TBC3 Terrestrial Biodiversity Climate Change Collaborative

Pepperwood PRESERVE Inspiring conservation through science

Berkeley UNIVERSITY OF CALIFORNIA

Climate Ready Vegetation Management in the Bay Area: A Pilot Workshop for Land Managers

Workshop Proceedings

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A Dwight Center for Conservation Science **Technical Report**

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EXECUTIVE SUMMARY

Representatives from UC Berkeley and Pepperwood's Terrestrial Biodiversity and Climate Change Collaborative (TBC3) convened a workshop for open space managers and researchers to focus on management responses to vegetation change triggered by changing climate. Through a scenario planning exercise, participants identified current and new conservation strategies that can be implemented under different future scenarios (drought-induced oak-die backs, catastrophic fires, and wetter future) in response to new plant species arriving or expanding, and existing species declining. In addition, the group evaluated the utility of existing vegetation models as decision support tools for climate-smart open space management in the North Bay. The input provided by participants will be used to improve TBC3's Climate Ready Vegetation Reports and Climate Ready Management Implications document, and to inform design of future workshops.

Participants generally found the combination of the scenario planning exercise and presentation of tools like the Climate Ready Vegetation Reports to be useful for identifying applications of existing conservation and management tools to new situations, and considering new strategies in the future. In addition, participants highlighted the need to focus on reevaluating and refining management objectives, as feasible given agency mandates and constraints.

BACKGROUND

Climate change is projected to drive shifts in vegetation and habitats of the San Francisco Bay Area. Under these shifts, conservation strategies based on maintaining historical landscape patterns may be ineffective, prompting changes in management strategies to ensure healthy ecosystems. In a changing climate, will some current conservation tools become maladaptive? Will new conservation goals or new management actions be needed?

To help answer these questions, the TBC3 team developed projections of potential vegetation responses to climate change for several landscape units of the North Bay. The model projections are summarized in Climate Ready Vegetation Reports for several landscape units and a supplemental Climate Ready Management Implications document with suggested management responses to changing conditions (http://www.pepperwoodpreserve.org/tbc3/our-work/climate-ready/; Appendices V and VI).

TBC3 organized this workshop (held at Pepperwood, February 17, 2017) to pilot test a scenario-based approach to address the conservation implications of projected vegetation change, and

to seek feedback on the Vegetation Reports for future revision and development of additional landscape units.

DESIRED MEETING OUTCOMES

1) Participants will identify a) current and new conservation strategies that can be implemented under different future scenarios in response to new plant species arriving or expanding, and existing species declining, b) possible thresholds for shifting to new management tools or objectives, and c) situations in which current actions may become maladaptive.
2) Participants will have a good understanding of how to apply the Climate Ready Vegetation Reports in their management work to plan for the future.
3) Input from participants will help TBC3 improve the Climate Ready Vegetation Reports and Climate Ready Conservation Implications document and other decision support tools for climate-smart conservation and resource management.

GENERAL MANAGEMENT OBJECTIVES

Prior to the workshop, participants filled out a survey with the main management objectives and tools used by their organizations. At the top of list of objectives were the following (though every option except one was selected by one or more participants; Appendix III):

- Protection of biodiversity / natural resources, in particular:
  - Habitat / vegetation matrix
  - Threatened / endangered species
- Protection of water supply / flooding management
- Reduction of catastrophic fire risk
- Management of low-impact recreation

Based on these pre-workshop choices, we focused the discussions during the scenario planning exercise around *biodiversity*, *fire*, and *water*.

Additional comments from participants related to the listed objectives and tools:

- In order for management to be successful, the human social and psychological element is crucial, since it influences how things are done on the ground. We need to create a new land ethic.

- Communication with the public is highly relevant. Here we can take advantage of the fact that people are easily engaged with animal related outreach and science (e.g., wildlife cameras)
- In terms of management for recreation, it is noteworthy that a vast amount occurs in riparian zones
- Elements the survey may have missed:
  - Interest in protection of common species (not only endangered)
  - Management for public health (e.g. clean air, clean water, exercise)
  - Education and nature interpretation

SCENARIO PLANNING EXERCISE

1. Why Scenario Planning?

Scenario planning is a tool that has been developed to enable groups to incorporate uncertainty into their planning process. The tool is intended primarily for situations in which future conditions are highly uncertain and have a great impact on management targets or goals. A set of plausible but contrasting future scenarios are defined, ideally emphasizing the extremes of future possibilities, and then management strategies can be discussed that would successfully achieve management targets and goals in each scenario. Groups can use the process to come up with novel strategies and/or create a shared understanding among diverse stakeholders about the impacts that future scenarios could create and the actions that would be necessary to reduce these impacts. Importantly, scenario planning exercises have proven valuable, even if none of the scenarios represents the actual future that transpires; the process of considering several scenarios enhances planning for a wide range of possible futures.

Stephen Ladyman, the UK Minister for Transport in 2006 summarized the rationale behind scenario planning: “We can either stumble into the future and hope it turns out alright or we can try and shape it. To shape it, the first step is to work out what it might look like.”

Thus, at this workshop, the goal of the scenario planning exercise was to get participants to think creatively about management objectives and tools that can be used under each future scenario.

2. Scenarios

The current landscape was set to be like Southern Mayacamas, dominated by Montane Hardwoods (especially oak woodlands), grasslands, Douglas Fir forest, and some Mixed Montane Chaparral. Part of the landscape is also cultivated or used for urban/residential purposes (Figure 1).

Three scenarios for mid-century were presented for the landscape with storylines representing:

A. massive drought-induced oak-dieback
B. catastrophic fires in the landscape
C. wetter, warm future

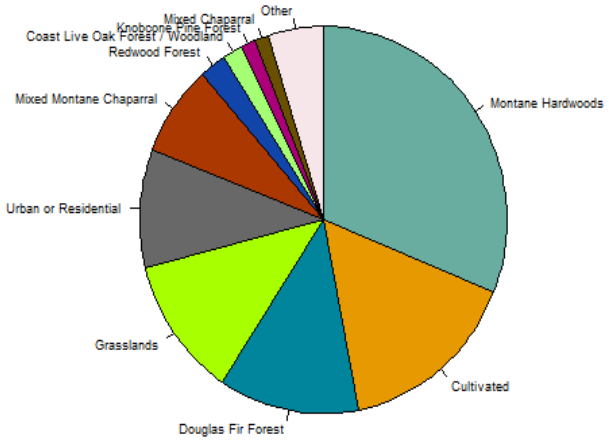

Figure 1 Vegetation types present in the current landscape setting for all future scenarios.

Full descriptions of the scenarios including images are found in Appendix IV.

Participants divided into three break-out groups to discuss each of the scenarios and brainstorm about management objectives and tools. In a second break-out session after lunch, the same groups were asked to summarize novel tools that could be considered, current tools that would make sense to maintain, and current tools that would become maladaptive – all within the areas of biodiversity, fire, and water management, with the option of adding more categories relevant to the scenario.

The following prompts were given to each group to guide discussions in the break-out sessions:

Objectives questions

1) Which conservation and management objectives are challenged under this scenario?
2) What thresholds would trigger consideration of new actions or redefinition of management objectives?

Action questions

3) What management actions (current or new ones) would you implement under this scenario to accomplish particular objectives, if you were allowed to use any measure (i.e. not constrained by your organization's principles, objectives, mandates, or budgets)?
4) What new actions would you consider that are not being implemented today?
5) Which current actions make sense to keep implementing under each scenario?
6) Would any current actions become maladaptive under this scenario?
7) What arguments are there for and against implementing new actions?

3. Participant's Proposed Management Tools

Scenario A – Massive Drought-Induced Oak-Dieback

Common themes and highlights of break-out group discussion:

- Most tools identified were focused on biodiversity protection.
- Participants expressed the importance of embracing change
- Importance of looking at landscape level, beyond a single management unit. This could e.g. apply to seedbanking, although participants expressed discomfort about planting different ecotypes from other parts of California (e.g., warmer climates)
- The importance of education of the public and of wording used to describe change by managers and researchers (e.g. "non-natives arriving" vs. "new natives").

Table 3.1. Proposed management tools identified by break-out group under Scenario A (massive drought-induced oak-dieback). Grey text are additional comments from the joint discussion.

	BIODIVERSITY	WATER	FIRE	HUMANS
Current tools to keep	Erradication of high-priority invasives especially those having impact on biodiversity, but also those that are manageable			
	Downscale climate models			
	Working with the restoration palette you have and allow for expansion as well e.g. removing invasive species in certain areas to allow further establishment of already-existing natives			
	Using traditional knowledge		Low fire (prescribed burns)	
New tools to consider	Larger scale programs to manage matrix (increase habitat connectivity and heterogeneity) e.g. working across reserves and developing comprehensive broad-scale management programs			
	Early detection and rapid response through education of volunteers		Experiment and research with new tools, e.g. burning grass around oaks to get more water thus reducing water stress on oaks	Revise semantics e.g. terms like 'invasive' – from different county? different country/continent?
	Management heterogeneity (use multiple strategies)			Become better story-tellers of how we tell what changes are occurring
	Expand plant palette and work with those you have			Educating public to value new communities and accept change
	Find ways to enhance new niches			

Table 3.1 (cont.)

	BIODIVERSITY	WATER	FIRE	HUMANS
New tools to consider	Plant southern oak species i.e. species/individuals from warmer, drier habitats			
	Moving wildlife populations			
	Moving plants across topography (microsites!) i.e. planting ecotypes			
	Seed banking (beneficial for connecting landscape units)			
	Anticipate new pathogens			
Tools becoming maladaptive	Hold on to dying oaks! generally holding on to familiar state of plant communities			

Alison Forrestel presents discussion results from break-out group on fire scenario. Photo: David Ackerly

Scenario B – Response to Catastrophic Wildfire

Common themes and highlights of break-out group discussion:

- "Let nature be nature" standpoint (some participants surprised about consensus around this)
- Fires are very different, so scenario was very general (though hard to make specific enough)
- In real world: would do a post-fire assessment of how severe fire and its impacts were
- Ideally, we need to plan for different scenarios of intensity and severity
- Fire goal: mosaic on landscape

Table 3.2. Proposed management tools identified by break-out group under Scenario B (response to catastrophic wildfire). Grey text are additional comments from the joint discussion.

	BIODIVERSITY	WATER	FIRE	ALL
Current tools to keep	Traditional weed management of classic non-native species, and new arrivals post-fire. A grey area is if species arrive from nearby gardens	Erosion control to manage sediment	Fuels management	Education
	Accepting changes in vegetation composition what choice do you have?	Seed amplification	Defensible space	
	Replanting iconic species* e.g. redwoods			
New tools to consider	Planting species better adapted to future climate* incl. genetic mix, getting seed from an ecoregion and not just from within a single watershed			
	Embracing changes in vegetation composition e.g. more serotinous pines			
	Seed bank of prelisted species			
Tools becoming maladaptive		Planting sterile seed for erosion control		

*Tool that potentially would bring other challenges if implemented

Scenario C – Warmer, Wetter Future

Common themes and highlights of break-out group discussion:

- Some historical management practices such as preventing conifer encroachment may not be effective
- Managing for constant change – the philosophical context plays into specific management suggestions
- We may need vocabulary to explain situations related to assisted migration, for instance with articulated goals, a higher focus on process (e.g. keeping same level of diversity, flavor of diversity change)

Table 3.2. Proposed management tools identified by break-out group under Scenario B (warmer wetter future). Grey text are additional comments from the joint discussion.

	BIODIVERSITY	WATER	FIRE	CAR-BON	ALL
Current tools to keep		Grazing exclusion from riparian areas		Grazing	
		Watershed restoration to reduce erosion issues (e.g. remove dams)			
New tools to consider	Early detection, rapid response through education of volunteers	Move infrastructure (campgrounds, roads, trails) out of flood zones including new larger flood zones	Open space managers engage county and city planners to have fire breaks (and flood control) built into their development instead of in parks		
	Focus on natural processes and resilience more than specific biodiversity goal				
	Expanded vegetation and "indicator" monitoring (e.g. of creeks, incl. development of new metrics)				
	Management focused on regional/landscape level perspective				
	More prescribed fire for invasives control and fuels management (something we struggle to do in the Bay Area)				
Tools becoming maladaptive	Succession management controlling doug-fir				Keeping specific mandates for park management if those may change in future may need to e.g. rename parks designated to manage certain resources (e.g. Joshua Tree NP)
	Sudden oak death management since it is expanding, management attempts may not be worthwhile				

4. Joint Discussion

Participants noted several observations from the field that made scenarios believable, and that several of the 'future' changes are already happening. For instance, *manzanita seedlings* are often found under oak canopies, so it is realistic that they would expand in case of drought-induced oak diebacks. *Sudden oak death* (SOD) is already observed, e.g., Jack London Park. Here small-scale efforts in management are in place, but mostly they are noting changes in SOD distribution across the landscape. Over the last 20 years, issues like those described in the scenarios have taken place (e.g. 2014-2016 drought and winter 2017 wet year), and managers have had to address them. *Cost* is the most limiting factor to managing in a preventive way. Maybe a major change is the spreading sense that we (humans) are *responsible* for many of these largely climate change-induced changes.

Climate change will likely have impacts on *budgets*. This happened recently with Governor Brown's veto of an education bill, in part because firefighting took up the entire budget. Conservation land managers in some cases feel more responsible for the effects on our *built environment*.

The scenarios are not mutually exclusive – some elements could happen across all of them. We expect that what is the *extreme* now could become more normal.

Some tools identified that were relevant to all three scenarios

- Improving monitoring metrics for successive management, including metrics to determine when to abandon a certain approach
- For catastrophic events such as floods, resource advisors could be useful (expanding the current model for wildfires)
- Continuation of modelling efforts
- Communication of new park priorities

What kinds of things trigger changes in management?

- Public pressure is a huge motivating force, e.g. when agencies and managers are asked "what do you notice and what are you doing about it now?"
  - This can be used to harness momentum and engage possible funders
  - On the other hand, public pressure can be tough if it pushes for actions undesirable to managers
- More risk-adverse agencies such as NPS do ask for management experiments (e.g. at Pepperwood)
- Ultimately, it boils down to availability of resources
  - It is relatively easy to abandon tools, but more difficult to add anything to the mix
  - More regular maintenance/interventions hard to do

Perceptions of success and failure

- Need to change cultural perceptions
- Failing at new endeavors is not the worst-case scenario – rather, it is not sharing information about failures with other managers and the public

Communication

- Need to communicate specific conservation goals to the public

Abandoning certain management efforts

- Only way is to have clearer, quantifiable management objectives
- No action pathway may be taken based on resource constraints, based on manager's intuition, or because management objectives change

Treating management endeavor as an experiment

- Anecdotal information is better than no information, even if we cannot always present statistically robust experiments including controls.
- Without enough replication, we have case studies, but sharing those will ultimately lead us to robust statistics (meta-analyses possible)
- Hypothesis-driven land management is already happening now at the non-profit level
- Applying same treatment in multiple parks may be more interesting than only using one, where local design limits what you can derive from an experiment.
- Examples:
  - Pepperwood:
    - adaptive management plan just finalized, including rationale for management for each habitat.
    - 50 plots studied by Ackerly lab, looking at whether intensity of climate change will be differential. Hesitant to add experimental treatments across plots as it would lessen statistical robustness.
  - STRAW Project (Students and Teachers Restoring a Watershed) at PointBlue: trying new planting palettes, and thinking about food resources for wildlife to be available through different seasons.
- Challenges:
  - hard to evaluate success of intentionally planting for the future, since change may not come for a while
  - resource availability may limit experiments – can explore options of engaging students to try different treatments across the landscape

TBC3'S CLIMATE READY VEGETATION REPORTS

The afternoon program was dedicated to a presentation and discussion of the bioclimatic modelling and thoughts behind the Climate Ready Vegetation Reports (Appendix V & VI). The presenters put an emphasis on the fact that models are focused on patterns, since it is hard to model actual processes (e.g. trees dying, dispersal, etc.). The model predictions show the expected direction of change based on climate change scenarios. In practice, change will depend on triggers such as droughts, fires, and management choices.

Will updated climate models be included in the bioclimatic models as they become available?

There are no plans to include new climate models. Climate model accuracy will obviously be better the closer we get to mid- and end-century. However, new models are unlikely to change projections of vegetation change very much. The state of California is deeply engaged in climate adaptation planning and has chosen 10 models they think will be the best representation of possible futures.

Could maps of change in climate suitability for each species be made available?

Maps can give a false impression of precision of expected changes at sites within management landscape units. By giving average trends of change across the whole landscape units, the thought is that managers can use their local knowledge of microrefugia and distribution of particular populations to identify areas most susceptible to change. Maps could be provided, but likely at coarser resolution than modelled simply to give a sense of the direction of changes across the Bay Area and trends in neighboring landscape units.

Feedback on Climate Ready Vegetation Reports

- most useful for informing planting palettes
- filling a gap for informing climate adaptation
- nice that they are short, as managers then have time to read them
- highlight species already on properties that are worth monitoring (reluctant to plant projected new arrivals)
- a useful next step would be to look specifically at restoration palettes.

WORKSHOP EVALUATION

In general, participants found the scenario planning exercise effective for generating new ideas for climate adaptation management. Scenarios were realistic (maybe a little too realistic and not futuristic enough?), and funneling general ideas into a concrete table was useful.
89% of participants (see Appendix VII) agreed that they developed a better understanding of how to use the Climate Ready Vegetation Reports, and intend to integrate them in their management work. 89% also agreed that thanks to the workshop they can now better identify conservation strategies in response to new species arriving and species declining due to climate change effects. However, participants disagreed on whether they were now better able at identifying situations in which current management actions may be maladaptive.

Most (66%) participants neither agreed nor disagreed that they can better identify environmental thresholds at which to shift management tools or objectives – organizers of future workshops should make sure to cover this issue more specifically.
All participants felt better equipped to tackle challenges in maintaining ecosystem health in the face of climate change.

Overall, there was an interest in ongoing engagement. For instance, participants recommended the organizers to follow-up with managers in the future and see if any new tools are being implemented, and to adapt the post-it activity (table summary of management suggestions) for internal use within management organizations. Such future engagement is feasible via Pepperwood's Fire Mitigation and Forest Health network.

CONCLUSIONS

The scenario planning exercise was helpful to give more visceral examples of what the future projections may look like on the ground for the participants to identify climate-smart management actions. Many of the actions identified were already in the management toolbox or relatively slight modifications of existing tools.

Participants found high value in thinking about management challenges that went beyond their organization's mandate, and sharing knowledge, attempts and failures at implementing climate-smart actions with adjacent land managers. One participant acknowledged that

adaptive management and knowledge from experiments is moving forward (compared to several years ago when TBC3 work began).

During the course of the workshop and a post-workshop evaluation meeting it became clear that measurable, time-bound management objectives need to be defined, clarified, and evaluated. Many conservation organizations do not have clear conservation objectives in place, yet these are needed to evaluate success of actions and to define climate change thresholds at which objectives or actions may need to be changed. An additional point that was not addressed sufficiently was whether thresholds for action would be considered based on modelled projections or only based on monitoring, and it may be that threshold-based management planning is not commonly used in this context.

A future workshop could revise the agenda of this pilot workshop to cover management objectives more specifically, as well as cover thresholds for action. Materials and instructions could be made available so that an internal workshop can be offered at conservation organizations (potentially with one member of TBC3), adjusting the agenda to target discussions to be more specific to the management plans of each organization. A full day workshop may not be entirely necessary (and is a very large time commitment), though more time for producing the table summarizing management tools was desired. Alternatives could be: 1) use the second break-out session on more extreme scenarios relative to the first round to help identify thresholds for action, 2) use two scenarios instead of three and swap groups so everyone has time to discuss both, 3) a World Café format where everyone rotates with one moderator at a separate table for each scenario, 4) a land management board game, where two scenarios and two sets of objectives are addressed, having participants prioritize limited 'tickets' (funds) – this could help identify trade-offs, win-win actions, and thresholds for action. Conference presentations and Pepperwood's Fire Mitigation and Forest Health network could be used for outreach to communicate the possibility of a workshop like this to other organizations.

APPENDIX I: AGENDA

9.00	Sign-in and Coffee
9.30	Meeting goals and overview
9.40	Introductions
9.45	**Scenario Planning Exercise** 1. Shared management objectives for purpose of exercise
10.00	2. Visualizing future vegetation scenarios for the North Bay
10.30	3. Break-out prompts and instructions for groups around each scenario
10.40	BREAK
10.50	4. Break-out sessions (1st round): what management strategies would work well for your scenario under unlimited funds and mandates?
11.45	5. Re-grouping with reporting and new prompts for 2nd round of break-outs
12.00	LUNCH (Provided)
12.30	6. Break-out sessions (2nd round): summarizing results of 1st round; what management strategies would be plausible under your organization's funding and mandate levels?
1.00	7. Report back from break-outs and joint discussion
2.00	BREAK
2.15	**Modelling & Vegetation Reports** 1. Overview
2.45	2. Discussion
3.30	**Evaluation of workshop -** did we achieve the desired outcomes?
3.45	Closing thoughts
4.00	Adjourn

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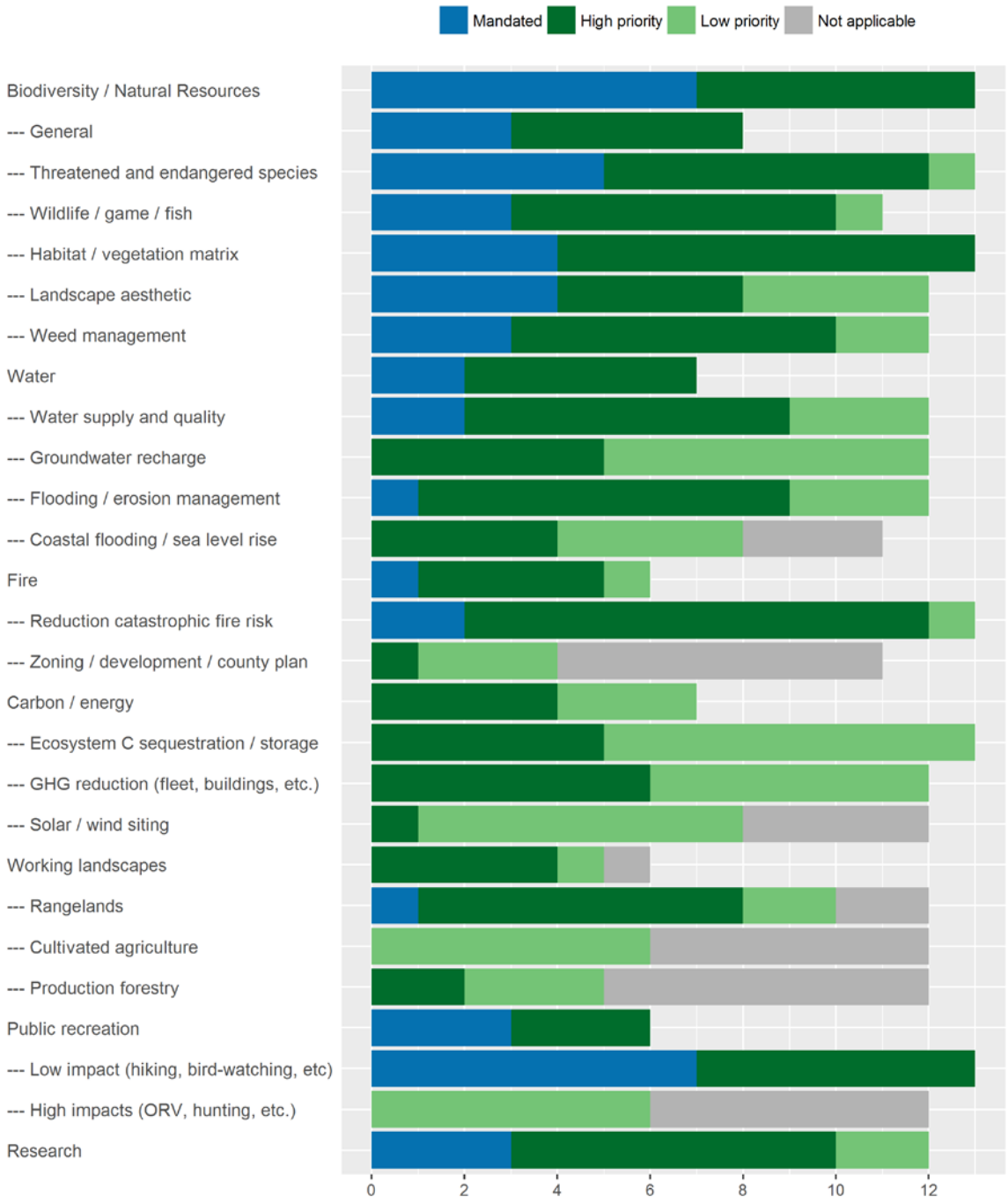
APPENDIX III: ANSWERS TO PRE-WORKSHOP SURVEY

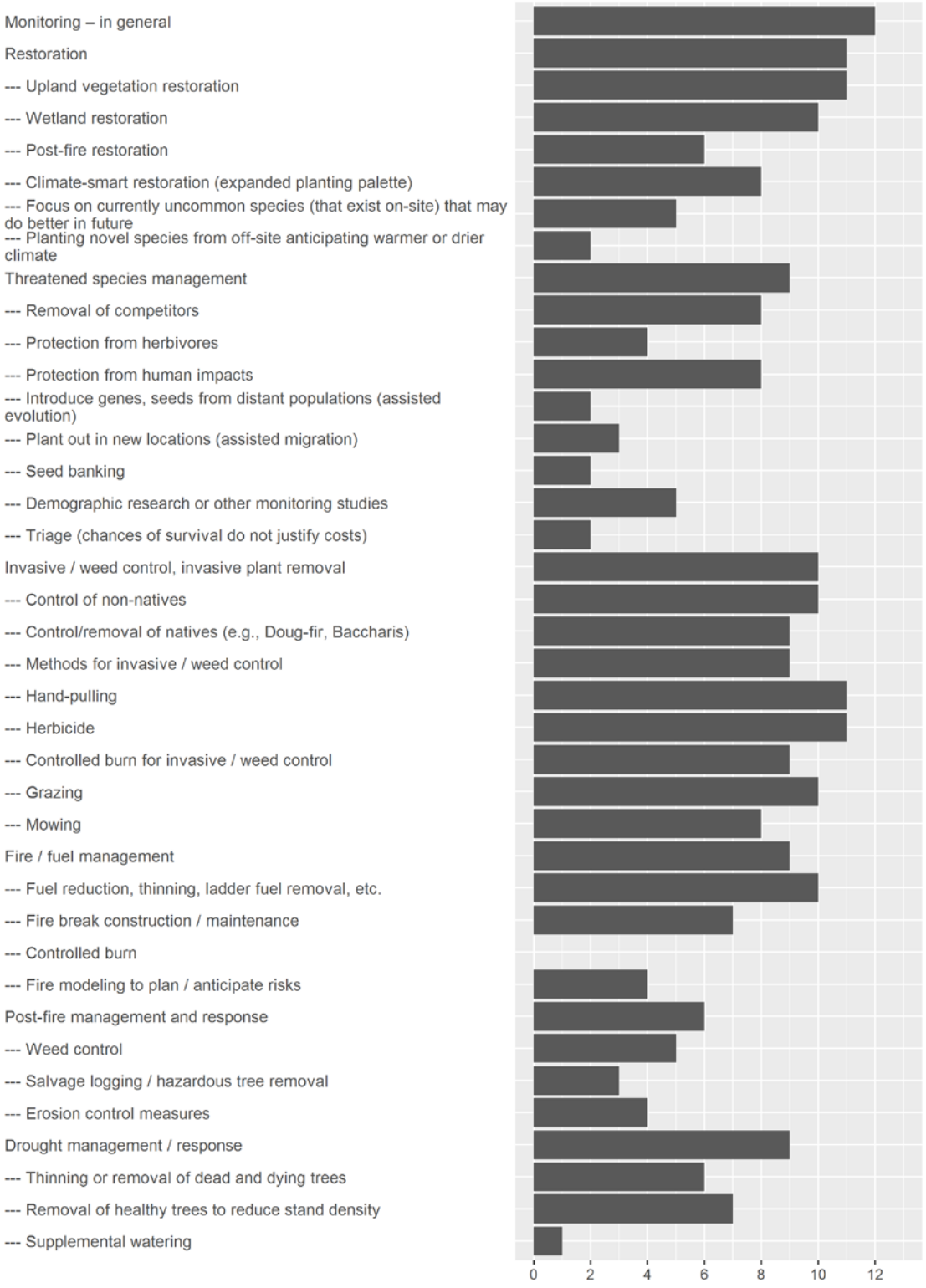
Number of responses: 13

What are primary management objectives for your organization?



APPENDIX III (CONT.)

What methods, approaches and tools does your organization use, and not use, to accomplish your goals?



APPENDIX IV: SCENARIO DESCRIPTIONS

Scenario A

Scenario A:
Massive drought-induced oak dieback

What's the mid-century situation?

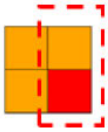
- Droughts like the one observed in 2012-2015 have been increasing in frequency
- Over the course of five years, 25% of the oaks in the landscape have died due to the repeated droughts, including many individuals over 300 years old
- Blue oaks have been setting very small leaves for a few years, with very low acorn production.
- Others, including valley oak, are shedding 40% of their leaves prematurely
- Groundwater table is very low - even oaks in valleys with deep soils are showing signs of die-back
- Tree mortality is higher on south facing slopes
- Hot, south facing slopes are particularly prone to new invasives (brooms, etc.)
- Several shrubs are thriving and expanding under dead oaks and edges of woodlands: Coyote Bush (*Baccharis pilularis)*, Toyon (*Heteromeles arbutifolia*), Manzanitas (*Arctostaphylos* spp)
- Models suggest the oak dieback will continue to get worse

Scenario A (cont.)

What does it look like?

Dying blue oaks, especially on south facing slopes Photo: Todd Dawson

Struggling oaks

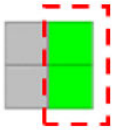


Miniature leaves produced by blue oaks during 2015-2016 drought in San Luis Obispo county, compared to normal leaves below. Photo: Todd Dawson

Toyon. Photo: Wikimedia Commons, Miguel Vieira

Manzanita. Photo: Wikimedia Commons

Thriving bushes



Coyote bush. Photo: Wikimedia Commons, Franco Folini

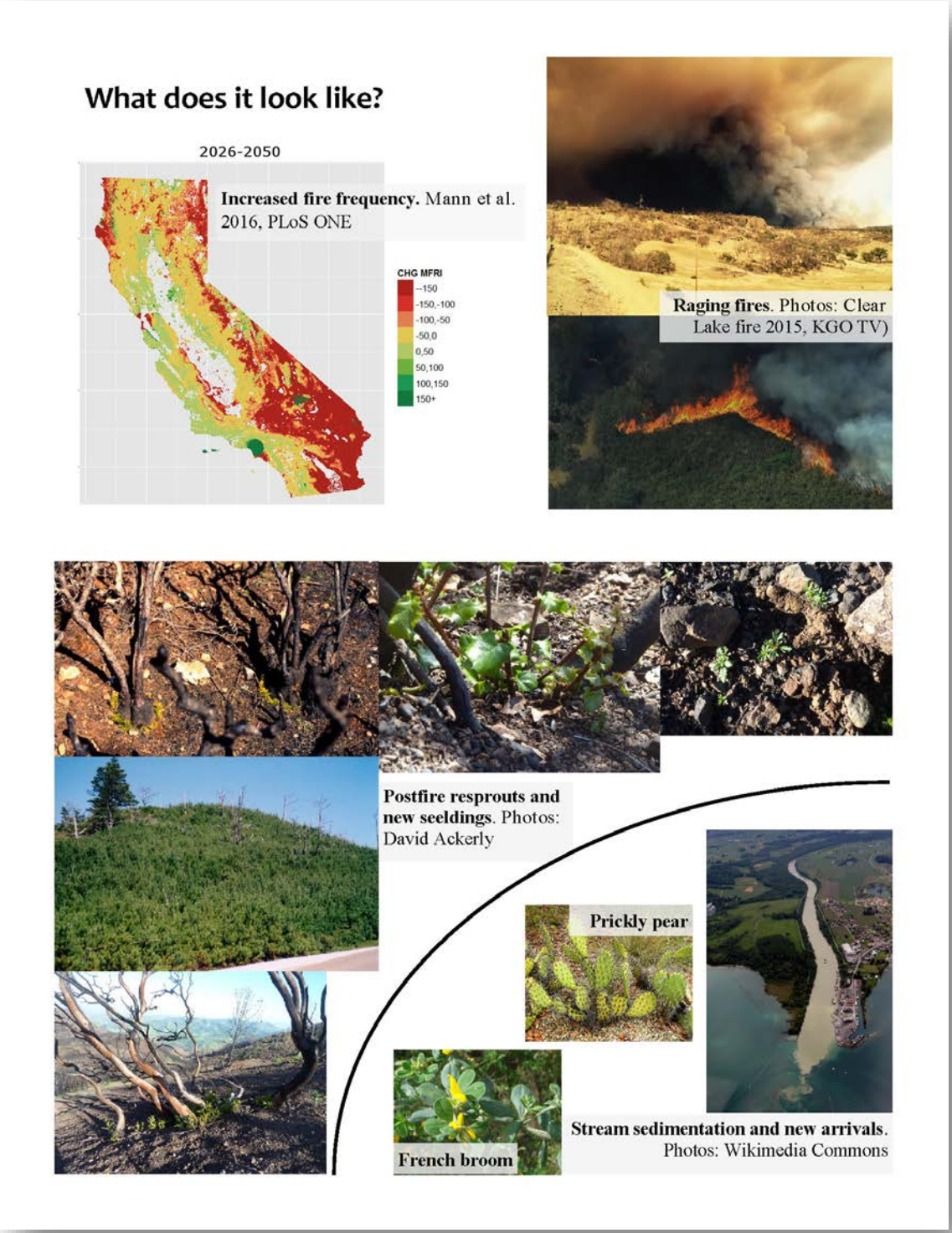
Scenario B

Scenario B:
More extreme fire regime

What's the mid-century situation?

- A large fire burnt 5 years ago. Warmer, drier climate, and spread of serotinous pines makes a new fire more likely.
- Post-fire effects on existing vegetation:
  - Oaks resprout, canopy recovery could occur over 10-20 years
  - In the short term, resprouters are more resilient to drought (due to small leaves, and large root systems)
  - Seeds from Grey pine (*Pinus sabiniana*) and Knobcone pine (*Pinus attenuata*) germinate and populations are spreading on landscape. Population recovery/establishment only possible if they reach reproductive age before next fire
  - Chamise Chaparral, previously only in about 5% of the landscape, is spreading across 30% of the landscape, along with other chaparral shrubs: Manzanita (*Arctostaphylos* spp), California lilac (*Ceanothus* spp), Coyote Bush (*Baccharis pilularis*)
- Post-fire 'new native invasives':
  - Semi-Desert Scrub vegetation becoming more common
  - Southern California natives now observed occasionally, either as new dispersals or escaped from gardens
  - California sagebrush (*Salvia mellifera*) (currently present on Mt. Diablo), Chaparral cherry (*Prunus illicifolia*), Coulter pine (*Pinus coulteri*)
- Rare, but present:
  - Prickly pear (*Opuntia littoralis*), Chaparral yucca (*Hesperoyucca whipplei*)
- Post-fire invasives:
  - Invasives such as French broom (*Genista monspessulana*) and Scotch broom (*Cytisus scoparius*) increasingly hard to control
- Other effects:
  - Parks closed periodically post-fire due to risk of tree falls on visitors
  - In the season following a fire, streams have sediment problems

Scenario B (cont.)



Scenario C

Scenario C:
A wetter, warmer future

What's the mid-century situation?

- More annual precipitation, but still drier soils in summer because of the higher temperatures (winter 2016-17 conditions more frequent)
- Rain comes in brief, but more intense storms
- Douglas fir (*Pseudotsuga menziesii*) finds more suitable conditions in the North Bay
- Douglas fir continues to invade grasslands and overgrow oak woodlands, in the absence of fire
- Higher ecosystem productivity increases the risk of more intense fires, where larger areas get burnt
- Larger human populations, with sprawl allowed, means urban-wildland interface is larger, increasing the probability of ignition and pressure for fire suppression and protection of homes
- Sudden oak death continues to expand in the landscape
- More intense rains lead to increased erosion, with consequences for terrestrial ecosystems, trails, and streams.
- New exotic species appear because of the amounts of soil moved to deal with landslides in riparian areas
- Camping grounds get closed periodically due to flooding
- Mudslides and tree fall happen more frequently, and soil structure is changing
- Resources are diverted to erosion control due to road failure and tree fall

Scenario C (cont.)

What does it look like?

Douglas fir. Photo: Wikimedia Commons

Growing urban-wildland interface. Photo: Wikimedia Commons

Sudden oak death. Photo: Wikimedia Commons

Oroville dam 2017. Photo: City of Oroville

APPENDIX V: VEGETATION REPORT EXAMPLE

Climate Ready Vegetation Report

Southern Mayacamas Landscape Unit

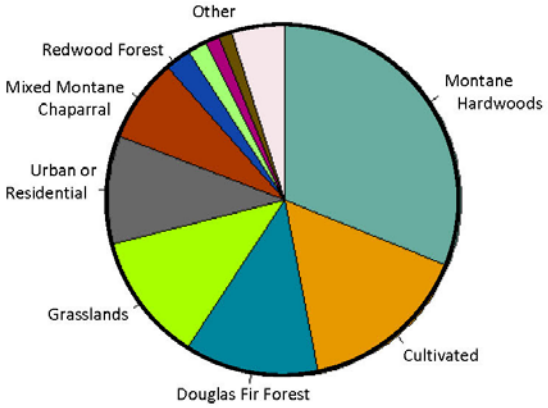
How is a changing climate going to impact vegetation native to the Bay Area?

The San Francisco Bay Area's climate is already changing in ways that may impact which plants can grow where–the spatial pattern or distributions of native plant communities. From coastal redwood forests to stands of blue oaks in inland valleys, the diversity of local plant communities today reflects the region's steep climate gradients, complex topography, varied soils and history of ecological disturbance and human land use.

This report summarizes current conditions and potential climate change impacts for one of the Bay Area's 35 "landscape units" (as defined by the Bay Area Open Space Council's Conservation Lands Network). The last page provides links to additional information on Bay Area climate impacts, how scientists use computer models to estimate which plants may be resilient or vulnerable in the face of projected change, and recommendations for land managers.

Southern Mayacamas: Current Natural Land Cover

The pie chart to the right shows land cover for Southern Mayacamas landscape unit, which is currently dominated by montane hardwoods, douglas-fir forest and grasslands with significant representation of mixed montane chaparral, redwoods and coast live oak.



What will the Bay Area climate be like in the future and how might it effect vegetation?

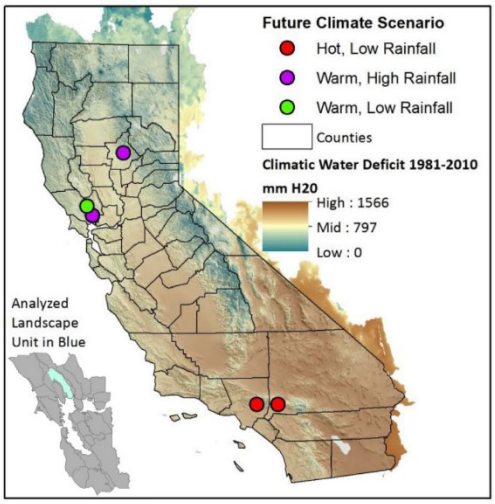
By the end of the 21st century, average temperatures in the Bay Area are likely to rise at least 3-4°F, and possibly as much as 8°F, depending on the trajectory of greenhouse gas emissions. Rising temperatures will intensify the summer dry season, while also moderating the occasional winter frost. Changes in rainfall and the duration and intensity of future droughts are hard to predict. Warming temperatures and changes in rainfall may also lead to an increase in wildfire. These changes will in turn impact local vegetation in ways that can eventually lead to shifts in the distribution of native plant communities. On the next page you can visualize climate change by thinking about what locations in California already experience the climate that is projected for this landscape unit in the future.

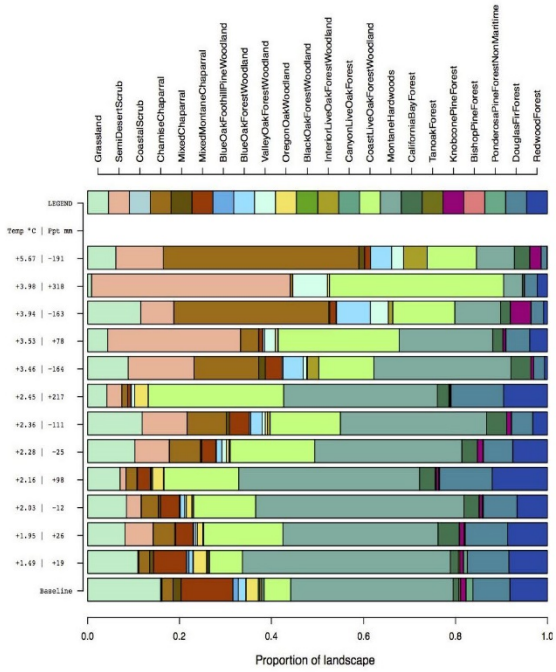
Southern Mayacamas Vegetation 1

APPENDIX V (CONT.)

Understanding potential climate change using "climate analogs"

A "climate analog" is a place that today has the climate (including temperature, rainfall, and soil moisture) that most closely matches what is projected for a place of interest in the future. This map is colored to show the relative aridity (climatic water deficit or CWD) of soils, with blue less arid and brown more arid. Colored dots show "climate analogs" for the Southern Mayacamas unit. There are a variety of analogs for mid-century climates for this landscape unit ranging from Plumas to San Bernardino counties, as shown in the map to the right. Shifts in climate of this magnitude could cause vegetation to change along trends shown in the stacked bar chart below.





The lowest bar in this stacked chart represents current land cover. As you move up the stack future temperatures increase and the relative area of climate suitability for each vegetation type is shown.

What might the future vegetation of Southern Mayacamas look like?

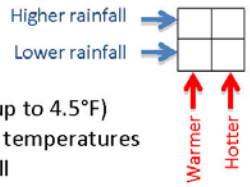
Potential changes in vegetation suitability across a wide range of future climate scenarios are arranged here in order of increasing temperature (bottom to top). As temperatures warm, intensifying the summer dry season, future conditions for the Southern Mayacamas may favor the expansion of drought adapted vegetation such as chaparral and possibly evergreen live oaks as well. These changes may occur slowly over many decades (or even centuries!), as long-lived trees eventually die off, and are replaced by other species. Major disturbance events, such as fire or drought-related tree mortality, may speed up these transitions. Seed dispersal, the way a plant produces and spreads its seeds, will be a key factor that may limit the expansion of well-adapted species or favor invasive weeds as conditions change, particularly after a major disturbance.

APPENDIX V (CONT.)

What are the potential native plant winners and losers for Southern Mayacamas?

The color shows the projected response of vegetation to future climate.
Red: Dramatic Decline - 25% less than current
Orange: Moderate Decline - 25-75% less than current
Gray: Relative Stability - 75-125% current
Green: Increase - 125% more than current

The four squares represent different climate futures: combinations of warmer (up to 4.5°F) vs. hotter (+4.5°F or more) temperatures and lower vs. higher rainfall



Possibly Expanding		Chamise Chaparral		Occupies hot, dry, steep slopes, and favorable conditions are projected to expand throughout the Bay Area under future climates. Seed dispersal and establishment may limit expansion. For existing chaparral stands, succession to oak woodland can happen over time in the absence of fire.
		Knobcone Pine		Knobcone pine is uncommon in our region, but could expand under hotter and drier conditions.
Likely Stable		Baccharis		Aggressive invader of grasslands in the absence of fire or grazing, and spreads rapidly in wet years. Models project expansion in interior regions of the Bay Area, especially under higher rainfall future scenarios.
		Blue Oak		Models disagree on the fate of Blue Oak. Native range includes very hot and dry locations, but it may be negatively impacted by warmer winters near the coast and loss of groundwater. Recruitment failure has been observed in parts of California, possibly due to competition with grasses and impacts of grazing.
		California Bay		Sensitive to hot, dry summers, but responds positively to warmer winters; the balance of these two makes projections uncertain. Bay regenerates vigorously from seed and seems to be expanding in many North Bay woodlands.
		Coast Live Oak		Reaches its northern range limit in the Bay Area, and may persist or even expand under warmer climates. While it is sensitive to warmer summers, it may be favored by increasing winter temperatures.
		Valley Oak		Endemic to California. Valley Oak is usually dependent on access to groundwater. Recruitment failure has been observed in some populations over the past decades. Models predict some declines under future climates, mainly in response to drier summers and/or warmer winters.
Possibly Declining		Douglas-fir		Establishes in grasslands, shrublands and oak woodlands, and in the absence of fire invades and overtops oak woodlands. It responds positively to modest winter warming, but is sensitive to drier summers and reduced rainfall.
		Oregon Oak		Near the southern limit of distribution along the California coast. Declining suitability is projected under all future climate scenarios, due to drier summers and warmer winters. Recruitment failure has been observed in some populations, though causes are uncertain.

Southern Mayacamas Vegetation 3

APPENDIX V (CONT.)

Priorities for biodiversity conservation

Land protection is more critical than ever to protect biodiversity in the face of climate change. Plants and animals need large, well-connected areas of natural and working landscapes. The landscape itself has a strong influence on local climate diversity and resilience. Rugged terrain creates variable conditions, including cold air pools in valley bottoms, hot dry south-facing slopes, and mesic north-facing slopes. Conserving a range of conditions via our Conservation Lands Network will enhance the resilience of living systems' in the face of climate change. Cool and moist locations can serve as "climate refugia". Enhanced connectivity between protected areas could provide important migration pathways for plants and animals adapting to climate change. For species of concern, including those that only occur in California, protecting both current populations and locations where they can live in the future may be critical to long-term survival. Co-benefits of land protection include water supply, water quality, reduced carbon emissions, and higher land values and quality of life for neighboring communities.

How to learn more

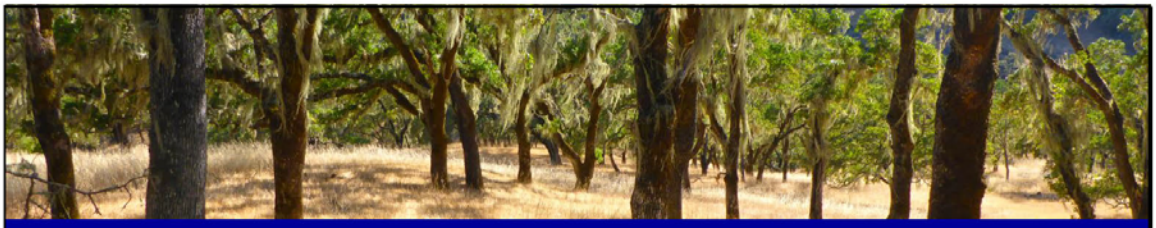
- To access a companion summary report of management implications based on this vegetation modeling see http://www.pepperwoodpreserve.org/tbc3/our-work/climate-ready
- For details on the vegetation modeling summarized here, see http://www.pepperwoodpreserve.org/tbc3/our-work/vegetation-impacts or for the peer reviewed research paper see Ackerly et al. 2015, "A Geographic Mosaic of Climate Change Impacts on Terrestrial Vegetation: Which Areas Are Most at Risk?", *PLOS ONE*, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130629
- For more information about current vegetation types and distribution, conservation goals, land use and climate in landscape units and other areas of interest, see the Conservation Lands Network report and Explorer Tool http://www.bayarealands.org
- For more information about projected climate change and impacts on watershed hydrology used for the vegetation modeling, check out the USGS Basin Characterization Model: http://climate.calcommons.org/article/featured-dataset-california-basin-characterization-model
- For more information about California conservation in an era of changing climate see Chornesky, E. A. et al. 2015, "Adapting California's ecosystems to a changing climate", *BioScience*, http://bioscience.oxfordjournals.org/content/early/2015/02/06/biosci.biu233.abstract

Special thanks to TBC3 team members, Climate Ready North Bay partners and the Gordon and Betty Moore Foundation.

Pepperwood PRESERVE · Berkeley UNIVERSITY OF CALIFORNIA · Point Blue Conservation Science · USGS science for a changing world · Creekside Science · Bay Area Open Space Council

Southern Mayacamas Vegetation 4

APPENDIX VI: MANAGEMENT IMPLICATIONS DOCUMENT



Biodiversity, ecosystems and land management in the face of a changing climate

Recommendations for land managers in the San Francisco Bay Area

Land Conservation is more critical than ever to protect biodiversity in the face of climate change. Species need to migrate to track suitable climate and the more habitat that is available, the more likely dispersal will be successful. The landscape has a strong influence on local climatic conditions. Rugged terrain creates variable conditions, including cold air pools in valley bottoms, hot dry south-facing slopes, and moist north-facing slopes. Conserving a range of landscape conditions (e.g. via the Conservation Lands Network) will enhance living systems' resilience in the face of climate change. Cooler, moister locations may serve as "climate refugia" (areas where a species can survive during otherwise unfavorable conditions). Enhanced linkages between protected areas will provide migration pathways. For species of concern (e.g. threatened, rare and California endemics), protecting both current populations and locations where they are likely to live in the future will be critical to long-term survival. Co-benefits of open space protection include greater water supply and water quality, increased carbon sequestration, and higher land values and quality of life for neighboring communities.

Fire: Climate change is expected to increase the frequency and intensity of wildland fire due to more hot, dry weather that in turn increases the flammability of vegetation. If winter rainfall increases, faster plant growth can increase available fuel loads, particularly given current fire suppression practices. Fuel reduction, such as forest thinning or prescribed burns, is an important management tool. Revegetation and succession management following fires provides an opportunity to promote a diversity of species likely to succeed under future climates. It is important to ensure availability of seed stock of climate-adapted species for post-fire treatments, both by protecting native populations and enhancing available nursery stock.

Grazing is an important management tool for grasslands that can promote native vegetation, especially in wetter grasslands, vernal pool systems and serpentine, where competition with non-native grasses and other invasive species is strong. Carefully managed grazing can be a valuable part of a manager's toolbox to enhance water retention and carbon sequestration in grassland soils. Grazing may also be useful to reduce fuel loads and fire risk, suppress woody plant encroachment, and in some cases compensate for the impacts of atmospheric nitrogen deposition. A good source for grazing management is the "Grazing Handbook – A Guide for Resource Managers" by the Sotoyome Resource Conservation District which is available online. Also see Point Blue Conservation Science, Water and Working Lands.

APPENDIX VI (CONT.)

Invasive Species: Non-native, harmful species will continue to pose threats to local ecosystems, especially following disturbances such as wildfires and drought-induced tree deaths. Early detection and control efforts are critical, especially where conditions are projected to improve for invasive species. The California Invasive Plant Council provides an online CalWeedMapper tool with information on climate change and invasive plants.

Restoration in a Changing Climate: Habitat enhancement strategies have traditionally focused on restoring degraded habitats to historical baseline conditions, relying on local seed sources where available. In the face of rapid climate change, this may not be best approach to ensure success under novel conditions. Planting a broader range of genotypes (high genetic variation) within species and perhaps even including non-local species may need to be considered. Climate analogs for a site of interest may be helpful for long-term restoration planning. However, given the uncertainty around future trajectories, planting non-local species based on projected future suitability may be premature. The risks and benefits of using new reference sites and non-local versus local seed are best assessed by the land manager on a case-by-case basis. Some general recommendations include the following.

- Use an experimental approach: test the introduction of new genotypes and species initially in small areas and compare survival rates, pathogen or insect vulnerability, and competitive success across multiple years.
- Be proactive about seed collection and nursery propagation to be prepared for opportunities (e.g., widespread fire) to set systems on climate-adapted trajectories:
    - Collect seed from across climatic conditions within or near your site to capture potential genetic variation along environmental gradients.
    - Collect seed from drier and hotter areas within the distributions of target species, and from other native species adapted to hotter and drier conditions which currently may not be widely used in restoration.

Also see Point Blue Conservation Science, Climate-Smart Restoration.

Monitoring: Biodiversity and environmental monitoring is critical to long-term conservation success. Important targets include foundation species that create and define major habitats, climate change sensitive species that are likely to decline, as well as species projected to persist or positively benefit from climate change. Changes in phenology, recruitment and mortality may provide early indicators of longer-term impacts of climate change. Collaborative monitoring, coordinated at the regional level will enhance the value of monitoring data; in the North Bay, contact Pepperwood Preserve to learn more about ongoing monitoring projects and partners at tbc3@pepperwoodpreserve.org.

Special thanks to TBC3 team members and the Gordon and Betty Moore Foundation.

Pepperwood PRESERVE Berkeley UNIVERSITY OF CALIFORNIA

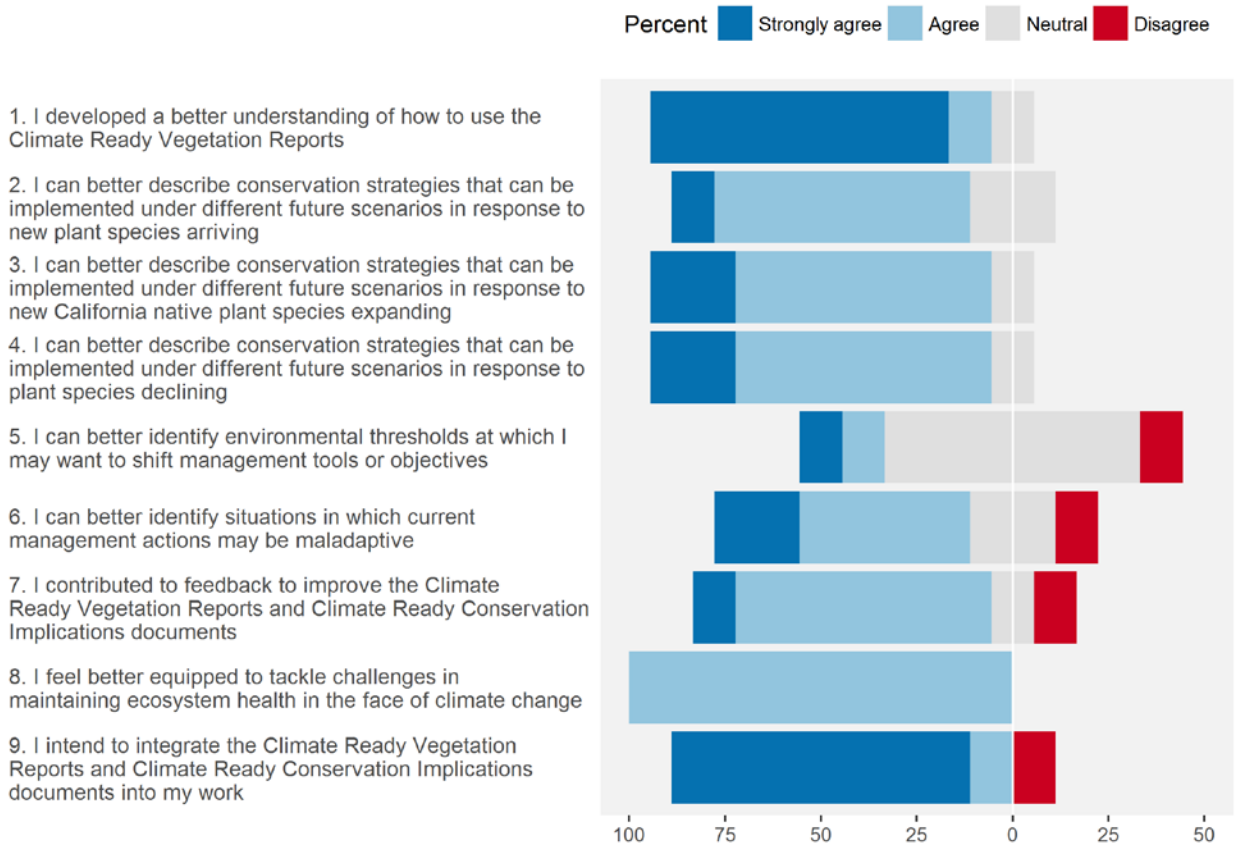
For more information see www.pepperwoodpreserve.org/tbc3.

APPENDIX VII: EVALUATION RESPONSES

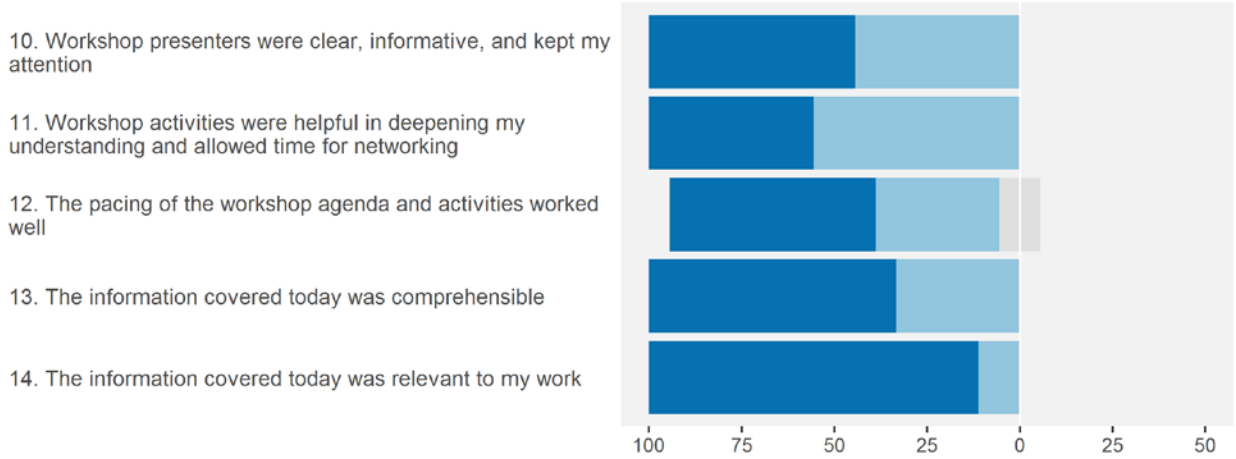
Survey Reponses

Number of responses: 9[1]

Because of the workshop…



Overall workshop feedback



[1] As most questions were related to applications to management, researchers participating in the workshop chose not to fill out the survey.

APPENDIX VII (CONT.)

Highlights of Narrative Responses

Next step I will be taking to apply what I learned…

- Incorporate veg reports into plant palettes and management plans
- Educate coworkers on the tools
- Reviewing the rest of the Climate Ready Veg. Reports for open space areas I manage
- More research, check website, observe our lands
- Refining our land management priorities to reflect a more regional context and identifying how we might complement other sites/organizations/agencies' work
- Watching Oregon oak

Best things about the workshop…

- The broad focus on what land managers need and the scenarios planning
- Scenarios got me thinking about implications for planning
- Discussion of veg reports
- The knowledge of potential scenarios; the discussion during the activity
- Talking and interacting with the rest of the group (networking, idea exchange) as well as learning about the Climate Ready Veg. reports
- The discussions. The thought-provoking questions and challenge to think beyond our comfort level
- The people!

One thing I might change about the workshop:

- I think the scenarios exercise will get more refined and focused as you continue to do it. I think this is a globally useful activity for helping managers think about climate change adaptation
- Show specific example of how species range may change under diff climate scenarios through maps
- Location on 101 or other accessible transportation corridor; skip the second breakout session, instead switch to a different scenario and repeat exercise of 1st breakout session
- Include discussion of broad scale ecosystem objectives
- A little shorter. Full day is big commitment
- Graphics printed larger in handout material; clearer instructions on group activities
- Field tools for data checking, pressure bombs…