Species Lost, Found, and on the Edge of Gone on Mt. Tamalpais

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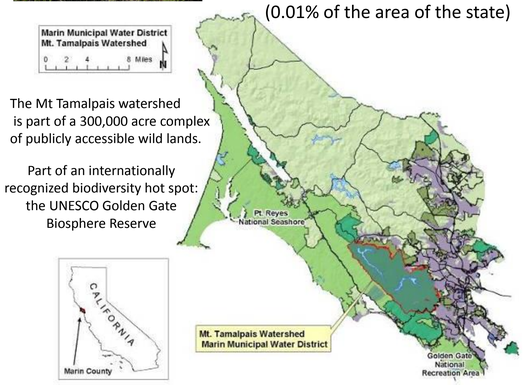
INTRODUCTION

Mt. Tamalpais in Marin County is a well-botanized site with a legacy of over 3700 specimens collected since the 1840's. The Marin Municipal Water District (MMWD) has stewarded most of the land in the Mt. Tamalpais Watershed over the past 100 years. To mark its centennial, MMWD partnered with the California Academy of Sciences on a series of bioblitzes to document the flora of the Mt. Tamalpais Watershed using teams of citizen science volunteers and professionals. The project was partially funded through a year-long planning grant from the S.D. Bechtel, Jr. Foundation to answer real research questions about California biodiversity. The project has continued through 2016, now as "safari" hunts, as more plants remain to be found.

More than 50% of Marin's flora is found in the watershed (only 12% of the area of Marin County)

15% of California's flora is found on watershed lands (0.01% of the area of the state)



The Mt Tamalpais watershed is part of a 300,000 acre complex of publicly accessible wild lands.

Part of an internationally recognized biodiversity hot spot: the UNESCO Golden Gate Biosphere Reserve

THE GOALS

Document current state of flora on Mt. Tamalpais.
Fill taxonomic gaps in collections.
Establish benchmark for exploring shifts in the flora.
Increase local expertise and engagement.

THE METHODS

Volunteers with botanical or photography skills were recruited and trained in specimen collection and pressing, data recording, and photodocumentation.

Organizers formed teams based on interests, skills, and experience of members. After a morning refresher on methods, teams gathered their tools and packets and head to their site.

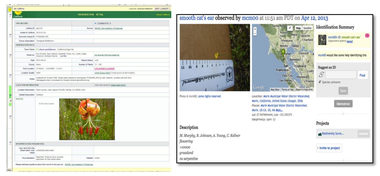
Uncollected reproductive plants were **photographed and collected**; others just photographed.

The team spends about **4 hours in the field**, then returns to base.

Back at base, plants are transferred from field presses to plant presses, arranged and given better ID if needed.

As we searched for fewer, more cryptic or rare species, we switched to roving "safari" mode with fewer people.

Dwarf pearlwort (*Sagina apetala*) tops out at 3 inches tall, and wasn't found until 2016.



We used both **Calflora and iNaturalist** in different years to turn photos into georeferenced observations with notes on abundance and habitat.

Comparison to historic data

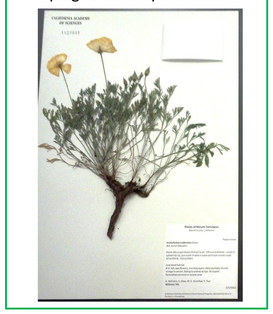
- Searched Consortium of California Herbaria[3] records for "Tamalpais"
- Adjusted records as able to Jepson II nomenclature, combined some non-recognized taxa (822 taxa to 737 taxa)
- Assigned taxa to native, non-native, or unknown status

"Likely Extirpated" list

- Reviewed 1970 "Marin Flora" for taxa noted on MMWD lands but not on MMWD species list
- Reconciled names as able to Jepson II nomenclature and dropped synonyms
- Reviewed additional sources (Calflora, CCH, iNaturalist) and local experts

The "Locally Rare" list includes natives with fewer than 3 known populations.

Pairing Old and New Methods
Herbarium specimen collection is a centuries-old technique to document plant occurrences. New methods such as geotagged digital photography circumvent the old problem of poor location data which plague older specimens.



[3]Data provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/)

THE RESULTS

Bioblitz Totals:
2394 observations

- Of 837 taxa
- Representing 114 plant families
- 1417 specimens
- Representing 826 taxa

- Between 60 and 70 plant taxa appear to have been extirpated from MMWD lands
- We are "adding" non-native species to our list at twice the rate of natives
- An additional 210 species appear to have three or fewer populations

Pre-2012 collections
- 130/3735 specimens (3%) and
- 73/737 taxa (10%) non-native

Blitz collections
- 369/1344 specimens (27%),
- 220/792 taxa (28%) non-native

Early medick (*Medicago praecox*) is a typical new weed.

Reason	Taxa Added	Taxa Dropped	Unsubstantiated Taxa
Observation	115		
Mistaken id	1		
Name change	14	16	
Unrecognized hybrid		2	
No records from area		9	
Prospective rare species		7	
Prospective nonnative species		1	
Presumed extirpated		2	
Records	17		5
			95
Grand Total	**147**	**37**	**100**

70 of 115 "true" adds from surveys are non-native. 100 of 1021 taxa remain unsubstantiated.

Lifeform	Rare	Moisture-dependent	Fire-follower	None of the Above
Annual	6	10	5	12
Fern		3		
Perennial	6	18	1	5
Shrub, Tree	1	1	1	4
Grand Total	**13**	**32**	**8**	**21**
% of Total	**19%**	**48%**	**12%**	**31%**

Likely Extirpated taxa skewed to wet and open sites; 1/5 were already rare. Locally rare species appear similar in habitat and lifeform.

Lifeform	Open areas	Rock outcrops	Chaparral	Chaparral, riparian	Wetlands	Grasslands	Woodlands	Forest gaps	Forests	Grand Total	% of Total
Annual	3		7		6	14	1			31	46%
Fern					2				1	3	4%
Perennial	1	1	1		13	5		2	2	25	37%
Shrub, Tree			3	1				2	2	8	12%
Grand Total	4	1	11	1	21	19	1	4	5	67	100%
% of Total	6%	1%	16%	1%	31%	28%	1%	6%	7%		

THE DISCUSSION

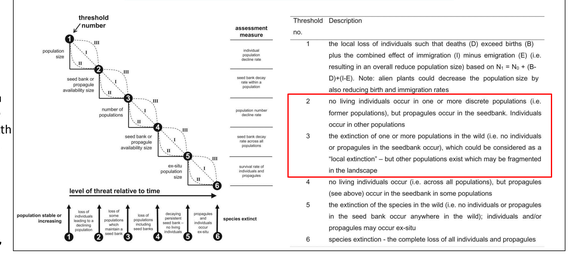
Creating Useful Benchmarks
Many studies, including this one, are using herbarium specimens as a way of looking back, to compare present-day data on phenology or distribution. This project highlights some of the historic lack in location specificity and taxonomic breadth that plague such comparisons, and offers a true benchmark against which future change may be measured.

The **first Tamalpais collection** of Canada goldenrod (*Solidago elongata*); only the sixth specimen for Marin.

Enchanter's nightshade (*Circaea alpina* ssp. *pacifica*) ©2013 Debra L. Cook
Plants abound less than 1km NW of MMWD lands but the last Tamalpais record is from 1939.

West and North
Many of the extirpated species have healthy populations remaining to the north and west, suggesting climate change may already be affecting our flora.

Alien plant invasions and native plant extinctions: a six-threshold framework
Paul O. Downey and David M. Richardson, in AoB Plants 2016
http://aobpla.oxfordjournals.org/content/8/plw047.full



Threshold no.	Description
1	the local loss of individuals such that deaths (D) exceed births (B) plus the combined effect of immigration (I) minus emigration (E) (i.e. resulting in an overall reduce population size) based on $N_1 = N_0 + (B-D)+(I-E)$. Note: alien plants could decrease the population size by also reducing birth and immigration rates
2	no living individuals occur in one or more discrete populations (i.e. former populations), but propagules occur in the seedbank. Individuals occur in other populations
3	the extinction of one or more populations in the wild (i.e. no individuals or propagules in the seedbank occur), which could be considered as a "local extinction" – but other populations exist which may be fragmented in the landscape
4	no living individuals occur (i.e. across all populations), but propagules (see above) occur in the seedbank in some populations
5	the extinction of the species in the wild (i.e. no individuals or propagules in the seed bank occur anywhere in the wild); individuals and/or propagules may occur ex-situ
6	species extinction - the complete loss of all individuals and propagules

Hotspots of Rarity: Extirpated and locally rare species cluster in a few species-rich sites

Likely List Issues
The historic lack in specimen location specificity and taxonomic breadth, coupled with limited record access and potential misidentifications reduce confidence in the "Likely Extirpated" species list. "Locally Rare" species may be under-mapped, but concerted efforts will be made to find and document them.

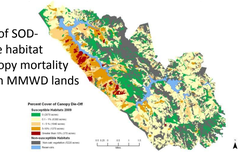
Annual checkerbloom (*Sidalcea calycosa* ssp. *calycosa*) is locally rare: found in a single wet meadow, it also shows up in CNDDB as rare ssp. *rhizomata*, a lump/split error.

Involving Citizen Scientists
Over the course of 30 events, we involved over 200 volunteers in nearly 3,500 hours of plant species documentation. Through thoughtful team formation—pairing expert with novice, repeat with newcomer; assigning tasks and tapping into existing skills—everyone was able to learn, teach, and produce useful information.

Gairdner's yampah (*Perideridea gairdneri* ssp. *gairdneri*) is one of 16 rare or locally rare plants found at one diverse site.

Axes of Extirpation
Habitat preferences of extirpated and locally rare species suggest possible causes:
Climate change, invasive plants, loss of fire, and forest micro-climates and structure altered by disease (Sudden Oak Death)

Over 80% of SOD-susceptible habitat shows canopy mortality on MMWD lands



Implications of Extirpation
The below-posited framework of extinction thresholds shows extirpation as halfway to extinction. While proposed as a way to look at rare species, it is cautionary for our extirpated and locally rare plants.

Pacific dogwood (*Cornus nuttallii*) Photo by Albert Everett Wieslander and the Marian Koshland Bioscience and Natural Resources Library, U.C. Berkeley, www.lib.berkeley.edu/BIOS/vtm/ from Laurel Dell on MMWD lands. Possibly planted in the late 1800's, now dead without offspring. The site has been altered by Douglas-fir invasion, weeds, and Sudden Oak Death.

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