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Janet Clark, Director
Center for Invasive Plant Management
MSU Dept. LRES
P.O. Box 173120
Bozeman, MT 59717-3120

RE: Final Report for CIPM funded project: *Multi-scale detection of Potentilla recta using remote sensing technologies and geographic information systems in Northeastern Oregon*

Dear Ms. Clark:

Attached is the final report to be submitted to The Center for Invasive Plant Management titled *Multi-scale detection of Potentilla recta using remote sensing technologies and geographic information systems in Northeastern Oregon.* This submission fulfills the requirements for MSU subcontract No. GC168-2-Z1138 that was awarded in July 2002.

We at the Pacific Northwest Research Station appreciate the financial support from The Center for Invasive Plant Management to partially fund this research project. We think the project was a success and helps to fill a critical knowledge gap in detection and monitoring of invasive plants.

Please direct any questions regarding this report to Dr. Catherine Parks or me at (541) 962-6531.

BRIDGETT J. READ
GIS Manager

Enclosure

cc:
A.E. Hutton

Multi-scale detection of *Potentilla recta* using remote sensing technologies and geographic information systems in northeast Oregon (awarded 2002)

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ABSTRACT

In this study, we evaluated the effectiveness of natural color aerial photography as a tool to improve detection, monitoring, and mapping of sulfur cinquefoil (*Potentilla recta* L.) infestations. *Potentilla recta* is a non-native invasive perennial plant that is increasing in interior Pacific Northwest rangelands. Because *P. recta* produces abundant pale yellow flowers, we timed aerial photography to be collected during early July when *P. recta* was at peak bloom. Photography was collected at three scales (1:3,000, 1:6,000, 1:12,000) along a 6.5 km strip within the Wenaha State Wildlife Area, in northeastern Oregon. A systematic grid (250 m between points) was superimposed over photographs of the entire study area. At each grid intersection point (n=80), we visually analyzed the aerial photographs and recorded if *P. recta* could be identified. Sample points on the grid were then located in the field using GPS. Field data collected on 11.35 m radius plots at each point included: (1) *P. recta* presence and percent cover, (2) vegetation composition and structure, and (3) stem density in 12, nested 1m^2 plots. Results showed that the accuracy of detecting *P. recta* increased from small to large scale photographs (P<0.0001); at the largest scale (1:3,000) we correctly identified *P. recta* presence in 77 % of cases, while at smaller scales (1:6,000 and1:12,000), we identified infestations 68 % and 59 % of the cases, respectively. Detection of low density infestations (< 1 % cover) was possible at all scales, with decreasing effectiveness from large to small scales (74 % to 41 %). Vegetation structure, including tree and shrub cover hindered detection. Our results indicate that aerial photography can be used to detect *P. recta* infestations in ponderosa pine and grassland plant communities in the intermountain West. We suggest that aerial photographs may be useful to detect *P. recta* in open forests and rangelands, particularly in areas such as wilderness where field access is restricted. One limitation for the widespread use of this methodology is obtaining aerial photographs taken at the optimum plant phenology of *P. recta*, peak bloom.

INTRODUCTION

A native of Eurasia, sulfur cinquefoil (*Potentilla recta* L.) was introduced to North America prior to 1900. In eastern North America *P. recta* is primarily considered to be a minor agricultural weed (Werner and Soule 1976). However, in the last two decades *P. recta* has been recognized as having a broad ecological amplitude in drier climates of northwestern North America where it forms dense populations and is considered a threat to native plant communities (Rice 1991, 1993, 1999, Rice et al. 1994). *Potentilla recta* may have gone unnoticed in many parts of its range as this non-native plant as it is often confused with native *Potentilla* species that are found in the West. There is a need to improve methods for detection, monitoring, and mapping of *P. recta* infestations to increase success of prevention, control, eradication, and restoration activities.

The value of remote sensing techniques for rangeland assessment is well established (Carneggie et al. 1983, Tueller 1989, Driscoll et al. 1997), and natural color aerial photography has been used with limited success to detect and map invasive plants in rangelands (Driscoll and Coleman 1974, Carneggie et al. 1983, Driscoll et al. 1997, Anderson et al. 1999, Everitt et al. 2001). In this study, we evaluated the effectiveness of natural color aerial photography at different scales to detect and map *P. recta* infestations in ponderosa pine and bunchgrass plant communities in northeastern Oregon. Specifically, our objectives were to:

1. Determine if natural color aerial photography effectively detects *P recta*
2. Determine the minimum percent cover of *P. recta* that can be detected at each flight scale
3. Assess the pros and cons of each flight scale and whether it is a practical tool for resource managers

METHODS

Natural color photography was collected at three scales (1:3,000; 1:6,000; 1:12,000) along a 6.5 km strip within the Wenaha State Wildlife Area near Troy Oregon. The area is characterized by a matrix of abandoned agricultural fields, ponderosa pine stands, and bunchgrass plant communities. Flights were conducted during the first week in July 2002, when *P. recta* was at peak bloom. Because *P. recta* produces abundant pale yellow flowers we predicted this timing would maximize visibility and contrast of P. recta in association with surrounding vegetation. The photographs were orthorectified and mosaiced using ground control points collected using real-time differential GPS (DGPS) and post processed. To mark the sample locations, a systematic grid with 250 m spacing was placed over the mosaiced photographs. From the photographs, three individual photo-interpreters recorded *P. recta* presence or absence and percent cover by comparing the color produced by a known *P. recta* infestation to the color within the sample location in question. Each sample area was a circular area of 404.7 square m (11.35 m radius). This sample area was chosen because it represents 1/10th of an acre and is considered a standard minimum detection area for 1:12,000 photography. Percent cover was grouped into eight cover classes (1, 1-5, 5-25, 25-50, 50-75, 75-95, 95-99, 100). All interpretation started with the smallest scale (1:12,000) and progressed to the largest (1:3,000) to avoid interpreter bias.

Using real-time DGPS in the field, we navigated to each sample point in the study area and delineated the circular plot boundary with flagging. For each plot, the overall *P. recta* percent cover, tree canopy cover, elevation, slope, aspect, plant association, and soil type were documented. In addition, 12 1 m^2 quadrats were placed within each plot to collect additional data (Figure 1). At each quadrat we recorded the percent cover for *P. recta* and vegetation life form categories (forbs, grasses, shrubs, trees) and if present the number of *P. recta* stems. One plot was dropped from analysis because a GPS malfunction resulted in a loss of data.

From this data, we compared the results from the pre-field photography interpretation to the field collected data using log-likelihood goodness-of-fit tests (G^2). This allowed us to examine differences in correctly identifying *P. recta* infestations among the flight scales and among the different interpreters. We also used log-likelihood goodness-of-fit tests (G^2) to determine if tree canopy cover or shrub cover affected our interpretation accuracy.

RESULTS

Potentilla recta was found in 74.7 % of our sampled plots (59 of 79 plots). Percent cover of *P. recta* within the plots ranged considerably from < 1 % to 55-65 % cover, with 65 of the plots (82 %) having less than 5 % *P. recta* cover (Table 1). Infestations were not restricted to areas with little or no tree canopy cover (Table 2), although areas with zero tree overstory had the greatest densities of *P. recta*.

We were able to detect *P. recta* at all three scales of photography (Figure 2). We correctly detected *P. recta*'s presence 76.9 % of the time at 1:3,000 scale photography. Detection rate at the 1:6,000 scale was 67.9 %, and 59.1 % at the 1:12,000 scale. Accuracy was gained as scale increased at about 10 % for each scale, resulting in an 18 % increase in our detection capability moving from the smallest to largest scales. The primary reasons for the increased detection was the increased ability of correctly identifying present *P. recta* infestations and a reduction in the number missed observations.

As *P. recta* cover increased, we had a significantly greater chance of detecting its presence (Figure 3; 1:12,000, G^2=15.26, P=0.0042; 1:6,000, G^2=28.02, P<0.0001; 1:3,000, G^2=14.53, P=0.0058). New or small infestation, where *P. recta* cover was < 1 %, could be accurately detected in 74 % of cases in 1:3,000 photographs, 57 % of cases in 1:6,000 photographs, and 41 % of cases in 1:12,000 photographs.

Tree canopy cover affected our ability to detected infestations at all scales. Canopy cover was least detrimental with 1:12,000 photographs to correctly identifying *P. recta* presence, reducing detection from 61.9 % with no canopy cover to 41.7 % with > 50 % canopy cover (G^2=8.156, P=0.086). Correct detection of *P. recta* using 1:6,000 photographs dropped substantially, going from 87.3 % with no canopy cover to 33.3 % with > 50 % canopy cover (G^2=25.81, P<0.0001). A similar result was found for the 1:3,000 photographs, with a 34 % decrease in correct detection from no canopy cover to > 50 % canopy cover (G^2=12.46, P=0.014).

Despite the fact that interpretation accuracy increased with increasing scale, the success of correctly interpreting sites that did not contain *P. recta* decreased with increasing scale. For the 1:12,000 scale photographs, we correctly identified 86.7 % of the sites that did not have *P. recta* and identified 58.3 % and 56.4 % of the sites for the 1:6,000 and 1:3,000 scale photographs respectively. Therefore, at larger scales we were more likely to interpret the presence of *P. recta* when if fact it was absent (a false positive result) than at smaller scales.

Interpretation did vary depending on the photo-interpreter, but differences were not significantly different at any scale (1:12000, G^2=1.078, P=0.58; 1:6000, G^2=3.53, P=0.17; 1:3000 G^2=2.88, P=0.24).

DISCUSSION

Results suggest that aerial photography can be used to identify *P. recta* infestations, even at low *P. recta* densities. Photography at 1:3,000 scale is clearly better at detecting *P. recta* than the smaller scales used in this study. This approach will be most useful in grassland communities or open ponderosa pine forests (< 25 % canopy cover), as trees do prevent *P. recta* detection.

Several challenges exist which may limit the widespread use of the methodology. First aerial photography can be costly, and for it to be useful, it must be taken during the summer months where *P. recta* is in peak bloom. Second, by increasing the sample size of plots with > 15 % tree cover, we could have strengthened our analysis of the affects of tree canopy cover on our detection success. In addition, while we were able to occasionally detect low density infestations (< 1 % cover), the use of aerial photography for early detection may be limited as results varied considerably depending on scale. Its use is most valuable for detecting more established infestations. However, our approach can be particularly valuable to land managers seeking to assess *P. recta* invasions across large, mostly inaccessible areas, such as wilderness areas.

CONTINUING RESEARCH

Based on our results we are developing 3 new projects/extensions of the current research:

1. We hope to extend the scope of our work to determine how feasible it is to delineate *P. recta* infestations using aerial photography.
2. We will initiate a study to assess *P. recta* invasion in the Wehana-Tucannon Wilderness Area, Umatilla National Forest which is located near our study site.
3. We will use data collected to analyze the contributions of environmental, historical, and biological factors on the distribution and abundance of *P. recta*.

FUTURE PUBLICATIONS

Manuscript to be submitted in January 2004 to Journal of Range Management as follows:

Multi-scale detection of *Potentilla recta* using remote sensing technologies and geographic information systems in Northeast Oregon.

ACKNOWLEDGMENTS

Center for Invasive Plant Management provided partial funding, Ron Harris, USFS Region Six, organized flights and conducted photography, Michael Golden assisted with study design development, Rick Madigan, Oregon Department of Fish and Wildlife, assisted in plot selection and installation.

Table 1. Percent of plots sampled in each *Potentilla recta* cover class in northeastern Oregon (n=79).

P. recta Cover Class (%)	Number of Sample Sites	Percent of Sample Sites (%)
0	20	25.3
< 1	35	44.3
1-5	10	12.7
5-15	5	6.3
15-25	4	5.1
25-30	2	2.5
35-45	2	2.5
45-55	0	0
55-65	1	1.3
> 65	0	0

Table 2. Relationship between *Potentilla recta* density and tree canopy cover in plots sampled in northeastern Oregon.

Canopy Cover (%)	Number of Sample Sites	Percent Infested (%)	Mean stem density	Maximum stem density
0	26	32.9	29.0	154
< 1	9	11.4	6.4	11
1-5	9	11.4	17.6	66
5-25	18	22.8	3.2	20
25-50	10	12.7	15.1	74
50-75	5	6.3	1	1
> 75	2	2.5	1	1

Figure 1. Field sampling plot design, including the location of each 1m^2 subplot.

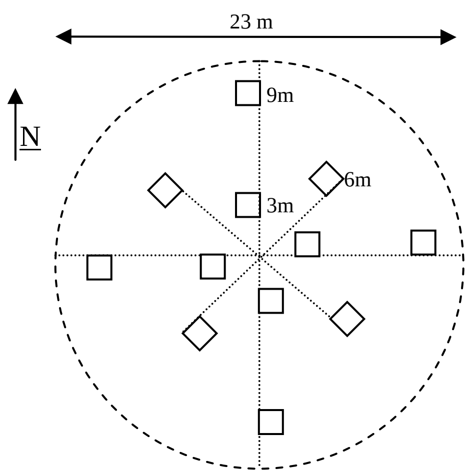


Figure 2. Accuracy of three photo-interpreters to determine *Potentilla recta* presence in aerial photographs taken at three scales.

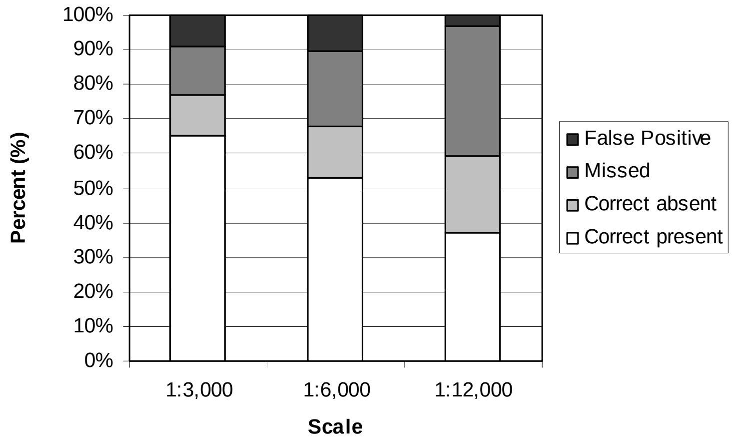


Figure 3. *Potentilla recta* presence detected by photo-interpreters for five *P. recta* cover classes at three photography scales.

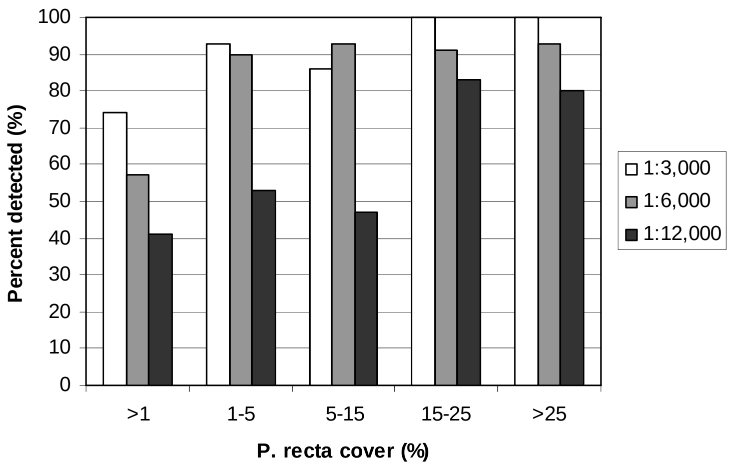
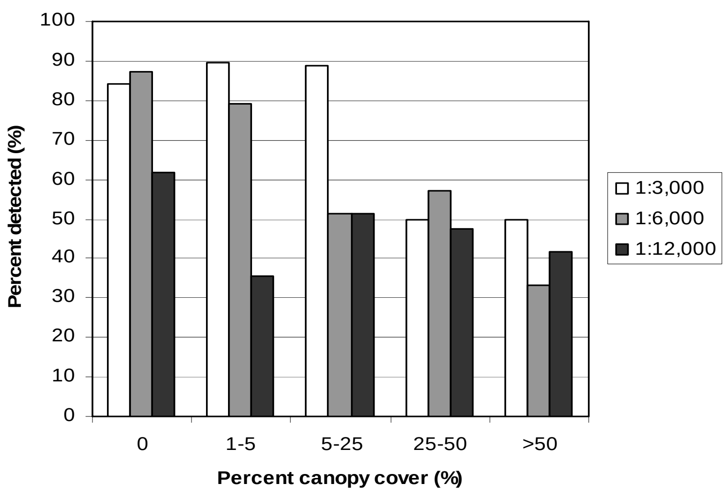


Figure 4. *Potentilla recta* presence detected by photo-interpreters for five tree canopy cover classes at three photography scales.



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