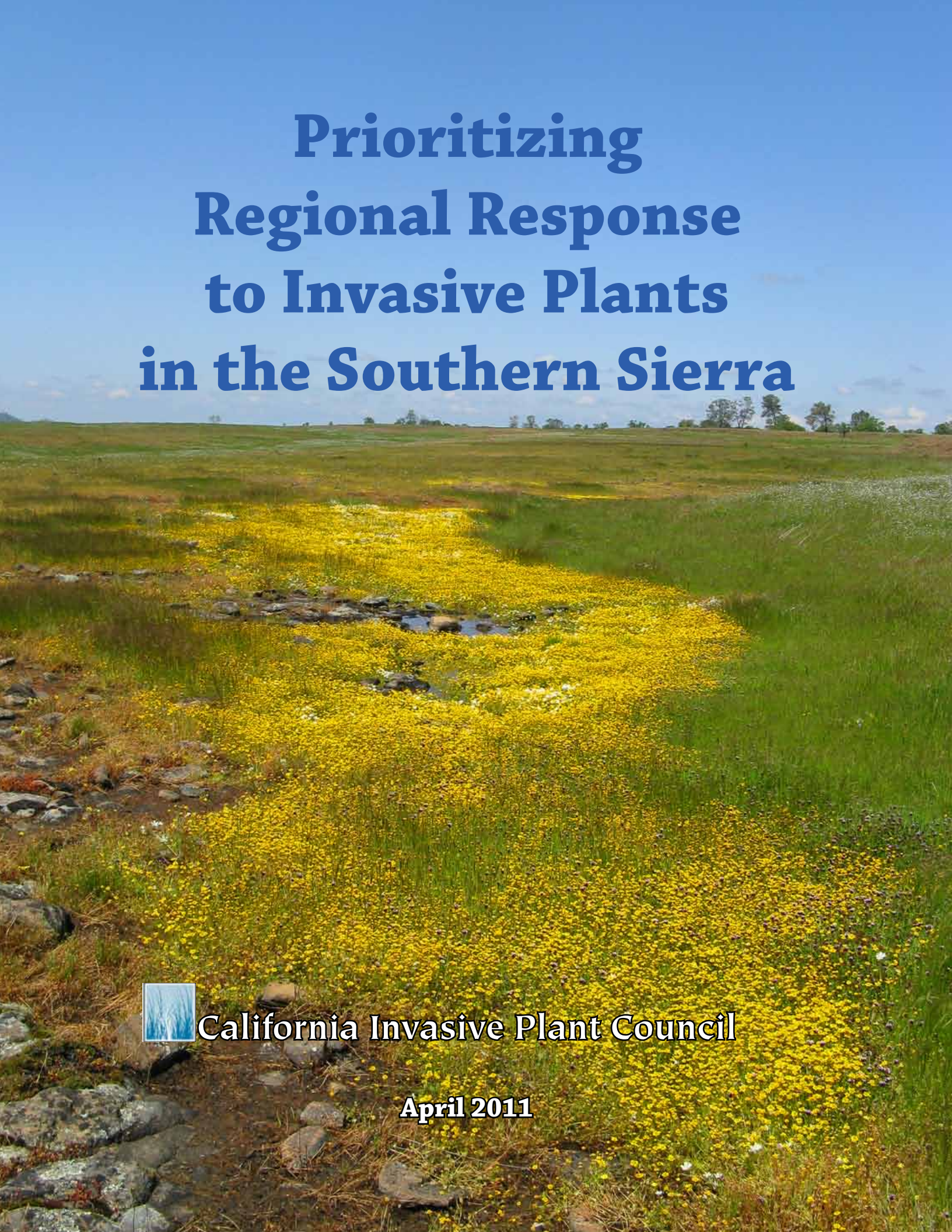
Prioritizing Regional Response to Invasive Plants in the Southern Sierra



California Invasive Plant Council

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RECOMMENDATIONS FOR THE SOUTHERN SIERRA

Reducing the impact of invasive plants on wildlife habitat is an essential part of wildland stewardship, and will be a key part of climate change adaptation strategies. Natural resource managers need maps of invasive plant distribution to most effectively address their impacts. Tracking the spread of a species over time, selecting strategic priorities, designing management programs and evaluating their effectiveness depend on landscape-scale maps that can be updated regularly.

To address this need, Cal-IPC initiated a statewide mapping effort specifically designed to produce landscape-scale invasive plant distribution maps. For each invasive plant species, distribution data is complemented by suitable range projections based on climate. These "risk maps" are necessarily coarse in resolution (they are based on USGS 7.5-minute quadrangles) and depend on expert opinion as much as on ground-mapped GIS datasets for current distribution data. These maps support strategic prioritization for addressing particular species in specific areas using specific management approaches.

This report presents Southern Sierra Nevada risk maps and management recommendations for twelve invasive plant species of high priority to conservation in the region. (For our purposes, the Southern Sierra comprises portions of Kern, Tulare and Fresno counties within the Sierra Nevada ecoregion.) These maps and recommendations were developed for 43 species selected to be of special importance for the Sierra Nevada region of California. The recommendations consider three types of strategic management opportunities: eradication, containment, and surveillance. As part of this project, Cal-IPC also mapped suitable range across the state for 29 of the study species, based on climate data. The resulting

This report supplements Cal-IPC's report on "Prioritizing Regional Response to Invasive Plants in the Sierra Nevada", which presents maps and recommendations for 43 invasive plants of concern in the region. Please see the full Sierra report (available at www.cal-ipc.org/ip/mapping/sierra) for statewide maps for all 43 species, a detailed description of methods, and information on each invasive plant studied.

maps show areas that are most vulnerable to spread. In addition, we used suitability modeling to assess future suitable range based on climate change projections.

This report does not constitute a comprehensive study of all invasive plant species in the Southern Sierra. We selected a representative sample of the approximately 100 invasive plant species currently found in the Sierra Nevada (as identified in Cal-IPC's Invasive Plant Inventory, Cal-IPC 2006). As our data collection effort continues, we expect to map the distribution of all invasive plants and model suitable range for as many of these species as possible.

The results of this project can help natural resource professionals design invasive plant management programs that most effectively achieve long-term conservation goals. By providing maps that show the spatial basis for management strategies can also help secure funding for these programs. Project results also provide important information for integration into collaborative region-wide conservation efforts like the Southern Sierra Partnership (2010).

Regional Assessment

The Southern Sierra is infested with fewer of the 43 invasive plant species studied in this project than is the Sierra Nevada region as a whole. Many species that are serious problems in the northern and central Sierra Nevada, such as brooms, musk thistle, diffuse knapweed, and Canada thistle, are not yet present or have a limited distribution in the Southern Sierra. This presents important opportunities in the region. Some species that are too widespread to be eradicated elsewhere may still be candidates for region-wide eradication in the Southern Sierra, avoiding more extensive infestation—and impacts—in the future. Species not yet present in the region provide surveillance opportunities for monitoring particular species likely to spread into the region, especially from the Sierra farther north or from the Central Valley to the west.

Our results indicate that the Southern Sierra may see more increase in suitable range for these 43 species between 2010 and 2050 than will the Sierra Nevada as a whole. While 17 species showed an overall increase in suitable range in the entire Sierra Nevada region, 22 species showed an increase in suitable range in the Southern Sierra. On the other hand, six species showed a decrease in suitable range for the entire Sierra Nevada, while only four showed decrease in the Southern Sierra. (Our comparisons from 2010 to 2050 are based on the amount of suitable area, and do not compare the relative level of suitability.) As the downscaling of global climate models evolves, it will be important to examine the range of projections under different scenarios, especially precipitation, to clarify the level of uncertainty.

Management Recommendations

For each of the 43 species, we identify and rank opportunities for eradication, containment, and surveillance. These opportunities are identified in large part based on the geographic distribution of a particular species. Limited infestations characterized by isolated populations offer the potential for eradication. More extensive infestations may only be candidates for containment, active management aimed at preventing spread. Species not yet present in the region, but judged to be a threat to spread into the region in the future, are targets for surveillance. Rankings of opportunities for each plant species depend on factors including the impact of the species and the suitability of the region for the species.

The twelve top-ranking opportunities are recommended below as priority actions for the region. The recommendations summarize the primary strategic management approach that should be adopted for that species for the Southern Sierra region. (Of course, all of the species are surveillance targets, even if the primary recommendation is eradication or containment.) The accompanying regional risk maps show the current distribution and suitability for the species discussed. (Refer to the full Sierra report for maps of all 43 species, including suitable range in 2050.) Following the recommendations and risk maps for the twelve priority species is a full table of all 43 invasive plant species studied in this project, with management opportunities rankings and summary statistics for the Southern Sierra.

Russian knapweed (*Acroptilon repens*): Russian knapweed is a priority for **eradication**. Only one quad in the Southern Sierra is infested with Russian knapweed, in southern Kern County, and it is currently under management. However, GIS data indicates several neighboring populations in the Central Valley areas of Fresno, Tulare, and Kern counties as well as in Mono and Inyo counties along the Eastern Sierra. Our modeling shows

the climate in much of the Southern Sierra to be suitable and to remain so through 2050, raising the possibility of further spread in the region. Continued surveillance for Russian knapweed is important.

Italian thistle and **slenderflower thistle** (*Carduus pycnocephalus, C. tenuiflorus*): Italian and slenderflower thistles were combined for this project. They are priorities for **containment** in the Southern Sierra. These species are much more prevalent in the Central Sierra, where they are spreading to fairly high altitudes. Populations exist in the northern part of Fresno County and the southern end of the Sierra in Kern County, and should be actively contained. We did not model suitability for these species.

Spotted knapweed (*Centaurea maculosa*): Spotted knapweed is a priority for **eradication**. It is present at low abundance in several quads, is already under management in some, and has previously been eradicated in a few areas. Spotted knapweed is present more widely in the Central and Northern Sierra, and is a management focus throughout the region. Our modeling indicates that the amount of suitable range in the Southern Sierra for spotted knapweed is likely to increase, and only a small proportion of the suitable area is currently infested. Of the three knapweeds studied, it is the most difficult to remove.

Yellow starthistle (*Centaurea solstitialis*): Yellow starthistle is a priority for **containment**. It is under management in many quads in the western half of the Southern Sierra, and is continuing to spread in many of the quads. Our modeling indicates that the amount of suitable range in the Southern Sierra is likely to stay approximately the same for yellow starthistle, but only 39% of the suitable area is currently infested so there is a large potential for spread. Continuing the containment work of the regional Yellow Starthistle Leading Edge Project (CDFA 2011), which coordinates 14 counties, is important to prevent spread to higher elevations.

Rush skeletonweed (*Chondrilla juncea*): Rush skeletonweed is a priority for **eradication**. It is present only at the edge of the Southern Sierra in the Central Valley portion of Fresno County and on the eastern Sierra in southern Inyo County. Much of the Fresno County infestation is already under management. Active surveillance is important to prevent spread to higher elevations,

as has happened in the Northern Sierra. Our modeling indicates that the amount of suitable range in the Southern Sierra is likely to increase for rush skeletonweed, and very little of the suitable area is currently infested.

Scotch thistle (*Onopordum acanthium*): Scotch thistle is a priority for **containment**. Expert opinion data indicates that Scotch thistle is present (and spreading) in only two quads in Tulare County, but additional observation data indicates several more quads potentially infested in and adjoining the Sierra part of the county. Verifying these populations is an important next step in planning region-wide containment. Our modeling indicates that the amount of suitable range in the Southern Sierra for Scotch thistle is likely to decrease.

Scotch broom (*Cytisus scoparius*): Scotch broom is a priority for **eradication**. Only two quads are infested in the region. Broom species, including French broom and Spanish broom below, are much less prevalent in the Southern Sierra than in the rest of the Sierra Nevada. Our modeling indicates that the amount of suitable range for Scotch broom in the Southern Sierra is likely to more than double by 2050.

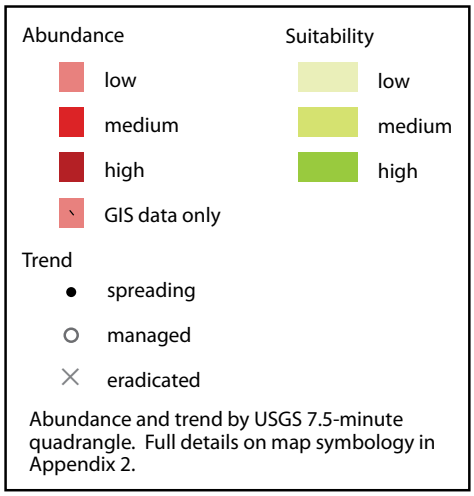
French broom (*Genista monspessulana*): French broom is a priority for **eradication**. Only two quads are infested in the region, and one is already under management. Our modeling indicates that the amount of suitable range for French broom in the Southern Sierra is likely to more than double by 2050.

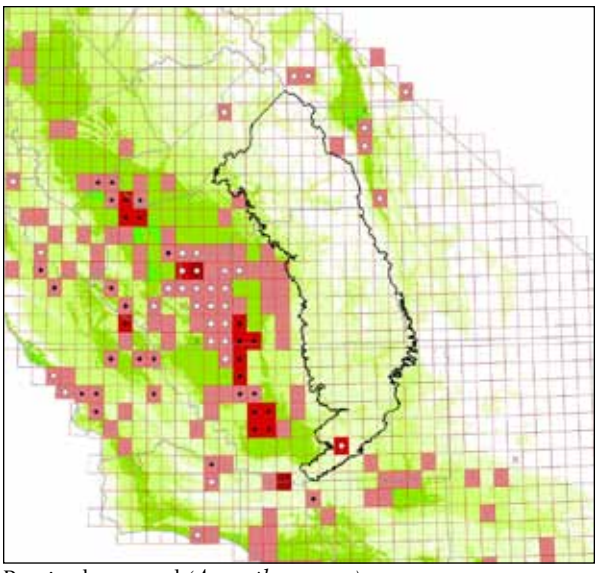
Spanish broom (*Spartium junceum*): Spanish broom is a priority for **containment**. Spanish broom is more widely distributed in the Southern Sierra than the other two broom species studied. Our modeling shows more suitable range in the region than for the other brooms, and only 10% of the suitable range is currently infested, with the amount of suitable range in the Southern Sierra likely to more than double by 2050.

Red sesbania (*Sesbania punicea*): Red sesbania is a priority for **eradication**. It is present and spreading in one quad in Fresno County on the edge of the Southern Sierra region. This species is a relatively new invasive plant in California, and our modeling indicates that the amount of suitable range in the Southern Sierra is likely to more than double by 2050.

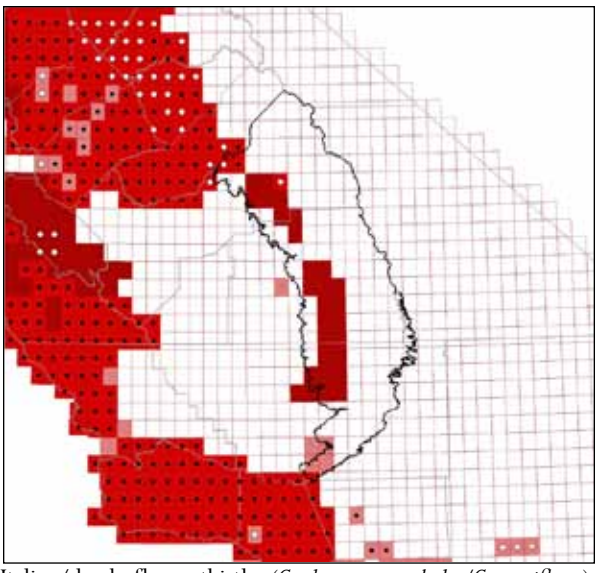
Giant reed (*Arundo donax*): Giant reed is a priority for **containment**. Infestations in Tulare and Kern counties are spreading, and probably too extensive for eradication. Our modeling indicates that only a small portion of the suitable range in the region is currently infested and the amount of suitable range is likely to increase by 2050.

Dalmatian toadflax (*Linaria genistifolia* subsp. *dalmatica*): Dalmatian toadflax is a priority for **eradication**. It is currently known to be present in only two quads. Our modeling indicates that only a small portion of the current suitable range is infested in the region, and that the amount of suitable range is likely to more than double by 2050.

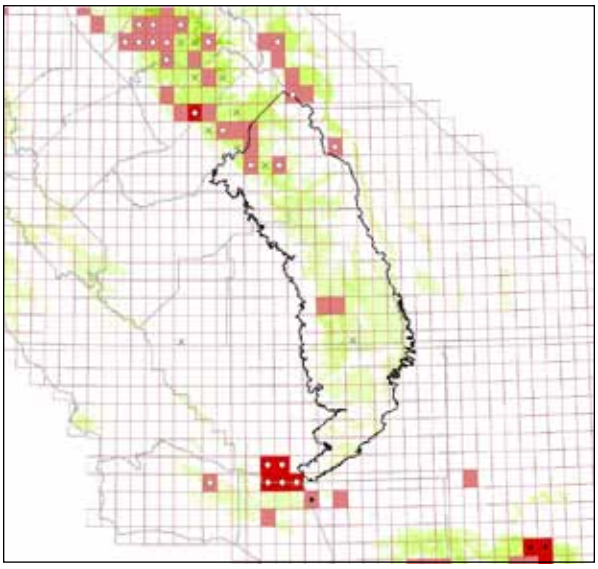




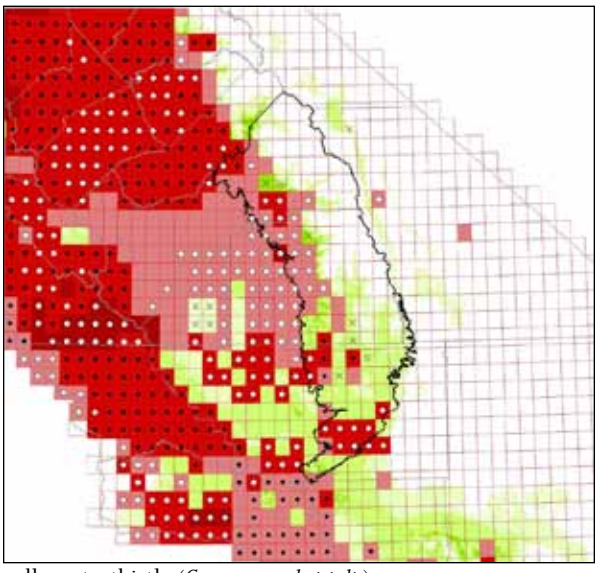
Russian knapweed (*Acroptilon repens*)



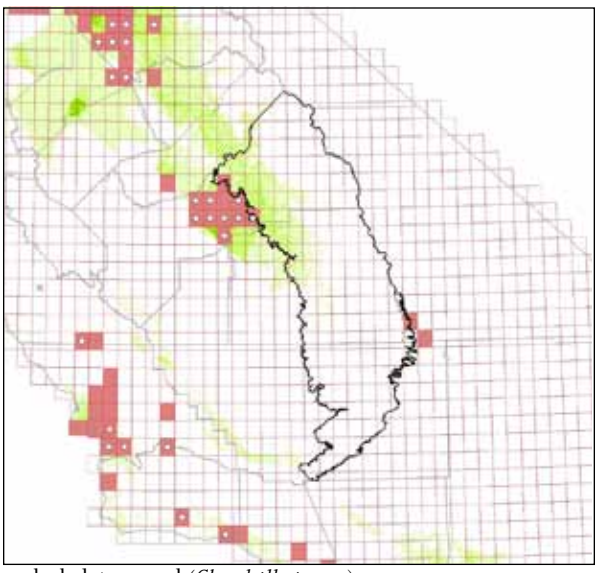
Italian/slenderflower thistles (*Carduus pycnocephalus/C. tenuiflorus*)



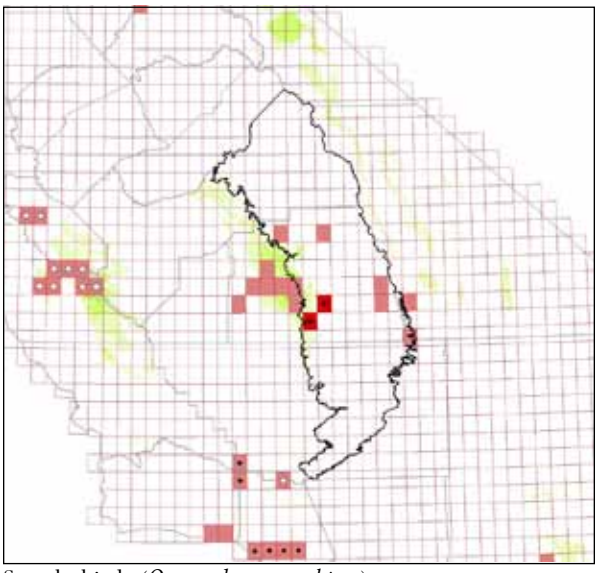
spotted knapweed (*Centaurea maculosa*)



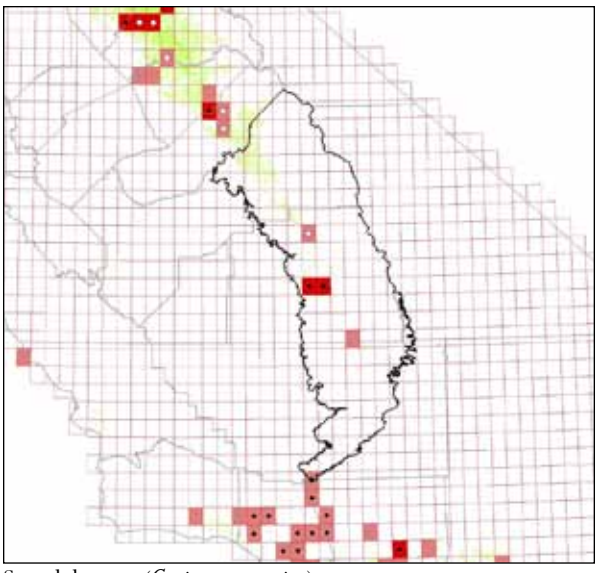
yellow starthistle (*Centaurea solstitialis*)



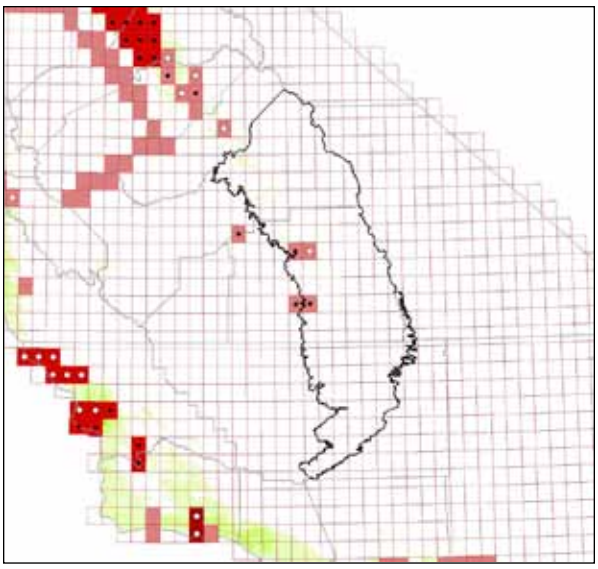
rush skeletonweed (*Chondrilla juncea*)



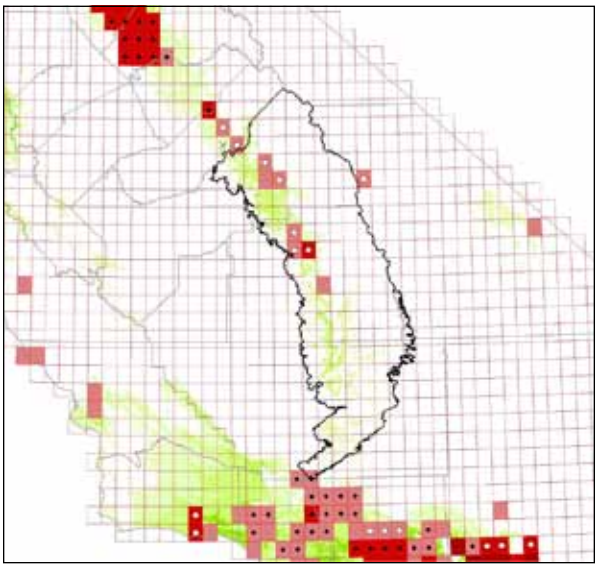
Scotch thistle (*Onopordum acanthium*)



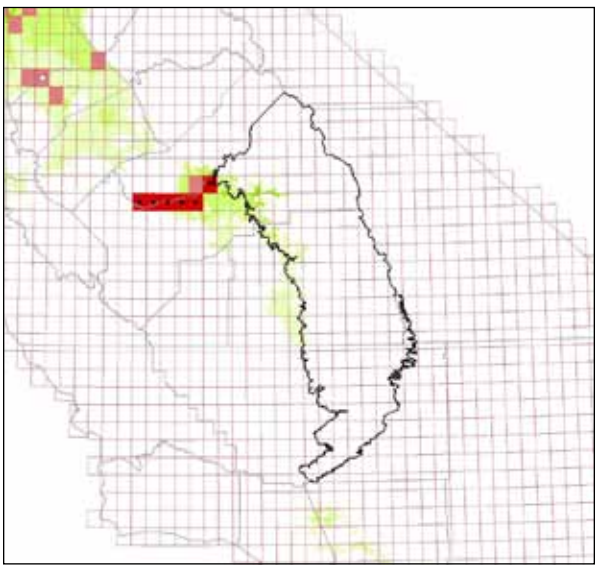
Scotch broom (*Cytisus scoparius*)



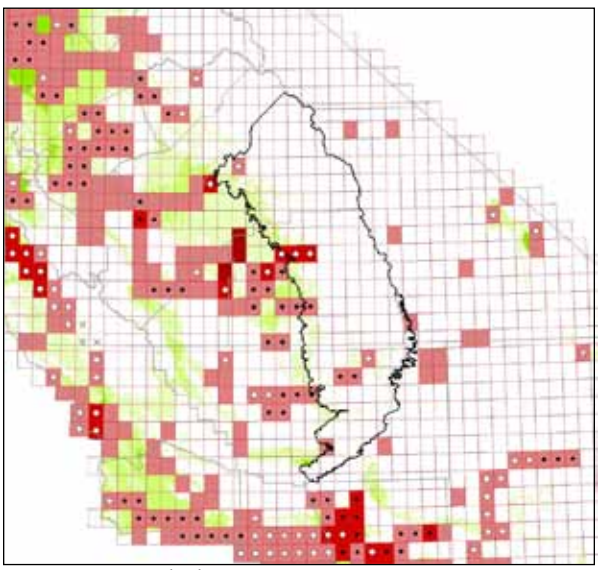
French broom (*Genista monspessulana*)



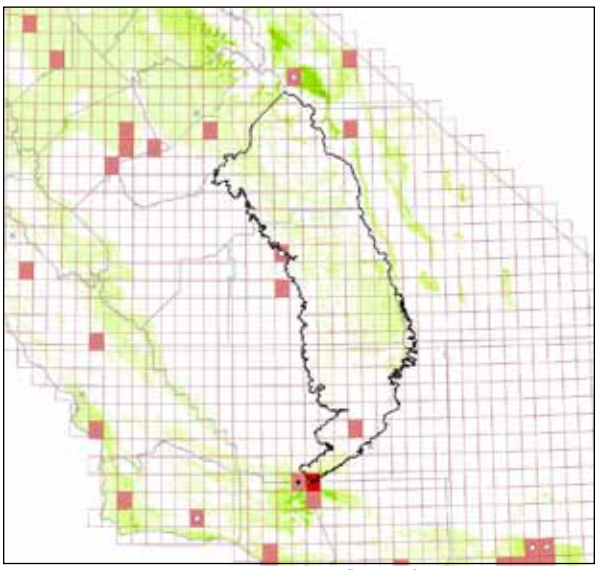
Spanish broom (*Spartium junceum*)



red sesbania (*Sesbania punicea*)



giant reed (*Arundo donax*)



Dalmatian toadflax (*Linaria genistifolia* subsp. *dalmatica*)

Management opportunities and statistics for the Southern Sierra

Priority	Species	Opportunities			Statistics							
		Eradication	Containment	Surveillance	% Infested	% Suitable Infested	% Spreading	% Managed	% Eradicated	% Suitable 2010	% Suitable 2050	Suitability change
	Family Apiaceae											
	Poison-hemlock	-	M	-	23	45	36	2	0	20	2	↓
	Family Asteraceae											
●	**Russian knapweed**	**H**	**-**	**-**	**3**	**3**	**20**	**20**	**0**	**73**	**82**	**-**
	Musk thistle	-	-	L	-	0	-	-	0	1	0	-
●	**Italian thistle & slenderflower thistle**	**-**	**H**	**-**	**7**	**-**	**69**	**0**	**0**	**-**	**-**	**-**
	Woolly distaff thistle	-	-	M	0	-	-	-	0	0	0	-
	Diffuse knapweed		-	M	0	0	-	-	0	33	33	-
●	**Spotted knapweed**	**H**	**-**	**-**	**6**	**7**	**10**	**40**	**2**	**42**	**55**	**↑**
	Tocalote	-	M	-	54	-	20	1	0	-	-	-
●	**Yellow starthistle**	**-**	**H**	**-**	**36**	**39**	**55**	**26**	**2**	**72**	**74**	**-**
●	**Rush skeletonweed**	**H**	**-**	**-**	**3**	**6**	**0**	**40**	**0**	**20**	**28**	**↑**
	Canada thistle	M	-	-	2	4	50	25	1	13	7	↓
	Bull thistle	-	L	-	61	62	7	7	0	69	83	↑
	Stinkwort	-	-	M	0	0	-	-	0	1	0	↓
	Ox-eye daisy	-	M	-	1	2	50	0	0	12	20	↑
●	**Scotch thistle**	**-**	**H**	-	**6**	**16**	**20**	**0**	**0**	**7**	**1**	**↓**
	Family Boraginaceae											
	Houndstongue	-	-	-	0	-	-	-	0	-	-	-
	Family Brassicaceae											
	Lens-podded white-top & hoary cress	M	-	-	5	-	0	22	0	-	-	-
	Dyer's woad	-	-	M	0	0	-	-	0	1	3	↑
	Charlock mustard	-	L	-	8	-	7	0	0	-	-	-
	Family Dipsacaceae											
	Common teasel & fuller's teasel	-	M	-	6	9	0	0	0	18	32	↑
	Family Fabaceae											
●	**Scotch broom**	**H**	**-**	**-**	**1**	**6**	**0**	**0**	**0**	**4**	**26**	**↑↑**
●	**French broom**	**H**	**-**	**-**	**2**	**20**	**75**	**25**	**0**	**1**	**18**	**↑↑**
●	**Spanish broom**	**-**	**H**	**-**	**6**	**10**	**10**	**40**	**1**	**17**	**59**	**↑↑**
	Black locust	-	L	-	3	-	17	0	0	-	-	-
●	**Red sesbania**	**H**	**-**	-	**1**	**2**	**100**	**0**	**0**	**7**	**21**	**↑↑**
	Gorse	-	-	-	0	-	-	-	0	0	8	-
	Family Poaceae											
●	**Giant reed**	**-**	**H**	**-**	**8**	**16**	**64**	**7**	**0**	**17**	**31**	**↑**
	Annual false-brome	M	-	-	1	3	0	0	0	6	2	↓
	Japanese brome	L	-	-	0	-	-	-	0	-	-	-
	Red brome	-	M	-	55	56	16	0	0	79	60	↓
	Jubatagrass	M		-	4	-	0	0	1	-	-	-
	Pampasgrass	-	M	-	4	100	0	0	1	0	1	↑↑
	Orchardgrass	-	L	-	20	21	33	3	0	71	79	-

	Mediterranean barley	-	M	-	27	-	31	0	0	-	-	-
	Hare barley	-	M	-	52	-	15	0	0	-	-	-
	Italian ryegrass	-	M	-	28	43	63	0	0	31	30	-
	FAMILY POLYGONACEAE											
	Japanese knotweed	-	-	-	0	-	-	-	0	-	-	-
	Giant knotweed	-	-	-	0	-	-	-	0	-	-	-
	FAMILY SCROPHULARIACEAE											
●	**Dalmatian toadflax**	**H**	**-**	**-**	**2**	**3**	**75**	**0**	**1**	**28**	**74**	**↑↑**
	Yellow toadflax	-	-	M	0	0	-	-	0	42	66	↑
	FAMILY SIMAROUBACEAE											
	Tree-of-heaven	-	M	-	28	38	71	6	0	45	66	↑
	FAMILY SOLANACEAE											
	Tree tobacco	-	M	-	29	80	2	0	0	16	18	-

Opportunities: H = high priority, M = medium, L = low

% Infested: portion of USGS quads in the area in which the species is present in wildlands

% Suitable Infested: portion of quads in the area with suitable climate that are currently infested

% Spreading: portion of infested quads in which the species is spreading

% Managed: portion of infested quads where species is under management

% Eradicated: portion of all quads in the area in which the species has been eradicated

% Suitable in 2010: portion of area with current climatic suitability of at least a level of "low" or higher

% Suitable in 2050: of area with projected 2050 climatic suitability of at least a level of "low" or higher

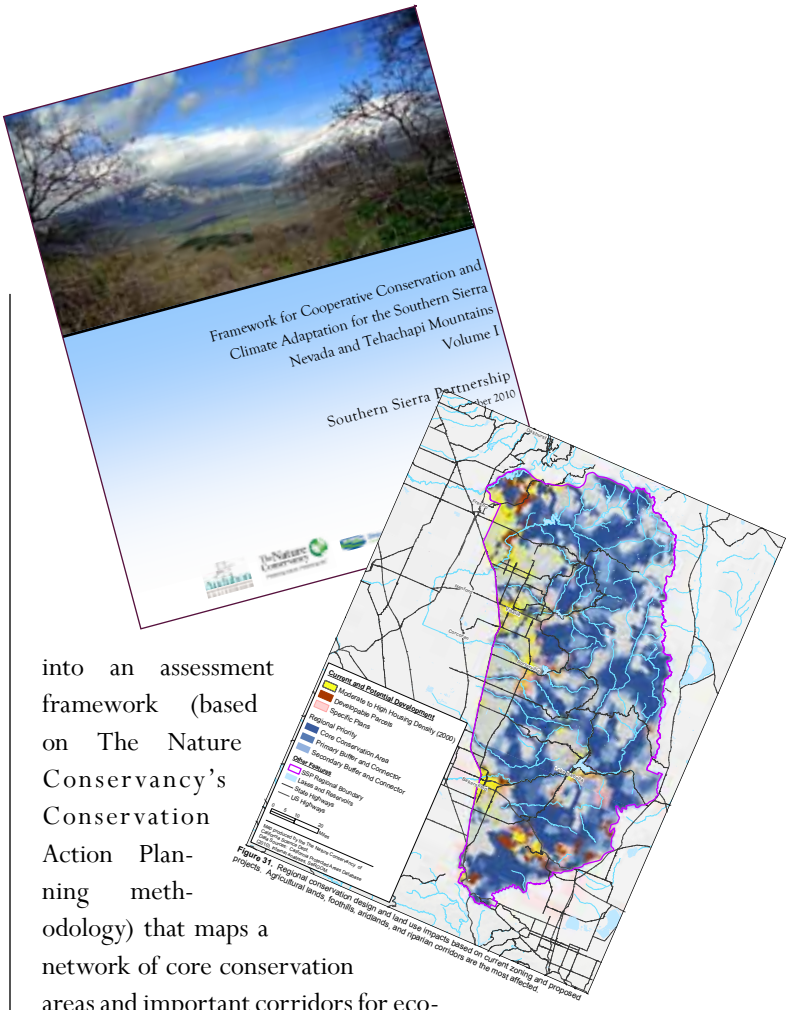
Suitability change:
↑ = a 15% - 99% increase from 2010 to 2050
↑↑= an increase of greater than 100%
↓ = a decrease of greater than 15%

Integration

The results of this project (including the risk maps for all 43 species contained in the full Sierra report) can be integrated into existing activities and future planning at multiple scales. Individual natural resource managers can determine which species are in or near their immediate area, and use this information to help set priorities for the properties they manage. County-based cooperative Weed Management Areas–Kern WMA, Tulare WMA, and the Sierra-San Joaquin WMA that includes Fresno County as well as Madera and Mariposa to the north–can use the risk maps to identify priorities and strategies for their areas. (The full Sierra report summarizes recommendations for each WMA in the region.) Region-wide planning through collaborations like the Southern Sierra Partnership can incorporate our results into their conservation analysis. In addition, Sierra-wide programs like the Yellow Starthistle Leading Edge Project (CDFA 2011), coordinated through WMAs stretching from Plumas County in the north to Kern County in the south, can use our maps to support their efforts.

The Leading Edge Project works to prevent the spread of yellow starthistle, which densely infests the Central Valley and Sierra foothills, farther eastward to higher elevations. Multiple agencies work together to treat infestations of the plant found beyond the defined leading edge line, and to educate landowners on identification and control techniques. Our risk maps provide a current assessment of the leading edge, and can help monitor future spread–as well as progress made in addressing spread–as data for quads is updated through the online risk mapping tool being developed. The risk maps can also show opportunities for other species with distribution patterns similar to that of yellow starthistle to be incorporated into the leading edge project (though this in general appears to be better suited to species distributions in the Central and Northern Sierra).

The Southern Sierra Partnership (SSP), in their report "Framework for Cooperative Conservation and Climate Adaptation for the Southern Sierra Nevada and Tehachapi Mountains" (Southern Sierra Partnership 2010), has laid extensive groundwork for assessing threats and opportunities in the region using spatial data. They combine numerous factors including connectivity across elevation gradients, condition of particular vegetation communities, and sustainability of particular ecosystem services



into an assessment framework (based on The Nature Conservancy's Conservation Action Planning methodology) that maps a network of core conservation areas and important corridors for ecological linkage. They also used an ensemble of downscaled climate data from the IPCC A2 scenario to determine areas of future climate stress, climate refugia, and areas of possible range expansion.

The SSP report identifies invasive plants as one of the top threats to conservation targets in the Southern Sierra, with specific threats including the expansion of drought-tolerant species and the invasion of non-native annual grasses into communities including chaparral and montane shrublands. Some conservation targets, such as foothill oak woodlands, are currently assessed as having only a moderate level of impact from invasive plants, while alpine habitats are currently the least impacted. Given the potential for many invasive plant species to spread further in the region, especially as suitability increases with climate change, active surveillance and response activities will be essential for maintaining these relatively low levels of impact.

Our maps of current distribution and projected suitable habitat can be productively overlaid with the results of the SSP. (This will require some GIS work to relate our mapping units–USGS quads–with the hexagonal Marxan

cells output by the SSP system for conservation targets.) Indeed, other spatial layers aimed at capturing conservation values, such as the California Department of Fish & Game's Areas of Conservation Emphasis (ACE II) and the California Department of Transportation's Essential Linkage Analysis, can also be overlaid with our statewide risk maps to help determine high-priority "no regrets" invasive plant management actions. Invasive plant populations located within areas identified by the SSP and other analyses as important refugia, core conservation areas or key linkages are high priorities for management. In addition, tracking and addressing the spread of source populations neighboring these zones is also critical.

Urban expansion and exurban sprawl are identified by the SSP report as a stressor in the region. Construction disturbance and landscaping associated with such development can also serve as a primary pathway for spreading invasive plants. In addition, many invasive plants spread along roadsides as seeds are blown by traffic or attached to vehicles, including road maintenance equipment. These pathways must certainly be addressed on the ground, and may also be integrated into GIS analyses to help prioritize particular areas.

The SSP report, like ours, identifies giant reed (*Arundo donax*) as a species of special regional concern in riparian habitats. Protecting these habitats requires regular surveys of riparian conditions. Such surveys should delimit the extent of giant reed, red sesbania, and other invasive species. Likewise, foothill areas should be a key focus, not only because their particular habitat values are compromised by invasive plants but because they form a buffer between extensive infestations of some invasive plant species in the Central Valley and largely un-impacted upper elevations. Coordination with groups active in the valley, such as the Tulare Basin Wildlife Partners Working Group, can help monitor source populations of invasive plants more prevalent in the valley.

Overlaying invasive plant risk maps with land ownership would also be fruitful. Coordination between the major federal landowners, such as the USDA Forest Service, National Park Service, Bureau of Land Management, and private ranching operations is essential for successful regional strategies to manage invasive plants. Regular meetings among natural resource managers from these entities throughout the region could be used to set priorities and plan response efforts, helping ensure this coordination.

Invasive plant species will continue to affect the vulnerability and resilience of conservation targets. As native vegetation shifts with a changing climate, invasive plants may restrict recruitment in new areas, and may even have potential to drive community type conversion. Invasive plant risk maps provide a foundation for developing sound invasive plant management strategies in the region. Future analytic efforts will assess additional species, create an online risk mapping tool, and overlay invasive plant risk maps with spatial layers representing conservation values. Together, these efforts support critical resource management activities of those dedicated to protecting the unique natural heritage of the Southern Sierra.

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Species List

Study species with ratings from Cal-IPC (Cal-IPC 2006) and the California Department of Food and Agriculture (CDFA 2010). Some closely-related species were combined for the purposes of this project when identification is difficult and they grow in the same habitats.

Species	Scientific Name	Cal-IPC	CDFA
Family Apiaceae			
Poison-hemlock	*Conium maculatum*	Moderate	
Family Asteraceae			
Russian knapweed	*Acroptilon repens*	Moderate	B
Musk thistle	*Carduus nutans*	Moderate	A
Italian thistle & slenderflower thistle	*Carduus pycnocephalus &* *C. tenuiflorus*	Moderate Limited	C C
Woolly distaff thistle	*Carthamus lanatus*	Moderate-Alert	B
Diffuse knapweed	*Centaurea diffusa*	Moderate	A
Spotted knapweed	*Centaurea maculosa*	High	A
Tocalote	*Centaurea melitensis*	Moderate	
Yellow starthistle	*Centaurea solstitialis*	High	C
Rush skeletonweed	*Chondrilla juncea*	Moderate	A
Canada thistle	*Cirsium arvense*	Moderate	B
Bull thistle	*Cirsium vulgare*	Moderate	C
Stinkwort	*Dittrichia graveolens*	Moderate	
Ox-eye daisy	*Leucanthemum vulgare*	Moderate	
Scotch thistle	*Onopordum acanthium*	High	A
Family Boraginaceae			
Houndstongue	*Cynoglossum officinale*	Moderate	
Lens-podded white-top & hoary cress	*Cardaria chalepensis &* *C. draba*	Moderate-Alert Moderate	B B
Family Brassicaceae			
Dyer's woad	*Isatis tinctoria*	Moderate	B
Charlock mustard	*Sinapis arvensis*	Limited	
Family Dipsacaceae			
Common teasel & fuller's teasel	*Dipsacus fullonum &* *D. sativus*	Moderate Moderate	
Family Fabaceae			
Scotch broom	*Cytisus scoparius*	High	C
French broom	*Genista monspessulana*	High	C
Spanish broom	*Spartium junceum*	High	C
Black locust	*Robinia pseudoacacia*	Limited	
Red sesbania	*Sesbania punicea*	High	B
Gorse	*Ulex europaeus*	High	B

FAMILY POACEAE			
Giant reed	*Arundo donax*	High	B
Annual false-brome	*Brachypodium distachyon*	Moderate	
Japanese brome	*Bromus japonicus*	Limited	
Red brome	*Bromus madritensis* subsp. *rubens*	High	
Jubatagrass	*Cortaderia jubata*	High	B
Pampasgrass	*Cortaderia selloana*	High	
Orchardgrass	*Dactylis glomerata*	Limited	
Common velvet grass	*Holcus lanatus*	Moderate	
Mediterranean barley	*Hordeum marinum*	Moderate	
Hare barley	*Hordeum murinum*	Moderate	
Italian ryegrass	*Lolium multiflorum*	Moderate	
Family Polygonaceae			
Japanese knotweed	*Polygonum cuspidatum*	Moderate-Alert	B
Giant knotweed	*Polygonum sachalinense*	Moderate-Alert	B
Family Scrophulariaceae			
Dalmation toadflax	*Linaria genistifolia* subsp. *dalmatica*	Moderate	A
Yellow toadflax	*Linaria vulgaris*	Moderate	
Family Simaroubaceae			
Tree-of-heaven	*Ailanthus altissima*	Moderate	
Family Solanaceae			
Tree tobacco	*Nicotiana glauca*	Moderate	

All abundance, spread, and management values are based on USGS 7.5-minute quadrangles (hereafter referred to as "quads"). This grid offers fairly uniform rectangles across the U.S. Quads measure approximately 8.5 miles north to south, and range from approximately 7.2 miles east to west on the southern border of the state to 6.5 miles east to west on the northern border of the state.

Data on abundance, spread, and management are primarily based on interviews with local natural resource managers to collect "expert knowledge". The online risk mapping system in development will document who has contributed information for a given quad and will allow ongoing updates. As a secondary source, we also used GIS data sets collected from organizations throughout the state, as well as invasive plant location data aggregated in the Calflora and Consortium of California Herbaria online databases. These data appear in quads only where resource managers indicated that they are not aware of a plant species' presence. A small "\" symbol and shading for low abundance indicate quads where presence is assumed due only to GIS data. Actual presence in these quads should be confirmed on the ground, since the GIS data may not be current or accurate.

Abundance: Red shading indicates three categories for abundance: low, medium and high. These are relative values based on the typical invasion curve, where abundance starts low (during the "lag phase"), then increases rapidly, and finally levels off when the ecological niche is saturated. In our schema, "low" represents an infestation that is early on the invasion curve. "Medium" represents the expansion phase of invasion, where abundance is increasing. "High" represents the final stage where an infestation has filled the available ecological niche and is no longer increasing appreciably. Depending on the extent of the ecological niche for a given species, the actual area infested can vary considerably from species to species.

Spread: A black dot in the center of a quad indicates that the species is spreading. No dot means the infestation is stable and not increasing. Quads where abundance is low can be stable or spreading. Quads where abundance is medium are, by definition, spreading, unless there is active management. Quads where abundance is high are, by definition, not able to spread any further.

Management: A white dot in the center of a quad indicates that the species is under active management. Management does not imply that the infestation is necessarily decreasing; in some cases the overall trend in the quad may still be that the infestation is increasing. However, we do not show that information on these maps. Quads where the species has previously been eradicated and is no longer present are shown with an "×" symbol.

Suitability: Green shading indicates three categories of climatic suitability: low, medium, and high. These are based on output from models based on current populations in California. In general, we believe our range maps are conservative and may underestimate the potential range of a given species, because: (1) they are based only on places where a plant has already invaded in the state, (2) they are based only on places where we have data on that plant, and (3) we calibrated the models to restrict estimates to only areas that are very similar climatically to those areas already invaded. Suitability projections for 2050 use an A2 emissions scenario (IPPC 2007), downscaled climate data from the Canadian Centre for Climate Modeling and Analysis, and Maxent software (Phillips et al. 2006) to extrapolate from current plant locations to potential range.