Incorporating Climate Resilience into Invasive Plant Management Projects: Guidance for Land Managers

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Climate resilience is a high priority for protecting wildlife habitat and ecosystem services. The health of watersheds is critical for protecting water quality downstream. Invasive plant management can protect such ecological function and support resilience to climate change. The connection between climate change and invasive species is addressed in detail in "Bioinvasions in a Changing World" (Ad Hoc Working Group on Invasive Species and Climate Change 2014).

A 2013 survey of California land managers showed that they want to integrate climate resiliency into their work, but are unsure about how to do so. The National Wildlife Federation (2013, 2014) describes steps that natural resource managers can follow as part of a climate-smart adaptation cycle. But how can we integrate these principles into the practices of invasive plant management?

Cal-IPC's recent work designing regional invasive plant management projects includes climate resilience as a goal. In particular, we have undertaken an effort to protect Sierra meadows from invasive plants, with support from the Wildlife Conservation Society's Climate Adaptation Fund. This report describes our perspective on connections between invasive plant management and climate resiliency, and provides guidance for land managers on how they can incorporate climate resilience into their invasive plant management projects.

Invasive plant management and climate resiliency

Invasive plant management is itself a key action toward climate resiliency. As described by plans such as the National Wildlife, Fish and Plant Climate Adaptation Strategy (2012), actions to reduce known ecological stressors are key steps that should be taken immediately. (The plan has an entire section on recommended strategies for strengthening invasive species control.) The California Wildlife Action Plan (CDFW 2015) shows that invasive species are one of the top ecological threats to wildlife.

Removing invasive plants from sensitive habitats like mountain meadows can improve resilience to climate change. Photo by Ed King, Placer County Agricultural Commissioner's Office.

Climate change will affect the spread of particular invasive plant species in particular places. The rate of spread may increase or decrease, and the area vulnerable to spread may increase, decrease, or simply shift in location. Though plant communities are generally expected to move to greater latitudes and elevations to maintain their temperature range (Kelly and Gouldon 2008, Pauchard et al. 2009), the reality will be more complicated. At a local scale, plants can

move either up or down in elevation (Rapacciuolo et al. 2014), and in some areas changed precipitation patterns will be as much of a driver as temperature shifts.

Of course native plant communities will shift in composition and location as the natural response to climate change. Invasive plants can impede such necessary shifts by occupying habitat and outcompeting native vegetation. Protection of critical linkages identified as wildlife corridors may also serve to maintain as corridors for native plant movement.

Increased CO_2 levels have a direct impact on plant growth, and this will favor some plants over others. Increased nitrogen deposition from exhaust generated by power plants and automobiles can change soil nutrients and plant communities. Nitrogen-fixing plants may have a similar impact. (Cal-IPC's modeling showed that Spanish broom, *Spartium junceum*, a leguminous shrub, is expected to enjoy significantly greater suitable range in California under future conditions, which could result in altered soil chemistry that facilitates additional invasion.)

Fire is another ecosystem process affected by both invasive plants and climate change. Invasive woody plants can add to fuel loads, increasing fire frequency and intensity. Cheatgrass (*Bromus tectorum*) has led to extensive type conversion of pinyon-juniper woodlands in the Great Basin by creating a positive feedback loop that significantly alters fire cycles and vegetation communities (Brooks and Pyke 2001). With climate change expected to increase wildfires, such dynamics could reinforce each other.

Patterns of human land use practices may change, resulting in increased disturbance and opportunity for introduction. For example, the number of hikers in a high-elevation site could increase as the climate warms and the site is accessible earlier in the spring and later in the fall. Homeowners might plant new ornamental species, some of which may spread into natural areas. And of course growing populations and global movement are trends that increase the potential for invasive plant spread.

The effectiveness of some invasive plant control techniques may change, such as how plants respond to herbicides (Ziska 2003, Ziska et al. 2004). Managers may need to change control methods and control timing. Re-vegetation parameters may change. Some managers are broadening the palette of plants used in their re-vegetation efforts after weed removal, including more species and genotypes to provide genetic diversity to adapt to future changes.

Guidance for land managers

To address climate change, natural resource managers will use approaches of restraint (doing nothing), resilience (maintaining function), resistance (near-term ways of buying time), and realignment (long-term adaptation) (Stephenson and Millar 2012). Resilience requires keeping strong native plant communities that are not easily invasible (Peterson et al. 2011). Realignment can include de-prioritizing removal of less-impactful invasive plants.

This section provides guidance on specific ways climate resilience and invasive plant management work can be integrated by land managers. Some of these recommendations are simple and can be adopted readily, while others require significant capacity.

Prioritization

1. Work at the landscape-level

To be most effective, invasive plant management should be planned at the landscape level. This means that individual land managers need to address invasive plants at multiple scales: while focusing on the property they manage, also working with regional partners on landscape-level eradications. (Cal-IPC works with county-based Cooperative Weed Management Areas to plan coordinated early eradication projects in each region.)

2. Aim for eradication

When investing resources in management of an invasive plant population, set full eradication as the goal whenever feasible. This involves a long-term commitment, but it's the most cost-effective approach.

3. Focus on "early eradication" target species

Addressing species that are still early on the invasion curve is the most cost-effective approach. It offers the potential for fully eradicating a species from the area. This work may focus on new weed species, or on known weed species that are actively moving into an area. (Cal-IPC uses the online CalWeedMapper decision-support tool to assess distribution and potential for spread in a given region. See Resources list.)

4. Screen naturalized non-native species for future threat

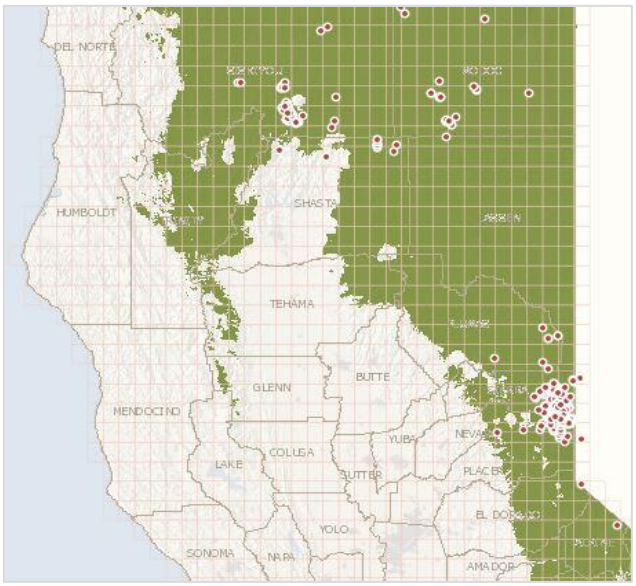
Early eradication work can also be beneficial for naturalized non-native plant species that have not yet caused damage, but that rank "high risk" when screened using a risk assessment. (Cal-IPC uses the Plant Risk Evaluation system developed at UC Davis. See Resources list.)

5. Prioritize individual populations for control as appropriate

For invasive plant species that are too widespread for landscape-scale eradication to be feasible, prioritize which individual populations are most important to remove first. This can be assessed by rating factors such as proximity to valuable habitats, isolation relative to other populations of the same weed, proximity to vectors of spread such as roads, trails and streams, and feasibility of access and control. Ideally the individual population can be fully eradicated. (Cal-IPC uses the WHIPPET routine to prioritize populations. See Resources list.)

6. Rank level of infestation in important habitats

When working at a landscape level to protect a discrete type of habitat (for instance, montane meadows), consider ranking each occurrence via a simple scoring system. By assessing factors such as level of current invasive plant impact, projected future impact, urgency of action to stop imminent spread, feasibility of control, and quality of habitat at risk, such a system can help prioritize which locations should be worked on first. Strategic prioritization can also give funders confidence that their investment will leverage the most important conservation outcomes. (Cal-IPC is working on a pilot "vulnerability index" scoring system for tidal marshes.)



Existing populations of invasive musk thistle (red dots) and suitable range for musk thistle projected for 2050 climate. Map from CalWeedMapper.

7. Map suitable range for weed species, including effects of climate change if possible

If possible, map suitable range for each weed species of concern to compare against current distribution, and determine how that suitable range may shift with changing climate conditions. This can be done with a model that uses existing known locations to extrapolate climatically similar locations in the region of concern. Local-specific climate projections are

becoming more widely available (for example, Morelli et al. 2011). Knowing whether climatic suitability for a particular weed is expected to increase or decrease (or neither) in a given area can help prioritize management efforts. (Cal-IPC used a MAXENT routine that incorporated existing population locations, historic weather data, and projections of future climatic conditions from multiple General Circulation Models. These results are incorporated into CalWeedMapper and are used in selecting priority species.)

Climate change planning

8. Determine top climate impacts for your area

Scenario planning requires selection of top climatic variables expected to change in your area and the possible direction and magnitude of change. There are many overlapping levels of uncertainty in predicting future conditions, so it is most realistic to focus on the most likely direction of the most important changes (Matzek 2013). Moore et al. (2013) and the National Park Service (2013) provide instructions for conducting scenario-planning for natural resource management. While their steps are detailed, many land managers could use an abbreviated version and still gain benefits. Websites and reports of climate change projections are increasingly available and land managers can use these rather than trying to do all the research themselves. The Nature Conservancy's Climate Wizard is a good place to start for maps of climate change. CAKE, the Climate Adaptation Knowledge Exchange portal, provides a clearinghouse of reports and case studies. These and other websites with links to resources are listed at the end of this paper.

9. Predict how each change would affect habitat and management

For each scenario, predict which habitats and species would be favored. Consider whether some non-native plant species might provide replacement habitat value in place of stressed native vegetation. (For instance, in the case study used for Cal-IPC's climate adaptation workshop, land managers determined that invasive artichoke thistle might provide useful structure for songbirds if native shrub species declined.) Some actions will be beneficial regardless of what happens with climate change, while the benefit of others depends heavily on whether reality matches predictions (Matzek 2013). Changing nothing is in itself a decision; it is better to think through the options and decide to continue current actions rather than having that simply occur by default.

10. Use your community of expertise

In many cases land managers may not be able to find published research addressing topics of relevance to scenario planning or project design, and so it will necessary to extrapolate based on expert knowledge and experience. Networks through Cooperative Weed Management Areas may be able to provide a connection to appropriate experts. They can also provide a venue for organizing broader-scale planning efforts.

Early detection

11. Set routine surveillance for early detection

Identify key locations with a high volume of foot or vehicular traffic that makes them a hotspot for introduction of invasive plants. These include trailheads, pullouts, maintenance facilities and staging areas. Design an annual surveillance schedule to detect new infestations.

12. Train professionals and volunteers on weed identification

It is important to train those performing surveillance—both professionals actively surveying and citizen scientists just keeping their eyes out—to recognize the key weeds that they may encounter. True early detection involves spotting weeds that are unfamiliar in the area; training can help people recognize these important plant species. Regional mapping helps determine which invasive plants are not

in an area but are found relatively nearby. (Cal-IPC uses CalWeedMapper.

Prevention

13. Collaborate with road and utility maintenance workers

Linear corridors such as roads and utility rights-of-way have the potential to spread invasive plants into otherwise undisturbed areas. Maintenance activities, from grading dirt roads to mowing or spraying vegetation on roadsides or under power lines, are an integral part of maintaining these corridors, and have the potential to limit weed spread or exacerbate it. Though it is often challenging for maintenance activities to fully support weed management goals, coordination is important so that the best solutions can be found. (Cal-IPC uses BMPs developed for road and utility workers, Cal-IPC 2012a.)

14. Maintain weed-free wildfire staging areas

Staging areas are a key part of successful firefighting. Many vehicles and firefighters move between the staging area and burn areas, with the potential for spreading weed seed from the staging area into vulnerable wildlands. Identify common staging areas and make them a high priority for invasive plant management.

15. Require weed-free forage

If pack animals or livestock travel through an area, require that feed brought is certified weed-free and that animals have been feed weed-free forage for three days prior to entering the area. (The North American Invasive Species Management Association maintains a standard for certified weed-free forage. See Resources list.)

Project planning

16. Coordinate invasive plant management with other planned restoration

Delay addressing invasive plants in sites where major restoration work, such as stream channel reconstruction, is scheduled, and plan to work after the restoration to remove any invasive plants that have taken advantage of the disturbance. Include specifications in contractor agreements to use best management practices (BMPs) to prevent spread of invasives into or out of the restoration site. (Cal-IPC uses BMPs developed for land managers, Cal-IPC 2012a.)

17. Document and monitor

Whatever a land manager decides to do, it is important to write up a justification for the actions with the steps used to make the decision and describe how climate change was considered. This serves two purposes: first, to show why changing actions (or continuing current actions) is justified, and second, so that someone coming later can understand what is being done and why. With the uncertainty inherent in climate change effects, especially at the local scale, monitoring what is happening on the ground becomes even more important than it may be today (Matzek 2013).

Surveying the Kirkwood Meadow for invasive plants. Photo by LeeAnne Mila, El Dorado County Agricultural Commissioner's Office

Resources

CalWeedMapper – Decision-support tool with maps of 200+ invasive plants in California, including projections of future suitable range for 79 species. calweedmapper.cal-ipc.org

Climate Adaptation workshop – Presentations from the workshop "Climate-Smart Land Management," Lake Arrowhead, CA, October 2013. California Invasive Plant Council, Berkeley, CA. www.cal-ipc.org/ip/climateadaptation/index.php

California Climate Commons – Clearinghouse of guidance materials for climate-smart conservation. Includes materials that can be helpful anywhere, not just California. climate.calcommons.org/article/climate-smart-conservation

Cal-Adapt – Maps of how climate change will affect many different aspects of land management in California, from the California Department of Natural Resources. cal-adapt.org

CAKE–- Climate Adaptation Knowledge Exchange portal. Search for case studies and climate change tools for your region. Also has an Advice Column, Discussion Forum, and Ask the Expert feature for getting help on specific questions. www.cakex.org

Climate Wizard – A good first place to start for maps of climate change. Interactive maps of climate projections from The Nature Conservancy. Case studies give examples of how the information has been used in real projects. www.climatewizard.org

National Wildlife Federation – Climate change adaptation guides and a review of climate adaptation literature. www.nwf.org/what-we-do/energy-and-climate/climate-smart-conservation/adaptation-reports.aspx

PRE – Plant Risk Evaluation Tool. An adaptation of a border-screening tool that uses 19 questions to assess invasiveness of plants for a particular region. Developed by the University of California-Davis and University of Washington. ccuh.ucdavis.edu/industry/pre

TACCIMO – Web tool from the US Forest Service. Allows a user to search for and generate reports on climate change literature on particular topics and summaries of projected changes. (Uses information from Climate Wizard for their maps.) www.taccimo.sgcp.ncsu.edu/tbl_sector_list.php

Weed-Free Forage Standards – North American Invasive Species Management Association. Uniform standards for North American states and provinces to provide assurance to land managers that noxious weeds will not be spread through the movement of forage. www.naisma.org/weed-free-forage

WHIPPET – "Weed Heuristics: Invasive Population Prioritization for Eradication Tool" prioritizes weed infestations for eradication based on potential impact, potential spread, and feasibility of control. Developed by the California Department of Food and Agriculture, UC Davis, and Cal-IPC. whippet.cal-ipc.org

Landscape Conservation Cooperatives – Programs through the US Fish and Wildlife Service that connect land managers and scientists to develop information for climate change planning. lccnetwork.org

USDA Climate Hubs – Links to online tools and information about USDA programs that can help land managers with climate adaptation practices. climatehubs.oce.usda.gov

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