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Photo-Guided Tracing: A Low-Cost Method for Monitoring Targeted Plant Species

Abstract

This article describes a method of producing accurate and relatively inexpensive maps of plant distribution, used here for mapping *Arundo donax* in a riparian ecosystem as part of an Extension outreach and community development effort. This produced a verifiable map of the plant's distribution over 16 km for approximately $3,000. This method had modest requirements for technical skills and equipment, and produced reference imagery that could be archived for later review. This made long-term monitoring more feasible to the community and provided Extension staff opportunities for training and public education.

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Introduction

This article describes a resource management tool developed to make long-term monitoring of a noxious weed population more feasible for a community organization and provide Extension staff opportunities to deliver training and public education. Extension has long played important roles in facilitating collaborative outreach for those involved in resource management. McReynolds and Howery (2001) described an example of Extension's contribution to an interagency noxious weed management effort in Southeastern Arizona. A similar model was followed here, but on a local scale, in north central California. Geospatial information was used to identify over 300 landowners for outreach for a noxious weed control and riparian restoration project spearheaded by the Glenn County Resource conservation District (GCRCD). Extension staff and other technical specialists evaluated methods to map and monitor the weed infestation over time and assisted the RCD's efforts to organize a management strategy and gain landowner participation. Milla, Lorenzo, and Brown (2005) provided recommendations for using spatial technologies in Extension work. This project made use of most of these, as a variety of options were sifted through to find a solution that would deliver the desired information but be within the financial and technical resources of the project partners.

The subject of this article is the use one particular method for mapping the invasive weed *Arundo* *donax* ("arundo") in a 16 km reach of the riparian corridor (Rieger & Kreager, 1989) as part of the GCRCD's riparian restoration effort. Extension staff sought a cost-effective means by which the GCRCD could effectively monitor and evaluate the progress of its restoration work over an extended period of time.

The method we developed came from a process used by the United States Forest Service (USFS) called "aerial sketch mapping" (ASM), whereby an observer in an aircraft traces ground/vegetation targets onto either a physical or a digital map while in flight (Johnson & Wittwer, 2008; Schrader-Patton, 2003). Our adaptation of this we call "photo-guided tracing." Using this method, the observer takes oblique high-resolution photos of vegetation in the survey area as the aircraft transits overhead. Afterwards, those images are used to guide the tracing of plant canopy targets over base imagery in a Geographic Information System (GIS).

Application of Method

Two passes over the riparian area were flown at an approximate altitude of 305 m in a Cessna 172, a single-engine high-wing light aircraft, in January. The riparian system was 16 km long and not more than 800 m wide. Two hundred and sixty reference photos were taken of all areas where arundo was visible, using consumer-grade digital cameras (Kodak Z7590 and Nikon 5700). A Global Positioning System (GPS) receiver (Garmin GPSMAP 76) was used to keep a continuous tracklog of the flight path, and mark start/end coordinates.

The process of mapping the infestation from the aerial reference photos had two phases. First, a GIS point layer representing the approximate physical location of the center of each of the 260 reference photos was created in ArcView 3.3 (ESRI, 2001) by matching features (vegetation, stream braiding, structures) in the individual reference images to those visible in the NAIP base imagery (USDA-FSA, 2005) (Figure 1). This allowed the matching reference photos to be identified and retrieved more easily during the second phase. In the second phase the GIS was used to trace polygons around the arundo canopies in the NAIP orthoimage, using the reference photos as a guide for deciding which plants in the image were arundo (Figure 2). A dual-screen workstation allowed the user to view the reference image at the same time they were tracing polygons around plants visible on the base image (Figure 3). Polygon tracings were made at a map scale of 1:1,000.

Figure 1.

Completed Arundo Distribution Map. Arundo Polygons Indicated in Red.

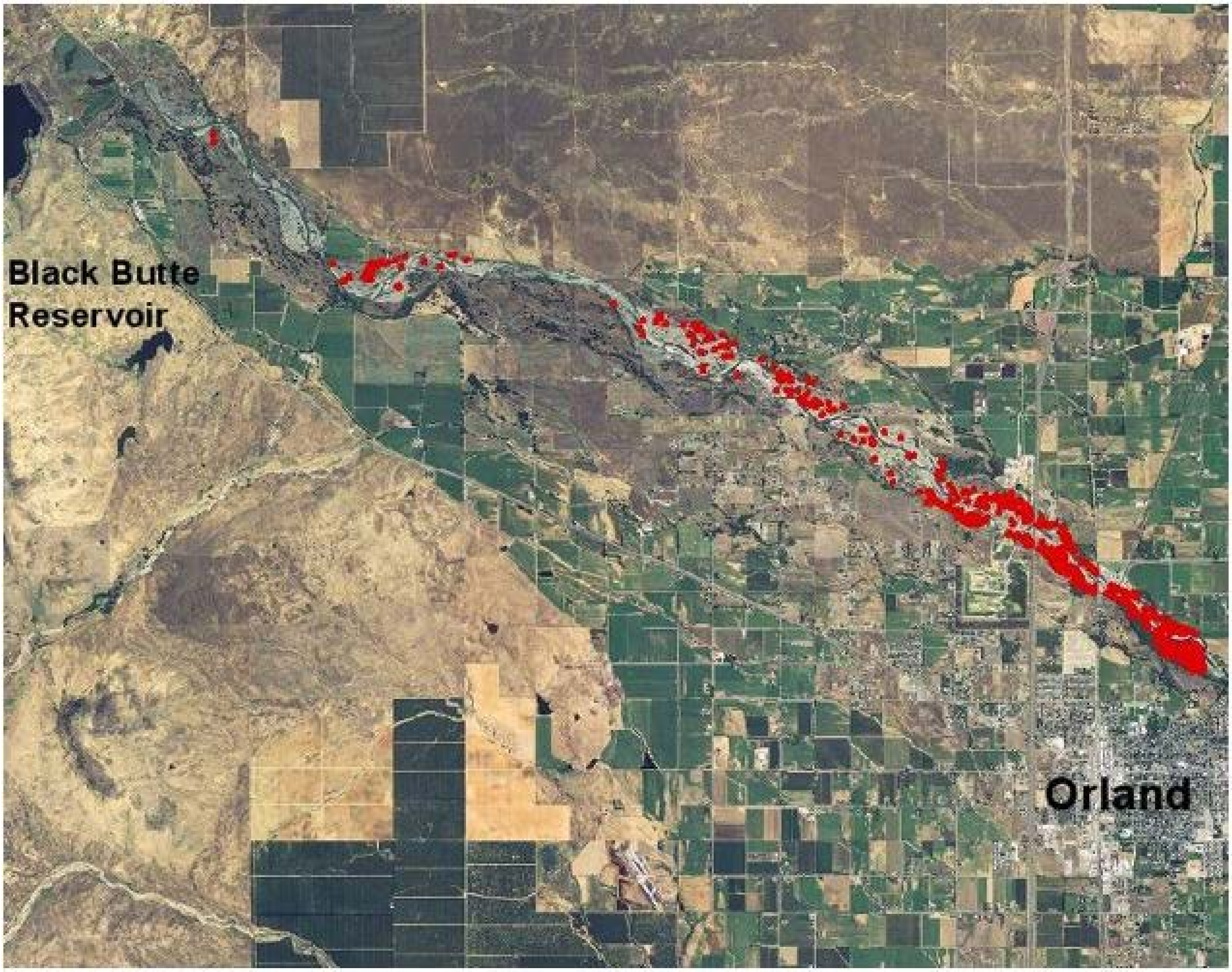
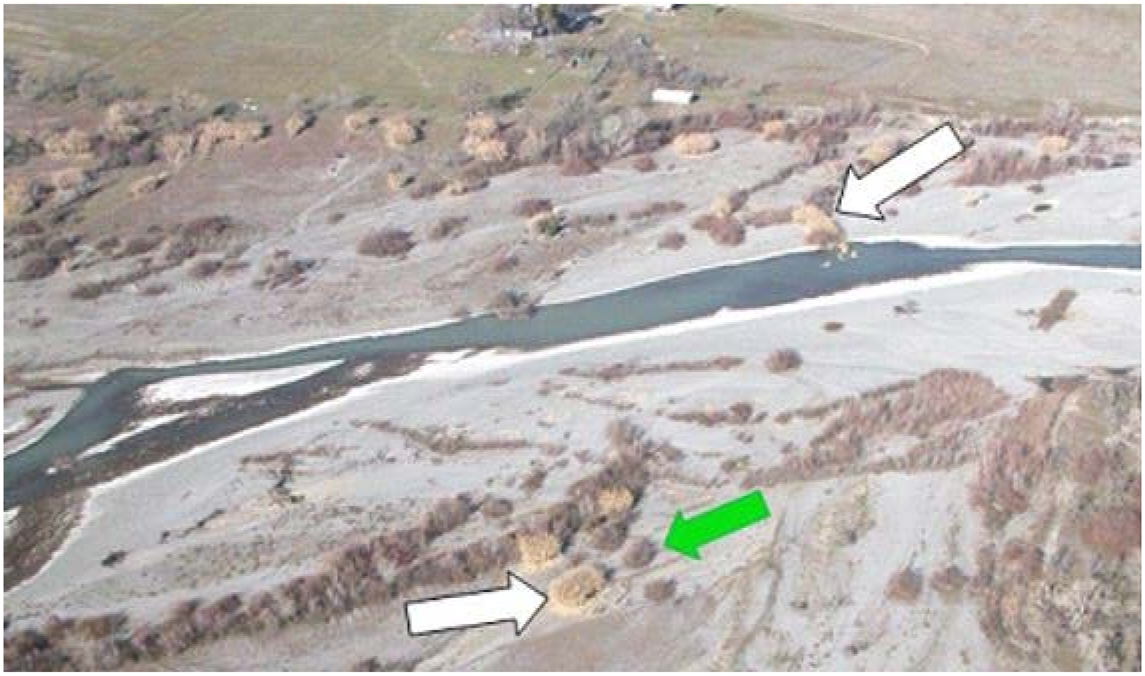


Figure 2.

Screenshot of Arundo (Red Polygons) Mapped Onto NAIP with Digital Photo Center Layer Active (Yellow Circles/Points). Area of Reference Photo #100_0227, Upper Right (Yellow) Box.

Figure 3.

Example Digital Reference Image. White Arrows Indicate Senesced Arundo Plants. It Is Easier to Confuse *Salix* Spp. (Green Arrow) with Arundo in Images Acquired During the Green Season (Compare the Contrast Between Plants in This Image with the Contrast in Figure 2).



Results

The flight took approximately 30 minutes over the survey area, making two complete passes. It would have cost less than $600 to obtain the imagery through private contract with a local pilot, allowing an additional hour for travel to/from the survey area (90 min total). This was consistent with commercial air charter rates in the local area for small piston-driven fixed-wing aircraft (Air Charter Guide.com, 2013). Creating the photocenter point layer and image index for the 260 photographs required 2 days (16 hrs) for one technician (Table 1). Using this method, 674 arundo canopy polygons were mapped, totaling just over 200,000 m2 within the reach (Table 2). Over 80% of the arundo colonies were less than 200 m2 in size (Table 3). We estimated the total cost of mapping the infestation of the reach to be $3,100 (Table 1).

Table 1.

Project Costs

Item	**Cost**	**Hrs**	**Total**
Aircraft rental	$150/hr	1.5	$150
Pilot contract	$225/hr	1.5	$338
Observer/photographer	$20/hr	3	$60
GIS technician	$20/hr	86	$1,720

Report development	$30/hr	25	$750
			$3,093

Table 2.

Arundo Canopy Map Results

Units	Total Area	Smallest Canopy Area	Largest Canopy Area	Mean Canopy Area	Median Canopy Area
Meters2	212,047	8	57,571	315	65
Acres	52	0.002	14.23	0.08	0.02

Table 3.

Arundo Canopy[a] Area Distribution

Canopy Area	# Polygons
0-50 m^2	266
50-200 m^2	306
200-800 m^2	83
800-3,200 m^2	15
3,200-12,800 m^2	2
12,800-51,200 m^2	1
> 51,200 m^2	1
[a] Continuous canopy with no boundary gaps greater than 5 m	

Altitudes at which successful surveys can be flown depend on the required image resolution, minimum safe speed of the aircraft, and the amount of additional maneuvering made necessary at lower altitude (as needed for following riparian systems or navigating irregular topography). The zoom features of most mid-range digital cameras (10x or better) can compensate somewhat for altitude, as long as the aircraft is able to fly smoothly, and there is little smoke/haze in the atmosphere.

Plant canopies must be visible in the base GIS imagery to make good targets for this technique. Arundo canopies were visible in the NAIP imagery, but they could not easily be distinguished from other vegetation when green. Images taken at higher-resolution, in different seasons, or from different angles can then be used to aid in identification. This process was to be repeated approximately every five years to track areas of population expansion as the restoration effort proceeded.

Conclusion

For plant species whose canopy structures can be observed but not confidently identified in base imagery, this photo-guided tracing approach can be a useful solution. Operational costs and requirements for technical skills and equipment are modest. The ability to archive high-resolution imagery of the survey area for later use would be an advantage for many projects. Use of this method affords conservation organizations an opportunity to build their capacity to conduct moderate-scale monitoring and assessment projects. In this case, it also allowed Extension educators to develop the technical and management capacity of community members and conservation organization staff.

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