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Management in Practice

The San Francisco Bay Area Early Detection Network

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Abstract

This paper summarizes the strategies of the San Francisco Bay Area Early Detection Network (BAEDN). BAEDN coordinates and implements Early Detection of and Rapid Response to infestations of target invasive plants throughout the nine county San Francisco Bay Area. Limited-distribution invasive plant species in the Bay Area were identified by analyzing occurrence records within the Calflora database. Target species were then prioritized according to whether or not they were documented as invasive and by expert opinion. Weed Heuristics: the Invasive Population Prioritization for Eradication Tool was used to prioritize the 272 known occurrences of the 73 target priority species based on relative impact, invasiveness, and feasibility of treatment. BAEDN coordinated two years of removal of these populations. Lessons learned and next steps are reviewed. As new populations and species are identified additional funds are needed to carry out coordinated evaluation, prioritization, and control efforts.

Key words: rapid response, regional, San Francisco, California, prioritization, WHIPPET

The need for BAEDN

The need for early detection and rapid response

Carried out at a regional scale, the benefits of early detection and rapid response (EDRR) at one site contribute both site-specific and regional benefits, as the threat of spread by new invasives to new sites is pre-empted. Early detection is the process of identifying new populations of known or potentially invasive species. Rapid response is action taken to control infestations of species with limited distributions. Control of early infestations is a critical component of any successful invasive species management strategy (Mehta et al. 2007; Moody and Mack 1988). Treatment of invasive plant infestations when they are small greatly increases treatment efficacy and saves money (Cusack et al. 2009). In addition, early detection reduces ecosystem damage, treatment impacts (physical, biological, and chemical), and financial costs. EDRR represents an incentive for coordination, information sharing, and partnership across jurisdictional boundaries to maintain common goals.

The need for a San Francisco Bay Area solution

The San Francisco Bay Area comprises the nine counties bordering San Francisco Bay in Northern California: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma (Figure 1). The region includes the cities of San Francisco, Oakland, and San Jose. The area exhibits a Mediterranean climate across its 17,885.5 km^2 (US Census Bureau 2013) and includes a wide variety of plant communities, elevations, and microclimates. The area includes portions of the Coast Range, Central California Foothills and Coastal Mountains, and Central California Valley Level III ecoregions (EPA 2013). The metropolitan centers of San Francisco, Oakland and San Jose are forecast to have a population of 8 million by 2020 (ABAG 2002).

Figure 1. The San Francisco Bay Area region and the position of the study area on North America.

The San Francisco Bay Area lies at the heart of the California Floristic Province, one of the world's biodiversity hotspots (Myers et al. 2000). Invasive species are threatening biodiversity in California (Bossard et al. 2000). The area is also a major hub of international trade, potentially increasing the rate of new species introductions.

The threats posed by invasive species are projected to increase under the altered environmental conditions associated with predicted climate change scenarios (IPCC 2014). Higher winter temperatures, longer and warmer growing seasons, and more frequent abnormal disturbance events (e.g., drought, storm events, atypical runoff timing) may all favor invasive species. Such conditions are predicted to be less favorable to native species adapted to local conditions, while simultaneously being more favorable to pest species (IPCC 2014). Acting on the problem early represents the best opportunity to protect rare ecosystems.

Recognizing the extraordinary significance and exposure to threats in the region, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and the Biosphere (MAB) program designated the Central California International Biosphere Reserve in 1988.

What others have done

Early detection is a core function of border security at the national or island level. Border security efforts are essential at stopping many pests from a wide range of taxa. Many border efforts are conducted by national governments although there are some island border programs that are run by non-governments. For example, islands off the coast of California (USA) have been the subject of a Biosecurity Plan (California Islands Biosecurity Program Subcommittee 2013).

Partnerships are an important part of successful Invasive Plant Management (Higgins et al. 2007). Many states and regions in the United States have partnerships in the form of Cooperative Weed Management Areas (CWMA) – organizations that bring together public, private, and tribal stakeholders to combat invasive plants. These CWMAs are particularly common in rural areas where they often spend time and money controlling species that are agricultural pests. In recent years some groups have modified the CWMA model, increased their focus in non-agricultural weeds, and called themselves Cooperative Invasive Species Management Areas. In addition, there are many Exotic Pest Plant Councils (EPPC) or Invasive Plant Councils (IPC) that work collaboratively to raise awareness of and control invasive plants. The National Association of Exotic Pest Plant Councils is an umbrella group for all of the EPPCs and IPCs (NAEPPC 2014). Each of these organizations has its own priorities but most include early detection and rapid response.

In the United States there are only a handful of regional organizations that expressly focus on the early detection of invasive species including the Great Lakes Early Detection Network

(GLEDN; Crall et al. 2012), Mid Atlantic Early Detection Network (MAEDN; MAEDN 2014), Southeast Early Detection Network (SEEDN; SEEDN 2014), and the Bay Area Early Detection Network (BAEDN). Outside of the United States there appear to be fewer collaborative early detection/rapid response organizations but a larger commitment from government entities. For example, South Africa has a program funded by the national government (Wilson 2013). A plant-focused early detection program has been set up on a regional scale in Saxony-Anhalt, Germany (Schneider 2012).

BAEDN overview

The Bay Area Early Detection Network (BAEDN) was initiated in December 2006 to apply the principles of EDRR at one of the world's biodiversity hotspots. Professionals met for a full-day workshop at which partners presented updates on current early detection efforts and needs, shared information regarding existing networks, and discussed research and technical innovations available to support such efforts. Programs with EDRR components that were discussed included the National Park Service's San Francisco Area Network Inventory and Monitoring Program (Williams and Speith 2008), the California Department of Food and Agriculture's California District Biologists (Schoenig 2005), the Invasive *Spartina* Project, The California Invasive Plant Council, and the US Fish and Wildlife Service's efforts at the San Pablo Bay National Wildlife Refuge (USFWS 2011). Participant's discussions centered on refining the vision, identifying additional partners, defining the project scope, and setting strategies for building a robust and efficient Early Detection Network. Key principles for an effective Early Detection Network were defined. The new network must:

1) Be coordinated by paid staff (volunteers and existing professional capacity are insufficient).
2) Include all counties adjoining the San Francisco Bay.
3) Include all major stakeholders from the service region.
4) Provide stakeholders with the opportunity to help structure the network.
5) Apply science-based techniques in a rigorous and transparent manner.
6) Adapt existing tools rather than create new tools.
7) Share the techniques used to prioritize populations and occurrences.

Guided by these principles, the BAEDN partnership was formalized by a Memorandum of Understanding (MOU) which brought together partners from the San Francisco Bay area to "work cooperatively to develop and implement an ecological and integrated approach to the early detection of harmful and noxious weeds, and the rapid response to these environmental impairments". The MOU provided a framework for partners to collaboratively and voluntarily "identify priorities and obtain funding to facilitate effective weed control," "share scientific and technical expertise (including monitoring, results of research findings, weed ecology and biology information, GIS and other mapping capabilities, and integrated pest management methods)," and meet to coordinate BAEDN priorities.

In 2007 BAEDN began developing financial support; contributed funds supported staff, contractors, and operating costs. Funds were administered by a non-profit partner that served as BAEDN's fiscal sponsor. Having a fiscal sponsor removed the administrative burden of achieving non-profit status for BAEDN itself.

BAEDN was publicly launched during California's Invasive Weed Awareness Week, July 2009. The launch included targeted outreach through articles in numerous agency and organization newsletters. This campaign sought to inform and involve all key stakeholders in early formation of the network. New partners either signed the MOU or established less formal agreements to collaborate with BAEDN. The partner list grew from about one dozen organizations in 2007 to over one hundred in 2010. The public launch both brought together professionals to guide the work of the organization and raised BAEDN's profile among Bay Area land managers.

Major funding for BAEDN ended in 2011. In 2013 BAEDN became a project of the California Invasive Plant Council. The shift from dedicated funding source to a project of a larger organization has brought about a significant slowdown in the pace of activity. However, it has also increased access to the fund-raising, outreach, and administrative capacity of a well-established and very active organization focused on invasive plants in California. The early infusion of funds jump-started an enduring project. BAEDN strives to achieve long-term control of early detection targets. As new populations and species are identified additional funds are needed to carry out coordinated evaluation, prioritization, and control efforts.

Data collection

Calflora

Calflora's online tools and data were essential to BAEDN's success. Calflora is a non-profit organization that runs a web-accessible database providing information about plants that grow wild in California. Information is derived from data submitted by public agencies, non-profits, scientists, and private citizens. The website received 364,094 unique visitors in 2012 and includes information on almost 12,000 plant taxa. Because most land managers in the San Francisco Bay Area were already familiar with the database both as a repository and a source of information it was relatively easy to expand the use of the database and request additional data. Because Calflora was well-established and well used, land managers did not need to provide data to a new source and they already had the experience in the database being useful.

Data collection tools

To facilitate the use and collection of occurrence data, BAEDN worked with Calflora to develop the BAEDN Occurrence Reporting Database in 2009. The BAEDN database is an extension of Calflora's database and is a shared repository for new and existing plant occurrence data collected by agencies and the public. BAEDN worked with Calflora to develop additional tools for data entry and extraction: an upload tool for geotagged photos, a smart phone application for effective and easy field mapping, a "My Observations" portal to allow users to edit and manage their occurrence reports, and Web applications for uploading and downloading larger datasets in a variety of formats. With these tools, BAEDN and partners worked to consolidate previously unshared mapping data into a single shared database. Calflora adapted code from *What's Invasive* (http://www.whatsinvasive.org/index.html) to create the *Calflora Observer* smartphone app for field documenting plant occurrences with location and photographs. This app can run from any GPS-enabled smartphone even without a phone plan or signal. All of the activity resulted in more records entered into the online database, enhancing its completeness and utility for early detection. Since the launch of the online and mobile BAEDN tools in the summer of 2008 until May 21, 2014, Calflora has logged 10,183 entries from BAEDN tools (Powell, pers. comm. May 21, 2014). Providing a range of tools all funneling data to Calflora increased participation because land managers understood how their contributions helped their own efforts and regional efforts to track and control invasive species.

Creating a list of target species

Compilation of candidate species

Prioritization has been recognized as an important component of invasive species management at the international policy level (COP 10 2010). To create a list of prioritized species the first task was to compile a comprehensive list of candidate species with the potential to be invasive in California. Consulted sources of plant species and traits included: the Calflora database of non-native plant occurrences (Calflora 2010), California Invasive Plant Council (Cal-IPC) Invasive Plant Inventory (Cal-IPC 2008), California Invasive Plant Council Mediterranean weed list (Brusati et al. 2014), California Invasive Species Council Species Scorecards (CISAC 2010), United States federal noxious weed list (USDA 2010a), state noxious weed lists for all available states (e.g., AZDA 2010, CDFA 2010, NDA 2010, NWCB 2010, and ODA 2010) a published list of California non-native plant species (Shierenbeck et al. 2007), Presidio of San Francisco, prohibited plant list (Presidio Trust, unpublished data), Weed Risk Assessments from Florida (Gordon et al. 2008), Hawaii (Daehler et al. 2004), and Queensland (unpublished by Csurhes, 2010), and the World Wildlife Fund's Australian National list of naturalized invasive and potentially invasive garden plants (Groves et al. 2005). After initial compilation, records were corrected to remove misspellings and formatting errors and each taxon was associated with its unique USDA Plants database code (USDA 2010b). All synonymous entries were consolidated using the USDA Plants code. The resulting list included 1417 plant taxa.

For the purposes of the work outlined in this paper we use the term occurrence instead of the term population because each plant record in the Calflora database is made by different individuals and each individual may have his or her own definition of what an occurrence is – it may not be the same as a population. We applied a buffer to all records to help eliminate some of the inherent error with this approach. See below for a description of the buffering technique. Taxa were put into broad categories according to the number of occurrences in Bay Area counties reported in the Calflora occurrence database (Calflora 2010): *No Bay Area Reports*, *Limited Bay*

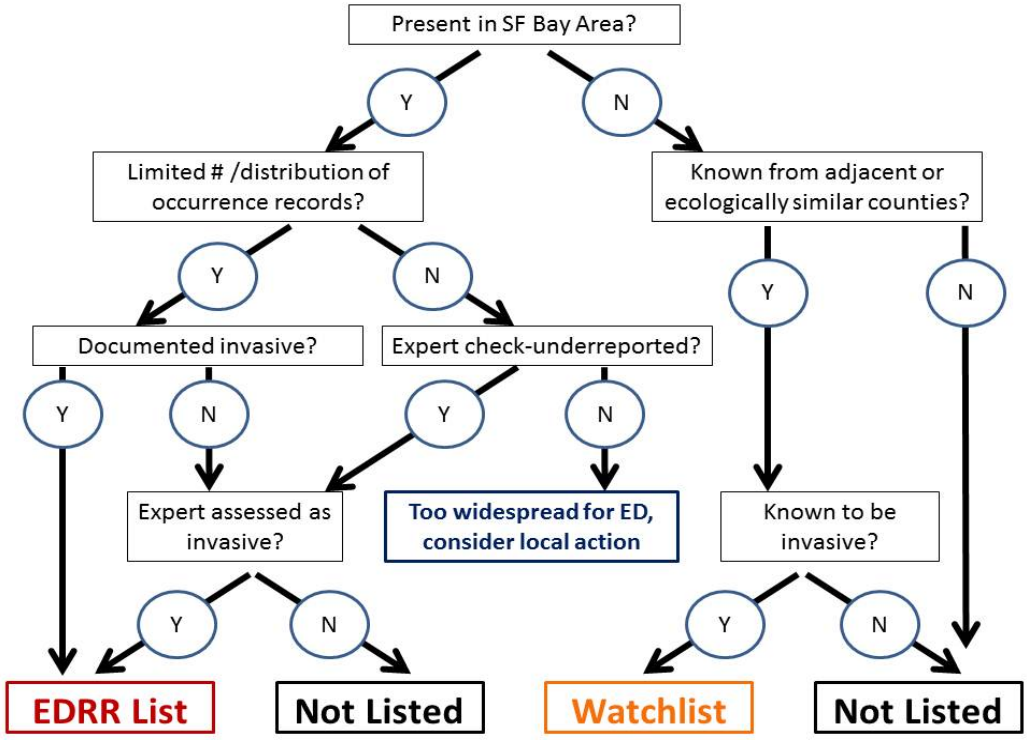

Figure 2. Decision tree showing the species prioritization summary for the Bay Area Early Detection Network. Note: the Watchlist has not yet been created.

Area Reports (fewer than 100 known occurrences), *Widespread* (more than 100 known occurrences). Williams, Gluesenkamp, Perlmutter, and other regional botanists used their expert opinion to move some species form the *Limited Bay Area Reports* category to a new category, *Underreported*. *Underreported* species had few mapped occurrences but were known to be more common. For example, *Kniphofia uvaria* (L.) T. Durand and Schinz (redhot poker), 1894 had been reported 19 times in all of California but was known from hundreds of locations so it was assigned to the *Underreported* category. In all cases, each species was carefully reviewed by experts and The *No Bay Area Reports* list was set aside for further evaluation in the creation of a watch list. The *Widespread* and *Underreported* taxa were removed from further consideration, since they were considered too abundant to be early detection and rapid response candidates. Figure 2 summarizes the species prioritization process. *No Bay Area Reports* included 255 taxa, *Limited Bay Area Reports* included 286 taxa, and the *Underreported* list plus the *Widespread* list totaled 876 taxa.

Prioritization of candidate species

Taxa in the *Limited Bay Area Reports* list were classified as "known to be invasive" if they had a weed ranking in any of the databases, weed lists, and assessments or "not known to be invasive from consulted sources," if there was no such ranking. A small set of taxa not listed in consulted sources were categorized as invasive based on expert opinion (e.g., *Limonium ramosissimum* (Poiret) Maire, 1936 [Algerian sea lavender] and *Danthonia pilosa* Brown, 1810 [hairy wallaby grass]). These species were either only known as invasive in the San Francisco Bay Area or they were recently identified as invasive so they did not appear on the consulted lists.

The resulting list of species that were both known to be invasive and had limited reported occurrences was shared with additional experts from county Weed Management Areas, county Agricultural Commissioners, weed scientists, Cal-IPC, and local land managers to verify limited distribution and invasiveness. The final list of 73 taxa comprised the 2010 BAEDN Early Detection

Table 1. 2010 target species list.

Latin name	Common name	Latin name	Common name
Acacia paradoxa Candolle, 1813	paradox acacia	*Gunnera tinctoria* (Molina) Mirbel, 1805	Chilean gunnera
Acaena novae-zelandiae Kirk, 1871	biddy-biddy	*Halimodendron halodendron* Voss, 1894	common salttree
Achnatherum brachychaetum (Godron) Barkworth, 1993	shortbristled needlegrass	*Helichrysum petiolare* Hilliard & Burtt, 1973	licorice-plant
Aegilops triuncialis Linnaeus, 1753	barbed goatgrass	*Hypericum canariense* Linnaeus, 1753	Canary Island St. Johnswort
Ambrosia trifida Linnaeus, 1753	great ragweed	*Isatis tinctoria* Linnaeus, 1753	Dyer's woad
Araujia sericifera Brotero, 1818	white bladderflower	*Lepidium campestre* (Linnaeus), 1812	field pepperweed
Arctotheca calendula (Linnaeus) Levyns, 1942	Capeweed	*Ligustrum lucidum* Aiton, 1810	glossy privet
		Ligustrum ovalifolium Hort ex Decaisne, 1877	California privet
Arrhenatherum elatius Palisot de Beauvois, 1812	tall oatgrass	*Limonium ramosissimum* (Poiret) Maire, 1936	Algerian sea lavender
		Linaria genistifolia ssp. *dalmatica* (Linnaeus) Miller, 1768	Dalmatian toadflax
Asparagus asparagoides (Linnaeus) Wright, 1909	African asparagus fern	*Linaria vulgaris* Hill, 1756	butter and eggs
Asphodelus fistulosus Linnaeus, 1753	onionweed	*Lonicera japonica* Thunberg, 1784	Japanese honeysuckle
Brachypodium sylvaticum (Linnaeus) Palisot de Beauvois, 1812	slender false brome	*Lythrum salicaria* Linnaeus, 1753	purple loosestrife
Buddleja davidii Franchet, 1888	orange eye butterflybush	*Nassella formicarum* (Delile) Barkworth, 1990; *N. manicata* (Desvaux) Barkworth, 1990	tropical needlegrass
Cardaria pubescens (Meyer) Jarmolenko, 1934	hairy whitetop	*Nassella tenuissima* (Trinius) Barkworth, 1990	finestem needlegrass
		Onopordum acanthium Linnaeus, 1753	Scotch cottonthistle
Carduus acanthoides Linnaeus, 1753	spiny plumeless thistle	*Onopordum illyricum* Linnaeus, 1753	Illyrian cottonthistle
Carex pendula Hudson, 1762	hanging sedge	*Paspalum urvillei* Steudel, 1853	Vasey's grass
Carthamus leucocaulos Smith, 1837	whitestem distaff thistle	*Polygonum aubertii* Henry, 1907	Bukhara fleeceflower
Centaurea diffusa Lamarck, 1785	diffuse knapweed	*Polygonum cuspidatum* Wildenow ex Sprengel, 1825	Japanese knotweed
Centaurea iberica Treviranus ex Sprengel, 1826	Iberian knapweed	*Polygonum polystachyum* Wallich, 1829	cultivated knotweed
Centaurea maculosa Lamarck, 1785	spotted knapweed	*Pyracantha coccinea* Roemer, 1847	scarlet firethorn
Centaurea repens Linnaeus, 1763	hardheads	*Pyracantha crenulata* (Don) Roemer, 1847	Nepalese firethorn
Centaurea sulphurea Wildenow, 1809	sulphur knapweed	*Ricinus communis* Linnaeus, 1753	castorbean
Cestrum parqui L'Heritier, 1788	night jessamine	*Rubus laciniatus* Wildenow, 1806	cutleaf blackberry
Chondrilla juncea Linnaeus, 1753	rush skeletonweed	*Rumex dentatus* Linnaeus, 1771	toothed dock
Cirsium undulatum Sprengel, 1826	wavyleaf thistle	*Sapium sebiferum* (Linnaeus) Roxburgh, 1814	Chinese tallow
Coprosma repens Hooker, 1844	creeping mirrorplant	*Scolymus hispanicus* Linnaeus, 1753	common goldenthistle
Crupina vulgaris Persoon ex Cassini, 1818	common crupina	*Senecio jacobaea* Linnaeus, 1753	stinking willie
Cuscuta japonica Choisy, 1855	Japanese dodder	*Senna multiglandulosa* (Jacquin) Irwin & Barneby, 1783	glandular senna
Cytisus striatus (Hill) Rothmaler, 1944	striated broom		
Danthonia pilosa Brown, 1810	hairy wallaby grass	*Sesbania punicea* Bentham, 1884	rattlebox
Echium plantagineum Linnaeus, 1771	salvation jane	*Solanum carolinense* Linnaeus, 1753	Carolina horsenettle
Euphorbia esula Linnaeus, 1753	leafy spurge	*Solanum rostratum* Dunal, 1813	buffalobur nightshade
Euphorbia terracina Linnaeus, 1762	Geraldton carnation weed	*Spartina alterniflora* Loiseleur-Deslongchamps, 1849 (hybrids)	smooth cordgrass
Festuca pratensis Hudson, 1762	meadow fescue		
Gaura drummondii Torrey & Gray, 1840	Drummond's beeblossom	*Spartina densiflora* Brongniart, 1876	denseflower cordgrass
Gaura sinuata Nuttall ex Serringe, 1828	wavyleaf beeblossom	*Spartina patens* (Aiton) Muhlenberg, 1813	saltmeadow cordgrass
Gazania linearis Druce, 1917	treasureflower	*Tripidium ravennae ssp. ravennae* (Linnaeus) Scholz, 2006	ravennagrass

list of species (Table 1). The species prioritization list was used to raise awareness about the species on the list. In addition, once the species list was created, individual land managers were approached and asked to provide additional occurrence data for the targeted species. By creating a relatively short list and making personal appeals, we were able to increase the quantity of occurrence information for the next step in our process.

Box 1

Canary Island St. John's wort (*Hypericum canariense*) easily grows to 10 feet tall in dense single species stands (Figure 3). The plant is highly invasive elsewhere in the world but California has just a few occurrences. The species was found in a few populations along the coast of California from San Diego to Marin. BAEDN helped control small populations on land managed by California State Parks and the non-profit organization, Audubon Canyon Ranch. The largest known California population was on the San Mateo Coast near Año Nuevo State Park where a large stretch of high-quality coastal scrub habitat had been invaded. In 2010, with the support of BAEDN, a collaboration of non-profit organization (San Mateo Weed Management Area and the Peninsula Open Space Trust), government entities (California State Parks, San Mateo Resource Conservation District, California Department of Food and Agriculture, and the US Fish and Wildlife Service San Francisco Bay Coastal Program), and a private landowner worked to control and contain this large population. A successful petition was made to the California Department of Food and Agriculture to list the plant as a noxious weed, the status gives county personnel and landowners important tools to ensure effective response. BAEDN secured funding to do an assessment in 2012 of new EDRR targets on lands along the coast and *Hypericum caneriense* came out as one of the highest management priorities. BAEDN, now a part of Cal-IPC, is coordinating with local partners (Resource Conservation District, San Mateo County Department of Agriculture, Peninsula Open Space Trust, and local landowners) to find funding to follow up.

Figure 3. *Hypericum canariense* infestation in central California - just south of Gazos Creek, east of Highway 1 in San Mateo County. Neal Kramer©

Creating a list of target occurrences

Compilation of occurrences

Georeferenced Calflora data for all occurrences of the 73 target species were converted to an ArcGIS shapefile and viewed using ArcMap 9.3 (ESRI 2010) to allow for spatial analysis and transformation. Reports were buffered to reduce the number of redundant reports, convert point data to polygon data and reduce the effect of errors such as varying degrees of spatial precision, limitations of zooming to reporting locations on aerial imagery, mapping offsets used in the field, and varying inter-patch distances. 10, 50 and 100 meter buffers were tested. After ground truthing the effects of choosing each of these buffer sizes, the 100 meter buffer was selected because it was most effective at consolidating redundant records, was within the range of short-term dispersal ability of most species, and generated patch areas that were within the ability of field personnel to effectively search. Approximately 800 records were merged into 272 distinct occurrences. The data were spatially joined with a layer of California counties in order to assign

county locations corresponding to each non-native occurrence polygon. The resulting attribute table was then exported to Microsoft Excel (Microsoft 2007), where number of occurrences of each species was determined by county across the nine county San Francisco Bay Area.

Prioritization of occurrences

Each of the 272 occurrences of a priority species was prioritized using WHIPPET (Skurka Darin 2010). WHIPPET (Weed Heuristics: the Invasive Population Prioritization for Eradication Tool) prioritizes eradication targets based on relative impact, invasiveness, and feasibility of eradication. Proximity to high value assets and vectors of spread were measured and scored for each occurrence using Geographic Information Systems software. Propagule pressure is an important factor in biological invasions (Simberloff 2009) but geoprocessing models were not available for propagule pressure. Rather than generating scores based on distance to nearest conspecific population, we scored conspecific populations equally on this factor based on the number of populations in the region, with higher scores going to species with fewer populations. We provided maps by County to all stakeholders and fostered collaboration across boundaries to control prioritized targets. We also produced maps for individual land management agencies. Occurrence prioritization was well received by land managers.

Taking action

BAEDN identified rapid response partners, provided training, funded contracts, and coordinated partners to treat and track priority invasive plant populations throughout the region. We responded to the first reported North American population of *Hypericum grandiflorum* Salisbury, 1796 (large-flowered St. Johnswort) Large-flowered St John's wort, helped to contain the *Helichrysum petiolare* Hilliard and Burtt, 1973 (licorice-plant) in Marin County state and national parks, helped to contain the largest population of *Hypericum canariense* Linnaeus, 1753 (Canary Island St. Johnswort) in California (see Box 1), increased awareness and control of *Limonium ramosissimum* (Poiret) Maire, 1936 (Algerian sea lavender) within San Francisco Bay wetlands, worked on the leading edge of the Napa county population of *Tripidium ravennae* ssp. *ravennae* (Linnaeus) Scholz, 2006 (ravennagrass) to protect neighboring counties, supported removal of *Brachypodium sylvaticum* (Linnaeus) Palisot de Beauvois, 1812 (slender false brome) within San Mateo County, and re-started removal of various high priority invasives for which funding had been lost as part of state budget cuts (e.g, *Lythrum salicaria* Linnaeus, 1753 [purple loose-strife], *Centaurea iberica* Treviranus ex Sprengel, 1826 [Iberian Knapweed], *Ricinis communis* Linnaeus, 1753 [castorbean], and *Sesbania punicea* Bentham, 1884 [rattlebox]).

Although many intensive invasive plant management projects were being undertaken before BAEDN was established, the formation of BAEDN allowed the actions to be prioritized and coordinated. BAEDN partners and staff completed two nine-county rapid response field seasons in 2010 and 2011. By the end of 2011, 6.6% of priority occurrences were believed extirpated, 7.7% were totally removed and under surveillance, and 52.4% were actively being treated. The management success record from before the BAEDN approach is hard to quantify but anecdotal reports from land managers suggest that more occurrences of priority species are being reported and being eradicated than before the BAEDN was established.

Lessons learned

Data quality

McGeoch et al. (2012) identify many of the challenges faced when attempting to create prioritized lists of invasive plants including access to data, inconsistent distribution of data, and difficulty accessing accurate data. Although we faced these challenges, the online Calflora database provided essential pre-existing plant occurrence data and a sharable repository for new data. However, data were unevenly distributed in space, varied in quality by taxon, were especially limited on private land, had unknown spatial accuracy, and were collected by a range of observers with varying identification and mapping skills. Common weed species which are not management targets for land managers (e.g., *Aira caryophyllea* Linnaeus, 1753 [silver hairgrass]) are especially underreported. For example, as of September 5, 2014 there are no Calflora records of *Aira caryophyllea* within the lands from 0 km to 10 km north of the Golden Gate Bridge in Marin County but the authors know of thousands of plants in this zone. Uneven reporting may give a false impression that well reported regions have more invasives than poorly reported regions. Populations reported multiple times by separate

observers may lead to overestimation of the number of occurrences for a given species (our buffering technique helps with this problem but must be applied after extracting data). Overestimation may also result from inclusion of historical populations no longer present, as there is no built-in method in place to track population and treatment status of reported populations. Species identification errors are also a concern. Because limited-range weed species are often unfamiliar to land managers, they may be under-reported. Underreporting may give a false impression that species are less common or widespread than they really are. Managers must assume that occurrence data are incomplete (Chen et al. 2013); we used expert opinion to mitigate data limitations. Encouraging the use of an existing online data repository (e.g., http://www.calflora.org, http://www.eddmaps.org, http://www.inaturalist.org, http://www.europe-aliens.org, http://www.ispot.org.za/) will improve the quality of available data or at least improve its quantity. Having the capacity to record absence data will also help (Václavik and Meentemeyer 2009). Starting with as thorough an inventory of occurrences as possible provides a solid framework to build upon. Data on the distribution of species occurrences is essential for success and sharing data leads to better data for all (Simpson et al. 2009).

Prioritization

BAEDN used existing species assessments rather than conduct a regionally-adapted assessment for each of the 1417 candidate species. This approach carried the benefit of previous research results and presented an efficient first ranking of invasiveness. Adapting an existing ranking system, such as the 49 question weed risk assessment process developed for Australia by Pheloung et al. (1999), for the San Francisco Bay Area would have yielded useful region-specific information, but would have required significant time to first adapt the assessment and then to implement for each taxa. Average time to complete a weed risk assessment is reported to be between 6 and 24 hours (Gordon et al. 2008). We chose to use invasive elsewhere as our primary filter because analysis of formal weed risk assessment performance has indicated that abridged weed risk assessments using the single question "Is the species a weed elsewhere?" resulted in the same or higher accuracy than that of the full 49 question weed risk assessment (Gordon et al. 2008; Kolar and Lodge 2001; Mack 1996; Reichard and Hamilton 1997). Taken together, the consulted sources cast a wide net for determining invasiveness.

Most land managers are anxious to focus their limited resources on priority species or occurrences. Prioritizing species down to a reasonable number can increase the likelihood of land managers using the created list; a short list can motivate and inspire rather than overwhelm and frustrate. Prioritizing occurrences of target species rather than just the species provides a clear benefit to managers, and provides a bigger positive impact at the landscape scale (Skurka Darin et al. 2010). Valuable resources can be wasted if low priority occurrences are treated before high priority occurrences. By providing a clear framework and authoritative priorities BAEDN increased participation.

Partnerships

Forming relationships across political boundaries helps lead to successful invasive plant management programs (Higgins et al. 2007). Building the partnership ahead of time can facilitate data sharing and rapid response. Having many partners brings knowledge, skills, land access, and data to the effort. Creating a formal Memoranda of Understanding was useful because the formality encouraged managers to articulate the need for early detection to organizational leadership. In addition, organizations were able to provide resources in the form of funding, staff time, data, and other ways not envisioned when the agreement was established. However, less formal agreements are needed too and have their place.

Outreach

Although controlling invasive plants is BAEDN's focus, investments in reporting and outreach materials, the kickoff event, personalized outreach, and training all contributed to success. Reports are useful tools to demonstrate the organization's long-term existence, support funding requests, and provide a record of the work of the organization. Reports can be viewed at http://www.cal-ipc.org/WMAs/BAEDN/. Our kick-off event publicized the work of the organization and motivated collaboration. Personalized outreach to land managers resulted in more shared data and the treatment of prioritized occurrences. BAEDN trainings increased awareness of the issues, motivated managers, and encouraged sharing of methods and data. Producing useful tools for managers increased efficacy.

State-wide integration

Cal-IPC is supporting continued work on Bay Area populations that have been selected for eradication. BAEDN's regional coordination set a strong precedent, and the effort now joins a growing network of regional partnerships coordinated by Cal-IPC to develop landscape-level priorities. Cal-IPC has incorporated lessons learned from BAEDN into their process for working with resource managers in other regions with setting their own strategies. As these regional efforts develop, Cal-IPC is working to coordinate them with each other in a statewide network.

Summary

BAEDN was able to harness pre-existing data and other resources to initiate a regional EDRR organization. Early collaboration positioned the organization to secure funding to prioritize species and occurrences, share information, create new tools, and remove high priority occurrences. By adopting strategies that made BAEDN a success other regional groups can either add a robust EDRR component to what they already do or new groups can be formed. Additional information can be found at http://www.cal-ipc.org/WMAs/BAEDN/.

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