sites along the coast including Monterey harbor, Santa Barbara harbor, Channel Island harbor (Ventura), Oxnard harbor, Cabrillo Beach (San Pedro), and a cove at Catalina Island. It has also been found near Ensenada, Baja California Norte, Mexico.

U. pinnatifida is easy to identify because its brown or olive-colored blades (0.9 to 1.5 meters long) are thin and delicate, have prominent midribs and are elaborately lobed along the margins. The reproductive sporophylls develop just below the blade (above the holdfast) and are deeply frilled, like old-fashioned ribbon candy. The blades appear in early spring, persist through summer, and then dieback to the holdfast and sporophyll.

Dr. Carol Thornber of UC Davis has done research on *U. pinnatifida*'s biology and invasive potential in Santa Barbara harbor, and Dr. Kathy Ann Miller of the Wrigley Marine Science Center on Santa Catalina Island is studying and attempting to eradicate the population in the cove there. If you find and/or encounter this species, please contact either Dr. Thornber at csthornber@ucdavis.edu (530-754-5733) or Dr. Miller at kam@usc.edu (310-510-4012).

Washingtonia robusta (Mexican fan palm) is a member of the Arecaceae (palm family) and has been widely planted as an ornamental tree in much of Southern California for over the past 100 years. The non-native *W. robusta* is frequently planted in natural-gardening landscapes, especially on mesas above riparian areas. It is in these moist riparian areas where *W. robusta* can become problematic – displacing native plants and animal species. It spreads relatively slowly, but *W. robusta* can convert diverse riparian communities into nearly monospecific palm stands. Cindy Burrascano (CNPS) notes that infestations of *W. robusta* have taken over a few wildland riparian areas in Southern California, including: along the San Diego River, the Sweetwater River, in the Penasquitos watershed, and in small populations in the Santa Monica Mountains.

Washingtonia robusta is endemic to northwestern Mexico. Wiggins (1980) states that it is endemic to Baja California and can be found from Cataviña and Isla de la Guarda near Bahía de los Angeles in the southern half of the state of Baja California Norte. Felger et al. (2001) states that it is native to west-central Sonora and Baja California Sur. *W. robusta* is often mistaken for its congener *W. filifera*, which is native to the Sonoran Desert in southeastern California, southern Arizona and Sonora as well as to northern Baja California. However, *W. robusta* differs in having a narrower trunk flaring abruptly towards the base, old fruiting branches that stand nearly horizontal through the old leaves and petiole bases forming a regular

criss-cross pattern (Wiggins 1980). The California native *W. filifera*'s old fruiting branches and leaves droop nearly vertically and its petiole bases do **not** form a regular criss-cross pattern. For more information on *W. robusta* see Felger et al. (2001)

Recent Range Expansions of Non-Native Species Previously Reported in Other Publications as Established in California:

Hypericum canariense (Canary Island St. Johnswort) is a shrub with bright orange flowers native to the Canary Islands. It is in the Hypericaceae (formerly Clusiaceae; St. Johnswort family), and is thought to have escaped from cultivation. *H. canariense* has previously been reported in California from only San Diego (Point Loma area; Mike Kelly, pers. comm.) and Santa Barbara counties (CalFlora 2002) in disturbed coastal sage scrub and grassland communities up to 100 meters elevation in coastal areas. John Wade of the Pescadero Conservation Alliance now reports that *H. canariense* is naturalized in northern California and that it currently covers approximately 25 to 40 hectares near Gazos Creek in San Mateo County. Also invasive in Australia and Hawaii, *H. canariense* appears to exclude nearly all other vegetation (except trees that are already over 1.5 meters tall) once it becomes established.

Katrina Dlugosch is a doctoral student at UC Santa Cruz who is currently studying the biology, genetic diversity and invasion ecology of *H. canariense*. To see updates on her research and the current population status of this species in California, see: m/

Additional information on the species and photos can be found at http://tncweeds.ucdavis.edu/alert/alrthype.html

Centaurea x pratensis (meadow knapweed) is a hybrid between black and brown knapweeds (*C. nigra x C. jacea*) and has already been documented in Colusa, Del Norte, Glenn, Humboldt, Lake, Mendocino, Napa, Shasta, Siskiyou, Solano, Sonoma, Tehama, Trinity and Yolo counties (CalFlora 2002). *C. x pratensis* has large flower heads that are round and fairly large, and thick stands can develop that compete and exclude both native and other non-native grasses, and threatens wildlife habitats and pastures. Although it has not been reported as naturalized in any additional counties at this time, Patrick Griffin of Siskiyou County Agriculture and Carri Pirosko of CDFA report seeing the number of locations of this species increase in northern California. It has become especially well established along Indian Creek near Happy Camp in Siskiyou County and also near Mount Shasta.

There is a description of *C. x pratensis* in the Jepson Manual (Hickman 1993) and more information and photos can be found at http://www.agf.gov.bc.ca/cropprot/weedguid/meadowknap.htm

Cynoglossum officinale (houndstongue) is another species that is currently experiencing large increases in abundance within counties where it has already been recorded as established in northern California. Already present in Lassen, Plumas, Shasta and Siskiyou Counties (CalFlora 2002), Carri Pirosko (CDFA) reports that *C. officinale* is now spreading on private timber grounds in these counties. She has seen it in reforested areas on Sierra Pacific and Fruit Grower's properties, and she speculates that cattle and tree planting crews may be unintentionally spreading it.

Centaurea maculosa (spotted knapweed) is an already widespread weed throughout much of the western U.S. According to CalFlora (2002), *C. maculosa* is already documented in California from Alameda, Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, El Dorado, Fresno, Glenn, Humboldt, Lassen, Mendocino, Mono, Monterey, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, San Bernardino, San Diego, Shasta, Sierra, Siskiyou, Sonoma, Tehama, Trinity, Tuolumne and Yuba counties. *C. maculosa* is now established in Los Angeles County, from the Malibu area, a single site in the Angeles Forest, and from the Charmlee Natural Area in the Santa Monica Mountains (Fred Hrusa, pers. comm; Jo Kitz, pers. comm.).

For more information about and photos of *C. maculosa* see http://tncweeds.ucdavis.edu/esadocs/centmacu.html

Sesbania punicea (Chinese wisteria, rattlebox) is a deciduous shrub or small tree (up to 4 meters tall) in the Fabaceae (pea family) and is native to South America. It is often planted as an ornamental because of its attractive compound leaves, bright red flowers and persistent winged fruits, and is thought to have escaped from cultivation. *S. punicea* is already a serious pest in South Africa (Natal, Transvaal and Cape Provinces), Lesotho and Zimbabwe, and the southeastern U.S. In Florida, Texas and Georgia, it is a problem in areas and with damp soils where it forms dense thickets.

This is the first CalEPPC RedAlert! report of *S. punicea*, but it was documented as naturalized in California previously, first in small populations in Butte County in 1994 (Oswald & Ahard 1994), then along

the American River Parkway in the Sacramento area in 1997 (Meyers-Rice et al. 2000). We report here for the first time that it is now established in the Lake Oroville vicinity, along the banks of the Feather River, and in other sites in Sacramento and Placer counties including: Dry Creek, Steelhead Creek, Arcade Creek, Robla Creek and Morrison Creek watersheds, extending into the Sacramento-San Joaquin Delta (J. Dempsey, pers. comm.; P. Buck, pers. comm.).

For more information and photos of this species see http://tncweeds.ucdavis.edu/alert/alrtsesb.html

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