APPENDIX J-3
INVASIVE SPECIES CONTROL PLAN

CHAPTER 1: INVASIVE SPECIES CONTROL PLAN OVERVIEW

Invasive exotic plant and animal species adversely affect native habitats, sensitive species, and valuable crops worldwide. The adverse impacts occur because invasive exotic species out-compete native species for valuable resources, invasive exotic animals often act as predators upon native species, and in some instances invasive exotic plants can cause type changes within entire ecosystems, altering fire or hydrologic regimes. Given the seriousness of the effects of non-native species introductions, both ecologically and economically, many agencies, land managers, and the scientific community have begun to recognize the importance of regulating, controlling and studying this phenomenon.

Many of the vegetation communities, both upland and aquatic, on RMV have been adversely affected by the proliferation of non-native invasive plant and animal species. Using baseline data, plans have been prepared to protect, restore, and enhance the affected natural vegetation communities that support sensitive species. The Invasive Species Control Plan (ISCP) is an element of the overall Adaptive Management Program.

Examples of invasive species addressed by this plan include the problematic giant reed (*Arundo donax*), which can overrun and clog riparian reaches. Removal/eradication of this species will increase the function of these habitat linkages and wildlife corridors by enhancing dispersal and movement by both large and small animals (NCCP/SAMP Working Group 2003). Similarly, control of the brood parasitic brown-headed cowbird (*Molothrus ater*) through trapping efforts will reduce their impacts on songbird nests, especially adverse effects on listed species such as the California gnatcatcher (*Polioptila californica*) and least Bell's vireo (*Vireo bellii pusillus*). Bullfrog (*Rana catesbeiana*) controls will reduce predation on native amphibians and fish species, especially the federally-listed endangered arroyo toad (*Bufo californicus*). Long-term control of invasive plants and introduced predators on RMV will enhance habitat functions for native plant and animal species, which use and occupy Open Space lands. It will substantially increase the likelihood that the RMV Open Space will function successfully and provide for persistence and recovery of target species.

The Adaptive Management Program has adopted an "Environmental Stressor" approach that recognizes invasive plants and animals as key stressors that can adversely affect sensitive species, either directly (e.g., predation of arroyo toad larvae by bullfrogs) or through habitat degradation or type conversion (e.g., loss of willow riparian breeding areas for least Bell's vireo to invasive giant reed or tamarisk). This plan is intended to serve as a guideline for the eradication and control of invasive plant and animal species that occupy RMV. As with the upland coastal sage scrub and grassland restoration program, this plan is intended to serve as a "tool box" that provides the necessary tools for successful invasives control. As part of the Adaptive Management Program it will be subject to modifications and expansion as data collection warrants.

This initial Invasive Species Control Plan includes:

(1) Census and mapping of invasive plant species and introduced predators on RMV.

(2) A review of the ecology and habitat requirements for invasive species profiles targeted for control.

(3) An overview of species-specific and density-dependent eradication methods.

(4) An analysis of short- and long-term impacts and benefits to habitats and target/sensitive species that will derive from implementation of the ISCP.

The plan is divided into three major sections

- The invasive plants section discusses the specific concerns surrounding invasive plants, details the current status of invasive plants species targeted for control on RMV, describes characteristics of the invasive plants, outlines species-specific control method options, and analyzes the benefits and impacts of invasive plant control. Invasive plant species can have negative impacts on entire ecosystem processes where infestations are severe. Typically there are more than one, sometimes several, invasive encroachments occurring in a habitat at any given time (e.g., giant reed and bullfrogs occur in areas of San Juan Creek inhabited by the arroyo toad, representing separate and distinct threats).

- The second section discusses introduced vertebrates. Like invasive plants, introduced vertebrates can affect both native plants and animals; although, their direct impact on native animals (e.g., predation) is most easily documented.

- Finally, non-native Argentine ants and fire ants will be addressed as invasive species that will be subject to various levels of control within RMV.

The report integrates results of an invasive plant species investigation and mapping within riparian areas, and associated adjacent uplands of RMV, performed by PCR Services Corporation (PCR), invasive species management information (PCR), additional riparian and upland invasive plant analysis by Glenn Lukos Associates (GLA), overview of site-specific control methods (GLA), report integration and compilation (GLA), and an analysis of introduced vertebrates and eradication methods by Peter H. Bloom. The mapping effort consisted of a review of historic literature and aerial photography followed by a series of field surveys. The field assessments were conducted to determine areas of particularly pernicious invasive exotic plant and animal species occurrence and infestation in support of future land use and natural resource planning. The initial phase of the investigation focuses on the RMV riparian systems and associated adjacent upland areas, which occur within portions of the San Juan Creek and San Mateo Creek watersheds where additional data were available relating to other lands and prior invasive species control efforts they have been included. Importantly, the methods set forth herein are applicable to the entire RMV Open Space area.

Successful control of invasive plants and animals within RMV will require a cooperative effort among the various stakeholders including RMV, the County of Orange, Santa Margarita Water District, and Coto de Caza. As noted above, coordination with the Cleveland National Forest will also be important. Timing and geographic coordination (e.g., starting control programs for some species at the top of the watershed) will be critical in creating a program that is effective for the long-term. For example, elimination of species such as giant reed or bullfrogs from portions of RMV, without eliminating source populations from upstream areas within County of Orange lands or the Cleveland National Forest will not ultimately benefit the Identified Species.

CHAPTER 2: INVASIVE PLANTS

2.1 Introduction

According to *Invasive Plants of California's Wildlands*, non-native invasive plant species can alter ecosystem processes such as nutrient cycling, hydrological cycles, and frequencies of wildfires, erosion and sediment deposition (see Stressor Models depicted in *Figures 2-11* of the Adaptive Management Program that shows the relationships between invasive species, other stressors, and selected focal species). Invasive plants interfere in ecosystem functions by out-competing and displacing native plants and animals, by providing refuge for non-native animals, and by hybridizing with native species (Bossard *et al.* 2000). Several organizations, such as the California Native Plant Society (CNPS) and the California Exotic Pest Plant Council (Cal EPPC), have provided detailed documentation regarding invasive plant species that threaten California's native flora and fauna.

Although fewer than ten percent of the 1,045 non-native plant species that have established in California are identified as threats, they have dramatically changed the landscape of the state (Bossard et al. 2000). Although numbering less than 100 species, those exotic plants that are of highest concern are aggressive invaders that displace natives and disrupt natural habitats (CalEPPC). Many species, like black mustard (*Brassica nigra*) and non-native annual grasses of Mediterranean origin (e.g., *Bromus* spp., *Hordeum* spp., and *Avena* spp.) have become naturalized to the point that they are beyond realistic control measures at a landscape level and are not addressed specifically by this program plan although they are addressed as part of the AMP through restoration, grazing and fire management. Generally, invasive plants that are targeted for eradication and control are those that inflict the most damage on native plants and animals and which are to some degree controllable.

In the last two decades, as the problems with invasive species have become better understood, more public and private action to control invasive species has occurred. In southern California, for example, the Southern California Wetlands Recovery Project is an organization that largely is involved with funding wetland and watershed restoration projects, many of which employ eradication of non-native species as an effective tool in the restoration process (Southern California Wetlands Recovery Project 2003). Other local efforts to remove invasive plants include mapping, monitoring and control programs by the California Department of Parks and Recreation Inventory, Monitoring and Assessment pilot program (Chino Hills State Park removal of sweet fennel, giant reed, and tree of heaven) (Marsden 2001), and eradication programs sponsored by the Santa Ana Watershed Project Authority (giant reed removal along the Santa Ana River) (Santa Ana Watershed Project Authority 2003). Additionally, at the 4,000-acre Starr Ranch Audubon Sanctuary in the Southern NCCP/HCP planning area there is ongoing extensive research and eradication of invasive plant species (artichoke thistle and Italian thistle research and removal studies and programs) (DeSimone 2002).

The invasive species identified initially for eradication and control on RMV were selected based on the degree to which they affect or potentially affect selected focal species and habitats (see Adaptive Management Program). Generally, portions of the RMV Open Space include both aquatic habitats and upland habitats that exhibit moderate to high levels of habitat function and large portions of the RMV Open Space do not exhibit impacts from many of the invasive species addressed in this plan. Nevertheless, each of the invasive exotic species addressed in this plan, exhibits at least some potential for impacts on one or several listed or otherwise Identified special status animal species or vegetation communities and/or (to a lesser extent) special-status plants that occur on RMV.

Invasive plant species identified as threats within some reaches of the RMV riparian and wetland ecosystems and mapped as part of this effort include giant reed, pampas grass (*Cortaderia selloana*), tamarisk (*Tamarix ramosissima*), castor bean (*Ricinus communis*), tree tobacco (*Nicotiana glauca*) and Spanish sunflower (*Pulicaria paludosa*). The upland invasive plant targeted for eradication in this plan is the artichoke thistle (*Cynara cardunculus*).[1] Through time, other invasive species may become established within RMV. As threats from previously undocumented species are recognized, they will be addressed through the Adaptive Management Program.[2]

Many of the identified and other focal planning species will benefit from the ISCP implementation. In riparian areas the removal of giant reed, pampas grass, and tamarisk will allow native vegetation to reestablish, providing for expanded and enhanced breeding and foraging habitat for avian species such as least Bell's vireo, southwestern willow flycatcher (*Empidonax traillii extimus*), and several raptors including the white-tailed kite (*Elanus leucurus*). Removal of the same species would also benefit species such as southwest pond turtle (*Clemmys marmorata*) and arroyo toad, along with improved aquatic environments for native fish species.

Removal of artichoke thistle will benefit the California gnatcatcher and other scrub birds and grassland species like the grasshopper sparrow (*Ammodramus savannarum*), by allowing for areas previously occupied by the thistle to become established with native coastal sage scrub or

[1]Invasive species such as castor bean or tree tobacco can also occur in upland areas; however, their impacts in upland areas is typically minimal and do not affect Identified Species and as such, the focus on these species in this plan is in riparian areas where their effects are more severe.
[2] One of the goals of the Adaptive Management Program will be to identify threats from newly arrived species during the early stages of infestation, when eradication efforts are most effective and least costly.

grasslands used for nesting and foraging. Identified native plants like the state and federally listed thread-leaved brodiaea (*Brodiaea filifolia*) and CNPS List 1B many-stemmed dudleya (*Dudleya multicaulis*) will benefit from artichoke thistle eradication in that they will not have to compete against this aggressive invasive for valuable resources.

2.2 Existing Setting

The proposed RMV Open Space includes a diversity of aquatic and terrestrial habitats. Habitats associated with the aquatic ecosystem include southern willow riparian forest, mulefat scrub, and localized areas of freshwater marsh associated with large, high-energy streams such as San Juan Creek, Trabuco Creek, Gabino Creek, and Cristianitos Creek. Gobernadora and Chiquita creeks support areas of southern willow riparian forest mixed with areas of alkali marsh and alkali meadow. Southern willow riparian forests are dominated by willows including black willow (*Salix gooddingii*), arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), mulefat (*Baccharis salicifolia*), and narrow-leaved willow (*Salix exigua*). Marsh habitats are generally dominated by southern cattail (*Typha domingensis*), California bulrush (*Scirpus californica*), hardstem bulrush (*Scirpus acutus*), Iris-leaved rush (*Juncus xiphioides*), creeping spikerush (*Eleocharis macrostachya*), and Olney's bulrush (*Scirpus americanus*).

Upland habitats most affected by artichoke thistle include coastal sage scrub and native grasslands. Coastal sage scrub on RMV is represented by a variety of subassociations dominated by a variety of shrubs or sub-shrubs including California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), sage (*Salvia* spp.), coast brittlebush (*Encelia californica*), and coyote brush (*Baccharis pilularis*). Native grasslands are dominated by purple needlegrass (*Nassella pulchra*), with other native grasses such as beardgrass (*Bothriochloa barbinodes*), San Diego agrostis (*Agrostis diegonensis*) and three-awned grass (*Aristida* spp.) locally common. Common forbs associated with native grasslands include shooting stars (*Dodecatheon clevelandii*), golden stars (*Bloomeria crocea*), wild hyacinth (*Dichelostemma capitatum*), and wild carrot (*Daucus pusillus*). For a further description of vegetation communities on RMV see the Biological Resources Section of the EIR.

2.3 Summary of Prior and Ongoing Eradication Efforts

Invasive species eradication has been conducted within portions of RMV and the Northrop Grumman Capistrano Test Site (formerly TRW).

2.3.1 Rancho Mission Viejo

As part of its cattle ranching operations, RMV has performed eradication of artichoke thistle across most of the RMV property since the 1970s and efforts continue annually. A comprehensive artichoke thistle removal program has also been implemented for the approximately 1,600-acre Ladera Open Space area that has been ongoing since 2001. RMV has also begun a program to control Spanish sunflower in Gobernadora Creek and Chiquita Creek; however, this program is currently in the beginning phases with a pilot program that is comparing control methods (i.e., hand removal versus spraying).

2.3.2 Northrop Grumman

Pursuant to Biological Opinion 1-6-00-F-6 and Department of the Army Permit 199915591 RLK, Northrop Grumman has conducted invasive species eradication in lower Cristianitos Creek. This program is to be continued through the life of the lease. The program has achieved performance standards to date.

2.4 Invasive Plant Species Mapping and Results

Invasive species mapping within RMV riparian systems and adjacent or contiguous upland areas was conducted by PCR.[3] This effort began with a review of previous riparian mapping and classification of the RMV drainages, and included photographic interpretation of historic and current aerial imagery, field mapping and data collection, and report preparation. Artichoke thistle was mapped in the Ladera Land Conservancy open space areas by PCR. Artichoke thistle mapping throughout the rest of RMV was performed by GLA.

2.4.1 Literature Review

Previous mapping efforts, performed for a variety of landscape-level evaluations, were evaluated and included: **(1)** an assessment of riparian ecosystem integrity for San Juan and San Mateo Creek watersheds by the U.S. Army Corps of Engineer's (ACOE) Waterways Experiment Station (the "WES Investigation") (Smith 2000); **(2)** the riparian vegetation communities mapping performed as part of the ACOE (WES) Planning Level Delineation performed by Robert Lichvar (the "Planning Level Delineation") (Lichvar 2000); and **(3)** the giant reed distribution mapping of southern California's coastal watersheds by Bill Neill and Jason Giessow (the "Neill and

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[3] The mapping of invasives conducted by PCR included areas outside the proposed RMV Open Space discussed in the plan, including Arroyo Trabuco.

Giessow Investigation")(Neill and Giessow 2002), and supporting GIS data developed by PCR (the "GIS Index") (PCR Services Corporation 2001).

The overall objective of the WES Investigation was to conduct a baseline assessment of riparian ecosystem integrity for the evaluation of potential impacts of future development projects within the San Juan and San Mateo Creek watersheds. The riparian systems were divided into assessment units, or "riparian reaches" and assessed utilizing a suite of indicators of ecosystem integrity. The riparian reaches were defined segments numbers of the mainstem, bankfull stream channel, and the adjacent riparian ecosystem exhibiting relatively homogeneous characteristics with respect to geology, geomorphology, channel morphology, substrate type, vegetation communities, and cultural alteration (Smith 2000) (Olson and Harris 1997).[4] Reach lengths were determined by changes in stream gradient or channel morphology. Reach widths were delineated by either the 100-year flood elevation contour, the extent of identifiable historic alluvial terraces, or the base of valley wall or artificial structure. Field data sheets used during the assessment provided information on the occurrence of invasives for each reach and included codes for abundance (dominant, common, or present) and geomorphic setting (channel, floodplain, side slope, or terrace).

The Planning Level Delineation included mapping of riparian vegetation at a minimum mapping unit of approximately 0.25 acre. Riparian vegetation units were assigned Federal jurisdictional probability ratings (as regulated under the Clean Water Act). Jurisdictional probabilities were based on the results of the field verification sampling, evaluation of the hydrologic parameters for each geomorphic surface, and the vegetation/land use type. These designations were further evaluated using GIS software to compare their spatial distribution patterns with those of other types (e.g., watersheds, human disturbance, and geomorphic surfaces). Areas of giant reed dominance were identified as separate communities.

The Neill and Giessow Investigation resulted in a regional-scale giant reed survey of southern California's coastal watersheds from the Santa Ynez River in Santa Barbara County to the Mexican border. Giant reed distribution was mapped based on visual inspection from accessible routes and based on knowledge of local experts and verbal reports. The survey adopted the reconnaissance mapping protocol developed by Team Arundo del Norte (Team Arundo del Norte). The abundance of giant reed was classified according to the average number of clumps per mile (minimum mapping unit of 0.25 mile) within relatively narrow corridors, or the average distance between clumps in a broad floodplain. The survey was conducted during the second half of 1999, early 2000, and January 2002 and included potions of RMV.

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[4] *As an example, riparian reaches, as defined by Smith are depicted on Figure 1. Riparian reaches TB-06b, TB-06c, and TB-06d are depicted along Arroyo Trabuco Creek in red on the west-central portions of the map.*

The GIS Index previously developed by PCR was utilized to aid the current investigation's information and data consolidation, mapping, and classification effort. The interactive aerial photograph GIS Index contains copies of existing aerial photography taken in 1999 and 2000 by Hammon, Jensen, Wallen and Associates, Inc., boundaries of dia-positive prints, links to the odd numbered images, flight lines, and U.S. Geological Survey topographic maps. The Index provided as an organizational tool for locating images for locating invasive species both in the office and in the field.

2.4.2 Aerial Photography Review

A review of historic aerial photographs was conducted to identify previous and current drainage patterns on RMV, and to make preliminary determinations on the occurrence of invasive species. Photographic interpretation of invasive species occurrence began with aerial photographs taken in June 1999 (San Juan Creek watershed) and March 2000 (San Mateo Creek watershed) at 1-meter resolution by Eagle Aerial. Images of the RMV in its entirety were available as 9-inch by 9-inch, 1:4,800 scale (1"= 400') dia-positive prints. The dia-positives were viewed with the aid of a magnifying glass and light table to identify invasive species occurrence. Additional, more recent imagery taken by Eagle Aerial in 2001 and obtained from EDAW was digitally viewed in combination with other project-specific GIS data. Point locations of invasive plant species were marked on the aerials. Areas were then "ground-truthed" during field observations from October 28 to November 5 2002 to obtain specific density counts and heights.

2.4.3 Field Mapping and Data Collection

Following the initial data gathering and preliminary photo-interpretation of RMV imagery, field visits were scheduled to determine invasive species occurrences. Large, E-sized maps (RMV overview maps) identifying previously mapped areas of invasive species infestation with sub-basin designations were prepared for use in the field. Additional information obtained from the WES Investigation's data sheets and giant reed distribution from the Planning Level Delineation were accessed and occurrences were noted on maps. These maps were generated at a scale of 1:480 (1"=40') for the entire RMV property.

PCR implemented a modified reconnaissance mapping protocol established by Team Arundo del Norte similar to the Neill and Giessow Investigation. The "windshield" survey methodology was originally developed to determine general characteristics of giant reed growth, habitats, and other factors that may promote or inhibit its spread, and areas that are at risk of invasion. Instead of just recording giant reed abundance based on average numbers of individuals per one-mile units, this mapping effort identified five invasive species (giant reed, pampas grass, tamarisk, castor bean, and tree tobacco) by point locations on field maps and dia-positives. Species distribution was based on visual inspection of riparian corridors, viewed from roads, bridges, paths, and readily accessible riparian reaches where possible. Special attention was paid to the primary drainages of San Juan Creek watershed (Cañada Chiquita, Cañada Gobernadora, Verdugo, Central San Juan) and San Mateo Creek watershed (Gabino, Cristianitos, and Talega) on RMV. Occurrences within tributaries to these mainstems and adjacent upland habitats outside the riparian zones were also noted as encountered.

Each PCR Biologist was assigned one of the major tributaries (mainstems) to map. RMV overview maps and dia-positives corresponding with that watershed were distributed. Field Biologists mapped invasive species following these steps:

1. Positions were located on the RMV overview map.

2. Dia-positive photographs were identified from the overview map.

3. Invasive species were mapped as points onto the dia-positives with colored markers. Each point represented 1 to 5 individuals spaced a minimum of 100 feet apart.

4. Each point marked on the dia-positives was identified with the following species codes[5]: Priority 1 Species: AD – *Arundo donax* (giant reed) Priority 2 Species: CS – *Cortaderia selloana* (pampas grass), TR – *Tamarix ramosissima* (tamarisk), RC – *Ricinus communis* (castor bean) Priority 3 Species: NG – *Nicotiana glauca* (tree tobacco)

5. For each data point, the average maximum height of the populations was indicated on the dia-positives (<6, 6-12, 12-18, >18 feet).

6. The abundance of each invasive species within each sub-basin was indicated on the RMV overview map with the following abundance codes:

    a. "Absent" – areas not containing invasive species during observation.

    b. "Isolated" – 1 to 5 individuals/clumps; >1,000 feet average spacing between clumps/individuals.

[5] *Invasive species are listed in order of importance. When other invasive species not listed above were found, they were noted on dia-positives (time permitting).*

c. " Scattered" – 5 in a single 328 feet (100 meters) section; fewer than 20 clumps/mile; 250 to 1,000 feet average spacing.

d. "Abundant" – less than 25 in a single 328 feet (100 meters) section; 20 to 200 clumps per mile; 25 to 250 feet average spacing.

e. "Dominant" – Amalgamated clumps, continuous in places.

f. "Cleared" – areas cleared by equipment or restoration activities.

2.4.4 Data Interpretation and Map Classifications

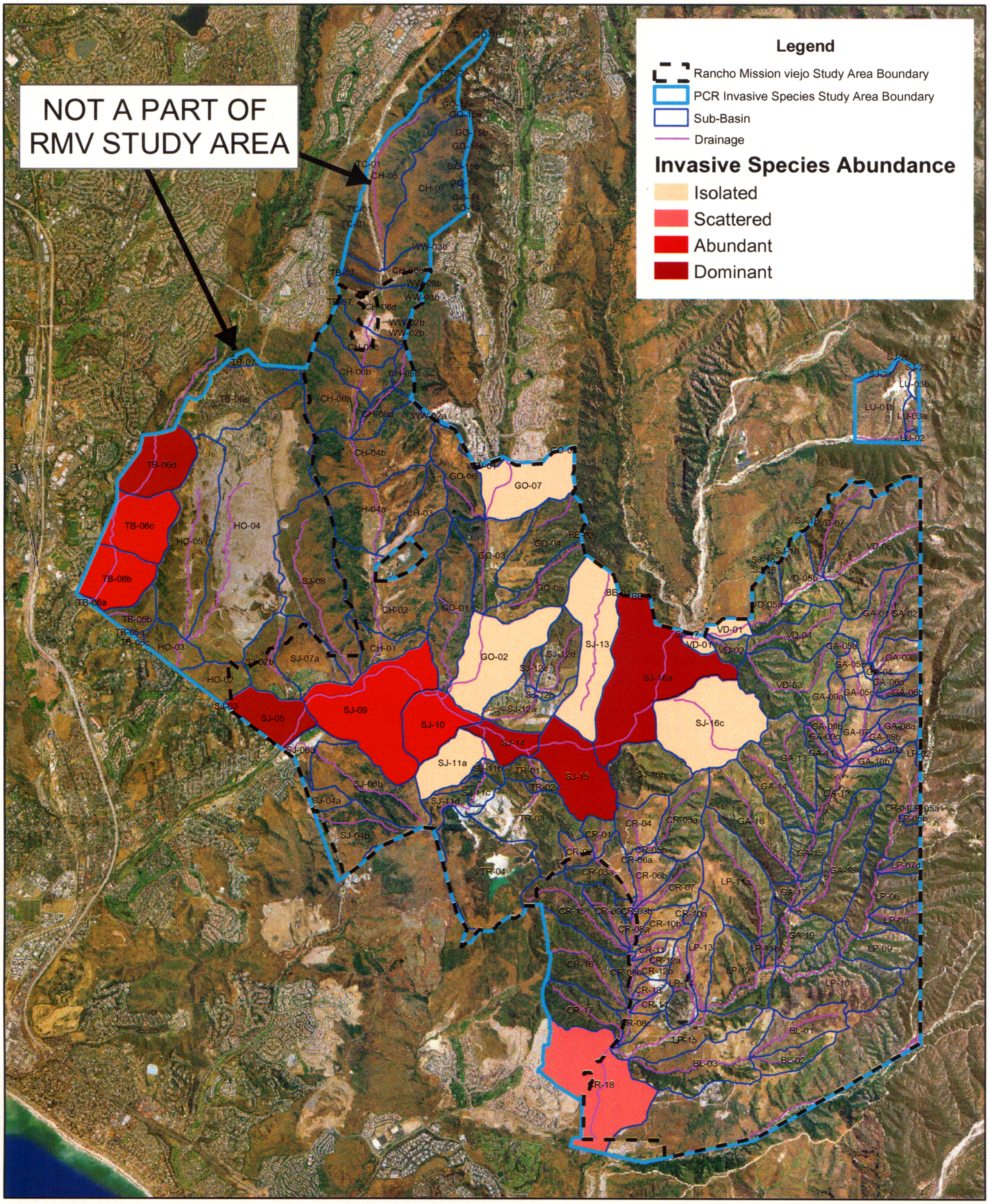
Riparian system invasive species mapping conducted during this effort included two mapping classifications: species densities and abundances. Following field mapping, invasive species occurrences were digitized from hard copy maps to PCR's project GIS with the aid of high-resolution, onscreen imagery (Eagle Aerial 2001 photography) and other key spatial data. Point locations, representing between 1 to 5 individuals or clumps, were attributed with the species code, exact number of individuals, and average maximum height. The digitized point locations provided "density", or distribution, maps focused on four general areas on RMV (Cañada Chiquita & Gobernadora, San Juan (East), San Juan (West), and Cristianitos). The second type of mapping products are watershed-scale "abundance", or dominance, maps that were developed to give the end-user an idea of each species dominance within the WES Investigation's functional sub-basin "reaches." The hydrogeomorphic, functional sub-basin reaches (polygons) were attributed with the species (Priority 1, 2, and 3) and abundance codes (Absent, Isolated, Scattered, Abundant, Dominant, and Cleared) listed above.

Maps displaying the abundance of each invasive species over the entire property are attached as Figures 1 through 5.[6] Maps displaying invasive species densities focused on five areas of the property are attached as Figures 6 through 9.

2.4.5 Results

PCR's invasive exotic species mapping effort was limited to riparian habitats within the RMV property and focused on five invasive species: giant reed, pampas grass, tamarisk, castor bean, and tree tobacco. The initial literature and data review proved extremely useful in identifying

[6] Note that the PCR study area extended beyond that of the RMV study area addressed in this plan.

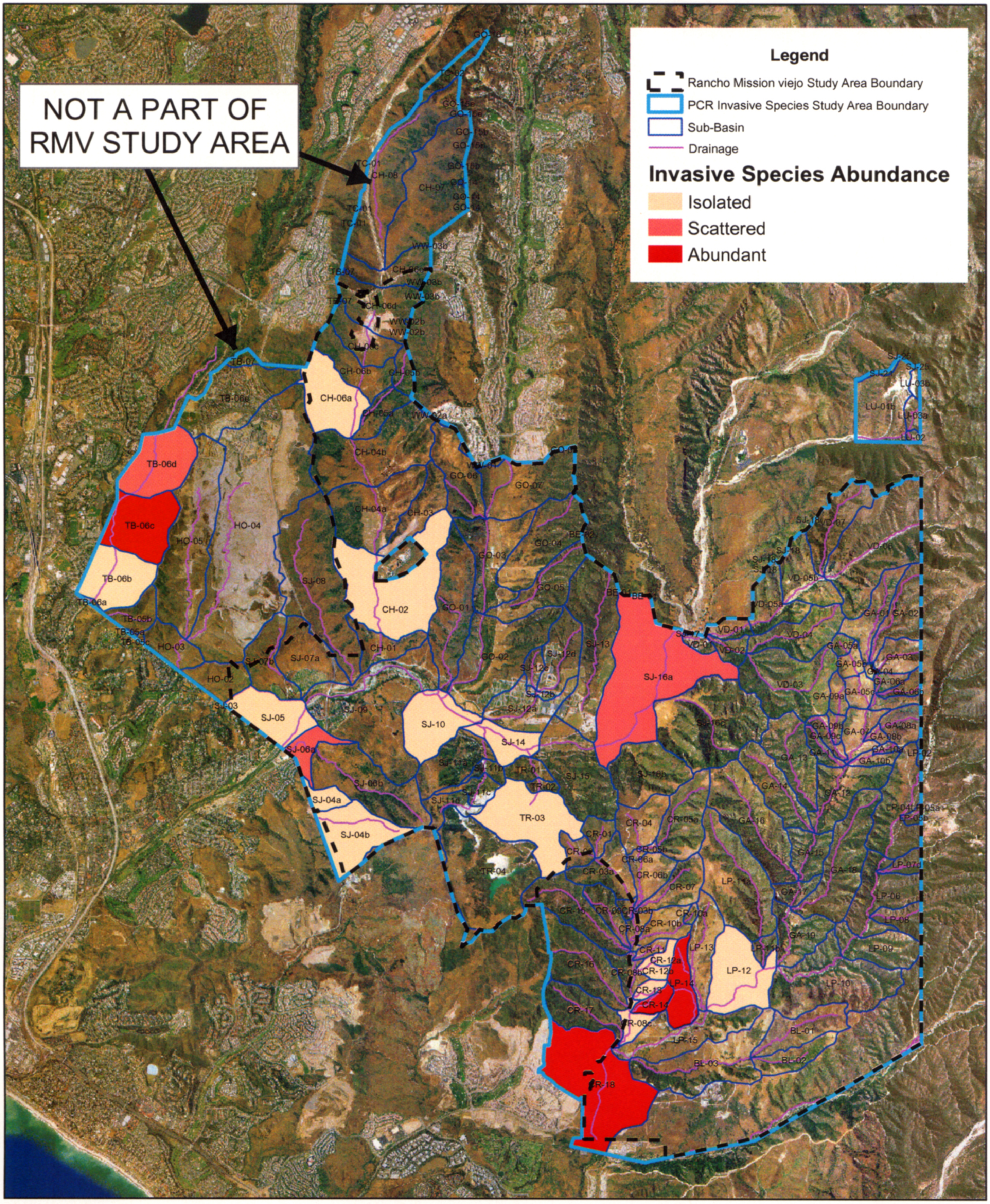


Adapted from Digital Data provided by PCR Services Corporation
Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001

N

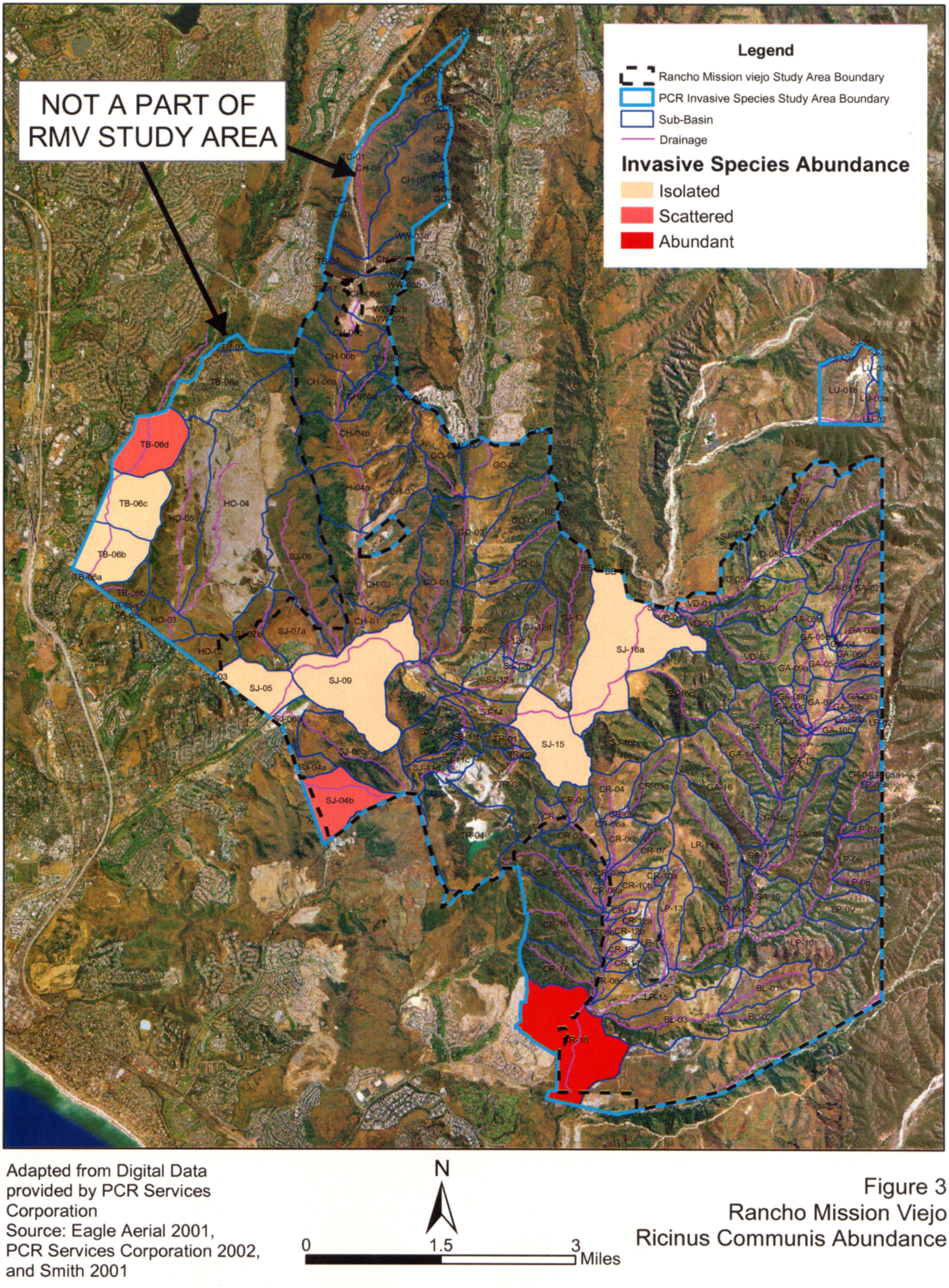
0 1.5 3 Miles

Figure 1
Rancho Mission Viejo
Arundo Donax Abundance



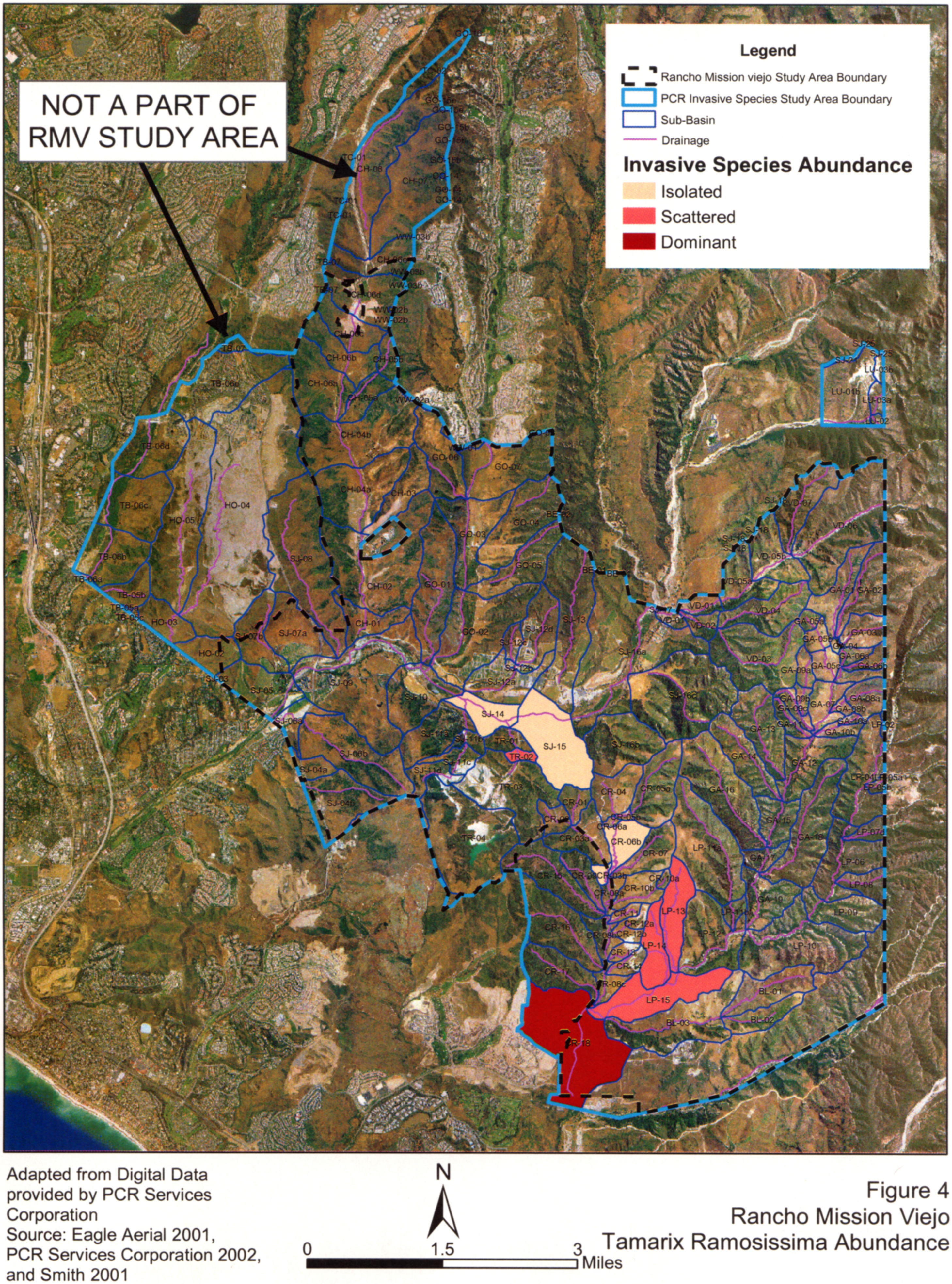
Adapted from Digital Data provided by PCR Services Corporation
Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001

Figure 2
Rancho Mission Viejo
Cortaderia Selloana Abundance



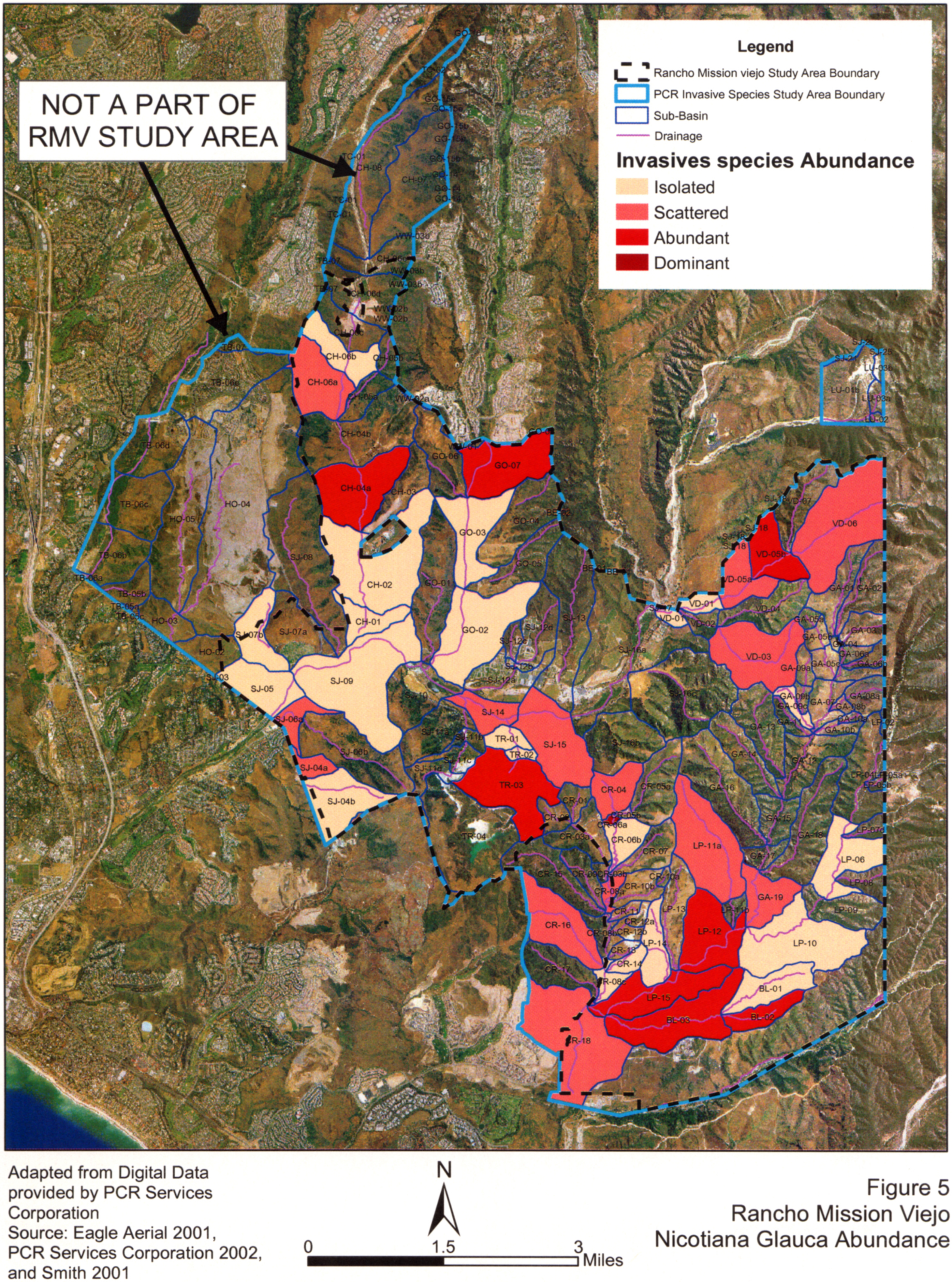
Adapted from Digital Data provided by PCR Services Corporation
Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001

Figure 3
Rancho Mission Viejo
Ricinus Communis Abundance



Adapted from Digital Data provided by PCR Services Corporation
Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001

Figure 4
Rancho Mission Viejo
Tamarix Ramosissima Abundance



Adapted from Digital Data provided by PCR Services Corporation
Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001

Figure 5
Rancho Mission Viejo
Nicotiana Glauca Abundance

PCR

N

1600 0 1600 Feet

Source: Eagle Aerial 2001, PCR Services Corporation 2002, Smith 2001

Figure 6
Rancho Mission Viejo
Invasive Species Occurrences
Canada Chiquita & Gobernadora

PCR

N

1600 0 1600 Feet

Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001.

Figure 7
Rancho Mission Viejo
Invasive Species Occurrences
San Juan (East)

PCR

Source: Eagle Aerial 2001, PCR Services Corporation 2002, and Smith 2001.

Figure 8
Rancho Mission Viejo
Invasive Species Occurrences
San Juan (West)

Figure 9
Rancho Mission Viejo
Invasive Species Locations
Cristianitos

areas of historic invasive species occurrence. Field data sheets obtained from the WES Investigation provided information on the occurrence, abundance, and geomorphic setting of invasives within select reaches of La Paz, and Cristianitos. Riparian vegetation mapping provided in the Planning Level Delineation identified areas of giant reed infestation within the central and northeastern portions of San Juan Creek's channel. The Neill and Giessow Investigation identified reaches of riparian corridors where giant reed was "present" and "abundant."

The review of available aerial photographs of RMV was useful for the preliminary identification of invasive exotic species. However, only the 1:4,800 scale dia-positives combined with the use a hand lens and light table allowed appropriate identification of individuals. Evidence of invasive species on the dia-positives was primarily limited to mature stands of giant reed identified along San Juan Creek and Cristianitos Creek, and pampas grass along Cañada Gobernadora. The rest of the invasive species occurrences were determined during the field surveys.

Data from all of the previous investigations were used to focus the current investigation's surveys on invasive species "hot spots," data gaps, and allowed development of short- and long-term approaches to control. PCR's field verification of previously identified invasive exotic species occurrences as well as documenting new occurrences throughout the RMV's riparian corridors was completed by five PCR Biologists within three days. Combined information from these resources is provided below and organized by watershed, drainage, and invasive species priority classifications.

a. San Juan Creek Watershed

Cañada Chiquita – Invasive species occurrences were not previously documented within this drainage. The current investigation identified only Priority 2 species, pampas grass, and Priority 3 species, tree tobacco. Two, isolated pampas grass individuals were located within reaches CH-02 and CH-06a. Isolated tree tobacco individuals were located within downstream reaches CH-01, CH-02, CH-06b; scattered within reach CH-06a; and abundant within reach CH-04a (central). Spanish sunflower (*Pulicaria paludosa*) occurs at scattered locations, typically in wetter areas associated with Chiquita Creek.

Cañada Gobernadora – Invasive species occurrences were not previously documented within this drainage. The PCR investigation identified Priority 1 species, giant reed, and Priority 3 species, tree tobacco. Isolated individuals of giant reed were located within reaches GO-02 and GO-07. Isolated individuals of tree tobacco were located within downstream reaches GO-02 and GO-03 and abundant within GO-07 upstream. In addition, Spanish sunflower (which was not mapped by PCR) has been identified by GLA as an invasive exotic within localized portions of the riparian areas associated with Gobernadora Creek.

San Juan Creek – Results from the Neill and Giessow Investigation performed in 2002 characterized the upstream and downstream on-site portions of San Juan Creek as containing an "abundance" of giant reed; whereas, the central portion of the drainage contained "scattered" populations of the same species. This mapping effort documented the spread of giant reed downstream from early plantings at San Juan Hot Springs and nearby cabins outside the Cleveland National Forest boundary. According to the Neill and Giessow Investigation, giant reed was cleared within Caspers Wilderness Park during 1997-98. Other efforts to clear infestations of giant reed occurred downstream and south of the RMV portion of the Habitat Reserve in San Juan Capistrano between La Novia Avenue and Interstate 5 during 1995, but the species has subsequently reinvaded. The current investigation identified all of the Priority 1, 2 and 3 species. Giant reed is abundant throughout San Juan Creek. Isolated castor bean and tamarisk individuals were located throughout the on-site portions of this drainage. Scattered tree tobacco occurrences were located within the mainstem as well as tributary reaches along the southern bank of the mainstem, as was Spanish sunflower.

Verdugo Creek – Invasive species occurrences were not previously documented within this drainage or its tributaries. The current investigation identified Priority 1 species, giant reed, and Priority 3 species, tree tobacco. One, isolated giant reed individual was located within reach VD-01. Isolated tree tobacco occurrences were located within downstream reach VD-01 and increased in abundance upstream with a dominance of this species located within reach VD-05b.

b. San Mateo Creek Watershed

Gabino Creek – The WES Investigation identified tamarisk, a Priority 1 species in the San Mateo Creek watershed, as being "present" within the LP-13, LP-14, which are tributary to Gabino Creek as well as associated with Gabino Creek (LP-15) near the confluence with Blind Canyon Creek. These occurrences were confirmed during field reconnaissance by GLA. The PCR investigation also identified Priority 2 species, pampas grass, and Priority 3 species, tree tobacco associated with Gabino Creek and its tributaries. These included abundant occurrences of pampas grass within reach LP-14 and scattered occurrences in LP-12. Tree tobacco was identified within the mainstem of Gabino (GA-18, LP-10, LP-12, and LP-15).

La Paz Creek – Previous investigations did not identify invasive species as associated with La Paz Canyon Creek. Two occurrences of tree tobacco were identified in LP-10 immediately upstream of the confluence of La Paz and Gabino creeks.

Cristianitos Creek – Invasive species occurrences were not previously documented within this drainage or its tributaries. The current investigation identified all of the Priority 1, 2 and 3 species. Giant reed is scattered in the downstream portion of this drainage (CR-18). Isolated castor bean and tamarisk individuals were located throughout the on-site portion of this drainage. Abundant occurrences of pampas grass were located within the central (CR-14) and southern (CR-18) portion of the drainage. Scattered tree tobacco and Spanish sunflower occurrences were located along the entire mainstem.

Talega Creek – Invasive species occurrences were not previously documented within this drainage. Furthermore, the current investigation did not detect any new occurrences.

2.5 Eradication Approaches for Invasive Plants

In order to eradicate exotic species, various methods of weed management are often used in different combinations depending on the most effective methods. Methodologies include mechanical (hand pulling, digging, machetes, axes, etc), biological (although none yet approved for the target species), competition, and chemical (use of herbicides) (Jackson 1998). Recommended methods for control of particular species have been cross-referenced using the California Interagency Noxious Weed Coordinating Committee and Invasive Plants of California Wildlands' CalWeed Database, a series of published papers from the 1998 *Workshop on Combating the Threat from Arundo and Saltcedar*, and a various other sources (Bossard *et al.* 2000).

Methods of control will depend on the characteristics of each species, including considerations associated with site-specific density, area of infestation, and the ecological sensitivity of the habitat. Hand or mechanical means are preferred methods for control of weed species around sensitive flora and fauna because of potential adverse effects on sensitive native species. Some species may be controlled by a combination of cutting and removal followed by spot foliar herbicide spray application immediately following the cut or upon re-growth depending on level of infestation. All exotic plants and their associated humus should be removed and disposed of at an off-site location in order to minimize effects of the biomass on downstream locations and to minimize the possibility of resprouting by cuttings.

Because of the cost and potential effects on native flora and fauna, herbicide treatment should be conducted only when weather conditions are conducive to effective uptake of the herbicide by the target species (e.g., sunny, dry with ambient temperatures 65 degrees Fahrenheit, and when plants are at the specified growing stage), and when wind conditions are such that herbicide drift is minimized (five mph or less). The preparation of herbicide solutions should also be allowed only in approved staging areas more than 100 feet from a stream course or body of water such that accidental spills are quickly contained.

Herbicides that are registered for use in California for natural areas are specified for particular weed species at specific rates noted on the labels. Because the target species on the RMV property are near or immediately adjacent to aquatic sites, glyphosate-based herbicides (e.g., Round-up Pro® or Rodeo®) and triclopyr-based herbicides (Garlon 3-A®) are recommended. Only EPA approved, glyphosate-based, systemic herbicides (e.g., Rodeo®) are legally allowed when applying herbicides within 100 feet of a natural watercourse or body of water. Glyphosate is a non-selective type of herbicide, and its mode of action works against both broadleaf weeds and grasses. Triclopyr acts on woody and broadleaf species. Treated plants or stumps shall not be disturbed until the applied herbicide has had time to take effect per the manufacturer's instruction. A third type of herbicide, imazapyr (Arsenal®) is suggested for use on tamarisk in upland areas. Herbicide concentrations should be used according to the type of application required as per the product label. For glyphosate-based herbicides, a minimum of two percent solution is recommended for foliar spray applications, a 33 percent solution is recommended for foliar wick applications, and a 100 percent solution is recommended for cut stump treatments. For triclopyr-based herbicides, a 15 percent solution is recommended for foliar spray applications, and a 100 percent solution is recommended for cut stump treatments. For imazapyr-based herbicides, a 25 percent solution diluted with diesel or natural oils is recommended for cut stump treatments.

Because the above described herbicides are not species-specific and over-spray often occurs with foliar spray methods, the application of these herbicides must be performed by an experienced professional in order to minimize effects on native species. The chosen contractor must have a pest control business license which requires that at least one individual employed by the business be in possession of a pest control applicator's (PCA) license. All licenses are issued by the State of California and should be registered in Orange County, and be of current status. If a PCA is not present during the herbicide treatment, all applicators should have undergone documented herbicide application training. Personnel must wear all protective clothing required by law and follow all label directions and precautions. All re-entry times specified on an herbicide label should be observed and posted. During herbicide application, it is recommended that a brightly colored dye or food coloring be used to aid the applicator in achieving good coverage of the target species. The material should be a non-toxic material, such as Blazon, Turfmark, or equivalent. The dye should be mixed with the herbicide at no more than half the rate specified on the label.

Below are brief descriptions of each invasive plant species organized by management priority. The relative abundances of the invasive plants mapped, their accessibility, and their proximity to sensitive habitats and species are considered in the specific eradication method recommendations. Those abundance codes were defined and described in Section 2.3.3 Field Mapping and Data Collection.

Areas categorized as sub-basins by PCR and as depicted in the attached figures correspond to the riparian reaches as defined by Smith (2000). This document follows Smith and refers to each segment as a riparian reach.

RMV is known to have a number of listed or other special-status species that are either residents or which seasonally occur onsite. For the purposes of this plan those species which are of greatest concern and most likely to be influenced by an eradication program are addressed within the recommendations for control. For a complete list of "planning species" considered for conservation within RMV see the Draft Southern NCCP/HCP Planning Guidelines Section 3.2 General Policy 2. Also, Section 3.1 General Policy 1 provides definitions of major populations, important populations, and key locations as they pertain to identified and focal species.

2.6 Riparian Species

2.6.1 Priority 1 Species: Giant Reed (*Arundo donax*)

Giant reed was introduced into the southwestern United States from the Mediterranean Region and is thought to have become the most destructive invasive weed found in many riparian areas (Jackson 1998). Giant reed occurs throughout elevations less than 1,000 feet within central and southern California. This species is abundant in wet and dry streams and creeks, but is also found in isolated clumps in moist sites such as springs or seeps (Bossard *et al.* 2000). The species was originally used in bank stabilization projects and harvested from the Los Angeles River for roofing material and fodder as early as 1820. The species is also commercially grown for various other domestic and horticultural uses such as erosion control, wind breaks, and noise barriers.

Giant reed is a perennial grass appearing much like bamboo with hollow fibrous stems partitioned by nodes. Heights of giant reed stands range from 9 to 30 feet and it grows in large clumps often made up of a single individual because it reproduces vegetatively from underground stem structures (rhizomes). The stems root at the nodes along the stalk and can span of up to 40 feet in diameter allowing the species to grow as much as ten inches a day (Bossard *et al.* 2000). This growth rate produces a large amount of above-ground biomass that can quickly monopolize local resources and restrict native species. Giant reed has alternate leaves and a tall, plume-like head with closely packed flowers. From summer to early fall, the flowers are creamy-brown and the culms are green in color. Later the culms transition to brown during semi-dormancy through the winter months or drought (Bossard *et al.* 2000).

Effects on native environments by giant reed include exclusion of riparian species and subsequent reduction in wildlife habitat and species diversity. The species also reduces soil moisture through evapotranspiration rates three times that of native riparian species, converts channel morphology through trapping large amounts of sediment, and increases water temperature by providing little shade (Jackson 1998). Furthermore, giant reed has a shallow rooting system that is often uprooted by large precipitation events causing increased erosion. Finally, the massive amounts of biomass associated with giant reed are increasing fire frequency and intensity in riparian systems, which in turn hastens the process of conversion to monocultural stands of giant reed (Jackson 1998).

Sparse or small isolated clumps of giant reed of less than six feet in height or that occur in proximity to identified or other focal species can be removed by manual methods such as hand pulling, digging, using weed eaters, axes, and machetes. These removal measures are not always the most effective due to the resilience of underground rhizomes that easily resprout (Jackson 1998). Cut material is often burned onsite as it is difficult to chip the fibrous stalks as the massive amounts of biomass can cause problems to downstream facilities. However, fire should not be used as the primary removal techniques as it does not kill the underground rhizomes and plants regenerate rapidly with often greater levels of infestation due to the removal of native competitors. Currently, the most effective techniques for controlling giant reed is through chemical treatment (foliar and cut stump applications) of glyphosate-based herbicides. For large clumps or monocultural stands, foliar methods can be applied using a backpack, handgun or handwand or by aerial application (fixed or rotor wing). In order to use the cut stump method (for small patches), cut the plant at two to four inches above the surface and paint with a cloth covered wand or sponge or spray with a hand mister within two to five minutes from cutting (Jackson 1998). Both methods should be applied post-flowering and pre-dormancy, usually late August to early November when plants are translocating nutrients into root and rhizomes, at which time the rate of downward translocation of glyphosate is greatest.

Because the size and density of giant reed stands can vary substantially the method selected for a given site should be based specifically on the site conditions where it will be used. As such, it is not likely that multiple methods will be employed in removing this invasive within RMV. Each method exhibits advantages and disadvantages and the methods can often be used in combination to achieve the desired result. The primary consideration for giant reed eradication is the presence of identified and other focal species, such as the arroyo toad, and their proximity and use of the area where the removal will occur. It is recommended that no removal activity occur during the avian breeding/nesting season March 15 to September 15, unless surveys indicate that identified or other focal species are not present.

Other considerations include proximity to water, accessibility, topography, degree of infestation and costs.

There are five commonly used methods considered for this program.

Manual Removal -This method uses techniques like hand pulling, digging with a shovel, using a pick-ax, loppers or machete. It is usually most effective when dealing with plants that are less than six feet tall and easiest when the soil is loose (Bossard *et al.* 2000). This is the most favorable method when working in and around sensitive species. For more difficult stands of vegetation weed-whackers and chainsaws can be used. It is important to note that the rhizomes must be thoroughly removed, by sifting them from the soil, or the reeds will resprout this is a major disadvantage to manual removal alone. If conditions permit it can be followed up with a herbicidal treatment of any resprouts. Presumably, herbicide treatment following mechanical removal can be more focused than a broader herbicide treatment without prior mechanical removal.

The following giant reed or Arundo removal methods are adapted/summarized from the Santa Margarita and San Luis Rey Watershed Weed Management Area website (Santa Margarita and San Luis Rey Watershed Weed Management Area 2003).

> **Foliar Spray Herbicide Application** - This method involves herbicide application by spraying the stems and leaves of Arundo with no cutting. The most effective agent is a glyphosate based herbicide. If treatment is to occur in or adjacent to water then Rodeo®, which is the only product approved by the EPA for use in aquatic environments, must be used. When using this technique, it is important that leaves and stems are thoroughly sprayed (in some cases this is difficult due to the height of the vegetation and the presence of non-target native vegetation nearby). Pressurized sprayers (mounted on an ATV) and the use of ladders maybe helpful where the Arundo is tall. In some cases non-target plants can be trimmed if there is concern of overspray. The Arundo can be 'prepped' prior to spraying by pulling the stem away from non-target vegetation. The stems should not be cut too soon after the herbicide application otherwise the herbicide does not fully kill the plant and resprouting occurs. Due to the potential for resprouting, since the Arundo biomass remains in the ground, this method requires follow-up for at least three years and preferably five. Follow-up treatments require much less herbicide and effort. There is no mechanical disturbance to the soil or vegetation with this method and it should be consideration where endangered species such as the arroyo toad may be impacted,

or if there is concern about non-native herbaceous plant colonization post-treatment.

Cut Stem/Stump Herbicide Application- This method involves cutting the Arundo stems followed by immediate application of herbicide to the cut stem surface. Application can occur by spraying (generally with a backpack sprayer using glyphosate) or for smaller projects herbicide may be applied using a hand pump sprayer or a sponge dauber. There are varying success rates for this method, ranging from about 50% to 90% kill in the first year. The difference in success rate may be due to factors such as: size and age of the Arundo clump, proximity to water, herbicide concentration, time between cutting and herbicide application, etc. When this method is used, there is typically some degree of resprouting; therefore, this method almost always requires follow-up treatment. Follow-up treatment of resprouts can either be the foliar spray method or by repeating the cut and spray method.

Cut, Resprout, and Spray (using foliar herbicide application): This represents a combination of the cut and spray method and the foliar application method. The Arundo stems are cut and the plants are allowed to resprout. The resprouts are then sprayed using the foliar application method (described in the foliar application section). The best time to cut the Arundo and force resprouting is during the spring and summer. Resprouts should be treated when they are still relatively small and easy to reach, but enough time should elapse to ensure that a full 'crop' of resprouts are produced before spraying.

Mechanical Removal of Arundo Stems and Rhizomes - Mechanical removal of Arundo is effective where it is possible to remove entire rhizome. If any of the rhizome mass is left in the ground resprouting will occur. This method requires heavy equipment such as an excavator or other specialized equipment. Because this technique can be very time consuming and costly, an alternative approach includes less thorough excavation and then follow-up treatments with herbicide as described above. Resprouting from rhizome pieces that are left behind during the mechanical removal process can be treated with a foliar application of glyphosate herbicide. Alternatively, resprouting rhizomes can be excavated if the number is limited and manageable.

This method causes soil disturbance and may lead to colonization of predominantly non-native weedy herbaceous plants. Soil disturbance, may have both biological and regulatory consequences. Soil disturbance could result in impacts to aestivating arroyo toads and must be seriously considered. Furthermore, such soil disturbance may require authorizations from the Corps or CDFG.

Arundo Biomass Disposal – An important aspect to consider when conducting Arundo control is the handling and disposal of the dead Arundo biomass. When conditions allow, it can be left on site to decompose naturally over time. However, this is often not acceptable due to its potential as a flood or fire hazard, aesthetics, or the biomass may need to be removed for native re-planting. The cost of removing Arundo stems and disposing of them can be rather expensive. There are two commonly used options for dealing with the Arundo stems are chipping and mowing.

Conventional chippers often do not work well in chipping Arundo, however a high powered (at least 80hp) drum chipper has been shown to be effective. The high cost of high powered drum chipper rental is off set by the increased safety factor for workers, their production of finely chipped material, and their speed. The chipped material should be spread out for faster drying. Drum chipped material is similar to straw and could be used for similar purposes.

Mowing is carried out in place using a hammer-flail mowing attachment that is mounted on the front of a rubber-tired tractor. Alternatively, slope mowers and other mowing devices can be used. Generally, all these devices work very well on relatively flat even terrain. Some newer machines are articulated, allowing them to maneuver over more difficult terrain while others have been attached to a mechanical arm, allowing them to mow banks. Mowing is generally best suited to dense Arundo stands. Mowing dead cane is much easier and produces finely mulched material. The limitations to mowing include site access, terrain, amount of native vegetation, and noise issues.

The following eradication methods and timing in *Table 1* below are recommended for RMV.

TABLE 1
ERADICATION METHODS FOR
GIANT REED AND OTHER RIPARIAN INVASIVES

Method	Recommended Application	Time	Equipment	Advantage	Disadvantage
Manual	Best on isolated individual patches	Remove late summer to early fall	-Shovel -Weed wacker -Loppers -brush cutters	-No herbicide use -Low soil disturbance	-Low effectiveness -Resprouting likely to occur
Foliar Spray	Small or moderate stands of pure invasive	Spray late summer to early fall	-Sprayer (backpack or mounted) -Glyphosate Herbicide	-Low soil disturbance -Relatively effective	-Use of herbicide -Drift spray on non-target plants -leave above ground biomass
Cut Stem/Stump Spray	Large pure stands of invasive or for stands near or mixed with native vegetation	Cut & Spray late summer to early fall	-Weed wacker -Loppers -brush cutters -wand applicator -Glyphosate Herbicide	-Reduction of overspray on non-target -Can remove above ground biomass	-Resprouting likely to occur -Cost of removing biomass off site if necessary
Cut, Resprout, & Spray	Large pure stands of invasive	-Cut in spring - Spray resprouts late summer to early fall	-Weed wacker -Loppers -brush cutters -Sprayer (backpack or mounted) -Glyphosate Herbicide	-Reduction of overspray on non-target -Can remove above ground biomass	-Resprouting likely to occur -Cost of removing biomass off site if necessary
Mechanical	-Large pure stands of invasive	-Cut or mow canes outside of nesting season -Excavate in dry season	-Specialized excavator	-Root/ rhizome removal	-High soil disturbance -Some resprouting likely to occur if all roots are not removed

a. Site-Specific Eradication and Control Measures

1. San Juan Creek Watershed

Cañada Chiquita - PCR reported no giant reed occurrences in Cañada Chiquita and their review of previous investigations confirmed this. These areas should be monitored periodically and if patches appear they should be removed by mechanical methods following spot spraying.

Cañada Gobernadora - In previous investigations no giant reed was found in Cañada Gobernadora. However, the PCR survey found four isolated individuals of giant reed in two of the seven riparian reaches (two per reach) (*Figures 1* and *6*). This likely indicates a recent invasion. Arroyo toad habitat is located downstream of the giant reed location at the mouth of the creek, near its confluence with San Juan Creek. Least Bell's vireo nesting sites have been documented both upstream and downstream of giant reed locations and a southwestern willow flycatcher nesting site downstream only (PCR Services Corporation and Dudek & Associates, Inc. 2002). Although, these species have not been found to occupy the riparian reaches where the giant reed occurs, it is possible that they could use the areas and thus giant reed removal in this area warrants special precautions presumably outside the breeding season. In both riparian reaches, the giant reed can be removed by the foliar spray method or the cut stem/stump method.

San Juan Creek - The PCR investigation noted that of the 17 riparian reaches associated with San Juan Creek four were found to be dominated by giant reed, two have an abundance of the species and four more contained isolated individuals (*Figure 1, 7* and *8*]. The other investigations indicated a long standing presence of giant reed both onsite and upstream of RMV. A major population of arroyo toad occupies portions of San Juan Creek through RMV and nesting of least Bell's vireo has occurred in areas of the creek where eradication is proposed.

Eradication of giant reed in San Juan Creek will require a combination of techniques. Some portions of San Juan Creek may topographically allow for mechanical eradication. However, the majority of the giant reed removal in the creek should include foliar spray treatments where pure stands occur and the cut stem/stump method where native riparian habitat and sensitive species occur. Avoidance of native vegetation and minimization of soil disturbance to the extent possible will be an important consideration due to the potential presence of the arroyo toad.

Verdugo Creek - PCR found one isolated giant reed individual detected in a riparian reach of Verdugo Creek, there were no previous records of occurrence there, indicating a recent invasion (*Figures 1* and *8*). The arroyo toad may occur near the mouth of Verdugo Creek where it confluences with San Juan Creek. Because of its isolated distribution, and the potential impact on arroyo toads the foliar spray treatment or cut stem/stump method is appropriate here.

2. San Mateo Creek Watershed

Gabino Creek - PCR reported no giant reed occurrences in Gabino Creek and their review of previous investigations confirmed this. This area will continue to be monitored and a cut stem/stump method would be used if detected during future monitoring.

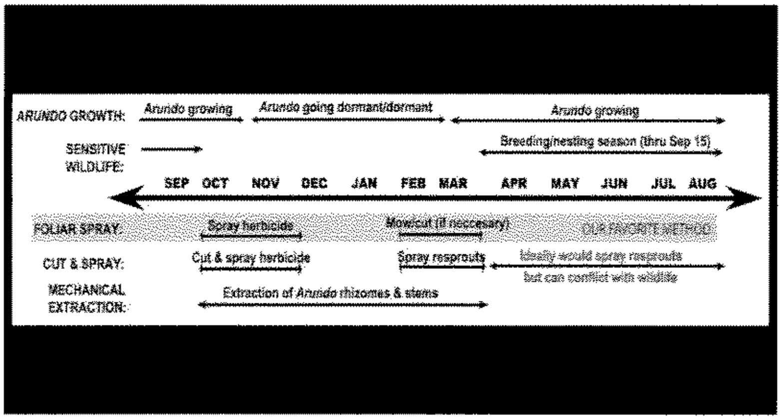
La Paz Creek - PCR reported no giant reed occurrences in La Paz Creek and their review of previous investigations confirmed this. This area will continue to be monitored and a cut stem/stump method would be used if detected during future monitoring.

Cristianitos Creek - Although previous investigations found no giant reed in Cristianitos Creek, the PCR survey found three scattered clumps of giant reed in the southernmost riparian reach of the creek within RMV [*Figures 1* and *9*]. These occurrences thus appear to be of recent origin. This reach of the creek is documented arroyo toad habitat and currently supports an important population in a key location. There also are least Bell's vireo nesting sites in the vicinity. In the areas of the creek where the giant reed occurs there is a broad canopy of willow riparian vegetation therefore the cut stem/stump method would be appropriate here. Access to the locations is good.

Talega Creek - PCR reported no giant reed occurrences in Talega Creek. This area will continue to be monitored and a cut stem/stump method would be used if detected during future monitoring.

Based on the findings of the PCR investigation and their review of previous investigations, the greatest infestation of giant reed occurs in the high order creeks, such as San Juan Creek. Infestations initially take hold in the mainstems of the high order creeks and from there they spread into the lower order tributary creeks, perhaps by cattle or human activities. Eradication efforts should first be concentrated on removing the isolated and scattered clusters of giant reed from the upstream low order tributaries and then focused on the larger downstream infestations in the mainstem creeks. This "watershed down" approach will prevent reinfestation of the mainstem creeks by ensuring that upstream infestations are controlled. In order to effectively accomplish watershed-wide eradication and control of giant reed, and so that reinfestation is minimized on RMV, it will be necessary to partner with upstream landowners/managers to ensure that upstream efforts are in place to manage infestations.

The graphic below depicts optimal treatment timelines of three common giant reed removal methods (Giessow 2002).



(From Santa Margarita and San Luis Rey Watershed Weed Management Area Website)

2.6.2 Priority 2 Species: Pampas Grass (*Cortaderia selloana*)

Pampas grass was introduced to the southern United States from South America. Pampas grass is a perennial herb that is known for its tall seed plumes and long leaves with sharply serrated edges. Mature plants produce large quantities of wind-dispersed seeds. Throughout its range in California, this species is found in wetland and riparian areas and in some upland habitats within a wide range of soil types and hydrologic regimes. However, within RMV, nearly all occurrences are within riparian areas or on the margins of riparian or wetland areas from where they can readily colonize the wetland and riparian areas. For purposes of this plan, this species is treated as a riparian species because its overwhelming potential for harm is associated with wetland and riparian areas. Where it occurs in uplands, it should be removed to limit potential threats to wetland or riparian areas. Apart from being planted as an ornamental species throughout southern California, this species colonizes areas disturbed by landslides, fire, and erosion. Its environmental effects are native species displacement through its quick seed germination and rapid growth. Plants produce millions of seeds that develop without pollination.

Seedling and medium size plants can be removed manually by pulling or digging when the soil is moist. Removal can be accomplished during winter or spring. The mature plants are more difficult to remove by hand and often require the use of a winch and a choker cable around the plant's base. Prior to removal, the inflorescences should be cut off and placed in bags to prevent further seed dispersal. When inflorescences are cut and left on bare ground germination may result. After removal, the plant should be removed from the site. If main roots are left behind, the cut-stump chemical treatment using glyphosate-based herbicides, at a 25 percent solution should be applied within two to five minutes. Plants should be checked about one month after application to determine the success of the herbicide treatment. Re-application may be necessary for mature individuals.

Strategies for elimination of pampas grass from a watershed area differ from those employed for giant reed, which generally is performed from the top of the watershed down. Pampas grass is dispersed by seed, and prevailing wind patterns must also be considered in determining strategies. Large source populations, such as occurs in the lower portions of Trabuco Creek between Oso Parkway and Avery Parkway should be subject to initial efforts with upstream areas that exhibit lower densities to follow once source of wind-blown propagules are eliminated.

a. Site-Specific Eradication and Control Measures:

1. San Juan Creek Watershed

Cañada Chiquita - Two isolated individuals of pampas grass were detected within two of the riparian reaches of Cañada Chiquita (*Figures 2* and *6*). These plants occur near locations previously documented to support least Bell's vireo nesting sites. There is easy access to these plants and they can be removed by hand, or the cut stem/stump method. Removal should be performed outside the nesting season.

Cañada Gobernadora - PCR reported no pampas grass occurrences in Cañada Gobernadora and their review of previous investigations confirmed this. This area will be monitored for future invasions, and plants will be removed as necessary.

San Juan Creek - Within six of the San Juan Creek riparian reaches there are scattered individuals of pampas grass and in two riparian reaches there are scattered clusters (*Figures 2, 7* and *8*). A major population of arroyo toad occupies portions of San Juan Creek where eradication is proposed. There is easy access to these plants and they can be removed by hand, cut stem/stump or foliar spray methods when conditions allow.

Verdugo Creek - PCR reported no pampas grass occurrences in Verdugo Creek and their review of previous investigations confirmed this. This area will be monitored for future invasions, and plants will be removed as necessary.

2. San Mateo Creek Watershed

Gabino Creek - PCR reported no pampas grass occurrences in Gabino Creek and their review of previous investigations confirmed this. This area will be monitored for future invasions, and plants will be removed as necessary.

La Paz Creek - Abundant occurrences of pampas grass were reported by PCR in one riparian reach of La Paz Creek and there are two isolated individual plants in another (*Figures 2* and *9*). In the reach characterized as abundant, the plants occur in patches around ponds and in some upland areas. These areas are in very close proximity to riparian reaches of Cristianitos Creek that support arroyo toad habitat noted as an important population in a key location. There is easy access to these plants and they can be removed by hand, cut stem/stump or foliar spray methods when conditions allow.

Cristianitos Creek - In two of the riparian reaches of Cristianitos Creek on RMV pampas grass is abundant and there are isolated individuals within four of the reaches (*Figures 2* and *10*). These reaches are known arroyo toad habitats, which support an important population in a key location, and there are some previously documented least Bell's vireo nesting sites in the southernmost reach of Cristianitos Creek on RMV. Those plants occurring in the upstream reaches are easily accessible and those in the downstream reach are more difficult to access. Removal can be accomplished by hand, cut stem/stump or foliar spray methods when conditions allow.

Talega Creek - PCR reported no pampas grass occurrences in Talega Creek and their review of previous investigations confirmed this. This area will be monitored for future invasions, and plants will be removed as necessary.

Pampas grass is most problematic in Cristianitos Creek with some patches of infestation in San Juan Creek that may be expanding. Previous investigations indicated that there were no invasive plants documented in Cristianitos Creek; therefore the invasion of pampas grass is recent and may be rapidly aggressive. Unlike the vegetative spread of the giant reed, pampas grass is dispersed by seed. It is likely spread through the watershed in a watershed up pattern, where coastal winds carry seeds up the valleys where these creeks are located. Therefore, a "watershed up" approach to eradication is appropriate for pampas grass eradication as noted above. Plants downstream should be removed first to prevent any more upstream infestations, in the meantime seed heads of upstream plants can be removed while downstream eradication is being implemented to prevent its spread further upstream.

In general, the same basic techniques used to remove giant reed can be used to control pampas grass- note the overview of pampas grass control methods above. However, pampas grass infestations on RVM are not as extensive as the giant reed infestation and the least aggressive control method options should be used when applicable.

2.6.3 Priority 2 Species: Castor Bean (*Ricinus communis*)

Castor bean was introduced to the southern United States from Asia and Africa where it was cultivated as an oil crop and grown as an ornamental plant. The species appears to have been naturalized below 1,000 feet in elevation throughout southern California. The species is found in riparian areas and upland habitats in full sun, but in wide range of soil types and hydrologic regimes. The species most commonly escapes from frequently disturbed areas such as agricultural fields, farm drainages and ditches, and along roadsides.

Castor bean is a perennial shrub that ranges in height from three to 15 feet, with alternating leaves on the stem, and deep green palmately lobed leaves. The species has monoecious flowers (separate male and female) and small round spiny fruit containing up to three shiny seeds that resemble ticks (Bossard *et al.* 2000). Propagation is through dropping seed near the parent plant and dispersing through moving water, disturbances, and, less likely, animals. This species is susceptible to cold temperatures and will often show signs of mortality within a 24-hour period at two degrees Fahrenheit or less (Bossard *et al.* 2000).

Its environmental effects are native species displacement through its quick seed germination, rapid growth, shading native seeds, and subsequently creating monotypic stands, thus lowering species diversity. Seed can germinate throughout the year depending on weather and a plant can grow up to six and a half feet in a single season (Bossard *et al.* 2000).

Seedling and medium size plants can be removed manually using a weed wrench in wet sandy soils, removing the bulk of the root system to insure that the plant does not resprout. If main roots are left behind, chemical treatment of 25 percent solution immediately following is recommended. Larger individuals should be removed using either the foliar spray treatment method or the cut-stump treatment using glyphosate-based herbicides: Rodeo® near aquatic sites, and Roundup® in upland areas at the prescribed minimum two percent solution with a non-ionic surfactant. If using the foliar spray method, the plants should be sprayed during active growth in the spring. For cut-stump treatments, use saws or loppers to remove the above ground biomass down to two to four inches in height and a 25 percent solution applied within two to five minutes. Plants should be checked about one month after application to determine the success of the herbicide treatment. Re-application may be necessary for mature individuals. All visible seeds should be removed.

a. Site-Specific Eradication and Control:

1. San Juan Creek Watershed

San Juan Creek - There are some isolated and scattered castor bean plants occurring within and along riparian reaches of San Juan Creek [*Figures 3, 7* and *8*]. In total these patches contain fewer than thirty plants [*Figures 7* and *8*]. The same sensitive species concerns apply along these reaches of the creek as mentioned in previous sections. Most of the plants occur in accessible areas and can be removed manually, by the cut stem/stump or by the foliar spray techniques.

PCR reported no castor bean occurrences in Cañada Chiquita, Cañada Gobernadora, and Verdugo Creeks. Review of previous investigations indicated similar conditions. These areas will be monitored for future invasions, and plants will be removed as necessary.

2. San Mateo Creek Watershed

Cristianitos Creek - There is a substantial infestation of castor bean plants in the southernmost reach of Cristianitos Creek on RMV [Figure 3]. There are over 100 plants exhibiting moderate to high density in an upland area adjacent to the creek (*Figure 9*). This area is in the vicinity of known least Bell's vireo nesting sites, and also proximate to arroyo toad occupied habitat that is identified in the guidelines as an important population in a key location. Outside of breeding season these mostly upland areas can be treated using the foliar spray technique.

PCR reported no castor bean occurrences in Gabino Creek, La Paz Creek, and Talega Creek. Review of previous investigations found the same conditions. These areas will be monitored for future invasions, and plants will be removed as necessary. Castor bean has some limited infestations on RMV, the most notable occurring in the downstream reach of Cristianitos Creek. Manual eradication is the best method for removal within the flood plain and in the upland areas cut stem/stump or foliar spray techniques are acceptable when conditions are appropriate.

2.6.4 Priority 1 Species: Tamarisk (*Tamarix ramosissima*)

Tamarisk, also called saltcedar, is a many-branched shrub or tree with scale-like leaves and salt glands that exude salt crystals (Bossard *et al.* 2000). Like giant reed, tamarisk was introduced into the American Southwest from the Mediterranean region.

The genus has reddish brown stems, inflorescence of white or pink flowers, and is usually less than 26 feet tall. Four species of *Tamarix* have been identified as occurring in southern California, but *Tamarix ramosissima* is the species identified on RMV and is the only species expected to occur in the Habitat Reserve. This species is abundant where surface or subsurface water is available intermittently or perennially, including stream banks, ditches, and washes where saline soils are common. The species is also extraordinarily good at establishing disturbed sites such as recently burned, graded, or flooded areas where native vegetation has been removed. Tamarisk reproduces, in part, by vegetative growth; i.e., producing new plants from existing structures without sexual reproduction. The species flowers year round, allowing for individuals to propagate by seed and produce an estimated 500,000 tiny seeds per year that are easily dispersed by wind and water (Jackson 1998). As a result, this species is difficult to eradicate (Bossard *et al.* 2000).

Tamarisk adversely affects the stream environment by changing the geomorphology, groundwater availability, soil chemistry, fire frequency, plant community composition, and native wildlife diversity. Stream morphology is impacted through alteration of sediment regimes. The evapotranspiration rate of tamarisk is much higher than native vegetation and consequently is contributing to decrease base flows and lowed groundwater tables. Soil chemistry is altered and fire frequency is increased through the deposition of large amounts of saline leaf litter and fine woody debris. The reduction in native wildlife diversity is directly related to the reduction in habitat diversity and structure as areas convert to monocultures of tamarisk (Bell 1998).

Singly, and especially in combination the above-noted impacts of tamarisk, including changes in stream morphology, changes sediment regimes and reduction in water availability makes this species very undesirable in areas occupied or potentially occupied by the arroyo toad. Tamarisk poses a potentially serious threat to arroyo toad populations, if not addressed, and should be eliminated from areas such as Cristianitos Creek or Gabino Creek where it is established but in low enough numbers to be fully controllable. As noted above, Northrop Grumman has been very successful in controlling tamarisk within the reach of Cristianitos Creek that traverses the Northrop Grumman lease, providing a template for future control programs.

Hand removal of small trees and saplings is easiest if sediment is wet, loose, or sandy allowing for the entire root structure to be pulled out. However, complete eradication of adult tamarisk is especially difficult with only mechanical methods because the species is able to resprout vigorously following cutting or burning. Therefore, if biomass is removed initially in large infestations, follow up with herbicides when resprouting occurs is essential. Similar to giant reed, the most effective way of eradicating tamarisk is through the use of herbicides. Currently, six herbicides are used to combat the species: imazapyr-based (Arsenal®), triclopyr-based (Garlon 3A®, Garlon 4®, and Pathfinder II®), and glyphosate-based (Rodeo® and Roundup®). Unfortunately, only Rodeo® has an EPA approval for aquatic sites; therefore, infestations in creeks and streams would require initial removal of biomass followed by the cut-stump method in late spring or early fall during good growing conditions.

a. Site-Specific Eradication and Control Measures:

1. San Juan Creek Watershed

San Juan Creek- There are a few isolated clusters of tamarisk in the San Juan Creek riparian reaches which can be removed by hand (*Figures 4, 7* and *8*). The same sensitive species concerns apply along these reaches of the creek as mentioned in previous sections. Most of the plants occur in accessible areas and can be removed manually, by the cut stem/stump or foliar spray techniques where appropriate.

Previous investigations did not report tamarisk in Trabuco Creek, Chiquita Creek, Cañada Gobernadora and Verdugo Creeks. Similarly, PCR reported no tamarisk occurrences in Cañada Chiquita, Cañada Gobernadora and Verdugo Creeks. These areas will be monitored for future invasions, and plants will be removed as necessary.

2. San Mateo Creek Watershed

Cristianitos Creek - The southernmost riparian reach of Cristianitos Creek, just below the confluence with Blind and Gabino Creeks, has exhibited a substantial infestation of tamarisk (*Figures 4* and *9*); however, the areas within the Northrop Grumman lease have been subject to control and will be subject to continuing control for the life of the lease. This reach of Cristianitos Creek is in the general vicinity where least Bell's vireo nesting sites have been documented and within the arroyo toad habitat or potential arroyo toad habitat. Due to the extent of the infestation the cut stem/stump or foliar spray treatments should be considered for use here outside of breeding/nesting seasons. As noted above, control of tamarisk in this area is important for the arroyo toad and would be among the first areas where invasive species eradication should begin.

Gabino Creek - Three of the riparian reaches of Gabino Creek (LP-13, LP-14, and LP-15) support scattered clusters of tamarisk (*Figures 4* and *9*). These areas are in very close proximity to reaches of Gabino Creek and Cristianitos Creek that are known arroyo toad habitat, which have been identified in the guidelines as an important population in a key location. There is easy access to these plants and they can be removed by hand, cut stem/stump or foliar spray methods when conditions allow.

PCR reported no tamarisk occurrences in Talega and La Paz creeks. These areas will be monitored for future invasions, and plants will be removed as necessary. Tamarisk presents the same removal challenges as giant reed therefore the same techniques should be used to eradicate it. This plant reproduces both vegetatively and by seed dispersal making it difficult to control. Like pampas grass the seeds are easily carried by wind and water and should be subject to the "watershed up" approach in control efforts.

2.6.5 Priority 3 Species: Tree Tobacco (*Nicotiana glauca*)

Tree tobacco was introduced to the southern United States from South America. This species is believed to have naturalized in waste places below 3,000 feet in elevation. The species is found in riparian areas and upland habitats and is commonly found in frequently disturbed areas such as drainage ditches and roadsides. Tree tobacco is a perennial woody, evergreen shrub that ranges in height from six to 20 feet, with erect sparsely branched stems and long, tubular yellow flowers. The capsule fruit produces many seeds that are dispersed by wind and water.

This species of tobacco has been used ritually and medicinally by man, but due its to high level of alkaloids it can be deadly. This plant's toxicity also makes it dangerous to grazing wildlife. It establishes rapidly in disturbed or recently burned areas, preventing reestablishment of native plants. The long yellow flowers are attractive to hummingbirds, making it a popular and readily available ornamental species. Its widespread appeal with gardeners and its ability to disperse well have made this a successful invader.

Seedling and small plants can be removed by hand pulling. For larger individuals, stump treatment with glyphosate-based herbicides is recommended. The plants should be treated in spring when actively growing. A phased treatment is recommended, starting with horizontal cutting close to the ground using a saw, rotary brush cutter, or similar tool (Bossard *et al.* 2000). All the cut vegetation should be removed from the vicinity the same day it is cut and disposed of at an authorized dump site. Later, the stumps or stems should be re-cut, cleared of sawdust, and immediately painted with a 100 percent glyphosate-based herbicide within two minutes of cutting before the cut surface begins to congeal to ensure penetration of the herbicide (Bossard *et al.* 2000). Plants should be checked a month after application to determine the success of the herbicide treatment. Any re-growth from the treated stumps should be treated with the foliar herbicide application in the same season or as re-growth appears in the next growing season.

a. Site-Specific Eradication and Control:

1. San Juan Creek Watershed

Cañada Chiquita - There are four riparian reaches (CH-02, CH-04a, CH-06a and CH-06b) with isolated clusters of tree tobacco, two with scattered clumps, and one with abundant numbers along Cañada Chiquita (*Figures 5* and *6*). These plants occur near locations where there are documented or at least potential least Bell's vireo nesting sites. There is easy access to these plants and they can be removed by hand or the cut stem/stump methods.

Cañada Gobernadora - There were no previous reports of tree tobacco in Cañada Gobernadora; however, PCRs investigation noted that there are now two reaches (GO-02 and GO-07) with isolated individuals of tree tobacco and one with numerous large individuals [Figure 5 and 7]. There is a major population of arroyo toad downstream where Gobernadora Creek discharges to San Juan Creek. There have been documented least Bell's vireo nesting sites in both upstream and downstream locations and southwestern willow flycatcher nesting site downstream in The Gobernadora Ecological Restoration Area (GERA). These species have been shown to occupy reaches of the creek supporting tree tobacco, thus eradication in these reaches may warrant special precautions. This invasive should be removed by hand or the cut stem/stump treatment method.

San Juan Creek - In San Juan Creek there are four riparian reaches (SJ-05, SJ-09, SJ-15, SJ-15) with scattered clusters of tree tobacco (*Figures 5, 7* and *8*). A major population of the arroyo toad occurs along San Juan Creek on RMV. In addition nesting of least Bell's vireo is documented in areas of the creek where eradication is proposed. Thus eradication of tree tobacco in this creek warrants special precautions. This invasive should be removed by hand or the cut stem/stump treatment method.

Verdugo Creek - PCR found tree tobacco to be abundant in one riparian reach in Verdugo Creek, scattered in three areas, and isolated in three areas (*Figures 5* and *8*). There were no previous records of occurrences in Verdugo Creek, indicating a recent invasion. The arroyo toad may occur near the mouth of Verdugo Creek at the confluence with San Juan Creek. To avoid potential impacts, tree tobacco should be removed by hand or the cut stem/stump method.

2. San Mateo Creek Watershed

Gabino Creek - Although there were no documented occurrences mapped of tree tobacco in Gabino Creek, PCR did locate numerous scattered clusters of the plant in their investigation (LP-10, LP-12, LP-15, and GA-18), thus possibly indicating a recent invasion (*Figures 5* and *9*). The downstream riparian reaches of Gabino Creek support an important population of the arroyo toad and overlaps where eradication for tree tobacco is necessary. The invasive should be removed by hand or by the cut stem/stump method.

There is also a concentration of tree tobacco in Blind Canyon Creek, upstream of the confluence with Gabino Creek (BL-01, BL-02, and BL-03). The invasive should be removed by hand or by the cut stem/stump method.

La Paz Creek - Tree tobacco was recorded in one riparian reach of La Paz Creek, immediately upstream of the confluence with Gabino Greek (*Figures 5* and *9*). The entire downstream reach of Gabino Creek is known to support a major arroyo toad population in this a key location. Tree tobacco is rather abundant in this area as noted above). Hand removal is the best option for removal in La Paz and Gabino with the sensitive species concerns but due the heavy infestation the cut stem/stump method is more practical if implemented outside of the breeding season.

Cristianitos Creek - In one of the upstream riparian reaches of Cristianitos Creek tree tobacco was reported as dominant. It was found to be scattered within four reaches and isolated in three, essentially appearing along the entire mainstem of the creek (*Figures 5* and *9*) These reaches are included a major population of arroyo toad in this key location. Also, there are some previously documented least Bell's vireo nesting sites in the southernmost reach of Cristianitos Creek on RMV. As with La Paz Creek, the sensitive species issues warrant hand removal. However, the high degree of infestation could be better dealt with using the cut stem/stump method in this location.

PCR reported no tree tobacco plant occurrences in Talega Creek. These areas will be monitored for future invasions, and plants will be removed as necessary.

2.6.6 Priority 2 Species: Spanish Sunflower (*Pulicaria paludosa*)

Spanish sunflower is a large herb to small shrub of Mediterranean origin. This species was first collected in California in the early 1960s and was first described as occurring in California by Raven in 1963 (Raven 1963).

This large herb to small shrub commonly reaches up to three feet tall (sometimes four) and exhibits multiple branches, each which has numerous flowering heads, each which produces numerous seeds. Exact dispersal mechanisms are unknown, but given the success that this species exhibits along streams and in seasonally wet areas, it is likely that the seeds float and can be transported along streams via floods. Once established, this species can form dense monocultures, crowding out most understory species. Although this species grows in full sun in wet environments, it also appears to tolerate shade well and can form dense thickets in the understory of willow riparian forest.

The ability of the Spanish sunflower to form dense monocultures is troublesome because it can dominate the herb layer once established, crowding out native hydrophytes such a *Juncus* spp., *Eleocharis* spp., and *Carex* spp. This species also occurs in habitats that support special-status plants such as southern tarplant (*Centromadia parryi var. australis*), Coulter's saltbush (*Atriplex* *coulteri*), salt spring checkerbloom (*Sidalcea neomexicana*), and mud nama (*Nama stenocarpum*).

In Orange County, this species has only recently been recognized as an invasive exotic that exhibits the potential for adverse impacts to native riparian and wetland habitats. As such, effective control techniques have not yet been developed.

a. Site-Specific Eradication and Control:

Because this species has been detected within wetland restoration/mitigation sites associated with the GERA as well as in Chiquita Canyon, it has been subject to eradication efforts. It has also been identified as patchy in San Juan Creek and Cristianitos Creek but, has not been subject to removal in these areas. To date, the primary methods of control have been hand weeding. Foliar spraying has not been implemented; however, a pilot spraying program might be useful to begin development of a long-term approach to controlling this species. Removal in areas where it is beginning to occur may be important because removal during the early stage of infestation would likely have a higher chance of success.

1. San Juan Creek Watershed

Cañada Chiquita - Spanish sunflower occurs within the willow understory associated with Chiquita Creek. To date it has not become a dominant understory component, but early eradiction is recommended.

Cañada Gobernadora - Spanish sunflower occurs within the willow understory associated with Gobernadora and it also occurs within portions of the GERA where it has been subject to control efforts. In some areas along Gobernadora Creek, this species forms dense monocultures and intensive eradication efforts should be undertaken.

San Juan Creek - Spanish sunflower occurs within the willow understory associated with San Juan Creek. To date it has not become a dominant understory component, but early eradiction is recommended.

Verdugo Creek - Spanish sunflower does not occur with regularity in Verdugo Creek. Eradication efforts are not recommended at this time, but the area should be periodically monitored for future infestations.

2. San Mateo Creek Watershed

Gabino Creek - Spanish sunflower does not occur with regularity in Gabino Creek. Eradication efforts are not recommended at this time, but the area should be periodically monitored for future infestations.

La Paz Creek - Spanish sunflower does not occur with regularity in La Paz Creek. Eradication efforts are not recommended at this time, but the area should be periodically monitored for future infestations.

Cristianitos Creek - Spanish sunflower occurs within the willow understory associated with Cristianitos Creek to date it has not become a dominant understory component, but early eradiction is recommended.

Talega Creek - Spanish sunflower does not occur with regularity in Talega Creek. Eradication efforts are not recommended at this time, but the area should be periodically monitored for future infestations.

2.7 Upland Species

2.7.1 Priority 1 Species: Artichoke Thistle (*Cynara cardunculus*)

Artichoke thistle escaped cultivation and began to infest California rangelands in the 1860s. This plant is native to the Mediterranean and has taken well to the similar climate is California. It has also been introduced into South America and Australia. Also known as wild artichoke and cardoon this spiny wild type differs form the cultivated globe artichoke which produces an edible flowerhead.

This very prickly perennial can reach five feet in height and has a taproot that can grow down nearly six feet deep. Each plant can have three to five or more flowerheads which each produce hundreds of seeds (DeSimone 2002). Artichoke thistle has large heavy seeds. They can be spread by water and animals, but typically are deposited within only six feet of the parent plant. The flower looks like a striking purple ball of bristles with pinnate petals. This invasive is common in annual rangelands, disturbed grasslands, and can be found up to 1,650 feet elevation throughout the state (Bossard *et al.* 2000). It is also found in riparian, coastal sage scrub, native grassland, and chaparral vegetation communities where it poses a larger ecological threat in these native habitats.

Due to its unpleasant spines and dense patches this invasive plant inhibits cattle and wildlife movement. Its inhibitive nature and root system displaces native vegetation. Occurring mostly in upland areas in coastal regions artichoke thistle competes with native vegetation for space, water, and nutrients. Although some birds and other animal species are known to feed on the pollinators of the plant or its seeds, overall it is ecologically less valuable because it provides very limited habitat value for wildlife.

The spiny nature of artichoke thistle makes it a difficult species to remove manually, but it can be done. Although difficult, when plant densities are low hand removal is possible. It is important to remove as much of the taproot as possible; if not removed entirely plants can resprout. Root plowing can be done to remove roots. One way of preventing the spread of the thistle is to cut the seed heads off, when removal of the entire plant is not possible. The cut stump treatment with the application of glyphosate-based herbicide can be affective for thistle removal. For artichoke thistle this would involve removing the top growth of the plant with brush cutters and quickly applying a glyphosate solution to the stump (Bossard *et al.* 2000). This method is appropriate where foliar spray treatment could adversely affect surrounding vegetation and wildlife. This species can have a seed bank that lasts for up to five years, often several treatments maybe necessary.

A detailed plan for artichoke thistle eradication has been prepared for the Ladera Open Space by RMV and is attached as Appendix A. Methods described in this plan are appropriate for use on RMV.

a. Site-Specific Eradication and Control:

1. San Juan Creek Watershed and San Mateo Creek Watershed

Based on observations made during general reconnaissance, jurisdictional delineation visits, and focused botanical surveys no areas of RMV have significant infestations of artichoke thistle. On going treatment of Artichoke thistle has occurred on RMV property for over 30 years. This spot and treat (spraying plants with an approved herbicide) method along with cattle grazing has kept this invasive suppressed on RMV lands. However, continued control is needed as this invasive is problematic on adjacent lands and could readily invade portions of RMV if neglected.

2.8 Implications of Control Methods for Invasive Plants

Removal and control of primary riparian invasive plants, including giant reed, pampas grass, castor bean, tamarisk, tree tobacco, and Spanish sunflower will increase ecosystem functions and habitat quality throughout RMV and the surrounding areas. Removal of these invasives immediately benefits native plants. Native plants like willows (*Salix* spp.) and mulefat (*Baccharis salicifolia*) will no longer compete with the invasive plants for space, soil moisture, nutrients, and other resources. Areas where removal occurs become available for revegetation by native species. In some locations where invasive plants have been cleared, depending on the extent of the area, it maybe appropriate plant plugs or seeds of natives in order to enhance their chances of reestablishment and to avoid rapid re-colonization of unwanted invasives. Increased native species cover increases nesting and foraging habitat for riparian bird species. Giant reed and the other targeted invasives overall provide poor habitat for native insects, birds and other species. Giant reed, for example, excludes native riparian species, causing an increase in water temperatures of streams as a result of not providing the shading typical in riparian areas, which in turn, reduces the aquatic habitat quality (Bossard *et al.* 2000).

Upland vegetation and animal communities will benefit from the removal of artichoke thistle. Artichoke thistle eradication will allow for ecologically valuable native species to reestablish in areas where the thistle has been cleared. Birds like the threatened California gnatcatcher and other scrub birds will benefit from the potential increase in coastal sage scrub habitat. Areas cleared of thistle, particularly wildlife corridors, will enable wildlife to move and disperse more readily.

Impacts of giant reed and the other targeted riparian invasives removal on riparian habitats vary based on removal methods. Manual removal with hand tools causes little to no impact except for the temporary disturbance while removal is being completed. It is important that all eradication and control efforts occur outside of the breeding/nesting season so as not to disturb the wildlife during this sensitive period. Heavy mechanical removal methods can cause soil disturbance and consequent sediment and debris loading of streams. Impacts of chemical removal treatments can include inadvertent spraying of non-target plants and accidental contamination of waterways if type and directions of chemicals is not closely monitored. Impact concerns with the upland removal of artichoke thistle also include inadvertent spraying of non-target plants and disruption to wildlife.

2.9 Performance Standards

Performance standards associated with eradication of the invasive exotic plant species are set forth below. As noted above, removal of giant reed and pampas grass is proposed as a component of compensatory mitigation that will be implemented to ensure no-net-loss of wetland/riparian area and function within the RMV Open Space. Because eradication of these particular species will be part of the mitigation program for impacts to Corps and CDFG jurisdictional waters specific performance standards have been developed. While it is recognized that one of the primary goals associated with removal of these species is enhancement and expansion of habitat for special-status species such as the arroyo toad and least Bell's vireo, the performance standards relate directly to the effectiveness of the eradication efforts. Successful eradication of giant reed and pampas grass will result in enhanced hydrology, natural fire regimes, natural sediment regimes, and habitat structure conducive to occupation by both special-status and common native wildlife species. As such, performance standards are aimed at measuring the effectiveness of the eradication efforts.

2.9.1 Giant Reed, Tamarisk[7], and Pampas Grass

Because the level of infestation for these species is higher than for the other wetland/riparian invasives, the following performance standards will be applied to these species alone. A description of performance standards for castor bean, tree tobacco, and Spanish sunflower is provided below.

Standard Vegetation Monitoring procedures (see below for detailed description of proposed monitoring methods) will be employed, regardless of which eradication methods (e.g. foliar spray, mechanical removal, cut-stump method, etc.) are used to eradicate giant reed, tamarisk, and pampas grass.

- **First-Year Monitoring.** During the first year, beginning one month from eradication efforts monitoring will occur every month. One quantitative survey will be performed during the first year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the first year:

  -- 50-percent reduction in coverage of live giant reed, tamarisk, or pampas grass (5-percent deviation allowed);

  Treatment will be required during the first year, with timing to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the first year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Second-Year Monitoring.** During the second year, beginning one month from eradication efforts monitoring will occur every other month. One quantitative survey will be performed

[7] Tamarisk is a Priority 1 species and poses substantial risk to stream geomorphology, sediment regimes, and water availability for native plants and animals. As such, early and ongoing control will be important.

during the second year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the second year:

-- 70-percent reduction in coverage of live giant reed, tamarisk, or pampas grass (5-percent deviation allowed);

Treatment will likely be required during the second year, with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the second year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Third-Year Monitoring**. During the third year, beginning one month from eradication efforts monitoring will occur every quarter. One quantitative survey will be performed during the third year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the third year:

-- 80-percent reduction in coverage of live giant reed, tamarisk, or pampas grass (5-percent deviation allowed);

Treatment will likely be required during the third year (though substantially reduced), with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the third year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Fourth-Year Monitoring**. During the fourth year, beginning one month from eradication efforts monitoring will occur every quarter. One quantitative survey will be performed during the fourth year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the third year:

-- 90-percent reduction in coverage of live giant reed, tamarisk, or pampas grass (5-percent deviation allowed);

Treatment may be required during the fourth year (though substantially reduced), with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the fourth year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Fifth-Year Monitoring**. During the fifth year, beginning one month from eradication efforts monitoring will occur every quarter. One quantitative survey will be performed during the fifth year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the fifth year:

  -- 100-percent reduction in coverage of live giant reed, tamarisk, or pampas grass (0-percent deviation allowed);

  Treatment will likely not be required during the fifth year; although, it will be performed as necessary, with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the fifth year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG. If treatment is required during the fifth year, monitoring will be performed during the sixth year to verify that giant reed and/or pampas grass have been removed as set forth above.

2.9.2. Castor Bean, Tree Tobacco, and Spanish Sunflower

Because the level of infestation for these species is lower and eradication typically requires only one or two treatments, a less intensive approach is required (as data is collected on the efficacy of the treatment approaches and the relative success, species may be shifted to more comprehensive monitoring programs as appropriate).

Standard Vegetation Monitoring procedures (see below for detailed description of proposed monitoring methods) will be employed, regardless of which eradication methods (e.g. foliar spray, mechanical removal, cut-stump method, etc.) are used to eradicate castor bean, tree tobacco, tamarisk, and Spanish sunflower.

- **First-Year Monitoring**. During the first year, beginning one month from eradication efforts monitoring will occur every month. One quantitative survey will be performed during the first year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the first year:

  -- 60-percent reduction in coverage of live castor bean, tree tobacco, and Spanish sunflower (5-percent deviation allowed);

Treatment will be required during the first year, with timing to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the first year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Second-Year Monitoring**. During the second year, beginning one month from eradication efforts monitoring will occur every other month. One quantitative survey will be performed during the second year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the second year:

  -- 80-percent reduction in coverage of live castor bean, tree tobacco, and Spanish sunflower (5-percent deviation allowed);

  Treatment will likely be required during the second year, with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the second year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG.

- **Third-Year Monitoring**. During the third year, beginning one month from eradication efforts monitoring will occur every quarter. One quantitative survey will be performed during the third year to determine growth by re-sprouting plants or re-colonization. The following performance standards will be achieved at the end of the third year:

  -- 100-percent reduction in coverage of live castor bean, tree tobacco, and Spanish sunflower (0-percent deviation allowed);

  Treatment will likely be required during the third year (though substantially reduced), with timing and method to be determined by the project biologist based upon phenology of the treated plants and the potential presence of resident or migratory special-status species. At the end of the third year, a report summarizing the success of the eradication efforts will be prepared and submitted to the Corps and CDFG. If treatment is required during the third year, monitoring will be performed during the fourth year to verify that castor bean, tree tobacco, and Spanish sunflower have been removed as set forth above.

2.10 Monitoring Methods

A variety of monitoring methods are appropriate to use in determining success of the eradication program. Appropriate methods include standard vegetation transects, use of high-resolution aerial photographs, or in some instances, the releve approach (Mueller-Dombois 1974). The approach used at any given site will be dictated by the density and distribution of giant reed, tamarisk, and/or pampas grass prior to implementation of eradication efforts. In all instances, direct visual inspection on a regular basis will provide the most reliable and meaningful information. The annual quantitative sampling will provide important information regarding trends but direct observations of treated areas will be a key component of any eradication program. Under any monitoring regime, it will be necessary to accurately record the pre-removal conditions to provide a baseline against which subsequent years can be measured.

2.10.1 Aerial Photographs

For areas where giant reed, tamarisk, or pampas grass are particularly dense, making access difficult and performance of vegetation transects impossible, aerial photographs will be used to monitor the performance of specific sites. The use of aerial photographs will require that annual flights with low-altitude photographs of target areas obtained. Where this method is employed, walking transects will be performed and the percentage of untreated, re-sprouting, or re-colonizing giant reed or pampas grass will be recorded. All surviving giant reed, tamarisk or pampas grass will be marked on maps or flagged in the field for future treatment.

2.10.2 Vegetation Transects

For areas that are accessible, sampling will be conducted using the point-intercept sampling method. This sampling method is based on a 50-meter long point-transect centered in a 50-meter by 2-meter belt plot. At each 0.5-meter interval along the transect (beginning at the 50-cm mark and ending at 50-meter) a point is projected vertically into the vegetation. Each living/surviving giant reed and/or pampas grass intercepted by the point will be recorded, providing a tally of hits for these species. Percent cover for each invasive species can be calculated.

2.10.3 Releve Method

For areas of low-density infestations of giant reed or pampas grass, it may not be possible to detect many of the individuals of the giant reed, tamarisk or pampas grass on the photographs. Similarly, transects may miss many of the individuals. In such cases, the releve approach, which depends on visual estimates by trained vegetation ecologists can be used. Similar to the approach used with aerial photographs, this method requires percent estimates of living, surviving and/or recolonizing giant reed and/or pampas grass. When using this method, all individuals subject to future treatment should be marked with flagging tape so as not to be missed by personnel responsible for treatment/eradication.

CHAPTER 3: INTRODUCED VERTEBRATES

3.1 Background for Invasive Animals

As discussed in the invasive plant section above, biologists consider exotic, or non-native, species to be one of the greatest threats to ecosystem function. Many experts believe the threat to be at least as severe as habitat loss. In terms of exotic vertebrates, RMV has a nearly full complement of the exotic vertebrates known to occur in Orange County. Many of the introduced species appear to have a relatively innocuous and do not appear to be obviously detrimental to the native fauna. However, some exotic species are known to pose a serious threat to the persistence of several native species of amphibians and birds. While most of the exotic vertebrates present on RMV are aquatic, including the bullfrog (*Rana catesbeiana*) and several species of fish, there are also four mammals and four bird species that have become well established.

While exotic mammals on the ranch appear to be having little negative impact on native populations, some introduced birds, amphibians, and fish are thought to be part of the root cause behind the federal endangered species listing of the least Bell's vireo (*Vireo bellii pusillus*), southwestern willow flycatcher (*Empidonax traillii extimus*), coastal California gnatcatcher (*Polioptila californica californica*), arroyo toad (*Bufo californicus*), and California red-legged frog (*Rana aurora draytonii*). Several amphibian declines in the western United States have been associated with introduced aquatic predators (Doubledee *et al.* 2003). Furthermore, several Orange County species of now rare to uncommon, but currently unlisted, amphibians and reptiles (e.g., western pond turtle, red-sided garter snake, two-striped garter snake, coastal glossy snake) are thought to have suffered from population declines as a result of exotic amphibians and fish. The two exotic vertebrate species that pose the most serious threat to the greatest number of native species on RMV at this time are the bullfrog and the brown-headed cowbird (*Molothrus ater*). Crayfish (*Cambarus clarkia*), which are common in San Juan Creek and portions of Gobernadora Creek, also pose a threat to the arroyo toad and are addressed in this plan in conjunction with the bullfrog, as bullfrog control efforts would also serve to control crayfish.

Although predation by introduced bullfrogs is only one of the factors negatively impacting native populations, it is one that can no longer be ignored. While red-legged frogs have not been observed on RMV since the mid 1960s, the impact of bullfrogs on this species has been well documented in other locations throughout California (Jennings and Hayes 1985). Several experiments, field studies, and observations have found red-legged frog abundance to be negatively correlated with the presence of bullfrogs (Doubledee *et al.* 2003). Of greatest concern at this time is the impact that bullfrogs are having on arroyo toad populations within the San Juan Creek and San Mateo watersheds. Loss of habitat, coupled with habitat modification, degradation and loss in central and southern California, as well as predation from introduced aquatic species, caused arroyo toads to disappear from about 75 percent of previously occupied habitat in California (Jennings and Hayes 1994).

Brown-headed cowbirds, which lay their eggs in the nests of other species, have been shown to significantly lower productivity in several species of songbirds, including least Bell's vireo (USFWS 1998). Cowbirds also parasitize willow flycatcher (Sogge *et al.* 1997) and California gnatcatcher nests. Although cowbird parasitism nearly always causes lowered individual productivity, the overall range-wide impact to flycatcher and gnatcatcher populations appears to be negligible. However, when there are only a few breeding individuals, as is the case of the willow flycatcher on RMV, the effects of brood parasitism are obviously detrimental.

Arroyo toad breeding distribution is potentially affected by the presence of crayfish in San Juan Creek. Any future detailed survey of arroyo toad populations in San Juan Creek should also survey for the presence of crayfish. The arroyo toad and crayfish evolved independently of each other suggesting that arroyo toad larvae may be considerably more vulnerable than bullfrog tadpoles, which share the same historic distribution with crayfish. Arroyo toad tadpoles being relatively small detrital feeders are more vulnerable to crayfish predation than the huge algal feeding bullfrog larvae. As discussed below under Section 3.5, eradication efforts aimed at controlling the bullfrog will also serve to control crayfish.

This section of the invasive species control plan is intended to lay out the groundwork for controlling, and in some cases hopefully eliminating, the most threatening exotic animal species present on RMV at this time.

3.2 Existing Setting

The current exotic mammal list on RMV includes Virginia opossum (*Didelphis virginiana*), black rat (*Rattus rattus*), house mouse (*Mus musculus*) and house cat (*Felis cattus*). The first three species are established throughout the ranch, with non-native grasslands as the habitat where these species are most often found. For the most part, black rats are uncommon while the house mouse is ubiquitous across the landscape. Opossum, black rat, and house mouse populations have been established in this area for probably over a century, and are thus unlikely to be successfully controlled. All three species thrive in urban environments and on the urban/wildland interface. At this time it is not clear what, if any, direct negative impacts these species are having on local ecosystem health. At the very least, these species may be potential indicators of degraded habitat quality.

The house cat is recognized as a major exotic predator of small native fauna, and has had a measurable impact on native southwestern California animal populations. Impacts of house cats on native fauna in Orange County have not been scientifically measured, but are believed to be significant. At present, healthy coyote and possibly mountain lion populations on RMV may be helping to prevent feral house cat populations from becoming established. Domestic house cats wandering onto ranch lands are also subject to predation by larger native carnivores.

Excluding the occasional parrot species escapee, there are currently four exotic bird species that inhabit RMV on a regular basis: brown-headed cowbird (*Molothrus ater*), European starling (*Sturnus vulgaris*), rock dove (*Columba livia*), and house sparrow (*Passer domesticus*). Only two of these species, the brown-headed cowbird and European Starling are known to have major negative impacts on native bird species. The cowbird is a nest parasite, laying its eggs in native species nests, while the starling competes with native birds for nest cavities. The rock dove and house sparrow are considered urban species, but they also live on the edge of natural habitats. While the house sparrow tends to be a bird of mainly urban environments, the rock dove may travel long distances away from urban areas. On RMV rock doves regularly visit agricultural fields in Cañada Gobernadora and Cañada Chiquita. However, the impact of the rock dove is probably positive since it feeds mainly on non-native plant seeds and is a regular prey item for several pairs of resident hawks.

Aquatic exotic predators currently known to occur on RMV include the bullfrog, mosquito fish (*Gambusia affinis*), catfish (*Ictalurus punctatus*), crayfish (*Cambarus clarkii*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*)), and bluegill (*Lepomis macrochirus*).

3.3 Problematic Introduced Predators on RMV

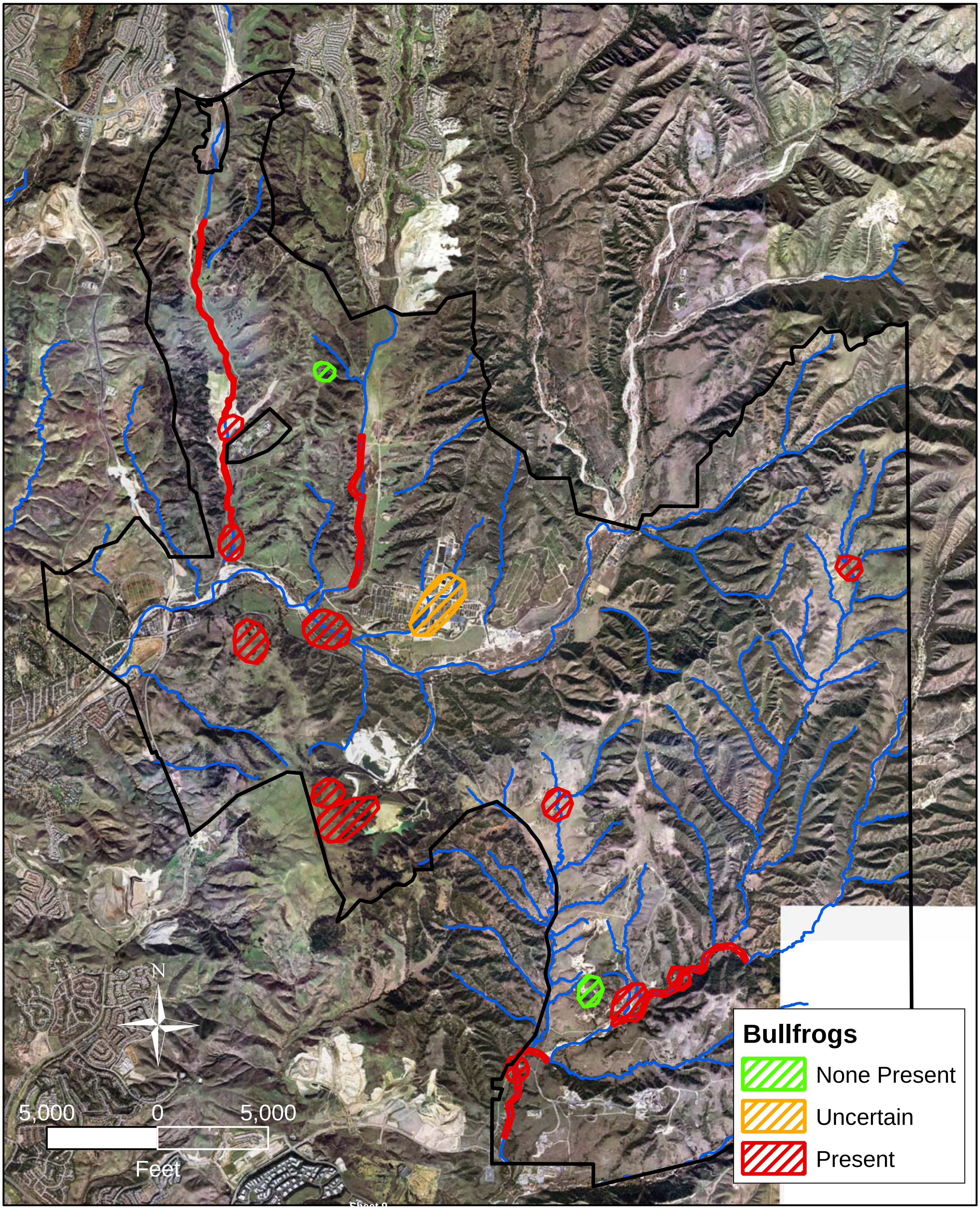
The following introduced aquatic and bird species appear to be having the most significant impact on local bird and amphibian populations, and thus will be dealt with in more detail.

Bullfrog. The bullfrog is a large amphibian with a voracious appetite that feeds on any living thing that it can fit into its mouth, from arthropods, fish, tadpoles, and snakes, to bats and birds. One individual was even observed attempting to swallow an adult American coot (*Fulica americana*) in Gabino Reservoir (R. Jackson, pers. com). It is also cannibalistic and commonly preys upon its own young. Native to southeastern United States, the bullfrog has since been introduced to the southwestern states where it has proliferated and expanded its range. This is explained in part by the fact that bullfrogs have few natural predators and can produce up to 20,000 eggs per female frog per year. Bullfrogs require permanent water for successful reproduction, and its larvae require two years to develop. Tadpoles require only perennial water and grazeable plant material; hence, transforming young can sustain a dense adult bullfrog population even if alternate prey is depleted (Rosen and Schwalbe 1995).

Bullfrogs have been blamed as part of the cause for amphibian population declines in much of western North America (e.g., Hayes and Jennings 1986, Leonard *et al.* 1993, Vial and Saylor 1993). The bullfrog has been implicated in the decline of the California red-legged frog (Doubledee *et al.* 2003), a federally listed threatened species and once a common southwestern California frog and resident amphibian on RMV. It has also been suggested that the bullfrog has played a role in the decline of the federally listed endangered arroyo toad, evidenced by the presence of individuals found in the stomachs of bullfrogs collected from San Juan Creek (R. Ramirez pers. comm.) and San Mateo drainage (J. Kidd pers. comm.). If allowed to go unchecked, bullfrogs will likely play a significant role in the continued downward population trend of garter snakes and pond turtles in Orange County.

The ponds and creeks on RMV support healthy populations of bullfrogs (*Figure 10*). When full, Gabino and Calmat (San Juan Creek) reservoirs each produce thousands of metamorphs annually (P. Bloom pers. obs.). Historically, bullfrogs likely arrived by dispersal from stock and irrigation ponds outside the ranch, but may also have arrived via fisherman using the larvae as bait, or simply as a result of someone's personal affinity for the call of the bullfrog. Most of the small to large ponds on the ranch are occupied by breeding bullfrogs, although some ponds are ephemeral and preclude successful bullfrog reproduction. Likewise, Gabino, La Paz, Cristianitos, Chiquita and Gobernadora creeks all contain bullfrogs, but usually only metamorphs. Permanent ponds within these drainages are occupied year-round by adults and represent the sources for most temporary ponds that dry up.

Brown-headed cowbird. The brown-headed cowbird is native to the central plains of North America, where it apparently co-evolved with the American bison (*Bison bison*). When the bison was essentially eliminated, the brown-headed cowbird's range and numbers expanded westward with the increase in cattle grazing and irrigated agriculture. While the previously mentioned exotic vertebrates are considered predators of native species, the brown-headed cowbird is known as a brood parasite. A brood parasite lays its eggs in the nests of other bird species, thus leaving all parental responsibilities to the host species. The end result is a much lower productivity for the native bird species. Together with riparian habitat loss, brood parasitism by brown-headed cowbirds is thought to be the principle reason for the decline of least Bell's vireo in southwestern California (USFWS 1998). The brown-headed cowbird regularly



RANCHO MISSION VIEJO

Bullfrog Distribution Map

GLENN LUKOS ASSOCIATES

FIGURE 10

parasitizes nests of many other songbird species as well, including the California gnatcatcher and willow flycatcher (Lowther 1993). Brown-headed cowbirds are found throughout RMV at any time of the year but are most problematic during the breeding season from about March 1 to August 1. They utilize the nests of many other songbirds in a wide variety of habitats including riparian and coastal sage scrub. During the non-breeding season cowbirds tend to form large flocks and are most common at Cow Camp and the Thoroughbred Farm. Several brown-headed cowbirds banded at Cow Camp have been recovered on the Irvine Ranch and in the Prado Basin of the Santa Ana River (P. Bloom pers. obs.).

European Starling. The European starling is another firmly established exotic bird species throughout the United States. Starlings are particularly abundant in urban environments that may provide many potential artificial nest cavities, and in wooded environments such as mature western sycamore groves that contain numerous natural cavities. During winter they often concentrate around livestock yards and agricultural areas.

The starling is a secondary cavity nester, meaning that it is incapable of creating its own cavity and thus relies on nest sites created naturally, or artificially by other avian species. As a result, starlings compete with native bird species for the relatively small number of woodpecker cavities, natural cavities, or artificial man-made structures (nest boxes, bridges, etc.). Starlings are aggressive birds that can cause the direct failure of native species' nests by adding sticks on top of the eggs and young. Populations of native obligate cavity nesters such as western bluebird *(Sialia mexicana)*, purple martin (*Progne subis*) and others, are thought to have declined due in large part to competition for nest cavities.

European starlings can be found throughout the ranch at any time of the year, but are particularly abundant at Cow Camp, and where nests are concentrated in mature western sycamores or among dwellings and other man-made structures. Starlings nest from about March 1 to August 15 and produce 3-5 nestlings per successful nest.

Fish (*bluegill, bass, mosquitofish, catfish*). Several exotic species of fish are known to occur in the ponds and streams on RMV, though there are currently no estimates available on population sizes. The direct effect of these fish on native species on the ranch has not been well documented. Fish most often eat the eggs and young of amphibians and reptiles, and, therefore, may be considered a threat to native species.

Arroyo toad breeding distribution is probably effected by the presence of crayfish in San Juan Creek. Any future detailed survey of arroyo toad populations in San Juan Creek should also survey for the presence of crayfish. The arroyo toad and crayfish evolved independently of each other suggesting that arroyo toad larvae may be considerably more vulnerable than bullfrog tadpoles which share the same historic distribution with crayfish. Arroyo toad tadpoles being relatively small detrital feeders are more vulnerable to crayfish predation than the huge algal feeding bullfrog larvae.

Possible future exotic predators. The African clawed frog (*Xenopus laevis*), which has spread through watersheds in northern and coastal Orange County (Bloom pers. obs.), could pose a serious threat to native amphibian populations on RMV if it becomes established. Measures, such as public education and removal of individuals, should be taken early on to prevent populations from expanding.

3.4 Introduced Predator Species Mapping and Results

3.4.1 Aerial Photograph Review

Aerial photographs of RMV show locations of many ponds and wetlands where bullfrogs are currently found (*Figure 10*). Also apparent are potential and existing brown-headed cowbird and starling locations. Aerial photos also show the juxtaposition of creeks and ponds, and may be used for easily measuring distances between breeding sites and potential dispersal sites. These measurements may aid in determining the likelihood of re-colonization of cleared ponds by nearby occupied sites. Aerial photographs are an excellent time-saving tool for examining existing and potential invasive species habitat, and will be used in combination with field checks to develop management strategies for the control of exotic species, as well as for documenting populations of sensitive native species.

3.4.2 Field Mapping and Data Collection

Field surveys of RMV have documented the presence of exotic species, as well as threatened and endangered native species. High concentrations of bullfrogs have been documented in stock ponds, creeks, and wetlands throughout the ranch. Brown-headed cowbirds likewise have been observed throughout the ranch, but are most abundant in and around Cow Camp and the Thoroughbred Farm. During the breeding season they may be more abundant near popular native bird breeding habitat (e.g., riparian corridors).

3.4.3 Results

San Juan Creek Watershed. San Juan Creek supports a sizable population of bullfrogs, as do several ponds within the watershed (*Figure 10*). The creek also supports one of the largest remaining populations of arroyo toads in southern California. Calmat reservoir annually produces several thousand bullfrogs, which then are able to disperse to Chiquita and

Gobernadora creeks. Bullfrog eradication in San Juan Creek will be more difficult than in creeks found in the Orange County portion of the San Mateo Watershed due to large bullfrog populations upstream in Cañada Gobernadora and within Casper's Park and extending at least 0.5 miles upstream into the Cleveland National Forest.

San Mateo Watershed. As mentioned previously, the source of bullfrogs for most creeks within this watershed is likely upper Gabino Reservoir and the old clay mine reservoirs in lower Gabino Canyon since these are the only permanent ponds in the drainage, and thus the only ponds where successful bullfrog reproduction can occur (*Figure 10*). Bullfrog metamorphs originating from Gabino Reservoir may be found in Cristianitos, Gabino, and La Paz creeks. Arroyo toad populations also occur in Gabino Creek from ¼ mile above the confluence with La Paz Creek and through the boundary of Camp Pendleton Marine Corp Base and beyond.

3.5 Eradication Approaches for Introduced Predators

An eradication program must be a permanent program and needs to be approached that way. Because of the widespread proliferation of bullfrogs and cowbirds, complete elimination of their populations from RMV may seem like an insurmountable task. Therefore, an eradication program needs to be initially approached with the goal of significantly reducing species' numbers, instead of entirely eliminating populations. However, the complete elimination of bullfrogs from some local water bodies is conceivable. Thinking in terms of 'management' or 'control' may make an eradication effort more plausible. Management efforts should be focused on those exotic species known to be most detrimental to native species currently inhabiting the ranch, especially those species listed as threatened or endangered. Efforts should also be concentrated in areas where impacts from these exotic species are known to be greatest. The following recommendations will focus mainly on bullfrogs and brown-headed cowbirds, with brief mention of other exotic species currently present on the ranch, and which may pose a significant future threat if not dealt with early on. It must be remembered that eradication efforts in suitable (optimal) habitat within core areas may leave survivors in unsuitable (suboptimal) habitat and outside core areas, which may re-invade the areas from which they were locally eradicated, thus stressing the fact that any eradication program must be on-going and wide-spread.

3.6 Introduced Predator Controls Methods

3.6.1 Bullfrog (*Rana catesbeiana*)

In order to successfully manage, and ultimately eradicate bullfrog populations, it is vital that efforts be viewed from a watershed perspective since there may be extensive movement between and among ponds. Eradication success, however, may be measured on a pond-by-pond basis. Ponds in close proximity should be managed as one unit and measures should be taken to minimize immigration from nearby streams and ponds. This may include erecting permanent or temporary structural barriers (fences) around managed ponds to prohibit re-colonization. Eradication efforts conducted during drought conditions when successful juvenile dispersal potential is lowest may be the most effective time for control efforts. In most cases, ponds prove to be the source population for nearby rivers and streams, so managing the pond sources may help to decrease bullfrog populations elsewhere (Doubledee *et al.* 2003). However, caution must be used in erecting barriers around ponds and streams so as to not adversely affect dispersal of native species, such as pond turtles and arroyo toads.

Public awareness should be raised on the issue of invasive plants and animals, in the form of signs, postings, and educational seminars, so that eradication efforts won't be destroyed by accidental and/or deliberate reintroduction of harmful exotic species. In addition, all private ponds and golf course ponds within the watershed need to be cleared of invasive species to ensure that cleared ponds will not be re-colonized by nearby occupied ponds. It must be understood that all future ponds will have drains or will be small enough so that they can be periodically pumped dry in order to maintain the bullfrog eradication program. A successful program would require cooperation from the public, from private housing associations, and from golf courses, as well as any person working in the field (biologists, ranchers, landscapers, etc).

The ultimate goal for a bullfrog management program is to eliminate bullfrog populations from the watershed. There are several possible solutions to the bullfrog problem. Most methods are time-consuming and costly, and therefore should be executed only after rigorous small-scale field experiments and testing are completed. In addition, for maximum effectiveness, each method needs to be timed with the appropriate periods of the bullfrog's life cycle. All methods should be used with care so as to not adversely affect native amphibian and reptile populations. The following are potential methods that could be used to eradicate bullfrogs:

> *Shooting:* the goal would be to shoot individuals from all age groups, metamorphs to adults; activities, would be conducted at night using a spotlight, and shooting with small caliber pistols and rifles using pellets and bird shot (steel).

Dip nets: bullfrogs will be individually swept up using hand nets.

Gigging: activities would be performed at night using a spotlight; individuals would be speared with multi-pronged harpoons.

Gill nets: a large net would be positioned vertically underwater to catch individuals, which would be retrieved several times per day; net mesh size would be rotated regularly and nets relocated if necessary.

Seine: pertains again to catching frogs in a net, but this method requires dragging the net through the water, as opposed to a stationary net; different gauged nets can be used to target different age groups.

Pond draining: this would consist of temporarily draining all of the water from a pond, then killing all bullfrogs and larvae left behind; depending on the season, the banks of the pond would also be searched for burrowing adults.

Structural barrier around ponds: this should be done in conjunction with pond draining; a tall silt fence erected prior to dormancy period will prohibit bullfrog movement in and out of pond area as the ponds drain; adults caught along fence line will be killed. Pitfall traps along the fence line would also help to capture individuals on the move. Efforts would also be made to dig up and kill burrowing adults and young.

Sifting water for eggs: a fine sifter or net can be used to extract identified bullfrog egg masses from ponds; this would be a key measure in reducing reproductive output.

Chemicals: such as Rotenone (derived from an aquatic plant), to be added to the water; used most affectively on the larval stage. Preferably use in ponds that no longer contain native species.

Electroshocking: stun and/or kill bullfrogs, then scoop them from the surface.

Bullfrog traps: experiment with different types of traps and lures; bullfrogs may be lured by calls from other species.

Bullfrog eradication efforts are expected to substantially reduce the number of crayfish within San Juan Creek and Gobernadora Creek, where they have been observed. Crayfish are recognized predators of amphibian eggs and their larvae and can contribute to population declines. Most of the methods noted above for bullfrog control would also eliminate crayfish by means of gill netting and trapping, particularly when the streams begin to dry up and the crayfish are forced into smaller and shallower pools. It might also involve electro-shocking and Rotenone. Fortunately, the female crayfish carries her eggs with her on the ventral side of the tail suggesting that crayfish population control may be more easily dealt with than bullfrogs, which lay their eggs in the water and are far more mobile.

3.6.2 Brown-headed cowbird (*Molothrus ater*)

Whereas the ultimate goal for bullfrogs would be complete extirpation, the goal for cowbirds would be to manage, or control, their populations to a level in which passerines can reproduce successfully and maintain high productivity levels. The most popular and effective method of managing cowbird populations is to trap and remove individuals from the population using modified Australian crow traps. Traps would be strategically placed in areas where cowbirds visit regularly, and preferably within or near host species habitat (especially sensitive species habitat) in order to target individuals that are having the greatest direct impact on native songbird populations. Trapping efforts must be ongoing since individuals from outside the trapping area will continue to move into target areas. Mist netting may be employed in concentration areas such as Cow Camp and the Thoroughbred Farm in summer and early fall months. Aerial photographs and field data will help to locate target trap sites based on cowbird numbers observed and on habitat type.

Thus far, the preferred breeding season locations for traps on RMV would be in Chiquita Canyon (3 traps), Gobernadora Canyon (3), Cristianitos Canyon at Northrop Grumman (1), and along San Juan Creek (5), particularly with a continued non-breeding season focus around Cow Camp and the Thoroughbred Farm.

All traps would remain open and monitored throughout the breeding season (March – mid July) to target breeding adults and to minimize exposure of native species to parasitism events. Trapping past the breeding season (until September) would target fledgling cowbirds, which would help to reduce the number of future breeders and the local population in general. The first 2 years of trapping would have experimental components, with all traps operating at least from March through September. Subsequent years would involve only those traps that captured a significant number of individuals per season. Some traps may be moved to new locations to ensure maximum capture rates.

3.6.3 European Starling (*Sturnus vulgaris*)

Due to their widespread distribution in the region and their high dispersal ability, complete eradication of European starlings from RMV would be an impossible, and basically unnecessary, task. The goal for starling population management on the Ranch would be to minimize their impact on native bird species. This may be accomplished by taking steps such as trapping individuals in cowbird traps and mist nets at known concentration areas such as Cow Camp. Providing species-specific nest boxes that restrict use by starlings (e.g., small holes) may help boost native populations.

3.7 Implications of Control Methods for Introduced Predators

Using model simulations, Doubledee *et al.* (2003) concluded that shooting adult bullfrogs in combination with pond draining was successful at decreasing bullfrog densities. Although these results were based only on computer model simulations, these methods are worth testing in the field, particularly in an area where the bullfrog threat on native amphibian populations is high. Decreasing bullfrog densities on RMV may increase arroyo toad densities in some areas, although the results may not be immediately apparent. Ongoing monitoring of bullfrog and arroyo toad populations will be necessary to discern the actual benefits of particular management methods in different locations.

In some areas, cowbird trapping has successfully removed enough breeding individuals from the population to reduce parasitism rates and thus allow native songbird populations to increase. This is most clearly exemplified by the long-term cowbird trapping effort conducted on Marine Corps Base, Camp Pendleton. This cowbird management effort resulted in a dramatic drop in nest parasitism (from 47% of nests parasitized in the early 1980's to less than 1% by 1990), and a subsequent dramatic increase in productivity of least Bell's vireo (USFWS 1998). Similar results have been documented in other areas as well, such as the San Luis Rey River, San Diego River, and Santa Ana River. Favorable results can be expected to occur on RMV once a management program has been initiated and secured.

Negative impacts of bullfrog pond management may include incidental netting of non-target species, as well as inhibiting movement and dispersal of native species by placement of fencing around ponds. However, close attention to netting activities and frequent checking of fence lines and pitfall traps will minimize adverse effects on non-target species. Barriers may be removed and replaced regularly depending on season. Frequent checking of cowbird traps, as well as keeping them well equipped with food, water, and shade, will minimize negative impacts to non-target species that inevitably enter traps.

3.8 Research Recommendations

More information is needed on local cowbird dispersal and movement in the breeding and non-breeding seasons, as well as their tendency to return to or remain in the same areas to nest (site fidelity). In addition to potentially eliminating several thousand cowbirds annually, a trapping program also offers the opportunity to band and release individuals in an attempt to learn more about survivorship and dispersal patterns. Therefore, a cowbird trapping effort on RMV should also include banding and releasing a large sample of individuals each year (numbers released to be based on numbers captured), in the hopes of obtaining recaptures and recoveries over an extended period of time.

In conjunction with any large-scale effort to manage bullfrog populations on RMV, there should be research projects directed at dispersal behavior, movement patterns, and over-wintering behavior of adult and young bullfrogs, as well as measuring the effectiveness of eradication methods. Dispersal and movement of amphibians are best studied by marking individuals with pit tags and/or radio-tags, and then subsequently monitoring their locations throughout the year. Eradication method experiments should be conducted within a small area (single pond(s)) before deciding which method to use on a large-scale effort. Experiments with new and innovative bullfrog trapping techniques should also be undertaken.

Similar approaches are recommended for the crayfish to ensure that an adequate understanding of their distribution within the RMV Open Space is developed. During surveys for bullfrogs, as well as during vegetation monitoring in wetland and riparian areas, crayfish occurrences should be mapped and investigated relative to densities and species composition. As more information is developed on potential impacts of crayfish within the RMV Open Space, additional measures may be added as part of the Adaptive Management Program.

Rigorous scientific monitoring designed to determine the effectiveness of exotic species removal programs should be implemented. In addition, the opportunity that management programs, such as these, offer to gain information on species behavior and ecological relationships should not be overlooked. Specific research questions and experimental designs may be determined after the initial year of management programs on RMV. Research project development will be an ongoing goal and consideration as invasive species management programs are established and progress.

CHAPTER 4.0 NON-NATIVE ANTS

4.1 Introduction

Non-native ants, like the Argentine ant (*Linepithema humile*), are most often viewed by humans as a simply a nuisance pest. Concerns about ants are typically from the perspective of how they affect humans and human activities like household invasions and agricultural crop damage. In recent years the aggressive Red Imported Fire Ant (RIFA) (*Solenopsis invicta*) has managed to expand its invasion of the southern United States in to southern California. This was a highly publicized event due to terrible toxic multiple stings these ants deliver when disturbed.

What is less often recognized is the affect non-native ants have on native plant and animal communities. Argentine ants have managed to monopolize resources and kill off many ants native to California, this has resulted in declines of coastal horned lizards since native ants make up half of their diet (Case *et al.* 2002). Recently published work suggests that the Argentine ants in California are all from a "supercolony" (Mc Donald 2000). The genetic similarities keep the ants from fighting each other as they do when they are from separate distinct colonies, which keeps their numbers in check (Mc Donald 2000). They tend to occupy urban areas and consequently urban sprawl is bringing them ever closer to natural sensitive habitats where they adversely impact native animals.

The RIFAs have similar destructive abilities, like Argentine ants, but they tend to be more aggressive and lethal. These ants occupy both urban and rural areas and prefer to be near water sources such as, streams, lakes, ponds, and irrigation basins. As studies in Texas, where RIFA infestation is severe, have shown these ants affect wildlife and reduce biodiversity of native plants and animals (Jetter 2002). Researchers warn that if RIFA is allowed to establish in California the ecological cost to sensitive species will be great.

The encroachment of these non-native ants has substantial edge effects on native habitats and species, such as the extirpation of wildlife from portions of high quality habitats near urban areas (NCCP/SAMP Working Group 2003). Complete infestation of natural habitats can have large-scale severe ecological consequences in southern California native habitats.

4.2 Eradication Approaches for Non-native Ants

In general complete ant eradication is not a practical undertaking, especially, when dealing with invasive species, which tend to be very prolific reproducers and have large colony sizes. A more practical objective is to control their populations and prevent their spread into new areas.

Ant control generally has two distinct approaches. One approach is source or nest/mound treatment. This requires locating the colonies nest or mound and applying an insecticidal treatment in or around the nest. Delivery of the ant poison can be through a liquid drench treatment, dust or granule cover, or by fumigation. Ants must come in contact with the insecticidal agent and killing the colonies queen is imperative to success. Nest/mound treatment can be effective, but it can also be costly because it is labor intensive.

The second approach involves broadcast applications. This treatment involves the distribution of insecticidal bait over large infested areas. Baits work because ants share food and nutrients among one another. If food contains a slow-acting toxicant that is not detected it gets passed from ant to ant and eventually to the queen. Baits can also be applied in a source treatment at the nest/mound. Specific site conditions will dictate which treatment method will be appropriate to use. With any of these treatments special consideration must be given to sensitive wildlife and plants that may be affected by the treatments, as well as the affects on non-target native ants and/or other beneficial insects.

It is also important to apply treatment at optimal times. Ant populations are low during the winter and build during the warm months of spring and summer (University of California Cooperative Extension Ventura County 2003). If baits are used, the best control usually results when temperatures are between 70 and 85 F, when ant workers are most actively foraging for food (Orange County Fire Ant Authority 2003). Control with drench treatments is more difficult to achieve during very hot summer months because ants remain deep within their mounds and are hard to reach with liquid insecticides (Apperson *et al.* 1993).

4.3 Non-native Ant Species Targeted for Control

4.3.1 Argentine Ants (*Linepithema humile*)

Argentine ants were introduced to North America via coffee and sugar shipments to New Orleans about 1890. They have spread to the east from the Carolinas south to Florida and west through Texas to California (Insecta Inspecta World Argentine Ants 2003).

Argentine ants are small bodied, about one sixteenth of an inch long, and are dark-brown to black in color. They are very social and live in large colonies functioning as one interdependent group. Colonies can consist of hundreds to thousands of members. These ants have more than one queen per colony, typically there are about eight queens for every 1,000 workers (Insecta Inspecta World Argentine Ants 2003). New colonies form from old ones when a queen leaves with a band of workers to start a new one. Argentine ants usually occupy the top six feet of soil. They prefer moist soil underneath buildings and sidewalks. Food sources and temperature dictate where they create their nests.

Argentine ants drive out or kill native ants of a newly invaded territory. In southern California, for example, this has greatly reduced the numbers of the coastal horned lizard which predominately feeds on native harvester ants. Argentine ants feed on seeds within the seed beds and they can damage crops by gnawing on ripening fruit. They are aggressive with other insects and are known to eliminate native termite colonies, paper wasps, and carpenter bees. These ants are even capable of driving off poultry from their nests and killing newly hatched chicks (Insecta Inspecta World Argentine Ants 2003). As urban development brings these aggressive ants closer to native habitats the threat of their aggressive behavior is more severe, particularly when considering the delicate nests of native songbirds and other sensitive animal species that can fall prey to these scavenging ants.

Control methods appropriate for Argentine ants in natural or rural settings employ a combination of methods. Because these ants thrive in urban areas and nest in moist soils under structures, development adjacent to natural areas brings them in closer proximity to these sensitive areas and increasing their likelihood of invading natural habitats. These ants prefer the moist soils that urban runoff provides. Zones between urban and natural habitats where there is little moisture may act a barrier for the ants and inhibit them from invading the natural areas. An interface zone around the RMV Open Space may inhibit the encroachment of invasives from developed and fuel modification areas. These interface zones can be planted with native drought resistant vegetation.

For specific control problems, Argentine ants can also be controlled by sprays and insecticidal baits, granules, and dusts as detailed below in the fire ant control section below. Treatment for this species can be done in tandem with a fire ant treatment regime.

4.3.2 Red Imported Fire Ants (*Solenopsis invicta*)

Red Imported Fire Ants (RIFA) are native to the lowland areas of South America. They were first introduced to the southeastern United States around 1930. Their aggressive behavior overwhelmed native fire ant species and they spread at a rate of more than 100 miles per year (Jetter 2002). They have spread throughout the south and are now in parts of southern California and areas within the Central Valley.

The Red Imported Fire Ant is a small ant ranging from one eighth to one quarter inch in length and is dark red in color with a dark brown shiny abdomen (Orange County Vector Control 2003).

Known for its painful bite the ant has one pair of toothed mandibles for grasping the skin before stinging. This ant is considered dangerous because, unlike most ants, this species delivers a venomous sting, which is relatively toxic and potentially lethal to pets, wildlife, livestock and sensitive humans (Orange County Vector Control 2003). The ants nest in the soil of open areas, pastures and agronomic fields, but are found occasionally in wooded areas (Cooperative Agriculture Pest Survey Program 2003). Several hundred thousand worker ants live in large mounds which conceal a nest. When nests are disturbed ants swarm out and sting the animal or human responsible for the disturbance. They prefer warm temperatures and moist locations and can be found in areas such as, golf courses, irrigated farmland, housing developments, and near ponds, lakes and streams (Jetter 2002).

Aside from the tremendous agricultural damage RIFAs can cause the ecological damage is also severe. They are omnivorous indiscriminate feeders and their usual diet consists of insects, spiders, myriopods, earthworms, and other small invertebrates (Cooperative Agriculture Pest Survey Program 2003). However, it has become increasingly evident that RIFAs are preying on the eggs and young of many sensitive wildlife species including other insects, birds, young mammals, reptiles, and amphibians (Jetter 2002). It is estimated that 58 of California's 79 endangered animal species either are directly susceptible to predation by the ants or indirectly affected by competition for food resources (Jetter 2002). They also feed on plants. They are known to devour saplings, seedlings and eat the seed of 139 species of native wildflowers and grasses (Lockey 1996).

Fire ant mounds are conically-shaped domes of soil. The average mound is one foot tall, but mound size its proportional to the size of the colony. Treatment over large areas is both difficult and impractical; however, there are some localized treatments that can successfully control fire ants in limited areas. Individual mound treatments can be effective however time consuming and costly. One such method is to flood or drench the mound with large volume of liquid containing an approved contact insecticide (Lockey 1996). The drench solution should be applied at a rate of approximately one gallon per six inches of mound diameter (Apperson, *et al.* 1993). It is important that enough liquid be used to ensure contact with the queen, who is often deep within the colony. Therefore saturating the mound and wetting the ground two feet around the mound is advised. Insecticidal surface dusts or granules spread on and around the mound have a limited effect on the colony, and the queen may never come in contact with these dusts or granules. Fumigants are also commercially available, but can be dangerous if not handled properly.

Broadcast treatment usually involves the use of baits or sometimes spraying. The bait is treated with a toxicant such as a slow-acting insecticide, an insect growth regulator, or a metabolic inhibitor (Apperson *et al.* 1993) (Lockley 1996). Baits containing only a stomach poison require several applications each season to control newly emerging workers when the if the queen is not killed, and when new colonies arise. Baits containing only and insect growth regulator can provide year long control with one or two applications when followed in 7-10 days with liquid residual application to kill the active foragers (Kills Fire Ants 2003). New baits containing avermectin, which acts as both an insect growth regulator and slow-acting stomach poison, provide good control without liquid application (Kills Fire Ants 2003). The bait is found by the foraging ants and taken back and feed to the colony. The advantage of this method is that the mounds don't have to be located the bait can be distributed in general areas and the ants will locate it which cuts down on labor costs per acre. The disadvantage is that baits deactivate if they get wet or are exposed to high temperatures and baits are slow-acting.

4.4 Implications of Control Methods for Non-native Ants

Although complete eradication of undesirable destructive non-native ants is impractical, control and exclusionary efforts to prohibit or lessen their negative impacts on native plants and animals within RMV is ascertainable. Native habitats of RMV will benefit from control of Argentine ants and RIFAs for several reasons. Control efforts will reduce predation pressures on native plants, seedlings, and seeds. RIFAs are especially destructive to plants particularly agricultural crops, they feed on bark, cambium, fruit, seeds and roots causing tremendous economic losses (Jetter 2002). Perhaps even more devastating, as increased evidence suggests, is their potential to reduce biodiversity of native plants and animals (Jetter 2002). RIFAs ability to out compete other insects and be formidable predators on bird, reptile, and amphibian hatchlings or other young animals can cause ecosystem wide devastation if they are allowed to become established. Control and exclusion of RIFAs and Argentine ants, which can be similarly harmful, from wildlife areas such the RMV Open Space is imperative to maintaining balanced ecosystem functions.

Impacts of non-native ant control are treatment type dependent. A contact insecticide can be delivered via a liquid solution (spray or drench treatment), a dust powder, granular form, or in a gaseous phase as a fumigant. Primarily contact insecticides are not species specific and therefore can be harmful to beneficial insects and other organisms. Baits which are coated with either a growth inhibitor or a stomach toxicant can be less harmful to other species.

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