DELTA SCIENCE PROGRAM

Determining the Factors Controlling Site Invasibility to *Lepidium latifolium*

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SUMMARY

In this project, the Delta Science Fellow compiled several years of airborne hyperspectral imaging data to produce detailed maps of the distribution of the invasive perennial pepperweed (*Lepidium latifolium*) at sites in the Sacramento San Francisco Bay-Delta. From the maps, inferences were made about the habitats that attract this noxious invasive plant, facilitate its spread and are vulnerable to future infestation. The Solano Land Trust, a non-profit that purchases land for preservation, is using the maps to more strategically and cost-effectively contain existing infestations and prevent colonization of presently weed-free places.

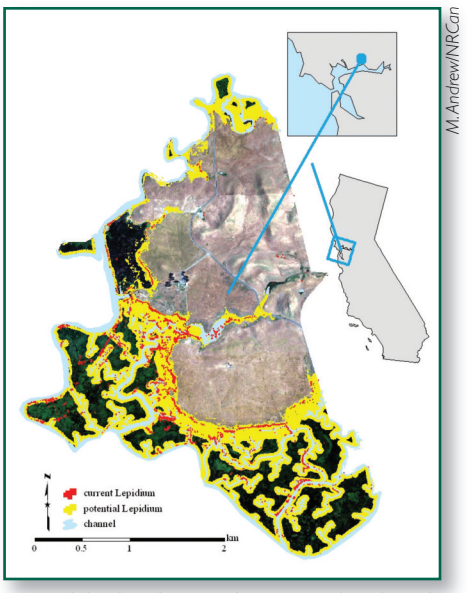
Perennial pepperweed is a long-lived herbaceous member of the mustard family, native to southeastern Europe and Asia and now common in the western United States. It forms large, dense stands with extensive root systems, displacing native vegetation, reducing native habitat for wildlife. Established populations are difficult to control and easily spread along entire stream corridors and irrigation structures. Floods often wash away roots growing along stream banks, spreading infestations progressively downstream.

RESULTS

The scientist was able to map distributions of pepperweed at the Rush Ranch Open Space Preserve in Suisun Marsh, the Greater Jepson Prairie Ecosystem on the northwest side of the delta, and on Bouldin Island in the central delta. A similar map of the Cosumnes River Preserve in the northeast delta could not be produced, however, because of the preserve's spectral complexity, which reflects its diverse flora and varied topography.

Flowering pepperweed plants.
M. Andrew/NRCan

By combining hyperspectral and LiDAR (Light Detection and Ranging) data, the scientist created a habitat model for Rush Ranch that identified sites vulnerable to future invasion. Model output suggests that pepperweed only occupies about 5 percent of its potential distribution at the ranch, and that the habitat could support a 20-fold spreading, leading to about 25 percent of the preserve being covered by the weed. The areas most vulnerable to invasion (those that minimize the plant's stress from brackish conditions) are the marshland-upland margin and natural levees along channels. Although pepperweed is capable of withstanding brackish conditions, the plant tends to avoid these habitats when others are available.



M. Andrew/NRCan

Map of the distribution of pepperweed (red) and its potential distribution (yellow) at the Rush Ranch Open Space Preserve in Suisun Marsh.

Hydrology, both through topographic effects and variable precipitation patterns, appears to play a critical role in phenology (i.e., its vegetative, flowering, fruiting and pepperweed's senescent life cycles). For example, the most advanced phenology was observed to occur at lower convexities, shallower slopes and at higher elevations, while phenology was delayed in years with above normal precipitation. (The most advanced phenology was also observed in the interior of infestation sites, likely due, in part, to intraspecific competition.)

The scientist characterized pepperweed's spreading patterns from five aerial surveys of Bouldin Island flown between 2004 and 2008. She reports that, at sites with pre-existing infestations, spreading was linear; the expanse of land invaded doubled during the four-year period. At a site colonized during the surveys, there was a 30-fold increase in the extent of the infestation. Pepperweed encroachment was as great as 215 meters per year, with the average ranging from 5 meters to 53 meters. Wet springs were observed to accelerate the weed's dispersal.

The scientist used the observations of dispersal on Bouldin Island to parameterize a simulation model of pepperweed's spreading characteristics. Results indicate that temporal variation in dispersal does not substantially reduce spreading, relative to the fastest constant dispersal scenario; pepperweed spreads the fastest when it

colonizes an area with abundant available habitat and, to a lesser extent, when corridors are nearby.

Findings underscore the importance of aggressively controlling pepperweed during years in which it is expected to spread most rapidly and if it has invaded favorite habitats connected to stream corridors and/or large expanses of suitable habitat. Priority should be given to eradicating new patches in these areas.

APPLICATIONS

This project demonstrates the feasibility of using hyperspectral imaging for large-scale mapping of perennial pepperweed in the San Francisco Bay-Delta. The Solano Land Trust is using these maps and others to develop invasive weed management plans at Rush Ranch, Eastern Wilcox Ranch and Jepson Prairie Preserve.

The scientist identified sites most likely to be invaded in the future, and habitats and precipitation patterns most likely to spur the weed's spread—information that should help focus management decisions. As has been seen with other invasive species, early detection and eradication are of critical importance, especially when invasions occur in the invasive's preferred habitat or when that preferred habitat is nearby. Control efforts should also be prioritized in these areas, and during years with greater than average springtime precipitation.

This project also highlights pepperweed's variable response to monitoring and control, depending on its phenology. (Its phenological plasticity may contribute to its success as an invader.) During drier than normal years, and at sites where the plant is subjected to greater stress because of limited available water, monitoring and control should be conducted earlier in the growing season.

In addition to the species-specific findings from this project, results have broad applications to ecology and management. Hyperspectral remote sensing is becoming a common tool for mapping invasive species; however, it is not evident that these maps are actually ever used to aid managers and wildlife preservation. The scientist leading this project says she hopes that her work will encourage ecologists and managers to re-evaluate the possibilities of remote sensing and its practical applications to science and conservation.

COLLABORATORS

California Department of Boating and Waterways; California Department of Food and Agriculture; Solano Land Trust; Cosumnes River Preserve; Information Center for the Environment, UC Davis; and Delta Wetlands.

PUBLICATIONS

Andrew, M.E. and S.L. Ustin (2010). The effects of temporally variable dispersal and landscape structure on invasive species spread. Ecological Applications. 20:593-608.

Andrew, M.E. and S.L. Ustin (2009). Effects of microtopography and hydrology on phenology of an invasive herb. Ecography. 32:860-870.

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S. Khanna/UC Davis

Postdoctoral fellow Margaret Andrew surrounded by the subject of her research, an infestation of perennial pepperweed.

The white flowers of the pepperweed plant provide a distinctive hyperspectral signal, which assists in mapping it remotely.
M. Andrew/NRCan

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