Measuring the sustainability of Artichoke Thistle (*Cynara cardunculus*) control efforts following suspension of control activities in historic southern California rangeland

2008 Report to the
Nature Reserve of Orange County (NROC)

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Overview. Artichoke Thistle (*Cynara cardunculus*; CYCA), a deep-rooted perennial thistle, is an extremely problematic invader of disturbed grasslands in southern California. It has invaded large areas (over 4,000 acres) of the Nature Reserve of Orange County (NROC). The NROC, working with The Nature Conservancy (TNC), established a control program for CYCA involving direct application of herbicide to individual plants. Thousands of acres have been treated annually since 1994. We had three objectives of this project. First, we resurveyed areas initially surveyed in 1998 to assess the changes in areas that have been part of the control program. We particularly focused on changes in CYCA cover, and if it was associated with other aspects of NROC management (*Brassica nigra;* BRNI, *Nassella pulchra;* NAPU, native species richness). Secondly, we assessed how treated areas responded to the cessation of herbicide control for one year. Thirdly, we initiated a restoration project in eight areas with low native diversity. We detail the results of these efforts in this report, and include data collected as part of the accompanying CD.

Summary of Results. We resurveyed 110 areas in the NROC coastal reserve where treatment to control artichoke thistle invasion had occurred for at least 3 years. These same areas were surveyed by The Nature Conservancy in 1998, and by UCI in 2007. Due to drought conditions of the 2007 survey, we compare results of the 2008 survey primarily to the 1998 survey although measures in 2007 and 2008 are qualitatively similar. Maps of the data are included in Appendix A, and the data (Appendix B) accompanies this report on CD. Our major findings are as follows:

- Control efforts have been successful in reducing the invasion of artichoke thistle, reducing cover of artichoke thistle to less than 4% in all the areas surveyed. The remaining CYCA populations tend to be in clay soils and with low abundance of *Bromus diandrus* (this exotic annual grass species was related to initial invasion trends; CYCA was less likely to invade areas with high *Bromus diandrus* abundance).

- Between 1998 and 2008, *Brassica nigra* cover, native species cover, and native species richness significantly increased. However, reduction of CYCA was not related to changes in abundance of native species, *Brassica nigra*, or native diversity. In addition, areas where there has been the largest decrease in CYCA cover were not associated with either greater invasion of *Brassica nigra* or increase of native cover.

- The abundance of *Brassica nigra* was not related to CYCA or the treatment history of the CYCA control program. Instead, its abundance was positively associated with clay soils and negatively associated with annual grass cover.

- To assess how reserve areas will respond after the control program ends, we excluded herbicide treatments in 18 30X30m experimental control plots. After one year, CYCA recruitment was minimal into these plots.

- We initiated a restoration experiment were we added seeds of native grassland and coastal sage species to six sites in the coastal reserve. Results in the first year indicated very low recruitment across the sites, ranging from 0.08 to 2.7 individuals per $0.5m^2$.

METHODOLOGY

I. Resurvey. During April and May 2007, we resurveyed 110 areas initially surveyed in 1998. We used the same polygon delimitation as the initial survey, and tried to make our sampling methods as comparable as possible with the previous effort. We use the terms "polygon" to describe the unit area of sampling, "TNC survey" to refer to the initial survey conducted in 1998, and the "UCI survey" to refer to the 2008 survey. We also refer to species with abbreviations comprised of the first two letters of the genus and first two of the species scientific name (e.g., CYCA for *Cynara carduncul*us).

We collected data in areas delineated by the TNC Weed Mapping survey. TNC polygons were coded by numbers (Example: 1.1.002). The first number corresponds to a "unit," or geographic region (e.g. Unit 1 = Central sites, Unit 2= Coastal sites). The second number corresponds to "subunit" of the area. Subunits are based on ownership, watershed, or geographic boundaries. The third number indicates the individual polygon located within a subunit. We continue the use of this nomenclature.

We followed similar methodology in 2007. However, 2007 was an extremely dry year, with approximately 2 inches of rainfall or less than a fifth of average annual precipitation. 2008 was a more typical year, and we base our analyses on the 2008 survey. However, it is important to note that cover class estimates of CYCA, BRNI, and Native cover did not differ much between years; class designations classed in approximately 10% of the polygons between 2007 and 2008.

Polygons range in shape and size. They were originally determined based on a combination of factors: the presence or absence of CYCA, the generally heterogeneity of the dominant vegetation, and geographic boundaries surrounding grasslands. These polygons were determined in the field by surveyors. To determine the extent of the polygons for the current survey, we used a combination of aerial maps superimposed with the polygon boundaries, GPS coordinates, ground-level photos taken by TNC during the initial survey, and their field notes. We are fairly confident that we were able to correctly identify the polygon boundaries to within several meters in most cases. In cases were it was unclear, we consulted Trish Smith, who was the lead on the original survey and had an excellent memory of the site delimitation.

The original TNC survey identified 917 polygons. We restricted the set of polygons we could potentially resample according to the following criteria: 1) that they had been treated at least two years for CYCA control during the last decade; 2) that they were not on "marginal" or unusual soil types (so we could stratify by the generalized sand-clay gradient in the reserve); and 3) that they hadn't been subjected to intense active restoration (burning, frequent mowing, seeding; this occurred mostly in Crystal Cove State Park). In total, our criteria resulted in 136 possible polygons to resurvey, and we surveyed 110 of these in 2008.

Survey method. In each polygon, 2 people conducted walk-through ocular estimates of polygons. In each walk-through, surveyors estimated percent cover of every species present. This differed from the 2007 protocol in that we did not use cover classes, and that we did not estimate groups of species (e.g., other native species) but collected cover estimations on every species present in each polygon.

We also used soil maps to identify soil type for each of the polygons. When there were multiple soil types, we characterized the soil type with the greatest coverage in the polygon. We also calculated average slope and aspect and the area for each polygon. We also calculated the number of years treated for each polygon; when some portions of the polygon were treated more often that other portions, we used the maximum years treated.

All data were compiled, quality-checked, and archived in a MS Access database. All data collected, with corresponding metadata, accompanies this report.

Data comparison with TNC survey. We have worked to standardize our survey with the TNC survey, reconciling some inconsistent values and notations. The TNC survey focused on problematic exotic weeds, and so did not explicitly record cover of particular native species (i.e., NAPU, *Artemisia*) or annual grasses as we did in our survey. Thus, we can not follow the change in specific native species or annual grass cover through time. In addition, the TNC survey estimated the cover of the four most abundant exotics, and so if they did not record the cover of one of the focal exotics (i.e., CYCA, BRNI), we assumed that its cover had to have been less than the cover of the exotics recorded. We had to make these estimations in 30% of the polygons for BRNI cover and 16% of the polygons for CYCA cover. We gave this dataset with complete documentation to NROC in our 2007 report.

For the 2008 data, we converted percent cover to cover classes used by TNC. We also converted our species richness values to richness classes, with the exception that we did include richness of the rare (<1 cover) species in this calculation because this resulted in values that were too high (e.g., for polygon 1.1.001, there were 30 rare <1% species). We expect that richness estimation by TNC (and by us in 2007) did not include these rare species, although it was not explicitly stated in the protocol.

Data analyses. Statistical analyses were preformed in SYSTAT. Change in cover of the focal groups were calculated as the difference in cover classes rather than the differences in the mean cover of each cover class to ensure normality in the dataset. Because cover classes are narrower at low abundances, this also preserves the natural abundance distribution (where most species are at low abundances and very few reach high abundances). We focused on four response variables: change in CYCA cover, change in BRNI cover, change in native cover, and change in native species richness. For all response variables, we followed the same analysis procedure. First, simple paired t-tests were used to test changes in cover across the entire dataset. Then multiple regressions were run with the following predictor variables: soil type (sand or clay), years treated, most recent year treated, and Nassella cover (2007). For species other than CYCA, the models also included change in CYCA cover. The best regression model was selected using AIC criteria.

To better describe variation in community structure, we also preformed a multivariate analysis that simultaneously incorporated 2008 cover of CYCA, BRNI, NAPU, coastal sage scrub species, annual grasses, and grassland shrub species. We used nonmetric multidimensional scaling to coalesce the variation in the cover data into two dimensions. Then, using these summary axes, we examined correlations of community structure in 2008 and management history (years treated, frequency in last four years), soil texture, and change in four response variables (see above) between 1998 and 2008.

Lastly, data were graphed spatially using GIS. These maps are included in Appendix A of this report.

II. Experimental Control Plots (ECP). We have also initiated work to address the question: what is the response of the treated areas after cessation of intensive control efforts? In 2007, we laid out plots to designate areas where we will ask the herbicide crew not to herbicide CYCA in the future so we can assess recovery. We have initiated vegetation monitoring in 26 plots within the Nature Reserve of Orange County. The 30m x 30m ECPs span the 2007 UCI surveyed areas in the NROC. The plots are delineated by flagged green t-posts on each corner, and are set up in locations which represent the predominant soil and vegetation types, as well as varying herbicide treatment history. A GPS coordinate has been recoded for each plot. In 2008, we focused on 18 of the plots, due to concerns of over-representation of Bommer Canyon. They are denoted by the following polygon numbers. Bommer Canyon:1.1.001, 1.1.004, 1.1.012, 1.1.035, , 1.1.042, 1.1.043, and 1.1.049. Shady Canyon: 1.2.021 and 1.2.056. Laguna Coast Wilderness Park: 1.3.013, 1.3.066, 1.3.071, and 1.3.072 Aliso and Woods Wilderness Park: 1.9.091, 1.9.106, 1.9.121, 1.9.146, and 1.9.210.

Transects. Three 30 meter transects were laid out in the ECP. Transects were set 5 meters from each t-post, inside the ECP, and were spaced 10 meters apart evenly. A ½ x ½ meter frame was placed every 5 meters, on alternating sides of the transect, beginning 2 meters within the edge of the ECP.

Data Collection. In 2007 (prior to herbicide exclusion) and 2008 (one year of herbicide exclusion), we collected data on species composition, and particularly NAPU and CYCA over time. In each plot, we recorded cover of the following groups: annual grasses, native grasses, other native species and other exotic plant species, as well as liter and percentage live vegetation. Counts of all *Nassella pulchra* and CYCA were also noted for each plot, as well as any plants species not accounted for in the transect data were noted.

III. Restoration Experiment. We initiated a restoration experiment in 2008, with the objective to address stuck polygons by creating native "islands" which could jumpstart native dispersal processes. The restoration experiment was conducted in six sites throughout the coastal reserve: Laguna Coast Wilderness (polygon #1.3.070, 1.3.047), Shady Canyon (1.4.015), Crystal Cove State Park (1.6.038), and Aliso and Woods Wilderness Park (1.9.082, 1.9.196). Each grid was 16.5m x 28m, with 2.5m drill seeded strips(Fig. 1). The seed mix was a mixture of grassland and coastal sage scrub species (Table 1), proportions based on consultation with Trish Smith and Margot Griswald, for a total application rate of 18lbs/acre. In addition, *Plantago insularis* (as a cover species) and mycorrhizae were added to the seed mix.

Within this grid, we conducted two additional experimental manipulations: i) herbicide to reduce competition and ii) herbivore exclosures to reduce predation. We conducted these manipulations in 6 1m^2 subplots per site. We did not get approval to conduct these manipulations at all of the sites; herbicide treatments were conducted at one of the Laguna Coast Wilderness sites (1.3.047) and Shady Canyon (1.4.015), and herbivore exclosures were set up at both sites at Aliso and Woods Wilderness Park (1.9.082, 1.9.196) and Crystal Cove State Park (1.6.038).

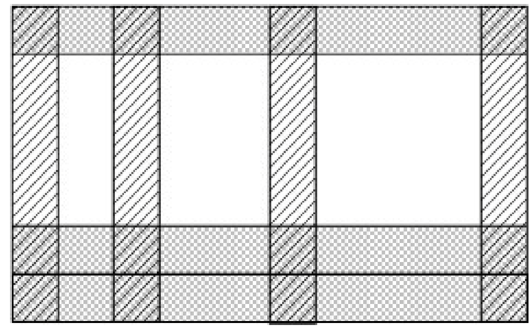


Fig. 1. General design of the restoration "island" experiment where we drill seeded a grid of overlapping drill seed strips in each of 6 degraded sites. Each grid was 16.5m x 28m, with drill seeded strips 2.5m, and the double hatched areas receiving twice the seeding density than the single hatch areas. To monitor recruitment, we sampled 25-37 subplots (0.5m^2) at each site.

Data Collection. In April 2008, we monitored recruitment at each of the sites. At 25 specific locations within the grid, we set up 0.5m^2 monitoring subplots. In the sites with an additional treatment (herbicide or herbivore exclosure), we sampled an additional 6 0.5m^2 monitoring subplots within these treatments. In all subplots, we counted all seedlings of seeded species present.

We also conducted a late season sampling (June 2008) to determine survival throughout the growing season. In this sampling, we increased the size of the sampling plots to 2.5 x 2.5m, focusing on the 12 grid intersections. We counted all individuals of seeded species.

Table 1. *Species added, and their proportion (by mass, not number) in the restoration mix.*

Species	*Proportion*
Artemisia californica	0.05
Baccharis pilularis	0.03
Ericameria palmeri	0.1
Eschscholzia californica	0.15
Hemizonia fasciculata	0.1
Isocoma menziesii	0.05
Nassella pulchra	0.33
Eremocarpus setigerus	0.068
Grindelia camporum	0.05
Lupinus bicolor	0.068

RESULTS

I. Dynamics over time: Resurvey results.

Since 1998, CYCA cover has decreased across the surveyed polygons (Fig. 2a; Fig. 3; Appendix A). Most notably, in areas that were heavily invaded in 1998, control has successful reduced cover to less than 10% in all of the surveyed areas. In almost 20% of the polygons, CYCA was completely eradicated, and it was only present in trace levels (<1% cover) in over 75% of the polygons. The worse invaded polygons (n=4), CYCA only reached to 4% cover. CYCA cover remained significantly higher on sites high in clay content (P=0.01) and in areas with low *Bromus diandrus* (BRDI) cover (P=0.015). Both of these relationships have persisted since the 1998 survey: CYCA invasion was initially lower in areas with loam soil type and high BRDI cover. There was no relationship in the change in CYCA cover and number of years treated, and because the majority of polygons were treated recently, we could not discern an effect of recent treatment history.

Our main question was focused on whether passive restoration of native perennial grasses (e.g., NAPU) was occurring or if other problematic exotics (such as BRNI) were replacing CYCA. Over this period, BRNI cover increased (Fig. 3). The majority of this change was due to the spread of mustard into 33 polygons that previously had no mustard present (Fig. 2b; we found similar results

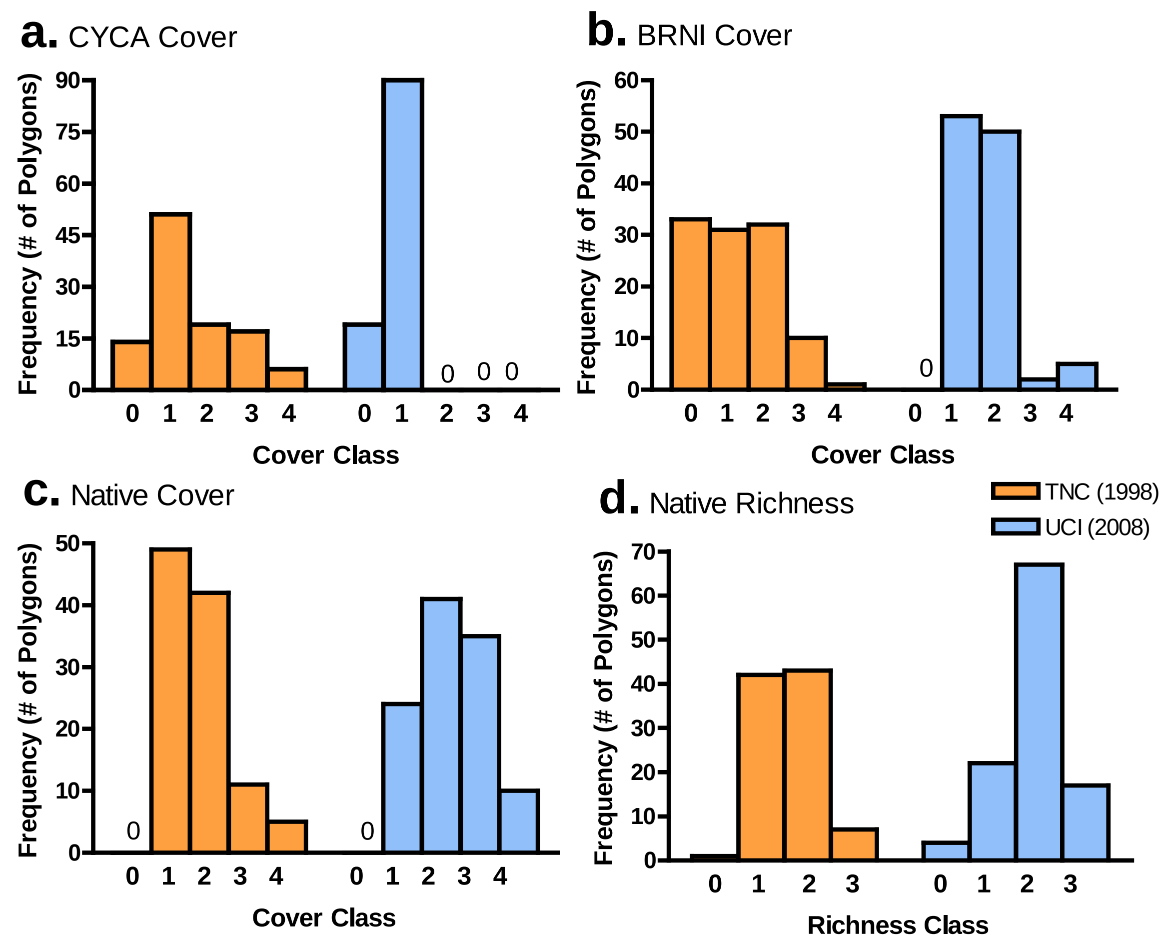


Fig. 2. Changes in the frequency distribution of CYCA (a), BRNI (b), and native plant species (c) cover and native richness (number of species)(d) between the 1998 and 2008 surveys. Polygons are grouped according to cover class (0, not present; 1, 1-10%; 2, 11-30%; 3, 31-50%, and 4, >50%) or richness range (0, none present; 1, 1-3 species; 2, 4-10 species; 3, >11 species). Native richness was not estimated in 14 Polygons in the TNC survey.

in 2007). There were no areas surveyed in 2008 that did not contain at least low levels of BRNI (Fig 2b), and the average cover of BRNI was 15% in 2008.

While the 2007 results that BRNI increased the most in areas where CYCA reductions were greatest, we saw less support for this trend in 2008. The change in CYCA was only very marginally related to the change in BRNI cover (P=0.09), and treatment history or current CYCA cover did not explain variation in BRNI change. Instead it appears that BRNI has increased the most in areas that had initially low BRNI cover, indicating a spread over the landscape. Current BRNI cover (2008) was related to soil type (highest in clay soils; P=0.003) and negatively related to the cover of annual grasses (P=0.01) and NAPU (P=0.001).

In many ways native cover changed over the last decade in a similar manner to BRNI cover. Native cover increased over the last decade (Fig. 2c, Fig. 3; Appendix A). Most notably, areas with over 30% cover of natives were fairly infrequent (a tenth of all areas) in the surveyed area in 1998 and

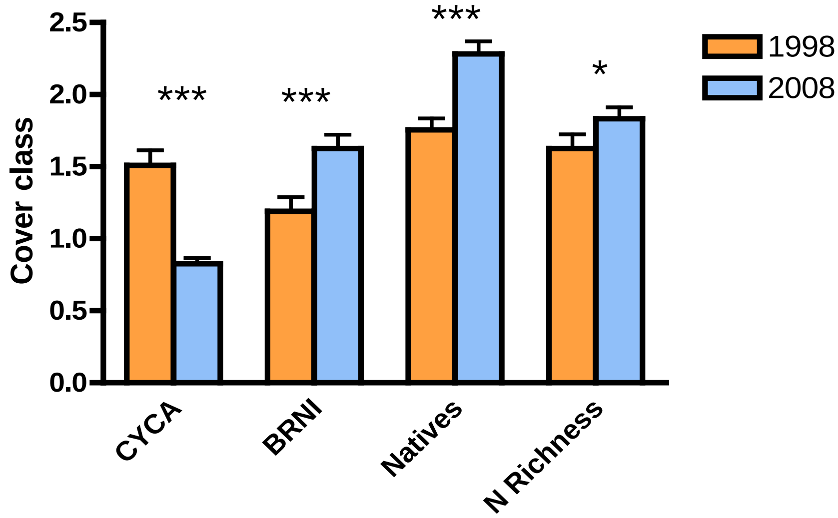


Fig. 3. Average cover class of the three focal groups: CYCA, BRNI, and Natives, as well as native richness, in 1998 and 2008. Shown are means across all polygons +/- 1 std error. Asterisks indicate significant differences (*** P<0.001; * P<0.05) between surveys. Cover class and richness ranges as in Figure 1.

substantially increased in frequency in 2008 (over a third of the areas had >30% cover). This result was similar to the 2007 survey. Native cover increased in the areas where CYCA was reduced but also increased in areas where control kept CYCA cover constant. Native cover change was not influenced by years treated, most recent year treated, or soil type.

Unfortunately, we cannot determine changes in *Nassella* cover over time because the TNC survey did not record specifically record *Nassella* cover. However, 2008 NAPU cover was not related to CYCA, treatment history, or soil type. Instead, it was negatively correlated with BRDI, BRNI, and Coastal Sage Scrub species cover (all P<0.005)(Appendix A).

Native richness also increased over time but to a lesser degree than native cover (Fig. 2, 3). It was also not related to reduction in CYCA cover (Fig. 4). It did, however, significantly increase with the number of years treated, as was also found in 2007 survey. In 2008 native richness was most influenced by BRNI cover (negatively; P=0.002), annual grass cover (negatively; P=0.01), and

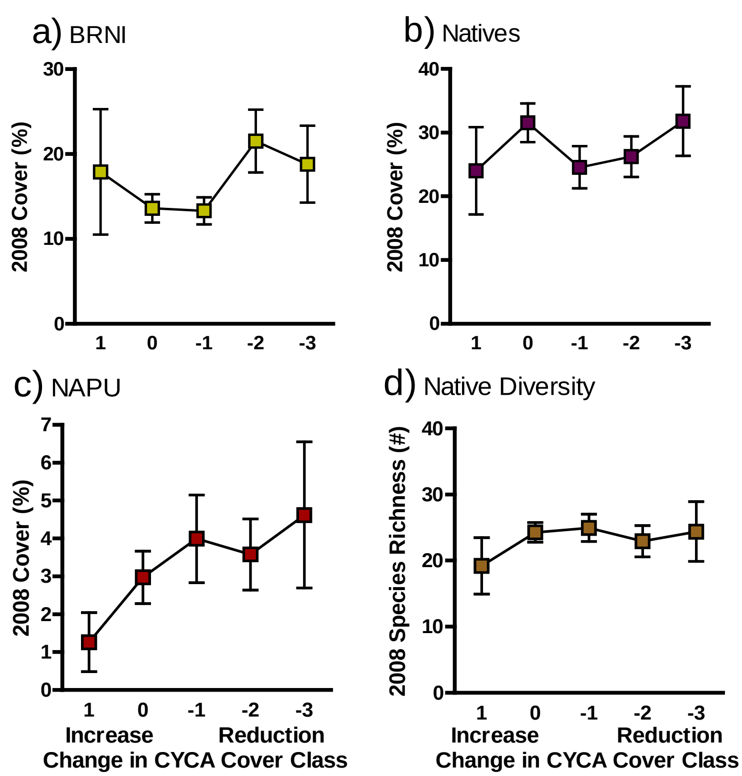


Fig. 4. The influence of CYCA reduction on current (2008) cover of BRNI (a), Natives (b), Nassella (c) and Native diversity (d). Cover is actual percent cover values and richness is actual number of native species found in each polygon including rare species. There is a increasing trend for NAPU with CYCA reduction; however it is not statistically significant.

coastal sage species cover (positively; P=0.015).

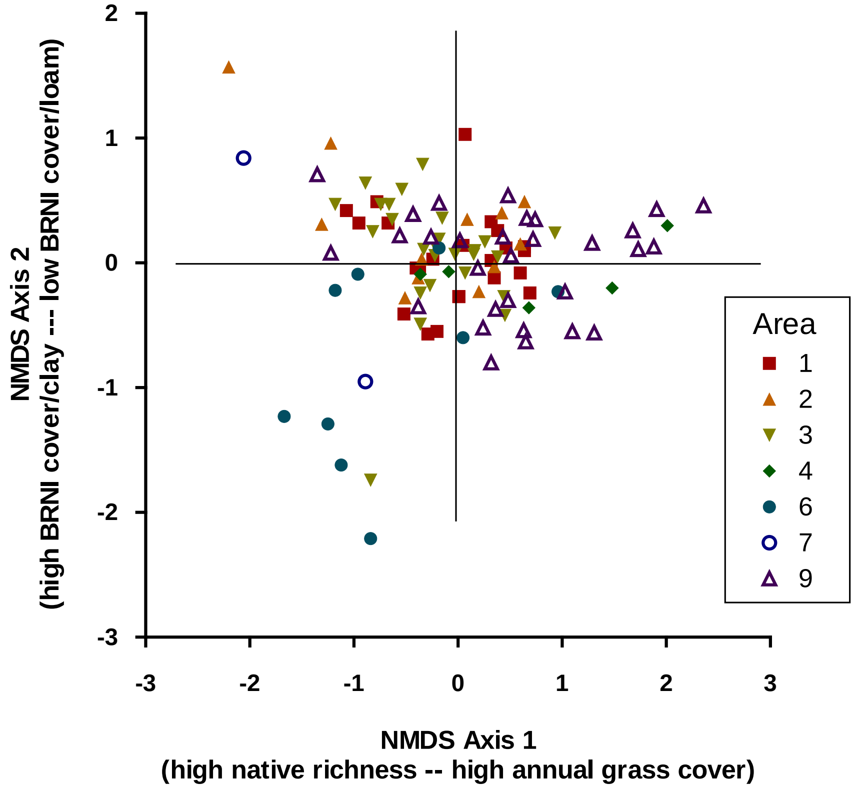


Fig. 5. Nonmetric multidimensional scaling plot showing the main axes of variation among polygons in the 2008 survey. The first axis describes a gradient of low annual grass cover, high native richness to high annual grass cover/low native species richness and the second axis describes variation in BRNI and soil type, from clay sites with high BRNI cover to loamy sites with low BRNI cover. Areas are coded as 1=Bommer canyon, 2=Shady canyon, 3=Laguna/Laurel Canyons, 4=Sand canyon, 6=Crystal Cove, 7=Muddy/Los Trancos, 9=Aliso Canyon.

Nonmetric multi-dimensional scaling indicated that the major variation among polygons were best described by a gradient of low annual grass cover, high native richness to high annual grass cover/low native species richness (Axis 1, P<0.001 for both annual grass cover and native species richness)(Fig. 5). The second axis described variation in BRNI and soil type, from clay sites with high BRNI cover to loamy sites with low BRNI cover (Axis 2, BRNI P=0.02, soil P=0.004). Overall the final stress in the model was 0.09, and the R^2 was 0.97.

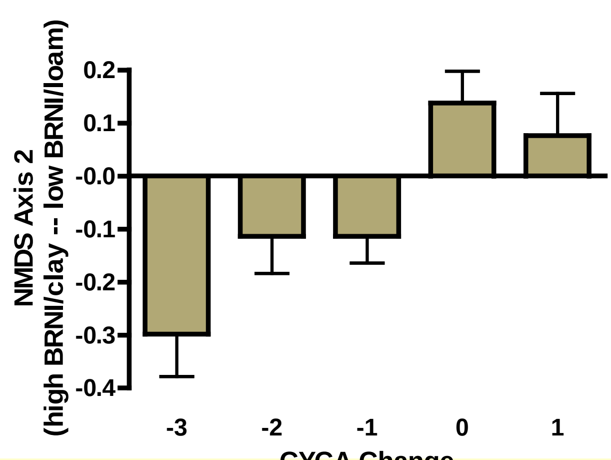


Fig. 6. The relationship between the second NMDS axis (BRNI cover and soil type) and the change in CYCA cover over the last decade (1998-2008). CYCA has decreased most in areas with clay soil type and high BRNI cover.

While the annual grass/native richness axis explained much of the variation among the polygons surveyed, it was not strongly associated with CYCA management. The one exception was with recent years treated (P=0.001), which may indicate that more recently treatment has focused on sites deemed high value. Changes in cover of the focal groups were more strongly related with the BRNI-soil type axis (Axis 2), with sites that decreased strongly in CYCA cover those with high 2008 BRNI cover/clay sites (P=0.03)(Fig. 6). Because CYCA cover has been uniformly reduced through management, this relationship indicates that sites that were strongly infested with CYCA in 1998 are those that have clay soils and currently high BRNI cover. High 2008 BRNI cover clay sites were also those associated with declines in native species cover (P=0.09) and richness (P=0.02) over the last decade.

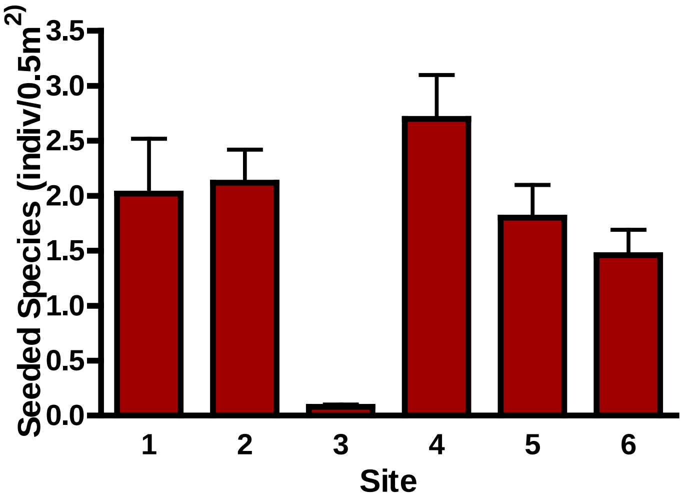


Fig. 7. The average density of seeded species present in each of the restoration sites in April 2008. Site numbers are as follows: 1 and 2, Laguna Coast Wilderness (1.3.070, 1.3.047); 3, Shady Canyon (1.4.015); 4, Crystal Cove State Park (1.6.038); and 5 and 6, Aliso and Woods Wilderness Park (1.9.082, 1.9.196).

II. Sustainability of control efforts: experimental control plots.
After one year of exclusion of herbicide treatment, we found minimal recruitment of CYCA into the plots. We recorded new invasions into 5 of the 18 exclusion plots, and a total of 7 CYCA individuals. This amounts to 0.0004 individuals per m^2. It remains to be seen whether this level of invasion will increase exponentially with time, or whether the rate will remain very slow.

In these same plots, we counted over 12,000 NAPU individuals, or an average of 644 per plot. Although it will be several years before we can assess changes in recruitment rate or survival of these individuals, and we could not distinguish any significant changes in NAPU density over the course of this first year.

III. Active Restoration.
We surveyed the restoration plots twice in 2008, once in April and once in June. In the first survey, seeded species density ranged from 0.08 to 2.7 individuals per $0.5m^2$ (Fig. 7). Of the seedlings, ESCA and ERSE were most successful, accounting for over two-thirds of all individuals, with NAPU and to a lesser extent, LUBI and HEFA, also present (see Table 1 for species names). In the late season survey, seeded seedling density was much lower, on average 0.02 individuals per $0.5m^2$. Surveys during the 2009 growing season will determine if more individuals will germinate this coming year.

Observationally, we also note that the areas where we drill seeded appeared to be lower in *Brassica nigra* cover compared to adjacent areas. This effect could be due to the mycorrhizae in the restoration seed mix: *Brassica* is not mycorrhizal and the addition of mycorrhizal could have been advantageous to its competitors (in most cases, this would be annual grasses). We will investigate this effect more closely in 2009.

CONCLUSIONS AND FINAL RECOMMENDATIONS

There is strong evidence that control efforts have substantially reduced CYCA over the past nine years. All the 110 areas we sampled, over 1,000 acres in total, had less than 5% CYCA cover. Thus, control efforts had been successful in both the moderately and highly invaded areas of the coastal reserve. The reduction in CYCA was not strongly related to current abundance of the focal groups, although there is evidence to indicate that *Brassica nigra* has increased more strongly in clay soil sites with where severe infestations of CYCA have been controlled. The remaining CYCA populations tend to be in clay soils and with low abundance of *Bromus diandrus*. These relationships are likely a legacy of initial invasion success rather than control treatment effectiveness: CYCA was less likely to invade areas of loam soil with low *Bromus diandrus* abundance.

Between 1998 and 2008, *Brassica nigra* cover, native species cover, and native species richness significantly increased. However, areas where there has been the largest decrease in CYCA cover were not associated with either greater invasion of *Brassica nigra* or increase of native cover.

The abundance of *Brassica nigra* averages 15% over the study area. While abundance was not directly related to CYCA or the treatment history of the CYCA control program, its abundance is related to similar environmental factors as CYCA (clay soils and low annual grass cover). Our measures suggest that *Brassica* and annual exotic grasses are the factors most strongly associated with low native cover and richness in the Coastal Reserve.

Restoration of areas with high levels of *Brassica* may need a multifaceted approach. We recommend examining the effect of mycorrhizal addition to give the other species in the community a relative advantage, as we saw some patterns consistent with this mechanism. Simultaneously, it will be imperative to develop approaches to re-establish native perennial vegetation in these areas, as once they are established, they will decrease the ability of an annual such as *Brassica* to persist. Re-establishment may be achieved with seed addition, with seed drilling as we are exploring in the restoration experiment described here, with seed imprinting, or with more intensive outplanting of individual plants.

While these data provide very strong evidence of the effectiveness of the control effort in reducing CYCA invasion, it is still very unclear whether this success implies that the control program effort should be decreased at the given time. After one year of experimentally excluding herbicide treatments from 18 30x30m plots throughout the reserve, we found minimal (7 individuals total) CYCA re-invasion. It remains to be seen, however, whether invasion levels will taper off due to seed bank depletion, increase linearly due to dispersal, or increase exponentially in the years to come. Recommendations about future control program efforts should wait until information about the fate of these areas that have stopped receiving herbicide control is obtained.

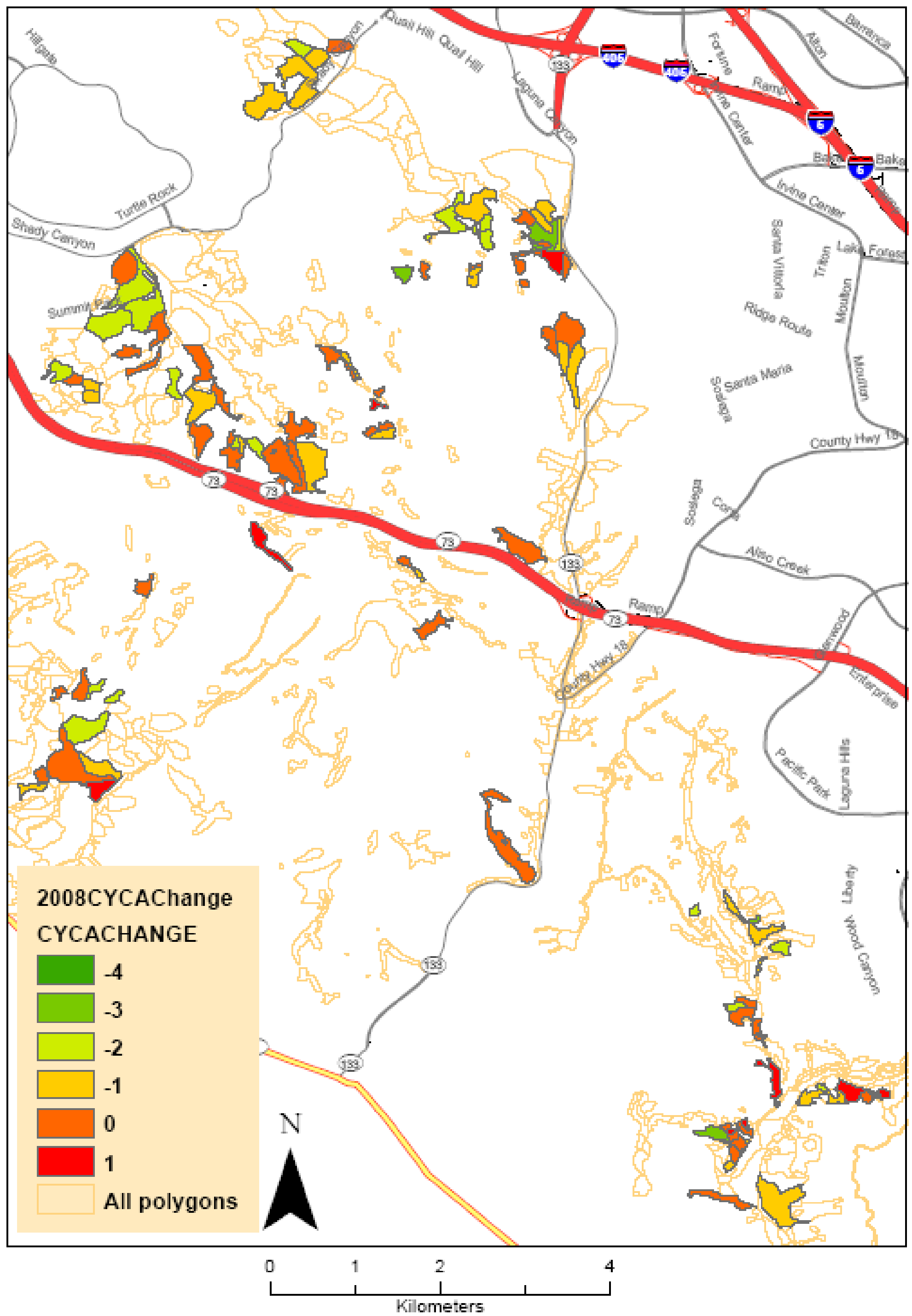
Active restoration, particularly in sites with high *Brassica nigra* and annual grass abundance, should be a future research priority, as these are strongly associated with low native cover and diversity. In six sites with particularly low native species present and little trends indicating that the areas were passively recovering after the CYCA control, we initiated native "island" restoration trials where we drill seeded 375m2 grids with a mixture of native grassland and coastal sage scrub seeds. In the first year, we found low recruitment across the sites (ranging from 0.08 to 2.7 individuals per $0.5m^2$). We expect that further recruitment will occur during the 2009 growing season, particularly of some of the more slowly growing shrub species.

APPENDIX A.

SPATIAL MAPS OF THE RESURVEY RESULTS

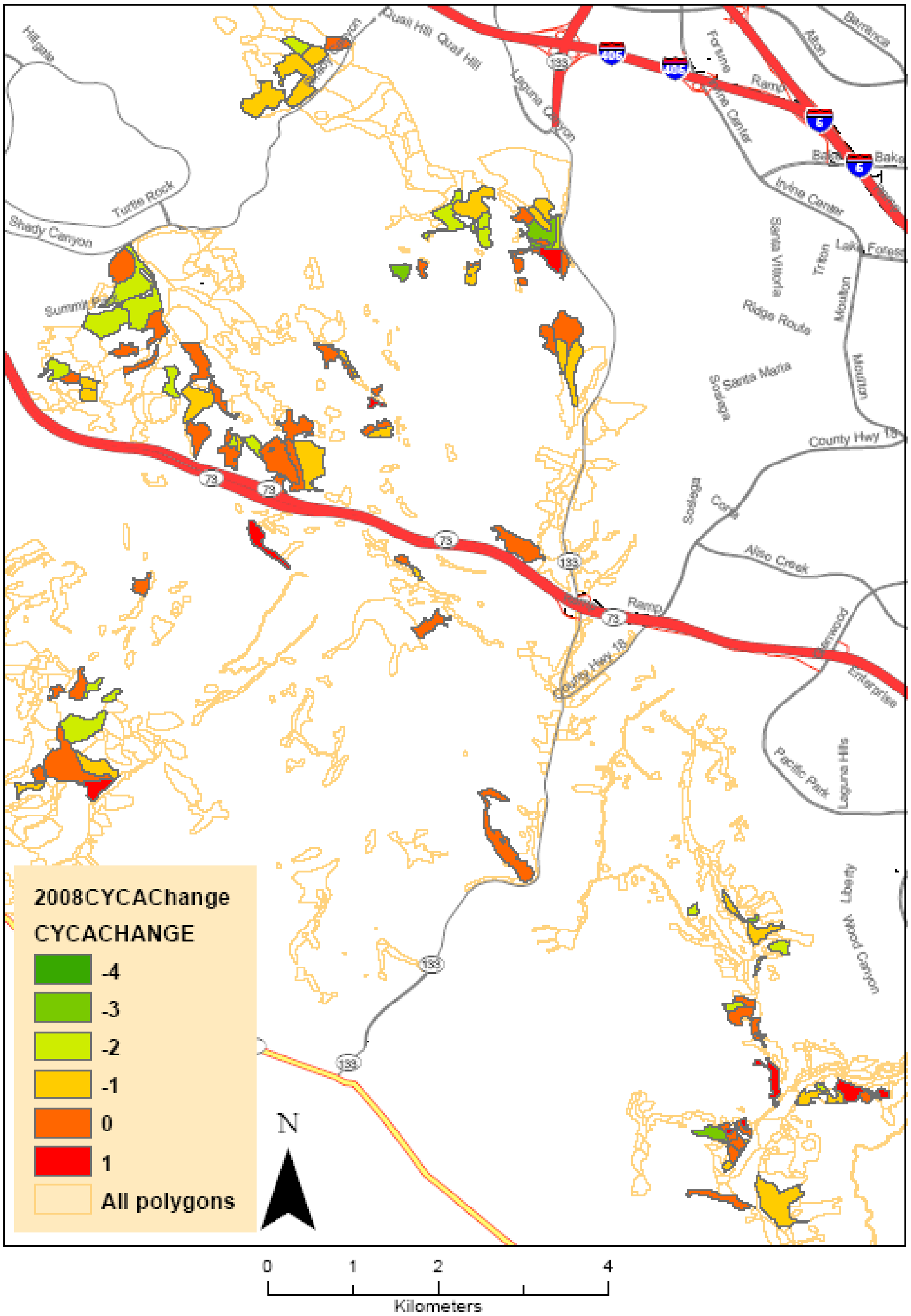
A-1. Change in CYCA cover class in the 110 polygons surveyed.
A-2. Change in BRNI cover.
A-3. Change in Native cover.
A-4. Change in Native species richness.
A-5. *Nassella pulchra* cover in 2008.
A-6. *Brassica nigra* cover in 2008.
A-7. Native cover in 2008.
A-8. Native richness in 2008.
A-9. Cover of annual exotic grasses in 2008.
A-10. Cover of coastal sage scrub species in 2008.

Change in Cynara cardunculus cover class, 1998-2008



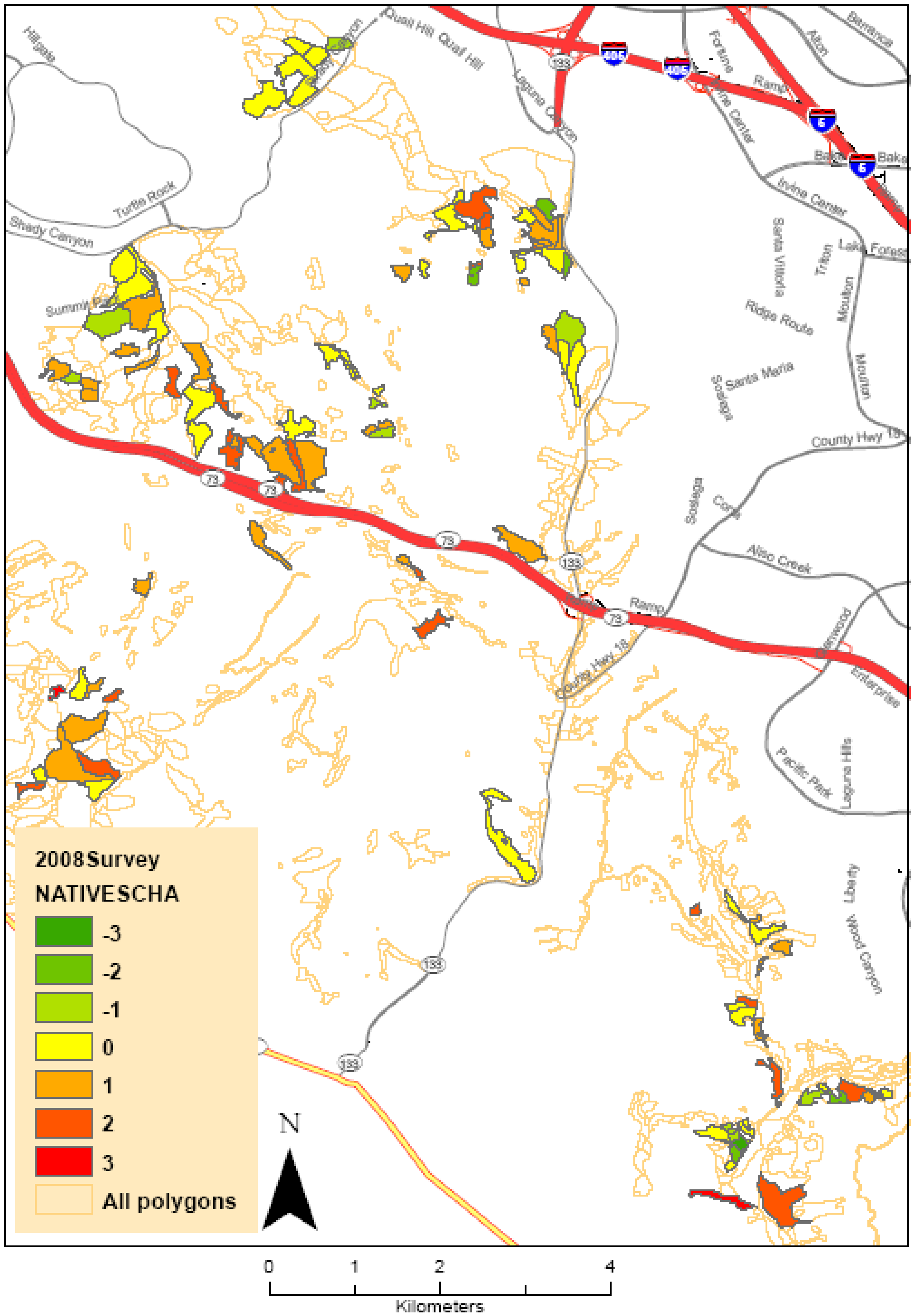
Appendix A-1. Changes in CYCA cover class between the 1998 and 2008 surveys. A positive value indicates that CYCA cover has increased; zero (orange) indicates no change in cover class; and negative values (green tones) indicate that CYCA cover has decreased. Cover classes are given in Figure 1.

Change in Cynara cardunculus cover class, 1998-2008



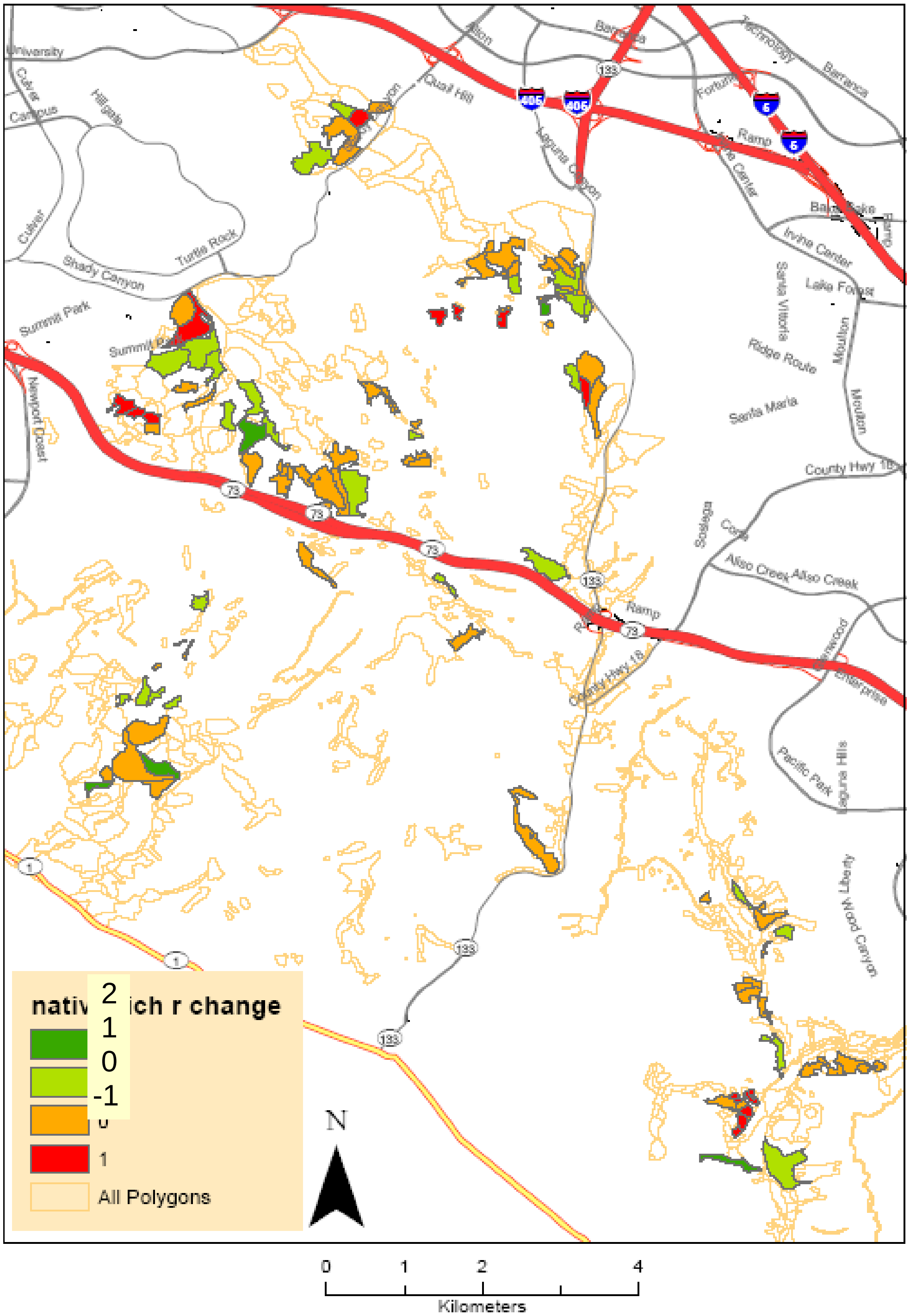
Appendix A-2. Changes in BRNI cover class between the 1998 and 2008 surveys. A positive value indicates that BRNI cover has increased in that polygon; redder tones indicate a larger cover class increase.

Change in Native spp. cover class, 1998-2008



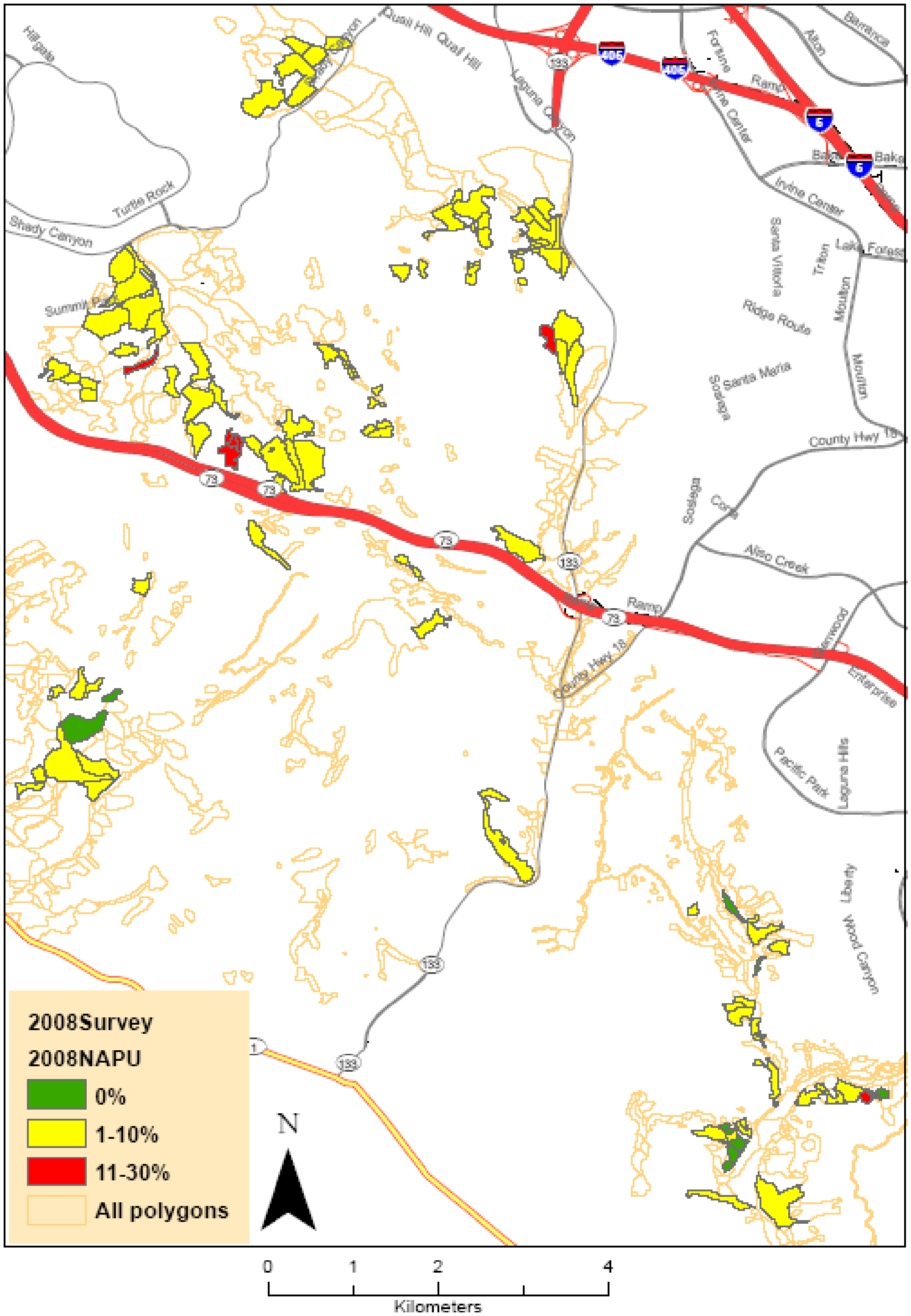
Appendix A-3. Changes in native species cover class between the 1998 and 2008 surveys. A positive value indicates that native cover has increased in that polygon; redder tones indicate a larger cover class increase.

Change in native spp. richness range, 1998-2008

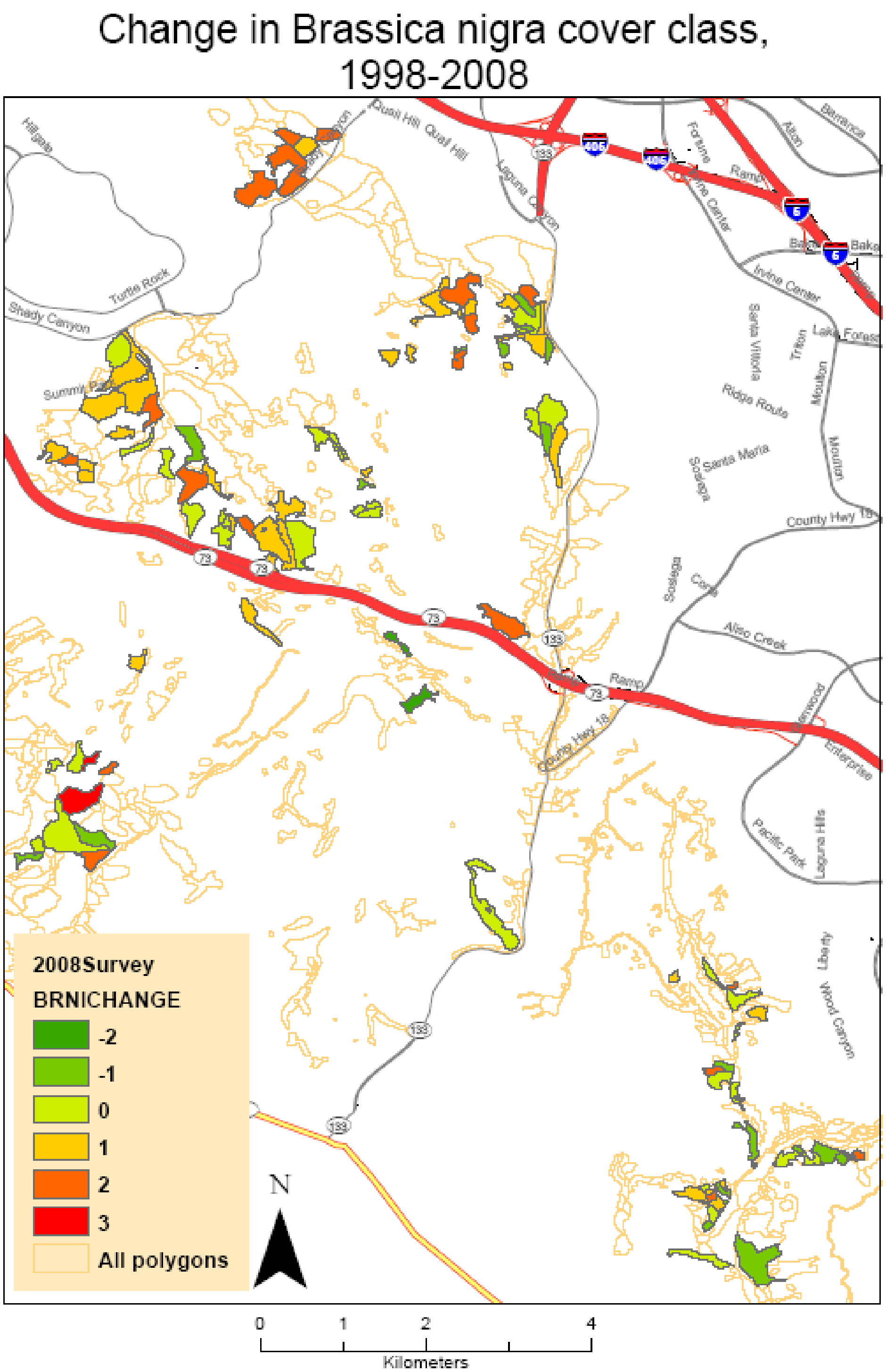


Appendix A-4. Changes in native species richness range (# native species) between the 1998 and 2008 surveys. A positive value indicates that native richness has increased in that polygon; red tones indicate a richness decrease.

Nassella pulchra cover, 2008

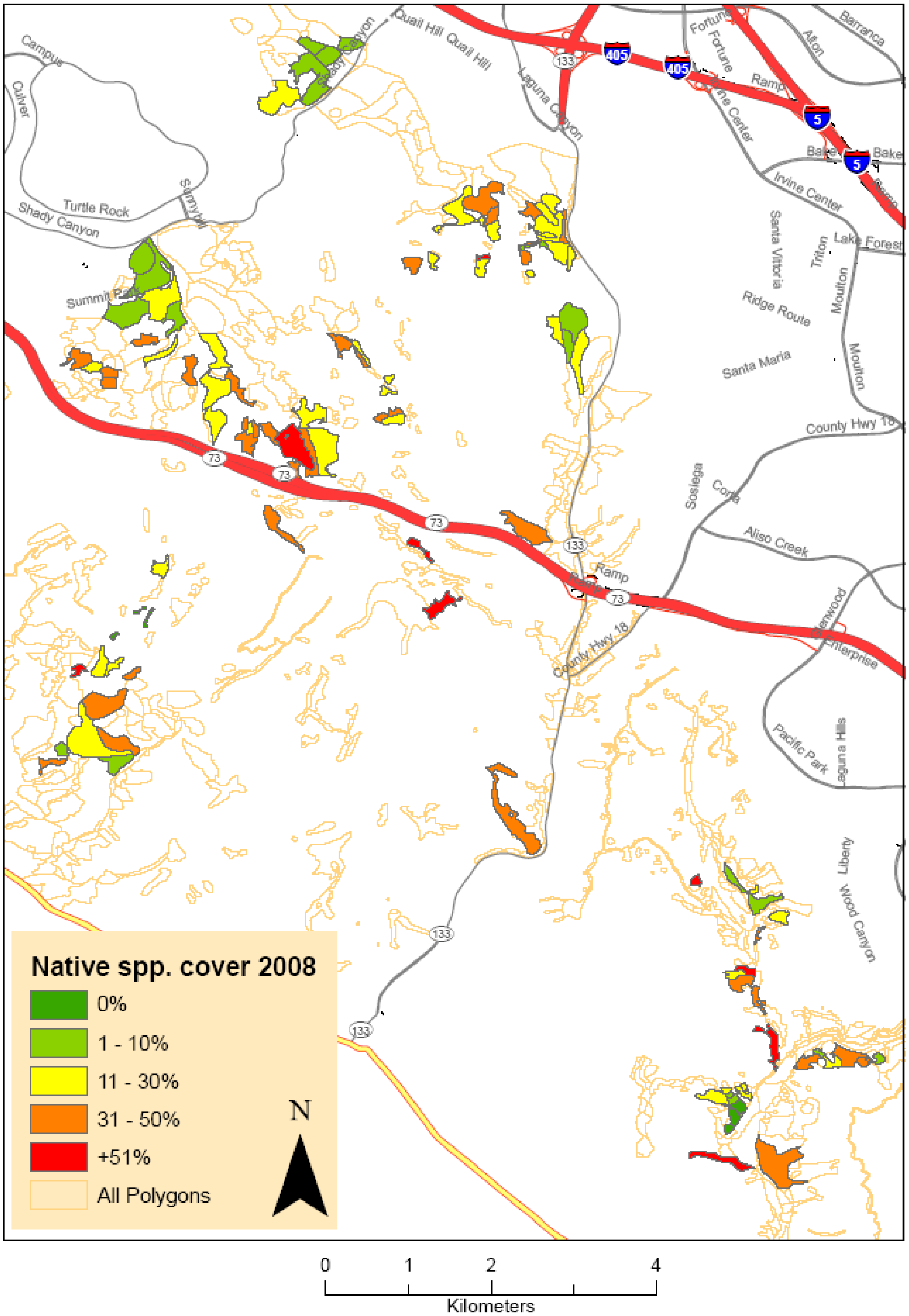


Appendix A-5. *Nassella pulchra* cover in the 2008 survey. The cover of this species was not specifically estimated in the 1998 survey, and so we cannot determine change over time. Most areas contain a low (<10%) abundance of the grass.



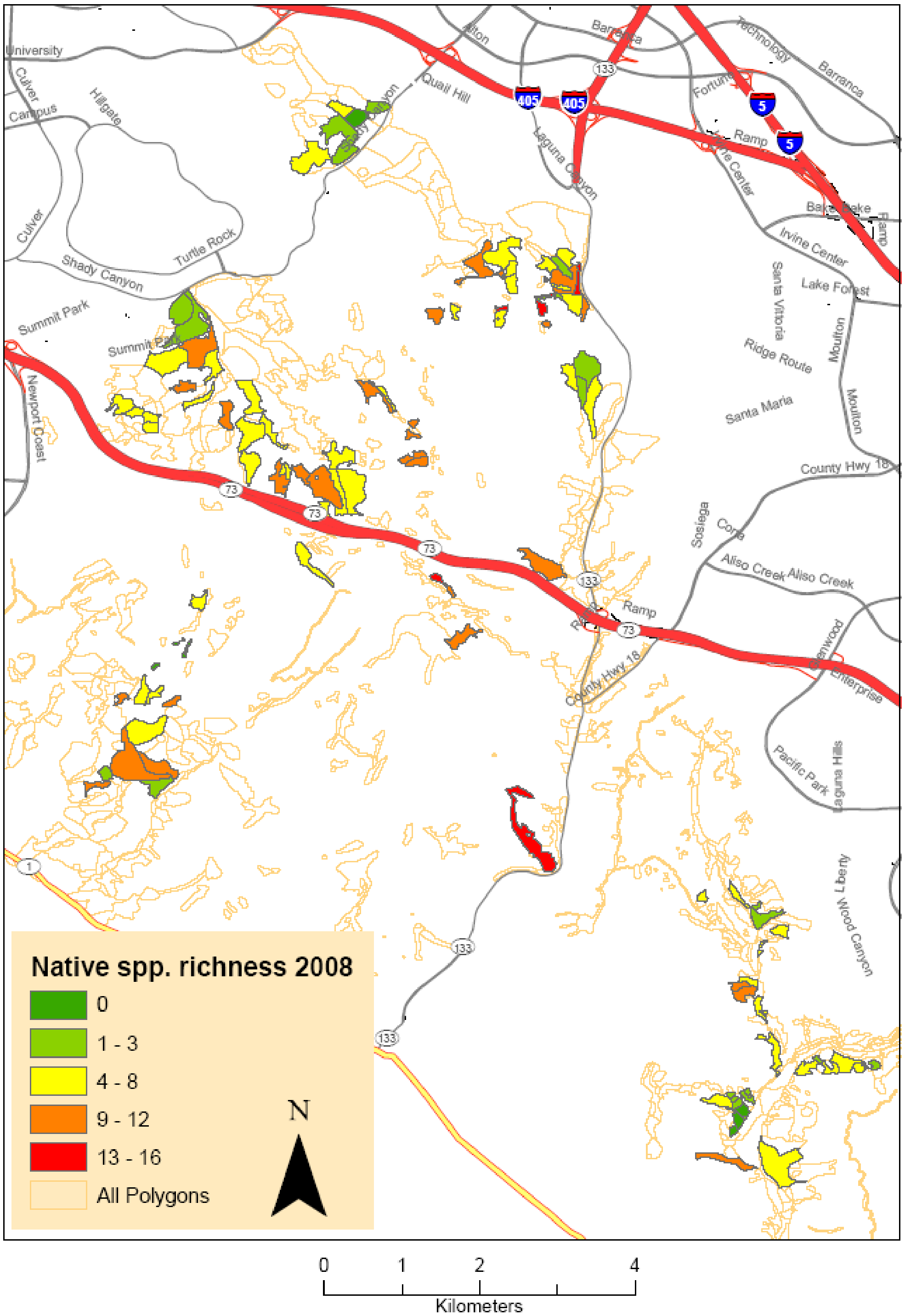
Appendix A-6. *Brassica nigra* cover in the 2008 survey.

Native spp. Percent Cover, 2008



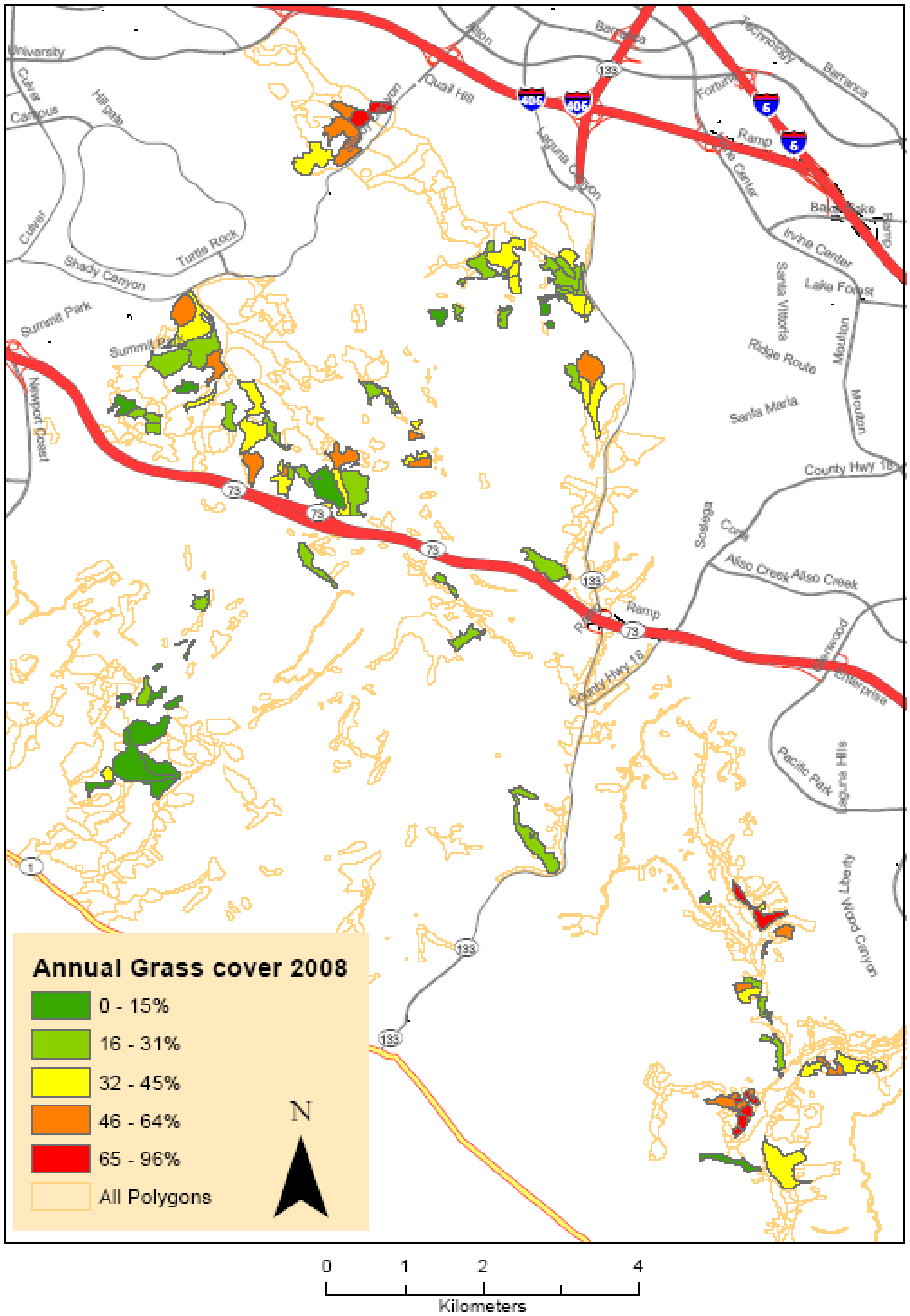
Appendix A-7. Native species cover in the 2008 survey.

Native spp. richness, 2008



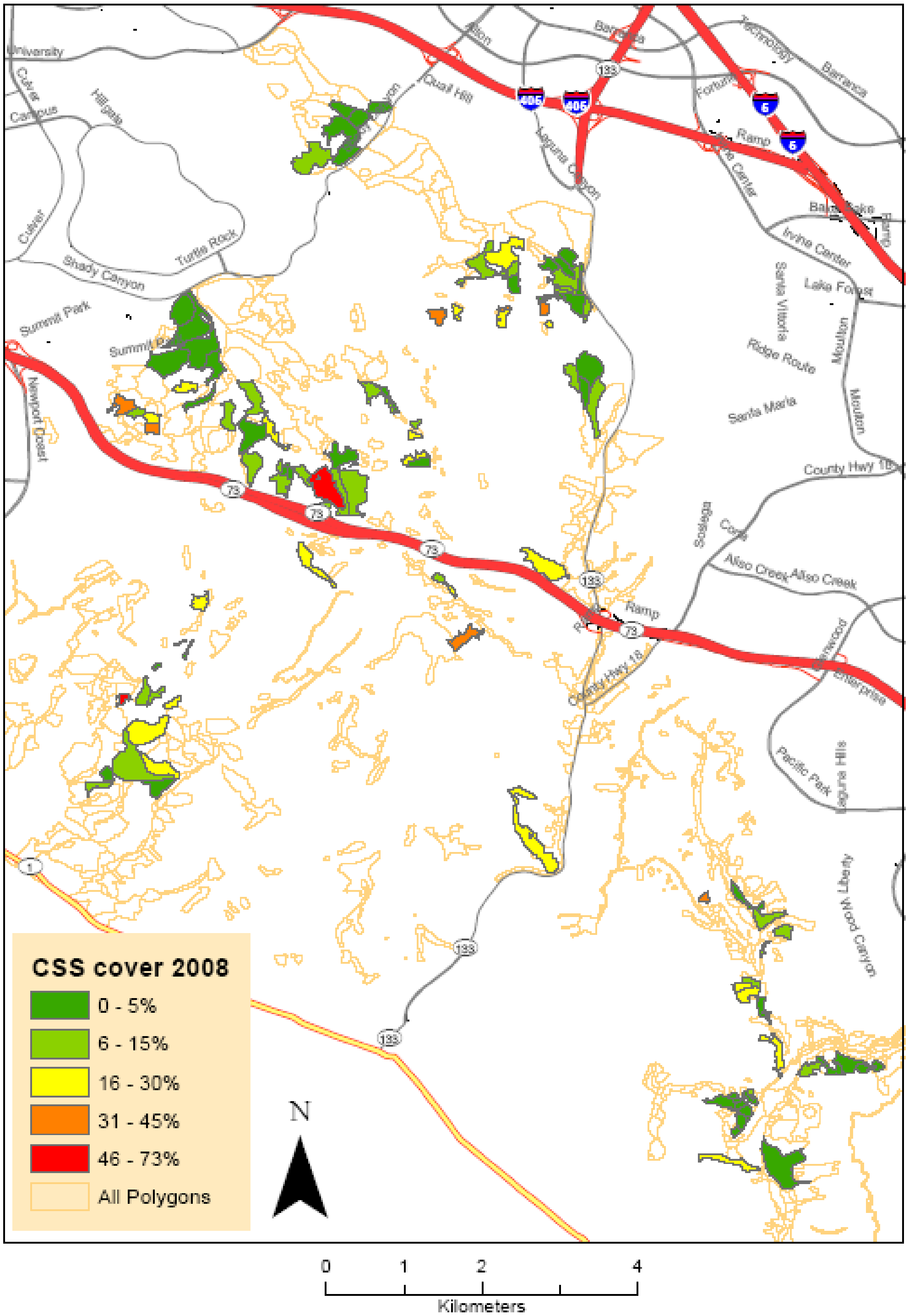
Appendix A-8. Native species richness (excluding rare species that were less than 1% cover) in the 2008 survey.

Percent Cover of Annual Grasses, 2008



Appendix A-9. Cover of annual exotic grasses in the 2008 survey. Cover classes follow appendix A-5.

Percent Cover of Coastal Sage Scrub spp., 2008



Appendix A-10. Cover of coastal sage scrub species in the 2008 survey. Cover classes follow appendix A-5. Species included in this category *Artemesia*, *Salvia, Encelia, Rhus integrifolia*, and *Erigonium.*

APPENDIX B.

DATA COLLECTED

B-1. Cover of all species (>1% cover) in 2008 survey.
B-2. Species codes of all species in the survey.
B-3. Species cover in experimental herbicide exclusion plots in 2008, one year of herbicide cessation.
B-4. Density of NAPU and CYCA in the experimental herbicide exclusion plots in 2008.
B-5. Density of seeded species in the restoration experiment, April 2008.

NOTE: These files are contained on accompanying CD.