

**Shipley-Skinner Reserve - Riverside County Endowment Proposal:
Incorporating Larval Host Plant *Plantago erecta* Niche Models into Quino Checkerspot
(*Euphydryas editha quino*) Niche Models to Improve Performance**

Richard Redak (Principal Investigator) and Kristine Preston (Co-Principal Investigator)

Background and Rationale

California supports more threatened and endangered species than any other state in the continental United States (<http://www.dfg.ca.gov/hcpb/species/>). Southern California is particularly biologically diverse with many species threatened by rapid and widespread urban and agricultural development. Recent conservation planning has focused on creating multiple species conservation plans, such as Western Riverside County's Multiple Species Habitat Conservation Plan (WRC MSHCP). The goal of these planning efforts is to conserve and protect natural communities, including rare, endangered and threatened species while allowing urban and agricultural development to continue. Spatially explicit habitat suitability (niche) models are becoming an important planning and management tool for multiple species conservation plans (Allen et al. 2005; Barrows et al. 2005). When combined with environmental data in Geographic Information Systems (GIS), these models can identify habitat suitable for a species occurrence (Hirzel et al. 2002; Rotenberry et al. 2002). Different modeling approaches are used to predict species occurrence over large geographical areas (Guisan and Zimmerman 2000). Niche-based modeling techniques focus on environmental variables consistently associated with a species occurrence (Rotenberry et al. 2002; Rotenberry et al. *In Press*). Niche models are directly relevant to conserving and managing sensitive species. They can identify the relative importance of individual environmental variables in determining suitable habitat for a species. This information can be used to guide further research into understanding species' habitat relationships and in developing adaptive management plans. Niche models provide a spatially explicit assessment of habitat suitability. They identify where the appropriate combination of biotic and abiotic conditions occur. Predictions about habitat suitability can be extended into areas where there is currently no information about the occurrence of a particular species. This type of information can guide the reserve assembly process and help focus monitoring efforts. Niche models can be used to evaluate restoration sites and areas vulnerable to exotic species expansion, and to predict the responses of species and communities to environmental change (Edwards et al. 1996; Hirzel et al. 2002; Neke and Du Plessis 2004; Hannah et al. 2005). For example, changes in the pattern of distribution of regional environmental stressors (e.g., spread of non-native grassland) can be used to make spatially explicit predictions about how species habitat suitability might be expected to change.

The University of California Riverside's Center for Conservation Biology (CCB) has developed GIS-based niche models predicting habitat suitability for over 30 sensitive plant and animal species over ~1.2 million acres in the WRC MSHCP (Allen et al. 2005). We use the Partitioned Mahalanobis D² technique (Rotenberry et al. 2002; Rotenberry et al. *In press*), which is a powerful tool for modeling species habitat relationships that uses presence-only data compiled from a variety of sources. A combination of local and landscape-scale variables reflecting natural and anthropogenic environmental conditions are used to construct the models. Alternative models are evaluated with validation datasets to identify the model best predicting a species' occurrence. As more species location data and/or environmental variables become available models are further refined and evaluated.

The Quino checkerspot (*Euphydryas editha quino*) is a federally-endangered butterfly that was once common throughout southern California in the coastal plain and foothills. With a loss of over 75% of its' historic range, remaining habitat for this species is largely fragmented and disturbed by anthropogenic processes (Mattoni et al. 1997; U.S. Fish and Wildlife Service 2003). Currently, Quino checkerspot is known only from northern Baja California, southern San Diego county and western Riverside county. This species is the focus of several multiple species conservation plans. Quino checkerspot occur in open shrub- and woodlands that support the primary larval host plant, *Plantago erecta* (Mattoni et al. 1997). As with the closely related, endangered Bay checkerspot (*E. editha editha*; Weiss 1999), invasion of natural habitats by non-native annual grasses and forbs has been suggested as a

factor in the decline of Quino checkerspot (Mattoni et al. 1997; U.S. Fish and Wildlife Service 2003). Microhabitat features such as exotic annual grass cover and dense shrub cover are negatively associated with the distribution and development of post-diapause larvae (Osborne and Redak 2000). The Quino checkerspot has a complex metapopulation structure with evidence of local population extinctions and recolonizations and is thought to be vulnerable to drought and altered fire regimes (Mattoni et al. 1997; U.S. Fish and Wildlife Service 2003).

Using 1997-2004 survey data for Quino checkerspot in western Riverside County, we have constructed preliminary partitioned Mahalanobis D^2 niche models predicting occurrence for this insect. Prior to modeling, 25% of species' locations were randomly selected and withheld for model validation. The remaining 75% of known locations were used to construct niche models. The models calculate Habitat Similarity Index (HSI) values, ranging from 0 to 1.0, for each map point in a grid placed across the study area. The HSI is a measure of how similar environmental conditions at each map point are to the multivariate environmental mean at locations where Quino checkerspot occurs. The closer the HSI value is to 1.0, the more suitable the habitat is. To date, the best model includes both local and landscape-scale vegetation variables, climatic variables and topographic variables (Table 1). This model predicts most suitable habitat for the Quino checkerspot is in the southern half of the WRC MSHCP, particularly in the southeast (Figure 1). Important environmental variables associated with Quino checkerspot occurrence (Table 1) include local- and landscape-scale vegetation variables and several abiotic variables. The performance of this model in characterizing suitable habitat is marginal, with a median HSI value of 0.62 for the validation dataset. We propose here to improve the performance of the Quino checkerspot model by including the predicted habitat suitability for *Plantago erecta*, the larval host plant, as an environmental variable

Research Objectives

The objective of our research project is to collect the necessary field data and improve the performance of Quino checkerspot niche models by developing models that incorporate the presence/absence of the primary larval host plant, *Plantago erecta*. Specifically, we propose to address the following three questions:

1. How important is habitat suitability of *Plantago erecta* in predicting the occurrence of Quino checkerspot in the WRC MSHCP? We hypothesize that suitable habitat for *Plantago erecta* is consistently associated with the occurrence of the butterfly (Mattoni et al. 1997; Osborne and Redak 2000). We predict that models incorporating measures of *Plantago erecta* habitat suitability will better predict the butterfly's occurrence than models that do not include this variable.
2. What is the combination of environmental characteristics consistently associated with suitable habitat for *Plantago erecta* in western Riverside County? We hypothesize that the presence of *Plantago erecta* is most consistently associated with open shrublands supporting bare ground and sparse cover of invasive, annual grasses and forbs (Mattoni et al. 1997; Osborne and Redak 2000). *Plantago erecta* is also likely to be associated with intermediate levels of disturbance such as abandoned dirt roads, recently burned shrublands, and lightly grazed areas (Mattoni et al. 1997; Weiss 1999; Osborne and Redak 2000). We predict that these environmental variables will be consistently associated with *Plantago erecta* occurrence.
3. Are there reserve lands within the WRC MSHCP suitable for restoring populations of *Plantago erecta* such that habitat suitability for Quino checkerspot is improved? We will use the *Plantago erecta* and Quino checkerspot niche models to identify areas within the reserve system where the host plant and the butterfly do not occur but which could provide suitable habitat within dispersal distance of extant butterfly populations. We will then identify areas where management actions could be undertaken to enhance occurrence of *Plantago erecta* potentially provide additional habitat for future colonization by the butterfly.

Table 1. Environmental variables included in a Quino Checkerspot niche model for the WRC MSHCP. An “*” indicates the variable is an “important” component of the niche model, whereas an “x” indicates it was included in the model but not considered “important”.

Variable Name:	
Annual Precipitation	*
Elevation	*
Mean Maximum July Temperature	X
Mean Minimum January Temperature	*
Northness	X
Eastness	X
Percent Slope	X
<i>Local Scale (250m x 250m)</i>	
Shrubland (Chaparral & Coastal Sage Scrub Scrub)	*
<i>Landscape Scale (2,250m x 2,250m)</i>	
Percent Developed	*
Percent Non-Native Grassland	*
Amount of Developed – Natural Edge	X

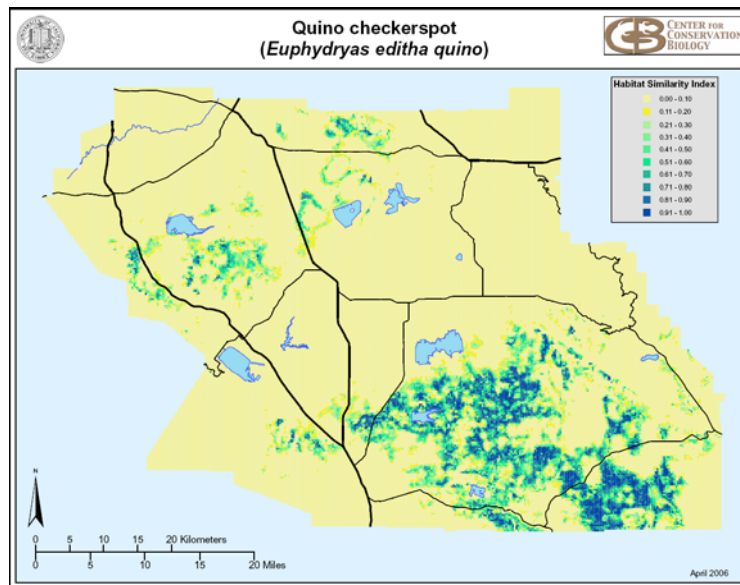


Figure 1. Habitat Similarity Index (HSI) for Quino checkerspot across the WRC MSHCP: The higher the HSI, the greater the similarity to occupied habitat.

Research Plan

We propose to improve Quino checkerspot niche models by incorporating information on the distribution and habitat requirements of *Plantago erecta*, the larval host plant. To achieve this we will:

1. Compile a *Plantago erecta* database:

Currently, there is no available database of *Plantago erecta* locations with which to construct niche models. We will create a *Plantago erecta* location database. We will compile location data from previous CCB/UCR vegetation and butterfly surveys, local herbariums (e.g., UC Riverside Herbarium and Rancho Santa Ana Botanical Gardens), and from local botanists and Quino checkerspot experts. We will augment

this database with survey data collected during winter of 2007 by a graduate student and undergraduate assistant. Surveys will be conducted for *Plantago erecta* at the Shipley Skinner Multiple Species Reserve and at other reserves within the WRC MSHCP during January and February 2007 after *Plantago erecta* has germinated and while it is detectable. In addition to gathering location data, we will also gather data on environmental conditions and vegetation characteristics at survey points with and without *Plantago erecta*. Some variables we will measure include: exotic grass and forb cover, percent bare ground, shrub cover and density, soil type, and level of disturbance. Prior to the surveys, we will identify reserve lands likely to support *Plantago erecta* by using GIS to screen for areas with bare ground, relatively low levels of invasive annual grasses and forbs, and intermediate levels of disturbance.

2. *Construct Plantago erecta niche models:*

We will use *Plantago erecta* location data and associated vegetation and environmental information to develop niche models predicting suitable habitat for *Plantago erecta* within the WRC MSHCP. We will construct two types of models. The first type of niche model will include the distribution and relative cover of invasive annual plants as environmental variables which we expect to be negatively associated with the occurrence of *Plantago erecta* (Mattoni et al. 1997; Osborne and Redak 2000). This model will identify current habitat suitability conditions for *Plantago erecta* in western Riverside County. The second type of niche model will focus on identifying areas that could support *Plantago erecta* populations in the absence of invasive annual grasses and forbs. We can use this second model to identify areas that with restoration (reduction of exotic annuals and forbs) could be made suitable for *Plantago erecta*.

3. *Construct Quino checkerspot models incorporating Plantago erecta habitat suitability:*

Plantago erecta is essential for larval development, and by including the habitat suitability of the plant as an environmental variable in the niche model for the insect we predict our ability to identify current and potential butterfly habitat will improve substantially. As with the *Plantago erecta* niche models, we will develop two types of Quino checkerspot niche models. For the first type of model we will use the results from the *Plantago erecta* habitat model that reflect current environmental conditions that include the presence of non-native annual grasses and forbs. We will use this niche model to identify current Quino checkerspot habitat suitability conditions. We will evaluate if including *Plantago erecta* habitat suitability predictions improves the performance of Quino checkerspot niche models. We will also create Quino checkerspot niche models that include *Plantago erecta* habitat suitability in the absence of invasion by exotic annual grasses and forbs. This model can be used to identify where suitable areas for restoration of *Plantago erecta* populations and optimum Quino checkerspot habitat overlap. This model can be used to guide management activities within existing reserves to enhance butterfly habitat.

The refined Quino checkerspot niche models could be used to evaluate lands for conservation value and potential inclusion in the WRC MSHCP reserve system. A second critical result of this research will be the ability to identify lands at existing reserves that have the appropriate environmental conditions to support populations of *Plantago erecta* following appropriate restoration and management activities. By actively managing suitable lands to support *Plantago erecta* there is the potential that Quino checkerspot could colonize these areas in the future.

Budget

This project is estimated to cost \$16,845. This will cover one month of 100% time for post-doctoral researcher, Kristine Preston (\$4,698), one quarter of graduate student research (49% time: \$7,789), one quarter of undergraduate research assistance (49% time: \$1,996), office/field supplies (\$600) and travel expenses (\$1,762). Kristine will compile species location databases, identify surveys areas, and construct models and evaluate their performance. The graduate student researcher and undergraduate researcher will conduct field surveys and assist with data entry. The total personnel expense is \$10,011 for salary and \$4,472 for fringe benefits). Travel expenses include mileage reimbursement of \$1,240 (4000 miles @ \$0.31/mile) and vehicle rental of \$522 (\$209/month).

Literature Cited

- Allen, M.F., J.T. Rotenberry, K.L. Preston, K.J. Halama, T. Tennant, C.W. Barrows, V. Rivera del Rio, A. Celis Murrillo, X. Chen, and V.M. Rorive. 2005: Towards developing a monitoring framework for Multiple Species Habitat Conservation Plans. Part I." (June 1, 2005). Center for Conservation Biology. <http://repositories.cdlib.org/ccb/CCB2005/>
- Barrows, C.W., M.B. Swartz, W.L. Hodges, M.F. Allen, J.T. Rotenberry, B.L. Li, T.A. Scott, and X.W. Chen. 2005. A framework for monitoring multiple-species conservation plans. *Journal of Wildlife Management* 69:1333-1345.
- Edwards, T.C., E.T. Deshler, D. Foster, and G.G. Moisen. 1996. Adequacy of wildlife habitat relation models for estimating spatial distributions of vertebrates. *Conservation Biology* 10:263-270.
- Guisan, A. and N.E. Zimmerman. 2000. Predictive habitat distribution models in ecology. *Ecological Modelling* 135:147-186.
- Hannah, L., G. Midgley, G. Hughes, and B. Bomhard. 2005. The view from the Cape: extinction risk, protected areas, and climate change. *Bioscience* 55:231-242.
- Hirzel, A.H., J. Hausser, D. Chessel, and N. Perrin. 2002. Ecological-niche factor analysis: how to compute habitat-suitability maps without absence data? *Ecology* 83:2027-2036.
- Mattoni, R., G.F. Pratt, T.R. Longcore, J.F. Emmel, and J.N. George. 1997. The endangered quino checkerspot butterfly, *Euphydryas editha quino* (Lepidoptera: Nymphalidae).
- Neke, K.S. and M.A. Du Plessis. 2004. The threat of transformation: quantifying the vulnerability of grasslands in south Africa. *Conservation Biology* 18:466-477.
- Osborne, K.H. and R.A. Redak. 2000. Microhabitat conditions associated with the distribution of postdiapause larvae of *Euphydryas editha quino* (Lepidoptera: Nymphalidae). *Annals of the Entomological Society of America* 93:110-114.
- Rotenberry, J.T., S.T. Knick, and J.E. Dunn. 2002. A minimalist approach to mapping species' habitat: Pearson's planes of closest fit. Pp. 281-289 in J.M. Scott, P.J. Heglund, M.L. Morrison, J.B. Haufler, M.G. Raphael, W.A. Wall, and F.B. Samson (editors). *Predicting species occurrences: issues of accuracy and scale*. Island Press, Washington, DC.
- Rotenberry, J.T., K.L. Preston, and S.T. Knick. *In Press*. GIS-based niche modeling for mapping species' habitat. *Ecology*.
- U.S. Fish and Wildlife Service. 2003. Recovery plan for the Quino Checkerspot Butterfly (*Euphydryas editha quino*). Portland, Oregon. X + 179 pp.
- Weiss, S.B. 1999. Cars, cows, and checkerspot butterflies: Nitrogen deposition and management of nutrient-poor grasslands for a threatened species. *Conservation Biology* 13:1476-1486.