# Appendix F

# Final Report:
# BRBNA Conservation Framework Modeling Using Universal Model Builder (UMB)

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**Project Background**

The Blue Ridge – Berryessa Natural Area (BRBNA) represents one of the most remarkable, predominately natural, large-scale landscapes still remaining in close proximity to a large urban population center in all of California. It's ~600K acres encompass a mosaic of candidate wilderness areas, publicly owned wildlands and privately owned ranches (~50% of the total area) that provides habitat for a wide diversity of animals, including top predators and other species with large home ranges. The BRBNA also supports a wide range of rare and vulnerable plant and animal species and significant ecological communities and vegetation types, including blue oak and valley oak woodlands, serpentine chaparral, serpentine bunchgrass, northern cypress forests, vernal pools, riparian forests and cliff habitats. This conjunction of rare and vulnerable species and communities make the BRBNA and adjacent regions to the west among the top rarity-weighted concentrations of biodiversity in the entire United States (see the TNC Precious Heritage map, file name "NatureServeRareRich.ppt", attached). The BRBNA Conservation Partnership was formed for the purpose of conserving and enhancing this remarkable landscape, its working ranches and open space values through partnerships, cooperative agreements and public education and out-reach, supported by scientific research and science based stewardship and best management practices.

To that end, the BRBNACP has sought grant funding to develop a computerized geographic information system of the spatially referenced data needed to develop a BRBNA Conservation Framework, focusing on three conservation domains: 1) Biodiversity, 2) Working Landscapes and 3) Recreation and Open Space. A November 2000 Biodiversity Mapping Analysis, prepared by the UC Davis Information Center for the Environment (ICE) for the Land Trust of Napa County (LTNP), concluded that the lack of a high resolution vegetation map significantly limited the ability to analyze biodiversity patterns and identify conservation priorities. Consequently, early work focused on the development of a state-of-the-art vegetation map with high floristic detail (57 vegetation types) and high spatial resolution (a 2.5 acre minimum mapping unit for most types, dropping to 0.6 acres for high priority types of limited spatial extent). The new Napa County vegetation map was completed a year and a half ago. The BRBNA Conservation Partnership, recognizing its potential value for conservation planning, then hired ICE to extend the vegetation map to portions of the BRBNA north and east, funded by the Packard Foundation and NFWF. 377,422 acres of the BRBNA have been mapped south of Highway 20, which forms the northern boundary of the study area for this report --159,413 acres of this total are within Napa County. Because considerable natural diversity and open space resources exist to the west of the BRBNA in Napa County, and because key data layers exist for this area, the study area for this report was expanded westward to the Silverado Trail/Highway 29 corridor along the eastern edge of the Napa Valley and south to the Napa County line. We refer to this area to this western extension as the BRBNA Sphere of Influence area. The total study area for this report, including the sphere of influence is 585,197 acres.

The most recent grant-funded work, addressed by this report, focused on using the GIS data compiled to date to identify conservation priorities at the parcel level and to assess the priorities identified by previous efforts, including: TNC's North Coast Ecoregional Plan, NatureServe's Project Aldo pilot project for Napa County, the BRBNA Proposition 40 report (Opportunities for Conservation in the Blue Ridge – Berryessa Natural Area: Land Acquisition and Easements) and the current portfolio of nine BRBNA priority projects. As stated in the grant proposal, this work was designed to address the general question, "How can science be used to validate a common conservation vision." More specifically, "… the next BRBNA conservation focus [this report]… [aims] at identifying and evaluating critical private lands for conservation easements, rangeland easements or fee-simple acquisition."

**The Project**

The modeling reported here constitutes the core of the BRBNA Conservation Framework planning process, as developed under contract to UC Davis - ICE. GIS layers have been created and collected for this project since 1999, initially in support of BRBNA map production needs. Despite the long time period over which the data have been assembled, considerable work remained to quality control the data and to reformat it so that data from disparate sources could be compatibly combined for analysis. This was especially true for the property ownership data, which came from five counties in different formats. Such data pre-processing was a major component of work for this grant cycle. Major task milestones for the data assembly and pre-processing, and the subsequent modeling are listed in Appendix A.

The modeling itself was implemented using ICE's Universal Model Builder (UMB), an ArcView/Spatial Analyst GIS software extension developed with ~$100K of grant funding from the US Forest Service. UMB is very similar in purpose and function to NatureServe's Project Aldo decision support tool, which cost more than $2M to develop. In contrast to the Project Aldo tool, UMB is an extremely user-friendly GUI tool that can be learned by laymen in under an hour. UMB allows GIS analysts to quickly and easily histogram the range of floating point values that vary from map to map into a consistent range of integer classes -- five classes for our BRBNA analysis --, needed to meaningfully combine the maps in a conservation priorities model. In this way, all data in a given histogram "bin" are assigned an integer to replace its floating point value for that class. A key feature of the histogram process allows the assignment of negative classes for cases where the factor being mapped detracts from the value of the conservation domain being modeled. Once the map values have been consistently binned, the UMB tool then allows the user to assign weights to each map layer (on a scale of zero to one), before they are combined in the model. Some types of mapped data are more important than others. Some are more reliable than others. Assigning weights allows the user to take these differences into account. (See the PowerPoint presentation on the companion CD for graphics and screen captures illustrating this process.)

It is very important to note that the work product we describe here is a computerized decision support tool whose conservation priority recommendations will vary as a function of the input data layers used and the weights applied by the user. The data specifics presented here represent a set of default map layers and associated model weights, determined by ICE personnel. Regrettably, delays associated with compiling a quality controlled parcel ownership map across five counties, did not permit the convening of stakeholder workshops to develop alternate analyses and weighting schemes for each of the three domains. These will be conducted in May 2004, using funds from other sources.

The details of how the models were implemented, including the data layers used, their value ranges and weighting schemes, and the explanations for each are found in Appendix B (Biodiversity Domain), Appendix C (Working Landscapes) and Appendix D (Trail-Based Recreation). Appendix E details the methods used to translate these raster-based model outputs into parcel-based maps and summary tables. Note that there are, in effect, three approaches to the model output: 1) the original gridded model outputs (one-acre pixels; only reproduced for the biodiversity runs in this report), 2) a parcelized version of the models using mean suitabilities per acre for each parcel of record and 3) a parcelized version of the models using summed suitabilities for parcels aggregated by ownership. Attached you will find one map for each domain for each of the two parcelized analyses (three maps for area-averaged parcels and three maps for summed suitabilities). Note that for the map of summed values aggregated by ownership, we have masked out the public lands, including Lake Berryessa itself, so that the remaining private lands can be more clearly seen. Public lands are the large white (blank) polygons on the maps.

Also attached are tables that list the priority vertebrate species and plant communities used, the cross-walk between the Manual of California vegetation types, the California Wildlife Habitat Relationships habitat types needed for vertebrate species predictive modeling in the CWHR system and priority aggregated ownerships. The details will not be discussed further in this report. Instead, the section below, titled Modeling Analysis and Discussion, will highlight the important factors distinguishing the UMB modeling approach from previous efforts, while comparing their respective findings. Given the complexity of the models, we would be pleased to present the model in person, if desired.

**Study Area**

The Study Area is roughly bounded on the west by the Silverado Trail (the eastern edge of the floor of the Napa Valley), on the south by the Napa County line, on the east by the eastern foot of the Blue Ridge and the Cortina Ridge extension to the north, and on the North by State Highway 20. Parts of Lake County and areas north of Highway 20 have been omitted from this study pending future vegetation mapping of this area. We are in the initial stages of organizing a consortium of agencies, organizations and local governments to seek CalFed funding to map the vegetation of the Upper Putah and Cache Creek watersheds, so we can extend the BRBNA Conservation Framework modeling process to these currently un-mapped regions. Based on the high priority conservation areas identified in the sphere of influence region, it is likely that recommendations will be made to expand the BRBNA boundary westward.

**Spatial Resolution**

As detailed in the grant proposal, previous conservation priority plans were relatively coarse, spatially. TNC's North Coast Ecoregional Conservation Plan identified ten high priority, sub-watershed scale conservation targets, averaging approximately 26K acres in size. Subsequent planning focused on the scale of the CalWater Planning Watersheds, averaging about 6K acres in size. More recently, NatureServe's Project Aldo modeling effort focused on the top 400 ownership parcels in Napa County, ranked on the basis of 40-acre GIS map pixels, derived, in part, from a generalized version of the vegetation map produced by ICE. The UMB model, described here, continues this trend of analysis at increasingly finer scales. The UMB model increases spatial resolution forty-fold, by using one-acre grid cells ("pixels" 63.615m, ~208 ft, on a side). Moreover, while Project Aldo generalized the Napa vegetation map from 48 natural vegetation dominated types to fewer, coarser "ecological community" types, the UMB model retained the full floristic resolution of the original vegetation map and its correspondingly finer-grained spatial polygons. The UMB model thus provides a significantly greater degree of floristic and spatial resolving power to more accurately identify high priority conservation values at the parcel level. As with Project Aldo, the UMB model emphasizes parcels greater than 40 acres. However, we include smaller parcels when they occur in blocks of contiguous common ownership. This approach has the benefit of allowing the identification of candidate priority projects on the basis of aggregations of commonly owned parcels, while allowing for negotiation flexibility by identifying sub-parcels with the highest conservation values.

**Data Confidentiality**

Parcel-level data are highly sensitive. Moreover, the MOUs governing UCD-ICE access to and use of parcel level data limit our ability to share parcel-specific information. Consequently, these data have been generalized for discussion in this report. We have listed generalized owner names for the nine BRBNA priority projects, since they were part of a request for Proposition 40 funds. We do so on the condition that the grantors to which this report is submitted do NOT share this information with any outside parties. Other owner names have been replaced by numbers to protect confidentiality.

**Modeling Analysis and Discussion**

Once the parcel-based conservation priority maps were produced for each of the three domains, we conducted a between-domain regression analysis to assess the extent to which the three domains were correlated or linked. This, in turn, allowed us to assess the extent to which the domain values might overlap and either conflict with or synergistically enhance conservation and acquisition efforts. For this analysis, two parcel subsets were selected. For reference, there are approximately 7500 parcels in the BRBNA Conservation Framework Study Area. The first subset included the 286 parcels encompassed by the nine BRBNA Priority Projects previously identified through a Delphi process involving knowledgeable stakeholders. (A tenth priority project is represented by a buffer along the Knoxville Devil's Head Road. It is not included in this analysis.) The second subset encompassed the 2958 parcels > 40 acres within the Study Area. The regression results are shown in Table 1.

Table 1. Regression analysis of suitability values averaged per unit area.

| Y Variable | X Variable | BRBNA Priority Projects (n=9) (# parcels = 286) | BRBNA Study Area Parcels >40 acres (# parcels = 2945) |
|---|---|---|---|
| Trail Recreation | Working Landscape | Y= 0.6300X + 53.101<br>$R^2$=0.3968 | Y= 0.0282X + 7.6546<br>$R^2$=0.0023 |
| Trail Recreation | Biodiversity | Y=-0.2425X + 178.30<br>$R^2$=0.0588 | Y=-0.1282X + 8.8604<br>$R^2$=0.0169 |
| Working Landscape | Biodiversity | Y=-0.0511 + 150.83<br>$R^2$=0.0588 | Y= 0.1967X + 5.0072<br>$R^2$=0.0144 |

The coefficient of simple determination ($R^2$), when multiplied by 100, can be interpreted as the extent of the variation in the dependent variable (Y) that is "explained" by the independent variable (X). If X and Y are perfectly related, $(R^2)$*100 = 100% and the variation in X perfectly predicts the variation in Y. The data points plot as a straight line. If $R^2 = 0$, there is no predictable relationship between X and Y, and the data points plot as an amorphous cloud. As the table documents, for parcels exceeding 40 acres in the entire study area, there is essentially no predictable relationship between priority values, *at the individual parcel level*, in any of the three domains using suitability values calculated on a per acre per parcel basis. $(R^2)$*100 values range between 0.2% and 1.7% explanatory power.

This somewhat surprising fact is a consequence of the exceedingly fine-grained pattern of environmental heterogeneity revealed in the one-acre pixel maps of the study area (see, for example, the all-vertebrates habitat suitability map in Appendix B). It is this fine-grained spatial heterogeneity that generates the high concentration of rarity-weighted biodiversity documented by NatureServe for the region. As you decrease the patch size of high-value resources, you decrease the odds of a given patch being highly suitable in another domain, resulting on low $R^2$ values.

Note that for the parcels encompassed by the nine BRBNA priority projects, the $R^2$ values are modestly higher – significantly so between the Trail-based Recreation and the Working Landscape domains. The ~40% "explanatory" relationship between the Trail/Open Space and Working Landscapes domains reflect the fact that many of these projects are clustered along the Blue Ridge and the north and east shores of Lake Berryessa. The grasslands and oak woodlands of this region are prime working landscape parcels, as reflected by the large ranch holdings found there, while the lake shore and the ridge crest are prime locations for recreational trail corridors. This conjunction of values is largely localized to this sub-region.

By averaging the conservation suitability values per unit area for a given parcel, the resulting maps emphasize portions of the Study Area with relatively broad patches of high suitability resources for a given domain. Thus, areas dominated by serpentine habitats tend to rank highly in the biodiversity domain, while oak woodlands rank lower due to their patchier distribution. Similarly, large grassland/oak savanna complexes rank highly in the working landscape domain and ridgeline and shoreline corridors rank highly in the trails and recreation domain. While this has the advantage of identifying high-value individual parcels, it has the disadvantage of ignoring, and hence down-weighting, larger concentrations of single-ownership parcels. To address this shortcoming, the parcel-based suitabilities were re-analyzed by summing the individual pixel-based suitabilities across groups of parcels aggregated by ownership. In this analysis, size of ownership dominates the map patterns, and the resulting high-suitability lands more closely match the maps produced by the TNC and NatureServe analyses. This is consistent with the coarser spatial resolution of their analyses. The two approaches reveal complimentary patterns.

Table 2. Regression analysis of suitability values summed by parcel.

| Y Variable | X Variable | BRBNA Priority Projects (n=9) (# parcels = 286) | BRBNA Study Area Parcels >40 acres (# parcels = 2945) |
|---|---|---|---|
| Trail Recreation | Working Landscape | Y= 0.7917X + 2.8862 $R^2$=0.8953 | Y= 0.8611X + 13.18 $R^2$=0.7391 |
| Trail Recreation | Biodiversity | Y=0.9382X + 0.1839 $R^2$=0.9079 | Y=-0.0.8365X + 6.5507 $R^2$=0.8428 |
| Working Landscape | Biodiversity | Y=1.1100X + 0.1764 $R^2$=0.8897 | Y= 0.7745X + 3.575 $R^2$=0.7249 |

A regression analysis of the *summed* suitability values by parcel (Table 2) reveal quite a different pattern. For the Study Area as a whole (parcels >40 acres), there is a 72% to 84% co-occurrence of high suitability parcels across all domains. This is good news for conservation planning, since it means that a single high priority acquisition has a high probability of addressing conservation priorities in multiple domains, stretching limited conservation dollars. The fact that the $R^2$ values are higher for the previously identified BRBNA Priority Projects validates their high value across all three domains. Economies of scale for resource management and protection, the importance of contiguous and defensible blocks of habitat for management feasibility, and the need to provide sufficient contiguous habitat to support species for large home ranges are all better represented in the model when the summed suitability data are used.

To further assess the extent to which the nine BRBNA priority project areas, identified by a Delphi process, are in agreement with the UMB modeling analysis, we calculated parcel suitability ratings in each domain, both as means normalized by the project areas and as summed totals by project. The normalized suitability values were then rescaled to fall in the range of values between one and 16. These data are summarized in the Excel file BRBNA_ProjSuitSumV2.xls. In the interest of data confidentiality and table compactness, the results have been lumped by aggregated parcel ownership.

In general, the highest project suitability ranks for an individual project occurred in the Working Landscapes and Trail-based Recreation domains when using the per acre per parcel data. This is consistent with the fact that the majority of the projects are large working ranches, which overlap with important trail corridors. For the summed suitability data, the patterns were less clear cut, since total project area largely determined the magnitude of the score. For the summed data, the biodiversity and working landscape domains scored highest, consistent with the fact that trails only require a small footprint. The effect of total project area is seen in the suitability scores for the Todd Ranch and the Scribner parcel. The Todd Ranch has been identified as high-priority acquisition by the California Department of Fish and Game, in conjunction with the much larger Lauff Ranch that surrounds it. The Todd Ranch scores high in the area normalized analysis, but it scores low in the summed analysis, due to its relatively small analysis. When lumped with the Lauff Ranch, the UMB analysis strongly supports this acquisition. The Scribner parcel is a similar case, in that it is a single small parcel, adjacent to the Quail Ridge Reserve and a priority parcel for reserve expansion. Although it encompasses qualities that make it valuable as a component of a working ranch, it is too small to meet the 1000-1200 acre minimum size threshold for a viable ranch and it is not adjacent to a viable ranch ownership.

<u>TNC – NatureServe Results Comparison</u>. The results of the UMB model, mapped as summed suitabilities by aggregates ownership give results which are consistent with the TNC and NatureServe Project Aldo analyses (see the LTNC fig_2_bio.pdf map). The high priority projects in fig2 are all found in the UMB map, with relatively minor differences in rank. There are some differences in Pope Valley and the Mayacamas Mts, outside of the BRBNA that may be due to NatureServe's limiting itself to the top 400 parcels only.

Proposition 40 Opportunities Comparison. In April 2002, the BRBNA Conservation Partnership prepared a report and associated map titled, Opportunities for Conservation in the Blue Ridge-Berryessa Natural Area: Land Acquisitions and Easements. The 11-page report contained a table of 14 Major Land Areas for Overall Habitat Integrity & Connectivity (11 in the Study Area), 6 Smaller Areas and Inholdings of Special Value and 15 Areas for Trail Access and Connectivity. The associated map was a generic bubble diagram and dot map, without parcel specificity. The UMB modeling effort not only fleshed out the parcel level detail for each of those areas, confirming their validity, but also identified many other high priority areas, including the Lake Curry to Highway 128 region.

**Findings and Implications**
The use of detailed vegetation mapping has important implications for conservation planning. It allows for one to two orders of magnitude improvement in the spatial resolution of resources of conservation concern, particularly narrow riparian habitats. It provides a roughly two-fold increase in floristic resolution in a format that facilitates translation of vegetation types into the California Wildlife Habitat Relationships (CWHR) System of habitat types used in predictive modeling of vertebrate species distribution. The advantage of the CWHR vertebrate data layer is that it compensates for the data voids and false negative occurrences of target species found in the California Natural Diversity Data Base data. This allows for more continuous maps of biodiversity distribution. This greater spatial and taxonomic resolution enables one to more accurately target and map target conservation resources within ownership blocks.

The Universal Model Builder (UMB) ArcView/Spatial Analyst extension, developed by ICE, provides a user-friendly interface to facilitate the combination of map layers in predictive models in two ways. First, it simplifies the histograming of mapped values and their translation into integer classes (“bins”) that allows maps to be added together. Second, it allows the user, including interested stakeholders, to easily apply weights to the resulting map layers that reflect stakeholder values or the functional role of a mapped layer in a particular domain. The UMB tool is a much more user-friendly tool for laymen to use than Project Aldo.

We explored three mapping approaches: 1) a grid-based model (one-acre pixels), 2) a parcel-based model using mean suitability data per acre per parcel and 3) a parcel-based model using suitability data summed by both individual parcel and by aggregated ownership (adjacent parcels). Approaches 2 and 3 required the output of approach 1 as an input layer. Approach 2 revealed the extent to which the environment is heterogeneous at a very fine scale, it was not a suitable approach to use for identifying high priority parcels where contiguity and connectivity are important. Instead, approach 3 is the approach of choice. Data summed across aggregated ownerships identify the large, high priority parcels that offer both high within-domain suitabilities as well as opportunities for corridor connectivity and habitat for large home range species. Data summed by individual parcels allows for the identification of key sub-parcels within an aggregated ownership block, which allows negotiators to identify key subparcels, if the entire block is not available.

The results are broadly consistent with the biodiversity findings by TNC and and NatureServe-Project Aldo, but the UMB approach appears to provide a slightly more comprehensive coverage of mid- to high-priority conservation targets.