GIS-Based Monitoring Techniques for the Rancho Mission Viejo Habitat Reserve Lands

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I. Introduction

In this paper we will discuss the use of Geographic Information System (GIS) based monitoring techniques on the Rancho Mission Viejo Habitat Reserve Lands.

II. Background – Rancho Mission Viejo

Rancho Mission Viejo (RMV) consists of approximately 22,815 acres located in Southern Orange County, California. This former Spanish land grant once stretched from Cooks Corner to Oceanside and included Camp Pendleton. Today the remaining portion of the Ranch is bound by the existing communities of Rancho Santa Margarita, Mission Viejo, San Juan Capistrano and the undeveloped Cleveland National Forest and MCB Camp Pendleton. Various habitat types including but not limited to coastal sage scrub, chaparral, grassland, oak woodland and riparian are present on the Ranch.

Since 1882, the O'Neill/Moiso family has been a responsible steward of the Ranch. To continue this tradition of stewardship into the future, and address the needs of Orange County's growing population, RMV, in conjunction with the County of Orange, undertook a coordinated approach to the Endangered Species Act, Clean Water Act and Orange County's General Plan. In 1993, RMV enrolled in the Natural Community Conservation Planning Program, aimed at the protection of coastal sage scrub plant community and associated species. In 1999, RMV also initiated a Special Area Management Plan (SAMP) process with the U.S. Army Corps of Engineers to develop and implement a watershed-wide management plan for the preservation, enhancement and restoration of aquatic resources including vernal pools. Similarly, a Master Streambed Alteration Agreement (MSAA) process was initiated with the California Department of Fish and Game. Finally, RMV and the County of Orange also initiated a general plan amendment/zone change process to determine future land uses on RMV land. All together these separate regulatory planning efforts were termed the South Orange County "coordinated planning process".

The coordinated planning process took over 20 years to complete, with the last regulatory approval being received in September of 2009. Through this effort, RMV gained several large scale entitlements including a General Plan Amendment/Zone Change from the County of Orange, a Habitat Conservation Plan from the U.S. Fish and Wildlife Services, a Special Area Management Plan from the U.S. Army Corps of Engineers and a Master Streambed Alteration Agreement from the California Department of Fish and Game. The use of GIS was integral to the planning process and continues to be integral to implementation of these approvals.

a. Southern California Habitat Conservation Plans

Private landowners, corporations, State or local governments, Tribes or other non-Federal landowners who are interested in conducting activities that might incidentally harm (or "take") endangered or threatened wildlife on their land are required to obtain an incidental take permit from the U.S. Fish and Wildlife Service (USFWS), to provide protection from violating the Endangered Species Act (ESA). Landowner have two potential options available to them to comply with ESA regulations, a Section 7 permit which requires a federal nexus such as a Section 404 permit from the USACE or a

Section 10 permit. A Habitat Conservation Plan prepared under Section 10 of the ESA is designed to conserve and protect federally listed and unlisted species while allowing for development activities.

According the USFWS:

> "HCPs simplify the permitting process, save time and money, and provide better protection by planning for entire landscapes rather than smaller project-by-project consultations.
>
> Large-scale HCPs, commonly referred to as Regional HCPs, help communities plan for development activities while protecting habitat and promoting species conservation. They help facilitate partnerships and provide solutions needed to achieve long-term biological and regulatory goals.
>
> HCPs benefit both the landowner and the species and are an effective conservation tool designed to balance urban development with wildlife and habitat conservation." (http://www.fws.gov/carlsbad/HCPs.html)

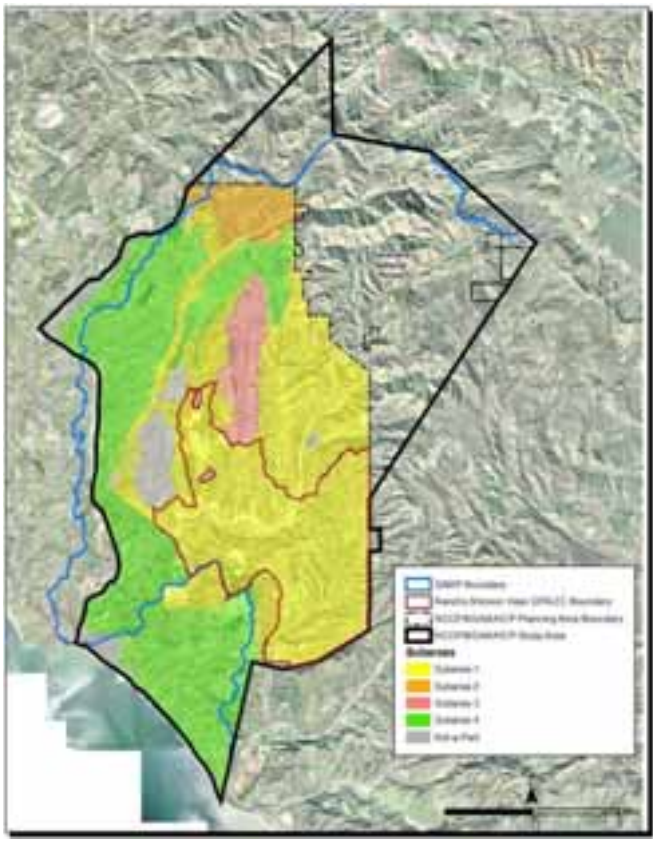
Five Habitat Conservation Plans have been processed and approved by USFWS in Southern California. These are: Central/Coastal HCP, Southern HCP, Riverside MSHCP, San Diego MSCP and Coachella Valley MSHCP. Refer to Figure 1 below.

Figure 1
Southern California Habitat Conservation Plans

b. Southern Subregion Habitat Conservation Plan (Southern HCP)

The Southern Subregion Habitat Conservation Plan or Southern HCP is located in southern Orange County. The planning area for the Southern HCP was 132, 000 acres including the Cleveland National Forest. For planning purposes the planning area was divided into 4 subareas. Subarea boundaries were designated under the Southern HCP based on several factors, including: land ownership pattern; the presence of significant habitats and extent of prior urbanization; the extent to which planned activities by the landowners and jurisdictions would impact Covered Species, Covered Vegetation Communities and CDFG Jurisdictional Areas and require authorizations for regulatory coverage of state or federal listed species; the ability of landowners within the Subareas to contribute to subregional and regional biological connectivity; and the willingness of Participating Landowners to assume species/habitat management responsibilities during implementation of the proposed Southern HCP and its Conservation Strategy. The Southern HCP was approved by USFWS in January of 2007. Incidental take permits were issued for three permittees, the County of Orange, RMV and the Santa Margarita Water District all located within Subarea 1. Refer to Figure 2.

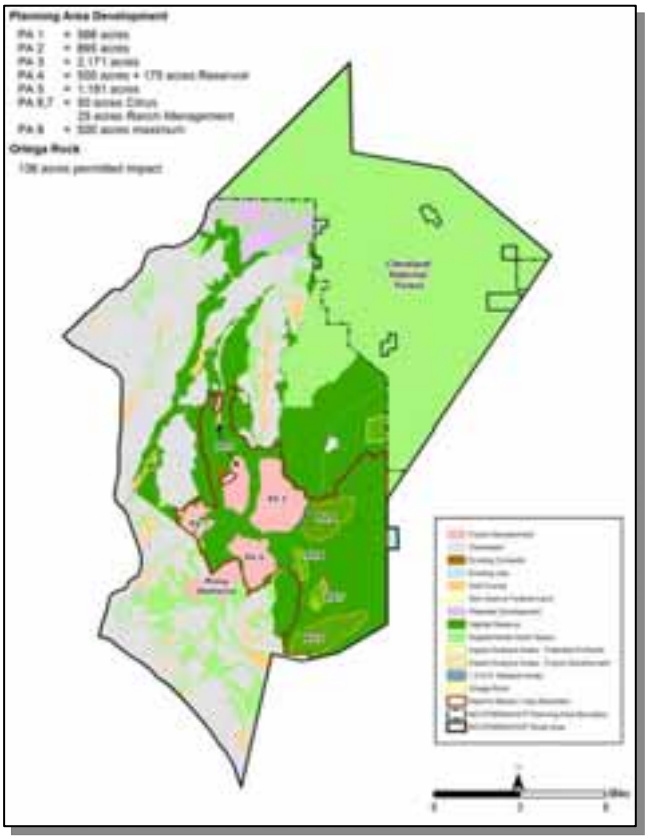
Figure 2
Southern Subregion Habitat Conservation Plan



c. Southern Subregion Habitat Reserve

Each of the permittees committed land, money or both to the Southern Subregion Habitat Reserve. The Southern Subregion Habitat Reserve will eventually total 32,818 acres, of which 11,950 are owned by the County of Orange and 20,868 are owned by Rancho Mission Viejo. SMWD will pay $3.7 million towards management and monitoring of the habitat reserve. Refer to Figure 3.

Figure 3
Southern Subregion Habitat Reserve



Nine (9) vegetation communities are conserved by the plan, these are:

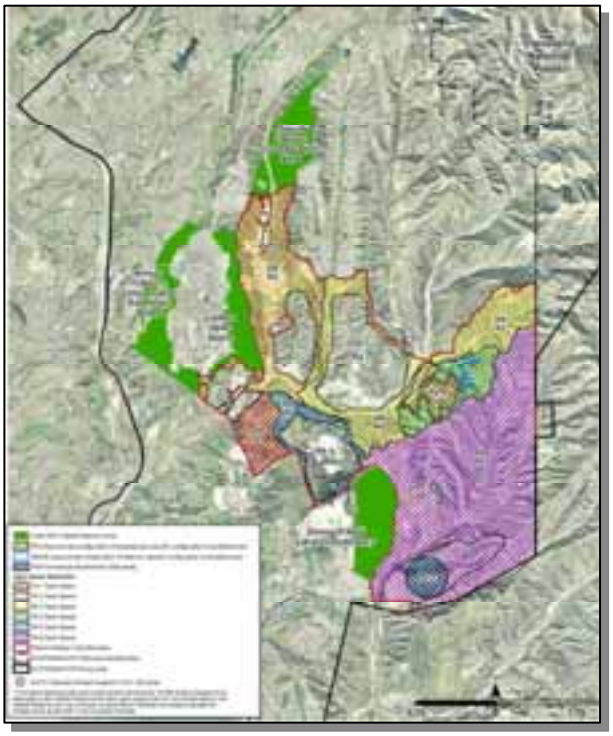
- Coastal Sage Scrub
- Chaparral
- Grassland
- Riparian
- Freshwater Marsh
- Alkali Meadow
- Open Water
- Streamcourses
- Woodland & Forest

Thirty-two wildlife species are addressed or covered by the plan. Seven of these species are listed as threatened or endangered, including the arroyo toad, thread-leaved brodiaea and south-western willow flycatcher shown below in Figure 4.

Figure 4
Examples of Southern HCP Covered Listed Species

The Habitat Reserve has large connected blocks of habitat, an integral feature of reserve design, that are themselves connected to other large blocks of habitat such as the Cleveland National Forest to the northeast, San Mateo Wilderness to the east and Camp Pendleton to the south. Significantly, the Southern Subregion Habitat Reserve will be created at no cost to the general public. No public acquisitions are required, instead the habitat reserve will be created over time through a phased dedication program that ties open space and development together. Each development area has an associated open space area that will be dedicated upon commencement of grading. Refer to Figure 5. Until that time, RMV has committed to maintaining the baseline condition of its land through ongoing management, the results of which are reported to USFWS every year.

Figure 5
Phased Dedication Program



III. Historical Use of GIS

The County of Orange and RMV began using GIS to support the HCP planning process in the early 1990's. All consultants hired to work on the HCP were required to be GIS capable. At least two firms started GIS departments because of the Southern HCP. The HCP database is made up of various layers representing data such as species distribution, extent of vegetation communities, soils, ownership boundaries, hydrologic units such as watersheds and sub-watersheds, existing infrastructure such as sewer and water lines, roads, drainage culverts and fire history to name just a few of the layers. The database is updated as new data becomes available such as new species occurrence data.

During the HCP planning process GIS was used to analyze reserve design alternatives, determine impacts on species and vegetation communities and convey the results of this work to the Wildlife Agencies. GIS was also integral to communicating with the general public. The general public and the environmental community in particular was an active participant in the HCP planning process both through informal discussions and formal public meetings and hearings. Maps, illustrations and exhibits were a key factor in being able to convey complicated information in an easily understood format.

IV. Current/Future Use of GIS

The ability to manage and monitor Conserved Vegetation Communities and Covered Species is a requirement of any habitat conservation plan. To fulfill this requirement the Southern HCP contains a Habitat Reserve Monitoring and Management Program or HRMP. The key elements of this program are:

1. The program is stressor based, i.e. the monitoring and subsequent management actions are keyed to stressors on the Covered Species and Conserved Vegetation Communities
2. Management is adaptive, i.e., is responds to conditions in the field
3. All species and vegetation communities have models that predict stressors
4. A Science Panel makes recommendations on monitoring techniques and management approaches
5. Coordination with USFWS occurs regularly

The HRMP is to be implemented in five year increments through Management Action Plans. The Initial MAP or IMAP covers the years 2009-2013 and addresses monitoring and management on lands that have been dedicated to the Habitat Reserve since 2007. The focus of the IMAP is a two-year pilot study to test field monitoring protocols. A properly designed monitoring program must be able to distinguish change attributable to anthropogenic causes from background noise. According to the IMAP, "There are several fundamental questions that must be considered in designing monitoring studies, as listed by Elzinga *et al.* (2001):

- What is the population of interest?
- What is the appropriate sampling unit?
- What is an appropriate sampling unit size and shape?
- How should sampling units be positioned?

- Should the sampling units be permanent or temporary?
- How many sampling units should be sampled?

What is the population of interest? This issue sets the boundaries for what biological resources are to be monitored in the Habitat Reserve and in what context.

What is the appropriate sampling unit? The appropriate sampling unit depends on the variable or attribute being measured, and includes several options: individuals of a species, quadrats, lines (transects), or points, as well as combinations of these methods (Elzinga *et al.* 2001).

What is an appropriate sampling-unit size and shape? This question is premised on the issues addressed in the selection of the appropriate sampling unit and also depends on the variables being measured. It is unlikely that with the variety of variables proposed for measurement that one sampling unit size or shape will be appropriate for all. In principle, the sampling-unit size or shape should optimize the relationship between statistical precision and efficiency. Factors to be considered include the spatial distribution and abundance of the variable being measured, potential edge effects along the boundary of a sampled unit (*e.g.*, are individual in or out of the unit), the ease in sampling, and potential disturbance of the monitored site by the sampling regime itself (Elzinga *et al.* 2001). Size and shape variables, for example, include transect line length and orientation and quadrat size and shape (*e.g.*, square vs. rectangular). As with selecting the appropriate sampling unit, selection of the sampling-unit size and shape will require field verification and pilot sampling. Elzinga *et al.* (2001) recommend that the following questions be addressed during preliminary field work to determine the appropriate sampling-unit size and shape:

a. At what scale(s) can you detect clumping?
b. How large are the clumps and what are the distances between the clumps?
c. How long will sampling units need to be to avoid having many of the sampling units containing none of the species in them?
d. How narrow will density quadrats need to be to avoid counting hundreds or thousands of the species wherever the quadrat intersects a dense clump?
e. How wide an area can be efficiently searched from one edge of a sample unit?
f. How big a problem will edge effect be?

How should sampling units be positioned? Some type of unbiased systematic or random sampling protocol should be used so that results can be statistically analyzed and inferences about the larger area can be made. Sampling units should also be selected in a way that represents the resource in the context of the factors that may be relevant to the long-term trend of the resource.

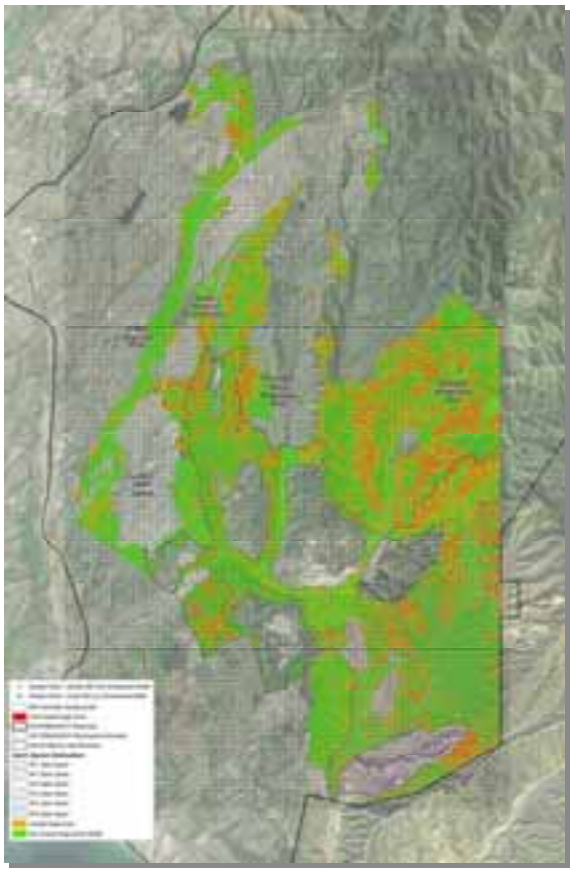
Should the sampling units be permanent or temporary? The main advantage to using permanent sampling units is that the statistical tests (*e.g.*, paired t-test) are more powerful for detecting change and require fewer sampling units. The main disadvantages of permanent sampling units are more logistical, including set up time and relocating permanent units. However, with the current precision of GPS technology, relocating permanent units should not be a significant problem. Another potential disadvantage of permanent units is that repeated sampling at the same location may negatively impact the biological resources. A statistical weakness of the permanent sampling is that at least two years of sampling is required to establish adequate sample size (Elzinga *et al.* 2001).

How many sampling units should be sampled? Determining the adequate sample size is a difficult problem in ecological monitoring because parametric statistical tests require assumptions about population variability. Unless the population variability is known beforehand based on real data or valid assumptions, adequate sample sizes can only be determined by actually measuring variability during pilot sampling. By determining variability based on actual measurements in the field, sample sizes necessary to meet certain statistical precision requirements can be calculated directly by existing sample-size formulas. For example, what sample size is needed to detect a 10 percent change in the population at a 95% probability of not concluding a false change?" Dudek (2009)

a. Sampling Methods

There are various types of probabilistic sampling methods utilized to select sampling locations. Some of the traditional methods employed are the following; simple random sampling, systematic sampling, and stratified random sampling. For this study a Spatially Balanced Sampling (SBS) approach has been incorporated. SBS is a survey design based on the spatial extent of a study area and the probability of a sample being included in the resource's sample set. The key concept is to produce a sample set that mimics the spatial pattern and distribution of a resource population.

Figure 6: Sampling Study Area



b. Spatially Balanced Sampling (SBS)

The Spatially Balanced Sampling approach was recommended by the RMV Science Panel, a group of experts in conservation biology, monitoring and botany, because of its improvement over traditional sampling methods. For example, simple random sampling can often lead to clumping of the sample set and can leave significant areas of the study area unsampled. Systematic sampling can achieve a uniform balance, but only when the entire sample set is ultimately measured. The SBS approach has also been widely adopted by the National Park Service as part of their nationwide Inventory and Monitoring Program. In addition, an SBS sample has less spatial autocorrelation effects of the sample set. A SBS procedure was used to ensure that points were randomly selected, but also spatially balanced.

c. Reversed Randomized Quadrant Recursive Raster (RRQRR)

The SBS procedure has been automated into an ArcGIS 9 macro (Theobald and Norman 2006: Theobald et al. 2007). The GIS implementation of SBS is based on the concept of the Generalized Tesselation Stratified (GRTS) algorithm (Stevens and Olson 2004), and the GIS SBS algorithm is called the Reversed Randomized Quadrant Resursive Raster (RRQRR). The RRQRR is based on a hierarchical quadrant-recursive ordering of a rectangle large enough to encompass a study area within the GIS representation. The RRQRR ArcGIS toolbox was developed with a Python script and requires an ArcINFO and Spatial Analyst license. Information can be downloaded from the following web address (http://www.nrel.colostate.edu/projects/starmap).

d. GIS Framework

The SBS procedure and RRQRR algorithm was applied to the five (5) major conserved vegetation communities in Rancho Mission Viejo's Habitat Reserve. These are scrub, woodland, riparian, chaparral and grassland habitats. The selection of sampling locations for scrub habitat is used in this paper to illustrate the SBS method.

Figure 7: Vegetation Habitat Examples

Three data layers were used to implement the RRQRR procedure: 1) the Southern Subregion Habitat Reserve boundary, 2) mapped vegetation communities and 3) a vector based index grid. The Southern Subregion Habitat Reserve boundary defines the spatial extent of the sampling area. Vegetation communities within the Habitat Reserve were mapped during the summer of 2007 at 200 scale on an ortho-rectified 1 foot aerial image provided by digital globe. The polygons were digitized and attributed using the Gray and Bramlet vegetation classification system. A vector based 500 ft^2 index grid was developed resulting in 5.7 acres per cell. The grid consists of 97 columns and 165 rows for a total of 16,005 polygons for the entire extent of the Habitat Reserve.

However, prior to implementing the RRQRR procedure, two main criteria must be satisfied for selecting the sampling point; (1) the observation point within the cell must be selected using an unbiased method; and (2) the observation point must be located far enough from the habitat patch edge (*i.e.*, the edge of the Scrub polygon), such that the proportions of observations of birds beyond the habitat edge is limited. To address these two criteria, Core Scrub Habitat was identified.

Core Scrub Habitat was identified using the following methods. The Index Grid was first overlain on the Habitat Reserve. Grid cells that have less than 25% of their area (1.4 acres) within the Habitat Reserve boundaries were excluded (Result 1). The grid was then overlain on the Scrub vegetation community. All cells containing less than 50% Scrub vegetation (2.85 acres) were also excluded (Result 2). The Result 2 layer was then buffered by negative 150 feet – this resulted in identifying the Core Scrub Habitat (Result 3). Through implementation of the RRQRR procedure, all potential sampling locations will be restricted to the Core Scrub Habitat (*i.e.*, at least 150 feet away from the cell edge).

To test for edge effects, scrub cells were further stratified by cells within and beyond 500 feet of existing and planned development edges and existing and planned paved public roadways. In order to be included as an “edge” cell, at least 90% of the area of the cell (5.13 acres) had to be within 500 feet of such landscape features. An example of Core Scrub habitat is illustrated in figure 8.

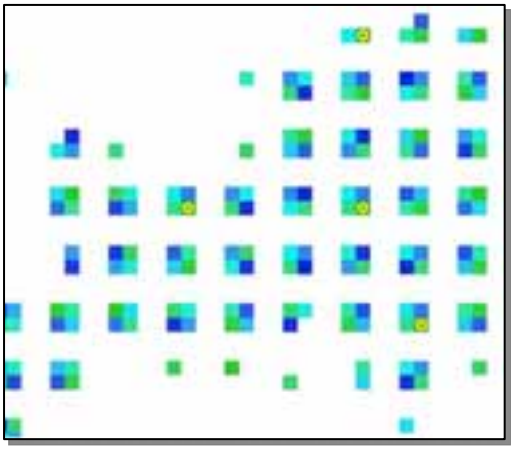
Figure 8: Core Scrub Habitat

e. RRQRR Implementation

The first step to implement the RRQRR algorithm involves converting the Core Scrub polygon layer to a raster based GRID. This provides the initial input into the RRQRR ArcGIS toolbox. The toolbox consists of 3 tools that generate the sequence raster, filter the sequence raster against a probability raster, and generate sampling site locations.

The Generate RRQRR Sequence Raster tool uses the Core Scrub GRID layer to create a sequence raster. The sequence raster is a reversed Morton address that identifies the spatially balanced sampling order for every grid cell within the extent of the study area. The Filter RRQRR Sequence Raster tool filters the sequence raster against an underlying random raster, shown on Figure 9. The filtered sequence raster is the reversed Morton address surface against a (0-1) random raster. The final step uses the Generate RRQRR Sample Points tool to generate sampling site locations that are random and spatially balanced. The output is an ESRI shapefile with an ‘Order’ attribute.

Figure 9: Filtered Sequence Raster



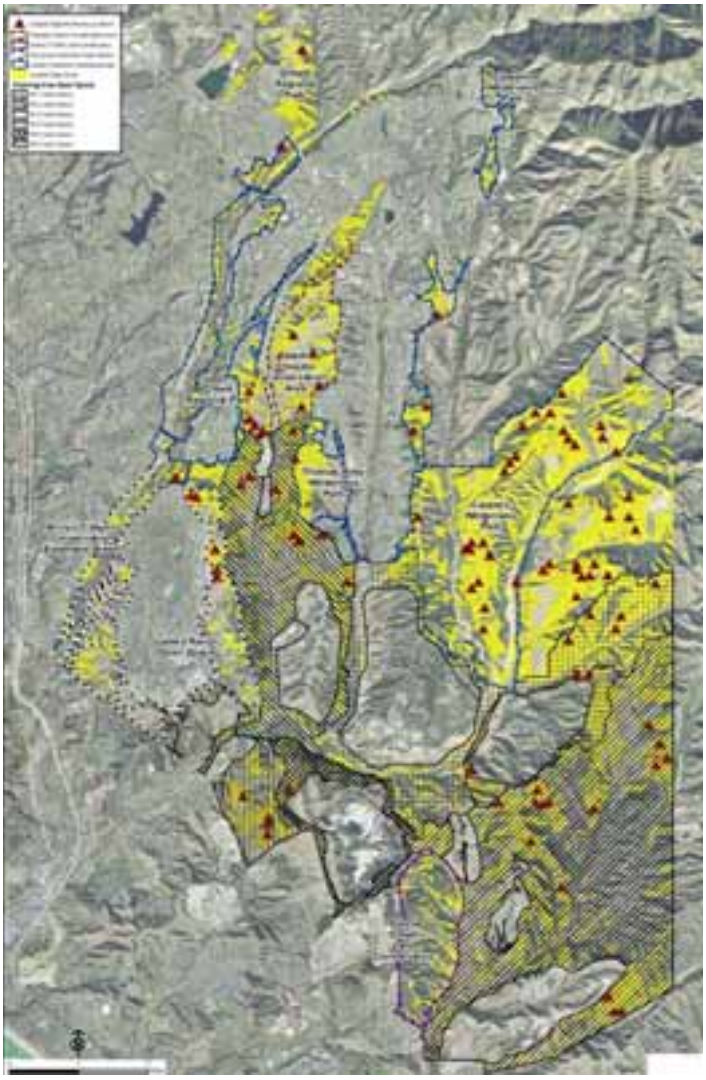
f. Scrub Sampling Locations

For the purpose of the pilot field program, a total of 100 grid cells were selected each to contain one sampling location located in Core Scrub Habitat. Of these, 30 points were selected in cells within 500 feet of the development/road edge, and 70 points were selected in cells beyond the 500 feet distance. The output shapefile consists of the number of sample points with the natural order being spatially balanced. The order of the points can be referenced from the ‘Order’ attribute. The 100 sampling site locations are illustrated in Figure 10.

The RRQRR algorithm located the sampling sites in a pattern and distribution that matches that of scrub habitat across the Southern Subregion Habitat Reserve. For example, in Caspers Wilderness Park which has significant Scrub habitat, there are many

sampling locations. In contrast, areas in Southwest RMV near the Donna O'Neill Land Conservancy with less Scrub habitat, there are very few sampling locations.

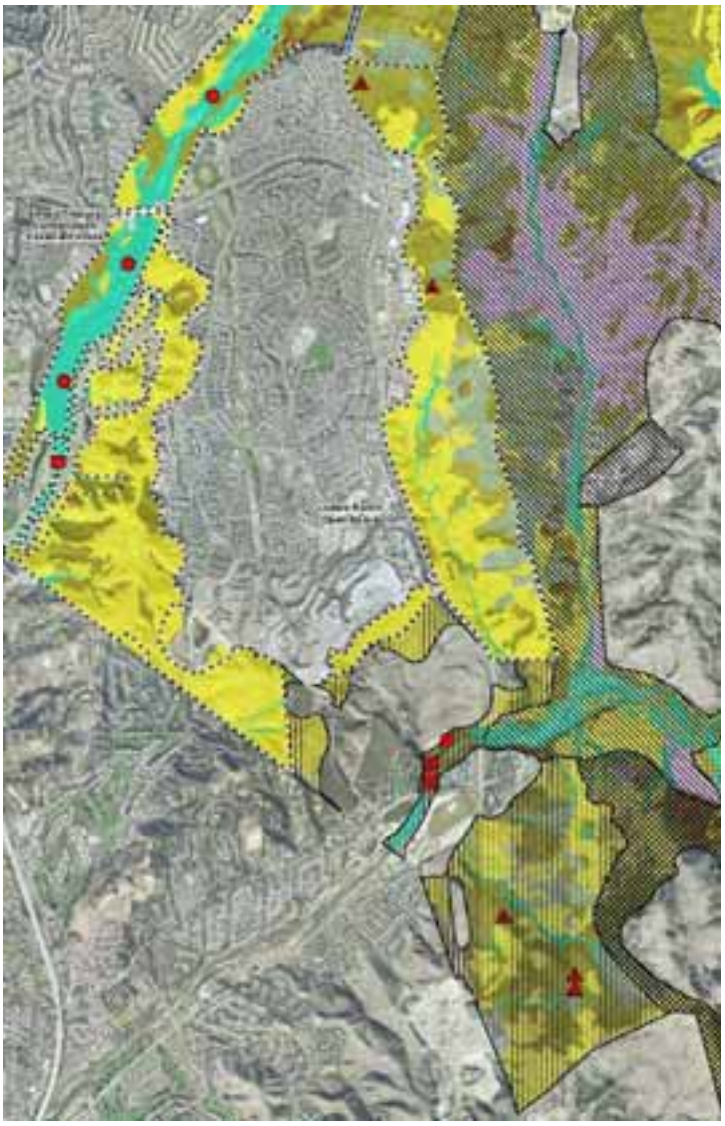
Figure 10: Scrub Sampling Site Locations



g. Looking Forward

Resource monitoring within the RMV Habitat Reserve began in April, 2010. This work will kick off a 2 year pilot program. The pilot program will collect baseline data and test the methods and procedures of the Initial Management Action Plan. This work is funding dependent and will focus on 12 sampling sites for the Scrub, Woodland and Riparian habitats, as shown in Figure 11. The number of sampling site locations consists of 5 for Scrub, 3 for Woodland and 4 for Riparian. Biologists will be installing vegetation transects, collecting species occurrence data, and conducting avian surveys.

Figure 11: Pilot Program Sampling Locations



Literature Cited

Dudek, 2009. Initial Action Management Plan – Years: 2009 – 2013.

Elzinga, C.L., D.W. Salzer, J.W. Willoughby, and J.P. Gibbs. 2001. Monitoring Plant and Animal Populations. Blackwell Science, Malden, Massachusetts. vii + 360 pp

Theobald, DM, and JB Norman. 2006. Spatially balanced sampling using Reversed Randomized Quadrant Recursive Raster algorithm. Available from: http://www.nrel.colostate/projects/starmap.

Theobald, DM, DL Stevens, Jr., D. White, NS Urquhart, AR Olson, and JB Norman. 2007. Using GIS to generate spatially balanced random survey designs for natural resource applications. Environmental Management 40:134-146.