

Fire on the Mountain*: a Land Manager's Manifesto for Broom Control

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[*Not only does this song by the Grateful Dead refer to fire on the Mountain, it fittingly expounds upon the power of flames and succeeding through perseverance.]

Introduction

French broom (*Genista monspessulana* (L.) L. Johnson), a garden escape introduced from the Mediterranean region (McClintock 1979), is the most widespread of five closely-related, nitrogen-fixing, leguminous pest plants in the West (Hoshovsky 1988). In California, French broom grows in at least 23 counties, from Del Norte southward to San Diego and eastward to the Sierra foothills and San Bernardino Mountains (McClintock 1985). Prolific seed production combined with lack of predation ensures that large numbers of seeds are deposited underneath shrubs. Longevity and dormancy of seed result in accumulation of a persistent seed bank ($\approx 10,000/m^2$, Parker and Kersnar 1989) that is particularly difficult to eliminate (Odion and Haubensak, in press).

Control of such a pest plant requires an understanding of its ecology, a sound strategy derived from this understanding, and the organizational means to accomplish the work. The Marin Municipal Water District (MMWD) has developed a program that incorporates these three requirements to control broom on its 22,000 acre Mt. Tamalpais Watershed. This land provides not only drinking water, but also accessible, widely appreciated natural beauty. As the land steward, MMWD is charged with maintaining the ecological integrity of this public resource.

French broom is a threat to this integrity because the grasslands, oak woodlands, chaparral and relatively open mixed evergreen forests of the watershed are vulnerable to its invasion (Howell 1970). With invasion comes the formation of dense, almost impenetrable 2-4 m tall broom thickets that suppress shorter vegetation and reduce local plant (Table 1), as well as overall biological diversity.

Table 1. Comparison of native species diversity and plant cover other than broom in 12 old growth broom plots versus 12 in adjacent unfested grassland. Plots were 1/2 x 1/2 m.

	No broom		Broom	
	Species present	Native cover	Species present	Native cover
Mean	11.7	15.1	3.1	5.1
S.E.	0.8	5.0	0.3	1.7

A 1990 inventory shows about 500 acres of broom on the Mt. Tarnalpais watershed (Charles 1993). Broom seed in soil and mud can easily be transported by passers-by, and the distribution of broom is closely associated with roads and trails. Many roads and trails on the watershed are heavily used for recreation and maintenance activities, making it difficult to control dispersal. New broom occurrences not included in the 1990 inventory have been identified, and it is likely that spread may have accelerated with soaring recreational use of the Watershed.

Ecology of French Broom as it Relates to Control

A persistent seed bank is a common trait among many exotics that are difficult to control (Cavers and Benoit 1989). This is the chief obstacle to controlling French broom (Parker and Kersnar 1989). The seed bank can be

exhausted by germination and mortality. Neither will occur at appreciable rates without procedures to enhance them - dormancy of most seed can only be broken by heat, and dormant seed is long-lived based on information about closely related species. Scotch broom seeds remain viable for at least 80 years (Turner 1933), and many other legume seeds are known to have much greater longevity (Baker 1989). Since there is no other practicable means of treating seed to reduce the seed bank, control of broom will require fire on the Mountain.

Odion and Haubensak (in press), studied response of French broom seed banks to burning. In mixed annual/native grassland on the watershed, 1-2 in tall, 5-10 year old broom stands had 500-4300 seeds/m². Burning cut stands with the addition of slash fuel significantly increased germination, and following a second burn 1 year later, emergence was reduced to low levels. In contrast, 2-3 in tall, 15-25 year old stands had 4,300-14,000 seeds/m², with a sizable portion too deeply buried to be killed or induced to germinate using fire treatments.

Grassland soils invaded by broom also had significantly more available nitrogen than soils in uninvaded plots. After burning, broom invaded areas remained enriched. Soil nitrogen enrichment is a concern because it has been documented in many cases, going back to the work of Lawes and Gilbert in 1880 (see Vitousek et al. 1997), that this may shift dominance to nitrogen demanding plants. Thus, French broom may alter sites to be more favorable to fast growing, weedy plants, and it is uncertain how to ameliorate this.

Broom Control Strategy

The most important conclusion from this research is that as broom stands age (Fig. 1), seed accumulation at greater soil depths will cause a transition from an infestation that may be possible to control with fuel addition, repeat burning and follow up treatments, to one that will require chronic treatment indefinitely to eliminate emerging plants. Unfortunately, most broom infestations on the watershed have already undergone this transition. Therefore, we developed a two-pronged management strategy, one for dealing with a resilient land ailment and another for preventing infestations from becoming a resilient ailment.

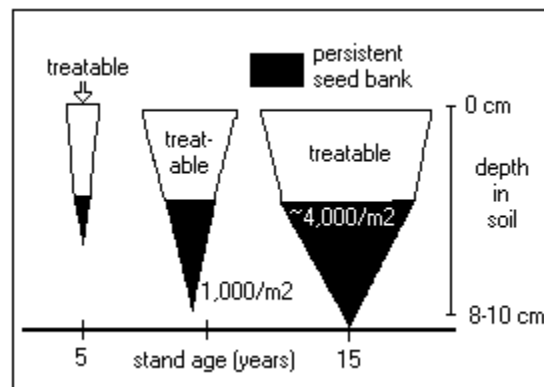


Fig. 1. Changes in French broom seed bank with time.

Fire is needed to control both young and old stands because it depletes the seed bank. It also controls resprouting if repeated every 1-4 years, so that regenerating broom does not reach reproductive age. Fire costs relatively little, provides additional ecological benefits, and does not raise toxicological concerns. MMWD has not considered methods of poisoning seed, or the soil that seedlings emerge through, because these have broad spectrum biocidal impacts that are unacceptable on Watershed lands. The same would apply in most wildland settings. Other methods of eliminating existing broom stands (Table 2) have little effect on the seed bank. Herbicides are listed among broom killing tools in Table 2 because they will be an option for many land managers. MMWD policy prohibits using these chemicals on lands draining into reservoirs, and, due to public sentiment, avoids any broadcast application on other lands it manages.

With prescribed fire, there is the risk of escape and of causing unintended mortality of non-sprouting conifers (Swezy and Agee 1991). There are also negative effects from repeat and out-of season burning in

chaparral (Zedler et al. 1983, Parker 1987). Because of these concerns, we have made chaparral infested areas a lower priority than mixed evergreen forest and grasslands, where fire as frequent as needed for broom control appears to have no unwanted side-effects.

Preventing Further Spread

Eliminating broom infestations before they become resilient will be critical to long-term control. Parameters in the model shown in Figure 1 need to be refined to predict at what point the critical transition in the seed bank occurs and to identify sites that can be restored now, but that will become inveterate infestations if treatment is delayed. The repeat bum method with initial pulling or cutting, and fuel addition will be effective for sufficiently young infestations.

Road grading, trail work, and other maintenance activities may disperse seed. Limiting or stopping use of roads and trails in infested areas during muddy conditions would be a beneficial prevention strategy, but may be impossible for MMWD and other public land managers in central and northern California because of the public's recreational demands.

Table 2. Properties of Broom Tools Used by Marin Municipal Water District

Tool	Advantages	Disadvantages	Cost (approx. retail)
hand pulling	Good for small plants in moist conditions	Limited season and size. Strains back.	labor cost only
Pulaski	Firefighting tool good for grubbing out gnarly root masses.	Disturbs soil. Not appropriate in most cases.	\$25-\$45
Root Jack™	Efficient hand puller. Light weight and portable.	Can't attach to really large stems Wooden handle breaks on tough plants.	\$90
Weed Wrench™	Heavy duty, powerful hand puller. Variety of sizes.	Larger sizes are heavy to carry. Doesn't attach to stems as easily as Root Jack but holds tighter.	\$50-\$150
Brushcutter (weed whip)	Good for cutting shrubs close to the ground. Useful for small stems and seedlings.	Difficult to use on steep ground. Cuts slower than a chain saw. Dangerous, need safety gear.	commercial grade \$500-\$600
chain saw	Good for cutting on steeper slopes and for larger stems. Cuts quickly.	Not good for smaller stems. Back strain to cut low. Dangerous, need safety gear.	\$250-\$500
propane torch w/flame spreader	Non-toxic technique for roadside seedlings.	Fire hazard, limited to wet season. Not very portable off of road.	\$150
flail mower tractor-mounted	Very productive for mowing roadside plants.	Sprouts require retreatment at 2-year interval. Can't go off of roads.	\$50,000
brush cutter excavator-mounted	Can travel off of roads. Low ground pressure. Excellent pre-treatment for prescribed burning.	Limited to slopes less than 35% slope. Can't maneuver between trees. Must treat stump sprouts.	\$100-\$150,000
prescribed fire	Only method that reduces seed bank. Can benefit natives.	May require pre-treatment. Escapes are a possibility. Not appropriate in all locations.	\$50-\$400/acre
Herbicide	Efficient, easy. See DiTomaso*	Toxicology concerns. See DiTomaso*	variable
bio-control	Benign	Not effective for broom.	research is expensive

*Proceedings. 1997. California Exotic Pest Plant Council Symposium, Vol. III.

Contaminated soil may be inadvertently distributed by other activities. Broom seeds float, and therefore may settle out and accumulate in reservoirs (Hoshovsky 1988). This seed may be redistributed in dredging spoils if they are not carefully handled and disposed of. Similarly, debris flow and landslide deposits removed from roads may be contaminated, as evidenced by the broom that commonly emerges from them when stockpiled.

Successfully controlling the spread of broom and elimination of young stands will require development of an enduring institution to organize and deliver treatments indefinitely. Such an institution is also integral to the strategy for dealing with old stands.

Attacking Inveterate Stands

The need for long-term organization and planning to deal with an inveterate land ailment has been illustrated by MMWD's experience. In the 1980s, some areas were burned once or twice, and then burning for broom control was largely discontinued until recently due to public controversy regarding fire effects. Infestations at these early burn areas became worse as a result of discontinuing burning treatment. Where burning has continued since the 1980s on the perimeter of one reservoir, broom cover has been for the most part controlled, but burning every 2-4 years has been required, and significant emergence continues. Thus, it is critical for the land manager to *develop a burn rotation schedule that can be followed indefinitely, and that will optimize acreage that can be treated without compromising effectiveness*. Areas should be burned frequently enough to prevent any flowering/seed production. Under prescribed burn conditions, broom may not burn unless mixed with more combustible fuels, so sites will have to be pre-treated accordingly. Cutting or pulling broom and allowing it to cure is the strategy employed by MMWD. Arranging the various labor sources to perform this work so that it meshes with the burn schedule complicates planning.

Once the burn rotation schedule has been developed, it will be possible to determine whether treatment of new areas can be achieved. The most important infestations to treat should be prioritized based on the principles described in the following section.

Using Fire Management Principles to Establish Priorities

Professional fire management organizations have developed effective strategies for reducing the negative impacts of wildfires. These strategies are relevant to managing French broom invasion in wildlands (Dewey 1995). We adapted the following principles from fire management strategies:

1. Attack newly discovered populations swiftly and aggressively. In fire management, the shorter the period between discovery and initial attack, the smaller the final fire size.
2. Focus efforts on stopping the spread of invasives before expending resources attacking well-entrenched stands.
3. Protect the most vulnerable plant communities such as woodlands and grasslands.
4. Protect high value areas: scenic areas, areas of heavy public use, and areas with high habitat value.
5. When resources are scarce, let some areas go until techniques are refined or more resources are available. This course is realistic and psychologically healthy.
6. Take on only what you are committed to manage for the long-term or risk failure and despair.
7. Follow-up treatments must be thorough and persistent. Mopping-up after wildfires are controlled is tedious but absolutely necessary. Without it, fires can rekindle and suppression activities must begin again.

The Broom-Killing Organization

At MMWD, creation of the organizational means to control broom began with the development of the Mt. Tamalpais Area Vegetation Management Plan in 1994. This plan has the dual aims of reducing fire hazard and protecting biodiversity. Land managers throughout California are faced with these concerns, which can effectively be addressed with comprehensive planning. For example, much of MMWD's fire hazard reduction consists of establishing a system of fuel breaks (vegetation is thinned along roads to create defensible space). These treatments have been designed to achieve fuel reduction and broom control in the same locations. Because follow-up treatment will occur regularly, broom "control" should be achieved in fuel break areas.

Guidelines for a Broom-Killing Organization

Implementation of the plan began in earnest in 1995 with the hiring of a professional resource management staff. The operational premise adopted by this staff was that *the major challenge for broom control is an organizational one*. Long-term control must rely on extensive landscape applications repeated indefinitely, requiring an enduring organization to deliver them. But, with budgetary and other constraints, how does a land manager sustain a long-term effort over a large area? MMWD established these guidelines to direct the development of its broom killing organization.

- 1. Create a thinking bureaucracy.** By incorporating monitoring and research into broom control activities, effectiveness can be measured and strategies and techniques can be refined.
- 2. Create organizational commitment.** Communicating the perils of broom and realities of control to decision-makers of land agencies can achieve this. Early in the implementation of MMWD's plan, presentations were made to the elected Board of Directors emphasizing the need for sustained institutional support. Regular updates are provided to keep the issue at the forefront.
- 3. Create organizational structure.** At MMWD, the supervisors of work crews involved in vegetation management were trained in MMWD's broom-control techniques. Various low-cost labor sources have been employed in broom removal projects under the direction of these supervisors. Also, projects will be incorporated into MMWD's "maintenance work-order system," a computer database that schedules tasks and tracks accomplishments for work sites. This final step will provide the structure for managing broom project sites over the long-term.
- 4. Build partnership with the community.** Participation of MMWD in broom control with the local community has many benefits. Informed citizens will be more likely to support restoration. Participation gives the public a stake in management based on real contributions on the ground. Finally, a volunteer work force can provide a significant amount of labor.

To help build partnerships with the community in Marin, the public needed to be informed of the vegetation management plan and the broom strategy. Presentations were made to interested community groups. A monthly tour of the watershed was instituted for elected local officials, local agency staff, environmental groups, watershed user groups, and other interested citizens.

Many agencies/landowners have already established formal volunteer programs. The development of a MMWD's formal volunteer program in 1996 opened the door to a variety of community volunteers and school groups. A once-a-month habitat restoration program was initiated. A one-day school broom pulling event for 250 elementary school students at Bon Tempe Lake has become a regular annual field trip for local elementary schools. Church groups, middle and high school service projects, university interns and interested individuals have participated in some aspect of broom control on the watershed.

- 5. Create mythology to sustain participants.** The restoration of broom-infested areas is truly heroic in terms of the resources at risk and the geographic and temporal scales under which control may be achieved. By blending humor with inspirational messages via such media as public presentations, news releases, brochures and newsletters, a mythology can be developed that gives weed warriors greater understanding of the purpose of their work. This understanding can sustain spirits in the face of the mundane task of pulling broom.
MMWD staff created the "Broom Free Press," a newsletter, to acquaint volunteers with the basics of broom ecology. Buttons with the slogan "Broom Free by 2003" surrounding MMWD's Mt. Tarnalpais logo were distributed to volunteers. A banner headlined article in the local newspaper urged volunteers to help control broom (Moses 1996). It quoted staff -- "an ecological disaster is brewing in the hills of Marin County." Finally, a watershed ranger wrote a poem that inspires volunteers.
- 6. Encourage diversity in all aspects of the organization.** We believe that diversity adds stability to an organization. We have used a variety of labor sources, tools and techniques (Table 2), and strategies in order to increase learning and to weather failures. For instance, MMWD has employed staff, Marin Conservation Corps, California Conservation Corps, Marin and Sonoma County Probation Departments, community service workers, County jail inmates, and San Quentin Boot Camp inmates. Inmate and

probation workers provided approximately \$320,000 of unpaid labor in a two year period. When the Boot Camp program was closed we suffered a loss in production, but broom control continued unabated.

Conclusions and Recommendations

The efforts described above provide the foundation for a long-term broom control program. The ultimate test is whether or not we can sustain labor requirements indefinitely. Developing a more vibrant volunteer program is a high priority. A promising community link is working with school groups to include exotic species control in environmental education curricula accompanied by field trips.

A large portion of the broom control effort will require large work crews, equipment, and prescribed fire, which will remain independent of school children and volunteers. Funding such efforts from rate payer revenues may be increasingly difficult in the future. The Golden Gate National Parks Association has proven to be a successful model for using private donations to fund a sophisticated volunteer auxiliary force for Golden Gate National Recreation Area's (GGNRA) resource management efforts. GGNRA's volunteer program also satisfies the park's goals of communitybased restoration (Halloran 1996). In order to allow private contributions for the management and protection of natural resources of the Mt. Tamalpais Watershed, MMWD formed the Mt. Tamalpais Watershed Fund in 1996.

Prison crews are another important source of labor. MMWD was a fortunate beneficiary of the San Quentin Boot Camp's work force. This pilot military-style, alternative sentencing program ended in 1997 when it failed to gain funding for implementation of a permanent program. Using service on public lands as an object lesson in a boot camp style inmate rehabilitation program was unique and effective. This approach needs to be developed widely.

Another uncharted frontier involves developing cooperative efforts among public land managers in controlling broom spread. By developing a regional strategy and sharing resources, agencies may realize efficiencies. Also, a regional strategy may more effectively attack areas with rapid spread and protect sensitive habitats.

MMWD efforts on the Mt. Tamalpais watershed have demonstrated that small victories can be achieved in controlling a particularly difficult pest plant invasion if work resources are allocated strategically and in a way that reflects ecological understanding. The real test will be maintaining efforts on public lands with increasingly scarce public money. Without stable long-term funding all current efforts may be futile and large areas of the watershed may be put at risk for an ecological disaster.

References

- Baker, H. G. 1989. Some aspects of the natural history of seed banks. *in* Leck, M.A., V. T. Parker, and R.L. Simpson eds. Ecology of Soil Seed Banks. San Diego: Academic Press; 9-21.
- Cavers, P. B. and D. L. Benoit. 1989. Seed banks in arable land. Pages 309-328. M. A. Leck, V. T. Parker, and R. L. Simpson (eds.) Ecology of Soil Seed Banks. Academic Press, San Diego, Ca., USA.
- Charles, L. and Associates. 1993. Mt. Tamalpais area vegetation management plan. Prepared under contract for Marin Municipal Water District, Marin County, California. 326 pages. Appendices.
- Dewey, S.A. 1995. A biological wildfire: applying fundamentals of wildfire management to improve noxious weed control. Publication AG 500. Utah State University Extension, Logan, UT 84322.
- Fuller, T. C. and G.D. Barbe. 1985. The Bradley method of eliminating exotic plants from natural reserves. *Fremontia* 13(2):2425.
- Halloran, P. 1996. The greening of the Golden Gate: community-based restoration at the Presidio of San Francisco. *Restoration and Management Notes*. Vol 14: 2 (112-123).
- Hoshovsky, M. 1988. Broom abstract. The Nature Conservancy, San Francisco, Ca.
- Howell, J.T. 1970. *Marin Flora*- 2nd edition. University of California Press, Berkeley, CA. 366 pp.
- McClintock, E. 1979. The weedy brooms - where did they come from? *Fremontia* 6(4):15-17.
- McClintock, E. 1985. Status reports on invasive weeds: brooms. *Fremontia* 12(4):17-18.
- Moses, J.R. 1996 Broom Busters take on pesky shrub: volunteers urged to help. *Marin Independent Journal*. April 29, 1996. San Rafael, CA.
- Odion, D. C., and K. A. Haubensak. In Press. Response of French broom to fire. *in* Fire in California Ecosystems: Integrating Ecology, Prevention, and Management. International Association of Wildland Fire, Fairfield, Wa., USA.
- Parker, V. T. 1987. Effects of wet-season management burns on chaparral vegetation: implications for rare species. Pages 233-237 in T.S. Elias and J. Nelson editors. Conservation and management of rare and endangered plants. California Native Plant Society, Sacramento, California.
- Parker, V. T. and R. Kersnar. 1989. Regeneration potential in French broom, *Cytisus nionspessulanus*, and its possible management. A report to the Land Management Division of the Marin Municipal Water District. 17 pages.

- Swezy, D. M., and J. K. Agee. 1991. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. *Canadian Journal of Forest Research* 21: 626-634.
- Turner, J.H. 1933. The viability of seeds. *Kew Bull.* 1933(6):257-269.
- Vitousek, P.M., J. D. Aber, R. W. Howarth, G. E. Likens, P. A. Matson, D. W. Schindler, W. H. Schlesinger, and D. G. Tilman. 1997. Human alteration of the global nitrogen cycle: sources and consequences. *Ecological Applications* 7: 737-750.
- Zedler, P. H., C. R. Gautier, and G. S. McMaster. 1983. Vegetation change in response to extreme events: the effect of a short interval between fires in California chaparral and coastal scrub. *Ecology* 64:809-818.