

Fennel Working Group Notes 2002 CalEPPC Symposium

Attendees:

Jennifer Erskine, moderator
Jean Ouellette
Jake Sigg
Ken Moore
Cameron Chabre
Carla Koop
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Sheila Daar
Dawn Lawson
Rob Klinger
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Dan Gluesenkamp
Tim Hyland

Questions posed:

- What are the germination requirements for fennel, and how long does the seedbank last?
- How do you control fennel early on to prevent heavy infestations?
- How effective are mowing and/or spraying?
- What type of removal methods work other than herbicides? What about biocontrol?
- How can fennel be treated and controlled in wetlands?
- How effective are volunteers and what is the most effective way to use volunteers in fennel removal?
- How should monitoring be incorporated into a fennel management scheme?
- What ecological problems does fennel pose where it is most invasive?
- What resources/literature are available relating to fennel management and monitoring?

Areas invaded by fennel:

- Annual grasslands and perennial grasslands
- Coastal sage scrub
- Fresh water and brackish water riparian/marsh communities
- Roadside ditches and disturbed areas

SEED BANK/LONGEVITY

- Germination is associated with disturbance.
- Annual grasses appear to suppress fennel seedlings- there appears to be a light requirement for germination.
- Propagule pressure increases seedling establishment.
- Seed bank data after 2 years in the soil are currently being collected/analyzed.
- See figure 1 and table 1 for 6 and 12 month seed bank data (Erskine, unpublished data).

Means Table for % germinated
Effect: Depth * Months in soil

	Count	Mean	Std. Dev.	Std. Err.
0, 6	3	21.333	5.033	2.906
0, 12	3	6.667	3.055	1.764
5, 6	3	35.333	14.742	8.511
5, 12	3	18.667	1.155	.667
10, 6	3	47.333	12.702	7.333
10, 12	3	54.667	20.033	11.566
20, 6	2	43.091	35.227	24.909
20, 12	3	3.905	3.385	1.954

Table 1: Means, standard deviations and standard errors for germination rates at different depths for fennel seeds. Count is the number of seed bags used. The first number in the first column indicates the depth of seed burial (0 cm, 5 cm, 10 cm, 20 cm), and the second number indicates how long the seeds were buried in months (6 and 12 months). Fifty seeds were used for each replicate, except for one 6 month 20 cm (11 seeds) and two 12 month 20 cm (35 and 8 seeds). The 20 cm data should be used with caution for those reasons.

Soil seed bank data for fennel seeds at 6 and 12 months

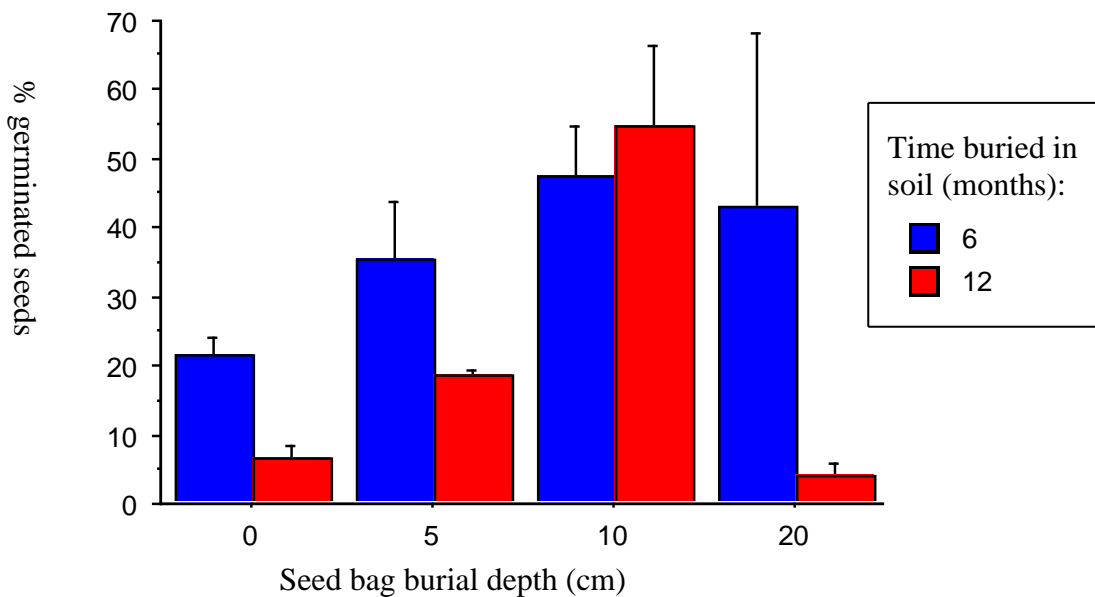


Figure 1: Percent germination of fennel seeds buried at 4 different depths (0 cm, 5 cm, 10 cm and 20 cm. (see table one for seed numbers and bag numbers). Note that the high variability in the 20 cm depth is likely due to the lack in replicates and seeds (see table 1).

HOW TO CONTROL EARLY/PREVENT HEAVY FENNEL INFESTATIONS

- If a manager notices a small infestation of fennel, start control with the outliers as the first defense. Remove plants as soon as possible and before seed production. A 2 year old plant can easily have over 100,000 seeds (Erskine, unpublished data). Within 3 years an area with a few plants can become a monoculture under the right circumstances!
- With small infestations, especially those in sensitive areas, the best bet is to remove the plants manually. If the upper portion of the crown is removed (usually not more than 6 inches (+/- 13cm) deep), the plant should not re-sprout. In these circumstances, be aware of the likelihood of seed germination (see figure 1).
- Feral pigs and birds are known to disperse fennel seeds, so expect more dispersal if plants co-occur with these animals.
- With seed sources in many coastal areas, preventing invasion is difficult unless managers look for seedlings in late winter/early spring. The key with fennel is early detection and removal.

HOW EFFECTIVE ARE MOWING, SPRAYING, AND COMBO'S OF THE 2?

- Mowing alone, unless applied often (approx 4 times/year) will not kill fennel. Even when mowing is performed every few months, some plants may still produce prostrate flowers that are difficult to remove with a mower. Cutting/mowing 4 times per year for 4 years will eventually kill the fennel plants.
- Mowing immediately followed by herbicide spray is not effective. The plants are moving materials upward to produce more leaves after mowing, therefore the herbicide will not be carried down into the crown and taproot. Also, the downed cane and plant material could intercept the herbicide.
- Mowing, followed by a period of plant resprout (to a “bushy” state), and then herbicide application is an effective way of killing fennel.
- Effective herbicides to control fennel include Round-up at the label recommended dosage and Triclopyr (Garlon 3A and 4) at 4.5-6%.
 - Triclopyr is a dicot selective herbicide, and many California native dicot species are sensitive to this herbicide. This should be accounted for when considering spraying a large area.
 - The same policy applies for Round-up, which is a non-selective herbicide and will kill most plants it contacts.
- Round up is most effective when sprayed in the spring. Triclopyr has a 50-60% kill rate if sprayed in Aug/Sept, and an 80-90% kill rate if sprayed in April/May (Klinger, unpublished data). Those plants not killed by the herbicide will still likely produce viable seeds in the fall (Erskine, unpublished data).

WHAT CAN BE DONE WITHOUT HERBICIDES/HOPES FOR BIOCONTROL?

Working group members have found the following result:

- As mentioned above, cutting, if done at least 3-4 times per year, will kill fennel plants in approximately 4 years.
- Digging plants up by removing at least the top 4-6 inches of the crown.
- Sawing/hacking the plants to the ground and scoring the crown will kill 60% of the plants.
- Cutting the plants to the ground, staking them at the center, and covering with black plastic will also kill many plants.
- Grazing will decrease aboveground biomass but seed bank will remain. At Camp Pendelton, sheep have been found to eat small fennel plants to the ground even when dry grass is present. Cattle will eat it fennel, although not preferentially. Sheep and/or goats could be used for flash grazing, but be wary of soil compaction from grazers.
- Biocontrol is not an option with fennel as it is cultivated in at least two coastal counties in California, and there are many other crops in the Apiaceae family.

FENNEL TREATMENT/CONTROL IN WETLANDS

- Herbicides mentioned above are not all registered (if any) for use in wetlands. No one in the group had looked into riparian registered herbicides before, and if anyone has more information on this issue, it would be helpful to many. Suggested possibilities included Rodeo-Aquamaster, and Roundout.
- Suggestions from the group included hand removal of plants if infestation was not too heavy.
- If management allows, cutting plants every few months (3-4) and watching for umbels would be the least disturbance to sensitive riparian areas. This management scheme would likely take 3-4 years to kill fennel plants, but would decrease the seed bank significantly.
- Cutting heavier infestations, allowing resprouting to occur, and using a wick to herbicide fennel plants would likely avoid sensitive species. Make sure the herbicide used is registered for a wetlands community. Cutting then immediately wicking would not be cost effective as most plants would survive (see herbicide/mowing section).
- The best time to cut would be late fall to remove dead biomass, and wick in spring (see above) when plants are bushy but have not begun flowering.
- Fennel has been observed in freshwater riparian areas as well as brackish riparian zones (Elk Horn Slough). It does not appear to tolerate tidal marshes.

WHAT IS THE BEST WAY TO EFFECTIVELY USE VOLUNTEERS/HOW TO USE MONITORING?

- Manpower- if you have a large/decent size group of volunteers, and a manageable size fennel infestation, have them remove the plants. That is the surest way of removing the seed source. Be aware that with such a disturbance, you will likely have a large recruitment of fennel seedlings (see figure 1).
- If you have a group of volunteers who help on a regular basis, then mowing/cutting can also be done every few months. This will help keep it in control, but watch for low growing flowers because you don't want the seedbank continuing to build up. This will also avoid the soil disturbance that could bring to the surface viable fennel seeds from the seedbank.
- With 20-50% of the seedbank viable in 6 months time, 6-50% of the seedbank viable in 12 months time (see table 1, figure 1), and plants that can easily produce over 100,000 seeds in their second year, there will be many seeds left in the soil after plant removal, and a lot of open space for germination. Monitoring of removal areas should be performed every 3-4 months, and new infestations should be dealt with as quickly as possible. It does not appear that fennel seeds have any "innate" dormancy, so exposed to the right conditions, seeds will germinate. Be wary though, in some areas where fennel has been removed, other invaders such as Mediterranean alien grasses and yellow star thistle can take over.
- As far as monitoring is concerned, important things to measure in fennel infested areas are number of plants (density), number of stems/plant, and distinguishing between fennel adults and seedlings. These parameters will give you an idea of what sort of seedbank will remain once plants are removed. The average plot size in grasslands is 1 m² (approx 3 ft by 3 ft) but in fennel infested areas, plots of at least 2-4 m² are recommended. Collecting percent cover of all other species in monitoring plots will allow managers to observe changes in species richness with the removal of fennel. It is very important to start collecting data before fennel is removed, so that correct estimates of increases and decreases in both native and exotic species can be assessed.
- This working group recommended that next year's symposium have a working group exclusively on monitoring and/or monitoring techniques.

WHAT ECOLOGICAL PROBLEMS DOES FENNEL POSE WHERE IT IS MOST INVASIVE?

- Unfortunately, this area has much conflicting data. Because fennel infests many disturbed communities, and when invading grasslands, fennel completely changes the structure of the communities, fennel can have both negative and positive consequences on native and non-native species richness and diversity.
- Fennel has been shown to decrease native plant species richness and diversity in some grassland communities.

- Other fennel infested communities have shown increases in native plant species richness and cover over time as fennel plant thinning occurs, and because the structure allows climbing native species to thrive better than they would in grasslands.
- Native bird, insect and rodent diversity increase in fennel infested grasslands compared to uninvaded **grasslands**. Fennel structure is more similar to a chaparral community, and in turn, the diversity of birds, insects and rodents is more similar to a chaparral community than a grassland community. This DOES NOT mean it is a “better” community. Grassland communities are often less bird and rodent species rich than more vertically structured communities.
- More monitoring work needs to be done in riparian communities to assess the effects of fennel on native and non-native species cover, richness and diversity.

RECOMMENDED RESOURCES:

- Beatty, S. W. and Licari, D. L. 1992. Invasion of fennel into shrub communities on Santa Cruz Island, California. – *Madrono* 39: 54-66.
- Brenton, R. K. and Klinger, R. C. 1994. Modeling the expansion and control of fennel (*Foeniculum vulgare*) on the Channel Islands . – In: Halvorson, W. L. and Maender, G. J. (eds.), *The Fourth California Islands Symposium: Update on the Status of Resources*. Santa Barbara Museum of Natural History, pp. 497-504.
- Brenton, R. K. and Klinger, R. C. 2002. Factors influencing the control of fennel (*Foeniculum vulgare* Miller) using triclopyr on Santa Cruz Island, California, USA. – *Natural Areas Journal* 22: 135-147.
- Dash, B. A. and Gliessman, S. R. 1994. Nonnative species eradication and native species enhancement: fennel on Santa Cruz Island. – In: Halvorson, W. L. and Maender, G. J. (eds.), 1994. *The Fourth California Islands Symposium: Update on the Status of Resources*. Santa Barbara Museum of Natural History, pp. 505-512.
- Elzinga, C. L., Salzer, D. W., and Willoughby, J. W. (BLM Technical Reference 1730-1). 1998. *Measuring and monitoring plant populations*. US Dept of Interior, BLM, TNC.
- Klinger, R. 2000. *Foeniculum vulgare*. – In: Bossard, C., Randall, J. and Hoshovsky, M. C. (eds). *Invasive plants of California’s wildlands*. University of California Press, pp. 198-202.