Appendix 3-7

OAHU ARMY NATURAL RESOURCES PROGRAM
MONITORING PROGRAM

VEGETATION MONITORING OF *ACHATINELLA MUSTELINA* ESU-E ENCLOSURE, 2016 PRE-CLEARING RESULTS

INTRODUCTION

Vegetation monitoring was initiated for the proposed *Achatinella mustelina* ESU-E predator resistant enclosure at Palikea. The enclosure is located approximately 20 meters (m) north of the existing snail enclosure for ESU-F snails, and is estimated to encompass approximately 2500 m^2 (Figure 1). The area is dominated by non-native vegetation, with low native cover in the understory and canopy. Prior to construction, non-native trees will be removed and all slash processed/compacted using a chipper. Once the enclosure is completed, active native plant restoration will begin. Vegetation monitoring will be conducted to document change in vegetation cover and canopy openness, with a goal of achieving a native plant dominated community favorable for *A. mustelina* habitat. Baseline pre-clearing vegetation monitoring was completed in June 2016.

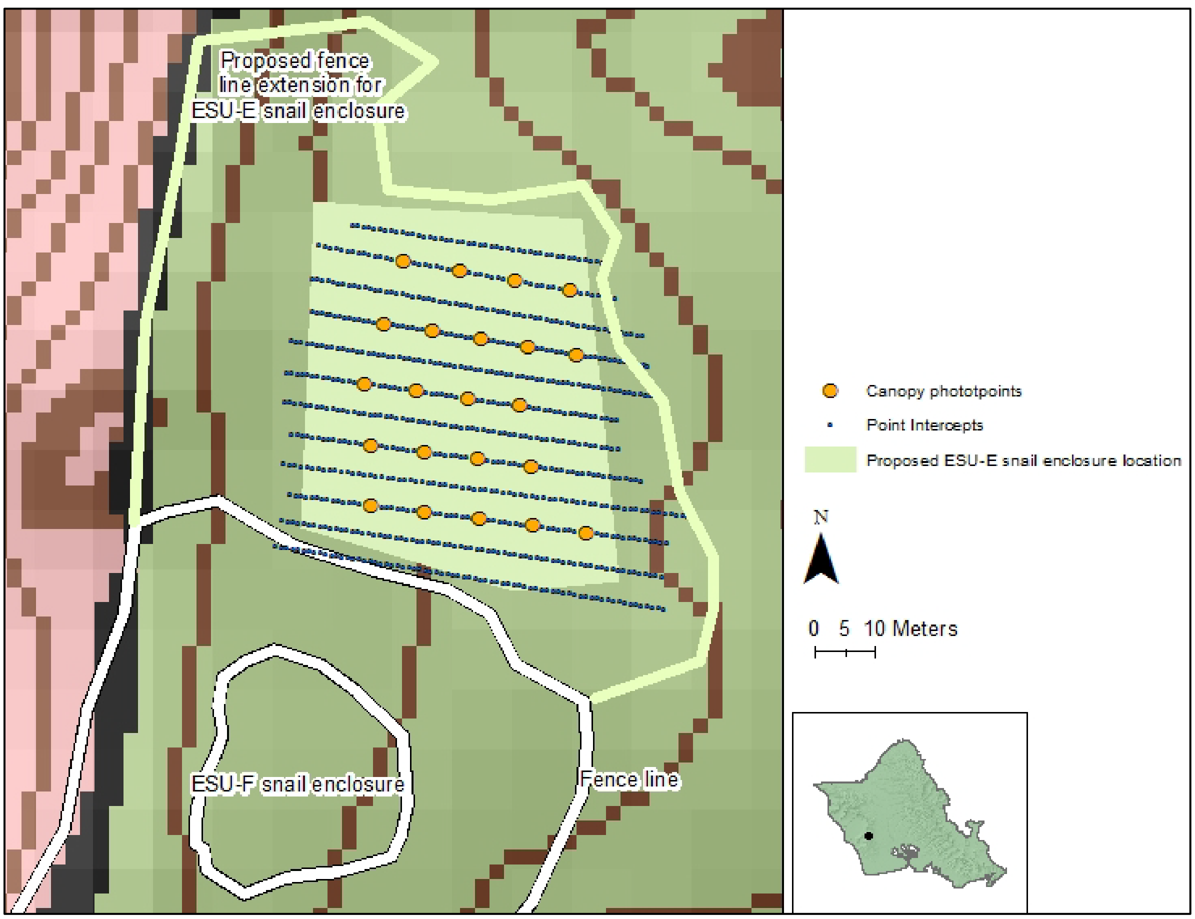

Figure 1. Location of proposed *Achatinella mustelina* ESU-E snail enclosure at Palikea, showing point intercept transects and canopy photopoint locations.

METHODS

Canopy and understory cover: Point intercept monitoring was used to measure percent cover of native and non-native taxa in the understory and canopy. All species "hit" at points along transects were recorded for understory and canopy vegetation. A 5 millimeter diameter, 6 foot tall pole was used to determine "hits" in the understory (live vegetation that touches the pole, including leaves, branches and trunks) along an outstretched measuring tape at regular intervals. To gain a better understanding of cover changes within the understory, particularly relevant in the early restoration years, and as means of guiding restoration and weeding efforts, vegetation "hits" were recorded separately from 0 – 1 m above ground level (AGL) and 1 – 2 m AGL. A laser pointer held against the pole was used to determine laser "hits" in the canopy (above 2 m AGL) at these same intercept points, where the point fell within the perimeter of a tree's canopy. Locations where no vegetation was intercepted was recorded as non-vegetated. Point intercepts were located every 1 m along transects spaced 5 m apart with a goal of achieving at least 500 points[1]. Transects were oriented east/west off of an arbitrarily placed axis running north/south through the center of the enclosure area. Locations of the sampled points are not permanent. Transect lines extended beyond the proposed enclosure boundary during monitoring, in the event that the actual location of the enclosure wall differs from the proposed route. Resulting sampled points that fall outside the actual boundary wall upon completion will not be included in future analysis. Approximations of percent cover were obtained from the proportion of "hits" among all intercepts. Prediction maps[2] of taxa occurrence were created using Geostatistical Analyst, ArcGIS 10.3.

Canopy openness: Hemispherical photography was used to document canopy openness. This complements the canopy cover data (where cover measures were based on tree perimeters), by providing data on light availability beneath the canopy layer. Photographs (n = 23) were taken using a fish-eye lens at 2 m AGL, aimed 180° from the ground, every 10 m along alternate transects. Gap Light Analyzer (GLA), Version 2.0 was used to measure canopy openness in the hemispheric photographs.

Supplemental data: Permanent photopoints were established (marked with PVC posts) for visual documentation of change in each cardinal direction for each of 5 points. An Onset HOBO U23-001 data logger will be installed on site to document hourly temperature and relative humidity. During the course of vegetation monitoring, a species diversity list was created documenting all species that happened to be observed, but not intercepted. The list will help document change in the presence or absence of species that have low cover, or are uncommon, and therefore less likely to be documented during point intercept monitoring.

[1] *A priori analysis of a sample size necessary to detect a 10% change (from proportions 0.45 to 0.55) with an alpha of 0.05 and power of 0.90, with 1:1 sample sizes, is 427 for chi-square one-tailed analysis (change is expected to occur in one direction) and 524 for two-tailed analysis (change may occur in either direction) (G* Power Version 3.1.9.2). A goal of around 500 points would be reasonable for either one- or two-tailed analyses.*

[2] *Maps created using statistical methods in association with geographic information to show predicted locations of one or more variables, with the probability of occurrence indicated by color coded values. The analysis maps probable, not actual, distributions. Known locations are used to predict presence/absence in unsampled locations. This method also includes statistical analyses of prediction error that indicate how well the model works, by removing known data points and predicting what they should be. When used in association with point intercept data, locations of taxa and taxon groupings with higher cover, particularly those that tend to occur in clusters, may be more accurately predicted. Those with low cover and spotty distributions will have considerably less certainty when mapped. As such, prediction maps for only taxon groupings (e.g., native, non-native) and the most predominant taxa will be created.*

Monitoring schedule: Monitoring will occur immediately pre- and post-chipping, and then annually for 5 years to track change in association with vegetation restoration. Once native vegetation fills in, the monitoring interval may be extended to every 2-3 years, and eventually to every 5 years.

PRE-CLEARING RESULTS

Non-native canopy (vegetation > 2 m AGL) was nearly continuous across the planned location for the snail enclosure, intermittently mixed with native canopy in < 20% of the area (Table 1). Average canopy openness among photopoints was 17.3% (n = 22). Approximately half of the lower portion of the understory (0-1 m AGL) was vegetated, with non-native taxa covering a third of the area, at times intermixed with native vegetation, which covered < 20% of the area. The upper portion of the understory (1-2 m AGL) was slightly less vegetated, with a similar amount of non-native cover, but < 10% native cover. Nine non-native and six native species were identified in the lower understory during monitoring, with non-native taxa *Psidium cattleianum* (20.4%) and *Clidemia hirta* (11.6%), and the native taxon *Nephrolepis exaltata subsp. hawaiiensis* (13.7%), most prevalent (Table 2). Six non-native and 12 native species were intercepted in the upper understory, primarily non-native taxa *Clidemia hirta* (19.1%) and *Psidium cattleianum* (15.0%). The canopy was dominated by non-native taxa *Psidium cattleianum* (79.6%) and *Schinus terebinthifolius* (36.5%), as well as native taxa *Metrosideros polymorpha* (8.8%) and *Freycinetia arborea* (6.0%). A total of 28 species (57% native) were identified during point intercept monitoring. Anecdotal observations of 17 additional taxa (88% native) were made while monitoring, but were not intercepted (Table 3). Several preferred snail host taxa were either intercepted (*F. arborea* and *M. polymorpha*) or anecdotally observed (*Antidesma platyphyllum* and *Myrsine lessertiana*) within the proposed enclosure site. Geostatistically predicted locations (using ordinary kriging) of most native and non-native taxa indicate patchy distributions in the understory and canopy, with the exception of the non-native taxon *P. cattleianum*, with locations nearly continuous throughout the canopy (Figures 2 - 4).

DISCUSSION

The presence of preferred snail host trees along with other native taxa in the understory and canopy provides a starting point for the establishment of appropriate snail habitat. However, the presence of tall *M. polymorpha* and thickets of *F. arborea* also presents a challenge for predatory snail removal. Large *F. arborea* thickets may need to be trimmed back to facilitate effective searches for *Euglandina rosea*, and/or the enclosure boundary wall placement may be shifted to avoid including *F. arborea* thickets. These plants are expected to grow and recover if trimmed, and in the future may require ongoing management (trimming and/or training) in order to keep the enclosure open enough to conduct effective *E. rosea* searches.

It is anticipated that there will be a flush of understory weeds in response to the non-native canopy removal that will require ongoing maintenance until native vegetation is restored. Care should be taken in particular to manage and prevent the spread of the ecosystem altering grass *Ehrharta stipoides,* as it was observed during monitoring and is prevalent in the Palikea area.

Table 1. Percent cover of native and non-native taxa and non-vegetated areas in the understory and canopy (n = 786 point intercepts).

	Understory 0-1 m	Understory 1-2 m	Canopy > 2 m
Non-native	35.9	34.7	94.3
Native	18.4	7.1	17.7
Non-vegetated	50.8	60.9	2.3

Table 2. Species percent cover (n = 786 point intercepts). Native taxa in boldface. *Snail preferred host plant.

Taxon	% cover
Understory 0-1 m	
Psidium cattleianum	20.4
Nephrolepis exaltata* subsp. *hawaiiensis	13.7
Clidemia hirta	11.6
Paspalum conjugatum	4.1
Microlepia strigosa	2.7
Rubus rosifolius	1.9
Freycinetia arborea*	1.7
Ehrharta stipoides	1.0
Blechnum appendiculatum	0.9
Asplenium contiguum	0.6
Metrosideros polymorpha*	0.3
Schinus terebinthifolius	0.3
Asplenium macraei	0.1
Cyclosorus parasiticus	0.1
Passiflora suberosa	0.1
Understory 1-2 m	
Clidemia hirta	19.1
Psidium cattleianum	15.0
Freycinetia arborea*	3.2
Nephrolepis exaltata* subsp. *hawaiiensis	1.7
Schinus terebinthifolius	0.9
Metrosideros polymorpha*	0.6
Kadua affinis	0.5
Microlepia strigosa	0.4
Rubus rosifolius	0.4
Cibotium chamissoi	0.3
Coprosma longifolia	0.3
Antidesma platyphyllum*	0.1
Broussaisia arguta	0.1
Cheirodendron trigynum	0.1
Morella faya	0.1
Passiflora edulis	0.1
Psychotria mariniana	0.1
Wikstroemia oahuensis* var. *oahuensis	0.1
Canopy > 2 m	
Psidium cattleianum	79.6
Schinus terebinthifolius	36.5
Metrosideros polymorpha*	8.8
Freycinetia arborea*	6.0
Morella faya	3.4
Clidemia hirta	3.2
Kadua affinis	1.0
Grevillea robusta	0.9
Cheirodendron trigynum	0.8
Passiflora edulis	0.8
Coprosma longifolia	0.6
Melicope clusiifolia	0.5
Broussaisia arguta	0.3
Cibotium chamissoi	0.3
Psychotria mariniana	0.3
Scaevola gaudichaudiana	0.3

Table 3. Species anecdotally observed but not intercepted during monitoring. Native taxa are in boldface. *Snail preferred host plant.

Asplenium caudatum	***Myrsine lessertiana***
Athyrium microphyllum	***Peperomia tetraphylla***
Coprosma foliosa	***Psilotum nudum***
Dianella sandwicensis	***Psychotria hathewayi***
Dryopteris glabra	***Smilax melastomifolia***
Epidendrum x obrienianum	***Streblus pendulinus***
Ilex anomala	***Vandenboschia davallioides***
Labordia kaalae	*Youngia japonica*
Lepisorus thunbergianus	

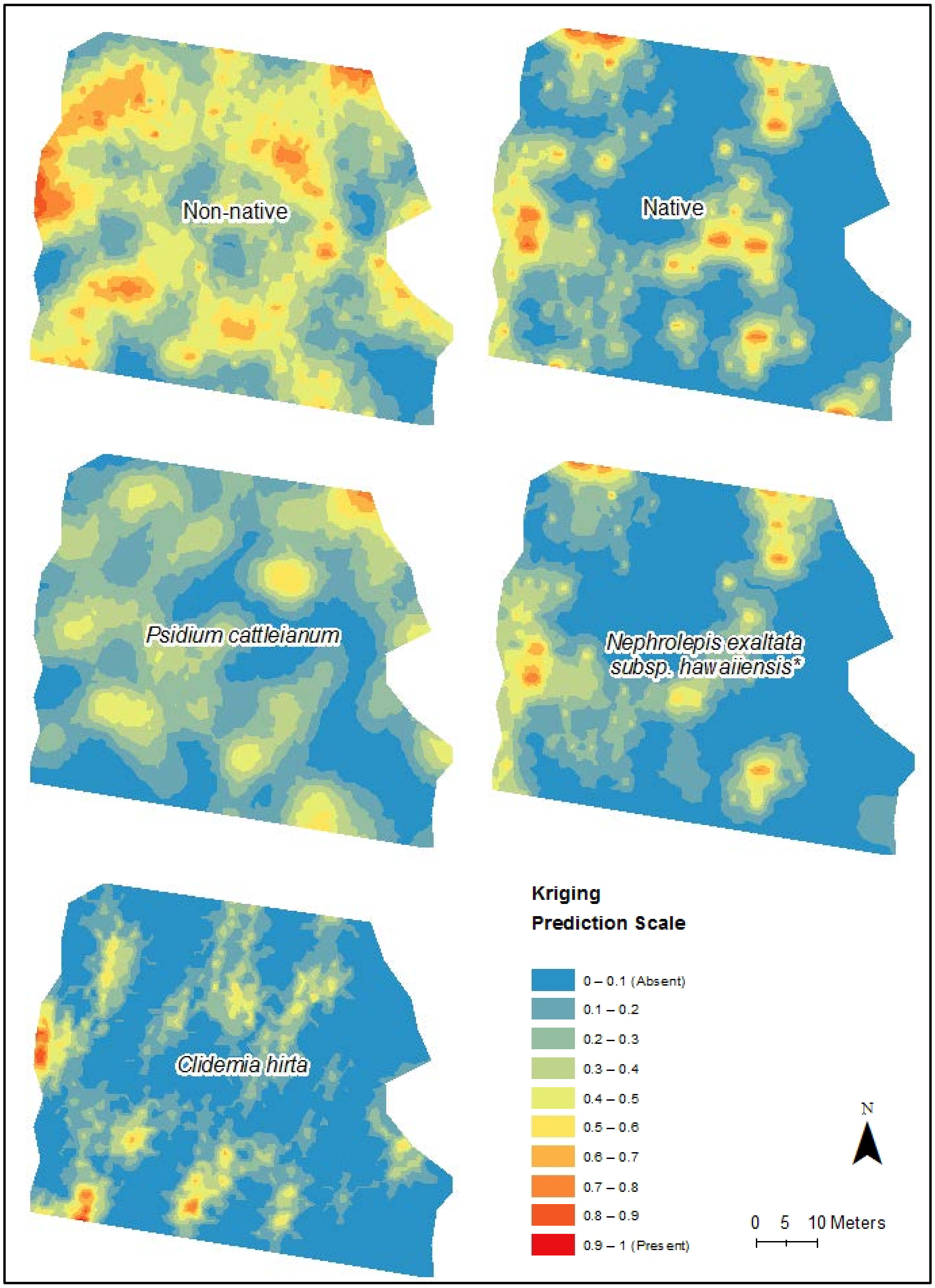

Figure 2. Ordinary kriging predicted locations of understory taxa from 0-1 m AGL, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence). *Native taxa.

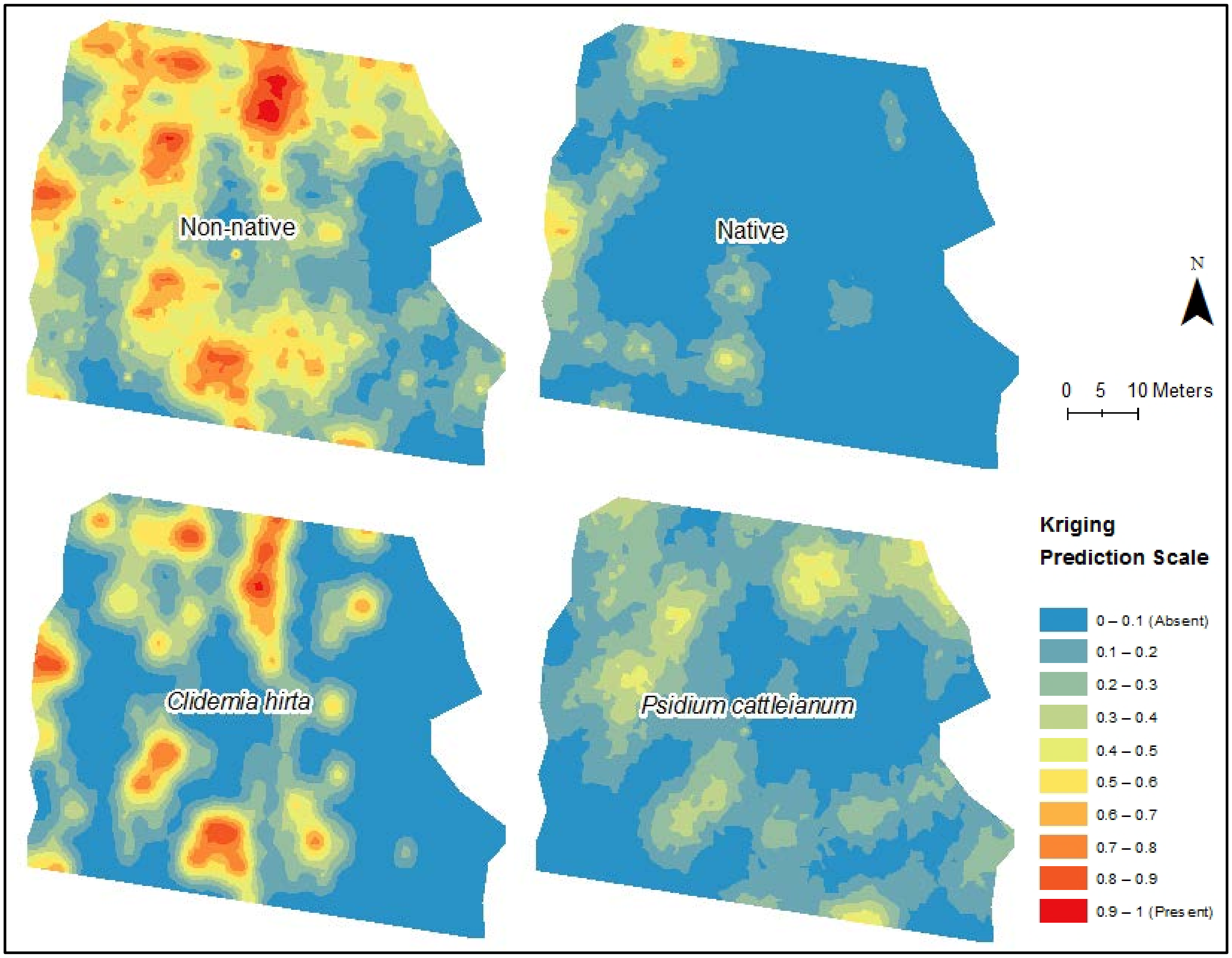

Figure 3. Ordinary kriging predicted locations of understory taxa from 1-2 m AGL, showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence).

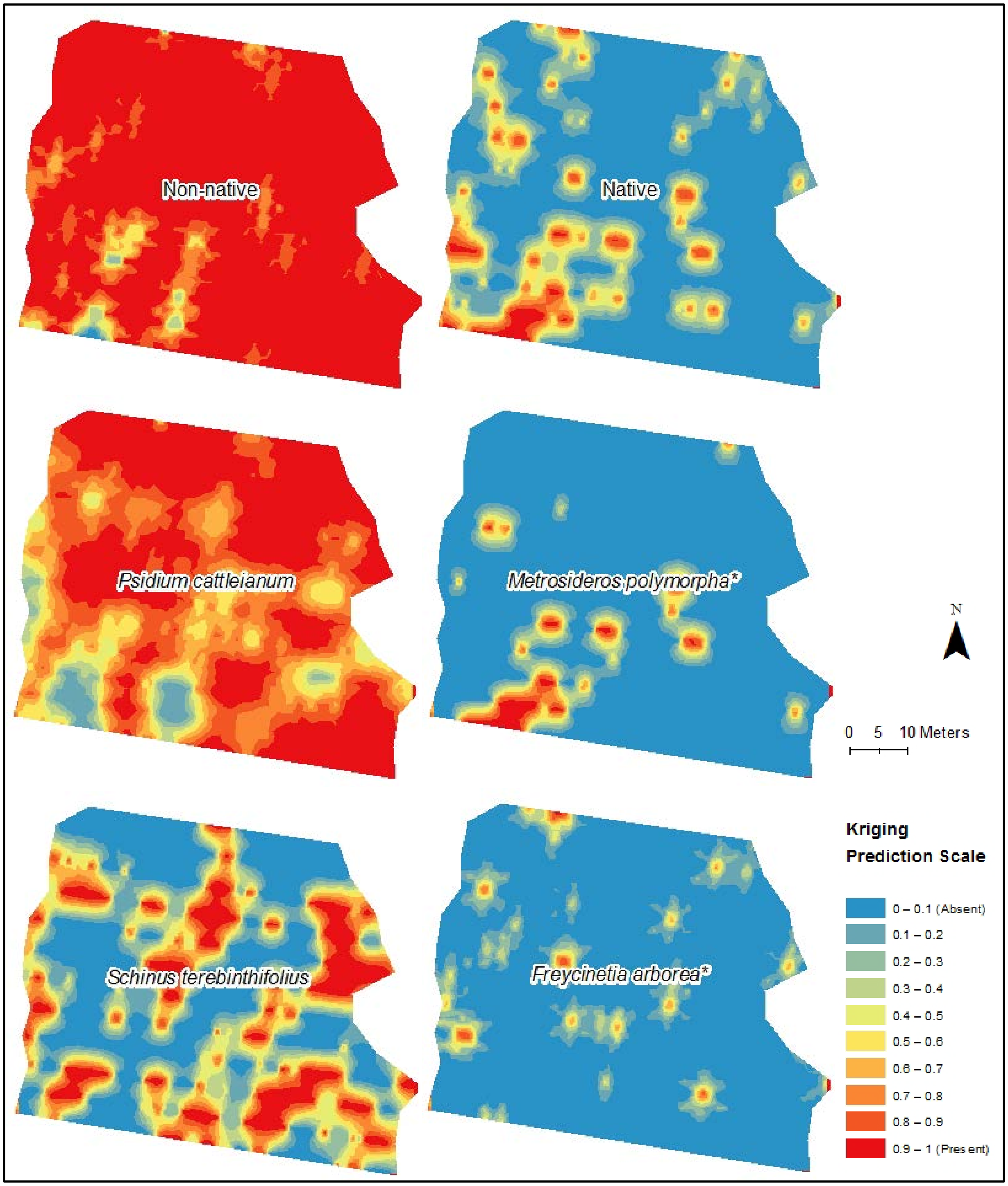

Figure 4. Ordinary kriging predicted locations of canopy taxa (> 2 m AGL), showing overall non-native and native cover as well as most prevalent species. Probability of occurrence is scaled from zero (shown in blue, indicating absence) to one (shown in red, indicating presence). *Native taxa.