



National Park Service San Francisco Bay Area Network Fire Ecology Annual Report Calendar Year 2022

Golden Gate National Recreation Area
Pinnacles National Park
Point Reyes National Seashore



Clockwise from upper left: GEMO plot with *Elymus glaucus* in Olema Valley, *Sambucus racemosa* two years after the Woodward Fire, bush lupine after the same fire (all three photos at PORE); and *Hordeum branchyantherum* in Dersch Meadows one year after the Dixie Fire at LAVO.

Wende Rehlaender, Lead Fire Effects Monitor

The National Park Service (NPS) Division of Fire and Aviation Management relies on science and long-term monitoring to inform an adaptive management approach for assessing and improving fire management programs and activities at park units. Adaptive management, along with policies, standards, and responsibilities for monitoring are described in Chapter 8 of [Reference Manual 18](#). The NPS Fire Ecology Program is responsible for the collection, analysis, and interpretation of fire effects monitoring data for park managers to use for program evaluation and decision making. This annual report is intended to partially fulfill reporting requirements for the Fire Ecology Program and does not constitute a complete analysis of any NPS fire management program or activity. Additional interpretation and reporting can be found in previous annual reports at [NPS DataStore](#) or by contacting the author(s) of this report.

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A. The Year in Review

This was another varied year, and again for the most part, the program of work looks very different from that of the typical lead monitor. Differences stem from how my network's parks are managed. For the first time since 2019 I read fire effects plots in one of my network parks; I also supported Mediterranean (MEDN) and Klamath (KLMN) networks with plot work. The big project of the year was producing a draft READ guide for Point Reyes National Seashore (PORE).

Plot Work and FFI

To start the field season, I traveled to Channel Islands National Park for a tour, to read long-term monitoring vegetation plots. Although these were not fire monitoring plots, the trip gave me good opportunities to brush up on my coastal California plant species and to engage in learning and teaching with park staff.

At Point Reyes National Seashore, I read the thirteen French broom (GEMO) plots located in two burn units in Olema Valley, in preparation for planned burns. I entered and checked the data in FFI.

Continuing our long-time support of the KLMN network, I traveled to Lassen Volcanic National Park (LAVO) to read plots one year after the massive Dixie Fire. Before the trip, the regional fire ecologist requested that I install some new plots in Dersch Meadows, a pine-invaded meadow that we have been working in. I designed methods, collaborated with the fire ecologist to refine the details onsite, and we installed the plots.

After the LAVO trip, I determined how the non-standard data would be entered into the established FFI protocols, and I entered and checked the data. I made a plot map and wrote up the methods and a data summary. Also, I tracked down some data entry errors in the LAVO database.

Keyed unknown plants.

READ Guide for Point Reyes

My year's major project was completing a new draft resource advisor (READ) guide for Point Reyes. The original was written in 2007, but it needed to be updated. I accomplished an extensive overhaul of the 2007 draft, making changes and additions to the organization, text, and maps.

I also created a set of five overlapping maps that showed the sensitive natural resources at PORE. I chose a scale that was large enough scale to see but led to a minimal number of maps. These will be the starting point for an incident, with the goal to create a set of finer resolution map tiles that each cover a small area.

Support for Fire Management

Our Fire Management staff is small, with just two others besides myself, so we try to help each other when possible. The two main ways in which I supported Fire Management were that I fulfilled all of our GIS needs and I photo-monitored our fuels reduction projects. I improved the Annual Operating Plan maps I'd made earlier, produced maps as requested for fuels projects and prescribed burns, and did other miscellaneous GIS tasks.

I was asked to monitor results of mechanical fuel reduction projects, and determined that photo monitoring was the best choice for the small linear projects. I established photopoints at five sites at Golden Gate National Recreation Area (GOGA) and four at PORE, and took “before” and “after” photos

Assisted with planning for prescribed burns, participating in site visits to determine line placement, providing information on past burns, and data for a smoke permit, and accessing data from a RAWS.

Also learned how to use Treatment Inspector, and uploaded the network polygons into it.

Reports

Wrote two reports presenting graphical examinations of FMH data. One was for Lassen (included in the KLMN annual report), looking at changes in a pine-invaded meadow over 20+ years. The other looked at changes also over 20+ years, in French broom plots at PORE that had been burned up to seven times, and had not burned for the last eight years.

Wrote the annual report.

Miscellaneous

Woodward Fire (2020) photopoints: I visited my seven dozen wildfire photopoints, and retook and labeled the photos.

Damage assessment: Continued work on the large encroachment at PORE: made three site visits, participated in Teams meetings, worked on HEA inputs, and retook some photopoint photos.

Virtual meetings and trainings:

- Fire effects/ecology meeting, half-day in November.
- Local READ cohort and also forest health meetings.
- Explained the FMH program and FFI to an I&M staff person.
- ArcGIS Pro training.
- Fire refresher and pack test.

Table 1. Fire Effects Plot Workload (2022)

Park	Monitoring Unit	Plot Type	Years Data Collected (oldest - most recent)	2022 Total	Total Plots
Point Reyes	French broom	FMH Brush	1995 - 2022	13	13
Total				13	13

B. Monitoring Results and Recommendations

Burning has not occurred in the SFAN for a number of years, but, as mentioned above, I looked at data from French broom (*Genista monspessulana*) plots at PORE, and wrote a report. The

data show that in the absence of fire, the cover of coyotebrush and blackberry (which are both native species) has increased sharply. This report is included here as an appendix. Table 2 ("Management Objectives and Monitoring Results") is omitted.

C. Research, Planning, and Communication

No monitoring plans exist for any of the SFAN network parks. No publications were produced.

D. Future Direction

In 2023, the plan is to finalize the PORE READ guide. After that, it's possible that I'll work on READ guides for GOGA or PINN. I will continue to photo-monitor the fuels management projects and the Woodward Fire. I plan to travel north to assist the KLMN with plot work. Will continue training in ArcGIS Pro, in order to become proficient in what is the current program for GIS.

E. References, Links, and Additional Reading

See Appendix D below for a couple of additional documents.

Appendices

Appendix A. Staffing and Accomplishments

Table A-1. Fire Ecology Staffing 2022

Lead Monitor	Starting Date	Ending Date	# Pay Periods	READ Qualified	Training and Development
Wende Rehlaender	2-28-22	12-9-22	20	Yes	RT-130, retirement, WDFSS, GIS, misc required trngs

There is no fire ecologist, so Table A-2 (Fire Ecologist Accomplishments) was omitted.

Table A-3. Fire Effects Lead Monitor 2022 Accomplishments/Focus Areas

Category	% Time	Notes
Data collection	15	Estimated amount of time spent collecting plot data; includes any preparation time and travel time to local plot locations
Wildfire assignments	0	
Prescribed fire planning	1	Walked sites in field, gathered info on past burns, including weather data, etc. (burns ended up not happening).
Travel out-of-park for plot or project work	3	Include <u>travel time only</u> for distant, multi-day work requiring a travel authorization (Note: data collection or project time associated with these trips is included in the plot or project categories above)
Data entry and management	8	Estimated amount of time spent entering data from paper to FFI database, managing data in FFI, preparing or archiving data, and/or conducting quality control activities
Data analysis and wrote two reports; annual report	10	Graphical analysis to look at data from GEMO plots at PORE and PICO plots in Dersch Meadows at LAVO. Wrote a report (with literature) on each. Wrote annual report.
Administrative activities	4	.
Training	2	Listed in Table A-1 above
Prepared READ guide draft	20	READ guide draft for PORE.
GIS support for Fire Management	5	Produced maps, buffer project areas, calculate project acreages, locate fires, maps of fuels projects etc.
Fuels project monitoring	5	Monitored mechanical fuels reduction sites using photopoints, managed the GPS/GIS data, labeled the photos.
Treatment Inspector	1	Was asked to learn how to use program and to enter data for the network parks.
Non-fuels photopoints	6	Re-took photos at Woodward Fire photopoints; labeled the photos.
Meetings	2	
Damage assessment	1	Some continued work on an encroachment, from previous year.
Planning	2	
Miscellaneous	15	PT, and all other things that didn't fit in other categories

Appendix B. History of Fire Effects Monitoring Plots

Table B-1. All Fire Effects Plots Established, SF Bay Area Network

Park	Monitoring Unit	Plot Type	Years Data Collected	Total Plots
Golden Gate NRA	Native Perennial <i>Nassella pulchra</i> Grassland	FMH Brush	1990 - 2009	25
Golden Gate NRA	Non-native Annual <i>Bromus diandrus</i> Grassland	FMH Brush	1990 - 2008	28
Golden Gate NRA	Non-native Annual <i>Brachypodium distachyon</i> Grassland	FMH Brush	1990 - 2003	8
Golden Gate NRA	Non-native Perennial <i>Festuca arundinacea</i> Grassland	FMH Brush	1990 - 2009	7
Golden Gate NRA	Non-native Perennial <i>Phalaris aquatica</i> Grassland	FMH Brush	1990 - 2008	8
Golden Gate NRA	Non-native Thistle (<i>Carduus pycnocephala</i>)	FMH Brush	1990 - 2008	5
Golden Gate NRA	Sagebrush (<i>Artemisia californica</i>) Scrub	FMH Brush	1990	1
Golden Gate NRA	Manzanita (<i>Arctostaphylos glandulosa</i>) Scrub	FMH Brush	1990 - 2000	6
Golden Gate NRA	Coyotebrush (<i>Baccharis pilularis</i>) Scrub	FMH Brush	1990 - 2009	18
Golden Gate NRA	French Broom (<i>Genista monspessulana</i>)	15m FMH Brush	2012 - 2014	5
Golden Gate NRA	Eucalyptus Forest	FMH Forest	1995 - 2005	1
Golden Gate NRA	Redwood Forest	FMH Forest	1990 - 2008	9
Golden Gate NRA	California Bay Woodland	FMH Forest	1990 - 1999	4
Golden Gate NRA	Mission Blue Butterfly	Modified FMH	2009 - 2013	8
Golden Gate National Recreation Area			Park Total	133
Pinnacles NP	Chamise Chaparral	FMH Brush	1989 - 2007	26
Pinnacles NP	Mixed Chaparral	FMH Brush	1989 - 2008	29

Pinnacles NP	Blue Oak Woodland	FMH Brush	1989 - 2008	16
Pinnacles NP	Yellow Starthistle	FMH Brush	1999 - 2013	3
Pinnacles NP	Yellow Starthistle	Point-frame	2009 - 2011	2
Pinnacles National Park			Park Total	76
Point Reyes NS	Native Perennial <i>Deschampsia cespitosa</i> Grassland	FMH Brush	2007 - 2018	7
Point Reyes NS	Non-native Annual Grassland	FMH Brush	1990 - 2017	36
Point Reyes NS	Non-native Perennial <i>Phalaris aquatica</i> Grassland	FMH Brush	2004 - 2010	7
Point Reyes NS	Coyotebrush (<i>Baccharis pilularis</i>) Scrub	FMH Brush	1990 - 2009	12
Point Reyes NS	Scotch Broom (<i>Cytisus scoparius</i>)	FMH Brush	1991 - 2015	15
Point Reyes NS	Scotch Broom (<i>Cytisus scoparius</i>)	15m FMH Brush	2010 - 2015	16
Point Reyes NS	French Broom (<i>Genista monspessulana</i>)	FMH Brush	1995 - 2022	13
Point Reyes NS	Bishop Pine	FMH Brush	2007 - 2010	6
Point Reyes NS	Bishop Pine	FMH Forest	1990 - 2014	3
Point Reyes NS	Bishop Pine PPC	Rapid Assessment	2011 - 2021	23
Point Reyes NS	Douglas Fir	FMH Forest	1999	1
Point Reyes NS	Eucalyptus Thinning	Rapid Assessment	2005 - 2010	5
Point Reyes NS	Tanoak SOD	Rapid Assessment	2007 - 2011	29
Point Reyes NS	Fuels	Rapid Assessment	2011 - 2016	5
Point Reyes National Seashore			Park Total	178
Network Total				255

Table B-2. All Fire Effects Plots Established, Mediterranean Network

In the pre-network days (during the twentieth century), the fire effects crew was the Central and Southern California team, and serviced what are now the MEDN parks. Because the MEDN no longer has any fire ecology/effects staff, the network's fire effects plots are listed here. Some of these plots have been read in recent years.

Park	Monitoring Unit	Plot Type	Years Data Collected	Total Plots
Channel Islands NP	Native Perennial <i>Nassella pulchra</i> Grassland	FMH Brush	1997 - 2017	19
Channel Islands NP	Sagebrush (<i>Artemisia californica</i>) Scrub	FMH Brush	1997 - 2017	21
Channel Islands NP	Manzanita (<i>Arctostaphylos viridissima</i>)	FMH Brush	2004 - 2010	4
Channel Islands NP	Fennel (both pure and mixed stands)	FMH Brush	2004 - 2010	9
Channel Islands NP	Mixed Coastal Sage Scrub	FMH Brush	2004 - 2010	6
Channel Islands NP	Island Scrub Oak (<i>Quercus pacifica</i>)	FMH Brush	2004 - 2010	6
Channel Islands NP	Coastal Sage Scrub Regeneration	Modified Keeley	2007 - 2009	6
Channel Islands NP	Fennel Regeneration	Belt and estimates	2007 - 2009	2
Channel Islands National Park			Park Total	73
Joshua Tree NP	Blackbrush Scrub	FMH Brush	1992 - 2021	12
Joshua Tree National Park			Park Total	12
Santa Monica Mountains NRA	Annual Grass (ANGR)	FMH Brush	2005 - 2013	24
Santa Monica Mountains NRA	Non-native Annual <i>Avena fatua</i> Grassland	FMH Brush	1991 - 2008	11
Santa Monica Mountains NRA	Non-native Annual <i>Bromus diandrus</i> Grassland	FMH Brush	1990 - 2008	10
Santa Monica Mountains NRA	Non-native Annual Grassland/Black Mustard	FMH Brush	1991 - 2008	1
Santa Monica Mountains NRA	Native Perennial <i>Nassella pulchra</i> Grassland	FMH Brush	1995 - 2006	8

Santa Monica Mountains NRA	Sagebrush (<i>Artemisia californica</i>) Scrub	FMH Brush	1990 - 2019	12
Santa Monica Mountains NRA	Chamise Chaparral (<i>Adenostoma fasciculatum</i>)	FMH Brush	1990 - 2019	18
Santa Monica Mountains NRA	Ceanothus Chaparral (<i>Ceanothus megacarpus</i>)	FMH Brush	1990 - 2019	10
Santa Monica Mountains NRA	Ceanothus Chaparral (<i>Ceanothus spinosus</i>)	FMH Brush	1990 - 2019	5
Santa Monica Mountains NRA	Miscellaneous Chaparral	FMH Brush	1990 - 2019	3
Santa Monica Mountains NRA	Coast Live Oak	FMH Forest	1990 - 2005	12
Santa Monica Mountains National Recreation Area			Park Total	114
Network Total				199

Appendix C. Fuels Treatments and Associated Monitoring

Table C-1 shows the photo monitoring that was done of mechanical fuels reduction treatments in the SFAN. This is not an exhaustive list of all the fuels work done in network parks, but only the ones that were photo-monitored. Some fuels work was done after I went on furlough; photos of that work will be taken in 2023.

Table C-1. Summary of 2022 Fuels Treatments and Associated Photo Monitoring

Park	Mechanical Reduction Site	Photos taken	Acres
Golden Gate NRA	Banducci, near Muir Beach	Pre	11.4
Golden Gate NRA	Bourne Trail, Bolinas Ridge	Pre and Post	0.6
Golden Gate NRA	Diaz Ridge, near Mill Valley	Pre	3.8
Golden Gate NRA	Stinson Beach Highlands	Pre	4.7
Golden Gate NRA	Waterview Dr, near Mill Valley	Pre	4.3
Point Reyes NS	Mesa Road eucalyptus	Pre and Post	0.2
Point Reyes NS	Olema Valley Residence	Pre and Post	2.2
Point Reyes NS	Sacramento Landing	Pre and Post	2.7
Point Reyes NS	Teixeira large residence	Post	0.7
			30.6

Appendix D. Report and Methods

Appendix D comprises two documents: First, a report written about the data from the French broom plots at PORE. Second, the methods created for the PIIM (Pine Invading Into Meadow) plots at LAVO, with a summary of the 2022 PIIM data.

French Broom and Other Species in Two Olema Valley Burn Units

Point Reyes National Seashore, 2022

Strain Hill and McCurdy are two burn units in Olema Valley, and are part of the Northern Lands of Golden Gate National Recreation Area. Both units were included in the historic McCurdy Ranch, established in the late 1800's, and were used to graze cattle. By the late 1990's, these areas had not been grazed in many years, and French broom (*Genista monspessulana*) had proliferated. To control the broom, prescribed burning was initiated, as well as mowing. The first burn took place in 1996 at McCurdy and 1997 at Strain. To date, parts of the units have burned as many as seven times, but the burn units were configured differently in different years. The most recent burn at Strain Hill was in 2014 (eight years ago), and at McCurdy in 2015 (seven years ago). (A small area of Strain was burned in 2019, but was fairly insignificant.) And the small segment of McCurdy has not burned in 20 years. The units have also been mowed several times (not recently), although good records of all mowing are not available.

Fig. 1: Map of southern half of Olema Valley, showing locations of Strain, McCurdy, and also Dogtown burn units. Imagery is from 2016.



Burns are planned for the fall of 2022, however the prescribed burning program has been hampered in recent years by myriad constraints (not the least of which was a large park fire in 2020). The lack of vegetation treatments impacts the plant species composition, so at this point it's worth taking a look at some data from the fire effects plots in the two units.

The main objectives of the burns at Strain Hill and McCurdy have been control of French broom, and also hazard fuel reduction. From a resource management standpoint, there are several species and groups of species that are of concern. The exotic species are an issue because they have the potential to displace natives, and the natives are a concern because we hope to retain them. These are the species:

- French broom, a non-native invasive species.
- Coyote brush (*Baccharis pilularis*) is native, but is an aggressive colonizer. A shift to more coyote brush increases the fuel loading.
- Native blackberry (*Rubus ursinus*) also tends to take over and to exclude other species. Often found in the understory of coyotebrush
- Non-native perennial grasses: Several species are found in the units, including purple velvet grass (*Holcus lanatus*), Harding grass (*Phalaris aquatica*), Chilean rice grass (*Piptochaetium* spp.), and *Agrostis* and *Festuca* spp. (there are also native species of the last two genera).
- Native perennial grasses and native sedges. Except for the peninsula and Olema Valley, the park does not have a lot of grasslands, so we'd like to see the ones in Olema Valley thrive. Found in the burn units are nice patches of *Elymus glaucus*, *Nassella pulchra*, *Danthonia californica*, and *Festuca rubra*.
- Non-native annual grasses and forbs

The data discussed below were collected from the fire effects (FMH) plots in the burn units. Plots were located randomly, but had to be in areas with at least 50% cover of French broom (by visual estimate) when established. There are eight plots at Strain Hill and five at McCurdy. The most recent read was in spring 2022.

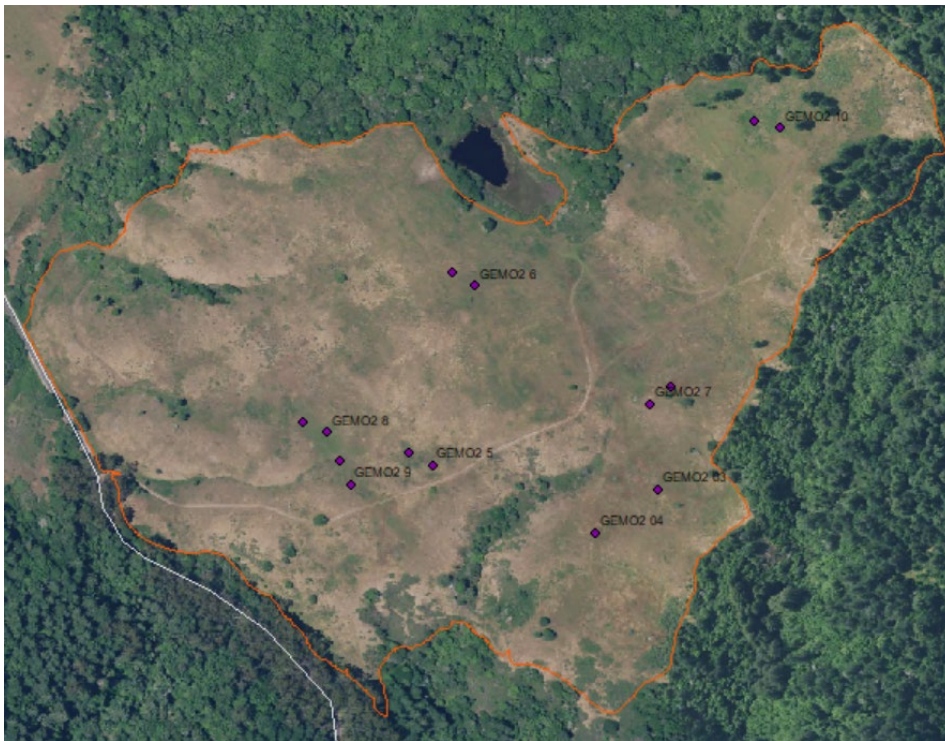
Unfortunately, the plots were not all burned on the same tidy schedule. The first four plots, two at each site, (one was later rejected) were established in spring, 1996 or 1997. In 2005, ten more broom plots were installed; these started with a status of "03 yr 03" which means the third year after the third burn. Since different segments were burned in different years, the result is that the plots have to be placed into groups in order to track change over time with uniform treatments among plots.

Broom and coyote brush over time

Casual observation onsite suggests that broom and coyote brush have become more abundant. This is also seen in aerial images of the units. In the pairs of photos below, the 2022 image was taken in March (it is unknown when the 2016 one was taken), which is just after the rainy season, and might be a reason that the 2022 images are more green. However, close inspection suggests that the dark green color within the units is either broom or coyote brush. If cover of these two shrub species is expanding, this would be an indication that the fuels on the plots could be shifting from grass mixed with shrubs to a shrub-dominated system. The purple dots in the photos are the two ends of the fire effects plots (which are line transects).

Fig. 2: Strain Hill in air photos from 2016 and 2022

Strain Hill, 2016



Strain Hill, 2022



Fig. 3: McCurdy air photos from 2016 and 2022

McCurdy, 2016

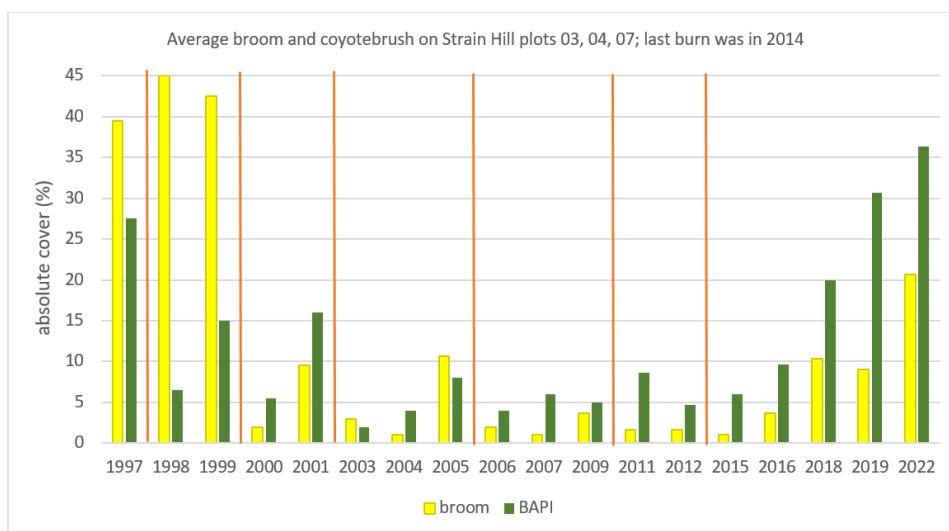


McCurdy, 2022

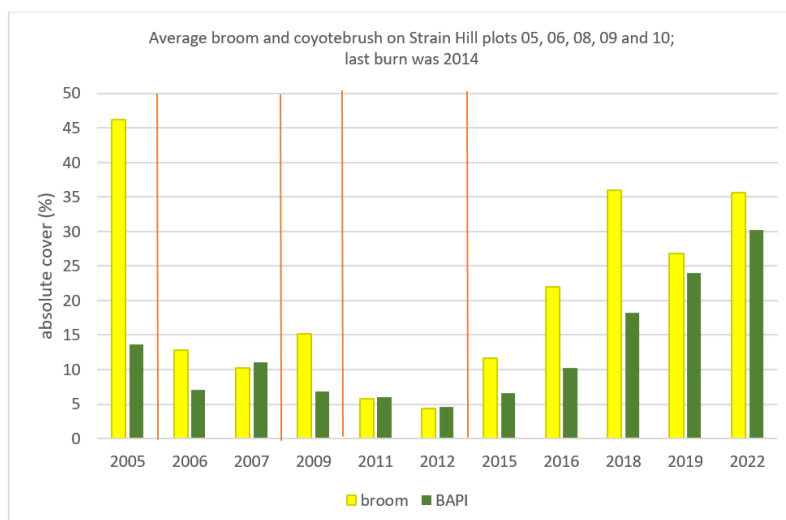


Figures 3a-3c below show the variability in cover of broom and coyote brush (BAP) and also burn schedules among the plots. The first two graphs are averages of two groups of Strain Hill plots, and the third one is of three of the five McCurdy plots. Plot numbers 12 and 14 had unique burn and read schedules, and were omitted. Orange vertical lines symbolize the burns.

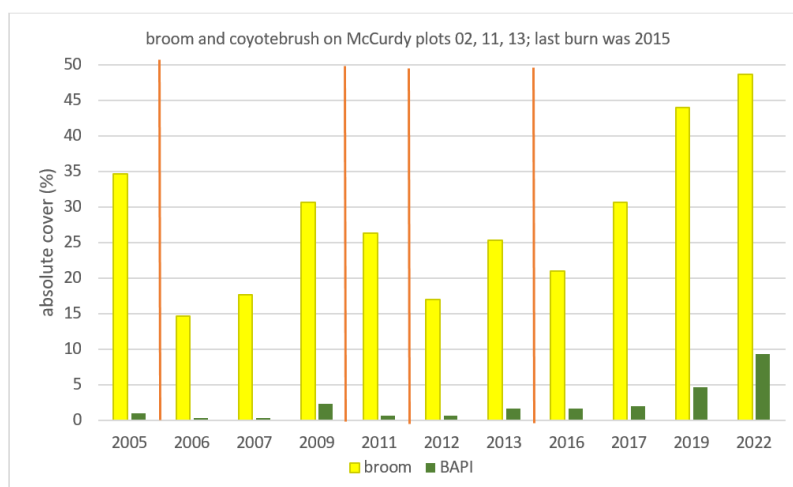
3a



3b



3c



Despite the variability in broom and BAPI cover among the plots, and also between the two sites (with the plots at McCurdy having a lot less coyote brush than Strain), some trends are visible: Cover of both broom and coyote brush tends to decrease after a burn, only to creep back up in the absence of fire. In all three groups of plots, cover of both species has marched steadily upwards over the last seven or eight fire-free years.

Cover of three shrubby species over time since fire

Because the plots were read on such different schedules, one could look at vegetation versus only time since fire, and ignore the calendar year and the number of burns. Does the amount of time since fire impact vegetative cover? Since the plots were on different schedules, this might not even be a legitimate way to look at the data, but if trends do show, they could highlight the importance of time since fire. Since the burn units appear to have gotten more shrubby, the focus will be on the shrubby species: broom and coyote brush, with the addition of blackberry (*Rubus ursinus*, or RUUR). Both coyote brush and blackberry are native, but they are also good at spreading. Figures 4a and 4b below (next page) show the three main “shrub” species: coyote brush (BAPI), broom (GEMO), and blackberry (RUUR).

The year 01 reads are the most abundant, with the plots being read a total of 35 times in a first year after a burn (year 01) at Strain and 18 times at McCurdy. After that there are fewer reads for each subsequent numbers of years since fire, as shown in the tables below. The data in the McCurdy graph rely on a single plot after year 09.

Strain (8 plots)		McCurdy (5 plots)	
# yrs since fire	# reads	# yrs since fire	# reads
1	35	1	18
2	29	2	11
3	8	3	4
4	11	4	10
5	8	5	3
8	8	7	6
		9	2
		10	1
		15	1
		16	1
		17	1
		20	1

The overall trend at both sites is that all three of these species are increasing in the absence of fire. The data are absolute cover, which is why, if you were to add up the cover for the three species, the total often is over 100%.

Fig. 4a

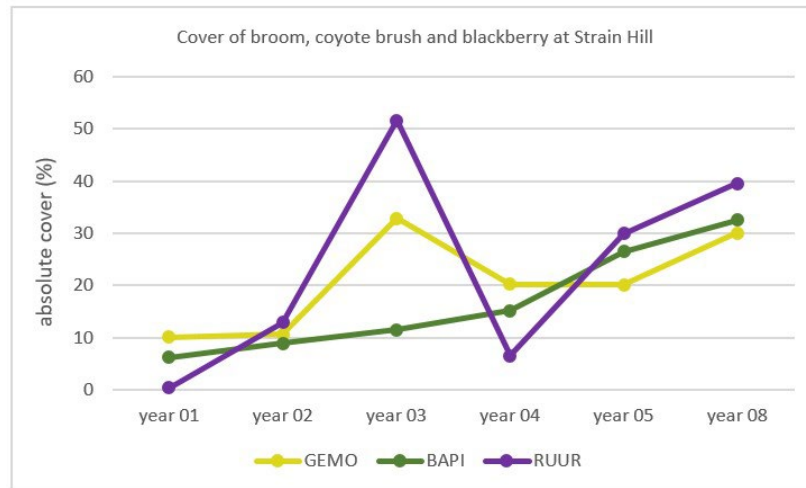
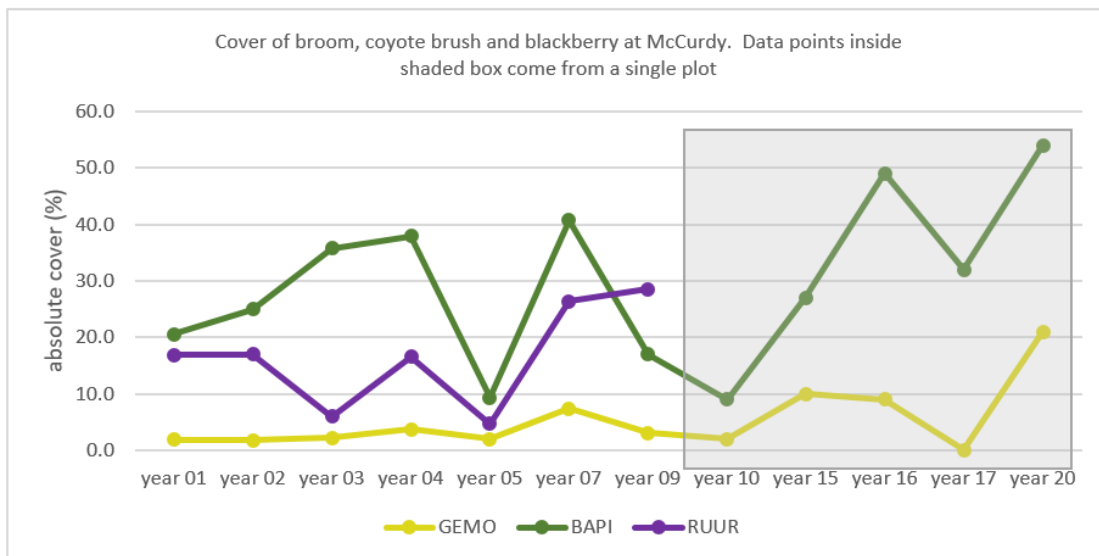


Fig. 4b

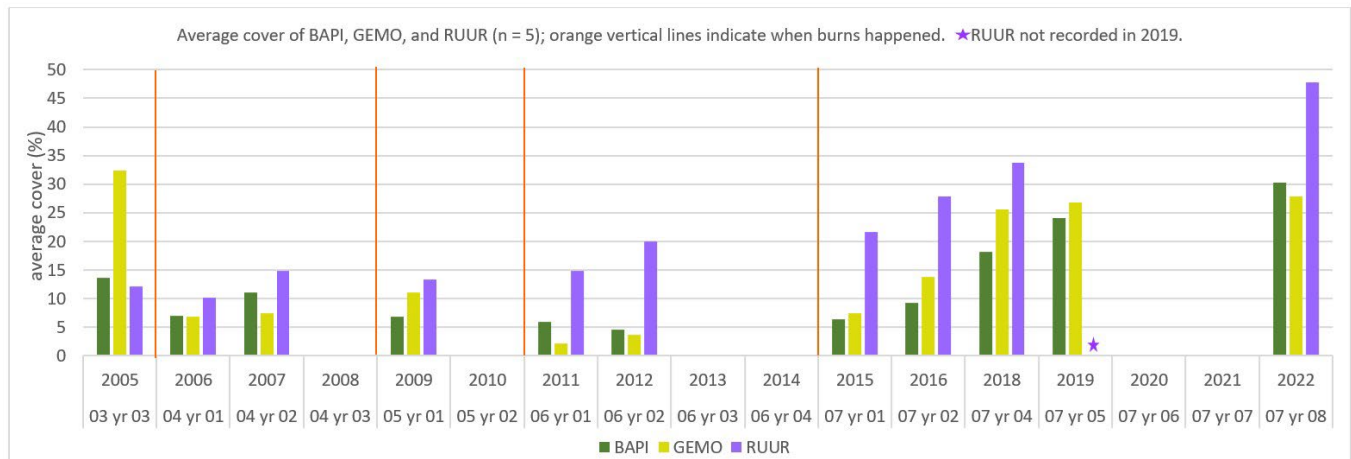


At McCurdy (Fig. 4b above), the reads of the five plots were more complicated than at Strain, making it hard to interpret the data. There is a drop in BAPI and RUUR for year 05 reads, however, these data come from only three plots (one of which never had RUUR). The last read for four of the plots was year 07, so the data from years 10 to 20 come from the one plot in the segment of the unit that hasn't burned in 20 years. This one plot does show the cover of both BAPI and GEMO climbing fairly steeply in the absence of fire.

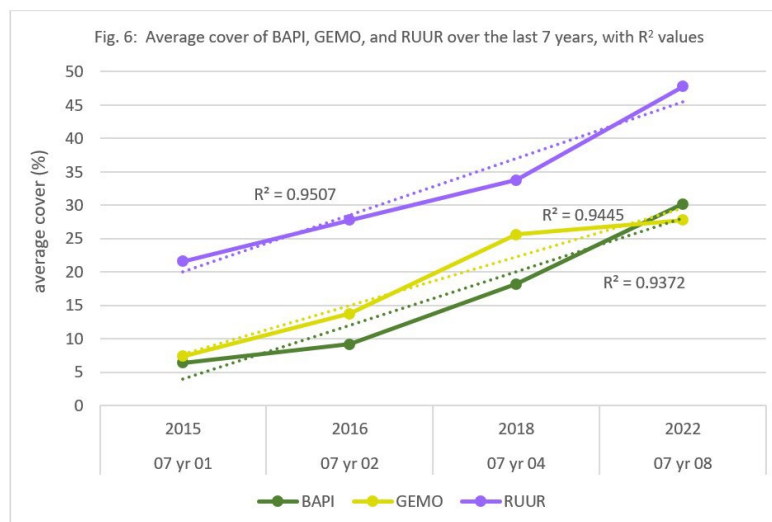
Next, the focus will be narrowed to five plots at Strain Hill which have been burned and read on the same schedule. This is the largest group of matched plots.

Fig. 5 below partly repeats information shown in Figs 3 and 4 (pages 5 and 7), however it is useful to see both time (in the form of calendar year) and burn/read status on the same graph. Years without data are those in which the plots were not read. Also, in 2019, only BAPI and GEMO were recorded. The orange vertical lines represent the burns. As in the previous graphs, the results here suggest that without more burning, the coyote brush, broom, and blackberry are likely to keep increasing their cover.

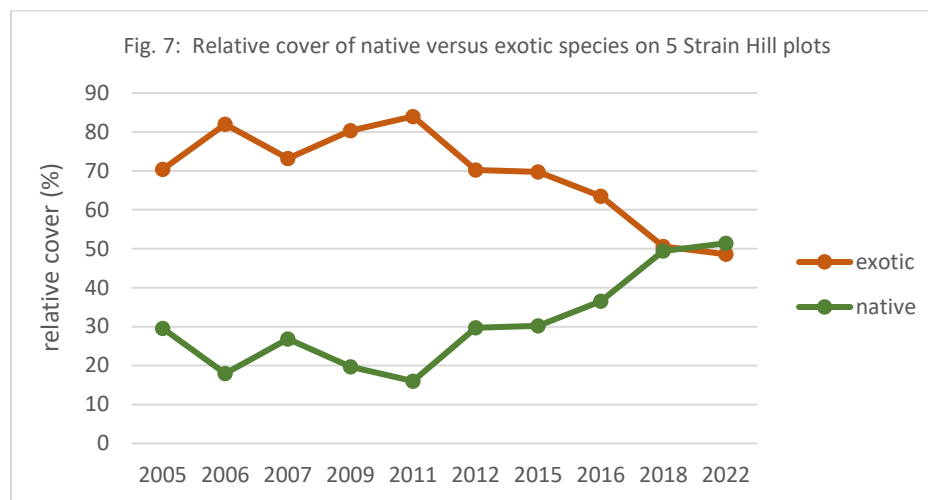
Fig. 5



The shrub-increase point is further driven home by zeroing in on the years since the last burn (2015 through 2022; Fig. 6). (Fig. 6 omits years without plot reads.) As seen by the high R^2 values, a straight line very well represents the increase in all three species. The equations for these lines (not shown) indicate that RUUR has the steepest slope (or upward trend), followed closely by BAPI and then GEMO.



The reason for starting the burning program at these two Olema Valley sites was to control broom, but at this point, we see that the expansive growth of BAPI and RUUR present strong reasons for intervention in the form of either burning or mowing, if we want to maintain grasses. The increase in these two species, BAPI and RUUR, is such that it is tipping the balance of native versus exotic species for the flora as a whole. See Fig. 7 below, which includes all species on the five plots (only the years when data were collected are shown).



Increased shrub cover means increased fuel loads, but in addition, what is happening to cover of the other species when the shrubs start to dominate?

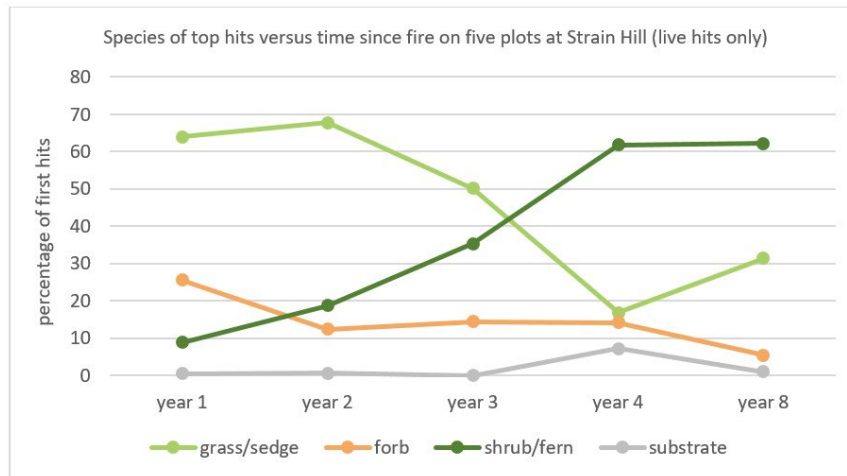
First hit versus time since fire

With the FMH sampling method, all species hit at each point are recorded, starting with the top species and working down. Plants can be in layers, and if different species are hit with the vertical sampling rod, all are recorded. The data are then lumped when calculating percent cover, ignoring which layer they were in. But, it is interesting to look at only the top species hit. This can give an idea of what the community looks like when viewed from a distance. The air photos seem to suggest that the sites are becoming more shrubby - do the data agree? Also, the top-most plants in the canopy get more sun, and could be shading out the plants below them.

Fig. 8 (next page) shows the top hits averaged over the same five Strain Hill plots, versus time since fire. In this graph, grasses and sedges have been lumped, and fern (which was bracken fern), and blackberry have been considered shrubs along with coyote brush.

Again, we see an increase in shrubs, and since the values are relative to each other (there can be only one top, or first hit per point), this increase is at the expense of the herbaceous vegetation - the grasses, sedges, and forbs. "Substrate" is only hit when there are no plants, and hovers near zero, even in the first year or two after a burn.

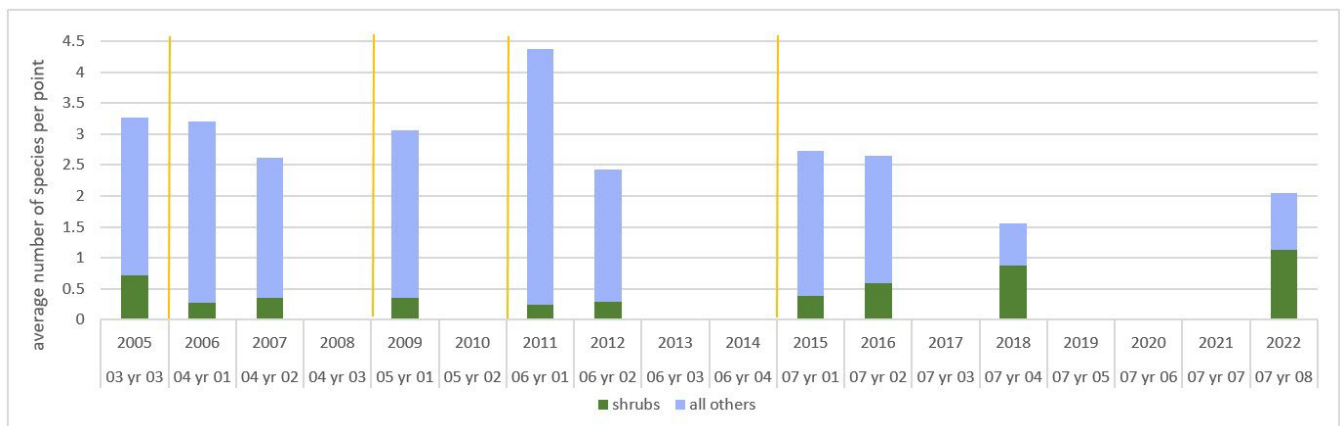
Fig. 8



Species diversity at each point

One way to assess species diversity is to calculate the average number of species hit at each transect point. A larger average number of hits per point indicates greater species diversity. Fig. 9 below shows that the number of species per point varied over the sampling period. The green sections of the bars are the shrub species, and the blue sections represent all other species. Fig. 9 suggests that species diversity was lower at the two most recent sampling dates. The highest diversity tended to be in the first year following a burn.

Fig. 9: Average number of species per point (n = 5 plots (100 points per plot)); live plants only

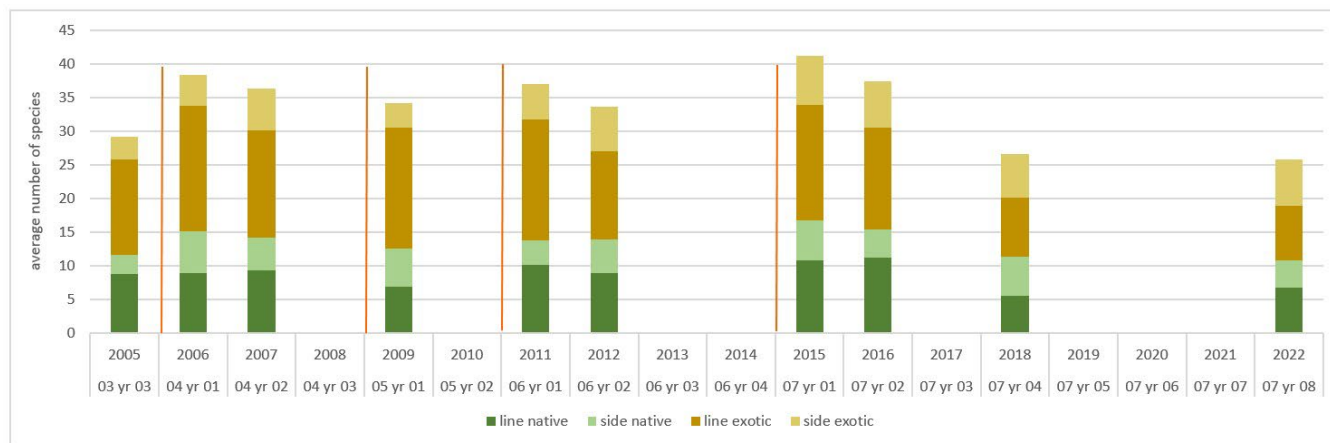


The reason for separating out the shrub hits is that while reading the plots in recent years, the impression was that a large portion of the points had BAPI and RUUR (and sometimes GEMO), and nothing else in the understory. This graph agrees with this supposition, as the green sections (shrubs) of the bars increased in recent years while the blue sections (all other species) decreased. And, the overall height of the bars was lower, indicating fewer species.

Species diversity by plot

We can also look at the number of species on the whole plot, and not just at individual points. In addition to recording the species hit at the 100 points along the line, a search is done at each read of the five meters on either side of the line (for a total of ten meters), and any additional species are recorded. Thus we can compare the total numbers of species found on the 30 by 10 meter plots. The combined total of line and side species per plot often reached or approached 40, when looking at averages of the five plots (Fig. 10). These highest levels of species diversity were all in the first year following a burn (echoing the number of species per point). The two years with the smallest number of species (24.6 and 25.2) were in the most recent two years that the plots were sampled (2018 and 2022). Exotic species were always more abundant (gold sections of bars) as compared with the natives (green sections of bars).

Fig. 10: Average number of species per plot, hit on the line and found on the side within 5 meters. Dark colors indicate species hit on the line, and light colors are for side species.

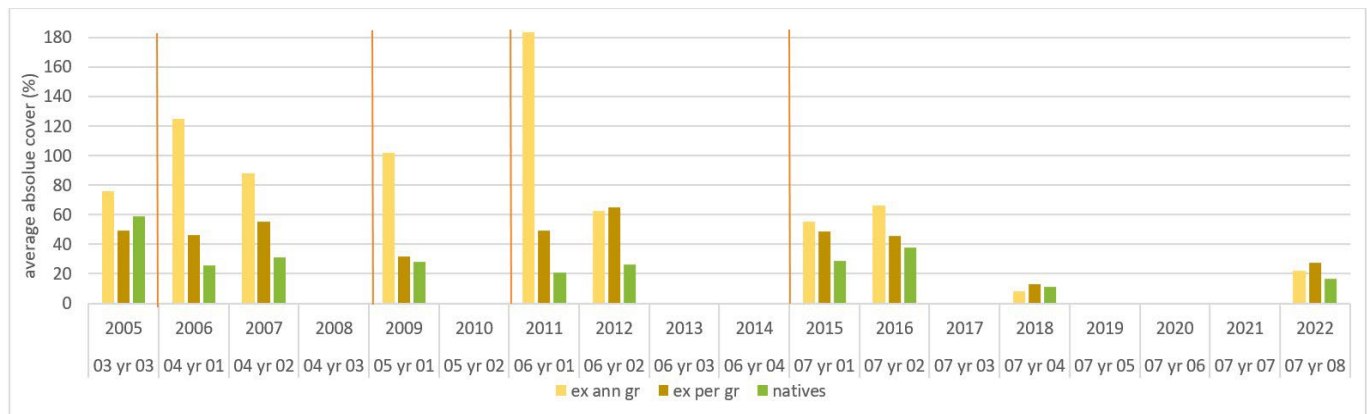


Which groups of plants are disappearing and leading to lowered species diversity, whether by point or by plot? Fig 8 (page 10) suggests that it is the grasses that are becoming less common, and to a lesser extent forbs. So, it's worth taking a look first at the grass and sedge species.

Cover of grasses and sedges

Fig. 11 (next page) shows the cover of exotic and native grass species. Since they are so abundant, annual and perennial non-native grass species are shown separately. Native grasses were all perennial; in addition, the sedges and rushes (which are all native and perennial) were lumped in with the native grasses. Because the values are absolute cover and not relative, the values often exceed 100%.

Fig. 11: Average cover (n = 5) of annual and perennial exotic grasses, and of native grasses, sedges, and rushes. Orange vertical lines indicate burns.



Exotic grasses

Exotic annual grasses were not only abundant as far as cover, but there were many different species; this contributes to their high cover totals. Our method counts every species hit at a point, but only once per species and point. For example there could be a dozen stems of a perennial touching the sampling rod and only one of a particular exotic, but each species counts as one hit each for that point.

Cover of exotic annual grasses averaged 79%, with a high of 183%. However, even the exotic annual grasses had drastically decreased by 2018 and 2022 (corresponding to 4 and 8 years after the last burn), to 8% and 22% respectively.

Exotic perennial grasses are often a concern, because they can be very persistent, and also because if you were to burn at a time of year or a rotation in order to favor perennial grasses over annuals, the exotic perennials would benefit along with the native ones. Over the ten reads and 17 years for these five plots, the exotic perennial grass species have averaged 43%, with a high of 65% in 2012, two years after the sixth burn. As a group, fire does not seem to be affecting their cover, but overtopping by shrubs does seem to be happening.

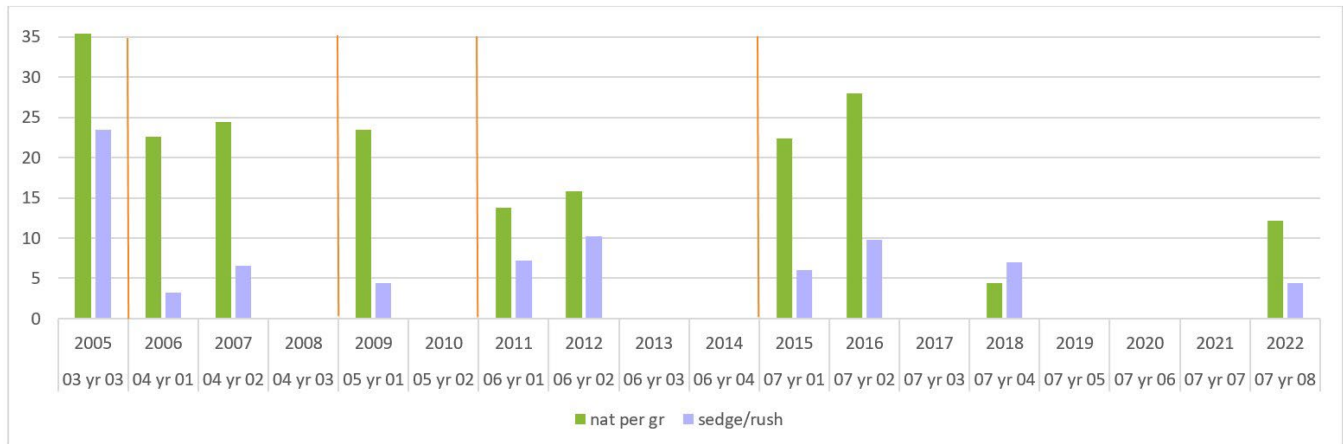
Native grasses and sedges

Unfortunately, native grasses and sedges on these five Strain Hill plots have declined over the time period. When the plots were established in 2005 (after three burns), native grass and sedge average cover was 59%. The average cover dropped as low as 11.4% in 2018, but rose slightly to 16.6% in 2022. Since the natives are present in so much smaller amounts as compared with the exotics, the cover of native grasses and sedges are shown (again) separately in Fig. 12, next page.

Fig. 12 shows that in the first year after the fourth, fifth and sixth times the plots were burned, cover of native grasses (green bars) declined, then rose the second year. In 2015, the first year after the seventh burn, cover was higher than in 2011 or 2012, but we don't know where it was in 2013 or 2014, so can't say whether or not the seventh burn knocked it back. The second year after the seventh burn, 2016,

showed the second-highest native grass cover, but at the next two reads, 2018 and 2022, cover was dismal. Cover of sedges and rushes (it's predominantly the former; blue bars) showed similar responses to native grasses over the 10-read/7-burn period.

Fig. 12: Average cover of native grasses and native sedges or rushes



To see whether the amount of time since fire strongly affected native grasses and sedges, the live cover data from all of the plots at the two sites were gathered, and graphed versus the number of years since a burn; see Fig. 13. There are preburn data from three plots, indicated by “year zero” on the graph. And on the other end of the scale, a grey box covers the part of the line that came from a very small set of data (one plot). When the five Strain Hill plots (a subset of the whole) are graphed separately, there is a similar pattern to that in Fig. 13.

Fig. 13: Cover of native grasses and sedges versus time since the last burn. The data inside the grey box come from a single read (two reads for year 9).

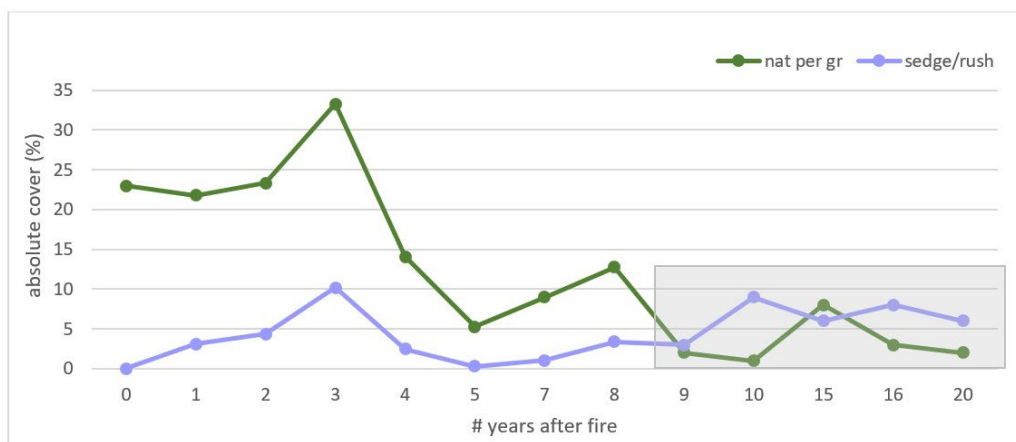


Fig. 13 seems to suggest that from the standpoint of native grasses and sedges, it's best not to allow too much time to elapse between burns. However it's possible that other factors are also contributing to the decline in cover of these groups of species.

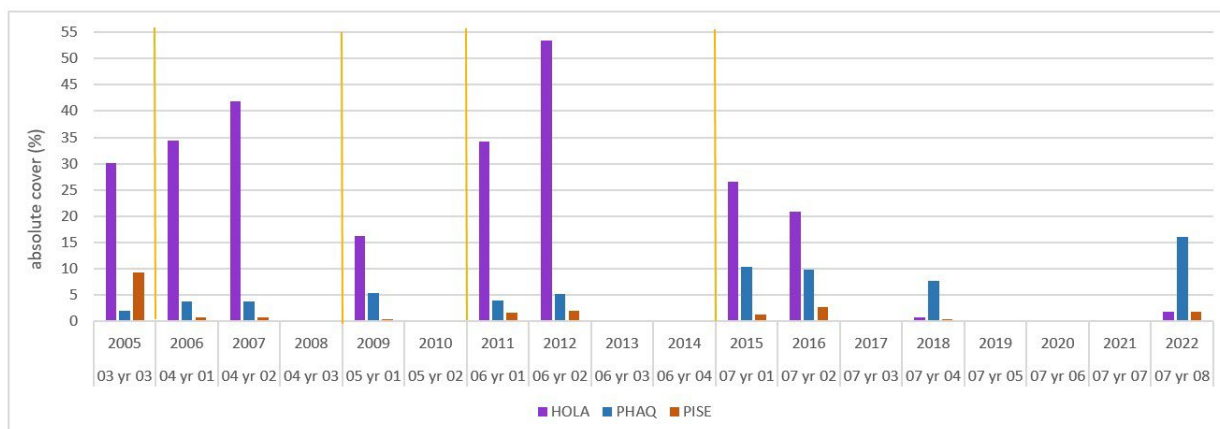
Individual grass species and plots

We will return to the five Strain Hill plots to consider some specific grass examples.

Important exotic perennial grass species

Purple velvet grass (*Holcus lanatus*, or HOLA) and Harding grass (*Phalaris aquatica*, or PHAQ) are both non-native perennial grasses that form dense, tough clumps which can exclude other species. Chilean rice grass (*Piptochaetium* spp., lumped here as PISE or *P. setosum*), though less common on the five plots, is included here because it does have the potential to be invasive, and is very common on the units as a whole. Fig. 14 shows the average cover of these three species over time. *Holcus* (purple bars) responded positively to fire in year 1 in both 2006 and 2011; cover went up even more in year 2 for these two burns. Since 2018, however, HOLA cover has been very low overall. *Phalaris* (blue bars) has done just fine in the absence of fire over the last eight years. The biggest 2022 increase in PHAQ came from a single plot, GEMO 08.

Fig. 14: Average cover of three species of exotic perennial grasses on five plots over time.



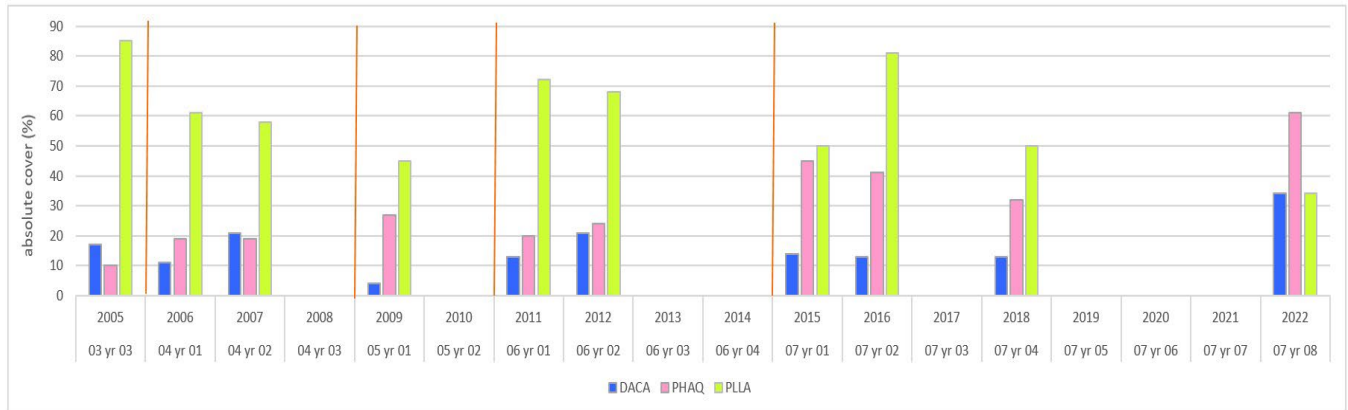
A focus on plot GEMO 08

The plot that had very the high PHAQ cover in 2022 (61%) was plot 08. This plot is unusual because it has not had any BAPI at any of the ten reads. Except for the GEMO, #08 is more of a grass plot. In addition to the PHAQ, the plot has had up to 44% cover of a sedge (*Carex gynodryama*), and it also has beautiful clumps of *Danthonia californica* (California oat-grass, or DACA), particularly at its far end. The other main species on this plot is the non-native English plantain (*Plantago lanceolata*, or PLLA).

Cover of these three species are shown in Fig. 15 as an example of the nuances that the interactions among fire, vegetation and the environment can have. The cover of DACA appeared to go down after fire, and then eight years after the last burn, in 2022, was at its highest point yet (34%). Cover of PLLA

was high at each read, but was at its lowest (also 34%) in 2022. Both of those were good results. But the undesirable PHAQ had also risen to its highest cover yet in 2022 (the aforementioned 61%). We want to burn these areas in order to control the broom, the coyote brush, the blackberry and now apparently the PHAQ, but we also need to be aware of potential effects on native grasses.

Fig. 15: DACA, PHAQ, and PLLA cover on plot 08.

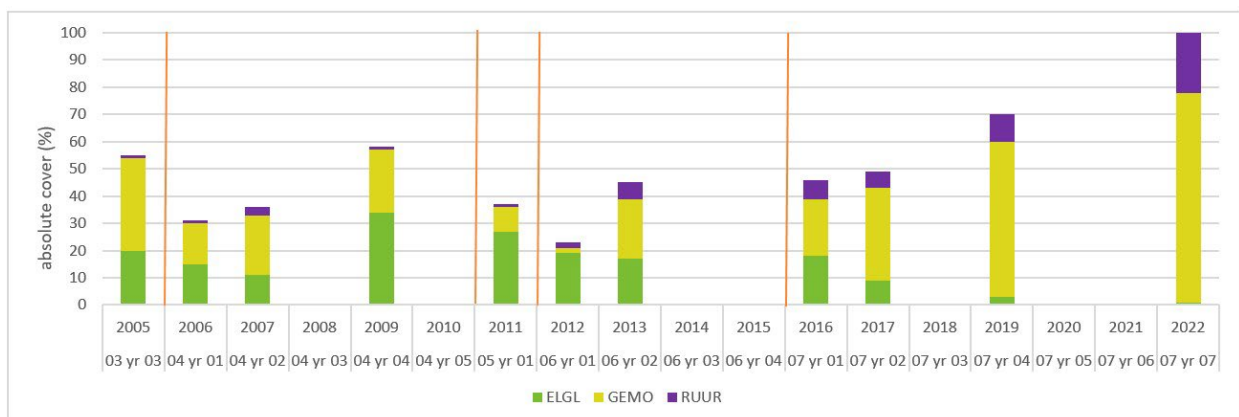


As a side note, since this plot never had BAPI or RUUR, excluding it from the 2022 averages would have led to BAPI cover going from 30.2% to 37.8% and RUUR cover from 47.8% to 59.8%. This means that four of the five plots are even shrubbier than Fig. 5 appears.

A focus on plot GEMO 11

Unlike the other plots that have been looked at, this one is in the McCurdy burn unit. Some of the plots had solid quantities of native grasses, and GEMO 11 had a fair amount of *Elymus californica* (California rye grass, or ELGL). Unfortunately this ELGL has now faded away. Fig. 16 suggests that the ELGL has been displaced in recent years by GEMO and RUUR. In 2022 after eight years without fire, GEMO had 77% cover, RUUR 22%, and ELGL only 1% (these values are absolute and not relative).

Fig. 16: Cover of ELGL, GEMO, and RUUR on plot 11

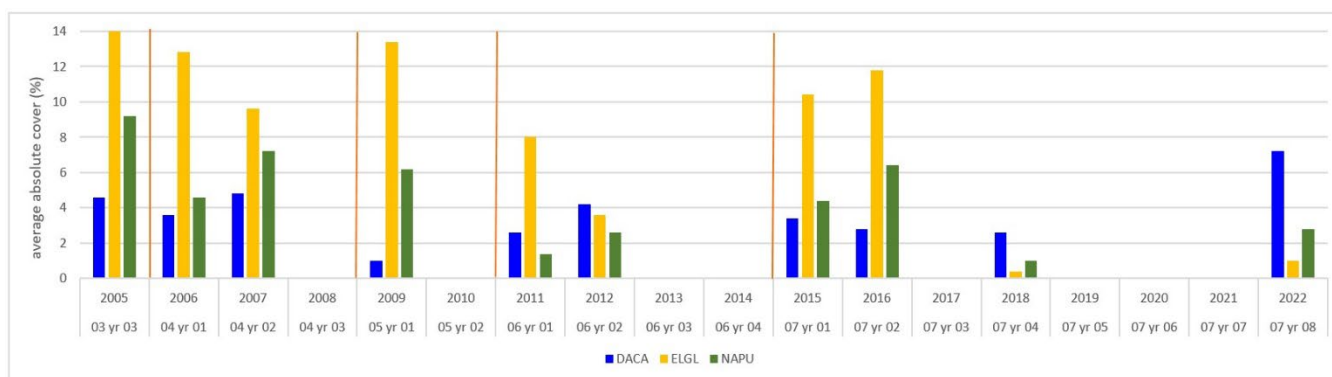


The plant species on this plot also show complex interactions with fire. Two burns in consecutive years (2011 and 2012) knocked the broom way back, but also appears to have affected the ELGL. But then even without fire, the ELGL has been in steep decline since 2016. During this time the GEMO has expanded while the RUUR, which clammers over other plants, has done increasingly well since 2013.

Important native grass species

The three most abundant native grass species on the five Strain Hill plots are *Nassella pulchra* (purple needle grass, or NAPU), *Elymus glaucus* and *Danthonia californica*; the latter two species were discussed in sections above. These native grasses have not done particularly well over the time period of the data (Fig. 16). ELGL in particular has seen in a drastic decline in recent years; these Strain Hill plots thus match McCurdy's plot 11. The average cover of ELGL over the first eight of the ten reads was 10.5% (the range was 3.6% - 14.6%). But in 2018, average ELGL cover was 0.4%, and in 2022 it

Fig. 17: Average cover of the four most common native perennial grass species



was 1%. Interestingly, the high point for ELGL on three of the five plots was the first year after either the sixth or seventh burn. One plot (08) had almost no ELGL. But the saddest case is plot 10, which went from an average ELGL cover over the first four reads of over 46% (36% - 59%) to zero hits of ELGL in either 2018 or 2022. (ELGL was recorded as being within 5m of the line transect for this plot in 2018, but not in 2022.)

Most of the NAPU was found on three of the five plots, with a high of 22% at 04 yr 02 (two years after the fourth burn) on plot 05. Plots 06 and 10 had their highest NAPU at the first read (17% and 13% respectively).

And most of the DACA cover comes from a single plot, 08; the trends in this species on plot 08 were discussed above. The other four plots all had DACA, but in low amounts, ranging from 0% to 4% over different plots and years.

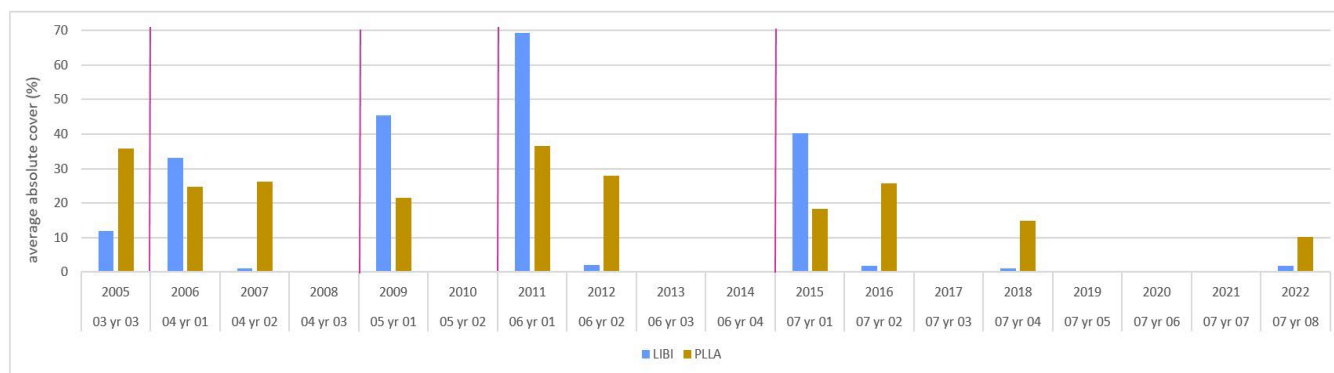
It's not clear what is causing these declines in native grasses, though shading by shrubs is evident in at least some cases. An example of shading is red fescue (*Festuca rubra*, or FERU) on plot 05, where this native grass formed a dense patchy carpet near one end of the transect. The highest number of FERU

hits was 8 (or 8% cover) in 2016. In 2022 it was surprising to not see the FERU clumps; a search found them only as dismal barely living remnants underneath the GEMO and BAPI.

Forbs on the five Strain Hill plots

Forbs were much less common than grasses and shrubs on the five Strain Hill plots. There were only seven forb species with an average cover of greater than 1% (the fern *Pteridium aquilinum* or PTAQ is included here, even though it was lumped with shrubs in Fig. 8). Two of these forbs are native and the rest exotic. Two of the non-native species, *Linum bienne* (flax, or LIBI) and *Plantago lanceolata* (PLLA; mentioned above regarding plot 08) had cover that was an order of magnitude higher than that of the other five species, so the former two species are shown in Fig. 17, and the latter five in Fig. 18. Note the difference in scale of the vertical axes. Along with PTAQ, the other native species is *Aster chilensis* (ASCH). The other exotic species are *Anagallis arvensis* (scarlet pimpernel or ANAR), *Cirsium vulgare* (bull thistle, or CIVU), and *Hypochaeris radicata* (hairy cat's ear, or HYRA).

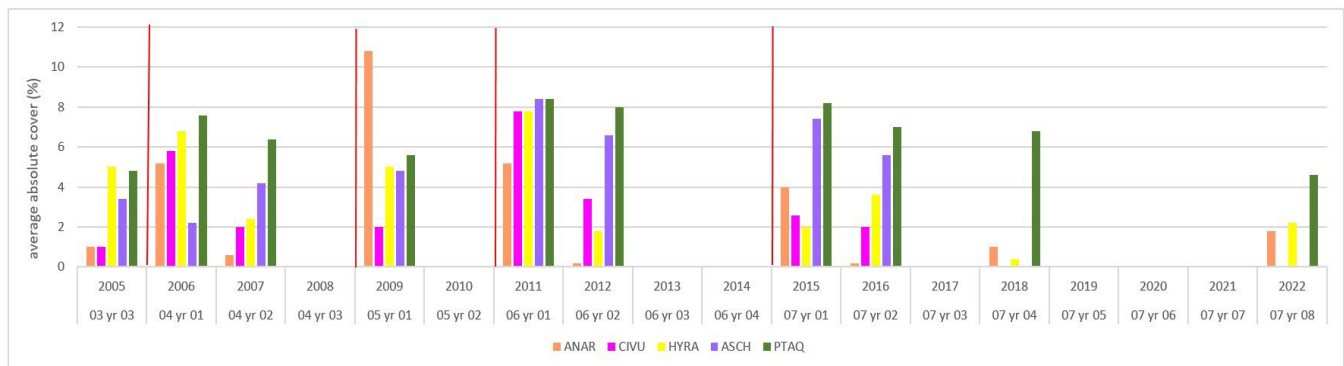
Fig. 17: Average cover of the two most abundant forb species, LIBI and PLLA. Both are exotic.



Cover of LIBI surged upwards after every burn, but after this burst in year 1, LIBI cover went back to hover around zero. In contrast to LIBI, PLLA is a perennial. It maintained fairly robust cover throughout the time period, though even it had diminished at the last two sampling dates.

Fig. 18 (next page) shows the next most common forb species. As mentioned above, the aster and the fern (ASCH and PTAQ) are native, while the other three species in the graph are exotic. PTAQ cover had its ups and downs, but it was the sole native among the three forb species (of the five total forb species) still present in 2018 and 2022. In contrast, ASCH dropped out after 2016 (though it was seen within 5 meters in later years on most of the plots).

Fig. 18: Average cover of the five next most abundant forb species. Only ASCH and PTAQ are native; the rest are exotic.



The other species that was not hit on the line in the last two reads was CIVU. When the cover of this species was graphed against the number of years since fire, the distribution very well fit ($R^2 = 0.982$) a downward-trending logarithmic curve.

ANAR and HYRA, along with PTAQ, were the only species of the five that were still present in 2018 and 2022. ANAR, an annual, had its highest cover values in the first year after being burned (with a highest high after the 5th burn in 2009). HYRA is a perennial and often grows on top of native bunch grasses, so is more of a concern than annuals are. Cover of HYRA has bounced around, but it persisted when most other species disappeared.

Discussion and Conclusions

The prescribed burns at Strain Hill and McCurdy in Olema Valley were carried out with the primary goal being to control French broom. Fire is often used as a tool to kill this invasive non-native species, however as researchers have discovered (Bossard et al. 2000, DiTomaso et al. 2006), control of the species poses challenges: French broom, a member of the legume family, has seeds that can stay viable in the soil for a long time, and fire stimulates seed germination. And plants not only produce large amounts of seed, they can also resprout. The consensus is that control strategies need to focus on depleting the soil seed bank, and a long-term commitment is needed (sometimes involving a variety of control methods such as cutting and drying the plants before a burn) in order to keep the species in check.

Frequent fire can be useful to control French broom; Bossard et al. (2000) suggest an interval of 2-4 years. However fire at too close of an interval may negatively impact native species. And a further challenge to burning broom is that it appears to be rather “fireproof” (personal observation). A stand of broom can look dense, but on closer inspection it is seen that plants grow vertically without interlocking branches that can serve as ladder fuels, and also the soft fuzzy leaves tend to scorch but not actually burn.

And now at this stage in the development of the vegetation in the Olema Valley burn units, another element has appeared: the rise of coyote brush. The main conclusion that this look at the data has yielded is that these burn units are shifting from being mixed grass-shrub (or even grass-dominated) to becoming shrub-dominated systems. Although French broom is contributing to shrubs becoming dominant (as is blackberry), the most important species as far as increased shrub cover is concerned is coyote brush. This shift in vegetation type has many implications.

With more shrubs, fuel loading has increased. These units were envisioned as areas of reduced fuels in case of a wildfire, but with more shrub biomass, that will no longer be the case. Prescribed burning is more difficult in shrub-dominated systems, both because the fuel loading is higher (potentially leading to more intense fire behavior, which would mean control challenges), but also because the window of opportune weather conditions will be smaller (since larger fuels like shrubs take longer to dry than fine grass fuels). Taller fuels also make cutting control lines and walking through with drip torches more difficult.

In order to kill coyote brush (not to mention French broom), quite a bit of heat needs to be applied. This resilient species has low flammability and is a vigorous resprouter. McBride and Heady (1968), in a study in four East Bay Regional Parks, found that when they burned only the aerial portions of coyote brush plants, the shrubs quickly resprouted. But when they burned the shrub bases, 8 of their 11 plants were killed. The authors stated that when shrubs were smaller and less common, grazing and fire could keep the species at low levels. However they concluded that it would not be possible to use fire alone to remove a dense stand of coyote brush.

Hobbs and Mooney (1986), in a study at Jasper Ridge (San Mateo County), found that coyote brush invaded rapidly into a grassland, and the shrub canopy closed. When that happened, the biomass of herbaceous species drastically declined. McBride (1974), in a study in the Berkeley Hills, described the path from grazed grassland to coyote brush to oak and bay woodland as a successional one. During ecological succession, the theory is that each seral stage leads to the next, as each group of organisms alters the environment, and that this proceeds forward unhalting unless there is some kind of disturbance.

Whether or not this can be considered “succession”, at this point, Strain Hill and McCurdy are beginning to be dominated by three shrubby species: coyote brush, blackberry (both native) and French broom. The formerly layered canopy has become a one- or two-species one, with coyote brush or broom in the overstory, and either nothing or blackberry in the understory. With these shrub advances come losses or decreases of other species. The data show that species diversity declined at two spatial scales (the individual point along the tape, and the plot as a whole). The loss of particular species and the overall loss of diversity in turn impacts the abundance of animal species. And thus the structure and function of the ecosystem change.

Briggs et al. (2005) note that changes in species composition can have “significant” effects on ecosystem structure and function. Although they were studying tallgrass prairie and not coastal grasslands, Briggs et al. (2005) felt that a change in life form (such as from grasses to shrubs), and not just shifts in species, can have the most “profound ecological consequences.” In the case of woody species invasion into prairie, apparently it was not possible to use simple tools (such as fire and moderate grazing) alone to bring back the grasslands.

Invasion by woody species into grasslands is common, and is often seen as a problem (Biswell 1954). Coyote brush invasion is also not a new phenomenon (Hobbs and Mooney 1968). Thus the spread of coyote brush over the past seven or eight years without fire is not new, and is not restricted to these Olema Valley burn units. However at this point we have to pause to ask, is this coyote brush dominance acceptable? This important question needs an answer, because ignoring it and doing nothing still affects the ecosystem. If we do nothing, is there any likelihood that the coyote brush will eventually go away on its own? McBride (1974) postulated an eventual conversion to oak or bay forest. If this were even likely to occur on the Olema Valley sites, such a transition would likely be on a very long time scale. The units are, however, surrounded by Douglas fir forest with coast live oaks and bays, and some trees are scattered in the burn units. Doug fir is known as an aggressive colonizer.

Herbivores can speed change away from grassland: Hobbs and Mooney (1986) in their Jasper Ridge study, found that when shrubs increased, so did the populations of mammalian herbivores such as rabbits and rodents. These animals focused on the grassland species that still remained under the shrubs, hastening the decline of these species (and making it harder for them to regain any ground). DeSimone and Zedler (1999) had comparable results.

In a study in a coastal sage scrub (CSS) ecosystem, Brennan et al. (2018) found that coyote brush actually acted to facilitate the reestablishment of other CSS shrub and native grass species. In their study area of the Santa Monica Mountains, exotic annual grasses had taken over the landscape. Coyote brush has characteristics that enable it to colonize these grasslands. The authors found that the coyote brush shrubs grew rapidly but then started to senesce at about nine years old, breaking down and leading to gaps in the canopy that were utilized by other native species.

Our system is very different, and here the coyote brush shows no signs of senescing eight years after fire. We do have older BAPI plots in the park though, so these data were examined to determine whether the shrub canopy was opening up after a much longer fire-free time period.

The older BAPI plots are located on Tomales Point, also known as the Elk Range. The peninsula was grazed by cattle until 1978, when tule elk were reintroduced. The Tomales Point BAPI plots on coastal bluffs turned out to be fairly different from the Olema Valley GEMO ones. BAPI cover was much higher on the Tomales Point plots, averaging 46% with a high of 91% (values are absolute cover). In contrast, in Olema Valley the highest average BAPI cover was 30% in 2022, and highest single plot was 57%. The Tomales Point plots tended to have greater species diversity, with an average of 30 species hit on the line, while the five Strain Hill plots looked at in depth had an average of 23. Wrubel and Parker (2018) found a similar pattern in species diversity, with the highest levels at the immediate coast.

When we try to use the Tomales Point plots as a proxy to see whether over time BAPI would decrease and give way to other species, the results are mixed but not particularly promising. On two twice-burned BAPI plots, BAPI cover steadily decreased from 52% to 37% over twenty fire-free years from 1994 to 2003. Fifteen percent reduction in BAPI, but BAPI cover was still higher than on the GEMO plots. On a set of four BAPI control plots, the BAPI cover percents were mostly in the 50's during the period 1992 to 1998, and at the next read in 2009 three plots had an average of 17% BAPI (the range for the three plots was 10% to 33%). But on a third group of four plots, these burned once, the BAPI cover was slowly creeping up, from 28% right after the burn, to 41% in 2003, twenty years later.

Despite the lack of comparable data to use as predictors which might help envision what the Olema Valley burn units may look like in the future without management actions, we do have anecdotal information based on observations at the sites. A pair of oak trees formerly with little growth around them now has a 10-foot tall understory of shrubs including hazelnut and toyon. *Ceanothus* (*Ceanothus thyrsiflorus*) shrubs already more than head-high were seen in another burn unit (Dogtown) south of the ones that have plots in them. Memory does not include a record of this species in this unit, but it needs to be noted that patches of *C. thyrsiflorus* were the location of the highest burn severities in the park's 2020 Woodward Fire.

Not mentioned in this discussion is the nativity of grasses, as the focus has been on grass versus shrubs. It's important to remember that non-native grasses tend to be highly adaptable and are fierce competitors with native grass species. Work in grasslands at Sea Ranch (Sonoma County) showed Foin and Hektner (1986) that some of the exotic perennial grasses (such as purple velvet grass, *Holcus lanatus*, also a big component of our grasslands) are likely to not only remain in place but to continue to be dominant. Where native grasses persist, it's important to do what we can to assist them in remaining onsite. Otherwise, exotic species are likely to take over.

Having grasslands of any kind, whether native or exotic, probably will require management actions. Barbour et al. (2007) state that shrubs will invade into grasslands in the absence of grazing or fire. Disturbance factors which will tend to maintain grasslands include frequent fire, rodent herbivory, and grazing and trampling by large mammals. Barbour et al. (2007), and the references therein, go farther, asserting that without disturbance, a complete shift from grassland to shrubland can occur in 15-25 years. And also, that fire alone cannot stop this conversion, because the shrub species tend to be fire-tolerant and adapted to recovery after disturbance. In many areas, trees as well as shrubs are likely to invade. In our area, the native but aggressive colonizer Douglas fir will make its way into grasslands.

If we want to restore native plant communities, we don't know what the "original" plant species assemblages in Olema Valley were, although the literature is full of arguments and speculations on pre-European vegetation in California (e.g. Keeley 2002). The question for managers though is, what does the park want to see? The first-level question for a particular site is whether the desired community is grasslands, shrublands, or forest? And, because much effort will be involved in maintaining or restoring plant communities, while budgets and staffing are limited, at which sites should efforts be focused? These are not easy decisions to make, but as mentioned, doing nothing is also a decision, and creates its own impacts.

It is hoped that the results in this report stimulate discussions on maintenance or restoration of at-risk grasslands at both Point Reyes National Seashore and Golden Gate National Recreation area. Both parks have some beautiful grasslands, many of which are being taken over by coyote brush. When the two parks are considered overall, the Olema Valley burn units may not even be of the highest priority for restoration or grassland maintenance. But the data presented here serve to highlight that what is happening in absence of fire, mowing, and grazing is the development of landscapes full dense coyote brush, blackberry, broom, and other woody species, with a paucity of grasses.

Quite a few other fire effects plots (most never burned) exist at both PORE and GOGA. In 2009, a few plots were re-read by the fledgling Inventory and Monitoring (I&M) program as they began to think

about how to look at long term vegetation change (some Tomales Point BAPI data were mentioned above). It could be interesting to monitor additional long-unvisited plots, particularly NAPU (*Nassella pulchra*) plots at GOGA, to find out what kinds of trends are occurring.

Written by Wende Rehlaender, Lead Fire Effects Monitor
Late summer, 2022

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Methods for Rapid Assessment Plots Installed in 2022 to Examine the Fate of Meadow-Invaded Pine Trees After They Burned in the 2021 Dixie Fire

Dersch Meadows, Lassen Volcanic National Park

Background

The size of Dersch Meadows was once much larger but over the decades, trees, in particular lodgepole pine (*Pinus contorta*), have encroached, invading the meadow and shrinking its extent. There is interest in restoring the meadow, and the 2021 Dixie Fire offers the opportunity to monitor potential changes caused by fire. Dersch Meadows was on the edge of the fire - the meadow extends across Highway 89, but the fire stopped short of the road.

Questions

What does killing trees with fire do for meadow recovery? Will meadow species be able to move into areas that were occupied before the fire by trees?

The focus of this study will be on thickets of trees, either on the edge of the meadow or inside it, that have clearly invaded over the past decades to half-century or more. This will be a pilot study, which can be expanded or modified later if desired.

Selection of Plot Locations

Choosing sites for plot locations was done subjectively. Plots were to be homogeneous with respect to burn severity and vegetation, and were to be dominated by lodgepole pine, avoiding red fir (*Abies magnifica*). There was no set minimum for the number of trees in a plot. The goal was to have plots that burned with moderate to high severity, and to contrast these with “controls” that either were unburned or had low burn severity. Having enough time available, we chose plots that covered the range of burn severities.

A map of the CBI values was used for the initial determination of where to put plots. Most of the meadow and nearby areas were mapped as having burned at low to moderate severity. The unburned section of the meadow on the other side of Hwy 89 provided a good location for control plots. The mapped CBI's proved not to be very accurate, but were a good starting point.

Plot Layout

The plots were circular, with a radius of 8 meters (16 meters diameter). Areas close to the current meadow were searched, with our criteria of lodgepole-dominated and within a single pixel of the CBI map. When a suitable site was found, the plot was placed with at least one edge in or near the meadow. First, one tape was stretched 16 meters, in a direction of either north-south or east-west, and the area assessed to see if it met the plot stipulations. Then the second tape was strung, again for 16 m, at right

angles to the first. Sometimes one or both tapes were moved in order to take in a more desirable section or to avoid undesirable patches. Tape ends were fixed with chaining pins. A rebar stake with a brass plot tag wired onto it was placed at the intersection of the two tapes, and its GPS location recorded. The resulting plot had a tape stretched from the center towards each of the cardinal directions. The outer limits were not marked, but when it was questionable whether a tree was within the 8-meter circle or not, a tape was used to measure the tree's distance from the center stake. This happened rarely.

The plots were called PIIM plots, which stands for **P**ine (or PICO) **I**nvaded **I**nto Meadow. (The name was selected because it forms a pronounceable acronym.) The plots were numbered in the order they were established with B or C (burn or control) added to the plot name.

Thirteen PIIM plots were established and read in August, 2022. It is expected that they will be re-read, so what follows are instructions on how to do so.

See map on next page for plot locations.

Dersch Meadows PIIM plots, and CBI

PIIM 04

PIIM 05

PIIM 06

PIIM 12

PIIM 07

PIIM 10

PIIM 09

PIIM 11

PIIM 08

PIIM 01

PIIM 03

PIIM 02

PIIM 13

Legend

severity of plot

- unburned
- low/unb.
- low
- moderate
- high

CBI

- 1
- 2
- 3
- 4



0 30 60 120 Meters

Methods and Data Sheets

Equipment

You will need either 2 or 4 tapes with meters, 4 chaining pins, a dbh tape, a stick marked with the FMH tree heights, a camera, and either clipboard and data sheets or mobile device for data recording. Chalk is useful where trees are numerous.

Photos

Take photos from plot center, facing each cardinal direction (or tape) in turn for a total of four photos. These photos will probably be needed to help place the tapes on subsequent visits.

CBI (first year only)

The CBI (Composite Burn Index) method was used to obtain a burn severity score. Only surface fuels and trees were assessed. The original plan had been to use FMH methods, considering the whole plot as one point, but CBI better captures conditions a year after the fire.

Vegetative cover

- Estimate the percent cover of each species or species group, using Daubenmire classes. Record the midpoint (or “Code” in the table below) of the class for entry into FFI. Do tree species separately, but within each of the following groups, lump the species: shrubs, forbs, grasses/sedges, and mosses/liverworts. Only consider live cover.

Daubenmire cover classes and codes. The code is the midpoint of the class, and is what gets entered into FFI

Code	Cover Class Range
0.5	<1 %
3	1% - 5%
15	5% - 25%
37.5	25% - 50%
62.5	50% - 75%
85	75% - 95%
97.5	>95%

- If there are any interesting species seen outside of the plot that you want to record, there is a place on the data sheet for them.

Trees

Seedlings (dbh <2.5 cm) and trees (dbh >2.5 cm) are counted separately.

Seedling trees

- Count tree seedlings in a one-meter belt along each of the four arms (tapes) of the plot. Each belt runs on the right side of the tape when you're at the center looking out. The belts are divided into

four 2-meter interval, numbered starting from plot center. Seedlings are tallied by species, status (dead/live), and height code, using standard FMH tree height classes.

- The data sheet is a modified brush belt sheet.

Poles and Overstory Trees

- All trees within the plot are counted. The quadrants formed by the four tapes are censused separately. For simplicity, start with the NE quadrant, and proceed in a clockwise direction. If there are a lot of trees, you might want to keep track by marking tallied ones with chalk.
- Tally trees by species, size class, and status (dead/live). Trees are divided into diameter (dbh) size classes as shown in the table below. Once your eye has calibrated, you probably won't have to measure every tree. Note: these codes come from FFI, but the size ranges were decided onsite.

Tree size categories

<u>code</u>	<u>description</u>	<u>size (cm)</u>
PT	pole tree	2.5 - 15
MT	medium tree	15 - 30
LT	large tree	30-50
VT	very large tree	>50

- Trees that did not have a dbh (i.e. were broken or cut below dbh) were not counted.
- Trees were only counted if they were rooted. In the first year, fallen trees were not counted since it was not always possible to determine whether they had fallen before or after the fire. When more trees fall in subsequent years, this will be reflected in lower total counts for dead trees.
- In the first year after the fire, it was noted whether dead trees had been alive before the fire.
- The data sheet is modified from a typical seedling density data sheet.

Data Entry into FFI

Vegetative cover

The vegetation cover values are entered into “Cover - Species Composition (metric).” This protocol is normally used for species on the side and not hit on a veg line. However, in addition to “Item Code” (species), under the “Cover” tab you will find the Daubenmire cover classes (scroll down to the bottom). One variation is that “<1%” is taken from the other system (entered as 0.5).

Seedling trees

The seedling data are entered into the “Density - Belts (metric)” protocol. The four arms of the plot are considered separate transects.

- The “Transect” tab takes only numbers, so use the following conversion:

N = 1, E = 2, S = 3, W = 4

- Instead of using “Age Class” use “Size Class” and code all as “SE” for seedling.

Trees

The tree data go into the “Density - Quadrats (metric)” protocol.

- Similar to seedlings, the “Quadrat” tab (which is actually quadrant for these plots) takes only numbers, so the letter names must be converted as follows:

NE = 1, SE = 2, SW = 3, NW = 4

- The first tab “Transect,” can be ignored as it doesn’t apply here with our circular plot that’s already been divided into four quadrants. Just leave all values as “1.”
- The first user variable was used, for the year after the fire: UV1 = killed by fire? The entries were “Y,” “N,” or “n/a.”

See next page for a table showing a summary of the 2022 PIIM data.

PIIM 2022 Summary of Data							
plot	B/C	CBI	# live trees		# seedlings*		% live cover
			PICO	other	PICO	ABMA	
PIIM 04	B	2.86	0	0	16	0	1-5
PIIM 06	B	2.86	0	2	75	0	5-25
PIIM 09	B	2.68	0	0	43	0	<1
PIIM 01	B	2.42	0	0	8	0	<1
PIIM 12	B	2.05	6	0	9	1	5-25
PIIM 08	B	1.47	11	0	99	0	25-50
PIIM 10	B	1.33	26	0	151	2	25-50
PIIM 07	B	0.85	19	0	73	0	25-50
PIIM 11	B	0.02	5	0	101	0	75-95
PIIM 02	C	0	19	2	5	0	75-95
PIIM 03	C	0	54	1	9	16	50-75
PIIM 05	C	0	47	2	11	4	75-95
PIIM 13	C	0	22	0	3	0	75-95

* Seedling numbers are for the 8m2 area sampled, not the whole plot

B/C indicates whether burn or control plot

CBI is composite burn index, and was calculated for each plot

PICO is *Pinus contorta*

ABMA is *Abies magnifica*

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