March 15 Report from BRRC on the Clark County MSHCP

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Preface

What follows is a March 15 “progress” report to Clark County on activities and recommendations from the BRRC at UNR in their capacity as AMP contractor for the Clark County MSHCP. All subreports herein are preliminary, incompletely edited, and not to be quoted - even as progress reports. Subreports included in this progress report provide a glimpse into the breadth of activities by BRRC as part of its role in the MSHCP rather than to provide finished documents containing mature scientific conclusions or well-reviewed recommendations for the MSHCP. This report provides a glimpse into BRRC activities bearing on adaptive management for the MSHCP, and indicates what is being pursued and what will likely be final products from those activities as well as how those activities are important to the AMP process in the CC MSHCP.

Introduction

This AMP contractor has been contracted to conduct a set of projects which has been developed by the Biological Resources Research Center of the University of Nevada, Reno, with extensive interaction with Clark County, the Implementation and Monitoring Committee, various State and Federal government agencies, and the U.S. Fish and Wildlife Service to fulfill the AMP requirements of the Clark County Multiple Species Habitat Conservation Plan (Plan). This set of projects focuses research on specific areas defined in the Plan. Additionally, the AMP contractor has attended meetings and provided scientific advice to the County in support of the creating a scientific basis for adaptive management of the MSHCP.

Many of the species covered or mentioned in the Plan are poorly known to science. Many of the potential threats discussed in the Plan have not been adequately documented by appropriate scientific studies, and some of the management actions prescribed by the Plan have not been shown to be effective. The Service states "an adaptive management strategy is essential for HCPs that would otherwise pose a significant risk to the species at the time the permit is issued due to significant data or information gaps. Possible significant data gaps that may require an adaptive management strategy include, but are not limited to, a significant lack of information about the ecology of the species or its habitat, . . .uncertainty in the effectiveness of habitat or species management techniques, or lack of knowledge on the degree of potential effects of the activity on the species covered in the incidental take permit."[1]

One purpose of the AMP contractor is to inform the I&M Committee and the Fish and Wildlife Service so that they can make decisions based on the best available scientific information. BRRC has provided scientific expertise to carry out the research designed to fill the information needs of the I&M Committee and the AMP requirements of the Service. The Plan (p. 2-305 in Table 2-14) specifies dates by which certain reports will be due. This report is the first of those reports scheduled for delivery by March 15 of even numbered years. The purpose of this report is to begin the cascade of adaptive management change within the MSHCP.

The MSHCP defined five specific areas of research and work for the BRRC in the first biennium. These have been developed into ongoing multiple task components of the AMP. Additionally, partner agencies have asked the BRRC to initiate additional projects in the second biennium of the Plan. Finally, the AMP contractor has served as consultant to Clark County in support of a strongly scientific adaptive management program. The following are reports of those contracted activities and the additional activities requested of the BRRC as part of being the AMP contractor.

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1 U.S. Fish and Wildlife Service. 2000. Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process. Federal Register 65: 35252. June 1, 2000.

Spatial Analysis/Database/GIS (SADG)

The goal of SADG has developed into two subprojects. The original subproject is to create a functional digital database of biological resources (DDBR) and their locations in Clark County. BRRC is developing a consolidated database that can be queried by request (for sensitive data) and queried over the web (for general distribution, management, and planning data). The second subproject is to develop an implementation database (ID) for projects that are part of the MSHCP. This latter database is being used for a variety of purposes including "compliance monitoring" of contractors working for the MSHCP.

In the first biennium, we have purchased all hardware and software, and we have staffed our GIS laboratory. The products that we produce from this laboratory are excellent, and we now have the ability to serve the GIS needs of the MSHCP.

DDBR Subproject

The DDBR is a large database the development and maintenance of which depends upon collaboration among all Plan participants. This database has become a tool for the MSHCP and adaptive management. To the extent possible, data are being put into GIS format for visual effectiveness and GIS analyses. These data have become important to scientists, managers, and Clark County officials who need additional information as part of making policy decisions. In particular, the database is being developed as part of the activities of working groups, and the database is becoming the backbone of discussions and decisions made as part of Plan and AMP. The database is being used to conduct analyses of the distribution of biodiversity and of particular species that need to be tracked under the MSHCP. These analyses will become an information base for management policy decisions and future research. The AMP database and associated spatial analyses provide the scientific basis for decision making, elevating decisions from guesses and politically motivated prescriptions to decisions influenced by objective criteria.

Each of the land management agencies has a GIS shop to service their immediate needs. Nevertheless, each agency has also expressed the desire for additional help with GIS. The existence of a fully functional GIS database is assumed in most of the proposed conservation actions (Section 2.4.2.6). For example, Threat 101 identifies unpredictable population threats to species with limited distributions. The proposed conservation action involves monitoring the populations with respect to geographical information. This is only possible on a large-scale if GIS technology and a database are available.

The GIS shop has been set up in the State Division of Forestry which requires only that we collaborate with them on development of their computer facilities in the Las Vegas Office. Thus, we share expertise and equipment with NDF in ways that make us a good partner in this facility.

To date virtually all projects are still being developed. Most projects are associated with working groups, but some projects associated with research conducted by BRRC in support of the MSHCP. Finally, some projects are not explicitly MSHCP projects, but are projects important to the County (e.,g, Clark County air quality projects). A log of projects and people associated with those projects is given in Table 1.

Table 1. GIS projects.

BRRC/MSHCP Database Project

Agency/Partners	Proj-ects	Contact	#ofmeets	Project Description	Draft Maps	Final Maps	Processed Data	Start Date	Status
BOULDER CITY	BCOR	Robert Puterski		Boulder City Open Roads Project			hard copy to arcinfo file		Finished
	BCORP1	Mike Creathbaum	3	Boulder City Open Roads Project area map	3	1	digitized roads		Ongoing
BRRC/I&M COMMITTEE	MRP-2	Dick Tracy	3	Muddy River Project Areal Photo maps	4	4			Finished
	MRP-1	Joan Wright	2	Registering NDOT arial photos of Moapa area					Finished
	MDTM-1	Ron Marlow	4	Mojave Desert Tortoise Monitoring maps for techs-1	24	1	GPS data		Ongoing
	CCLEP-1		3	Low elevation plants with The Nature Concervancy			MSHCP specific plants out of nnhp database		Ongoing
	MDTM-1		1	Styrotort Training Lines: Mojave Desert Tortoise	12		GPS data; digitized roads	2/19/2002	Finished
	SAND	Bob Elston	2	Mapping Sand Areas in Clark County	60				Ongoing
	DTD	David Hyde	2	Desert Tortoise Disease Study	5	2	digitized pen areas		Finished
	MDTM-4	Rachel Loubeau	3	Large Scale Translocation Study site	4		digitized BRRC tech tortoise roads, in Jean		Ongoing
	MDTM-3	Nancy Herms	2	Mojave Desert Tortoise Monitoring	3	1	Gps tortoise Pens		Ongoing
	PA	Jessica Bunkers	2	Pitfall Arrays Project, field study guides update			scanned in photos	1/20/2002	Finished
	CCRP	David Charlet	11	Clark County Road Project	40	40	Many clipped CC specific coverages		Ongoing
	CCGAP		3	Clark County GAP groundtruthing			Created color .avl for CC GAP		Ongoing
	MRP-4		3	Muddy River Project arial photo maps with "Stanford" butterfly points			GPS data		Finished
	MRP-5		1	Muddy River Project			GPS data		Ongoing
	MRP-6		3	Muddy River Project	4	2	Digitized Vegetation Polygons for bird project		Finished
	CCV-GAP		3	Clark County Vegetation Types according to GAP		4			Ongoing
	CRVDC		1	Carson Range Vegetation according to Dave Charlet		8		2/8/2002	Finished
	PA	Stephanie Franklin	2	Roads for Jean Pitfall arrays (Mike Sears)	3		Digitized roads for techs in Jean Dry Lake area	2/15/2002	Finished
	SAND		1	Mapping Sand Areas in Clark County			GPS data	2/7/2002	Ongoing
	PP	Cali Crampton	2	Phainopepla Project-2000	15	4	GPS data		Ongoing
			1	Phainopepla Project-2000 and 2001	10	1	Random points generated		Ongoing
			1	Phainopepla Project-2000 and 2001	4		GPS data		Ongoing
			1	Phainopepla Project-2000 and 2001	8	1	Random points generated		Ongoing
			1	Phainopepla Project-2002	8		GPS data	2/9/2002	Ongoing
			1	Phainopepla Project-2002	17		GPS data	2/16/2002	Ongoing
DEPT. OF INTERIOR		Ray Ahlbrandt	3	Phainopepla Project-2002			Registering ortho photos to Nad83	1/28/2002	Ongoing
	PA	Mike Sears	2	Pitfall Arrays			GPS data		Finished
	MRP-3	Erica Fleishman		Muddy River Project butterfly points for Moapa	4	2	Gps data		Finished
	WEEDTWG	Maria Ryan	2	Clark County all weed data for 2001	2			2/21/2002	Ongoing
CC	CDS	Brian Engbretson	1	Conservation Dist.of Southern NV serving CC, Nellis Dunes Air Quality Basin	1			1/2/2002	Finished
	N	Brian Engbretson	1	Conservation Dist.of Southern NV serving CC, Nellis Dunes Air Quality Basin	6			2/22/2002	Ongoing
DCNR-NV FORESTRY	NFD	Rob Ruffidge	2	Nevada Forestry Div. 3; Gapveg, DEM and Landuse Maps	3	3	Clipped coverages for NV Forerstry Div.3		Finished
	3CAMPEP	John Jones	1	Clark County AMP (low and high elevation) Endangered Plants	2	2	CC, MSHCP specific Plants		Ongoing
DCNR-NV PARKS	NPPR	Gary Rimby	1	Proposed Road Poject	2	1	digitized proposed "Moccasin" road		Finished
LVVWD	PP	Micheal Wallen		Phainopepla Project			WSA data for arial photos in Phainopepla areas		Finished
				Phainopepla Poject			arial photos in Nad27, 3 Phainopepla areas		Finished
	PP	CY Fernandez	1	Phainopepla Project					Finished
	LVWW	Liz Beckmore		Las Vegas Wash Weed Project, protocols			Draft of MSHCP Weed Protocol for CC Weed data		Finished
NRCS/NWAC	CCWDP	Dave Pickel	1	Clark County Weed Database Project (2 times a year)			GPS data and arcinfo files, Access database		Ongoing
THE NATURE CONCERVANCY	CCLEP-2	Teri Knight	2	CC Low Elevation Plants	4	1	Low elevation plants of concern: evaluation,watch, and covered		Finished
	MDTM	Sue Wainscott	2	Desert Tortoise Monitoring			Data CD created with DEM,Hillshade and GapVeg for CC		Finished
USFS	USFSSM-FT	Deb Couche		US Forest Service, Spring Mountains Fire Trails			digitized fire trails		Finished
	USFSSMWP	Kerwin Dewberry	1	US Forest Service, Spring Mountain Weed Project		2	created and attributed GPS point data		Finished
	USFSSMWP		2	US Forest Service, Spring Mountain Weed Project			Digitized, 7 1/2 minute card copy maps; poly and line data		Finished
	USFSSMWP		1	US Forest Service, Spring Mountain Weed Project			Digitize, Blue hard copy BLM cards and attribute		Finished
	USFSSMFMP	Mark Blankensop	1	US Forest Service, Spring Mountains Fire Modeling Project			Data CD created with DEM,Hillshade and GapVeg for CC		Finished
	USFSSMFMP	Lee Nelson	1	US Forest Service, Spring Mountains Fire Modeling Project			Received Data CD		Finished
USFWS	USF-WSWVP	Jeri Krugar	1	US Fish and Wildlife Service Weed/Vegetation Project			Data CD created with DEM,Hillshade and GapVeg for CC		Finished
	USFWSAM-WP	Debbie Johnson	4	US Fish and Wildlife Service Nevada Weed Project, Ash Meadows	2		GPS data, sent data to NWAC		Finished
	USFWSAM-WP	Cynthia Martinez	2	US Fish and Wildlife Service Nevada Weed Project, Ash Meadows	3	3	digitized/recreated plant data from copy of original, 11x 14 maps, times three		Finished
	USFWSAM-WP	Jodi Sawasaki (FWS)	1	US Fish and Wildlife Service Nevada Weed Project, Ash Meadows	3		polys created (incorrectly) from trackpoints		Finished
	MDTM-2	Phil Medica	4	Desert Tortoise Monitoring	8		GPS data		Ongoing
	MDTM-2	Phil Medica	3	Desert Tortoise Monitoring/NV	2		Select out of larger data set, create shapefile	3/5/2002	Ongoing
	MDTM-2	Ann McLuckie	2	Desert Tortoise Monitoring/ Utah side			Data sent to Ann Mcluskie in Utah, DEM, Hillshade and Gapveg for CC	1/8/2002	Ongoing
NPS									
BLM									
ENDOW									
NDOT									
CITIZEN INQUIRY	ACECA	Mark Trinko		ACEC Area (specific) map for offroad	1		Data provided by unamed USGS roads data		Finished

***ID** Subproject*

During the first biennium of the MSHCP, the BRRC was assigned responsibility for the technical aspects of implementation monitoring or keeping track of the implementation of projects conducted as part of the Plan. This includes projects paid for by the Plan and projects promised as ongoing actions by agencies that support the purposes of the Plan. Clark County has asked that all projects have quarterly reporting of progress in the implementation of the projects. The SADG lab is responsible for managing an electronic database of the implementation data that is accessible via the world wide web. Development of the ability to fulfill this additional responsibility requires creating a dynamic database that contains all descriptive fields that define the projects in the Plan.

We have established a working group with broad representation of the IMC. This group is helping guide the development of the ID. In the first biennium, we developed a static, flat file database with limited capabilities.

In September of 2000, we began transforming the ID database from a static database, consisting of a single file for each project, to a dynamic, relational database. This transition included changing the submission and data management interface from a manual process executed by the database manager, to an internet-based (live-entry) interface. During this transition and after receiving our first quarter of "live" data submission via the internet, we began to identify areas in which the database could improve in both user interface and content. We have instituted changes that address both of these areas in the following ways.

With the help of the MSHCP database subcommittee, we have moved most of the detailed information, which was until recently, reported quarterly (e.g. scope of work, procedures, location of activities, habitat, species included, management actions addressed, etc.) into the project descriptions. These items were indeed attributes of the project and were unchanging, and are now input to the database once each biennium. The Project descriptions now contain the information in Table 2.

Table 2. Descriptive fields for the Implementation Database.

Contract number	*Contractor*
Project number	*Project title*
Project funding	*Other funding sources*
Budget breakdown	*Invoicing schedule*
Scope of work	*Procedures*
Milestones	*Deliverables*
Management actions addressed	*Indices of success*
Locations of activities	*Landowner of Location*
Habitat/Ecosystem →	*Ecosystem threats and conservation actions*
Species covered →	***Species threats and conservation actions***

The quarterly reporting process currently consists of each contractor entering the Deliverables, Milestones, and Indices of Success that were detailed (by the contractor) in the Project description, and entering any new publications produced in that quarter. The reporting process is finalized by the submission of a final report, which can be submitted in any format (preferably PDF), which will be converted into Adobe PDF format, and included in the final quarter report submission.

We have taken steps to integrate the project descriptions, to correlate the reporting process with the management actions specified in the Plan, and to the conservation actions associated with the threats associated with both species and ecosystems as specified in the MSHCP. This allows Clark County directly to track the extent to which the 640 management actions, and the 258 conservation actions associated with the 48 threats in each the of the 232 species and 11 ecosystems as identified in the MSHCP. We have streamlined the project submission process to filter this complexity by filtering the management actions both by the contractor and by the action categories, to reveal only the pertinent management actions for each contractor. Similarly the conservation actions associated with threats are filtered by species and ecosystems, revealing only the relevant conservation actions. Focusing on the conservation actions for each of the 48 threats is paramount is bringing the biology back into each project. For example, it is easy for any project to claim that it is addressing the "problems facing small and isolated populations," but it is more precise to ask each contractor how, by identifying the conservation actions prescribed in the MSHPC, that they are addressing particular threats. We are also creating online "tools" to aid contractors in writing project proposals so that contractors can easily find the species, threats, conservation measures, and management actions that may be associated with their projects.

Finally, we have hand entered or verified all of the 1999, and 2001 biennial projects, such that Clark County can have a complete inventory of the projects for the last and current biennium. We are also accumulating all of the available literature with respect to general biology, life history, ecology, and conservation biology of each of the 232 species listed in the plan. We have begun gathering this literature with the priority of our efforts focusing on the species of concern, then shifting to evaluation species, and finally the watch list species.

A key adaptive change was made to the data tracked by the ID. We separated "milestones" from "indeces of success" as reporting items. This change separated "actions" from "consequences of actions" in the reporting scheme, and thus provides the material for assessment of the efficacy of actions under the MSHCP. In other words, this simple change in the database has provided the basis for adaptive management of the MSHCP. This change will require workshops and education to make sure that all understand what is meant by "indeces of success" (see Table 3

Table 3. Examples of milestones and indices of success

Bat Gates
- *milestones*
  - accumulate materials
  - hire gate contractor
  - assemble two gates per year
- *indeces of success*
  - upward trend in bat population in caves
  - reduction in negative habitat changes for bats
  - increase in biodiversity of cave fauna

Desert Tortoise Fencing
- *milestones*
  - purchase materials
  - hire fencing contractor
  - put in ten miles of fence per year
- *indeces of success*
  - reduction in mortality of tortoises along highway
  - increase in population of tortoises in areas near fence
  - increase in diversity of animal communities near fencing
  - increase in diversity of plant communities near fencing

Fencing: Las Vegas Bearpoppy Apex and ACEC/DWMA
- *milestones*
  - purchase materials
  - hire fencing contractor
  - fence 30 patches containing high densities of bearpoppy
- *indeces of success*
  - reduction in mortality of bear poppy in fenced areas
  - increase in population of bear poppy in fenced areas
  - increase in diversity of animal communities inside fenced areas
  - increase in diversity of plant communities inside fenced areas

Riparian Restoration
- *milestones*
  - hire crews for restoration activities
  - remove weedy species along one mile of stream
  - plant native species along one mile of stream
- *indeces of success*
  - increase in proportion of native to exotic riparian species
  - increase in diversity of native species in riparian
  - increase in water table
  - increase in diversity of plant communities within riparian

Road Maintenance, Barrier Installation and Signs
- *milestones*
  - hire crews for project activities
  - place 100 signs per year
  - replace damaged signs in area X
- *indeces of success*
  - increase in diversity of animal communities in signed areas
  - increase in diversity of plant communities in signed areas
  - decrease in mortality of covered species in restored areas

Springsnail Surveys
- *milestones*
  - hire crews for project activities
  - survey 100 springs per year
  - prepare spreadsheets of presence absence of species in springs
  - prepare pdf and hard copy report of survey analyses
- *indeces of success*
  - increase in diversity of animal communities in signed areas
  - increase in diversity of plant communities in signed areas
  - decrease in mortality of covered species in surveyed areas
  - mangmt channeled to springs in greatest need of protection
  - discovery of correlation between spring snails and amphibians

Wildlife Damage Control
- *milestones*
  - hire crews for project activities
  - trap 100 pest individuals per month
  - assess distribution of target pest species
  - prepare pdf and hard copy report of project implementation
- *indeces of success*
  - decrease in number of pest individuals
  - increase species diversity in areas where pests are removed
  - increase in biodiversity where pests have been removed

A logical outcome of a precise project description is that this description specifies the structure of the structure of proposals for MSHCP funding insofar as proposals are the time in which projects are described. Currently, the proposed proposal structure that yields the necessary data for the ID project is given in Table 4.

Table 4. Structure of project proposals

Project Proposal

1. Project title
2. Contractor
- *A. Agency/Organization of Contractor*
- *B. Address of Contractor*

3. Budget breakdown
- *A. Total Personnel Costs*
- *B. Total Equipment*
- *C. Total Travel*
- *D. Total Other Costs*
- *E. Indirect Costs (administrative costs)*
- *F. Budget Total*

4. Other funding sources for this project
5. Elements of the HCP Addressed
- *A. Species covered*
- *B. Habitat/Ecosystem(s) covered*
- *C. Locations of project(s)*
- *D. Threats addressed*
  - *i. species threats*
  - *ii. ecosystem threats*
- *E. Management action(s) addressed*

***6**. Scope of work*
- *A. Background and need for project in relation to MSHCP threats, conservation actions, and management actions (up to 3 pages)*
- *B. Progress on continuing project (up to 3 pages)*
- *C. Procedures (up to 3 pages)*
- *D. Literature Cited*
- *E. Milestones of project (reports of completion required quarterly)*
- *F. Indices of the success of the project (reports of completion required quarterly)*
- *G. Deliverable(s) (products and/or services) of the project*
- *H. Appendix 1: Final reports of previous MSHCP projects*
- *I. Appendix 2: Professional biographies or curriculum vitae of principal investigators*

Indicators and Indicator Species

The indicators project is designed explicitly to search for "shortcuts" to facilitate monitoring species assemblages without monitoring every individual species. This is a complex process that will depend on an initial intensive data gathering and analysis. The desired result is significant cost savings over the life of the Plan, compared to the alternative of monitoring every individual species.

Indicators are surrogates for population or ecosystem processes of concern. Indicators can be abiotic measures, species presence or absence, species abundance, community assemblages, or ecosystem properties and/or processes which are easy to measure and exhibit dynamics and responses paralleling those of the managed entity (particular species or the entire ecosystem). Indicators are efficacious when they demonstrate low natural variability and respond to environmental change that can be measured inexpensively. Finding reliable indicators requires research into correlations among managed resources and potential indicators. Identification of indicators and implementation of an indicator monitoring program will allow Clark County to meet its obligations to inventory and monitor covered species and provide the USFWS with species status reports on all covered species. The identification of indicators is the first step in the development of an inventory and monitoring program (as discussed in section 2.8.2.3 of the Plan). Ultimately, indicators will be needed to alert managers to problems associated with destructive, non-random environmental changes, and to assist in evaluating the efficacy of management actions. The indicator project will not produce all the answers necessary to inform management actions in the near term. It is the first step in a process that will increase the effectiveness and decrease the cost of managing the Plan through time.

What follows is a DRAFT report after the first full year of data collection on the indicators species experiment. The results so far will become the basis for hypothesis testing of the approach. The approach needs testing of robustness, and it needs testing for applicability for other ecosystems in Clark County.

Indicator Project: Human influences on small vertebrate communities in the Mojave Desert of southern Nevada.

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Abstract: *Small vertebrate populations were monitored with respect to human disturbance in a bajada community in the Mojave Desert of southern Nevada. Human disturbances were quantified with respect to roads and off-road vehicle use. Roads and off-road use negatively affected species richness and species diversity.* Cnemidophorus tigris *abundance was positively related to roads but* Cnemidophorus *abundance was negatively associated with species richness.* Dipodomys merriami *presence was negatively affected by off-road use, and where abundant there was a high species richness. Roads negatively influenced the presence of* Ammospermophilus leucurus*, and off-road use negatively affected the presence of* Chaetodipus penicillatus*.* D. merriami *and* C. tigris *are candidates for surrogate status based on their ability to predict species richness across all sites. Monitoring these two species may provide an opportunity to manage multiple species with a smaller amount of effort than would be required to monitor many species individually. Future efforts will evaluate the efficacy of prescriptive management tools by further analysis of the potential for animals to be umbrella species, analyses of population processes, and experiments that manipulate off-road use.*

Introduction

In general, disturbance is an important factor in determining community composition, and many hypotheses have used disturbance frequency to explain community structure (reviewed in Petraitis *et al.* 1989). Patterns of community species richness indicate that disturbance has both positive and negative effects. For instance, many ecosystems exhibit their highest diversity in areas of intermediate disturbance (Connell 1978). Furthermore, high diversity in the tropics has been attributed to higher frequencies of disturbance compared to that experienced in more temperate areas (Connell 1978, Hubbell 1979). While high disturbance is bad for many species, some species are disturbance specialists, including many exotic and pest (weed) species (Grime 1977, Sakai *et al*. 2001). For example, tumbleweed and kudzu spread along and dominate the roadside plant communities of many highways and roads across the United States.

Human expansion and activity into formerly, (relatively) undisturbed habitats will likely affect the composition of plant and animal communities through disturbances comprised of varying degrees of visitation and habitat destruction. For example, recreational uses--such as hiking trails, horse trails, off-road vehicle use, and golf courses--modify the natural habitats of plants and animals through relatively minor disturbances such as creating breaks in vegetation to more dramatic disturbances such as the creation of large areas of soil compaction unsuitable for all but the hardiest plants and animals. While human disturbance often negatively affects certain species by reducing or destroying tracts of suitable habitat (or corridors between suitable habitat patches), human development has also allowed some 'less desirable' species to invade urban and natural areas. European starlings and house finches are two notable examples in cities, and the expansion of brown-headed cowbirds and brown tree snakes are two notorious examples in natural habitats that have experienced human incursion. Often these same opportunistic species cause the eradication of native species (Shrader-Frechette 2001).

To manage human encroachment into otherwise undisturbed areas, effective biodiversity monitoring tools need to be developed. With the rapid growth of the Las Vegas area, these tools need to be developed expeditiously, as urban expansion generally shifts biological community composition away from earlier more pristine conditions (Pickett *et al*. 2001). Failure to implement management tools may cause rare species or endemics to suffer irreparable damage or even extinction. Tools employed to monitor biological health of a community include flagship species, indicator species, and umbrella species (Caro and O'Dougherty 1998, Simberloff 1998, Andelman and Fagan 2000, Fleishman et al. 2001a). Each of these approaches has advantages and disadvantages (see Simberloff

1998, Andelman and Fagan 2000, or Block *et al*. 2001 for critiques). While such surrogates are often difficult to identify, they provide a means to examine one more species intensely with the hopes that these species will indicate the condition of a greater number of species. Though not a perfect solution to a management problem, surrogates offer a cost effective approach where the task of monitoring every species in an ecosystem is impractical or impossible.

In this study, we investigate the effects of human use of animal habitat on species richness, species diversity, and species abundance. We quantify species abundance and distribution in a bajada community in the Mojave Desert in Clark Co., NV. Additionally, we document patterns of human activity in the same areas and relate animal abundances and distributions to this human disturbance. Our results show that species are affected differentially by human disturbance, and that some species which are sensitive to disturbance may be useful as surrogate species for monitoring disturbance in some desert communities.

Methods

Sampling locations

Potential pitfall trap array locations were determined from a set of randomly generated points in the Jean Dry Lake/ Hidden Valley area in Clark Co., NV. Road coverage in the area was determined through existing Geographic Information Systems (GIS) datasets and through the digitizing of potential roads from 30-m resolution digital photo-orthoquads (DOQs). Then, buffer zones were selected at a distance of 30-m to 300-m from all roads. Additional buffer zones were created with respect to elevation (X-m above sea level to Y-m above sea level) and vegetation zone (GAP: mixed desert scrub and creosote-bursage) to ensure similar ecological communities were sampled, i.e. differences in community composition were not due to gross differences in habitat. Two hundred random points were generated within the union of all defined buffer zones.

From the 200 randomly assigned points, vegetation cover and human disturbances were documented. For vegetation coverage, three line transects were sampled. Transects were begun at 10-m from the center point to avoid overlap of plants on transect lines. Transect lines were 50-m in length. The direction of the initial transect line was determined from a randomly generated number between 0 and 359, and this number represented a direction with respect to magnetic north. The remaining two transect lines were set out at 120 degree angles from the initial transect line. Perennial plants intersecting the transect line were identified to the species level, and distances along the transect line were recorded. Appendix I shows the perennial plant species list for the areas sampled. Plant coverage was then broken down into creosote, small shrubs other than creosote, and perennial bunch grasses. A k-means cluster analysis was then performed on the plant coverage data to group the sampled points in to similar sites with respect to type and coverage of plant species. Vegetation cover at the randomly sampled sites clustered into the following areas: grass-dominated, creosote-dominated, small shrub-dominated, and shrub-creosote mixed.

At the same randomly generated points, human disturbance was documented by walking the same transect lines out to 100-m. Each disturbance transect included a 2-m buffer on either side where human disturbance may have been counted. Measures of human disturbance included the number of off-road vehicle tracks (ATV, motorcycle, and truck), amount and surface area of trash, number of tumbleweeds (*Salsola sp*), numbers of cattle tracks and cattle dung, and the number of grazed plants. Additional measures of disturbance with respect to roads, which could not easily be determined through ground measures, were determined through GIS. These measures included the shortest distance to a road and the total length of roads within a 300-m distance from the center point.

Sampling points for pitfall trap arrays were determined by choosing areas that varied in their amount of human disturbance sampled as equally as possible in the previously mentioned vegetation clusters. While vegetation was not a part of the final analysis of species abundance, all vegetation areas were chosen to maximize the domain of generality over which our results would apply. Only off-road track and road measures of disturbance (distance to roads and length of roads within 300-m) were used to designate a human disturbance gradient due to their known effects on ecological communities (Haskell 2000, Forman 2000, Forman and Deblinger 2000, Trombulak and Frissell 2000). Furthermore, even though tumbleweed is associated with disturbed areas, tumbleweed abundance was not used as a disturbance factor because it is an outcome of disturbance and not necessarily a source, as is the case with the spread and abundance of many exotic plants with respect to road disturbance

(Parendes and Jones 2000). Sixty-one sampling locations were chosen (UTMs of points are listed in Appendix II), and besides maximizing the range of disturbance among sites, chosen locations also were not located within 0.5 kilometers from one another.

Animal sampling

Small vertebrates were sampled at each of the study sites through pitfall trap arrays. The design of pitfall trap arrays is shown in Figure 1. Pitfall trap arrays are an effective technique for sampling many species at once with relatively small effort compared to the techniques that would need to be employed for any one species, with the single species effort needing to be multiplied by the total of number of species in an area in order to sample all species (for examples of the use of pitfall trap arrays, see Fisher et al 2002, Suarez and Case 2002, Laakonen et al. 2001...do a web of science search for more references). Upon initial capture, animals were identified to the species level, given a unique mark (by toe clip) for future identification, and body size measurements were taken (for future estimates of growth and change in body condition and additionally for species identity verification in mammals). Additionally, mammal trapping was performed using Sherman traps for one three-day period (Oct X-Oct Y) to determine whether pitfall traps effectively captured all mammal species. Species richness and abundances from Sherman trapping were also used for analyses.

Pitfall traps were sampled once every two weeks for four-day periods from April X, 2001 through July Y, 2001 and from Sept X through Oct. Because all pitfall trap arrays were sampled equally, species richness was determined for each site simply as the number of species captured at each site, regardless of trapping method. Abundances for each species were measured as the number of individuals captured at each site, discounting future recaptures of the same animal. The number of individuals captured is a conservative estimate of animal populations that is correlated with actual population numbers. Future analyses will incorporate mark-recapture data to estimate true population size through such estimation methods as the Jolly-Seber and Robust Design methods (). An additional measure, the Shannon index, was calculated to compare species diversity among sites (Krebs 1989).

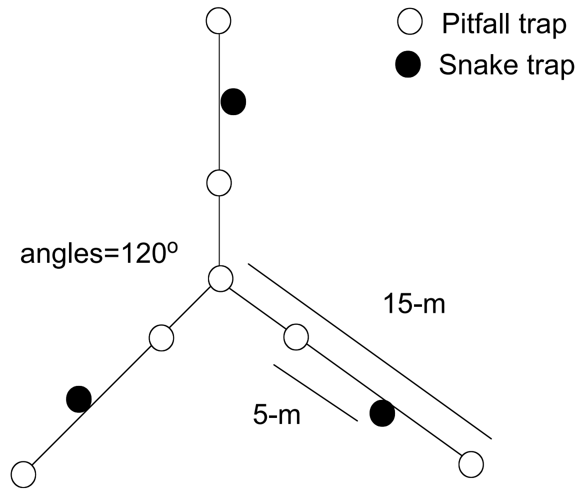

Figure 1. Design of a pitfall trap array used for this study. Both snake and pitfall traps are comprised of 5-gallon PVC buckets. Pitfall trap buckets are shielded by a lid that is elevated approximately 3 inches above the ground surface. Snake traps have wire mesh cone traps connected to the tops of buckets to prevent snakes from escaping. All traps are separated by 18 inch tall flashing.

Statistical Analysis

To determine the effects of human effects on small animal communities, species richness, species abundance, and species presence data were examined with respect to the human disturbances recorded earlier. A principal components analysis (PCA) was performed on the measures of roads (distance to the nearest road and length of roads within a 300-m radius) and the number of off-road tracks to determine independent (non-collinear) combinations of disturbances to be used in subsequent regression analyses. Road measures and off-road tracks were scaled to unit variance (for equal weighting in the PCA) and were log-transformed for normality. Retained principal components were regressed against species richness at each site. For species ubiquitous to all arrays, principal components were regressed against species abundance. For species that were not present at all sites, a logistical regression was used to analyze the effects of the principal components on presence-absence data for each species. For all regression analyses, only main effects (i.e., no interactive effects) were examined due to relatively small sample sizes (with respect to the analyses) and under-representation of all combinations of road measures and off-road vehicle use. All statistical analyses were performed using the JMP 4 statistical package (SAS Institute).

Additional analyses were performed to evaluate the potential for one or more species to be used as surrogates for monitoring small vertebrate communities in general. The first analysis regresses abundance or proportional abundance within a site (the number of individuals of a species divided by the total number of individuals of all species captured at each array) against species richness. Second, presence-absence data were used to calculate the potential for each species to act as an umbrella species using the methods of Fleishman and Murphy (1999, 2001a, 2001b). Due to a lack of knowledge of the effects of our road and off-road disturbance categories on life history characters, only measures of mean co-occurrence with other species and species ubiquity were used to evaluate potential umbrella species. Mean co-occurrence and ubiquity scores were added to determine an umbrella score. Species were then ranked based on the umbrella score.

Results

Quantification of human disturbance

Two principal component factors were extracted from the number of off-road tracks and road measures for use in subsequent regression analyses (Table 1). A Varimax rotation was performed on the extracted factors. Two extracted factors explained 92.5% of the data related to roads and off-road tracks. The first principal component (ROADS) describes a gradient from areas that are located distantly to roads with a low density of roads within a 300-m radius to areas close to roads with a high density of roads. The second principle component (OFFROAD) describes a gradient of areas with no off-road use to areas with high numbers of off-road tracks.

Table 1. Rotated factor pattern from principal components analysis.

	ROADS	OFFROAD
nearest distance to a road	-0.941	-0.097
length of roads within 300-m	0.907	0.242
off-road vehicle tracks	0.171	0.984
Variance explained	1.738	1.036
Percent	57.9	34.5

Species richness and human disturbance

Species richness was highly variable among sites. The total number of species captured in the Jean Dry Lake/Hidden Valley area was 30 (see Appendix III for a species list), though species richness only ranged from 4 to 12 among all sites. A trend (though not statistically significant) existed for roads to negatively affect species richness (Figure 2a). Off-road vehicle use was associated with decreased species richness. Species diversity was similarly affected by roads and off-road use (Figure 2b).

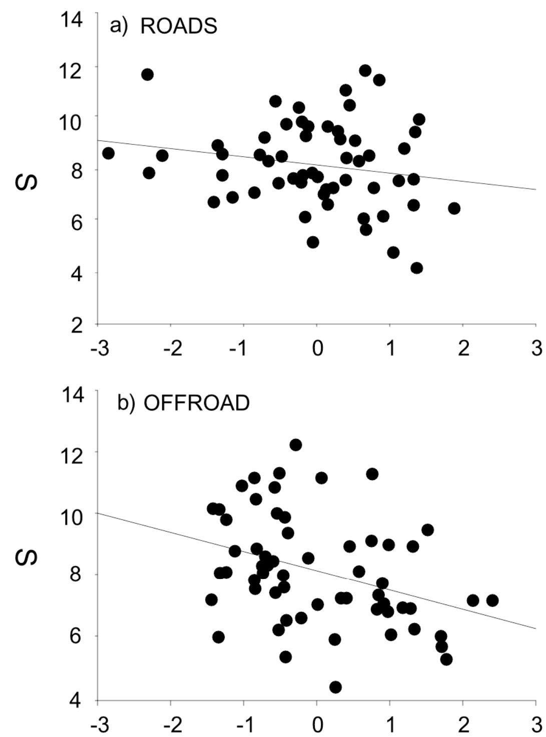

Figure 2. a) There is a trend for roads to negatively affect species richness (S), but this effect is not statistically significant (p<0.15). b) Off-road vehicle use negatively affects species richness (p<0.005).

Species abundance and human disturbance

The abundance and/or presence of individuals from some species are affected by human disturbance. The abundance of western whiptails (*Cnemidophorus tigris*) abundance increased with ROADS (Figure 3). The presence of Merriam's kangaroo rat (*Dipodomys merriami*) is negatively affected by OFFROAD (Figure 4). The presence of antelope ground squirrels (*Ammospermophilus leucurus*) (Figure 5) is negatively affected by

ROADS. The presence of desert pocket mice (*Chaetodipus penicillatus*) is negatively affected by OFFROAD (Figure 6) and preliminary results also indicate that there is a trend for a negative effect of ROADS (p<0.11, these relationships may improve with future increased sampling efforts because of the relatively few animals caught). There was also a trend for ROADS to affect the presence of long-tailed pocket mice (*Chaetodipus formosus*). Abundance and presence of all other species were not affected by road or off-road disturbance. For rare species, the effects of roads or off-road use could not be determined due to their sparse numbers.

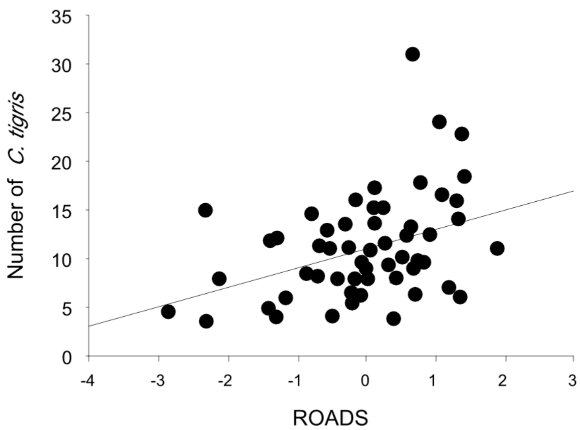

Figure 3. *Cnemidophorus tigris* abundance increases in areas near roads and of high road density (p<0.003).

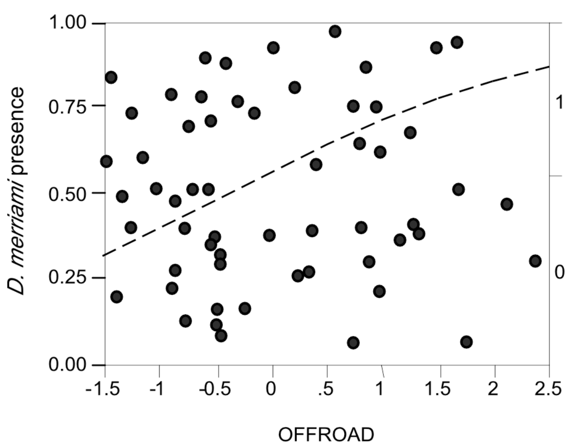

Figure 4. *Dipodomys merriami* presence is influenced negatively by off-road vehicle tracks (p<0.02). A logistic fit of presence data is shown above.

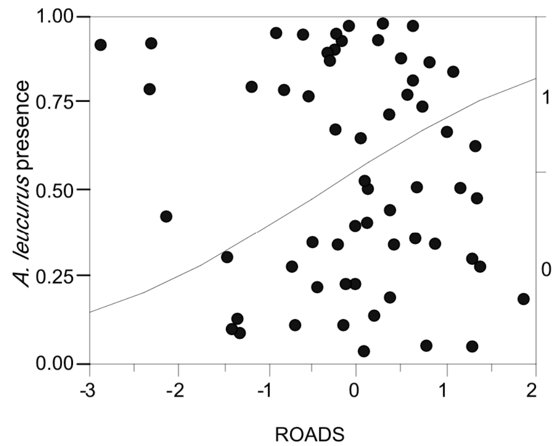

Figure 5. *Ammospermophilus leucurus* presence is negative influenced by a high density and close proximity to roads (p<0.03). A logistic fit of presence data is shown above.

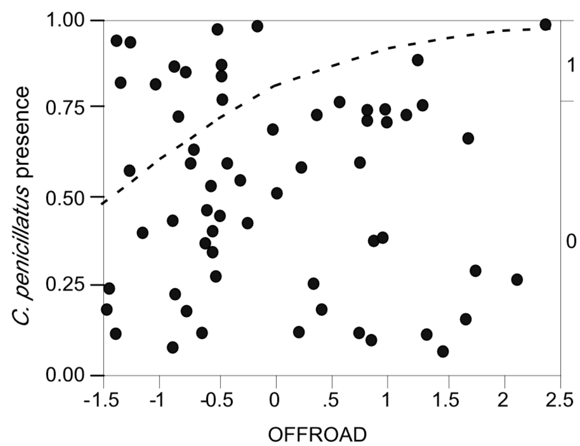

Figure 6. *Perognathus penicillatus* presence is negatively affected by off-road tracks (p<0.02). A logistic fit of presence data is shown above.

Indicators and umbrellas

The status of some species in our study may serve as surrogates for the study of other species. Abundances and relative abundances within arrays of each species were regressed against species richness. The relative abundance of western whiptails sampled at each pitfall trap array was negatively correlated with species richness measured at the same area (Figure 7). Abundance of Merriam's kangaroo rats (Figure 8) and abundance of Long-nosed leopard lizards (*Gambelia wizlensii*) (Figure 9) are correlated positively with species richness.

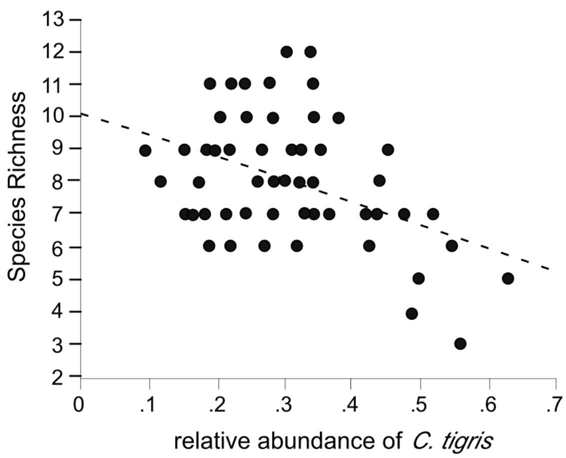

Figure 7. Species richness is correlated negatively with the relative abundance of *C. tigris* ($p<0.001$).

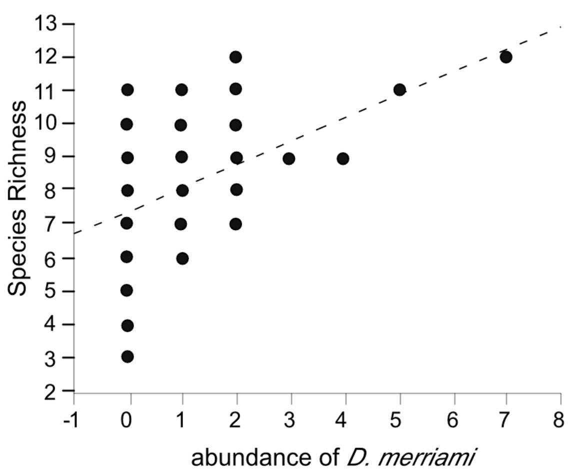

Figure 8. Abundance of *D. merriami* are correlated with species richness ($p<0.0001$).

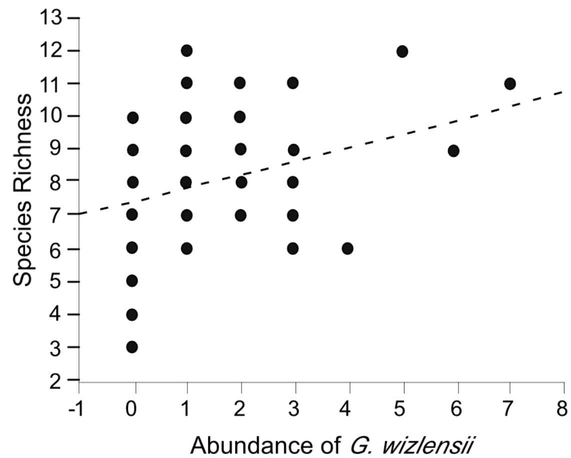

Figure 9. Abundance of *G. wizlensii* are correlated with species richness ($p<0.005$).

To investigate whether some small number of species can be monitored to assess local species richness, relative abundance of *C. tigris* and abundances of *D. merriami* and *G. wizlensii* were used to build a regression model to predict species richness. Abundance of G. wizlensii was dropped from the model as it had no predictive power and did not contribute to the explanatory ability of the model (plus fewer species to monitor are better with respect to management). Figure 10 shows the predicted versus actual species richness from this regression model.

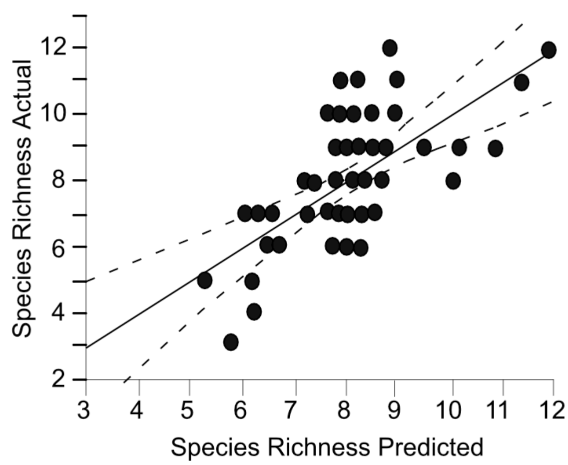

Figure 10. Predicted versus actual species richness using the relative abundance of *C. tigris* and the abundance of *D. merriami* ($p<0.0001$, adjusted $R^2=0.39$).

Potential umbrella species were evaluated using our modified methods from Fleishman et al (2000, 2001a, 2000b). Table 2 shows for each species the proportion of arrays in which they occurred, mean co-occurrence scores, ubiquity scores, and umbrella scores (only species which occurred at more than 10% of the arrays are included). Future work will incorporate an additional component to the umbrella score that is composed of a species response to road and off-road disturbances. Asterisked species indicate species whose scores will increase with such a criterion.

Table 2. Umbrella potential for all species captured in this study

Species	Proportion of arrays present	Mean co-occurrence	Degree of ubiquity	Umbrella score
Dime*	0.44	0.12	0.89	1.01
Amle*	0.44	0.11	0.89	1.00
Gawi	0.64	0.17	0.72	0.89
Mafl	0.30	0.08	0.59	0.67
Cova	0.82	0.20	0.36	0.56
Choc	0.23	0.06	0.46	0.52
Chpe*	0.23	0.06	0.46	0.52
Chfo	0.18	0.05	0.36	0.41
Utst	0.93	0.23	0.13	0.36
Arel	0.15	0.04	0.30	0.34
Phpl	0.95	0.23	0.10	0.33
Thbo	0.13	0.04	0.26	0.30
Pelo	0.98	0.24	0.03	0.27
Cnti*	1.00	0.24	0.00	0.24

* species responds in some manner to road or off-road disturbance.

Discussion and Future Direction

Disturbance often affects the abundance and distribution of species across landscapes. Our study shows that animals can be either positively or negatively affected by human disturbance. While the abundance of *C. tigris* increased with the density and proximity to roads, several mammal species were negatively affected by roads (*A. leucurus*) and off-road use (*D. merriami and C. penicillatus*). Furthermore, the relative abundance of *C. tigris* and the abundance of *D. merriami* can be used to potentially monitor ecosystem health (measured as species richness) as they were correlated to species richness at the array locations in this study.

Our study of the negative effects of road-use on small mammals has been corroborated. In a fenced area that excluded off-road vehicle access (in the California Mojave desert), plant biomass and the abundances of some small rodents was higher than in areas outside of such protective fencing (Brooks 1995). *Chaetodipus formosus*, *D. merriami*, and *Onychomys torridus* had higher numbers inside of protective fencing than outside of fenced areas. Incidentally, in our study, *D. merriami* was negatively affected by off-road use as well, and there was a trend for *C. formosus* to be negatively affected by roads. As more numbers of *C. formosus* are captured in future sampling efforts, this trend may become actualized. While the specific mechanism (e.g., road kill or decreased food availability) that causes small rodent populations to be smaller in areas near roads or off-road use has yet to be elucidated in our study, Brooks suggests that rodent numbers may be tied to higher seed sets of plants found in areas with no off-road vehicle use. Thus, another area of future study might examine whether the seed set of plants near roads is smaller, and whether rodents in the same areas are fewer in number.

Our results may be used as a conservation tool to manage large numbers of species with a smaller effort than the effort that would be required to monitor all species individually. Western whiptail abundance was positively correlated with road disturbance, yet high abundance of whiptails is indicative of low species diversity. Presence of Merriam's kangaroo rat is negatively affected by off-road use, and where abundant, there is high species richness. Merriam's kangaroo rat also received the highest umbrella score. When combined these two species are highly correlated with local species richness. As a management tool, monitoring these two species has much promise. Trapping kangaroo rats with Sherman traps is relatively simple, and trapping efforts can easily encompass large areas due to the ease of moving traps from place to place. Validation of kangaroo rat numbers would likely have to be validated for any given area. On the other hand, absolute whiptail abundance is not required to estimate species richness. Only the relative abundance is required. For example, Figure 7 shows that if 10% of a sample is whiptails, then approximately 9 species of other small vertebrates would be expected in an area; whereas if the proportion of whiptails rises to 60%, only 4 or 5 species may be expected in an area. This result will be tested in the future through sampling other areas in Clark County, and through the examination of other available data sets that have used pitfall sampling (e.g., data from the Las Vegas Valley Wash or from R. Fisher's data from southern California). Additionally, potential umbrella species will be evaluated by incorporating an index that relates species responses to roads and off-road use.

The above approach should be viewed with caution, as surrogates do not offer mechanistic links that help predict population dynamics of other species (Simberloff 1998, Block et al 2001). To minimize some of the dangers of managing one or a few species to assess ecosystem health, our future work will examine in more depth the effects of road use on desert species. Longitudinal data from established pitfall array sites will allow us to determine whether population rates are correlated in the same manner as abundance and presence data are, and whether the same observed patterns vary across multiple years and/or vary in response to climate (e.g., drought years or El Nino years). Mark-recapture models that estimate probability of capture also will be used to infer whether behavior is modified by road and off-road use. For instance, animals may not establish finite home ranges, or may be less active, in areas with high off-road vehicle use or in areas with large numbers of roads. Additionally, areas of high off-road use could be fenced off to determine whether the observed negative affects of roads can be mitigated by management actions that reduce off-road use.

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Appendix I. Perennial plants sampled on vegetation transects.

Scientific name	**Common name**
Achnatherum hymenoides	Indian ricegrass
Ambrosia dumosa	White bursage
Aristida purpurea	Mojave needlegrass
Chorizanthe rigida	Spineflower
Echinomastus polycephalus	Many-headed barrel
Ephedra sp	Mormon tea
Eriogonum inflatum	Desert trumpet
Erioneuron pulchellum	Fluffgrass
Gutierrezia sarothrae	Broom snakeweed
Hymenoclea salsola	Cheesebush
Krameria erecta	Rhatany
Krameria grayi	White rhatany
Krascheninni kovilanata	Winter fat
Larrea tridentata	Creosote bush
Lycium sp	Boxthorn
Machaeranthera tortifolia	Desert aster
Menodora spinescens	Menodora
Muhlenbergia porteri	Bush muhly
Opuntia acanthocarpa	Buckthorn cholla
Opuntia basilaris	Beavertail cactus
Opuntia echinocarpa	Silver cholla
Opuntia ramosissima	Diamond cholla
Pectis papposa	Chinchweed
Pleuraphis rigida	Big galleta grass
Psorothamnus fremontii	Psorothamnus
Salsola tragus	Tumbleweed
Sphaeralceae ambigua	Globe mallow
Sporobolus cryptandrus	Sand dropseed
Thymophylla pentachaeta	Thymophylla
Yucca schidigera	Spanish bayonet

Appendix II. Pitfall trap array locations.

Array ID	Easting	Northing	Array ID	Easting	Northing
1	664935	3967320	126	659979	3964853
4	666241	3968583	135	657588	3966452
9	655890	3962017	136	664935	3968096
15	657527	3959670	139	658139	3958742
19	656509	3963740	142	664571	3968572
20	665431	3969038	143	660186	3960090
23	656016	3959850	146	662366	3965473
24	663248	3963792	147	658447	3966593
25	667783	3968691	148	663861	3966036
29	662727	3965671	152	654984	3961058
32	656068	3962719	158	659494	3962052
33	660387	3962266	166	661403	3966191
37	663918	3963382	201	655744	3961521
40	655961	3960863	203	656446	3960176
41	658232	3966859	205	655591	3960540
43	659373	3966464	207	658843	3966025
46	657222	3965344	208	658807	3965541
56	657487	3963252	209	659084	3964818
59	655566	3961985	212	659100	3963906
62	659571	3964382	213	658803	3963623
70	655924	3963185	214	659062	3963369
75	657782	3967744	216	659978	3961272
82	664294	3967694	220	659957	3961873
89	664010	3966924	221	663289	3966313
93	656988	3960363	226	664267	3968101
95	659443	3963988	228	664144	3969127
102	659279	3965250	230	665172	3967560
112	660700	3964370	233	665633	3968554
120	664883	3969758	237	666246	3970217
124	663277	3958836	240	666604	3970861
125	665422	3970549			

Appendix III. Animal species caught in during the summer of 2001 in the Hidden Valley/Jean Dry Lake area.

Scientific name	Common name
a) Lizards	
Callisaurus draconoides	Zebra-tailed lizard
Cnemidophorus tigris	Western whiptail
Crotaphytus bicentores	Mojave collared lizard
Coleonyx variegatus	Western banded gecko
Gambelia wizlensii	Long-nosed leopard lizard
Phrynosoma platyrhynos	Desert horned lizard
Sceloporus magister	Desert spiny lizard
Uta stansburiana	Side-blotched lizard
Xantusia vigilis	Night lizard
b) Snakes	
Arizona elegans	Glossy snake
Chionactus occipitalus	Shovel-nosed snake
Crotalus cerastes	Sidewinder rattlesnake
Masticophus flagellum	Coachwhip
Phyllorhyncus decuratus	Spotted leaf-nosed snake
Pituophus catenifer	Gopher snake
Rhinocheilus lecontei	Long-nosed snake
Salvadora hexalepsis	Western patchnose snake
c) Mammals	
Ammospermophilus leucurus	Antelope ground squirrel
Dipodomys merriami	Merriam's kangaroo rat
Chaetodipus formosus	Long-tailed pocket mouse
Chaetodipus penicillatus	Desert pocket mouse
Neotoma lepida	Wood rat
Onychomys torridus	Southern grasshopper mouse
Peromyscus eremicus	Cactus mouse
Perognathus longimembrus	Little pocket mouse
Peromyscus maniculatus	Deer mouse
Reithrodontomys megalotus	Harvest mouse
Spermophilus tereticaudus	Round-tailed ground squirrel
Spermophilus townsendii	Townsend's ground squirrel
Thomomys bottae	Botta's pocket gopher

Biological Considerations in Rural Roads Management

There have been both adverse and positive biological effects hypothesized as a result of roads, but there has been little systematic research in the ecosystems present in Clark County that support any such hypotheses. Available data and analysis are not sufficient to support management actions. This ongoing component of the AMP is attempting to evaluate the biological effects of roads, and to relate those effects to the degree of use and condition of the roads studied and the species of plants and wildlife present. Evaluation of potential negative biological impacts caused by roads must be balanced by the positive social and economic value of roads. If the roads can be categorized according to their impacts on biota, they can be evaluated for management (e.g., closure and rehabilitation, fencing, managed as recreation roads, etc.) in attempts to balance biological and human costs and benefits. BRRC will be responsible for providing biological data that can be used by the I&M Committee and management agencies in making decisions on rural roads management.

This project partially overlaps with indicator species activities in scope and approach. Roads provide a quantifiable disturbance gradient. Indicator species topics-such as sampling schedules, methods, vegetation sampling methods, site characterization, and definition of the disturbance gradient and experimental variables-apply directly to work on evaluation of rural roads issues.

The recovery plan for the desert tortoise has identified the impacts of roads on adjacent populations of tortoises as a threat that should be mitigated. Clark County has based a significant portion of its mitigation for take of tortoises on private lands on this finding and has undertaken an aggressive program to retrofit highway range fences with tortoise barriers. However, the absence of clear conclusions from existing studies leads to the possibility that parts of this effort may be misdirected. As part of the AMP, we have been conducting a review and analysis of existing data and studies on road impacts on tortoises. We have offered to make our preliminary draft of this review and analysis available to the I&M Committee. The analysis will require cooperation from those who have collected data, and the analysis may suggest additional empirical study is necessary to support management actions.

This AMP component is a multi-faceted approach to evaluating the biological effects of roads in Clark County. In the first two biennia, specific biological studies are not planned to evaluate these effects. The work to be done during these two biennia represents only the essential first steps of this component, including mapping roads, mapping vegetation with respect to roads, evaluating intensity of use of selected roads, gathering data on microclimate and edaphic effects of roads, and review of existing data. It also includes monitoring tortoise fencing and developing a database on problem locations for fence maintenance.

Our activities are documented in the following bulleted list and preliminary reports:

- Cooperating with land managers to complete mapping of all unpaved roads within the project area for the Plan. We have mapped some roads in areas where we have on-going research activities, and we have assisted the Forest Service in mapping fire trails.

- Cooperate with land management agencies on their monitoring of traffic on selected roads to establish traffic levels and patterns. Some roads will be monitored continuously, others periodically. Characterization of roads and the monitoring of traffic will likely require several years. In this early phase of road traffic evaluation, only baseline information will be collected. When baseline road characterization, and traffic volume and patterns have been established, a study design for evaluating road traffic impacts will be developed. We have assisted the Bureau of Land Management in monitoring traffic counters during 2000-2001 in northeastern Clark County. We are currently collaborating with the Bureau of Land Management and the Rusual Roads Working Group in monitoring traffic levels on specific roads in the Boulder City Conservation Easement.

- We have installed several automated weather recorders and soil moisture monitors at varying proximity to roads. To the extent our budget will allow, we will continue to install these, with the goal of compiling sufficient data to evaluate potential microclimatic and edaphic conditions with reference to proximity to roads.

- We are assembling and reviewing available literature and reports on road impacts that might be important resources for AMP and the land managers. We will continue to assemble and review available literature and reports on road impacts, to the extent permitted by our proposed budget. GAP resources will be used by the AMP to enhance existing data, GIS coverages, and on-going investigations. We anticipate that review of agency files and reports will result in discovery of much additional information that will enhance the Plan, AMP and agency management. We will examine all data sets, files or other information made available to us by cooperating agencies, consistent with current staffing and time availability and integrate all that is appropriate and relevant subject to current funding levels.

- We have begun to monitor tortoise barriers installed along highway right-of-way fences with the intention of identifying those specific areas that require frequent maintenance. Monitoring will identify areas where rain runoff in washes and smalldrainage channels have caused the fencing material to wash out. We will establish a GIS database for barrier locations requiring maintenance. This database is important because it should allow us to identify washes and drainage channels that tend to require maintenance after rain. This will allow spot checks of tortoise barriers after rain rather than complete surveys. NDOT has agreed to maintain the tortoise barriers along their rights-of-way. We will report locations requiring maintenance of tortoise barriers along NDOT rights-of-way to NDOT.

What follows are two reports leading to an analysis of the confluence of biodiversity and rural roads. The first report is an adjustment of the Nevada GAP analysis to cause it to be more accurate than that presented by USGS. Associated with this report is a map that can be obtained from the BRRC GIS laboratory in Las Vegas. The second report is a preliminary report of our efforst to use of the new GAP to classify all rural roads according to their intersection with various levels of biodiversity in Clark County. This work is ongoing and will take considerable time to do an adequate job of classifying roads with respect to biodiversity in Clark County. Finally, we have a report on the relationship between desert tortoise and highways in this list of reports.

PRELIMINARY EVALUATION OF NEVADA GAP VEGETATION CLASSES AS DESCRIBED AND MAPPED IN CLARK COUNTY, NEVADA

The following is an edited version of the Nevada GAP (NV-GAP) (Edwards et al. 1996) discussion concerning the Nevada vegetation classes mapped by NV-GAP in Clark County. For each monograph, first an edited form of the monograph as written by NV-GAP is presented. Following the edited form of the monograph, are descriptions of the distribution of the class as mapped in Clark County (all entries preceded by "NV-GAP Clark County mapped:"). Following the description of the mapped class' distribution, are notes pertaining to the tree, shrub, and other plant species observed to be associated with the class in Clark County. The entry is concluded with one or more comments (all entries preceded by, "Clark County Commentary") concerning the accuracy of the NV-GAP mapping effort and other comments relevant to the presence of the class in the county. In addition, other Nevada vegetation classes described by NV-GAP, occurring in Clark County but not mapped there, are indicated, presented, and discussed. The following paragraph is the introductory paragraph of the NV-GAP write-up. As in this case, all Edward's et al. (1996) text appears in Courier font. All my text occurs in Times New Roman font.

Nevada vegetation classes by group and numeric code. Cover-Type categories are listed by principal species that define the cover-type. Landscape scale cover-type mapping includes many prevalent primary associated species that can substantially occur as part of the cover-type in localized areas. This is not intended to be a complete species list, but rather an overview of the most common species associated with each cover-type. General descriptions of each cover-type and a brief distribution of the cover-type are included.

TREE-DOMINATED VEGETATION (Forests and Woodlands)

2.) ASPEN_2 - Deciduous forest dominated by quaking aspen (*Populus tremuloides*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus ledifolius*), limber pine (*Pinus flexilis*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), whitebark pine (*Pinus albicaulis*), red fir (*Abies magnifica*) and Jeffrey pine (*Pinus jeffreyi*).

NV-GAP primary associated shrub species: mountain shrubs listed in mountain shrub class.

NV-GAP Distribution - Aspen is found in localized areas throughout Nevada, occurring at higher elevations and on cooler aspects. The largest areas of the class are in northeast Nevada.

NV-GAP Clark County mapped: Aspen_2 communities are restricted to small patches in the Spring Mountains and a small patch S of Sawmill Spring and E of Hayford Peak in the Sheep Range. All aspen patches mapped in the Spring Mountains occur N of Lovell Pass and S of Wheeler Pass.

Clark County primary associated tree species: *Quercus gambelii*, *Abies concolor*, *Pinus ponderosa*, *Pinus flexilis*

Clark County primary associated shrub species: *Symphoricarpos* spp., *Ribes* spp.

Clark County Commentary: The distribution as mapped by NV-GAP appears reasonable. The main error appears to be one of omission, as the stands in Lee Canyon have not been mapped. I have not verified the occurrence of the stands mapped in the Sheep Range.

3.) ASPEN_3 - Deciduous forest principally dominated by quaking aspen (*Populus tremuloides*) at canopies greater than 59 percent.

NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus ledifolius*), limber pine (*Pinus flexilis*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), ponderosa pine (*Pinus ponderosa*), lodgepole pine

(*Pinus contorta*), whitebark pine (*Pinus albicaulis*), red fir (*Abies magnifica*) and Jeffrey pine (*Pinus jeffreyi*).
NV-GAP primary associated shrub species: mountain shrubs listed in mountain shrub class.
NV-GAP distribution - Aspen is found in localized areas throughout Nevada, occurring at higher elevations and on cooler aspects. The largest areas of the class are in northeast Nevada.
NV-GAP Clark County mapped: aspen communities are restricted to small patches in the Spring Mountains and a small patch S of Sawmill Spring and E of Hayford Peak in the Sheep Range. An additional patch of **Aspen_3** is mapped in the Sheep Range immediately N of Hayford Peak. All aspen patches mapped in the Spring Mountains occur N of Lovell Pass and S of Wheeler Pass.
Clark County primary associated tree species: *Quercus gambelii*, *Abies concolor*, *Pinus ponderosa*, *Pinus flexilis*
Clark County primary associated shrub species: *Symphoricarpos* spp., *Ribes* spp.
Clark County Commentary: The distribution as mapped by NV-GAP appears reasonable. The main error seems to be one of omission, as the aspen stands in Lee Canyon were not mapped. I have not verified the occurrence of the stands mapped in the Sheep Range.

8.) JUNIPER_1 - Conifer woodland principally dominated by Utah juniper (*Juniperus osteosperma*) at canopies less than 30 percent.
NV-GAP primary associated tree species: Rocky Mountain juniper (*Juniperus scopulorum*), western juniper (*Juniperus occidentalis*) and single leaf pinyon (*Pinus monophylla*).
NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.) and blackbrush (*Coleogyne ramosissima*).
NV-GAP distribution - Juniper is widely distributed throughout Nevada in open canopy stands. Utah juniper woodlands typically occur at the lower elevations of the pinyon-juniper zone. Northern Nevada juniper woodlands lack singleleaf pinyon (*Pinus monophylla*). Small stands of western juniper occur in extreme northwest Nevada. In southern Nevada juniper occurs commonly with blackbrush.
Commentary on NV-GAP: singleleaf pinyon occurs in woodlands in extreme northeastern Nevada, E of Jackpot and N of Wells.
NV-GAP Clark County mapped: The main areas of **Juniper_1** woodlands as mapped are at mid-elevations in the Spring Mountains, mainly W of Red Rock and the S facing slopes of Mt. Charleston. The lower foothills of the N slope of the Spring Mountains, between Cold Creek and the Nye / Clark County boundary are also mapped, as well as both aspects of La Madre Mountain. Other areas mapped as **Juniper_1** include: Sheep Range, Las Vegas Range, Virgin Mountains, South Virgin Mountains, McCullough Mountains, Newberry Mountains, New York Mountains, El Dorado Mountains, Lucy Grey Range, Arrow Canyon Range, Muddy Mountains, Highland Mountains, Opal Mountains, and Tramp Ridge (between the Virgin and South Virgin Mountains).
Clark County Primary Associated Tree Species: *Pinus monophylla, Quercus turbinella, Mahonia fremontii, Yucca brevifolia. Acacia greggii* is commonly associated with *Juniperus californica* in the Newberry Mountains.
Clark County Primary Associated Shrub Species: *Fallugia paradoxa, Coleogyne ramosissima, Purshia stansburiana, Mahonia fremontii, Ephedra viridis, Chrysothamnus* spp.
Clark County Commentary: Woodlands may be dominated by either Utah juniper or California juniper (*Juniperus californica*). California juniper woodlands are restricted to the Newberry Mountains of extreme southern Nevada. Elsewhere in Clark County, Utah juniper dominates the woodland. Western juniper is not known from Clark County.
Clark County Commentary: The **Juniper_1** woodlands mapped in the El Dorado Mountains, Lucy Grey Range, Arrow Canyon Range, Muddy Mountains, Highland Mountains, and Opal Mountains, N end of the McCullough Range, and Tramp Ridge are completely in error. No conifers occur in these areas. I have found no **Juniper_1** in the McCullough Mountains, although it may occur on the periphery of the main portion of the range.

9.) JUNIPER_2 - Conifer woodland principally dominated by juniper (*Juniperus osteosperma*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: Rocky Mountain juniper (*Juniperus scopulorum*), western juniper (*Juniperus occidentalis*) and single leaf pinyon (*Pinus monophylla*).
NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.) and blackbrush (*Coleogyne ramosissima*).
NV-GAP distribution - Juniper is widely distributed throughout Nevada in open canopy stands. Utah juniper woodlands typically occur at the lower elevations of the pinyon-juniper zone. Northern Nevada juniper woodlands lack singleleaf pinyon (*Pinus monophylla*). Small stands of western juniper occur in extreme northwest Nevada. In southern Nevada juniper occurs commonly with blackbrush.
Commentary on NV-GAP: singleleaf pinyon occurs in woodlands in extreme northeastern Nevada, E of Jackpot and N of Wells.
NV-GAP Clark County mapped: the main distribution of **Juniper_2** woodlands are in the Virgin and South Virgin Mountains and the N end of the McCullough Range, S of Black Mountain. Lesser areas are shown to occur in the main portion of the McCullough Range, small patches in upper Lovell Canyon and on the N slope of La Madre Mountain in the Spring Mountains, along the high ridge of the Arrow Canyon Range, the lower foothills of the SW-facing slopes of the Sheep Range, small stands in the Muddy Mountains, and Spirit Mountain in the Newberry Mountains.
Clark County Primary Associated Tree Species: *Pinus monophylla, Quercus turbinella, Yucca brevifolia*
Clark County Primary Associated Shrub Species: *Fallugia paradoxa, Coleogyne ramosissima, Mahonia fremontii, Purshia stansburiana, Ephedra viridis, Chrysothamnus* spp.
Clark County Commentary: Woodlands may be dominated by either Utah juniper or California juniper (*Juniperus californica*). California juniper woodlands are restricted to the Newberry Mountains of extreme southern Nevada. Elsewhere in Clark County, Utah juniper dominates the woodland. Western juniper is not known from Clark County.
Clark County Commentary: the Black Mountain, Arrow Canyon Range, lower slopes of Sheep Range, and Muddy Mountain occurrences are completely in error, as no conifers occur in these areas. Virtually all the juniper woodlands in the Newberry Mountains have < 30% cover, and so should be mapped as **Juniper_1**. I have found no **Juniper_2** in the McCullough Mountains, although it may occur on the periphery of the main portion of the range.

10.) MOJAVE BRISTLECONE_1 - Conifer forest principally dominated by bristlecone pine (*Pinus aristata*) at canopies less than 30 percent.
NV-GAP primary associated tree species: limber pine (*Pinus flexilis*), Engelmann spruce (*Picea engelmannii*), white fir (*Abies concolor*), and ponderosa pine (*Pinus ponderosa*).
NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.) and snowberry (*Symphoricarpos* spp.).
NV-GAP Distribution - This class is distributed in the Snake and Sheep Creek mountains in Clark County usually from 9000-11,500 feet. It is distinguished as the largest, densest expanse of bristlecone pine within Nevada.
Commentary on NV-GAP: there is neither a Snake or Sheep Creek mountains or range in the Mojave Desert of Nevada. The Snake Range does have bristlecone pine forest, but it is in White Pine County, far from the Mojave Desert. The Sheep Creek Mountains are in Lander, Eureka, and Elko Counties of northern Nevada, and there is no bristlecone there.
Commentary on NV-GAP: this reference, "It is distinguished as the largest, densest expanse of bristlecone pine within Nevada." makes little sense here in forest that, by definition, has <30% cover.
Commentary on NV-GAP: *Pinus aristata* is the bristlecone pine of Colorado. *Pinus longaeva* is the bristlecone pine of Nevada and Utah. *Picea engelmannii* does not occur in the Mojave Desert or its mountains.
NV-GAP Clark County mapped: The high elevations of the Spring Mountains and Sheep Range are the only Clark County locations where bristlecone pine forests are mapped. In the Spring Mountains, they are restricted to the highlands between Wheeler Pass in the North and Lovell Pass in the South. In the Sheep Range, these stands are mapped as occurring along the main ridge between Sheep Peak in the S and Hayford Peak in the N.

Additional, larger, stands are mapped NW of Hayford Peak in the vicinities of Sawmill Spring and Perkins Spring.

Clark County Primary Associated Tree Species: *Pinus ponderosa, Pinus flexilis, Abies concolor*

Clark County Primary Associated Shrub Species: *Juniperus communis*, *Artemisia tridentata* var. *vaseyana*, *Symphoricarpos* spp., *Ribes* spp.

Clark County Commentary: This vegetation class has been mapped well. I have not verified the stands in Sheep Range, but herbarium collections verify the presence of the species along the main ridge.

11.) MOJAVE BRISTLECONE_2 - Conifer forest principally dominated by bristlecone pine (*Pinus aristata*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: limber pine (*Pinus flexilis*), Engelmann spruce (*Picea engelmannii*), white fir (*Abies concolor*), and ponderosa pine (*Pinus ponderosa*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.) and snowberry (*Symphoricarpos* spp.).

NV-GAP Distribution - This class is distributed in the Snake and Sheep Creek Mountains within the Mojave Desert usually from 9000-11,500 feet. It is distinguished as the largest, densest expanse of bristlecone pine within Nevada.

Commentary on NV-GAP: there is neither a Snake or Sheep Creek mountains or range in the Mojave Desert of Nevada. The Snake Range does have bristlecone pine forest, but it is in White Pine County, far from the Mojave Desert. The Sheep Creek Mountains are in Lander, Eureka, and Elko Counties of northern Nevada, and there is no bristlecone there.

Commentary on NV-GAP: this reference, "It is distinguished as the largest, densest expanse of bristlecone pine within Nevada." makes little sense here in forest that, by definition, has 30-60% cover while Mojave Bristlecone_3 has greater than 60% cover.

Commentary on NV-GAP: *Pinus aristata* is the bristlecone pine of Colorado. *Pinus longaeva* is the bristlecone pine of Nevada and Utah. Nowhere in the Mojave Desert does *Picea engelmannii* occur.

NV-GAP Clark County mapped: The high elevations of the Spring Mountains and Sheep Range are the only Clark County locations where bristlecone pine forests are mapped. In the Spring Mountains, they are restricted to the highlands between Wheeler Pass in the North and Lovell Pass in the South. In the Sheep Range, these stands are mapped as occurring along the main ridge between Sheep Peak in the S and Hayford Peak in the N. Additional, larger, stands are mapped NW of Hayford Peak in the vicinities of Sawmill Spring and Perkins Spring.

Clark County Primary Associated Tree Species: *Pinus ponderosa, Pinus flexilis, Abies concolor*

Clark County Primary Associated Shrub Species: *Juniperus communis*, *Artemisia tridentata* var. *vaseyana*, *Symphoricarpos* spp., *Ribes* spp.

Clark County Commentary: This vegetation class has been mapped well. I have not verified the stands in Sheep Range, but herbarium collections verify the presence of the species along the main ridge.

12.) MOJAVE BRISTECONE_3 - Conifer forest principally dominated by bristlecone pine (*Pinus aristata*) at canopies greater than 60 percent.

NV-GAP primary associated tree species: limber pine (*Pinus flexilis*), Engelmann spruce (*Picea engelmannii*), white fir (*Abies concolor*), and ponderosa pine (*Pinus ponderosa*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.) and snowberry (*Symphoricarpos* spp.).

NV-GAP distribution - This class is distributed in the Snake and Sheep Creek Mountains within the Mojave Desert usually from 9000-11,500 feet. It is distinguished as the largest, densest expanse of bristlecone pine within Nevada.

Commentary on NV-GAP: there is neither a Snake or Sheep Creek mountains or range in the Mojave Desert of Nevada. The Snake Range does have bristlecone pine forest, but it is in White Pine County, far from the Mojave Desert. The Sheep Creek Mountains are in Lander, Eureka, and Elko Counties of northern Nevada, and there is no bristlecone there.

Commentary on NV-GAP: The densest and most extensive stands of bristlecone pine in Nevada probably occur in the White Pine Range of White Pine and Nye counties, rivaled by the Spring Mountains and finally by the Snake Range.

Commentary on NV-GAP: *Pinus aristata* is the bristlecone pine of Colorado. *Pinus longaeva* is the bristlecone pine of Nevada and Utah. *Picea engelmannii* does not occur in the Mojave Desert or its mountains.

NV-GAP Clark County mapped: The high elevations of the Spring Mountains and Sheep Range are the only Clark County locations where bristlecone pine forests are mapped. In the Spring Mountains, they are restricted to the highlands between Wheeler Pass in the North and Lovell Pass in the South. In the Sheep Range, these stands are mapped as occurring along the main ridge between Sheep Peak in the S and Hayford Peak in the N. Additional, larger, stands are mapped NW of Hayford Peak on the N slope of upper Sawmill Canyon.

Clark County Primary Associated Tree Species: *Pinus ponderosa, Pinus flexilis, Abies concolor*

Clark County Primary Associated Shrub Species: *Juniperus communis*, *Artemisia tridentata* ssp. *vaseyana*, *Symphoricarpos* spp., *Ribes* spp.

Clark County Commentary: This vegetation class has been mapped well. I have not verified the stands in Sheep Range, but herbarium collections verify the presence of the species along the main ridge.

16.) PINYON_1 - Conifer woodland principally dominated by singleleaf pinyon (*Pinus monophylla*) at canopies less than 30 percent.

NV-GAP primary associated tree species: Utah juniper (*Juniperus osteosperma*), ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), mountain-mahogany (*Cercocarpus ledifolius*) and Jeffrey pine (*Pinus jeffreyi*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), Gambels oak (Quercus gambelii), alder leaf mountain-mahogany (*Cercocarpus montanus*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), cliffrose (*Purshia stansburiana*), manzanita (*Arctostaphylos* spp.), shrub live oak (*Quercus turbinella*), and bitterbrush (*Purshia tridentata*).

NV-GAP distribution - Pinyon is most widely distributed throughout eastern, central and western Nevada at elevations above the pinyon-juniper zone. It is absent in northern Nevada.

Commentary on NV-GAP: singleleaf pinyon occurs in woodlands in extreme northeastern Nevada, E of Jackpot and N of Wells.

NV-GAP Clark County mapped: **Pinyon_1** is mapped as occurring in the only in the Spring Mountains and Sheep Range. The major occurrence mapped in the Spring Mountains is near the Clark / Nye County boundary, W and N of Wheeler Pass Road, with minor occurrences mapped at the summit of La Madre Mountain and in Lucky Strike, Peak Spring, and Wallace Canyons. In the Sheep Range, **Pinyon_1** is mapped in the lower to middle elevations of the E slope of the main ridge, above "Yucca Forest," and in the N along the main ridge of the range.

Clark County Primary Associated Tree Species: *Juniperus osteosperma*

Clark County Primary Associated Shrub Species: *Artemisia tridentata, Coleogyne ramosissima, Mahonia fremontii*

Clark County Commentary: the only open woodlands of pinyon without juniper I know of in Clark County occur in the South Virgin Mountains at Summit Spring, mapped by NV-GAP as **Juniper_1**.

17.) PINYON_2 - Conifer forest principally dominated by singleleaf pinyon (*Pinus monophylla*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: Utah juniper (*Juniperus osteosperma*), ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), mountain-mahogany (*Cercocarpus ledifolius*) and Jeffrey pine (*Pinus jeffreyi*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), Gambels oak (Quercus gambelii), alder leaf mountain-mahogany (*Cercocarpus montanus*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), cliffrose (*Purshia stansburiana*), manzanita (*Arctostaphylos* spp.), shrub live oak (*Quercus turbinella*), and bitterbrush (*Purshia tridentata*).

NV-GAP distribution - Pinyon is most widely distributed throughout eastern, central and western Nevada at elevations above the pinyon-juniper zone. It is absent in northern Nevada.

NV-GAP Clark County mapped: **Pinyon_2** is mapped exclusively in the Spring Mountains and Sheep Range. In the Spring Mountains, it is mapped extensively N or Red Rock in the middle elevations of Mt. Charleston and as far south as Potosi Mountain. In the Sheep Range, it is mapped as encircling the main ridge of the range in the South, and along the main ridge N of Mormon Well.

Clark County Primary Associated Tree Species: *Juniperus osteosperma, Juniperus scopulorum, Pinus ponderosa, Quercus gambelii,* and *Cercocarpus ledifolius*

Clark County Primary Associated Shrub Species: *Artemisia tridentata, Prunus fasciculata, Chrysothamnus* spp., *Symphoricarpos* spp., *Ribes* spp., *Echinocereus* spp., and *Opuntia* spp.

Clark County Other Associated Species: Birds beak (*Cordylanthus parviflorus*) is an important and abundant annual plant in pinyon and pinyon-juniper woodlands in the county.

Clark County Commentary: Pinyon is widely distributed in the higher mountain ranges of the county, including the Spring, Sheep, Virgin, McCullough, New York, and South Virgin Mountains. There are dense stands of pinyon with very little juniper at high elevations in the Virgin Mountains. This class is also likely to occur in the McCullough Mountains, although I have not seen it there. The distribution as mapped in the Spring Mountains and Sheep Range seems reasonable.

18.) PINYON-JUNIPER_1 - Conifer woodland principally co-dominated by singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) at canopies less than 30 percent.

NV-GAP primary associated tree species: mountain-mahogany (*Cercocarpus ledifolius*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), Gambels oak (*Quercus gambelii*), alder leaf mountain-mahogany (*Cercocarpus montanus*), bitterbrush (*Purshia tridentata*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), and cliffrose *(Purshia stansburiana*).

NV-GAP distribution - Pinyon-Juniper is distributed throughout all but northern Nevada. It is most abundant in eastern and central Nevada. It typically occurs at the middle elevations of the pinyon-juniper zone.

NV-GAP Commentary: Pinyon-juniper woodlands occur in extreme northeastern Nevada, N of Wells and E of Jackpot.

NV-GAP Clark County mapped: The main distributions of **Pinyon-Juniper_1** that are mapped are in the Spring Mountains, from Potosi Mountain N, and in the Sheep Range, where they are also extensive. Less prominent is the occurrence in the higher elevations of the southern portion of the McCullough Range and the N slope of the Las Vegas Range. Incidental occurrences are found on the South Virgin Peak Ridge of the Virgin Mountains.

Clark County Primary Associated Tree Species: *Cercocarpus intricatus*, *Quercus gambelii*, and *Juniperus scopulorum* at the upper elevations, *Purshia stansburiana* at the lower elevations.

Clark County Primary Associated Shrub Species: *Fallugia paradoxa, Artemisia tridentata, Mahonia fremontii, Rhus trilobata, Quercus turbinella, Prunus fasciculata, Chrysothamnus* spp., *Echinocereus* spp., *Opuntia* spp.

Clark County Other Associated Species: Birds beak (*Cordylanthus parviflorus*) is an important and abundant annual plant in pinyon and pinyon-juniper woodlands in the county. *Hymenoxys cooperi* is a common late-blooming flower in pinyon-juniper woodlands in the taller mountain ranges of the county.

Clark County Commentary: Open pinyon-juniper woodlands are widely distributed in the higher mountain ranges of the county, including all the ranges mapped by NV-GAP but also including the New York Mountains.

19.) PINYON-JUNIPER_2 - Conifer woodland principally co-dominated by pinyon (*Pinus monophylla*) and juniper (*Juniperus osteosperma*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: mountain-mahogany (*Cercocarpus ledifolius*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), Gambels oak (*Quercus gambelii*), alder leaf mountain-mahogany (*Cercocarpus montanus*), bitterbrush (*Purshia tridentata*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), and cliffrose *(Purshia stansburiana*).

NV-GAP distribution - Pinyon-Juniper is distributed throughout all but northern Nevada. It is most abundant in eastern and central Nevada. It typically occurs at the middle elevations of the pinyon-juniper zone.

NV-GAP Commentary: Pinyon-juniper woodlands occur in extreme northeastern Nevada, N of Wells and E of Jackpot.
NV-GAP Clark County mapped: **Pinyon-Juniper_2** woodlands are mapped mainly in five mountain ranges in the county: Spring, Sheep, McCullough, Virgin, and Las Vegas. Incidental occurrences are also mapped in the East Desert and Desert Ranges, in the Desert National Wildlife Refuge.
Clark County Primary Associated Tree Species: *Cercocarpus ledifolius*, *Quercus gambelii*, *Amelanchier utahensis,* and *Juniperus scopulorum* at the upper elevations, *Purshia stansburiana* and *Cercocarpus intricatus* at the lower elevations.
Clark County Primary Associated Shrub Species: *Fallugia paradoxa, Artemisia tridentata, Chrysothamnus* spp., *Arctostaphylos pringlei* (Virgin Mts only), *Arctostaphylos pungens*, *Garrya flavescens, Mahonia fremontii, Coleogyne ramosissima, Rhus trilobata, Prunus fasciculata*, *Echinocereus* spp., *Opuntia* spp.
Clark County Other Associated Species: Birds beak (*Cordylanthus parviflorus*) is an abundant annual plant in pinyon and pinyon-juniper woodlands in the county. *Hymenoxys cooperi* is a common late-blooming flower in pinyon-juniper woodlands in the taller mountain ranges of the county.
Clark County Commentary: Pinyon-juniper woodlands are widely distributed in the higher mountain ranges of the county. The mapping by NV-GAP appears reasonable except for the following: these woodlands extend further S in the Spring Mountains, to near the California / Nevada border. **Pinyon-Juniper_2** is mapped extensively N of Bunkerville Ridge in the Virgin Mountains, where it is restricted to S of Bunkerville Ridge. These woodlands do not occur in either the Desert or East Desert Ranges. This class in the Sheep Range along Mormon Well Road is very well-mapped by NV-GAP.

20.) PONDEROSA PINE_1/MOUNTAIN SHRUB - Conifer woodland principally dominated by ponderosa pine (*Pinus ponderosa*) at canopies less than 30 percent, co-dominant with mountain shrubs including Gambels oak (*Quercus gambelii*), alder leaf mountain-mahogany (*Cercocarpus montanus*), snowberry (*Symphoricarpos* spp.), manzanita (*Arctostaphylos* spp.) and littleleaf mountain-mahogany (*Cercocarpus intricatus*).
NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), mountain-mahogany (*Cercocarpus ledifolius*) and bristlecone pine (*Pinus longaeva*).
NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.).
NV-GAP distribution - This class is predominantly found in the Spring, Sheep Creek, and Clover mountains of southern Nevada.
NV-GAP Clark County mapped: small stands of **Ponderosa Pine_1/Mountain Shrub** are mapped in the Spring Mountains and Sheep Range. In the Spring Mountains, these stands are restricted to N of Lovell Pass through the main mass of Charleston Mountain, N to Willow Peak, and a large stand along the Clark / Nye County boundary and ridge W of Wheeler Wash and S of Wood Canyon. The elevation range of this class in the Spring Mountains is from about 2550-2750m (8350-9000ft). In the Sheep Range, the class is mapped on both sides of the main ridge from S of Sheep Peak to about 9km NE of Hayford Peak. A few isolated stands are mapped near the Clark / Lincoln County boundary along the main ridge at about the same elevations.
Clark County Primary Associated Tree Species: *Cercocarpus ledifolius*, *Cercocarpus intricatus*, *Quercus gambelii*, *Pinus monophylla*, *Juniperus scopulorum*, *Amelanchier utahensis*
Clark County Primary Associated Shrub Species: *Symphoricarpos* spp., *Artemisia* spp., *Arctostaphylos pungens*
Clark County Commentary: there is no Sheep Creek mountain range in southern Nevada. In Nevada, *Cercocarpus montanus* occurs only in Lincoln County.
Clark County Commentary: NV-GAP completely missed the occurrence of both ponderosa pine woodlands and forest in the Red Rock area. NV-GAP also missed the occurrence of this class immediately W of Mormon Well Pass. The only variety of ponderosa pine known from Clark County is *Pinus ponderosa* var. *scopulorum*.

21.) PONDEROSA PINE_2 - Conifer forest principally dominated by ponderosa pine (*Pinus ponderosa*) at canopies from 30-60 percent.
NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*),mountain-mahogany (*Cercocarpus ledifolius*) and bristlecone pine (*Pinus longaeva*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), Gambels oak (*Quercus gambelii*), alder leaf mountain-mahogany (*Cercocarpus montanus*), snowberry (*Symphoricarpos* spp.), manzanita (*Arctostaphylos* spp.) and littleleaf mountain-mahogany (*Cercocarpus intricatus*).

NV-GAP distribution - This class is predominately found in the Spring, Sheep, and Clover mountains of southern Nevada, and the Snake, Wilson Creek, Quinn Canyon and Schell Creek mountains of eastern Nevada.

NV-GAP Clark County mapped: **Ponderosa Pine_2** is mapped in the Spring Mountains and Sheep Range. In the Spring Mountains, these stands are restricted to W and N of Charleston Peak in the Wallace, Clark, and Wheeler Wash drainages at about 2250-2500m (7380-8200ft) elevations, but also on Willow Peak at about 3000m (9850ft). In the Sheep Range, they are mapped on high elevations on W aspects along the main ridge of the higher, southern portion of the range, from Sheep Peak N to Sawmill Canyon.

Clark County Primary Associated Tree Species: *Cercocarpus ledifolius*, *Quercus gambelii*, *Pinus monophylla*, *Juniperus scopulorum*, *Abies concolor* var. *concolor*, and occasionally *Pinus flexilis* and/or *Pinus longaeva*.

Clark County Primary Associated Shrub Species: *Symphoricarpos* spp., *Artemisia* spp., *Arctostaphylos pungens*

Clark County Commentary: there is no Sheep Creek mountain range in southern Nevada. In Nevada, *Cercocarpus montanus* occurs only in Lincoln County.

Clark County Commentary: NV-GAP completely missed the occurrence of both ponderosa pine woodlands and forest in the Red Rock area. Ponderosa pine forest occurs down to 4000 ft elevation along Pine Creek in the Red Rock NCA. The only variety of ponderosa pine known from Clark County is *Pinus ponderosa* var. *scopulorum*.

36.) WHITE FIR_1 - Conifer forest principally dominated by white fir (*Abies concolor*) at canopies less than 30 percent.

NV-GAP primary associated tree species: ponderosa pine (*Pinus ponderosa*), pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus montanus*), Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus longaeva*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), snowberry (*Symphoricarpos* spp.), buckbrush (*Ceanothus* spp.) and manzanita (*Arctostaphylos* spp.).

NV-GAP distribution - This class is distributed throughout eastern and southern Nevada typically above 7500 feet on north and east aspects.

NV-GAP Clark County mapped: **White Fir_1** is mapped only in the Spring Mountains N of Lovell Canyon and along the main ridge of the Sheep Range. In the Spring Mts, elevations range from about 2500-2750m (8200-9000ft) on mainly N aspects. In the Sheep Range, elevations range from about 2250-2900m (7400-9500ft) on mainly N and W aspects.

Clark County Primary Associated Tree Species: *Pinus ponderosa*, *Pinus monophylla*, *Cercocarpus montanus*, *Cercocarpus ledifolius*, *Pinus flexilis,* and *Pinus longaeva*.

Clark County Primary Associated Shrub Species: *Artemisia* spp*., Symphoricarpos* spp., *Ribes* spp., *Arctostaphylos pungens.*

Clark County Commentary: The only white fir variety known in Clark County is *Abies concolor* var. *concolor*. NV-GAP completely missed the occurrence of white fir / Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forest on the N slope of the Virgin Mountains. NV-GAP also missed the occurrence of white fir forests on Potosi Mountain, in the south-central portion of the Spring Mountains. Other than this, NV-GAP seems to have mapped this class well.

37.) WHITE FIR_2 - Conifer forest principally dominated by white fir (*Abies concolor*) at canopies from 30-60 percent.

NV-GAP primary associated tree species: ponderosa pine (*Pinus ponderosa*), pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus montanus*), Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus longaeva*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), snowberry (*Symphoricarpos* spp.), buckbrush (*Ceanothus* spp.) and manzanita (*Arctostaphylos* spp.).

NV-GAP distribution - This class is distributed throughout eastern and southern Nevada typically above 7500 feet on north and east aspects.

NV-GAP Clark County mapped: **White Fir_2** is mapped only in the Spring Mountains and the Sheep Range. In the Spring Mountains, it is mapped as a nearly continuous band from about 2750-3000m (9000-9850ft) on all aspects, occurring from just S of Wheeler Pass to about 4km S of Griffith Peak along the ridge above Lovell Pass. In the Sheep Range, it is mapped along the main ridge in the higher, southern portion of the range, from Timber and Sawmill Canyons S to about Sheep Peak.

Clark County Primary Associated Tree Species: *Pinus ponderosa*, *Pinus monophylla*, *Cercocarpus montanus*, *Cercocarpus ledifolius*, *Pinus flexilis,* and *Pinus longaeva*.

Clark County Primary Associated Shrub Species: *Artemisia* spp*., Symphoricarpos* spp., *Ribes* spp., *Arctostaphylos pungens.*

Clark County Commentary: The only white fir variety known in Clark County is *Abies concolor* var. *concolor*. NV-GAP completely missed the occurrence of white fir / Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forest on the N slope of the Virgin Mountains. NV-GAP also missed the occurrence of white fir forests on Potosi Mountain, in the south-central portion of the Spring Mountains. Aside from these misclassifications, NV-GAP seems to have mapped this class well.

38.) WHITE FIR_3 - Conifer forest principally dominated by white fir (*Abies concolor*) at canopies greater than 60 percent.

NV-GAP primary associated tree species: ponderosa pine (*Pinus ponderosa*), pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus montanus*), Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus longaeva*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), snowberry (*Symphoricarpos* spp.), buckbrush (*Ceanothus* spp.) and manzanita (*Arctostaphylos* spp.).

NV-GAP distribution - This class is distributed throughout eastern and southern Nevada typically above 7500 feet on north and east aspects.

NV-GAP Clark County mapped: **White Fir_3** is mapped only in the Spring Mountains and the Sheep Range. In the Spring Mountains, it is mapped as small patches from about 2750-3000m (9000-9850ft) mainly on N and E aspects, occurring from just S of Wheeler Pass to about 4km S of Griffith Peak along the ridge above Lovell Pass. In the Sheep Range, it is mapped along the main ridge in the higher, southern portion of the range, from Timber and Sawmill Canyons S to about Sheep Peak.

Clark County Primary Associated Tree Species: *Pinus ponderosa*, *Pinus monophylla*, *Cercocarpus montanus*, *Cercocarpus ledifolius*, *Pinus flexilis,* and *Pinus longaeva*.

Clark County Primary Associated Shrub Species: *Artemisia* spp*., Symphoricarpos* spp., *Ribes* spp., *Arctostaphylos pungens*

Clark County Commentary: NV-GAP completely missed the occurrence of white fir / Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) forest on the N slope of the Virgin Mountains. NV-GAP also missed the occurrence of white fir forests on Potosi Mountain, in the south-central portion of the Spring Mountains. The only white fir variety known in Clark County is *Abies concolor* var. *concolor*.

SHRUB-DOMINATED COMMUNITIES (Shrublands)

40.) BLACKBRUSH – Shrubland principally dominated by blackbrush (*Coleogyne ramosissima*).

NV-GAP primary associated tree species: juniper (*Juniperus osteosperma*).

NV-GAP primary associated shrub species: spiny hopsage (*Grayia spinosa*), Mormon tea (*Ephedra* spp.), shadscale (*Atriplex confertifolia*), desert thorn (*Lycium* spp.), snakeweed (*Xanthocephalum* spp.), and creosote (*Larrea tridentata*).

NV-GAP other associated species: Joshua tree (*Yucca brevifolia*), and yucca (*Yucca* spp.).

NV-GAP distribution - Blackbrush is typically a transition vegetation class between Mojave and Great Basin shrublands. It usually occurs in elevation transition areas between 4000-5000 feet and in a latitude transition area north of creosote-bursage.

NV-GAP Commentary: Most of the genus *Xanthocephalum* has been submerged into the genus *Gutierrezia*.

NV-GAP Clark County mapped: **Blackbrush** communities as mapped by NV-GAP occupy nearly 15% of the county, ranking third in the county behind **Creosote-Bursage** and **Mojave Mixed Scrub**. The entire Spring Mountains, Virgin Mountains, and Sheep Range are ringed by broad swaths of **Blackbrush**. In addition, **Blackbrush** is mapped as continuous from the lower slopes of the Ivanpah Valley W of the McCullough Range E through Searchlight and into most of the lower western slopes of the El Dorado Range, and most of the Gold Butte area. Finally, a large area (4-7km wide) is mapped on the western slopes and upper bajada of the Newberry Mountains.

Clark County Primary Associated Tree Species: *Juniperus osteosperma, Juniperus californica, Pinus monophylla, Acacia greggii, Yucca brevifolia.*

Clark County Primary Associated Shrub Species: *Ephedra nevadensis, Ephedra viridis, Atriplex confertifolia, Larrea tridentata, Grayia spinosa, Yucca baccata*

Clark County Commentary: the distribution of **Blackbrush** communities is seriously overestimated in the county, virtually wherever it has been mapped. While the NV-GAP write-up is mainly correct as describing its elevation occurrence as being between 4000-5000 feet, much of the area mapped as **Blackbrush** is below 3000 feet and the species, much less the cover class, does not occur there. Some of the sharpest vegetation lines in the county occur at the boundary of **Blackbrush** with other communities. Most of the errors of NV-GAP for this vegetation class are errors of commission, mapping **Blackbrush** where it is not dominant.

Clark County Commentary: it is impossible by the descriptions contained in NV-GAP to tell which of the mapped cover classes has Joshua tree (*Yucca brevifolia*) as the dominant overstory species. There are three communities in which Joshua tree is mentioned: **Blackbrush**, **Creosote-Bursage**, and **Mojave Mixed Scrub**. In all three cases, Joshua tree is included under "other associated species." However, Joshua tree communities are mainly distributed with blackbrush understories, although it commonly occurs with mixed shrubland or sagebrush (*Artemisia tridentata*) understories. In the valley West of the Sheep Range, in the Desert National Wildlife Refuge, Joshua tree communities possess a shadscale (*Atriplex confertifolia*) understory.

41.) CREOSOTE-BURSAGE - Scrubland principally dominated by creosote (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*).

NV-GAP primary associated shrub species: blackbrush (*Coleogyne ramosissima*), Mormon tea (*Ephedra* spp.), dalea (*Dalea fremontii*), shadscale (*Atriplex confertifolia*), hopsage (*Grayia spinosa*), desert thorn (*Lycium* spp.), ratany (*Krameria parvifolia*), burro bush (*Hymenoclea salsola*), honey mesquite (*Prosopis glandulosa*) and brittlebush (*Encelia farinosa*).

NV-GAP other associated species: Joshua tree (*Yucca brevifolia*), yucca (*Yucca* spp.), prickly pear (*Opuntia engelmannii*) and cholla (*Opuntia* spp., in part).

NV-GAP distribution - This class occurs widely within the Mojave Desert below 4000 feet, typically found in valley bottoms, lowlands and flatlands of mild slope.

NV-GAP Commentary: The woody species formerly belonging to genus *Dalea*, including *Dalea fremontii*, have been put into their own genus, *Psorothamnus*. The current name for the shrubby "dalea" associated with **Creosote-Bursage** communities in Nevada is *Psorothamnus fremontii*.

NV-GAP Clark County mapped: This is the most widely distributed vegetation community in the county, occupying nearly 45% of the county's area. However, in spite of the text saying that it occurs "widely … below 4000ft (1220m), what is actually mapped is mainly below 915m (3000ft).

Clark County Primary Associated Tree Species: *Acacia greggii* (usually in and along washes)

Clark County Primary Associated Shrub Species: *Coleogyne ramosissima*, *Psorothamnus fremontii, Atriplex confertifolia, Lycium torreyi, Lycium andersonii, Krameria parvifolia, Hymenoclea salsola, Encelia farinosa, Encelia virginensis, Salazaria mexicana, Opuntia* spp., *Echinocactus* spp., *Echinocereus* spp., *Ferocactus acanthodes*.

Clark County Commentary: The distribution of **Creosote-Bursage** communities in Clark County appears to be well-mapped by NV-GAP in that there are few errors of commission. However, there are numerous errors of omission, in that large areas where these communities are dominant are mapped as **Blackbrush**.

Clark County Commentary: NV-GAP fails to mention an important distinguishing feature between this shrubland and other Nevada shrublands, and that is the importance of annual plants in the community. In no other vegetation class do annual plants maintain such a high proportion of the biodiversity in the community.

Clark County Commentary: It is impossible by the descriptions contained in NV-GAP to tell which of these communities would have Joshua tree (*Yucca brevifolia*) as the dominant overstory species. There are three communities in which Joshua tree is mentioned: **Blackbrush**, **Creosote-Bursage**, and **Mojave Mixed Scrub**. In all three cases, Joshua tree is included under "other associated species." However, Joshua tree communities are mainly distributed with blackbrush understories, although it often occurs with mixed shrubland, or sagebrush (*Artemisia tridentata*), or uncommonly with shadscale (*Atriplex confertifolia*) understories. I have never observed it with what could be called a *Larrea-Ambrosia* (Creosote-Bursage) understory.

Clark County Commentary: *Ephedra* species most typically occurring in **Creosote-Bursage** communities are *Ephedra torreyi* and *Ephedra nevadensis*.

43.) HOPSAGE - Shrubland characterized by the occurrence of hopsage (*Grayia spinosa*), typically in concert with desert thorn (*Lycium* spp.), rabbitbrush (*Chrysothamnus* spp.), Mormon tea (*Ephedra* spp.) and shadscale (*Atriplex confertifolia*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.), blackbrush (*Coleogyne ramosissima*), rabbitbrush (*Chrysothamnus* spp.), winterfat (*Krascheninnikovia lanata*), ratany (*Krameria parvifolia*), bursage (*Ambrosia dumosa*) and creosote (*Larrea tridentata*).

NV-GAP distribution - This is a transition shrubland, typically between Mojave and Great Basin ecosystems. This class occurs in the northern reaches of the Mojave and the southern fringe of the Great Basin.

NV-GAP Clark County mapped: the main area mapped occurs on the lower bajada of the western slope of the Sheep Range, the upper bajada of the north slope of the Spring Mountains, and the southern tip of the El Dorado Mountains NW of Searchlight. Small patches are mapped on both the lowest E and W slopes of the southern portion of the McCullough Mountains.

Clark County Primary Associated Tree Species: none

Clark County Primary Associated Shrub Species: *Artemisia* spp., *Coleogyne ramosissima*, *Chrysothamnus* spp., *Krascheninnikovia lanata*, *Krameria parvifolia*, *Ambrosia dumosa* and *Larrea tridentata*.

Clark County Commentary: Certainly **Hopsage** communities are uncommon and small in Clark County, but I have not verified their occurrence at any of the mapped locations, nor have I found occurrences where none are mapped.

44.) MESQUITE - Shrubland dominated by honey mesquite (*Prosopis glandulosa*).

NV-GAP primary associated shrub species: salt-cedar (*Tamarix ramosissima*), Torrey saltbush (*Atriplex torreyi*) and creosote (*Larrea tridentata*).

NV-GAP distribution - This cover-type is only found principally on the west side of the Mojave Desert in scattered clumps.

NV-GAP Clark County mapped: **Mesquite** is mapped in the Mesquite, Pahrump, Las Vegas, and Moapa Valleys. In the Las Vegas Valley, large stands are indicated at the Corn Creek HQ of the Desert National Wildlife Refuge. The most extensive occurrences are mapped in the Pahrump Valley, along the California / Nevada border, with additional stands to the SE in Mesquite Valley. A small stand is mapped at the intersection of SR 168 and Warm Springs Road along the Muddy River in the upper Moapa Valley.

Clark County Primary Associated Tree Species: *Tamarix ramosissima, Prosopis pubescens, Chilopsis linearis*, *Populus fremontii, Fraxinus velutinus*.

Clark County Primary Associated Shrub Species: *Atriplex lentiformis, Pluchea sericea, Baccharis emoryi, Lycium torreyi.*

Clark County Commentary: in Nevada, Torrey saltbush (*Atriplex torreyi* [SY = *Atriplex lentiformis* ssp. *torreyi*]) occurs only well north of the range of *Prosopis*. In Nevada, **Mesquite** communities are restricted to Clark and southern Nye counties only, where a common associate is the related quailbush (*Atriplex lentiformis* ssp. *lentiformis*). I have never observed Torrey saltbush with either creosote bush or mesquite.

Clark County Commentary: The distribution of **Mesquite** along the Muddy River is underestimated, and a few fragments remain within the urban development of the Las Vegas Valley, particularly in the S at Sunset Park and between Sunset and Warm Springs and Tomiyasu and Eastern. Otherwise, the mapping of this class appears very good.

Clark County Commentary: **Mesquite** communities occur in a variety of geomorphologic circumstances, but wherever they occur, they must have access to groundwater supplies throughout the growing season. They appear in concave surfaces (in washes, such as the badlands near Hidden Hills in southern Pahrump Valley), on convex surfaces (on stabilized dunes, such as those SE of Black Butte in northern Mesquite Valley and Sunset Park in

Las Vegas Valley), and on flat surfaces, either surrounding dry lakebeds (e.g., Mesquite Lake) or along rivers (e.g., Muddy River).

45.) MOJAVE MIXED SCRUB - Mojave desert mixed scrublands are usually characterized by the occurrence of creosote (*Larrea tridentata*), in association with several possible species including bursage (*Ambrosia dumosa*), dalea (*Dalea fremontii*), desert thorn (*Lycium* spp.), shadscale (*Atriplex confertifolia*), hopsage (*Grayia spinosa*), ratany (*Krameria parvifolia*) and Mormon tea (*Ephedra* spp.).

NV-GAP primary associated shrub species: blackbrush (*Coleogyne ramosissima*), brittlebush (*Encelia farinosa*), burro bush (*Hymenoclea salsola*), bebbia (*Bebbia juncea*), desert saltbush (*Atriplex polycarpa*) and desert holly (*Atriplex hymenelytra*).

NV-GAP other associated species: Joshua tree (*Yucca brevifolia*), yucca (*Yucca* spp.), cacti (*Echinocereus* spp.) and cholla (*Opuntia bigelovii*).

NV-GAP distribution - This class typically occurs on slopes, washes or upland areas within the Mojave desert that are difficult to characterize because of several mixed shrub species with no clear dominance.

NV-GAP Commentary: The woody species formerly belonging to genus *Dalea*, including *Dalea fremontii*, have been put into their own genus, *Psorothamnus*. The correct name for the shrubby "dalea" associated with **Creosote-Bursage** communities in Nevada is *Psorothamnus fremontii*.

NV-GAP Clark County mapped: two large areas of this class are mapped, one on the lowest elevations of the bajada on the western slopes of the Sheep Range, and the other at the upper bajada of the north slope of the Spring Mountains, near the Clark / Nye County line. Isolated occurrences of this vegetation class are mapped near Searchlight, in the New York Mountains and in the southern tip of the El Dorado Mountains.

Clark County Primary Associated Tree Species: *Yucca brevifolia, Yucca schidigerae, Acacia gregii*

Clark County Primary Associated Shrub Species: *Larrea tridentata*, *Ambrosia dumosa*,*Psorothamnus fremontii*, *Lycium* spp., *Atriplex confertifolia*, *Grayia spinosa*, *Krameria parvifolia, Yucca baccata,* and *Ephedra* spp.

Clark County Commentary: it is difficult to tell just what exactly NV-GAP means by this class, as is reflected by their statement under distribution in which the authors state that there are "several mixed shrub species with no clear dominance." Since it is mapped as a halo at elevations immediately above the **Creosote-Bursage** class, I am assuming that there is more diversity here and includes more of the arboreal yuccas, *Yucca brevifolia* and *Yucca schidigerae* than any other class. In this case, this class should have been mapped throughout most of the feature called "Yucca Forest" in the Sheep Range within the Desert National Wildlife Refuge, and along SR 164 W of Searchlight in the Joshua tree woodlands there.

46.) MOUNTAIN SAGEBRUSH - Mountain shrubland dominated or co-dominated by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), subalpine sagebrush (*Artemisia tridentata* ssp. *spiciformis*), low sagebrush (*Artemisia arbuscula*) and silver sagebrush (*Artemisia cana*), in concert with mountain shrubs, grasses and forbs.

NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus ledifolius*), limber pine (*Pinus flexilis*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), whitebark pine (*Pinus albicaulis*) and Jeffrey pine (*Pinus jeffreyi*).

NV-GAP primary associated shrub species: snowberry (*Symphoricarpos* spp.), alder leaf mountain-mahogany (*Cercocarpus montanus*), bitterbrush (*Purshia tridentata*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), buckbrush (*Ceanothus* spp.), manzanita (*Arctostaphylos* spp.), ninebark (*Physocarpus alternans*), currant (*Ribes* spp.), squawbush (*Rhus* spp.) and cliffrose (*Purshia stansburiana*).

NV-GAP distribution - This class is widespread throughout Nevada mountains usually at elevations from 6500-10,000 feet. It is especially prevalent in central and northern Nevada where mountain forests are minimal.

NV-GAP Clark County mapped: only in a few locations in the northern half of the Spring Mountains and along the main ridge of the Sheep Range

Clark County Primary Associated Tree Species: pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus ledifolius*), limber pine (*Pinus flexilis*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*)

Clark County Primary Associated Shrub Species:

Clark County Commentary: the mapping of this class seems reasonable, although I have yet to find this type of plant community in Clark County.

47.) MOUNTAIN SHRUB - Deciduous shrubland principally dominated by oak (*Quercus* spp.), maple (*Acer* spp.), alder leaf mountain-mahogany (*Cercocarpus montanus*), cliffrose (*Purshia stansburiana*), bitterbrush (*Purshia tridentata*), serviceberry (*Amelanchier* spp.), buckbrush (*Ceanothus* spp.), snowberry (*Symphoricarpos* spp.), manzanita (*Arctostaphylos* spp.) ninebark (*Physocarpus alternans*), currant (*Ribes* spp.), squawbush (Rhus spp.) and littleleaf mountain-mahogany (*Cercocarpus intricatus*).

NV-GAP primary associated shrub species: sagebrush (*Artemisia* spp.) and rabbitbrush (*Chrysothamnus* spp.)

NV-GAP primary associated tree species: pinyon (*Pinus monophylla*), juniper (*Juniperus osteosperma*), mountain-mahogany (*Cercocarpus ledifolius*), aspen (*Populus tremuloides*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), ponderosa pine (*Pinus ponderosa*), subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*).

NV-GAP distribution - This is a widespread class in the foothills and mountains of Nevada. Because of the landscape scale of the mapping, many of these species could not be isolated. The largest concentrations of this class are found in the mountains of southern, eastern and northeastern Nevada.

NV-GAP Clark County mapped: mainly in the Spring and Virgin Mountains, with minor areas in the McCullough, Sheep, and South Virgin Mountains. Incidental occurrences are mapped in the Newberry and New York Mountains. Elevations are from about 1830-2135m (6000-7000 ft).

Clark County Primary Associated Tree Species: *Pinus monophylla*, *Juniperus osteosperma*, *Juniperus scopulorum, Cercocarpus ledifolius*, *Populus tremuloides*, *Abies concolor*, *Pinus flexilis*, *Pinus ponderosa, Pinus longaeva,* and *Quercus gambelii.*

Clark County Primary Associated Shrub Species: *Artemisia tridentata* var. *vaseyana*, *Artemisia arbuscula*, *Chrysothamnus* spp., *Ribes* spp., *Ceanothus martinii*, *Arctostaphylos pungens, Arctostaphylos pringlei* (Virgin Mts only) *Symphoricarpos* spp.

Clark County Commentary: There is no reason to exclude *Pinus longaeva* from the list of associated tree species.

Clark County Commentary: The New York and Newberry Mountains occurrences are highly questionable, given the species list above. In the Newberry Mountains, the class is mapped along Christmas Tree Pass Road, upper Empire Wash, and Spirit Mountain. At the Christmas Tree Pass Road and Empire Wash locations, there are *Acacia greggii* - dominated communities that contain none of the associated species in the NV-GAP list except for a *Quercus* (*Quercus turbinella*). It is reasonable to assume that the high reflectance in the green and near-IR of Acacia could lead to a similar combined spectral signature resembling **Mountain Shrub**. Otherwise, the mapping of this class seems to be mapped at lower elevations than it occurs, and is greatly overestimated in distribution throughout Clark County.

48.) SAGEBRUSH - Shrubland principally dominated by big sagebrush (*Artemisia tridentata* ssp., in part), black sagebrush (*Artemisia nova*) or low sagebrush (*Artemisia arbuscula*).

NV-GAP primary associated tree species: juniper (*Juniperus osteosperma*), pinyon (*Pinus monophylla*), mountain-mahogany (*Cercocarpus ledifolius*), Jeffrey pine (*Pinus jeffreyi*) and ponderosa pine (*Pinus ponderosa*).

NV-GAP primary associated shrub species: rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia sarothrae*), blackbrush (*Coleogyne ramosissima*), shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus* spp.), spiny hopsage (*Grayia spinosa*), and bitterbrush (*Purshia tridentata*).

NV-GAP primary associated grass species: wheatgrasses (*Agropyron* spp.), cheatgrass (*Bromus tectorum*), bluegrasses (*Poa* spp.), needlegrasses (*Stipa* spp.), fescues (*Festuca* spp.), and galleta (*Hilaria jamesii*).

NV-GAP distribution - Sagebrush is the most widespread and abundant cover-type in Nevada. Typically this class occurs above 5000 feet with associated grass species making up less than 25% of the sagebrush canopy.

NV-GAP Clark County mapped: ringing higher elevations of the Spring, Sheep, Virgin, and McCullough Ranges. Incidental occurrences are mapped in the South Virgin, Newberry, and Muddy Mountains. **Sagebrush** shrublands are mapped as dominating most of the highest elevations of the Pintwater and Spotted Ranges at and just S of the Clark / Lincoln County boundary. Elevations are from about 1525-1830m (5000-6000ft).

Clark County Primary Associated Tree Species: *Pinus monophylla, Juniperus osteosperma, Juniperus scopulorum, Quercus gambelii*

Clark County Primary Associated Shrub Species: *Chrysothamnus* spp., *Gutierrezia sarothrae*, *Coleogyne ramosissima*, *Atriplex confertifolia*, *Grayia spinosa*, *Fallugia paradoxa,* and *Purshia tridentata*

Clark County Commentary: distribution in the southern Sheep Range is greatly overestimated, especially in "Yucca Forest." Also greatly overestimated (if occurring there at all) is the N slope of the Las Vegas Range, N of Gass Peak. NV-GAP shows this as the dominant vegetation type over the whole NW facing slope of the range. The Spring Mountain mapping is also greatly overestimated, especially along the NE facing slope of the range. There are very few **Sagebrush** communities in Clark County; those that do occur are mainly near pinyon-juniper stands, often restricted to linear communities along drainages where soils are deeper. The Virgin Mountains **Sagebrush** stands are also overestimated. Here, tiny **Sagebrush** communities occur from about 5000-5500ft, above the lower limit of pinyon and juniper woodlands, interspersed with these woodlands on NE-facing slopes. The best development of **Sagebrush** I found in Clark County is along Mormon Well Road, N of Peek-A-Boo Canyon and S of Mormon Well Pass, properly mapped (albeit overestimated even in this case) by NV-GAP.

49.) SAGEBRUSH/PERENNIAL GRASS - Co-dominant sagebrush (*Artemisia* spp.) shrubland and perennial grassland. Co-dominance is defined by either shrub or grass occurring at canopies at least 25% of the other Principal grass species include wheatgrasses (*Agropyron* spp.), bluegrasses (*Poa* spp.), needlegrasses (*Stipa* spp.), fescues (*Festuca* spp.), ricegrass (*Oryzopsis hymenoides* [SY=*Achnatherum hymenoides*]) and galleta (*Hilaria jamesii*).

NV-GAP primary associated shrub species include rabbitbrush (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*) and cliffrose (*Purshia stansburiana*).

NV-GAP primary associated grass species include cheatgrass (*Bromus tectorum*) and squirreltail (*Elymus elymoides*).

NV-GAP distribution - This class typically occurs mid-elevation between sagebrush and mountain sagebrush classes in central Nevada, and is widespread as part of the sagebrush steppe of northern Nevada.

NV-GAP Clark County mapped: principally in one area, that of the central eastern slopes of Lovell Canyon, immediately W of Red Rock. A few minor areas are mapped along Mormon Well Road near Peek-A-Boo Canyon, on the upper eastern slopes of the Las Vegas Range, a few patches in the Virgin Mountains, and in the north end of the New York Mountains.

Clark County Primary Associated Tree Species: *Pinus monophylla, Juniperus scopulorum*

Clark County Primary Associated Shrub Species: *Purshia tridentata*

Clark County Commentary: the only place I know where **Sagebrush/Perennial Grass** exists in Clark County is near Mormon Well Pass in the Sheep Range.

50.) SALT DESERT SCRUB - Shrublands principally dominated by one or more of the following; shadscale (*Atriplex confertifolia*), desert holly (*Atriplex hymenelytra*), bailey's greasewood (*Sarcobatus baileyi*), desert thorn (*Lycium* spp.), Torrey saltbush (*Atriplex torreyi*), winterfat (*Krascheninnikovia lanata*), budsage (*Artemisia spinescens*), fourwing saltbush (*Atriplex canescens*), Mormon tea (*Ephedra* spp.), greasewood (*Sarcobatus vermiculatus*), horsebrush (*Tetradymia canescens*), and snakeweed (*Gutierrezia sarothrae*).

NV-GAP primary associated shrub species: greasewood (*Sarcobatus vermiculatus*), sagebrush (*Artemisia* spp.), blackbrush (*Coleogyne ramosissima*), iodine bush (*Allenrolfea occidentalis*) and creosote *(Larrea tridentata*).
NV-GAP primary associated forb species: halogeten (*Halogeten glomeratus*).
NV-GAP primary associated grass species: saltgrass (*Distichlis spicata*) and cheatgrass (*Bromus tectorum*).
NV-GAP distribution - This is a broad, abundant class that can occur in a variety of physiographic areas throughout the state. Typically this class occurs below 5000 feet (except for central Nevada) and especially dominates the Lahontan basin of western Nevada.
NV-GAP Clark County mapped: mainly in the NW portion of the county, N of the Spring Mountains and W of the Sheep Range. Another significant portion is shown to occur N of Las Vegas and E of US 95. Smaller patches are mapped in the northern portion of El Dorado Valley S of Boulder City, N of the road between Searchlight and Cottonwood Cove, and in Jean Valley. Small patches mapped throughout the Red Rock Conservation Area in the Spring Mountains.
Clark County Primary Associated Tree Species: *Prosopis glandulosa*
Clark County Primary Associated Shrub Species: *Atriplex confertifolia*, *Atriplex hymenelytra*, *Lycium* spp., *Atriplex lentiformis*, *Krascheninnikovia lanata*, *Atriplex canescens*, *Atriplex polycarpa*, *Ephedra torreyana*, *Suaeda moquinii, Tetradymia canescens*, *Hymenoclea salsola*, and *Gutierrezia sarothrae*
Clark County Other Associated Species: *Sphaeralcea ambigua, Sphaeralcea grossulariifolia, Stanleya pinnata*
Clark County Commentary: This class does not occur where mapped in the Red Rock Conservation Area, nor in the Newberry Mountains. Thin strips of **Salt Desert Scrub** occur along the S bank of the Virgin River, but were not mapped. Large tracts of **Salt Desert Scrub** mapped in the northern El Dorado Valley should have been mapped as **Playa**, with **Salt Desert Scrub** surrounding it. Otherwise, NV-GAP mapped this class fairly well. Unfortunately, these communities can have enormously different habitat characteristics, depending upon which species dominates. I have found **Salt Desert Scrub** communities in Clark County dominated by any of the following species: *Atriplex canescens, A. confertifolia, A. hymenelytra, A. lentiformis, A. polycarpa,* and *Suaeda moquinii.*

HERBACEOUS-DOMINATED COMMUNITIES (Meadows and Grasslands)

52.) ALPINE - High elevation tundra vegetation, including forbs, sedges, grasses and shrubs.
NV-GAP principal forb species: alpine avens (*Geum rossii*), *Silene acaulis*, *Eriogonum* spp., *Draba* spp.,
NV-GAP principal sedge species: *Carex* spp.
NV-GAP principal grass species: tufted hair grass (*Deschampsia caespitosa*), *Trisetum spicatum*, *Agropyron scribneri*, *Festuca ovina*, *Phleum alpinum*.
NV-GAP principal shrub species: willow (*Salix* spp.), cinquefoil (*Potentilla* spp.), and blueberry (*Vaccinium* spp.)
NV-GAP primary associated tree species: limber pine (*Pinus flexilis*), whitebark pine (*Pinus albicaulis*) and bristlecone pine (*Pinus longaeva*).
NV-GAP distribution - This class usually occurs above 10,000 feet on mountains throughout Nevada. Because there is a wide variation in floristic composition in alpine zones throughout Nevada, this list includes only a sample of some of the most common species.
NV-GAP Clark County mapped: exclusively in the high elevations of the Spring Mountains, along the highest ridge from Griffith Peak in the south, through and including Charleston Peak, N and E to Mummy Mountain.
Clark County Primary Associated Tree Species: *Pinus longaeva, Pinus flexilis*
Clark County Primary Associated Shrub Species:
Clark County Other Associated Species: *Aquilegia scopulorum, Potentilla cryptocaulis, Dodecatheon jeffreyi*
Clark County Commentary: the **Alpine** class appears to be correctly mapped

54.) GRASSLAND - Perennial and annual grasslands.

NV-GAP principal perennial grass species: wheatgrasses (*Agropyron* spp.), bluegrass (*Poa* spp.), basin wildrye (*Elymus cinereus*), galleta (*Hilaria* spp.), needlegrass (*Stipa* spp.), sand dropseed (*Sporobolus cryptandrus*), blue gramma (*Bouteloua gracilis*), squirreltail (*Sitanion hystrix*) and Indian ricegrass (*Oryzopsis hymenoides* [SY = *Achnatherum hymenoides*]).
NV-GAP principal annual grass species: cheatgrass (*Bromus tectorum*).
NV-GAP primary associated shrub species: sagebrush (Artemisia spp.), shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*) and creosote (*Larrea tridentata*).
NV-GAP primary associated tree species: juniper (*Juniperus* spp.).
NV-GAP distribution - This is a wide-spread, broadly defined class distributed mostly in central and northern Nevada. The majority of this class occurs as a result of seeded perennial grasslands or fire induced annual grasslands. However, it does also include valley, foothill and mountain native grasslands.
NV-GAP Clark County mapped: Several areas in the county. The main distribution is along the eastern flank of the central portion of the Spring Mountains, especially S of La Madre Mountain and S to Shenandoah Mountain. Additional significant areas mapped include: immediately S of Moapa Peak in the Mormon Mountains, scattered throughout the Virgin and South Virgin Mountains S of Mesquite, the lower eastern slopes of the N end of the New York Mountains and the valley S of the Highland Mountains.
Clark County Primary Associated Tree Species: *Yucca brevifolia*
Clark County Primary Associated Shrub Species:
Clark County Commentary: it is mystifying to me that so much **Grassland** is mapped in Clark County. In trying to verify these occurrences, I went to the large block of **Grassland** mapped S of Moapa Peak. This was a broad expanse of dry **Creosote-Bursage** with some *Yucca brevifolia*. I did find correctly mapped **Grassland** at T27S R62E S32 in the extreme NW corner of Paiute Valley, along the lower SW slopes of the Highland Spring Range. However, the extent of the formation was greatly exaggerated, as most of what is mapped as **Grassland** in this area is actually *Yucca brevifolia* woodland with a diverse understory. Most of NV-GAP's errors in this class are of commission.

MISCELLANEOUS

56.) AGRICULTURE - Row crops, irrigated pasture and hay fields, dry farm crops.
NV-GAP distribution - Located state-wide
NV-GAP Clark County mapped: major **Agriculture** areas include Moapa Valley, the eastern portion of the Virgin Valley near Mesquite, Sandy (Mesquite Valley), and the area around Corn Creek station, Desert National Wildlife HQ.
Clark County Primary Associated Tree Species: *Tamarix ramosissima, Populus fremontii, Prosopis glandulosa, Salix goodingii*
Clark County Primary Associated Shrub Species: *Atriplex lentiformis, Pluchea sericea, Baccharis emoryi*
Clark County Commentary: there is no land currently in agriculture production at Corn Creek Wildlife HQ, otherwise good.

57.) BARREN - Barren soil or rock with less than 5 percent total vegetative cover.
NV-GAP distribution - This class is distributed throughout Nevada with the majority being low elevation barren soil or high elevation rock cliffs and talus slopes.
NV-GAP Clark County mapped: along the main ridge of Mt. Charleston and immediately E of Frenchman Mountain near Gypsum Wash.
Clark County Commentary: The largest distribution mapped (E of Frenchman Mountain) is highly questionable and are probably errors of commission. The Charleston Peak locations are talus **Alpine** communities. Small areas of **Barren** badlands S of Overton along the W shore of Lake Mead appear to be correctly mapped by NV-GAP.

58.) LOWLAND RIPARIAN - Localized vegetation influenced by the presence of abundant water in contrast to the surrounding landscape in lowland areas.

NV-GAP principal tree species include Fremont cottonwood (*Populus fremontii*) and black cottonwood (*Populus trichocarpa*).
NV-GAP principal shrub species include salt cedar (*Tamarix ramosissima*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*) and mesquite (*Prosopis glandulosa*).
NV-GAP distribution - Riparian areas generally lower than 4000 feet in the Mojave and 5000 feet in the remaining areas of Nevada. Velvet ash, desert willow and mesquite are only found in the Mojave. This class is common along the Carson, Colorado, Humboldt, Truckee, Virgin and Walker rivers.
NV-GAP Clark County mapped: the upper Las Vegas Wash, along the Colorado River at Big Bend and the Mojave Indian Reservation and small units S of Black Canyon and in Cottonwood Valley, along the Virgin River, the lower Muddy River near Overton, the upper Muddy River, mainly W of I-15, and the lower Meadow Valley Wash.
Clark County Primary Associated Tree Species: *Tamarix* spp., *Populus fremontii, Fraxinus velutina*, *Prosopis glandulosa, Prosopis pubescens*, *Salix goodingii*, sometimes *Pinus ponderosa* (southeast portion of Spring Mountains at Pine Creek and Oak Creek). *Populus balsamifera* ssp. *trichocarpa* (synonym = *Populus trichocarpa*) is not a component of Lowland Riparian, in either Clark County or anywhere else in Nevada.
Clark County Primary Associated Shrub Species: *Baccharis emoryi*, *Pluchea sericea*
Clark County Commentary: *Chilopsis linearis* occurs mainly in dry washes that receive episodic high flows of water, but not usually in perennial streams. If we include *Chilopsis* as a component of **Lowland Riparian**, then we must also include these other important trees in major dry wash communities: *Quercus turbinella* and *Acacia greggii*. However, no major dry wash systems were mapped as **Lowland Riparian**; instead they are lumped within the surrounding upland vegetation that the washes pass through and are not otherwise accounted for in the map.

59.) MOUNTAIN RIPARIAN - Localized vegetation influenced by the presence of abundant water in contrast to the surrounding landscape in highland areas.
NV-GAP principal tree species include narrowleaf cottonwood (*Populus angustifolia*), thinleaf alder (*Alnus tenuifolia*), quaking aspen (*Populus tremuloides*), water birch (*Betula occidentalis*), black hawthorn *(Crataegus douglasii*), and Rocky Mountain maple (*Acer glabrum*).
NV-GAP principal shrub species include willow (*Salix* spp.), red-osier dogwood (*Cornus stolonifera*) and wild rose (*Rosa woodsii*).
NV-GAP distribution - This class is found throughout Nevada in high valleys, foothills and mountains.
Commentary on NV-GAP: *Crataegus douglasii* is quite unusual in Nevada, known to occur only in the Ruby Mountains.
NV-GAP Clark County mapped: mainly distributed in higher elevations in the Spring Mountains. Minor units mapped in the Sheep Range and in the Las Vegas Range.
Clark County Primary Associated Tree Species: *Populus angustifolia*, *Populus tremuloides*
Clark County Primary Associated Shrub Species: *Rosa woodsii*, *Ribes aureum*
Clark County Commentary: the **Mountain Riparian** class appears to be correctly mapped, except the Las Vegas Range units are highly questionable.

60.) PLAYAS - Barren internal basin floors which can occasionally be covered by water.
NV-GAP distribution - Located state-wide on flat, low elevation valley floors.
NV-GAP Clark County mapped: Jean Lake, Roach Lake, near Nye County line in Pahrump Valley, dry lake bed in Indian Spring Valley, valleys E and NE of Indian Springs Valley, and along Gypsum Wash, immediately E of Frenchman Mountain.
Clark County Commentary: NV-GAP did not map **Playa** in El Dorado Valley where a large one occurs. Instead, the **Playa** here was mapped as **Salt Desert Scrub**. Otherwise, the map appears to be accurate.

61.) SAND DUNES - Sand dunes with less than 5 percent total vegetative cover.
NV-GAP distribution - Located state-wide, with major dunes near Winnemucca and Sand Mountain near Fallon.
NV-GAP Clark County mapped: not mapped by NV-GAP in Clark County

Clark County Primary Associated Tree Species: sand dunes immediately N of Clark County (Game Range Dunes) have *Chilopsis linearis* on them. Sand dunes immediately W of Clark County (Big Dune and Amargosa Dunes) have *Prosopis glandulosa* on them. The only trees I know of that are associated with Clark County dunes occur on the Fort Mojave Indian Reservation, where *Prosopis glandulosa, Prosopis pubescens, Salix goodingii*, and *Tamarix ramosissima* are present on the dunes. Dunes also occur in the Clark County portion of Pahrump and Mesquite Valleys, but these are mainly stabilized by *Prosopis glandulosa*, have few active surfaces, and are probably best classified as NV-GAP has done, as **Mesquite**.

Clark County Primary Associated Shrub Species: *Larrea tridentata, Pluchea sericea*

Clark County Commentary: present E of North Las Vegas and Mojave Indian Reservation, S of Laughlin

63.) URBAN - Commercial, mining and residential areas.

NV-GAP distribution - Located state-wide

NV-GAP Clark County mapped: main urban centers include communities in the Las Vegas Valley, Moapa Valley, Mesquite, Boulder City, Laughlin

Clark County Commentary: the dimension of the Urban cover class in the Las Vegas Valley has grown significantly in all directions since NV-GAP mapped the county.

64.) WATER - Open water

NV-GAP distribution - Located state-wide.

NV-GAP Clark County mapped: main features are Lake Mead, largest lake in Nevada, and Mojave Lake.

Clark County Commentary: this class is mapped correctly in Clark County.

65.) WETLAND - Low elevation marsh and wetland areas.

NV-GAP principal species: cattail (*Typha latifolia*), bullrush (*Scirpus* spp.), burreed (*Sparganium* spp.), common reed grass (*Phragmites australis*), pondweed (*Potamogeton* spp.) and sedge (*Carex* spp.).

NV-GAP distribution - This class occurs in limited areas throughout Nevada, typically in low elevation basins around a permanent water source. The largest expanses occur in Ruby Valley and the Carson Sink.

NV-GAP Clark County mapped: Not mapped by NV-GAP in Clark County.

Clark County Primary Associated Tree Species: *Tamarix* spp., *Populus fremontii, Fraxinus velutina*, *Prosopis glandulosa, Prosopis pubescens*

Clark County Primary Associated Shrub Species: *Baccharis emoryi*, *Pluchea sericea*

Clark County Commentary: present at Las Vegas Wash, Moapa Valley along the Muddy River, along the Virgin River. These small wetland areas are misclassified as Lowland Riparian or Agriculture

Progress Report on the Clark County Road Biodiversity Project

Biological Resources Research Center, University of Nevada, Reno

This report is designed to serve as an executive summary of the activities and progress to date on the Clark County road project. There are innumerable technical details but these are not reported in this document to enhance its readability. This report has been prepared by David Charlet with help by Lisa Smith, Bob Elston, and BrianMenamy. Questions concerning the technical GIS details of this project are best referred to the GIS personnel.

Overview

The long-term goal of the project is to rank all Clark County roads according to their biodiversity value. There are few direct geographic measures of biodiversity in the county, yet the need to understand the distribution of biodiversity in the county is immediate and great. Given this situation, we sought to use exploratory methods of inquiry on existing biological and physical data to the biodiversity value of the roads, to later be tested with direct measurements. The three main goals of this summer were to 1) acquire and assemble the databases, 2) extract the meaningful data from the GIS coverages, and assemble them into a spreadsheet, and 3) assign rankings to the roads according to their predicted biodiversity value.

Data Sources and Their Purpose

The first goal of the project was to assemble the databases necessary for the project. The data collected were from existing geographic information systems (GIS) coverages for Clark County. We identified all relevant GIS coverages for the county (Table 1). There were a few problems integrating them, and these problems are discussed below. It should be noted that through our process, it became clear that the metadata pages for Clark County at the BRRC website needs to be updated as they are largely out-of-date.

Road database: the coverage present at the Las Vegas BRRC GIS lab a Digital Line Graph (DLB). However, once road intersections with vegetation class were calculated, it was clear that a great many of these roads were outside the NV-GAP coverage. Upon investigation into the source of this error, we learned that the original data were from the US Geological Survey (USGS) but that sometime in the past, the DLG was reprojected incorrectly. This led to an eastward shift of the DLG by about 1000m, and so the data were corrupted. This detected, we scrutinized all the coverages more closely and noticed that few, if any, of the coverages we possessed had the same boundaries, but that several had the same boundaries as the road database. It was necessary to find new data for both the roads and streams (see below), and to apply some additional clipping procedures to make the boundaries of all coverages the same.

The new coverage and attribute table for Clark County roads was originally from the US Census Bureau, but was provided and modified by Environmental Systems Research Institute (ESRI). This data set was a different type of file, had a completely different (and inferior) road classification system, and so all biodiversity analyses had to be abandoned and we started over. This data set's classification system does not correctly identify all four-wheel drive roads, and there are many cases where it cannot be determined if the road is dirt, gravel or paved. This problem has yet to be resolved.

One prominent difference between the two road data sets was that in the ESRI coverage that we are now using, the roads were not segmented according to road intersection, but segments (hence a new "road") were created whenever the road crossed a feature, such as a wash or stream. As a result, there were more than 69,000 "roads" in the data set. Some of the same roads appeared two or more times in a dataset, such as when an Interstate and US Highway share some road. The segment is the same, but that same segment appeared as both a US Highway and an Interstate. All duplicate entries such as these were identified and copies were eliminated.

To simplify the analysis further, we eliminated all roads that were exclusively in the NV-GAP Urban cover class. After this procedure, more 19,000 segments ("roads") remained, but of these more than 3000 were segments less than 100m, with many segments as small as 10m. Segments were as long as 11.9km, a difference of orders of magnitude. Given the nature of the new road data, these small segments had to be joined to reduce the overwhelming effect of distance to the biodiversity results. The roads were rejoined into segments no shorter than 100m.

Multispecies Habitat Conservation Plan (MSHCP) Management Classes. This polygon database turned out to be surprisingly difficult to acquire. While reviewing the data sets already in the Las Vegas BRRC GIS lab's possession, we also discovered that the land ownership coverage in the lab was out of date, in that it did not incorporate the recent USDA FS acquisitions in the Spring Mountains. We ultimately found the current correct coverage for land ownership and for the MSHCP Management Classes.

Purpose: It has been largely assumed, although never systematically evaluated, that the Intensive Management Areas within the Clark County MSHCP sufficiently protect all habitat types within the county. One way to test this assumption is to calculate the total area of each NV-GAP vegetation cover class for each MSHCP management class. This analysis was performed this summer (see preliminary results below).

Digital elevation model (DEM). This grid database from the USGS was on hand in the Las Vegas BRRC office and was free of problems.

Purpose: The elevation gradient powerfully affects the distribution of species on a landscape. Species turnover is powerfully associated with elevation change, and so the range of elevation that a road possesses should be a strong indicator of biodiversity for that road.

Township, Range, and Section (TRS). A TRS polygon coverage database originally from the USGS was present in the Las Vegas BRRC office, this database also had the 1000m eastward shift error. This problem has been corrected.

Purpose: The TRS data were used to prepare the Nevada GAP (NV-GAP) (Edwards et al. 1996) draft vegetation maps as an overlay in order to locate vegetation polygons in the field. For the final, large-scale prints of NV-GAP vegetation maps, a transparent, color-coded overlay was prepared for precise location on paper maps of the vegetation polygons for the ground-truthing aspect of the project.

Spring database: The springs database present at the Las Vegas BRRC GIS lab consisted of point data for the distribution of springs. The initial results indicated a major problem with this dataset because while ground-truthing the NV-GAP vegetation map, more than 10 springs were visited within 250m of rural roads, yet only 4 springs in the database were shown to be near roads. Either these spring point data must be newly collected from paper maps, or a new digital source must be found.

Purpose: Another indirect measure of biodiversity can be garnered from the location of springs. Springs are biological hotspots in the Mojave Desert, and while not directly measuring the number of species at these springs, the fact that a spring exists provides that location a prominent importance in terms of biodiversity in that landscape.

Hydrology (streams, washes, and shorelines) database: The DLG database present at the Las Vegas BRRC GIS lab originally came from the USGS, but was also corrupted by the old projection error and had to be abandoned. The dataset we now have in our possession, like the road dataset, is a polygon coverage from ESRI. It consists of streams, washes and shorelines, each consisting of several categories (e.g., perennial and intermittent streams; manmade, intermittent, and indefinite shorelines).

Purpose: Upon close inspection of the NV-GAP vegetation map and its accompanying monographs describing the vegetation, it became clear that NV-GAP did not capture several cover types that occur in the county. Most notable as far as biodiversity is concerned, are wash communities. In particular, wash communities dominated by *Acacia greggii* are not accounted for. Wherever these *Acacia* communities occur, they provide and are associated with additional resources and higher biodiversity, distinct from the surrounding communities. Therefore, in order to account for these communities and the biodiversity they represent, it is important to account for it in some other way. The hydrology (streams, washes, and shorelines) dataset is an excellent substitute for direct measurements of the otherwise undetected wash communities. In addition, shorelines are vitally important to both terrestrial and aquatic organisms, and so roads crossing shorelines will be given a biodiversity value.

Soils database: The soils data from the Natural Resource Conservation Service (NRCS) are not yet completely digitized for Clark County. The local office of the NRCS is amenable to having the CCSN GIS advanced student laboratory digitize the remaining quadrangles, if they follow strict NRCS quality-control procedures. The local office will also let us use the pre-publication data for quadrangles they have already completed. Lacking the complete data set at this time, and given that CCSN was in summer sessions, we did not pursue this data set during the summer. This is a potentially very useful data set, and such a cooperative agreement could be pursued in the immediate future.

Purpose: Soils are a primary determinant of plant species distribution and abundance, thus affecting the biodiversity and species composition of ecosystems. To a large degree, soil is an excellent predictor of vegetation communities, and so a good soils map is a fine indirect measure of the heterogeneity of biodiversity on a landscape. The NRCS used different mapping methods from the NV-GAP methods, and included a significant amount of ground-truthing. Thus, the NRCS soils map will be an excellent inclusion into the project.

Geology database: The polygon database of geology was present in the Las Vegas BRRC GIS laboratory, but also possessed the projection error, causing the same 1000m eastward shift. This error was corrected, and uncorrupted database will soon be put up on the BRRC ftp site for our use. To date it has not been used, but will be in the next data extraction and analysis procedures. The road coverage will be analyzed in conjunction with the geology polygons in precisely the same way as the NV-GAP vegetation polygons were.

Purpose: Rock is a starting material for soils, and so geologic substrates are vitally important in determining the distribution of plant species. Thus, different geology usually results in different suites of plants and associated animals, fungi, and bacteria. While the geology database is somewhat redundant to the Soils database, until the Soils database is ready to use, the Geology database will be useful.

NV-GAP database: A consolidated version of this polygon database from the US Fish and Wildlife Cooperative Unit in Logan was present in the Las Vegas BRRC GIS laboratory, but we obtained the original data from the Reno BRRC GIS lab and worked with the original data exclusively.

Purpose: NV-GAP describes and maps 35 cover classes in Clark County. Each cover class is recognized based on different plant communities. Associated with these different plant communities, are different assemblages of animals, fungi, and bacteria. While not actually counting the number of species in any given class, the number of NV-GAP classes that a road crosses should increase the biodiversity value of the road in that with each class crossed, different species will be encountered.

Sensitive Species database: This dataset consists of point data from the Nevada Natural Heritage Program (NNHP). It was easy to obtain and free of problems.

Purpose: This database offers the only direct measure of biodiversity of all that available databases. However, since there are only 79 species included in this dataset, and there somewhere around 1500 species of plants alone in the county, this represents only a tiny sample of the biodiversity in the county.

Data Extraction and Database Assembly

The second goal was to extract the meaningful data from the GIS coverages, and assemble these data into a spreadsheet. Most roads consist of many segments, and these segments were assigned unique numbers. All segments of a given road can be combined to examine the entire length of the road, but this has not yet been done.

The total area of each NV-GAP vegetation class and each management class was extracted and the percentage of total Clark County area that each class occupied was calculated. Then the proportions of each NV-GAP vegetation class as they occupy each management class was compiled and compared.

The length of each numbered road was calculated and the intersections a road has with a streambed were counted. Additionally, the length of each road in each vegetation class was extracted. We still need to do this for each management class. The number of proximate traverses of roads to springs and sensitive species was extracted and compiled. All these data were compiled into an Excel spreadsheet, organized by roads as rows and attributes as columns.

Ground -Truthing. Draft maps of each NV-GAP vegetation class, displayed individually, were prepared. The vegetation class was displayed with the road, DEM, and Township-Range-Section (TRS) grid for orientation. Roads to travel and ground-truth were selected from the set of Clark County roads. While traveling these roads, special attention was given to several elements of the NV-GAP map: 1) errors of commission (misidentified vegetation units), 2) errors of omission (units of vegetation not distinguished in the NV-GAP map), and 3) fidelity of vegetation units (that is, are boundaries between vegetation units actually there, and are there boundaries or classes not identified by NV-GAP?).

Purpose: Since the NV-GAP is one of only two biological measures of biodiversity in our possession, our conclusions are largely based on the assumption that NV-GAP is accurate. This ground-truthing serves to test that assumption. I can verify the accuracy of the biodiversity assessment results obtained by counting the number of classes each road crosses and by finding if the types of vegetation occurrences predicted by NV-GAP in particularly areas are actually there. Ground-truthing also serves to verify the accuracy of the NV-GAP vegetation map. Cases of systematic errors of commission or omission will be corrected and so begin the task of refining the NV-GAP vegetation map for Clark County.

Road Biodiversity Scores. The third goal was to assign rankings to the roads according to their biodiversity value. The process began by using direct and indirect measurements of biodiversity as described above. In addition, the total number of NV-GAP classes that a road crosses were counted and compiled. As a direct measure of biodiversity value, the number of sensitive species' distributions that the road comes near was counted and compiled. Each road segment was ranked in each surrogate and direct biodiversity measure, and simple correlations were performed on the resulting road attribute table.

Preliminary Results

Management Area Effectiveness: The total area of NV-GAP cover classes within each management area was calculated (Table 2). This procedure revealed that most of the cover classes identified by NV-GAP have most of their Clark County area within the IMA (Intensely Managed Area) class. Exceptions to this are in the Juniper_2 (42%), Lowland Riparian (33%) and Mesquite (14%) classes.

Biodiversity Rankings of Roads: Road length was by far the highest correlate to any biodiversity measure- the longer a road was, the higher biodiversity score it had. Short roads either had a stream intersection or not, or came close to a species or spring or not. All attempts to normalize these data produced indices of extremely high values for very short roads that came close to a species or crossed a NV-GAP boundary. These results were artifacts of the orders of magnitude difference between road lengths.

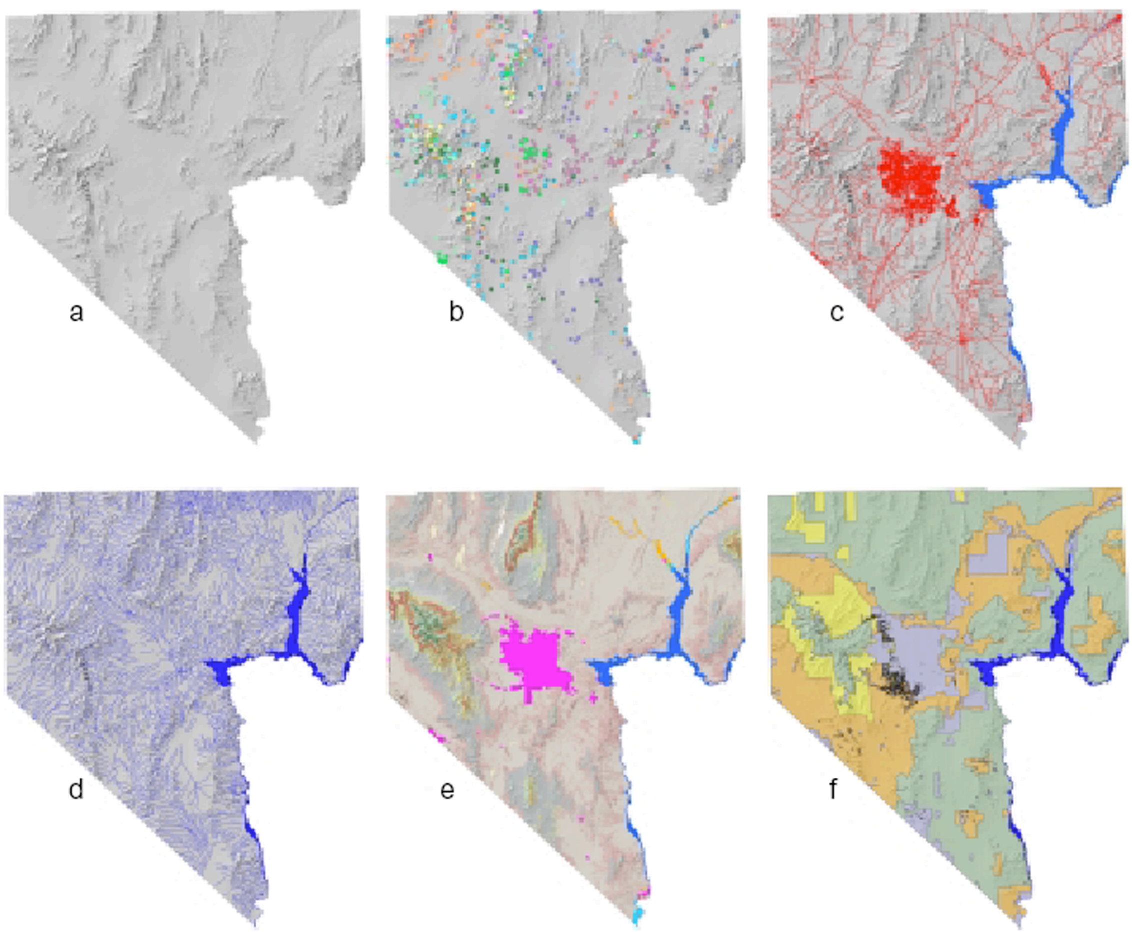
After this exploratory analysis, it became clear that the wide range road lengths made it impossible to assign a meaningful biodiversity ranking to the roads. I decided to join the road segments to make larger units. We devised a method whereby we joined the road segments, yielding a data set with segments having a minimum length of 77m (these all being city streets). There are about 6000 roads in this iteration of the road data set, prior to clipping out the roads in the urban cover class. An artifact of this procedure, however, is that new numbers had to be assigned to the new road segments. This makes the road lengths equivalent, allowing for a more meaningful comparison between roads and their biodiversity scores. This means that no result of the previous analyses can be used, and we have to start over with the analysis.

Ground-Truthing: I anticipated spending much more time in the field than I did because so much time had to be spent with the data sets. Nevertheless, throughout the summer I logged 1750 miles on Clark County roads of every type, in most major features in the county, in every land management class, and in all land ownership types (except for US Department of Defense and US Department of Energy). In addition, 950 miles were traveled on Clark County roads from 1-31 May. A journal with a mileage log was maintained, and observations of the vegetation communities, their boundaries, and species lists of abundant plants in these communities were kept. Some plant collections were made that will be donated to the herbaria at UNLV and UNR. Finally, I found, measured, and nominated the Nevada State Big Tree Champion *Acacia greggii* this summer in the Virgin Mountains of Clark County. This giant was fully 8m tall with a 9.5m average crown spread.

Written Report: What I have in the way of a deliverable written report is what is now a 20-page unedited, un-reviewed paper, *Preliminary Evaluation of Nevada GAP Vegetation Classes as Described and Mapped in Clark County, Nevada*. It is a detailed critique of the Nevada GAP map and write-up (Edwards et a. 1996), with the original text and my commentary. It is self-standing as it is now, but naturally, I want to expand and improve upon it. Know that this is an unedited work-in-progress; nevertheless, I think you will find it useful as an in-house document for the time being.

Current Status

While the process of database acquisition, extraction, assembly, and analysis were performed two times with different datasets, we have no presentable road ranking results. In fact, most of these procedures need to be done a third time. While this is frustrating, we have nevertheless made considerable progress. We began with incompatible datasets, and identified and corrected all those problems. Some datasets we did not have in our possession, but now we do. Ultimately, the roads were broken up into far too many segments, but now we are aware of the analytical problem this causes, and developed an appropriate method to correct it. Our methods for data extraction have been developed and we have considerable practice in their application. Useful NV-GAP maps have been prepared to facilitate the ground-truthing of NV-GAP. Enough field work was conducted so that we have identified some systematic and non-systematic errors in NV-GAP, and these are specifically documented.



GIS Layers of Clark County, Nevada. (a) Digital Elevation Model (DEM) alone, the remaining with DEM and other coverages: (b) species vulnerable to extinction, (c) roads and trails, (d) streams, washes, and lakes, (e) GAP vegetation classes, and (f) MSHCP land management classes.

Table 1. Data sources for the Clark County Road project and their status.

coverage name	possess	source	use	analysis
roads	x	USGS & US CENSUS	base for project	done 3x; ready redo
water (drainages)	x	USGS / EPA	# crossings	done 2x; not ready
water (springs)	need	USGS / EPA	# orbs[1] intersected	done 1x; bad data!
water (shorelines)	x	USGS / EPA	# intersections	done 1x; not ready
geology	x	NV Bureau of Mines	# classes crossed	pending
digital elevation model	x	USGS	elevation amplitude	done 1x; ready redo
GAP vegetation	x	Nevada GAP	# classes crossed*	done 2x; ready redo
township, range, section	x	USGS	sampling grid	
sensitive species	x	NV Natural Heritage	# orbs intersected	done 1x; ready redo
soils	need	SCRS	# classes crossed	pending
ima[2]	x	Clark County	quantified separately	complete
lima[3]	x	Clark County	quantified separately	complete
muma[4]	x	Clark County	quantified separately	complete
uma[5]	x	Clark County	quantified separately	complete

1: orb = biologically relevant diameter surrounding the dot (point)
2: ima = intensive managed area
3: lima = limited intensive managed area
4. muma = multiple use managed area
5. uma = unmanaged area

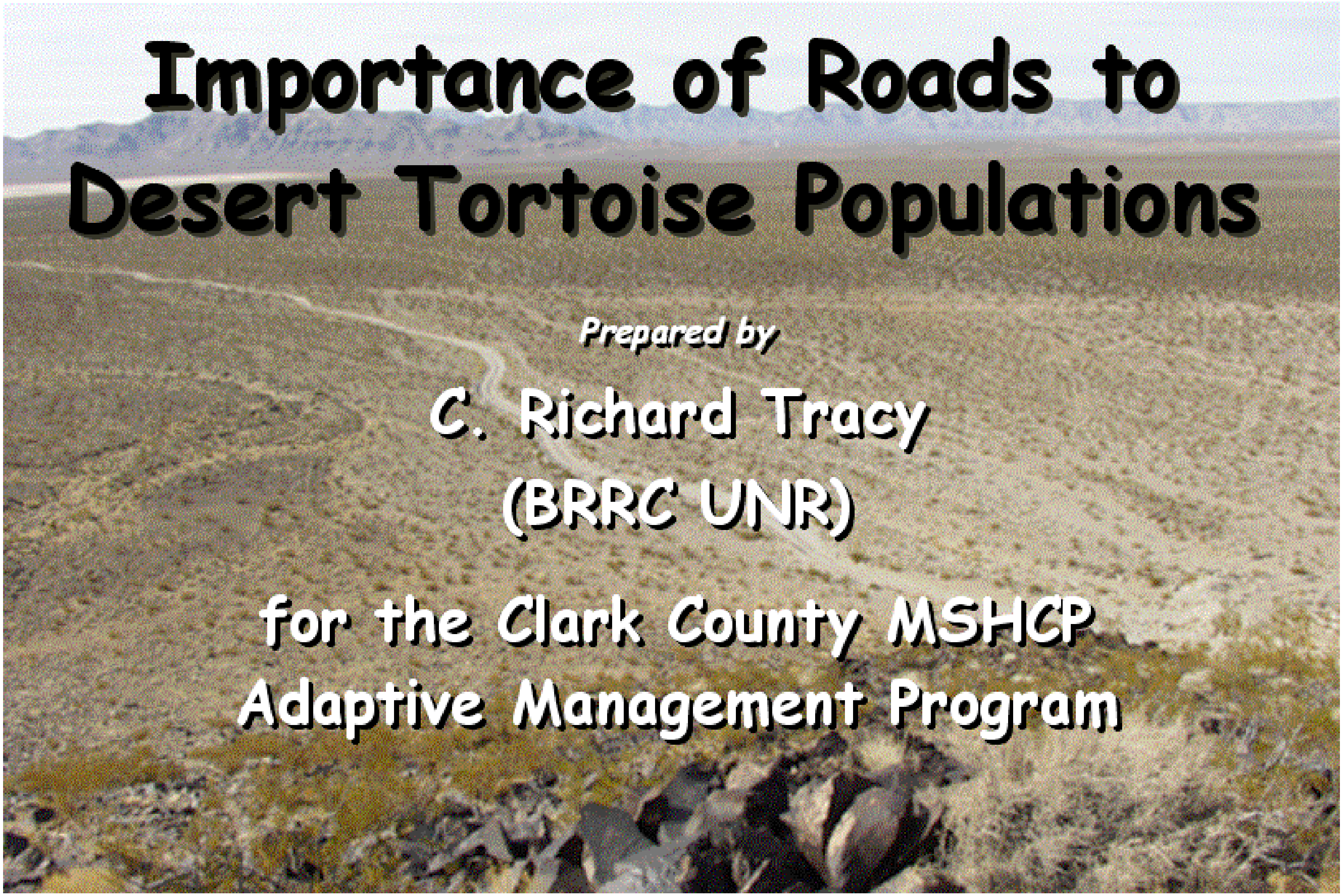
[management classifications on pg 2 -148 CC-MSHCP]

Table 2. Total area of each Nevada GAP (Edwards et al. 1996) vegetation class in each Multi-Species Habitat Conservation Plan (MSHCP) management area class, Clark County, Nevada

VEGETATION TYPES	Hectares LIMA	Hectares IMA	Hectares MUMA	Hectares UMA	Total Hectares of class	% LIMA	% IMA	% IMA + LIMA	% COUNTY
No Data	2.52	129.24	35.82	18.90	186.48	1.35	69.31	70.66	0.01
Aspen_2	9.54	25.47	1.71	0.45	37.17	25.67	68.52	94.19	0.00
Aspen_3	38.34	86.85	5.94	1.71	132.84	28.86	65.38	94.24	0.01
Juniper_1	1588.14	7963.83	1891.71	356.31	11799.99	13.46	67.49	80.95	0.56
Juniper_2	63.00	750.33	970.47	11.16	1794.96	3.51	41.80	45.31	0.09
Mojave Bristlecone_1	99.72	1882.26	61.20	0.00	2043.18	4.88	92.12	97.00	0.10
Mojave Bristlecone_2	63.81	3033.36	136.08	0.00	3233.25	1.97	93.82	95.79	0.15
Mojave Bristlecone_3	6.03	859.23	86.67	0.00	951.93	0.63	90.26	90.90	0.05
Pinyon_1	168.66	1960.92	1.71	56.34	2187.63	7.71	89.64	97.35	0.10
Pinyon_2	5188.41	14247.36	196.74	39.87	19672.38	26.37	72.42	98.80	0.94
Pinyon-Juniper_1	3741.30	6223.23	174.96	247.68	10387.17	36.02	59.91	95.93	0.50
Pinyon-Juniper_2	7167.51	20355.03	1683.99	26.01	29232.54	24.52	69.63	94.15	1.40
Ponderosa Pine_1/Mt Shrub	428.94	3248.10	19.71	254.70	3951.45	10.86	82.20	93.06	0.19
Ponderosa Pine_2	2331.00	8679.33	138.51	0.00	11148.84	20.91	77.85	98.76	0.53
White Fir_1	47.25	467.46	12.15	0.00	526.86	8.97	88.73	97.69	0.03
White Fir_2	170.55	2415.69	28.53	0.00	2614.77	6.52	92.39	98.91	0.12
White Fir_3	82.80	957.06	16.65	0.00	1056.51	7.84	90.59	98.42	0.05
Blackbrush	40798.17	159642.63	92690.19	16016.58	309147.57	13.20	51.64	64.84	14.77
Creosote-Bursage	30784.32	474186.24	339383.88	96294.15	940648.59	3.27	50.41	53.68	44.93
Hopsage	69.66	3252.15	1014.93	48.42	4385.16	1.59	74.16	75.75	0.21
Mesquite	0.00	369.90	1879.02	424.71	2673.63	0.00	13.84	13.84	0.13
Mojave Mixed Scrub	16646.22	223596.54	94779.00	21334.32	356356.08	4.67	62.75	67.42	17.02
Mountain Sagebrush	60.30	480.51	7.56	0.00	548.37	11.00	87.63	98.62	0.03
Mountain Shrub	16455.24	25124.76	5430.06	1585.17	48595.23	33.86	51.70	85.56	2.32
Sagebrush	13956.84	33179.22	7206.30	1045.26	55387.62	25.20	59.90	85.10	2.65
Sagebrush/Perennial Grass	426.51	522.09	71.55	77.40	1097.55	38.86	47.57	86.43	0.05
Salt Desert Scrub	11681.91	59660.01	24630.03	10596.87	106568.82	10.96	55.98	66.94	5.09
Alpine	3.24	307.98	38.25	0.00	349.47	0.93	88.13	89.05	0.02
Grassland	5767.92	10646.64	3010.68	1029.87	20455.11	28.20	52.05	80.25	0.98
Agriculture	1.08	384.12	1137.69	6399.00	7921.89	0.01	4.85	4.86	0.38
Barren	60.93	676.98	337.77	350.37	1426.05	4.27	47.47	51.75	0.07
Lowland Riparian	41.67	2462.22	2390.40	2598.48	7492.77	0.56	32.86	33.42	0.36
Mountain Riparian	202.59	252.00	20.07	21.60	496.26	40.82	50.78	91.60	0.02
Playas	4015.44	1837.62	1546.20	898.29	8297.55	48.39	22.15	70.54	0.40
Urban	2167.47	595.08	4992.84	71102.16	78857.55	2.75	0.75	3.50	3.77
Water	3515.22	37751.67	271.08	268.83	41806.80	8.41	90.30	98.71	2.00
TOTAL	**167852.25**	**1108213.11**	**586300.05**	**231104.61**	**2093470.02**	**8.02**	**52.94**	**60.95**	**100.00**

Tortoises vs. Highways Analysis

The BRRC was asked to analyze the existing data on the relationships, if any, between highways and tortoise populations. This analysis is not to assess the known fact that tortoises wander onto highways and get killed, but instead to determine the extent to which highways influence desert tortoise populations. What follows is a copy of the Powerpoint presentation of our report on this subject. The bottom line is that highways unquestionably have negative impacts on desert tortoise populations in general. However, the data are less clear on particular roads. Significantly, the data for Interstate 15 suggest that desert tortoise populations are not negatively affected by this highway. We hypothesize that the relentless traffic on this highway serves as its own deterrent to desert tortoises, and perhaps fencing of I15 would not be warranted! This hypothesis needs testing, and fencing of this highway needs to be delayed until further data are collected bearing on this hypothesis.


Importance of Roads to
Desert Tortoise Populations
Prepared by
C. Richard Tracy
(BRRC UNR)
for the Clark County MSHCP
Adaptive Management Program

Two unpublished reports present analyses of the effects of roads on desert tortoise.

Baepler DH, Heindl A, Singh AK, Pandey A, 1994. A study of the impacts of highways on desert tortoise populations. Report. Nevada Department of Transportation.

Marlow, RW, 1998. Impacts of vehicle road traffic on desert tortoise populations in the Piute, Cottonwood, and Eldorado Valleys Desert Management Areas of southern Nevada. Report. Biological Resources Research Center, University of Nevada, Reno.

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In both projects, tortoise sign was measured along transects in relation to distances from roads. And, roads differing in traffic level were measured as part of their studies. However,

(1) The methods used in each study were different.

(2) The statistics used were different.

(3) The conclusions reached were different.

Question: can we combine the data from the two reports to create a new analysis?

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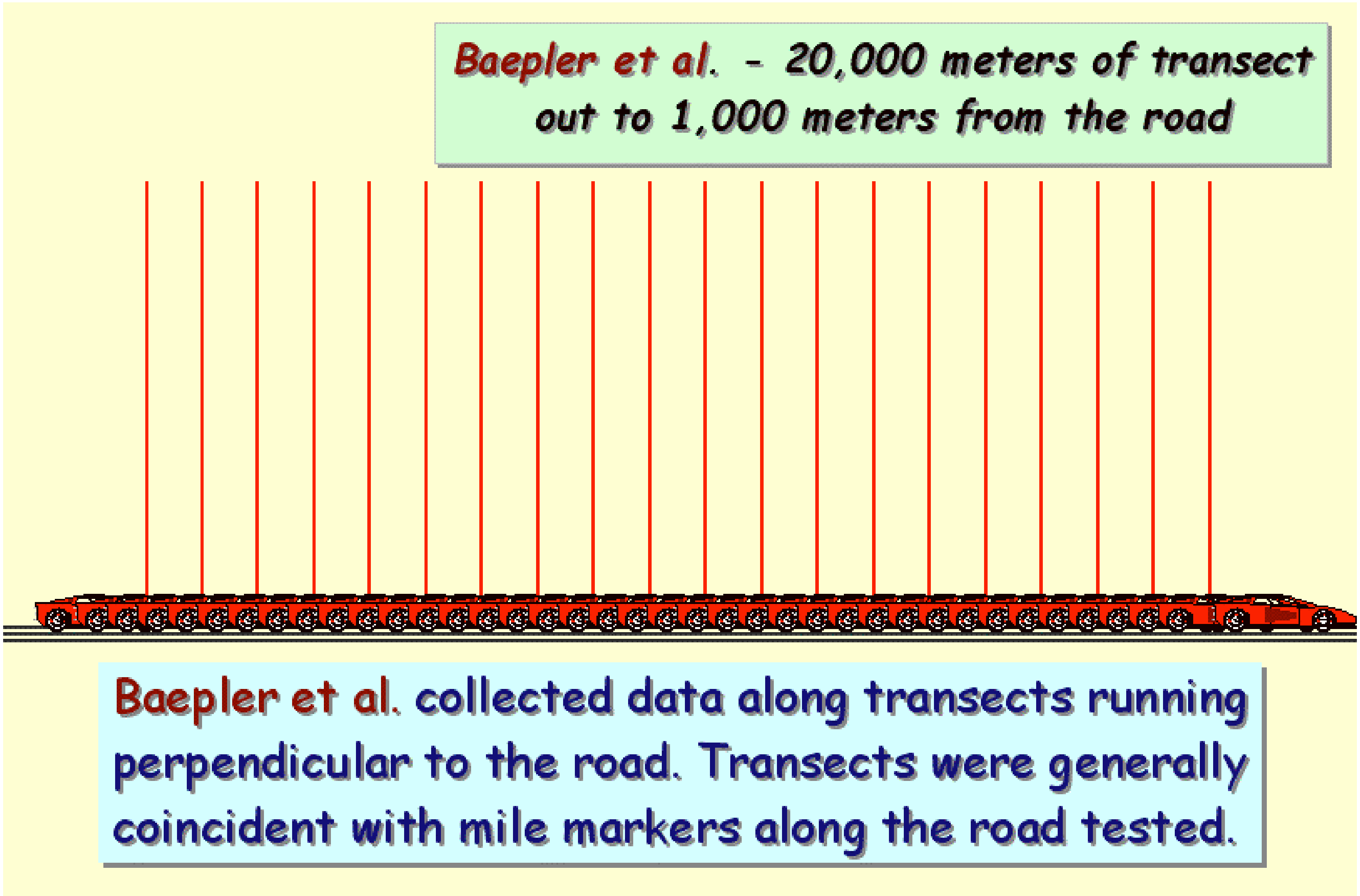
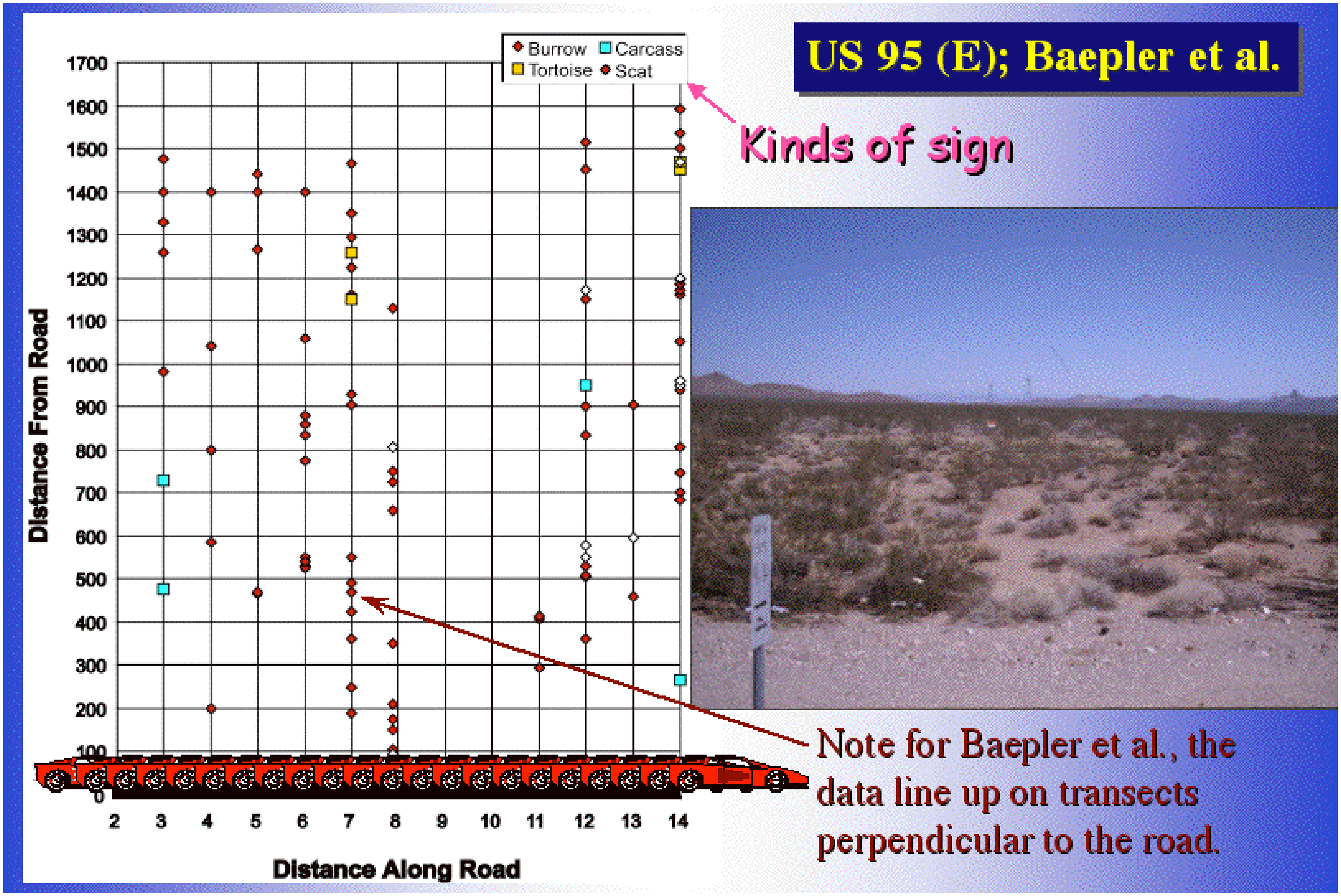
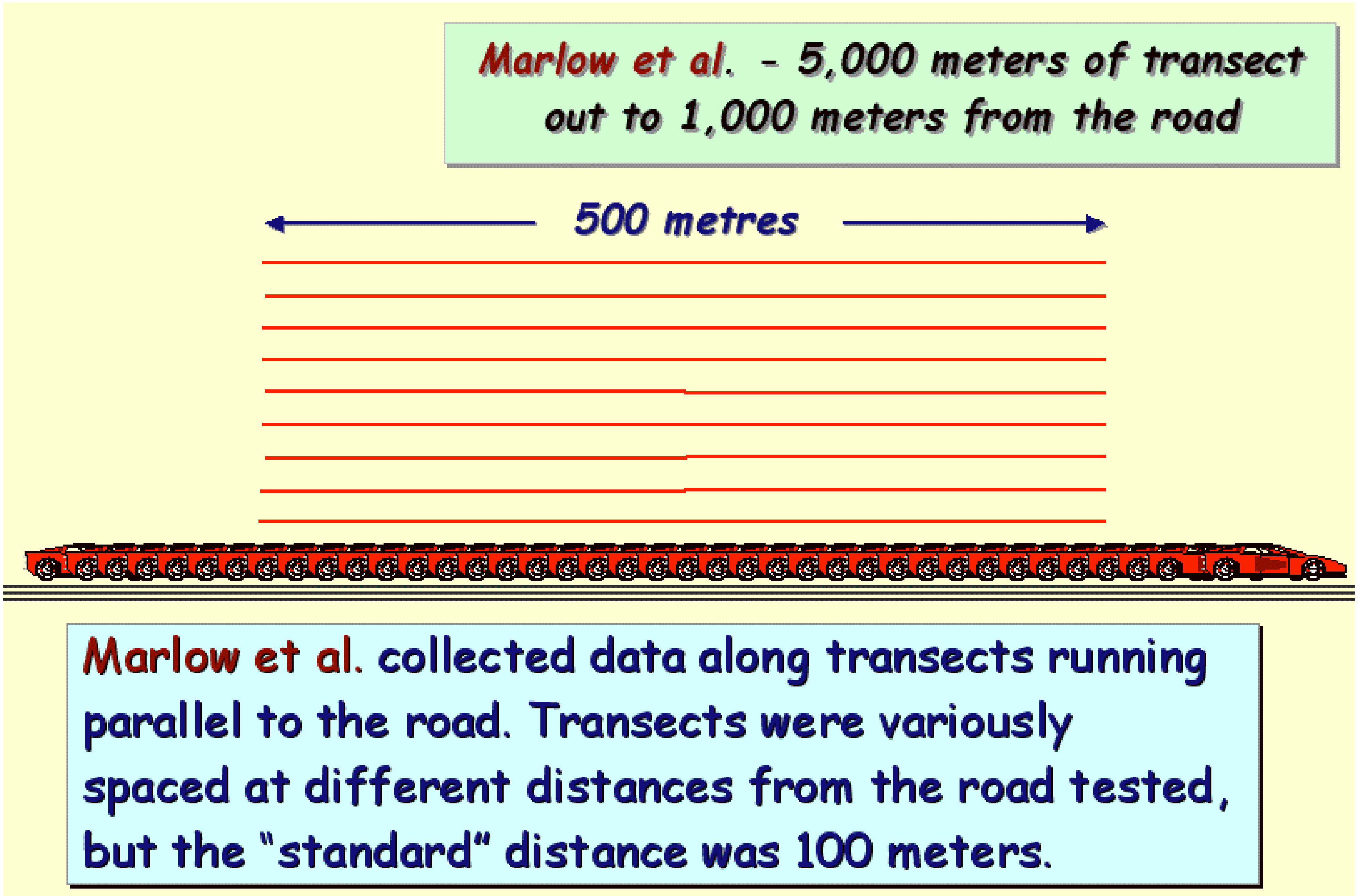
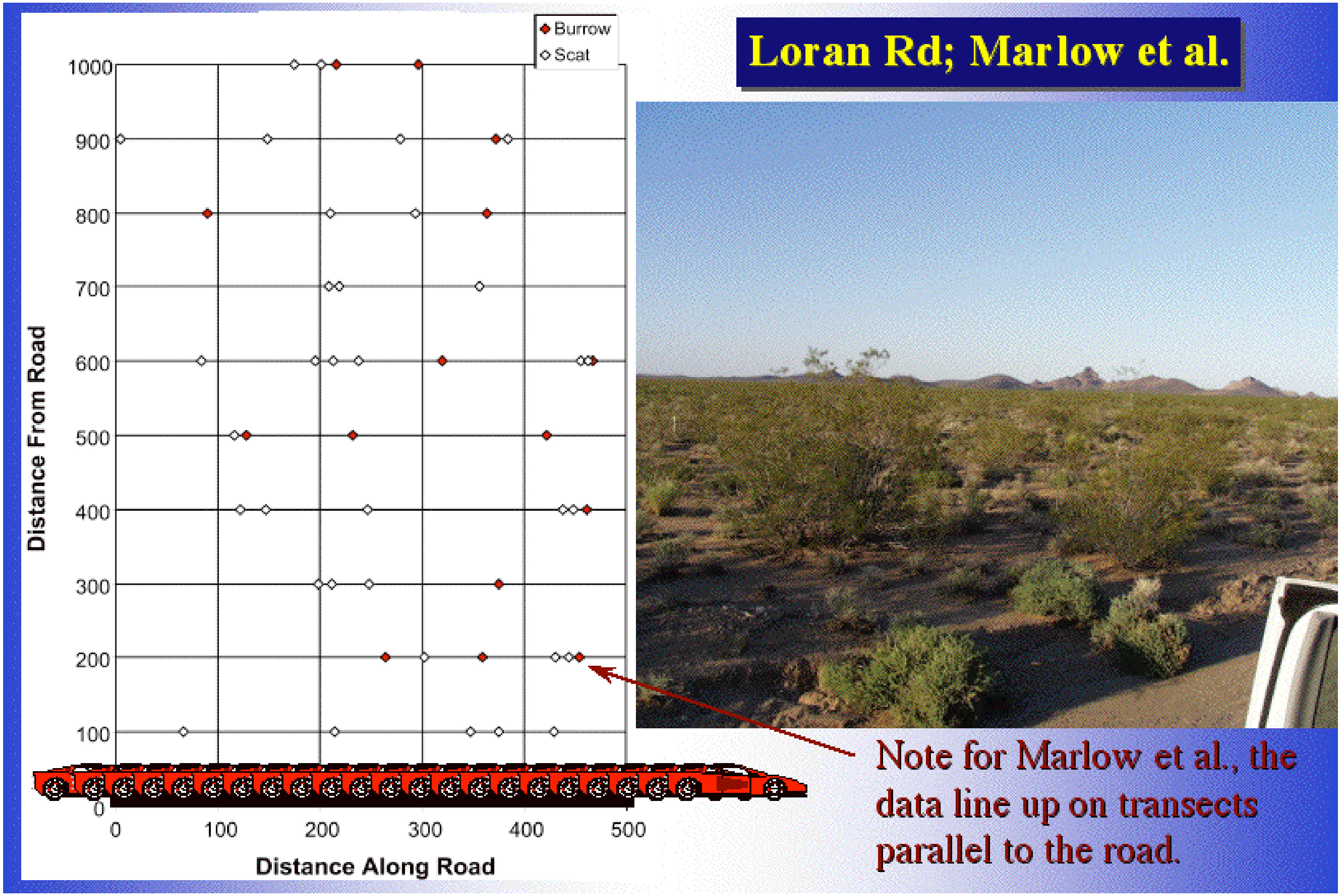
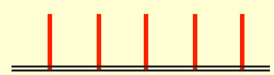

Baepler et al. - 20,000 meters of transect out to 1,000 meters from the road
Baepler et al. collected data along transects running perpendicular to the road. Transects were generally coincident with mile markers along the road tested.


US 95 (E); Baepler et al.
Kinds of sign
Burrow
Carcass
Tortoise
Scat
Distance From Road
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2 3 4 5 6 7 8 9 10 11 12 13 14
Distance Along Road
Note for Baepler et al., the data line up on transects perpendicular to the road.


Marlow et al. - 5,000 meters of transect
out to 1,000 meters from the road
500 metres
Marlow et al. collected data along transects running
parallel to the road. Transects were variously
spaced at different distances from the road tested,
but the "standard" distance was 100 meters.


Loran Rd; Marlow et al.
Burrow
Scat
Distance From Road
1000
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
Distance Along Road
Note for Marlow et al., the data line up on transects parallel to the road.

Differences between studies	Transect Orientation	Length of Transect (meters)	Statistics
Baepler et al.		20,000	Chi-square
Marlow et al.		5,000	Regression

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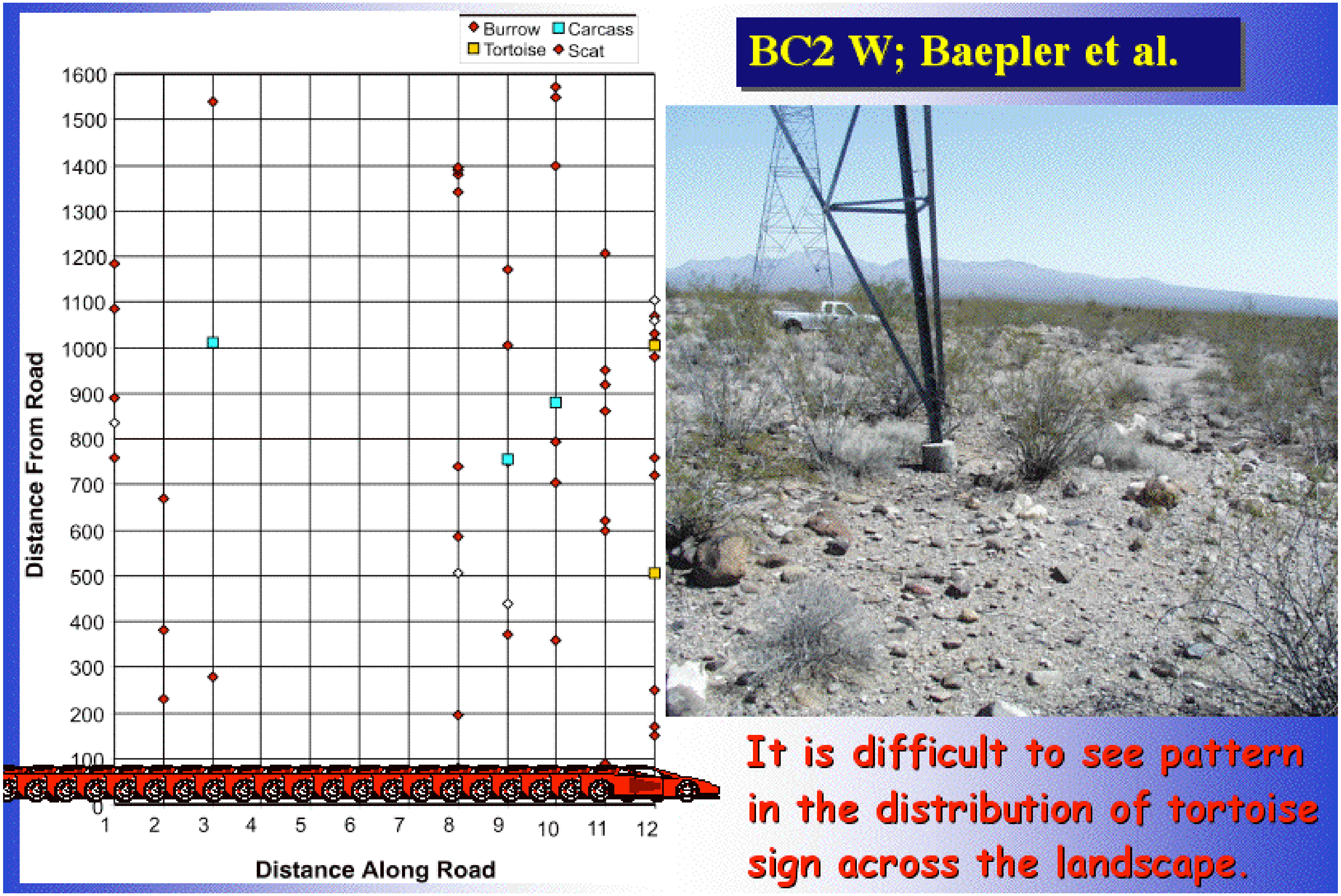
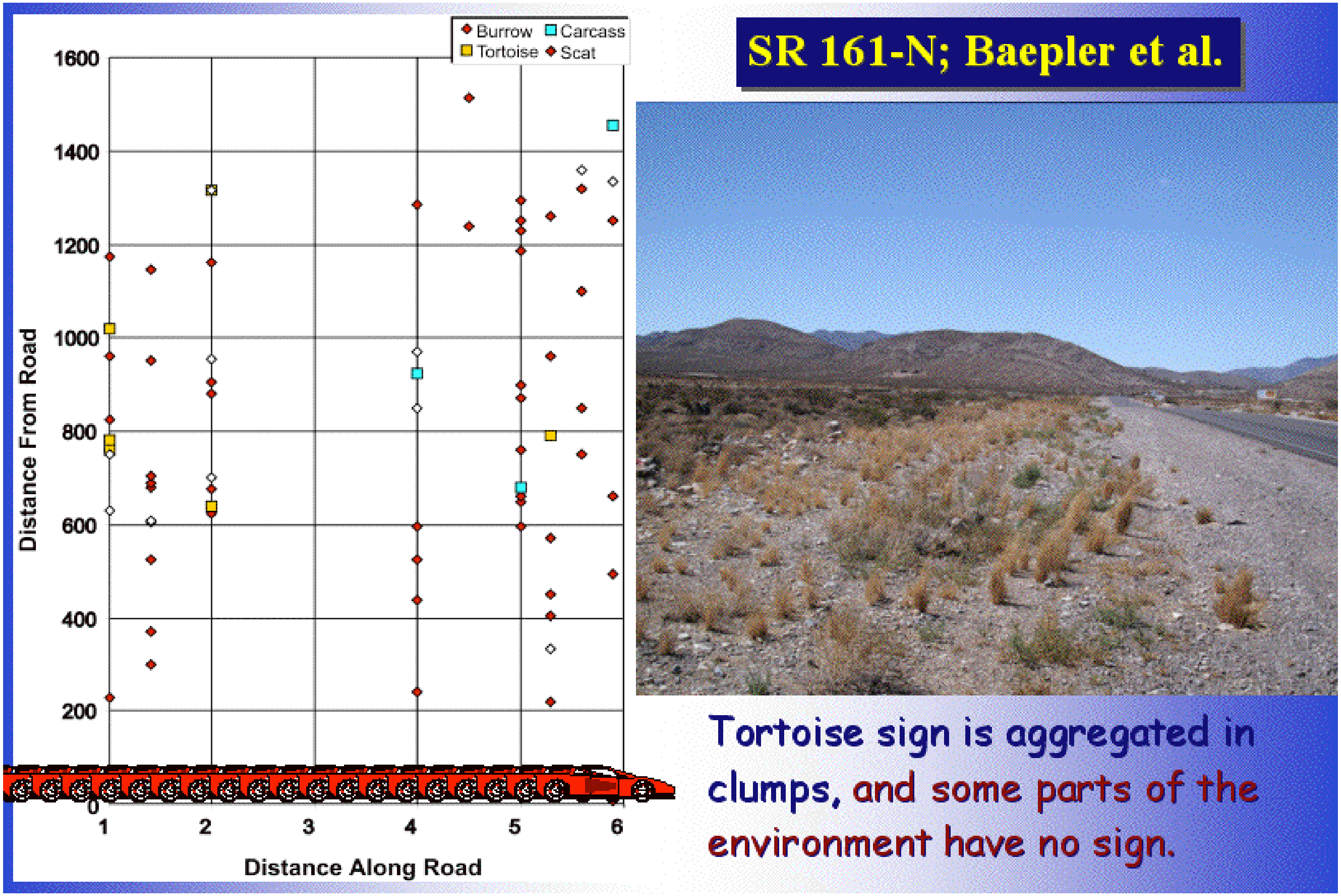
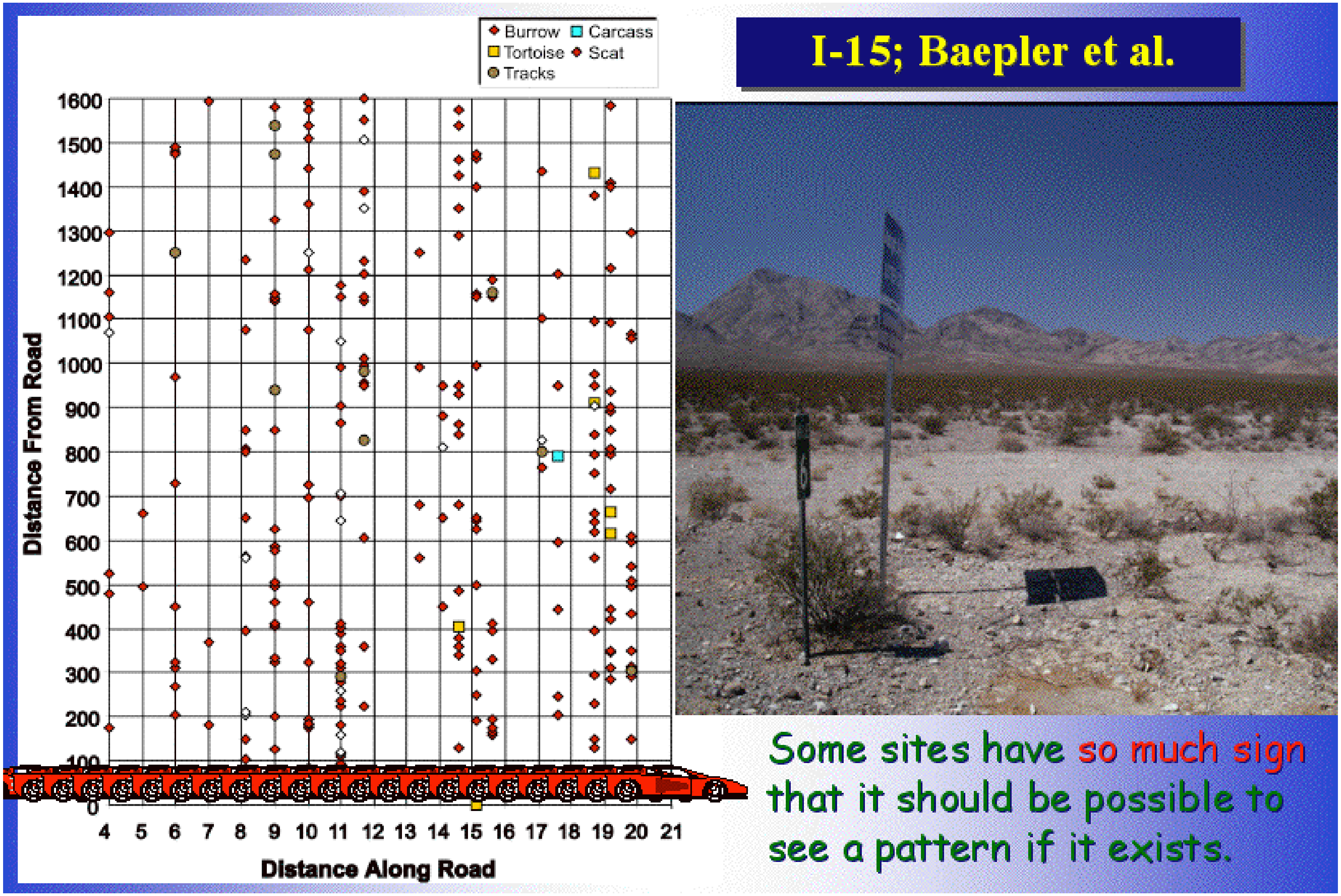
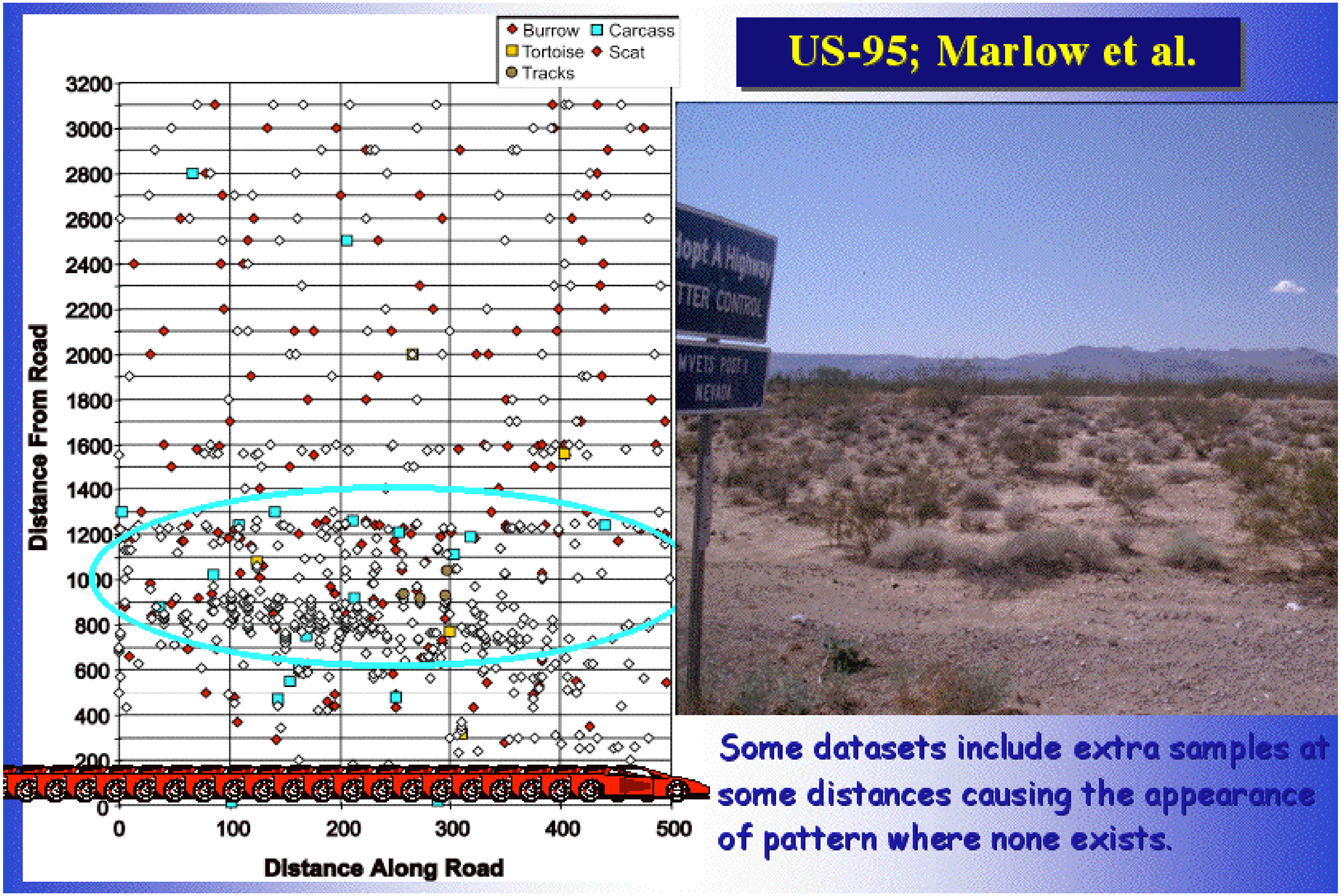

BC2 W; Baepler et al.
Burrow
Carcass
Tortoise
Scat
Distance From Road
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12
Distance Along Road
It is difficult to see pattern in the distribution of tortoise sign across the landscape.


SR 161-N; Baepler et al.
Burrow
Carcass
Tortoise
Scat
Distance From Road
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
Distance Along Road
Tortoise sign is aggregated in clumps, and some parts of the environment have no sign.


I-15; Baepler et al.
Burrow
Carcass
Tortoise
Scat
Tracks
Distance From Road
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Distance Along Road
Some sites have so much sign that it should be possible to see a pattern if it exists.


US-95; Marlow et al.
Burrow
Carcass
Tortoise
Scat
Tracks
Distance From Road
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
Distance Along Road
Some datasets include extra samples at some distances causing the appearance of pattern where none exists.

How were data used in the new analysis so that they were comparable among projects?

- There seemed to be consistency in collecting data along transects up to 1000 meters, so the new analyses were restricted to 1000 meters.
- Marlow et al. sampled in some areas at more than the standard distance. New analyses were restricted to data accumulated along the transects at standard distances.
- Marlow et al. sometimes had more than one person sampling the same transects. For new analyses, data from more than one investigator were averaged to produce the equivalent of a single sampling from an average data collector.

How were data used so that they were comparable among projects?

- For all sites, total sign were counted for five strips at different distances from roads: 0-200 meters, 201-400 metres, 401-600 meters, 601-800 meters, and 801-1000 meters. These counts were used in a single multiple regression analysis to partition the importance of three variables.

1. *Source of data* (Baepler et al. vs. Marlow et al.)
2. *"Road Effect"* (or whether there is less-and-less tortoise sign closer to the roads)
3. *Traffic Levels* (or whether any road effect varied with traffic levels)

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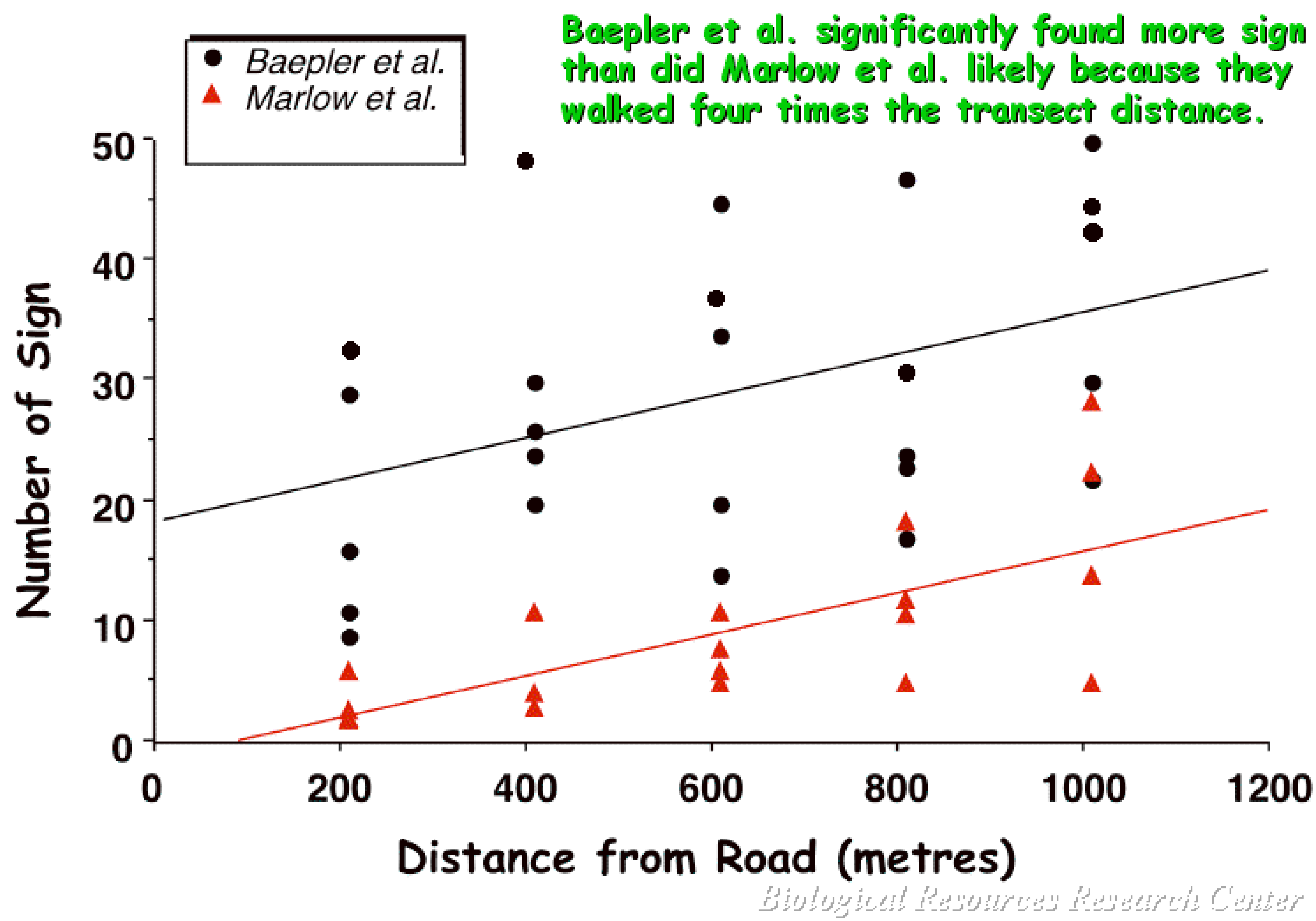
Baepler et al.
Marlow et al.
Baepler et al. significantly found more sign than did Marlow et al. likely because they walked four times the transect distance.
Number of Sign
0
10
20
30
40
50
0
200
400
600
800
1000
1200
Distance from Road (metres)
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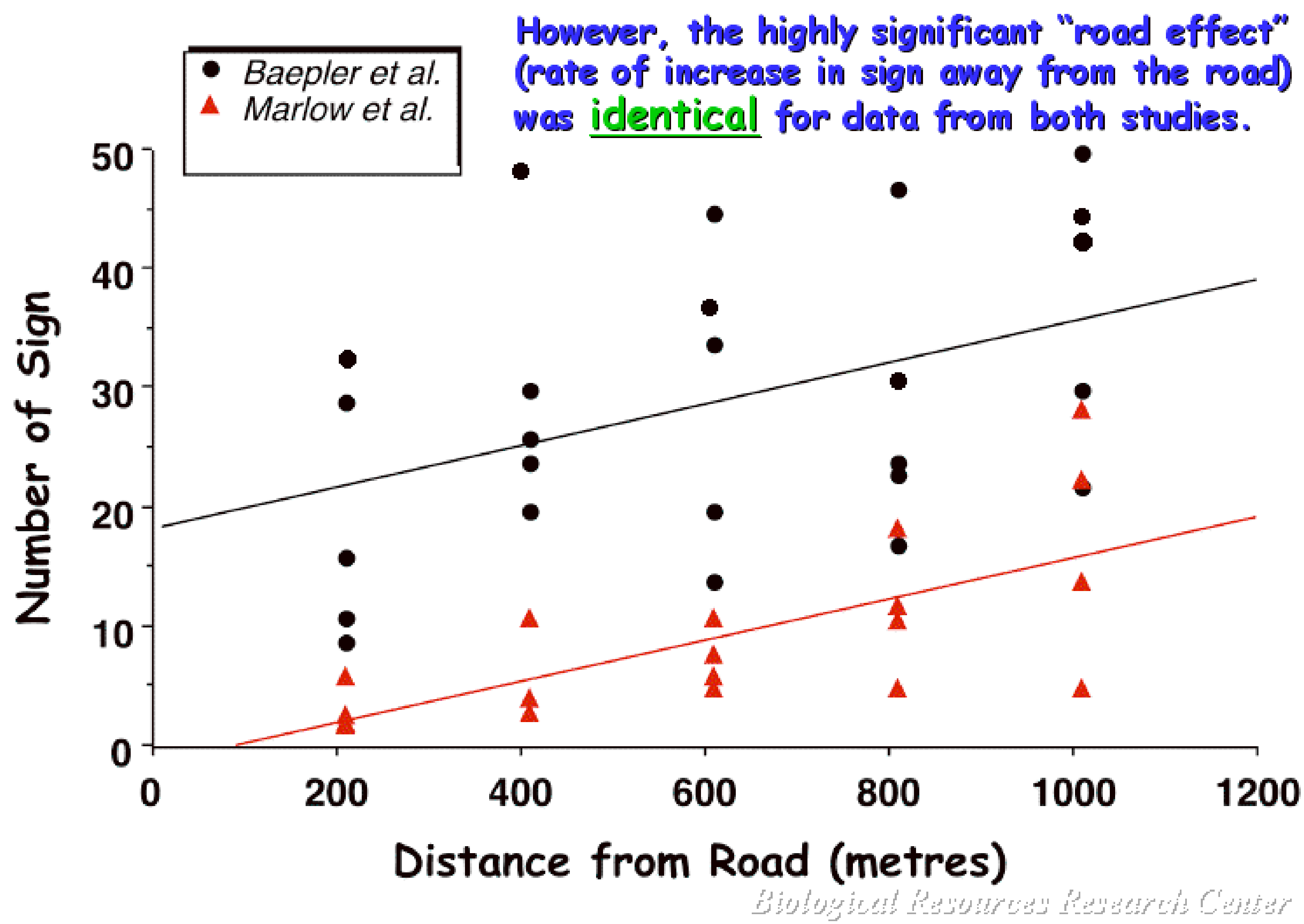
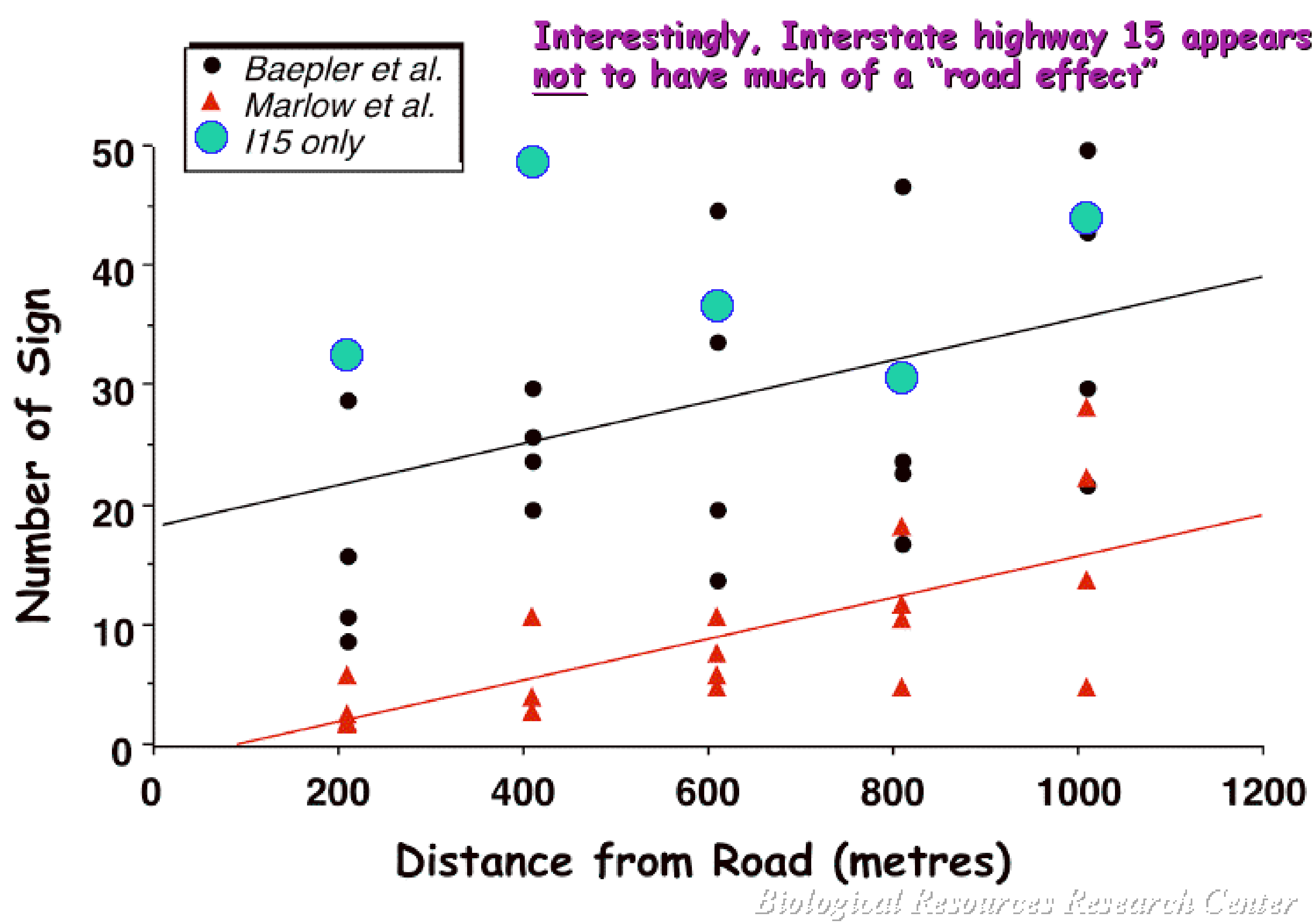
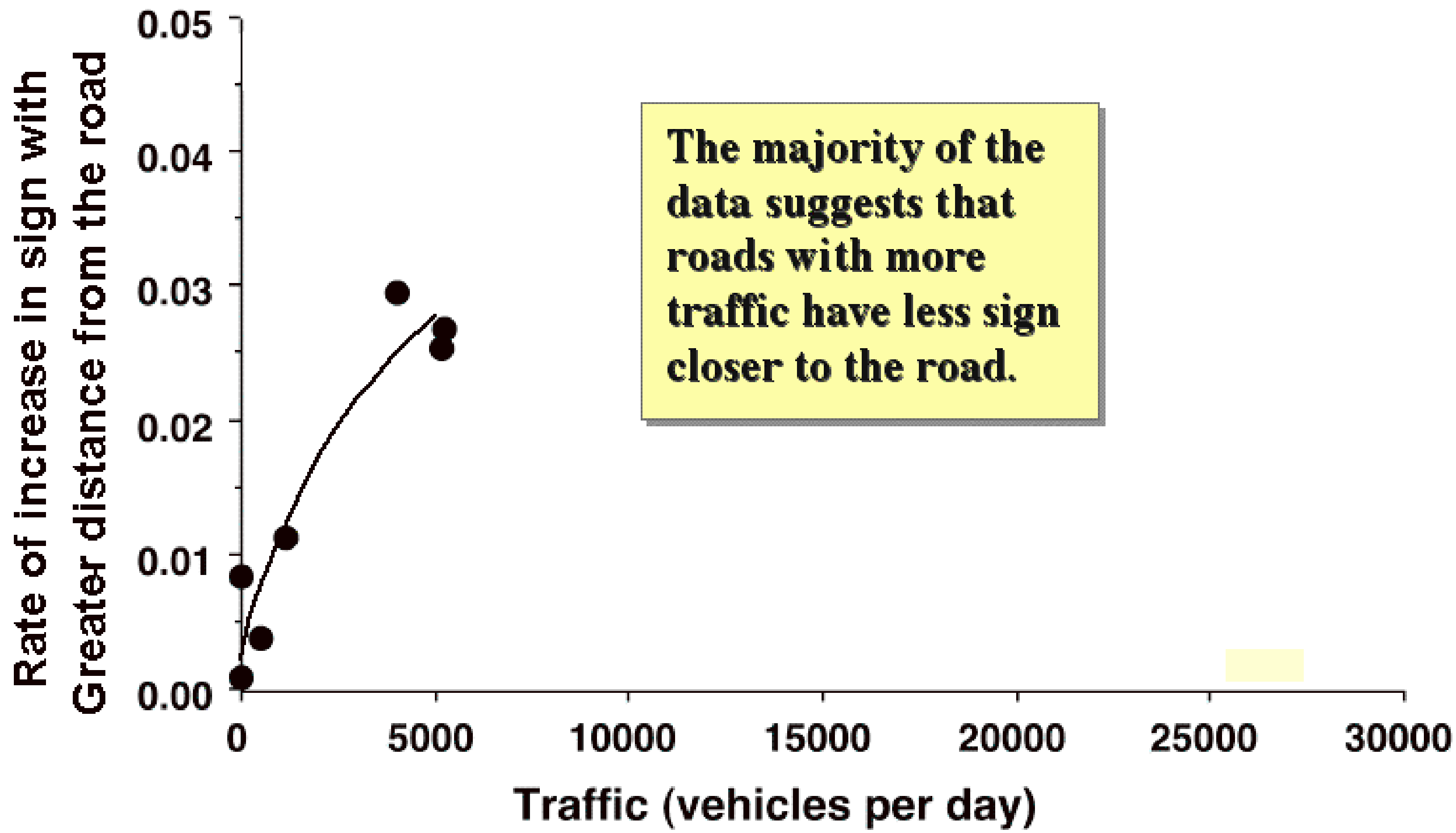

Baepler et al.
Marlow et al.
However, the highly significant "road effect" (rate of increase in sign away from the road) was identical for data from both studies.
Number of Sign
0
10
20
30
40
50
0
200
400
600
800
1000
1200
Distance from Road (metres)
Biological Resources Research Center


Interestingly, Interstate highway 15 appears not to have much of a "road effect"
Baepler et al.
Marlow et al.
I15 only
Number of Sign
0
10
20
30
40
50
0
200
400
600
800
1000
1200
Distance from Road (metres)
Biological Resources Research Center

Is there a Traffic Effect??



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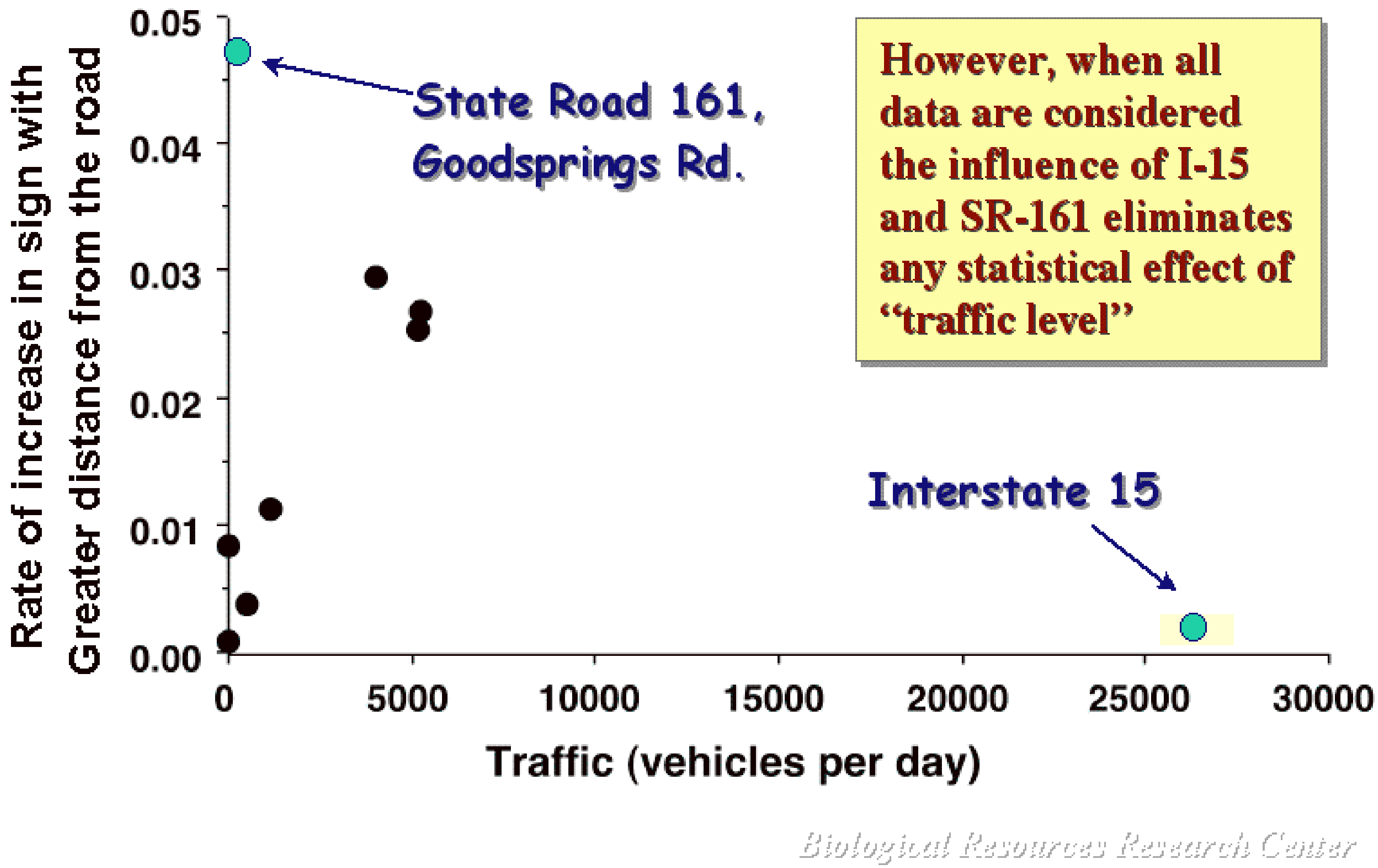
Rate of increase in sign with
Greater distance from the road
0.05
0.04
0.03
0.02
0.01
0.00
0
5000
10000
15000
20000
25000
30000
Traffic (vehicles per day)
State Road 161,
Goodsprings Rd.
Interstate 15
However, when all data are considered the influence of I-15 and SR-161 eliminates any statistical effect of "traffic level"
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Conclusions

- Roads appear to result in less desert tortoise sign near the roads relative to sign amounts away from the roads, and **the data from both Baepler et al. and Marlow et al. sustain this conclusion.**
- Traffic levels may not influence the negative effect of roads (this deserves further testing).
- Interstate 15 may have little negative effect on desert tortoise populations (this hypothesis needs to be tested). This may occur because the relentless traffic on I-15 discourages tortoises from walking out onto the highway (this hypothesis requires testing).

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Scientifically objective analyses can provide a basis for adaptive management.
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Remote Imaging Analysis of Biodiversity and Roads

Finally, we have been exploring image-analysis technologies to develop a technology to assess the vegetation and soils associated with roads remotely. This approach has the most potential in terms of developing methods to monitor ecosystems virtually in real time. This approach to monitoring is highly technical and may take us some time to be in a position to provide regular monitoring. Nevertheless, this approach will save enormous expense in monitoring generally.

AMP Workshops

Workshops have several objectives. We use the workshops:

(a) to bring the best expertise together to discuss specific and general issues,
(b) to create a public participation in the planning and course of AMP projects,
(c) to inform the scope of species that will ultimately be covered under the Plan, and
(d) to develop collaborations among agencies to meet the needs of the HCP.

In other words, the workshops become a major vehicle for communication among the various players in the MSHCP. The quality of workshops depends upon our ability to bring experts from outside Clark County, as well as to be as inclusive as possible with the players in the HCP in Clark County. It is through this process that we will incorporate as broad as possible participation in the adaptive management process of the MSHCP. This process also allows us to include students from various Nevada universities and colleges to expand expertise, and to use the HCP as a means to generate the future practitioners in building efficacious HCPs

The workshops frequently have moved from an "acute" meeting of people on a single occasion, to a more sustained effort. These sustained efforts have caused workshops to develop into working groups of people who continue to work on the topics for a more sustained period. Most of these working groups deal with the more difficult

To date, we have held workshops on Indicator Species, Roads, Muddy River Restoration, Bats, Butterflies, Birds, Springs, and Weeds. These workshops have developed new perspectives and seeded the development of new working groups. They clearly facilitate the essence of the Adaptive Management Process.

Several well-received workshops on species and issues of concern preceded the issuance of the Clark County HCP permit. Led by UNR scientists, daylong discussions on the status of birds, bats, and butterflies were attended by experts, agency biologists, and diverse stakeholders. Importantly, recognized experts for each of these taxa (Floyd, O'Farrell, and Austin, respectively) were in attendance and were able to advise land management agency staff, identifying the unique challenges of species conservation in specific geographical areas. A fourth workshop on springs, seeps, and riparian areas, attended by more that sixty concerned agency staff, both stimulated intense discussion and underscored the need for next step action. Workshops were at best a start to what was actually needed -- an ongoing dialogue in key conservation issues from species-specific management to whole ecosystem restoration efforts.

In response, a decision was made to initiate working groups, which would be designed turn the momentum generated at initial workshops into conservation strategies or action plans. Attendees are subject experts, agency biologists and other staff charged with managing key resources, and concerned stakeholders. Recognized was that formal and ad hoc groups in Clark County were already meeting with greater and lesser degrees of frequency and efficacy. Groups working on rare plants, relict populations of leopard frog, the Muddy River, and other species and issues seemed appropriate for integration into HCP efforts. To an extent, that has happened. Already-operating working groups have been engaged with varying success on issues of immediate substance to the HCP. However, the lack of specific guidance to some of the working groups has slowed progress. The county, on numerous occasions, has deferred from responding to requests from at least one working group for a statement of mandate, authority, and other directions. (The reason given during much of year 2001 is that direction to working groups needed completion of an adaptive management memorandum of agreement.)

Nevertheless, three key working groups were convened in 2001 with direct assistance from UNR, and now meet monthly or bimonthly. A rare-plant working group had evolved from meetings of agency biologists concerned specifically with the decline of Las Vegas Valley bear poppy in Clark County. The group has met regularly for more than six years. A subgroup was engaged by the AMP contractor to identify those plants on covered, evaluation, and watch lists that are the most restricted in distribution, are at most immediate risk, and require the most immediate conservation attention. (These are addressed elsewhere in this document.) Subsequently, the rare plant working group decided to respond to HCP needs by dividing its traditional meetings into two subsections; a first that continued under its historical constitution, and a second to address HCP-related issues. That latter effort has moved little beyond the generation of the list of most imperiled taxa. In addition UNR scientists with FWS cooperation built a matrix describing characteristics of species and habitats that will inform working group planning for Clark County's rarest and most imperiled plant species.

A second working group was initiated at request of the county to address conservation issues related to springs and seeps as habitats for species of concern. The Las Vegas Water District has hosted and chaired the group. The adaptive management contractor is represented by Don Sada (Desert Research Institute and BRRC) the authority on Clark County springs, who is directing the working group initial efforts. Sada has organized a comprehensive symposium and workshop on springs charged with addressing HCP concerns identified by UNR scientists, including – What is the definition of a spring for purposes of conservation planning under the HCP? What are the explicit goals of a conservation strategy for Clark County springs? Can the physical and biotic characteristics of healthy springs be identified? How complete is our current inventory of Clark County springs? What are the appropriate protocols and measures for assessing the physical and biotic value of individual springs for purposes of prioritizing conservation actions under the HCP? What additional information is necessary to inform an "importance" ranking of Clark County springs based on their overall attributes? Can a springs conservation action plan be identified while additional necessary information is gathered? Can measures of management and rehabilitation success be identified and the elements of a springs monitoring program be determined? Can the role of the TWG in information gathering, data analysis, and policy decision-making be articulated? Answers to these questions will form the basis for a focused conservation strategy for springs and seeps.

A working group on weeds was initiated in late spring of 2001 with two meetings hosted by UNR scientists. These meetings were designed to develop and institutionalize a standard data collection form that would bring existing weed reporting procedures (under direction from the state of Nevada) to a level of accuracy that could inform the HCP. The meetings were attended by weed experts, land and resource managers, and academic scientists. Participants since have employed the resulting protocol. The group committed to monthly meetings, elected a chair, and has tasked itself with a number of activities including: creating a mission statement (pending final AMP MOA); presentations by the land managers in Clark County on the status of weed issues, mapping activities, and control efforts; discussion of field techniques, mapping tools, and data management as related to HCP and state needs; creation of a matrix and narrative relating 14 noxious weed species to the 78 covered species and their habitats in the HCP for purposes of prioritizing future species control actions; collaboration with the PIE committee to four Clark County representatives to the Nevada State Weed Education Program Workshop; development of an interagency proposal to control tall whitetop infestations in the Las Vegas Wash; initiation of an effort to create a Weed Management Area (WMA) in the county to supplement HCP efforts; and ongoing exchanges on weed-related topics, including conferences, publication, and educational opportunities.

Notwithstanding these significant advances, the weeds working group struggles against a lack of mandate and formal relationship with HCP institutions. The group has benefited from a commitment by the University of Nevada's Cooperative Extension, which supports the chair for a 20% professional time commitment. No other formal support exists; none from the HCP itself. Several of the most active participants indicate waning interest by others absent clear recognition by HCP authorities.

University of Nevada scientists contend that working groups should provide a forum at which land and resource managers, technical experts, the adaptive management contractor, interested stakeholders, and the informed public advance issues of concern to the implementation of the Clark County HCP. Working groups should engage in a wide variety of activities including, but not limited to:

-- Informing conservation strategies and management plans (CMPs) on technical issues pertinent to the charter and expertise on the working group. That information is passed on to agency and other conservation planners as working group reports on the status and trends of resources, mapped resource distributions and conditions, and synthetic and analytical documents that can serve as advisories for management action and prioritization or conservation actions.

-- Developing resource encyclopedias that include contemporary information and sources of information pertinent to the working group charge. Knowledge should be developed in a format that can readily inform CMP development and other HCP efforts via resource-specific techniques, analytical tools, and field methods.

-- Contributing to a resources action plan and directly supporting the HCP's adaptive management program by developing a management actions agenda, a scientifically defensible monitoring scheme for each resource of concern, and a research priorities list. The working group provides a forum for information exchange; and sets and adheres to an annual schedule of planning, reporting, and updating the resource action plan.

-- Establishing a prioritization scheme for recommended conservation actions, which is reviewed and revised on a regular schedule in consultation with land and resource management agencies.

-- Establishing direct linkages between working group activities and the county's implementation database, the GIS laboratory, and other centralized data management efforts.

-- Identifying resource-specific funding needs and potential extramural sources of support for conservation activities (beyond HCP and PLMA funding).

-- Developing contributions to the HCP web site specific to the working group charge.

-- Fostering between-working group communication on shared conservation issues.

-- Providing outreach on key conservation issues to stakeholders and interested members of the general public.

-- Soliciting and seeking input, review, and cross-fertilization of information, approaches, and techniques from other large-scale, public and private land management efforts.

What follows in this section are reports, recommendations, and proposals developed from workshops and working groups important in forming the adaptive changes to our MSHCP.

A SYNOPSIS OF THE STATUS AND DISTRIBUTION OF BATS IN CLARK COUNTY, NEVADA

A short profile has been developed for all bat species that have been recorded in Clark County, Nevada, is presented below. A brief description of the distribution, relative abundance, and known life history and behavior is included. By overlaying all known species locations for the entire state of Nevada, the major vegetation types used by each bat species have been determined. In addition, the regulatory status that has been assigned to each bat species by land and resource management agencies is provided; and where available, the status according to the Western Bat Working Group, is also noted. The elevation range for each species has been determined using digital elevation models (U.S. Geological Service).

The following species accounts are undergoing review. In a next iteration each species will be assigned to "conservation guilds," that is, species will be grouped in several habitat use-based species assemblages to which a collective conservation strategy can be applied.

Macrotus californicus
(California Leaf-nosed Bat)

The distribution of this bat is limited to low elevations in the extreme southwestern portion of Clark County. Historic roosts in the Las Vegas Valley and along the Colorado River have been destroyed by inactive mine closures and inundation by Lake Mead and Lake Mohave. Only a few roosts are now known to exist, although some foraging activity has been recorded from Arizona at the confluence of the Virgin River and Beaver Dam Wash. Recent surveys indicate maternity and foraging activity in the Muddy River and Meadow Valley Wash drainages. This species is a year round resident. It does do not hibernate; however, both sexes typically congregate in winter roosts in mines and caves.

The California leaf-nosed bat is mostly found in low elevation desert scrub habitats, distributed between 210-690 m, and in close proximity to desert riparian areas. A majority of the records in Nevada have found this species in creosote, Mojave scrub, and riparian habitats. Mines used as winter roosts must have internal temperatures of greater than 29°C and are usually geothermally heated. More than one diurnal roost may be used during the year. Roosting at night occurs in many different locations including buildings, cellars, porches, bridges, rock shelters, as well as mines. Summer colonies may contain a few to several hundred individuals; winter colonies range in size from 100 to 1,000 individuals.

This species is currently not protected. It was formerly a Category 2 Candidate for federal listing under the Endangered Species Act. It is now listed as a Species of Special Concern and is considered a sensitive species by the BLM. The bats are extremely sensitive to disturbance to roost sites and foraging areas, including recreational caving, mine reclamation, renewed mining, water impoundments, and disturbance to desert wash riparian vegetation. Populations in adjoining states are declining. Surveys of roost sites along the Colorado River should be carried out and significant roost sites protected from disturbance.

Choeronycteris mexicana
(Mexican Long-tongued Bat)

This bat reaches the northern limit of its range in the southwestern United States. It had been known from a single individual found in Las Vegas (at 600 m); however the recent record of an individual along the Colorado River suggests occasional occurrence there as well. This species is a pollen and nectar feeder, and requires the presence of columnar cactus and agaves for forage. It does not hibernate and residence in Nevada is probably limited to summer months.

The Mexican long-tongued bat is found in a variety of habitats in the Lower and Upper Sonoran zones, but it appears to favor desert canyons with riparian vegetation. This species normally selects mines, caves, and rock fissures for diurnal roosting, but is known to roost in buildings.

This species is not currently protected. It was formerly a Category 2 Candidate for federal listing, and is now listed as a Species of Special Concern. Threats include recreational caving, mine reclamation, renewed mining, water impoundments, and diminished availability of desert wash riparian vegetation.

Myotis californicus
(California Myotis)

This bat is distributed throughout Nevada, primarily at low and middle elevations, although it is occasionally found higher. It is widespread, but most common in the southwestern portion of the state. This species is a year round resident in Clark County, with a patchy distribution throughout the Spring Mountains and Red Rock area; it roosts near the Colorado River and around Moapa. During the winter, individuals hibernate, but arouse periodically for foraging and drinking.

The California myotis is found in a variety of habitats from Lower Sonoran desert scrub to montane forests. A majority of the records in Nevada have recorded this species in pinyon-juniper, creosote, sagebrush, salt desert scrub, and urban habitats, distributed between 210-2,730 m. It selects a variety of diurnal roosts including mines, caves, buildings, rock crevices, hollow trees, and under exfoliating bark. It has been found roosting at night in a wide variety of structures, usually singly or in small groups, although in some mines in the Mojave Desert are known to shelter colonies of more than 100 individuals in both summer and winter.

This species is not currently protected. Closure of mines for reclamation, renewed mining, and pesticide spraying are threats to the species.

Myotis ciliolabrum
(Small-footed Myotis)

This bat is widespread and common throughout the state; in the south, it is primarily found at middle and higher elevations, and in many locations in the Spring Mountains. In the central and northern parts of the state it is most common in valley bottoms. The small-footed myotis is a year-round resident typically found hibernating in caves or mines during the winter. In some areas this bat may tolerate drier and colder hibernacula than other species. A colony of more than 100 individuals has been found 140 m deep in an abandoned mine near Eureka. A majority of the records in Nevada find this species in salt desert scrub, grasslands, sagebrush, blackbrush, greasewood, pinyon-juniper woodlands, pine forests, agriculture areas, and urban habitats, distributed between 510-2,760 m.

This species is not currently protected. It was formerly a Category 2 Candidate for federal listing, is now listed as a Species of Special Concern, and is considered a sensitive species by the BLM. Threats to this species include mine reclamation, renewed mining, water impoundments, and timber harvest.

Myotis evotis
(Long-eared Myotis)
This bat is distributed throughout the state, primarily in coniferous forests at higher elevations. It is more common in the northern half of the state. The records from Clark County are from locations throughout the Spring Mountains and at Gypsum Cave. This bat is considered to be non-migratory and has been found hibernating in caves and abandoned mines.

A majority of the records of the long-eared myotis in Nevada are from aspen, pinyonjuniper, ponderosa pine, sagebrush, and salt desert scrub habitats. In southern Nevada, it is typically found in ponderosa pine forest stringers or at higher elevations. Records from Nevada show this species to be distributed between 690-3,090 m. This species typically is found roosting singly or in small groups during the day in hollow trees, under exfoliating bark, in crevices in rock outcrops, and occasionally in mines, caves, and buildings. Night roosts have been found in caves, mines, and under bridges.

This species is not currently protected, and its status not well understood. A significant population decline apparently has occurred in the Spring Mountains. The long-eared myotis was a Category 2 Candidate for federal listing. It is now a Species of Special Concern and is considered a sensitive species by the BLM. Threats to this species include timber harvest, recreational caving, mine reclamation, renewed mining, water impoundments, highway projects, bridge replacement, building demolition, and pest control.

Myotis thysanodes
(Fringed Myotis)
The distribution of this bat appears to be limited to the central and southern portion of Nevada. It is widely distributed but locally uncommon, with relatively few records in the state. In Clark County, the majority of records come from areas in and around the Spring Mountains, and at a single location near the Virgin River. This species is considered a year round resident, using caves or mines as hibernacula, with periodic winter activity.
A majority of the records of the fringed myotis in Nevada have found this species in pinyon-juniper, blackbrush, creosote, sagebrush, and salt desert scrub habitats, distributed between 420-2,160 m. In Clark County this species has been found roosting in mines, caves, trees, and buildings. The majority of roosts documented in California have been in buildings or mines. A maternity colony of approximately 200 individuals was found in a mine in creosote bush scrub in the Mojave Desert. This species has been radio-tracked to tree hollows, particularly large conifer snags in Oregon and Arizona, and rock crevices in cliff faces in southern California.

This species is not currently protected. There seems to be an apparent increase in numbers of this bat and in occupied locations in southern Nevada over the past 20 years; however, the species is sensitive to roost disturbance and was considered a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and is considered a sensitive species by the BLM. Threats to this species include recreational caving, mine reclamation, renewed mining, water impoundments, building demolition, pest control, timber harvest, and bridge replacement. This bat is considered a priority for monitoring by the Nevada Division of Wildlife and a priority species for inventory by the U.S. Forest Service.

Myotis volans
(Long-legged Myotis)

This bat is common throughout the state but is more widespread and common in the northern half. It is conspicuously absent from the low desert. The long-legged myotis is probably a year round resident in Clark County, hibernating during the winter with the capability of periodic winter activity. Surveys in Clark County have recorded this species at the higher elevations throughout the Spring Mountains and in a few locations in the Desert Range. Elevational and latitudinal movements between summer and winter roosts may occur. A majority of the records in Nevada have recorded this species in pinyon-juniper, blackbrush, mountain shrub, sagebrush, and salt desert scrub habitats, distributed between 930-3,420 m. This species roosts by day primarily in hollow trees, particularly large diameter snags or live trees with lightning scars; it also uses rock crevices, caves, mines, and buildings. Caves and mines may be used for night roosts and hibernacula.

This species is currently unprotected. Population declines have been suggested from observations in the Spring Mountains. It was formerly a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and is considered a sensitive species by the BLM. Threats to this species include timber harvest, aerial pesticide spraying, recreational caving, mine reclamation, renewed mining, water impoundments, building demolition, and pest control.

Myotis yumanensis
(Yuma Myotis)

This bat is distributed throughout the southern and western half of the state, at low and middle elevations, but recent collection records in east central Nevada suggests a wider distribution in the state. The species is probably a year-round resident; however, no large winter aggregations have been found. Surveys in Clark County have found this species at just six locations.

The Yuma myotis is found in a wide variety of habitats. It is tolerant of human habitation and a bat that survives in urbanized environments. In natural settings it is found in forested areas and other habitats with extensive open water. A majority of the records in Nevada for this species are in sagebrush, salt desert scrub, agricultural areas, riparian habitats, and near playas, distributed between 450-2,340 m. The species roosts by day in buildings, trees, mines, caves, bridges, and rock crevices. Roosting at night usually occurs in buildings, under bridges, or associated other man-made structures.

This species is not currently protected. It is formerly a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and is considered a sensitive species by the BLM. Threats to this species include timber harvest, building demolition, pest control exclusion, bridge replacement, mine reclamation, renewed mining, and water impoundments.

Lasiurus blossevillii
(Western Red Bat)

Western red bats are known from only five locations in Nevada, and have been recorded acoustically from late April through June, including capture of a female in late June, 2000, within the Muddy River drainage. It is thought to be a migrant to the state, but may be a summer resident in the Fallon area. The timing of the recent first record in Clark County suggests residency in southern Nevada.

This species is found primarily in riparian and wooded habitats. Records in Nevada have found western red bats in mesquite riparian scrub and cottonwood riparian areas distributed between 420-2,010 m. It diurnally roosts within the foliage of trees.

This species is not currently protected but is extremely rare in Nevada. Since the red bat is particularly sensitive to habitat degradation and disturbance, conservation and protection should focus on riparian gallery forests. Threats include overgrazing and other exploitation of riparian habitats, agricultural spraying, water impoundments, fire, and predation, particularly by jays and by pets in suburban areas.

Lasiurus cinereus
(Hoary Bat)

This bat is known from only a few locations in Nevada, with the majority of the records in the southern half of the state. The species is likely only a summer resident. Although males are the sex usually observed in the summer, lactating females have recently been found at Great Basin National Park. During the winter this species is known to migrate, although many probably hibernate at the northern limits of their winter range. Surveys in Clark County have recorded this bat at several locations within the city of Las Vegas, near Moapa, in the Desert Range, and in several locations in the Spring Mountains. Records of occurrence in Clark County are primarily from the spring and all individuals captured have been females.

The hoary bat is found primarily in forested habitats, although it also occurs in sycamores and cottonwoods along the Colorado River. It has also been found in valley basins in pure stands of Rocky Mountain juniper, and in urban park and garden settings. A majority of the records from Nevada have found this species in pinyon-juniper, mountain shrub, sagebrush, salt desert scrub, cottonwood riparian, and agriculture habitats distributed between 570-2,520 m. This species typically roosts by day within foliage 3-12 m above the ground in both coniferous and deciduous trees. Some unusual roosting situations have been reported in caves, beneath a rock ledge, in a woodpecker hole, and in a squirrel's nest.

This species is not currently protected. Threats include reduction in forest cover, timber harvest, pesticide spraying, and loss of riparian. Urban threats may include encounters with people and pets (these bats are frequently turned in to public health facilities) and predation by jays.

Lasiurus xanthinus
(Yellow Bat)

A new state record has recently come from the Muddy River drainage, which represents the northernmost extension of the species' range. It is suspected that dispersal may occur along the Colorado River where palm groves may serve as stepping-stones.

The yellow bat is found in riparian habitats that support fan palms and outside of Clark County this species is known to occur in palms within urban habitats. Diurnal roosting is within dead leaf skirtings. It is undoubtedly a year-round resident. This species is not currently protected, but extremely rare in Nevada. With further sampling, this species may be found beyond the Muddy River drainage. Conservation of fan palm groves and adjoining riparian gallery forests will contribute to the conservation of this species. Further research should focus on habitat in palm groves and riparian corridors. Threats include overgrazing of riparian habitats and agricultural conversion of upland habitats, agricultural spraying, water impoundments, and fire.

Lasionycteris noctivagans
(Silver-haired Bat)

This species is widely distributed throughout the state, but is confined to forested habitats. It is found in riparian vegetation in the south and woodland habitats in the central and northern portions of the state. The silver-haired bat is probably a transient spring migrant in Clark County; it has been found in the Desert Range, Spring Mountains, and near Moapa, Glendale, and Las Vegas. There are recent October records of migrating individuals in Nevada; one juvenile recorded near Mesquite in the foothills of the Virgin Mountains and an adult in Humboldt County.

This bat is commonly found in mature forests. It has been recorded primarily from higher latitudes and elevations in coniferous and mixed forests, but also at lower elevations in southern Nevada, along riparian corridors. A majority of the records in Nevada have found this species in pinyon-juniper, sagebrush, salt desert scrub, agriculture and urban habitats, distributed between 480-2,520 m. This species roosts almost exclusively in trees in the summer; maternity roosts are generally in woodpecker hollows. It uses multiple roost sites, switching among them frequently. Small groups and individuals often roost under exfoliating bark. Winter roosts include hollow trees, rock crevices, mines, caves, and houses. Hibernating has been recorded under leaf litter. Records of occurrences for this species are often from foraging areas, rather than from roosting locations.

This species is not currently protected.

Pipistrellus Hesperus
(Western Pipistrelle)

This bat is distributed across most of the state, although most records are from the southern and western portions. Surveys have recorded this bat throughout Clark County and determined it to be a year-round resident. During the winter it hibernates, but periodically arouses to forage and drink.

This species is commonly found in Lower and Upper Sonoran desert habitats with occasional occurrences in ponderosa pine, usually in association with granite boulders and canyon walls. A majority of the records in Nevada have found this species in blackbrush, creosote, sagebrush, salt desert scrub, and agriculture habitats, distributed between 210-2,550 m. Day roost sites are primarily in rock crevices, but may include mines, caves, or occasionally buildings and vegetation. This bat generally roosts singly or in small groups.

This species is not currently protected. Population declines have been noted in the Spring Mountains in southern Nevada. Threats include destruction of roosting and foraging habitat by urban development, water impoundments, mine closures, and mine reclamation.

Eptesicus fuscus
(Big Brown Bat)

This bat is widespread and common in Nevada. It is a year-round resident, and has been recorded throughout the northern half of Clark County. During the winter it hibernates, periodically becoming active to forage and drink.

The big brown bat occurs in a variety of habitats, including those associated with human activity. A majority of the records in Nevada have found this species in pinyon-juniper, blackbrush, creosote, sagebrush, agriculture, and urban habitats, distributed between 300-3,000 m. This bat selects a variety of diurnal roosts, including trees (ponderosa pine, oaks, aspen, and sycamores), mines, caves, buildings and bridges. It often roosts at night in groups of up to several hundred individuals in buildings, in mines, and under bridges.

This species is not currently protected. Threats include timber harvest, bridge replacement, building demolition, recreational caving, mine reclamation, renewed mining, water impoundments, and pest control activities.

Corynorhinus townsendii
(Townsend's Big-eared Bat)

This bat is distributed throughout the state, from low desert to high mountain habitats. It seems to concentrate in areas offering caves or mines as roosting habitats. Found throughout Clark County, this species is a year round resident. During the winter, it hibernates in mixed sex aggregations of a few to hundreds of individuals. It periodically arouses, moves to alternate roosts, and actively forages and drinks throughout the winter. Hibernation is prolonged in colder areas, and intermittent where climate is predominantly above freezing.

Townsend’s big-eared bat is found primarily in rural settings from deserts to midelevation mixed coniferous-deciduous forest. A majority of the records in Nevada have found this species in pinyon-juniper, blackbrush, sagebrush, salt desert scrub, and agricultural and urban habitats, distributed between 210-2,670 m. This is a cavern-dwelling species that is dependent on suitable habitat in caves, mines, and buildings that offer cavelike spaces. This species will roost at night in open settings, including under bridges. Colony sizes have been large in the recent past in Clark County, but now more typically consist of 35-150 individuals.

This species is not currently protected. It was formerly a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and is considered a sensitive species by the U.S. Forest Service and the BLM. Serious population declines in the past forty years have occurred in parts of the western states, with roost size reductions documented in Nevada. This species is highly sensitive to disturbances at roost sites. Threats include recreational caving, mine reclamation, renewed mining, water impoundments, loss of building roosts, and bridge replacement. This species has a high probability of a proposed endangered listing in the near future. Significant roosts can be protected by gating.

This bat is considered a priority for monitoring by the Nevada Division of Wildlife and a priority species for inventory by the U.S. Forest Service.

Euderma maculatum
(Spotted Bat)

The distribution of this bat is patchy, although recent findings indicate it may be more common and widespread than previously thought. It is known from fewer than a dozen general locations in Nevada; a majority of the records from Clark County come from Las Vegas, with recent acoustic records in the Muddy River drainage. High elevation records exist from the Sierra Nevada Mountains and in southern Idaho. During the winter it hibernates, but it periodically arouses to forage and drink. In Clark County the bat is probably a year-round resident.

The spotted bat is found in a wide variety of habitats from low elevation desert scrub to high elevation coniferous forest habitats, and associated with rocky cliffs and water sources containing riparian or riparian scrub vegetation. A majority of the records in Nevada have found this species in pinyon-juniper, sagebrush, and urban habitats, distributed between 540-2,130 m. This species diurnally roosts as individuals in crevices within cliff faces; some records suggest that mines and caves may occasionally be used, primarily in winter. This species is currently provided protection in Nevada under NRS 501. This is the only bat in the state offered this protection. It was formerly a Category 2 Candidate for federal listing, and is now recognized as a Species of Special Concern and as a sensitive species by the U.S. Forest Service and BLM. Threats include recreational climbing, water impoundments, grazing/meadow management, and mining and quarry operations.

Idionycteris phyllotis
(Allen's Big-eared Bat)

This bat until recently was known only from records in southern Nevada in the Red Rock and Spring Mountain areas, and near Gold Butte; however, an acoustic record now places it in the Muddy River drainage. This bat is probably a year-round resident, but it shifts its habitat downward in elevation from summer to winter. During the winter this species is known to hibernate, but periodically arouses to forage and drink.

During the summer, Allen's big-eared bat generally occupies high elevation pine and oak woodland, but will also use a variety of riparian woodland types across a wide elevational gradient. In winter, it is generally found at lower elevations in creosote bush and pinyonjuniper habitats. A majority of the records in Nevada have found this species in blackbrush, creosote, sagebrush, and agriculture habitats, distributed between 510-1,830 m. This species typically roosts by day in trees and large dead snags, but may also use mines and caves. Recent records show this species roosting at night in cliffs and rock shelters.

Allen's big-eared bat is not currently protected. It was formerly a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and is considered a sensitive species by the BLM. Trends in the population status of this species are not well understood. Threats include mine and quarry operations, mine reclamation, renewed mining, water impoundments, grazing/meadow management, timber management (particularly snag management), recreational climbing and caving.

This bat is considered a priority for monitoring by the Nevada Division of Wildlife, and is a priority species for inventory by the U.S. Forest Service.

Antrozous pallidus
(Pallid Bat)

This bat is distributed throughout the state, primarily in the low and middle elevations, and is widely distributed in Clark County. The species is a year-round resident. During the winter it is typically found hibernating, but periodically arouses to forage and drink.

The pallid bat is found in a variety of habitats from desert to brushy terrain, to coniferous forest and non-coniferous woodlands. In Nevada the species has been found in pinyonjuniper, blackbrush, creosote, sagebrush, and salt desert scrub habitats, distributed between 420-2,580 m. This bat selects a variety of roosts by day, including rock outcrops, mines, caves, buildings, bridges, and commonly in hollow trees. Night roosts are found under bridges, but also in caves and mines.

This species is not currently protected. It was formerly a Category 2 Candidate for federal listing and is now listed as a Species of Special Concern. Threats include recreational caving, mine reclamation, renewed mining, water impoundments, and reduction in the availability of desert wash riparian vegetation.

Tadarida brasiliensis
(Brazilian Free-tailed Bat)

This bat is a common resident across most of the state and Clark County, ranging from low desert to high mountain habitats. Recent observations suggest that it is a year-round resident in southern Nevada; however, many colonies in more northern areas appear to migrate away from cold regions to winter-over in areas with predominantly above freezing temperatures. Individuals appear to be active in their winter range.

The Brazilian free-tailed bat is found in a wide variety of habitats. Although predominantly found at lower elevations, it has been recorded up to 3,000 m. A majority of the records in Nevada have found this species in creosote, sagebrush, salt desert scrub, and agricultural and urban habitats, distributed between 210-2,550 m. This bat selects a wide variety of diurnal roosts, including cliff faces, mines, caves, buildings, bridges, and hollow trees. Although colonies may reach into the millions of individuals in some areas, those in Nevada are smaller, usually made up of several hundred to several thousand individuals. This species is not currently protected. Although it is one of the most common species in many habitats, its current numbers in some locations may be well below what they were historically. A huge population decline has been documented for Rose Guano Cave, near Ely, in White Pine County, due to an introduction of a second entrance that altered the cave's microclimate and allowed easy access by humans. Recent acoustic surveys reveal that the bat is more widespread and abundant in southern Nevada than previously thought. Threats to this species include recreational caving, mine reclamation, renewed mining, water impoundments, agricultural spraying, bridge replacement, pest control exclusion, highway projects, and loss of foraging habitat due to urban and suburban development.

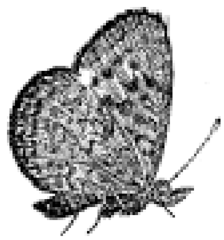
Nyctinomops macrotis
(Big Free-tailed Bat)
The historical distribution of this bat was limited to the Las Vegas area, but a recent observation has been made from the Muddy River. During the winter the bat probably does not hibernate, but rather migrates to warmer areas.

The Big free-tailed bat is associated primarily with rocky canyons in scrub desert, woodland habitats, and floodplain-arroyo associations. Typically the species is found at low elevations, although has been found to as high as 2,400 m in New Mexico, and yet higher elevations in northern Arizona and southern Utah. The two records from Nevada finds this species to be distributed at about 550 m. Diurnal roosts are primarily in crevices in cliff faces, although occasionally in buildings and caves. Generally the species roosts in groups of fewer than 100 individuals.

This species is not currently protected, but was formerly a Category 2 Candidate for federal listing. It is now listed as a Species of Special Concern and considered a sensitive species by the BLM. Threats to this species include recreational climbing, water impoundments, pest control exclusion, highway projects, loss of foraging habitat due to urban/suburban expansion, and agricultural spraying.

Eumops perotis
(Western Mastiff Bat)
The western mastiff bat is found in a variety of habitats from desert scrub to chaparral to montane coniferous forest, and has been detected in montane meadows above 2,400 m. The bat is known only from one specimen found dead in Las Vegas at 540 m. Elsewhere, it is active year round with winter activity limited to lower elevations. Its distribution is tied to availability of suitable roosting habitat and may be predicted based on presence of significant rock features (e.g., large granite or basalt formations). The bat roosts by day primarily in crevices in cliff faces and cracks in boulders, and occasionally in buildings. It generally roosts in groups of fewer than 100 individuals.

This species is not currently protected. It was formerly a Category 2 Candidate for federal listing and is now listed as a Species of Special Concern. Threats include recreational climbing, water impoundments, pest control exclusion, building demolition, highway projects, loss of foraging habitat due to urban and suburban expansion, and agricultural spraying.



A SYNOPSIS OF RARE AND RESTRICTED BUTTERFLIES IN CLARK COUNTY WARRANTING FOCUSSED CONSERVATION ATTENTION

Epargyreus clarus profugus
(Mojave Silver-spotted Skipper)

The Mojave Silver-spotted Skipper is known in Clark County and Nevada only from the Virgin Mountains where it flies in May and June. The overall distribution of this subspecies is in southeastern Nevada, southwestern Utah, and eastward across northern Arizona. The colony in Nevada is thus at the extreme southwestern edge of distribution of the subspecies. The species as a whole is widely distributed across the United States, southern Canada, and northern Mexico. In Nevada, it is found in the middle elevations of Cabin Canyon (above 1500 m in elevation) where it is not uncommon, but is only found in close proximity to its larval hostplant (*Robinia neomexicana*), which grows only along a short stretch of the canyon. Males are frequently seen drawing fluid from mud. Throughout its range, the species is usually common, but it occurs as localized populations at stands of its hostplants. The immediate threats to its continued existence in Clark County are habitat disturbances that would remove its hostplant, such as cutting *Robinia* for firewood.

Erynnis telemachus
(Rocky Mountain Duskywing)

The Rocky Mountain Duskywing is known in Clark County only from Cabin Canyon in the Virgin Mountains, where it flies from April to July and occurs in close association with its larval hostplant, *Quercus gambelii*. It also occurs in Nevada in Lincoln County in similar habitat along Meadow Valley Wash and in the Highland Range in Lincoln County. This distribution is on the western edge of the species' distribution, which is principally eastward to the Rocky Mountains from Wyoming to New Mexico. The species is relatively common in its habitat in Nevada and elsewhere. No immediate threats are seen to its continued existence in Nevada except for the cutting of its hostplants.

Hesperopsis gracielae
(MacNeill's Desert Sootywing)

MacNeill's Desert Sootywing is known in Nevada only from scattered colonies along the Muddy River where it occurs only in close association with its larval hostplant, *Atriplex lentiformis*. The species is an endemic to the southern Colorado River drainage ranging from southwestern Utah to northern Baja California, Mexico. Colonies in Nevada are the northernmost known. Although the hostplant is widely distributed in southern Nevada, the species has not been encountered elsewhere, such as in the Las Vegas Valley or along the Colorado River below Davis Dam; evidently the species requires some other habitat feature besides the hostplant. The species, however, is common where it is found through its flight season from April to September. Recent surveys along the Muddy River show the species to be well distributed and abundant. The major threat to its continued presence in Clark County is development; at least two sites where the species occurred historically have been lost to development.

Ochlodes yuma yuma
(Southern Yuma Skipper)

The Southern Yuma Skipper is locally common in Clark County, but only occurs in close association with stands of its larval hostplant, the common reed (*Phragmites australis*). Adults are frequently seen feeding on the nectar of flowers and fly from June to November. The Yuma Skipper occurs mostly in the southwestern United States, but has recently been found in Oregon and Washington; the populations in Clark County are at the southernmost distributional limit of the species. The Southern Yuma Skipper is found in the southern part of this distribution and extends northward to the western Rocky Mountains. Since the hostplant for this species grows only in immediate association with water, its populations are in constant threat of disturbance from altered water tables, capping of springs, channelization of rivers, and clearing of phraetophytic plants. Extirpations of at least three colonies of this species have been recorded in Clark County by the capping of springs (Arden and Paradise Valley) and development (Green Valley). Other population losses are suspected to also have occurred. Recent discussions among restoration managers working on the Muddy River have considered controlling or eliminating the weedy-appearing *Phragmites*, which would put this skipper at risk.

Atlides halesus estesi
(Western Great Purple Hairstreak)

The Western Great Hairstreak is found in Clark County in stands of mesquite (*Prosopis*) on which its larval hostplant mistletoe (*Phoradendron californicus*) grows. The species also occurs sparingly in the mountains where it may use another species of mistletoe (*Phoradendron juniperinum*) on junipers. Adults can be flushed from their hostplant, are commonly seen on flowers, and males are occasionally found on hilltops. The flight season is long in Clark County, extending from February to December. The species is widespread in the southern United States and occurs southward to Guatemala. Northern Clark County is the boundary of the species distribution in Nevada; the species does not penetrate into the western Great Basin. The western subspecies occurs from the Mississippi Valley, westward to California and Oregon. The decline of mesquite due to development and cutting for firewood is a threat to the species in Clark County. The species was once abundant in several parts in the Las Vegas Valley; many of these areas are now under concrete or have been cleared.

Ministrymon leda
(Leda Hairstreak)

The Leda Hairstreak is sparingly distributed and uncommon in Clark County in stands of mesquite (*Prosopis glandulosa*), its larval hostplant. Adults are seen from April to October perching on their hostplant and feeding on the nectar of its flowers. The Leda Hairstreak occurs in the deserts in the southwestern United States and ranges southward into northern Mexico. Clark County is at the northernmost edge of the species' permanent distribution, although strays have been encountered considerably further northward. The threats to this species are the same as noted above for the Great Purple Hairstreak.

Euphilotes ellisi euromojavensis
(Mojave Ellis Blue)

The Mojave Ellis Blue is known from only one colony in Clark County at a large stand of its larval hostplant, the buckwheat *Eriogonum heermannii*, on dry hillsides north of Red Cloud Mine in the southern portion of the Spring Mountains. Adults are found only late in the season (August and September) in the immediate vicinity of that plant, often feeding on its nectar. The Ellis Blue occurs from western Colorado, northern Arizona, southern and eastern Utah, and western Nevada, southward to southeastern California. The Mojave Ellis Blue occurs in the Mojave Desert of eastern California and southern Nevada. The only apparent threat to this subspecies in Clark County is habitat disturbance; part of its Red Cloud Mine habitat is now a microwave transmission facility.

Euphilotes mojave virginiensis
(Eastern Mojave Blue)

The Eastern Mojave Blue is known in Nevada only in the Virgin Mountains where it is relatively common from April through June in Cabin Canyon. The larval hostplants are annual species of buckwheat (*Eriogonum*). The species as a whole occurs in southern California, southern Nevada, southwestern Utah, and northwestern Arizona. The Virgin Mountains are near the northernmost limits of the subspecies distribution. No immediate threats to the continued presence of this species in Clark County are apparent, although grazing may impact the larval hostplant.

Apodemia palmerii palmerii
(Western Palmer's Metalmark)

The Western Palmer's Metalmark occurs in Clark County (and adjacent Nye and Lincoln counties in Nevada) wherever its hostplants, the mesquites *Prosopis glandulosa* and *P. pubescens*, occur. The species flies from April through October and is most commonly encountered perching on the outer leaves of these trees and feeding on the nectar of their flowers. The species occurs in the southwestern United States and northwestern Mexico with the western subspecies occurring from the Colorado River drainage westward. Clark County is near the northern and eastern edges of this distribution. The threats for this species are the same as were noted above for the Great Purple Hairstreak.

Polygonia satyrus satyrus
(Satyr Anglewing)

The Satyr Anglewing is known in Clark County only in the Spring Mountains. There it is known to exist in small and localized colonies at riparian sites where its larval hostplant, nettle (*Urtica dioca*), grows. The species flies from March to October. The best known colony is at Willow Creek. The species has also been recorded at Little Falls (no records since 1972) and at Cold Creek (no records since 1981). It has not as yet been found at other sites with stands on nettle (such as Upper Carpenter Canyon). The species as a whole is widespread through most of western North America. Because of the small apparent size of the colonies of this species in the Spring Mountains and their highly localized occurrences, any disturbance at riparian sites that support stands of nettle should be minimized.

Charidryas acastus robustus
(Spring Mountains Acastus Checkerspot)

The Spring Mountains Acastus Checkerspot is endemic to the Spring Mountains and flies campground in Kyle Canyon, and the other along the road to Harris Mountain. Although there are other sightings of this species in the Spring Mountains from the vicinity of Mt. Stirling southward to Mt. Potosi, these have been only of a few individuals. Because of its apparently very local distribution this species may be the most imperiled of the endemic butterflies in the Spring Mountains. Its habitat requirements are poorly understood and its larval hostplant has not been determined. Any plans for development or recreation in the vicinities of the two known colonies should take into account the presence of the butterfly. *Chlosyne acastus* as a whole is widespread in western North America, from southern Canada to extreme northern Mexico. Clark County is well within this distribution. Habitat disturbance including overgrazing, recreational activities overuse, and development pose threats to this subspecies.

Euphydryas chalcedona kingstonensis
(Kingston Checkerspot)

The Kingston Checkerspot is known in Nevada only from the Newberry Mountains where it occurs principally in Grapevine Canyon. The flight period is from March to September, although it is usually not active in July and August. The hostplant is a shrubby penstemon, *Keckiella antirrhinoides*. The species occurs in southern Oregon, throughout most of California and eastward through southern Nevada to eastern Arizona. The subspecies occurs in the Mojave Desert in California and southern Nevada; Clark County being on the northern edge of this distribution. Even though its hostplant has a very localized distribution, the Kingston Checkerspot should be secure within Nevada since its known distribution is nearly entirely within the Lake Mead National Recreation Area.

Limenitis archippus obsoleta
(Arizona Viceroy)

The Arizona Viceroy occurs in Nevada only in the Colorado River drainage, principally along the Muddy River. There it flies from May to October, and is closely associated with its larval hostplants, willow (*Salix* spp.) and cottonwood (*Populus fremontii*). The Viceroy occurs in much of the United States, northward to central Canada, and southward into Mexico. The Arizona Viceroy occurs from eastern Texas to southeastern California, Clark County being on the northwestern edge of this distribution. Threats to this species include altered water tables, channelization of rivers, and removal of phraetophytic plants. The species was most common in Nevada along the canal to Bowman's Reservoir until the willows and cottonwoods were removed in the late 1990s.

Asterocampa celtis montis
(Western Hackberry Butterfly)

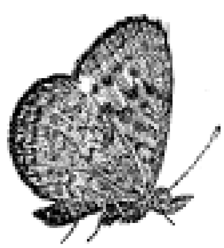
The Western Hackberry Butterfly apparently has a colony in Clark County on the western side of the Virgin Mountains in a small stand of its hostplant, hackberry (*Celtis reticulata*). It has only been recorded there in October. The species perches on hackberry and rarely feeds on the nectar of flowers. The only other apparent colony in Nevada is in southern Lincoln County in a canyon off Meadow Valley Wash. The species is widespread in the United States and the subspecies occurs from southwestern Texas to southeastern Nevada, on the westernmost edge of the species distribution. Destruction of the hostplant seems to be the only threat to this species in Nevada.

Cyllopsis pertepida dorothea
(Western Canyonland Satyr)

The Western Canyonland Satyr is known from one location in Clark County, in Cabin Canyon in the Virgin Mountains. It flies here from May to October. Elsewhere in Nevada, it is known only from colonies in Meadow Valley Wash and the Highland Range, both in Lincoln County. The species feeds as larvae on grasses; the species is as yet undetermined in Nevada. Adults fly close to the ground among thick brush, especially in oak groves. This species occurs in the western United States from northern Utah and Colorado southward into Mexico; the subspecies is found in Arizona and southeastern Nevada. Clark County is on the westernmost edge of this distribution. The only potential threat to the Western Canyonland Satyr in Nevada is habitat disturbance associated with development, increased grazing, and recreation.

Coenonympha tullia pseudobrenda
(Great Basin Ringlet)

The Great Basin Ringlet occurs in Clark County in the Spring Mountains. This subspecies, flying from May to August, was rather widespread and relatively common in these mountains into the 1970s, but has subsequently declined. There were only four records in the 1980s and two in the 1990s. None were encountered in extensive surveys from 1998 to 2000, although one individual was observed in 2001. The reasons for this decline is unknown. The larvae feed on grasses, the species in the Spring Mountains has not been determined. The Great Basin Ringlet otherwise occurs in the mountains of the eastern Great Basin in Nevada and Utah. Although the Spring Mountains is outlying, it is within the overall distribution of the species and represents the southwesternmost limit of the Great Basin Ringlet. The species as a whole is widespread in the western United States, extending to the east coast of the northern United States and southern Canada.



A SYNOPSIS OF THE SENSITIVE BREEDING BIRDS IN CLARK COUNTY, NEVADA

Coccyzus americanus

Yellow-billed Cuckoo

The Yellow-billed Cuckoo is widespread and fairly common throughout much of North America, but western populations of this species have undergone sharp declines in recent decades. In particular, the distinctive western subspecies (C. a. occidentalis) is imperiled throughout its extensive, but highly disjunct, range in the riparian bottomlands of the American southwest. In Nevada the cuckoo occurs only in lowland riparian forests with mature canopies of native willows or cottonwoods. The species is absent from many swaths of seemingly appropriate habitat, scarce in others, and reasonably common only in two -- the Mormon Ranch along the Upper Muddy River (Clark County) and the upper Pahranagat Valley (Lincoln County). Even where present in modest numbers, there is considerable concern about nest success, as many birds appear to be unmated. Management for the Yellow-billed Cuckoo in Nevada should emphasize the preservation or enhancement of very large patches of mature riparian forest. Even one or two such patches would be preferable to a mosaic of many smaller patches.

Vireo bellii

Bell's Vireo

Right through the mid-day heat, the peculiar and distinctive chatter of the Bell's Vireo can be heard from dense tamarisk and willow stands along washes and pond edges in southern Nevada. A less conspicuous, but considerably more common, species in these same riparian habitats is the brood parasitic Brown-headed Cowbird (Molothrus ater), which is currently inflicting a heavy toll on Bell's Vireos populations in Nevada. The prospects for Bell's Vireo in southern Nevada are not good, but not yet critical as they are elsewhere in its range, the species therefore has emerged as a top candidate for management in its southern Nevada strongholds, especially the Virgin River, the lower Colorado River, and Meadow Valley Wash. In addition to logistical and technical challenges posed by of Bell's Vireo management, there are the political and philosophical challenges (as there are with the ecologically similar Willow Flycatcher) in attempts to modify the environment in a manner so as to control native species (the cowbird) and non-native species (such as tamarisk).

Piranga rubra

Summer Tanager

An uncommon summer resident in lowland broadleaf forests in southern North America, the Summer Tanager is an especially suitable indicator of riparian ecosystem health in Clark County. The Summer Tanager's usefulness as a monitoring tool is further contributed to by its ease of detection: it has a loud and distinctive call, and it is a visually striking species. All North American tanagers are essentially woodland birds, and this is the case with both of the tanager species that breed in Clark County. The Western Tanager (P. ludoviciana) is common in the montane forests of the county's sky island mountains, while the Summer Tanager is restricted to remnant riparian forests as well as to oak woodlands at lower elevations in the mountains. While some degree of canopy brokenness is acceptable to the Summer Tanager, it nonetheless requires fairly extensive groves of mature broadleaf trees. Thus, it is found in the large willow groves along Meadow Valley Wash, as well as in oaks along streams at the lower elevations in the Spring Mountains. The major threat direct threat to this species in Clark County is habitat loss. On the bright side, it is a species that is likely to respond positively to long-term habitat restoration projects.

Guiraca caerulea

Blue Grosbeak

The Blue Grosbeak is a member of a suite of southern Nevada bird species with the following characteristics: late arrival each year on their riparian breeding grounds, a fairly short breeding season that coincides with the peak of abundance of the Brown-headed Cowbird (Molothrus ater), and the need for a complex conservation agenda that recognizes that their Nevada breeding grounds may act as "population sinks" for the species. In southern Nevada, Blue Grosbeaks appear to be most common along the Muddy River, but modest concentrations also can be found in brushy riparian habitat along all the major river systems, as well as in association with many springs and farm ponds. In the case of the Blue Grosbeak, habitat conservation, while essential, is probably not adequate for its management. As a first step toward management for this species, it will be necessary to conduct studies of recruitment and survivorship. It will also be necessary to identify major sources of mortality, among which have been cited nest predation, cowbird parasitism, and (in agricultural regions) pesticide use.

Empidonax traillii

Willow Flycatcher

Formerly numerous and widespread in Nevada, the Willow Flycatcher is now reduced to just a few remnant populations in scattered locations throughout the state. There are five subspecies of Willow Flycatcher, three of which occur in Nevada. Two of them (E. t. adastus and E. t. brewsteri) are considered to be at risk, and the third (E. t. extimus) is endangered. It is the latter subspecies, also known as the "Southwestern" Willow Flycatcher that occurs in Clark County. The major causes of decline for E. t. extimus have been cowbird parasitism and habitat loss. Ironically, this subspecies readily accepts Tamarix, an introduced species that is being considered for aggressive control. The Southwestern Willow Flycatcher has received considerable attention from researchers in Clark County and the emerging picture is that southern Nevada stands out as something of a bright spot for this globally imperiled subspecies. For example, areas such as the Virgin River and especially the Pahranagat Valley (Lincoln County) support Southwestern Willow Flycatcher populations that are large in comparison with those found elsewhere in this bird's disjunct range. This is not to say that the situation for Southwestern Willow Flycatcher in southern Nevada is especially favorable at present; rather, it calls attention to the fact that the preservation of suitable habitat in southern Nevada should be an especially high priority in the management of this endangered subspecies.

Phainopepla nitens

Phainopepla

An excellent counter-example to the generic paradigm that birds tend to be ecological generalists, the Phainopepla is actually a habitat specialist that is threatened by commercial development of the valley bottoms in southern Nevada and elsewhere. Phainopeplas are intimately connected with the mesquite-and- mistletoe woodlands that formerly spanned much of the Las Vegas Valley and that fingered into adjacent drainages to the east and south of the valley. To get a glimpse of what the valley once looked like, one must ironically visit urban Sunset Park - which still has a remnant old-growth mesquite woodlot, and which still has a sizeable population of Phainopeplas. At the present time, though, most of Clark County's Phainopeplas are found in the Muddy and Virgin River drainages, and spottily along the lower Colorado River below Hoover Dam. A great deal about the Phainopepla remains to be learned. In parts of the Phainopepla's range, for example, mid-elevation juniper forests are used for post-breeding dispersal by the species; yet this aspect of the Phainopepla's biology is completely unstudied in Clark County.

Falco peregrinus

Peregrine Falcon

The Peregrine Falcon recovery story points to many of the strengths as well as to many of the weaknesses of modern conservation biology. That Peregrine Falcon populations have increased, as a result of the ESA cannot be denied. However, the introduction methods have been controversial both because of their use of genetically engineered birds ("Pseudogrines") and because of their implications for threatened or endangered species that Peregrine Falcons prey upon. Fortunately, Peregrine Falcon management in Clark County has managed to sidestep many of the controversies. Except for the handful of birds that may be using the Las Vegas Strip, Clark County's Peregrine Falcons seem to be recolonizing ancestral nest sites in the mountains and along the high cliff walls of Lake Mead. Suitable habitat and food resources abound for the Peregrine Falcon in Clark County. A major conservation priority will be the protection of individual nest sites, as the species is very susceptible to human disturbance on and around its breeding grounds.

Pyrocephalus rubinus

Vermilion Flycatcher

For birders at the Mormon Ranch in northern Clark County, the Vermilion Flycatcher seems like a common and characteristic breeding bird species. Bruce Lund and Polly Sullivan have documented the presence of upwards of 25 breeding pairs on this 1200-acre parcel of private property that straddles the upper Muddy River. Elsewhere in Nevada, however, the species is essentially absent; the Nevada Breeding Bird Atlas, for example, turned up only two other records, both of them referring only to "possible" breeders. The presence of a substantial Vermilion Flycatcher presence at the Mormon Ranch is surely gratifying, but it also opens up the question of why the species is absent from other supericially similar habitats in Clark County. As it turns out, the dense concentration of Vermilion Flycatchers at the Mormon Ranch was seemingly anticipated by Kimball Garrett and Jon Dunn who, in their classic Birds of Southern California, described the species' favored habitat as: "riparian groves and mesquite which have bordering fields (especially irrigated fields)." As anyone who has sloshed through the flooded farm fields or picked through the mesquite thickets at the Mormon Ranch will readily attest, the description fits perfectly.

ADAPTIVE MANAGEMENT STRATEGIES FOR LOW ELEVATION SPRINGS CLARK COUNTY, NEVADA: *A PROPOSAL*

Background

Thousands of springs are scattered throughout alpine, mesic, and zeric climates of the western U.S. These wetland habitats have been a focus of human activity for thousands of years because they often provide the only reliable water over large areas. They have also been a focus of biologists over the past 70 years (Hubbs 1995), and they are now known to be 'biodiversity hotspots' that support a large proportion of the aquatic species in arid regions (Anderson and Anderson 1995). Their importance as water sources and wetlands that provide riparian cover and feeding areas to terrestrial species has also become increasingly apparent (Fisher et al. 1972, Williams and Koenig 1980, Gubanich and Panik 1986). More than 200 species or subspecies of fishes, mollusks, crustaceans, aquatic insects, and plant species are endemic to Great Basin springs, which shows that desert springs are also important to a wide variety of plants and animals that do not occur elsewhere (e.g., Hubbs and Miller 1948, Hubbs et al., 1974, Wiggins and Erman - 1987, Hershler and Sada 1987, Shepard 1990, Polhemus and Polhemus 1994, Hershler 1998 & 1999, Schmude 1999, Hershler and Frest 1996, Baldinger et al. 2000, Sada and Vinyard 2002)). Unfortunately, cultural use of springs for livestock and municipal water has altered habitat quality (Shepard 1993), causing this highly restricted biota to experience the highest rate of extinction known in the western U.S.A. (see Sada and Vinyard 2002).

Many springs have been surveyed by hydrologists and geologists, but biological surveys have been comparatively uncommon. As a result, knowledge in most regions is limited to discharge rates and aquifer affinities and there is a paucity of biological information for the vast majority of springs. The comparative absence of this information inhibits accurate assessment of how resource uses affect biological components of desert springs, and a large proportion of regional biodiversity.

Permit Condition J under the Clark County Multiple Species Habitat Conservation Plan (HCP) Section 10 permit requires development and/or revision of Conservation Management Plans to identify monitoring actions and management actions required for low elevation springs. These plans are to consider amphibians, aquatic mollusks, and bats. All low elevation springs in the county are to be included except those covered under the Spring Mountains Conservation Agreement and/or lying on U.S. Forest Service lands.

Contrary to what is possible in other regions, this planning process can build upon a comparatively large amount of recent work on springs in Clark County. Some of this work has focused on fish and aquatic macroinvertebrates at Moapa (e.g., Scoppettone et al. 1992; Scoppettone 1993; Scoppettone and Burge 1994; Sada 2000a, Sada and Herbst 1999). However, Sada and Nachlinger (1996, 1998) surveyed 63 riparian vegetation and aquatic macroinvertebrate communities at low and high elevation springs in the Spring Mountains, Sears (pers. comm..) has survey more than 100 springs in the Spring Mountains, and Bradford et al. (ms) and Sada (2000b) surveyed amphibians and aquatic macroinvertebrates in approximately 125 springs in Clark County and surrounding areas (some of these springs were also surveyed by Sada and Nachlinger). Much of the work at Moapa focused on management actions necessary to recover the Moapa dace (*Moapa coriaceae*) from endangered status (U.S. Fish and Wildlife Service 1996), and work by Sada and Nachlinger (1996, 1998) has been used to develop spring management strategies by the U.S. Forest Service and U.S. Bureau of Land Management. Environmental data collected by Bradford et al. (ms) and Sada and Nachlinger (1996, 1998) at individual springs includes approximately 40 fields of information, such as; location, land ownership, elevation, drainage basin, State and County, and physical (e.g., water width, water depth, substrate composition, habitat condition, etc.) and chemical (e.g., water temperature, dissolved oxygen concentration, electrical conductance, pH) metrics. The presence of other important species was also noted (e.g., Pisidium clams, leeches, amphibians, pulmonate mollusks, amphipods, and fishes).

<u>Project Summary</u>

This project will provide guidance to adaptively manage Clark County springs through two mechanisms:

1- By preparing a plan that will guide spring management. This plan will provide, but not be limited to, guidance that will:

- Define a 'spring' for purposes of conservation planning under the HCP.
- Identify conservation goals for Clark County springs.
- Provide methods to characterize physical and biotic characteristics of degraded and healthy springs, and to prioritize conservation actions under the HCP.
- Use existing information (available from the database described below number 2) to:
    - Recommend future programs to completely inventory Clark County springs, and potentially more adequately design conservation strategies, identify management priorities, and implement adaptive management.
    - Define key elements that can be used to monitor the efficacy of adaptive management programs.
    - Define the role of the Low Elevation Springs Technical Working Group (TWG) in planning and adaptive management programs.

2- By compiling data collected by Sada and Nachlinger (1996, 1998) and Bradford et al. (ms) in a relational database that can be used to identify management priorities. This information will be valuable to:

- Summarize existing data and organize in a format that can be used by resource managers.
- Determine what additional information is needed to guide adaptive management strategies. Allow GIS analysis of spring resources. Track the affect of management and the efficacy of rehabilitation programs.

Products

1 - A management plan that identifies management actions to conserve amphibian, aquatic mollusk, and bats at low elevation Clark County springs. It will also recommend survey methods to track affects of management on target organisms (ergo aquatic mollusks, amphibians, bats). This plan will be prepared following recommendations made by the Low Elevation Springs working group.

2- A relational database that will organize biotic and abiotic data for individual springs and provide a format that can be used by resource managers to identify affects of existing management and track the efficacy of adaptive management strategies.

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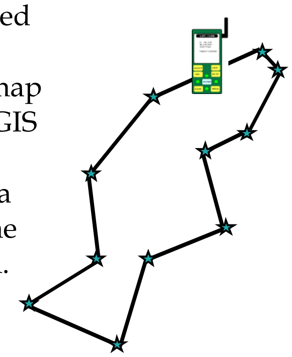
The Weeds Working Group

The Weeds Working Group has been very active and can be very important to the MSHCP. Weeds are the "wild card" in conservation insofar as they surprise us with invasions that trump our conservation efforts. The BRRC has proposed a protocol for data collection for weeds, and with help from BRRC, the weed group has put together a matrix of potential threats to covered species. This matrix is a first step in prioritization of management actions, and it is to be lauded as a necessary step in the adaptive management process.

CC-MSHCP Weed Monitoring Protocol (Draft)

What do we measure?

• *Coordinate Data* – it is necessary to walk around each patch of the weeds and take waypoints around the perimeter of the patch of weeds. A patch can be defined broadly or narrowly – it does not matter. However, generally patches can be defined as areas separated by intervening areas with no individual weed plants. The GPS should be set to collect data in UTMs (northings and eastings in meters), and the map datum should be set at NAD83. Each patch should be given a number so that the GIS lab can associate waypoints with patches. If a patch is too small to circumnavigate (i.e., under 3m wide), then GPS a point and estimate the size of the small patch. If a patch is linear and too narrow to circumnavigate (no wider than 3m), then walk the linear patch and take waypoints along its length and record the width of the patch.

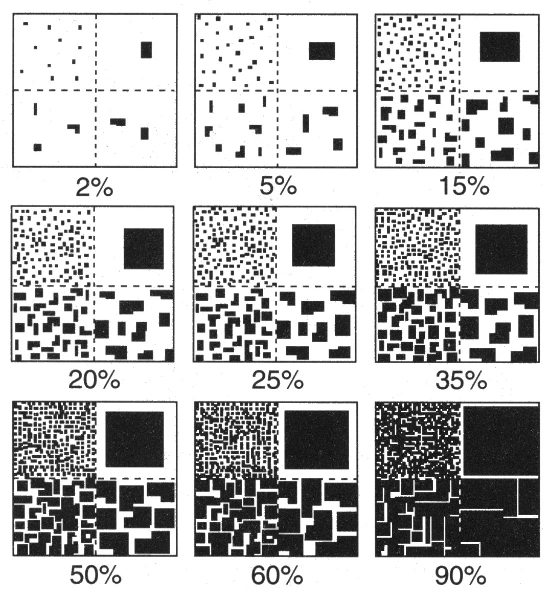


• *Observation Date* – Record the date at which a patch is measured.

• *Weed Species* – Record the weed species by recording the weed symbol. We will be updating the weed list for the important weeds of Clark County.

Common Name	Scientific Name	Weed Symbol
Tall Whitetop	*Lepidium latifolium*	TWT
Saltcedar (tamarisk)	*Tamarix ramossissima*	TA
Russian Knapweed	*Acroptilon repens*	RSK
Malta Star Thistle	*Centaurea melitensis*	MST
Yellow Star Thistle	*Centaurea solstiltialis*	YST
Common Reed	*Arundo australis*	CR
Common Read	*Phragmites australis*	CR
California Fan Palm	*Washingtonia*	CFP
Tapegrass	*Vallisneria americana*	TG
Perennial Sowthistle	*Sonchus arvensis*	PST
Fountain Grass	*Pennisetum setaceum*	FG

• *Cover Class* – For every patch, estimate the percent cover for the patch. Use the figure to help in estimating the percent cover.



• *Growth Stage* – For every patch, record the average growth stage of the plants in the patch.

• *Data Sheet* – For all data, fill out a data sheet equivalent to the data sheet on the reverse side of this page.

• *Data Transfer* – The first time you download data from your GPS, please work with the AMP GIS lab to make sure that the data download procedures will allow development of GIS coverages. Subsequent downloads can be done in your agency, but data must come to the AMP GIS lab.

Patch Waypoint Log

Name ____

GPS Model ____________________**Ser. #** ____________

Patch #	Northing	Easting	Waypt. #	Date	*Sp. Code*	Cover %	Grth Stage	Notes

Growth Stage: S=seedling, B=bud, F=flowering, S=seed set, M=mature [make a judgement about growth stage for the entire stand]

MSHCP COVERED SPECIES	sow thistle (*Soncus sp.*)	red brome (*Bromus madritensis*)	cheatgrass (*Bromus tectorum*)	Johnson grass (*Sorghum halpense*)	tree tobacco (*Nicotiana glauca*)	Mexican paloverde (*Parkonsonia aculeata*)	Euraisian watermilfoil (*Myriophyllum spicatum*)	hydrilla (*Hydrilla verticillata*)	giant salvinia (*Salvinia rotundifolia*)	athel (*Tamarix aphylla*)	camelthorn (*Alhagi pseudalhagi*)	russian olive (*Eleagnus angustifolia*)
Mammals	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
silver-haired bat	▯	P	P	▯	▯			▯	▯	P	P	P
long-eared myotis	▯	P	P	▯	▯			▯	▯	P	P	P
long-legged myotis	▯	P	P	▯	▯			▯	▯	P	P	P
Palmer's chipmunk	▯	P	P	▯	▯			▯	▯	P	P	P
Birds	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
American peregrine falcon	▯	P	P	▯	▯			▯	▯	▯	▯	▯
yellow-billed cuckoo	▯	P	P	▯	▯			▯	▯	P	▯	▯
vermillion flycatcher	▯	P	P	▯	▯			▯	▯	▯	▯	▯
phainopepla	▯	P	P	▯	▯			▯	▯	P	P	P
Southwestern willow flycatcher	▯	P	P	▯	▯			▯	▯	P	P	P
summer tanager	▯	P	P	▯	▯			▯	▯	▯	▯	▯
blue grosbeak	▯	P	P	▯	▯			▯	▯	▯	▯	▯
Arizona's bell vireo	▯	P	P	▯	▯			▯	▯	P	P	P
Reptiles & Amphibians	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
desert tortoise	P	P	P	▯	▯			▯	▯	▯	▯	▯
banded gecko	P	P	P	▯	▯			▯	▯	▯	▯	▯
desert iguana	P	P	P	▯	▯			▯	▯	▯	▯	▯
Western chuckwalla	P	P	P	▯	▯			▯	▯	▯	▯	▯
Western red-tailed skink	P	P	P	▯	▯			▯	▯	▯	▯	▯
large-spotted leopard lizard	P	P	P	▯	▯			▯	▯	▯	▯	▯
Great Basin collared lizard	P	P	P	▯	▯			▯	▯	▯	▯	▯
California (common) kingsnake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
glossy snake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
Western long-nosed snake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
Western leaf-nosed snake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
Sonoran lyre snake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
sidewinder	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
speckled rattlesnake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
Mojave green rattlesnake	P	P	P	▯	▯	▯	▯	▯	▯	▯	▯	▯
relict leopard frog	P	P	P	P	P	▯	P	P	P	P	P	P

MSHCP COVERED SPECIES	sow thistle (*Soncus sp.)*	red brome (*Bromus madritensis)*	cheatgrass (*Bromus tectorum)*	Johnson grass (*Sorghum halpense*)	tree tobacco (*Nicotiana glauca*)	Mexican paloverde (*Parkonsonia aculeata)*	Euraisian watermilfoil (*Myriophyllum spicatum)*	hydrilla (*Hydrilla verticillata)*	giant salvinia (*Salvinia rotundifolia)*	athel (*Tamarix aphylla)*	camelthorn (*Alhagi pseudalhagi*)	russian olive (*Eleagnus angustifolia*)
Insects	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
dark blue butterfly	P	P	P									
Spring Mtns icarioides blue	P	P	P	▯	▯			▯	▯	▯	▯	▯
Mt. Charleston blue butterfly	P	P	P	▯	▯			▯	▯	▯	▯	▯
Spr. Mtns. acastus checkerspot	P	P	P	▯	▯			▯	▯	▯	▯	▯
Morand's checkerspot	P	P	P	▯	▯			▯	▯	▯	▯	▯
Caroles' silverspot butterfly	P	P	P	▯	▯			▯	▯	▯	▯	▯
Nevada admiral	P	P	P	▯	▯			▯	▯	▯	▯	▯
Spr. Mtns. comma skipper	P	P	P	▯	▯			▯	▯	▯	▯	▯
Spr. Mtns. springsnail	▯	▯	▯	▯	P	P	P	P	P	P	P	P
Southeast Nevada springsnail	▯	▯	▯	▯	P	P	P	P	P	P	P	P
Plants	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey eggvetch	P	P	▯	▯	▯			▯	▯	▯	▯	▯
Blue Diamond cholla	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
rough angelica	P	▯	▯	▯	▯			▯	▯	▯	▯	▯
sticky ringstem	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston pussytoes	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Las Vegas bearpoppy	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
White bearpoppy	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Rosy King sandwort	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey milkvetch	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
three-corner milkvetch	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Spring Mtns milkvetch	▯	P	▯	▯	▯			▯	▯	▯	▯	▯
alkali mariposa lily	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
clokey paintbrush	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey thistle	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Jaeger whitlowgrass	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston draba	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
inch high fleabane	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
forked buckwheat	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
sticky buckwheat	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey greasebush	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
smooth pungent greasebush	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Red Rock Canyon aster	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
hidden ivesia	▯	▯	▯	▯	▯			▯	▯	▯		

MSHCP COVERED SPECIES	sow thistle (*Soncus sp.)*	red brome (*Bromus madritensis)*	cheatgrass (*Bromus tectorum)*	Johnson grass (*Sorghum halpense*)	tree tobacco (*Nicotiana glauca*)	Mexican paloverde (*Parkonsonia aculeata)*	Euraisian watermilfoil (*Myriophyllum spicatum)*	hydrilla (*Hydrilla verticillata)*	giant salvinia (*Salvinia rotundifolia)*	athel (*Tamarix aphylla)*	camelthorn (*Alhagi pseudalhagi*)	russian olive (*Eleagnus angustifolia*)
Jaeger ivesia	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Hitchcock bladderpod	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston pinewood lousewort	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
white-margined penstemon	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston beardtongue	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Jaeger beardtongue	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Parish's phacelia	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey mountain sage	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Clokey catchfly	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston tansy	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston kittentails	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Charleston grounddaisy ▯	▯	▯	▯	▯			▯	▯	▯	▯	▯	
limestone violet	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Mosses	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Anacolia menziesii	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Claopodium whippleanum	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Dicranowesia crispula	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Syntrichia princeps	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Ecosystems	▯	▯	▯	▯	▯			▯	▯	▯	▯	▯
Alpine	P	P	P	▯	▯			▯	▯	▯	▯	▯
bristlecone pine	P	P	P	▯	▯			▯	▯	▯	▯	▯
mixed conifer	P	P	P	▯	▯			▯	▯	▯	▯	▯
pinyon-juniper	P	P	P	▯	▯			▯	▯	▯	▯	▯
sagebrush	P	P	P	▯	▯			▯	▯	▯	▯	▯
blackbrush	P	P	P	▯	▯			▯	▯	▯	▯	▯
salt desert scrub	P	P	P	▯	P	P		▯	▯	P	P	P
Mojave desert scrub	P	P	P	▯	P	P		▯	▯	P	P	P
mesquite/catclaw	P	P	P	▯	P	P		▯	▯	P A	P	P
Muddy River	P	P	P	P	P	P	P	P	P	P A	P	P
Virgin River	P	P	▯	P	P	P	P	P	P	P A	A	P
Las Vegas Wash	P	P	▯	P	P	P	P	P	P	P A	P	P
Lake Mead	P	P	▯	P	P	P	P	P	P	A	P	P
spring systems	▯	▯	▯	P	P	P	P	P	P	A	P	P

CONSERVATION OF RARE PLANTS IN CLARK COUNTY

The Technical Working Group (TWG) process, developing under the Clark County Multiple Species Habitat Conservation Plan, Adaptive Management Plan (CC MSHCP, AMP) to conserve plants seems well conceived. The TWG consists of botanists from local, state, and federal agencies, along with a botanist/plant ecologist representative from the University and Community College System of Nevada, forms a nucleus of botanical and plant ecological expertise which is capable of evaluating the threats to plant species of concern in the county. There remains a need for expertise from Conservation Biologists on principles of viable population analyses.

Given that the preponderance of land considered for development is in the lower elevations, the TWG is considering the species occurring in low elevations first. The first mission is to compile all information known concerning the life histories and distributions of these species of concern in the county. The skeleton for this matrix of life history information is complete, and the distribution of these species is as well known as any species in the county. Once the matrix is complete with all known information, it will be necessary to fill in the blanks in our knowledge. This is essential to secure the persistence of the remaining populations.

Something that needs to be addressed in the immediate future will be the geohistorical and biogeographical context in which these species occur. That is, this area is particularly susceptible to dramatic changes in vegetation due to periodic and episodic climate change. One reason the species have persisted so far is that their populations have been capable of moving as climate changes. There is a tendency to think of vegetation formations to be static, when in fact they are fluid and always changing. It is dangerous to think of them as static, if we are really to consider the long-term survival of the species of concern. Therefore, after we fill in the blanks of our life-history information, we need to evaluate the ability of the species to disperse along either fronts or corridors into areas of suitable habitat in response to changing climate. Toward this end, the Nevada GAP vegetation map is a good starting point, but that map must be corrected and integrated with climate change models which can predict where vegetation communities can shift under different climate change episodes. That is, where can species A move during a continental glaciation? Where can the species move during a deeper interglacial than we are now experiencing? When we get a handle on that and plan accordingly, then perhaps we can be secure in the knowledge that we have provided good protection for these species for the lifespans of our grandchildren. Toward this end, we need a group of local botanical and plant ecological experts to work together on these problems and propose viable plans. The low-elevation plant TWG has assembled much of the needed expertise, but it continues to need a clearer mandate from Clark County, the IMC, and FWS.

MUDDY RIVER

The working group activity for the Muddy River has been confusing for us at BRRC. There are several indendent activities (of different kinds) in the Muddy, and it appears that there is a paucity of coordination among the players or the activities in this area. The Muddy River is a jewel in Clark County in terms of riparian habitats and sensitive species. Thus, it deserves attention in terms of coordination of activities in management/research/monitoring/land purchases/etc. Unfortunately, there are some politics associated with the Muddy River that appear to make the County tentative in promoting coordination in conservation efforts for the Muddy.

Focus on Selected Individual Species

Literature on Covered Species

This project has several dimensions. The first is to accumulate the existing literature on covered species to form a library of information in support of conservation actions. Obviously, this is a challenging task, and it is ongoing. It is taking considerable time just determining what constitutes pertinent literature to conservation planning given that several of the species have had much written about them, and much is written on aspects of biology that could be important, but sometimes tangentially.

Hot-Spot Analysis

We are doing various "hot-spot" analyses which are important to prioritization of efforts for Clark County. Below we present preliminary results from the hot spot analysis. The immediate conclusion from this analysis is that the largest number of species of concern in Clark County is in the Spring Mountains. However, species in the Spring Mountains are generally freer from threats than are species in areas in which aggressive land development and recreation occurs with only modest restraint. The hot spot analysis shows that small and fragmented habitats are frequently species rich and very vulnerable to change because they are confined to small areas in space. These species should be the object of our most intense conservation planning. The hot-spot analysis in the spreadsheet below parses species three different ways to show where species are found. It also shows us a great deal about our ignorance as it is not possible to fill in all cells in the spreadsheet. Nevertheless, there is much that can be concluded in spite of our ignorance, and we should work to reduce our ignorance so that we can adapt our approaches to prioritization. The bottom line is that there are several small and/or fragmented habitats which are essential to many sensitive species. Conservation efforts need explicitly to deal with these challenges.

Common Name	Scientific Name		Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
			Geographic Aggregates						
Mammals									
Covered									
Silver-haired bat	*Lasionycteris noctivagans*	1	1		1			1	
Long-eared myotis	*Myotis evolis*	1			1				
Long-legged myotis	*Myotis volans*	1	1		1				
Palmer's chipmunk	*Tamias palmeri*	1			1				
Evaluation									
Pale Townsend's big-eared bat,	*Corynorhinus townsendii pallescens*	2	1		1			1	
Kit fox,	*Vulpes macrolus arsipus*	2	1				1		
Desert kangaroo rat,	*Dipodomys deserti*	2	1					1	
Desert pocket mouse,	*Chaetodipus penicillalus sobrinus*	2	1		1		1		
Inyo shrew	*Sorex tenellus*	2							
Small-footed *myotis*	*Myotis ciliolabrum_*	2							
Fringed myotis	*Myotis thysanodes*	2							
Golden-mantled ground squirrel	*Spermophihis laleralis certus*	2							
Hidden Forest Uinta chipmunk	*Tamias umbrinus nevadensis*	2							
Panamint kangaroo rat	*Dipodomys panamintinus caudatus*	2							
Bushy tail woodrat	*Neotoma cinerea lucida*	2							
Short-tailed weasel	*Mustela erminea*	2							
Long-tailed weasel	*Mustela frenata*	2							
Nuttall's cottontail	*Sylvilagus nuttalli*	2							
Chisel-toothed kangaroo rat	*Dipodomys microps occidentalis*	2							
Watch-List									
California leaf-nosed bat	*Macrotus californicus*	3							
Spotted bat		3							
Allen's big-eared (lapped-browed) bat	*Idionycteris phyllotis*	3							
Southwestern cave myotis	*Myotis velifer brevis*	3							
Yuma myotis	*Myotis yumanensis*	3							
Greater western mastiff-bat	*Eumops perotis californicus*	3							
Big free-tailed bat	*Nyctinomops macrotis*	3							
Spiny pocket mouse	*Chaetodipus spinatus spinatus*	3							

Common Name	Scientific Name		Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
			Geographic Aggregates						
Desert bighorn sheep	*Ovis canadensis nelsoni*	3							
Birds									
Covered									
Southwestern willow flycatcher	*Empidonax traillii extimus*	1	1				1		1
American peregrine falcon	*Falco peregrinus anatum*	1	1		1	1	1		
Yellow-billed cuckoo	*Coccyzus americanus*	1					1		1
Blue grosbeak	*Guiraca caerulea*	1					1		1
Phainopepla	*Phainopepla nitens*	1	1			1	1		1
Summer tanager	*Piranga rubra*	1					1		1
Vermillion flycatcher	*Pyrocephalus rubinus*	1					1		1
Arizona Bell's vireo	*Vireo bellii arizoniae*	1					1		1
Evaluation									
Western hurrowing owl	*Athene cunicularia hypugea*	2	1	1		1	1	1	1
Bendire's thrasher	*Toxosroma bendirei*	2							
LeConte's thrasher	*Toxostoina lecontei*	2							
Gray vireo	*Vireo vicinior*	2							
Loggerhead shrike	*Lanius Indovicianus*	2							
Crissal thrasher	*Toxostoina (lorsale*	2							
Western bluebird	*Sialia mexicana*	2							
Watch List									
Green-backed heron	*Butorides striatus*	3							
Western least bittern	*Ixobrychus exilis hesperis*	3							
White-faced ibis	*Plegadis chihi*	3							
Yuma clapper rail	*Rallus longirostrus yumanensis*	3							
Northern goshawk	*Accepiter gentilus*	3							
Ferruginous hawk	*Buteo regalis*	3							
Golden eagle	*Aquila chrysaetos*	3							
Bald eagle	*Haliaeetus leucocephalus*	3							
Flammulated owl	*Otus flammeolus*	3							
Northern saw-whet owl	*Aegolius acadius*	3							
Northern pygmy owl	*Glaucidium gnoma*	3							

Common Name	Scientific Name		Geographic Aggregates						
			Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
Western screech owl	*Otus kennicotti*	3							
Cactus wren	*Campylorhynchus brunneicaptillus*	3							
Canyon wren	*Catharpes mexicanus*	3							
Scott's oriole	*Lcterus parisorum*	3							
Reptiles/Amphibians									
Covered									
Desert tortoise	*Gopherus agassizii*	1	1	1		1	1	1	
Glossy snake	*Arizona elegans*	1							
Banded gecko	*Coleonyx variegatus*	1	1	1	1	1	1	1	1
Sidewinder	*Crotalus cerastes*	1							
Speckled rattlesnake	*Crotalus mitchelli*	1							
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*	1							
Great Basin collared lizard	*Crotaphytus insularis bicintores*	1	1	1	1	1	1	1	1
Desert iguana	*Dipsosaurus dorsalis*	1	1	1		1	1	1	1
Western chuckwalla									
Western red-tailed skink	*Eumeces gilberti rubricaudatus*	1	1		1	1	1	1	
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*	1	1	1	1	1	1	1	1
California (common) king snake	*Lampropeltis getulus californiae*	1							
Western leaf-nosed snake	*Phyllorhynchus decurtatus*	1	1	1	1	1	1	1	1
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	1							
Sonoran lyre snake	*Trimorphodon biscutatus lambda*	1							
Relict-leopard frog	*Rana onca*	1	1					1	1
Evaluation									
Banded Gila monster	*Heloderma suspectum cinctum*	2	1	1	1	1	1	1	1
Southern desert horned lizard	*Phrynosoma platyrhinos calidiarum*	2	1	1	1	1	1	1	1
Arizona (Southwestern) toad	*Bufo microscaphus microscaphus*	2	1						
Desert night lizard	*Xantusia vigilis*	2	1	1	1	1	1	1	1
Sonoran mountain kingsnake	*Lampropeltis gyromelana*	2							
Regal ringneck snake	*Diadophus punctatus regalis*	2							
Sidewinder	*Crotalus cerastes*	2							
Western Diamondback	*Crotalus atrox*	2							

Common Name	Scientific Name		Geographic Aggregates							
			Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead	Upland	Riverine
Red-spotted toad	*Bufo punctatus*	2								
Southern plateau lizard	*Sceloporus undulatus tristichus*	2								
Watch List										
Zebra-tailed lizard										
Pacific tree frog										
Plains toad										
Woodhous toad										
Fish										
Covered										
none										
Evaluation										
Moapa dace	*Moapa coriacea*	2								1
Woundfin	*Plagopterus argentissimus*	2								1
Virgin River chub	*Gila seminuda*	2								1
Virgin River chub (Muddy River population)	*Gila seminuda*	2								1
Desert sucker	*Catastomus clarki utahensis*	2								1
Flannelmouth sucker	*Catostomus latipinnis*	2								1
Moapa White River springfish	*Crenichthys baileyi moapae*	2								1
Moapa speckled dace	*Rhinichthys osculus moapae*	2								1
Watch List										
Virgin spinedace	*Lepidomeda mollispinus mollispinus*	3								
Butterflies										
Covered										
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*	1			1					
Dark blue butterfly	*Euphilotes enoptes purpurea*	1			1					
Morland's checkerspot butterfly	*Euphydryas anicia morandi*	1								
Spring Mountains comma skipper	*Hesperia comma mojavensis*	1			1					
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*	1			1					
Mt. Charleston blue butterfly	*Icaricia shasta charlestonensis*	1			1					
Nevada admiral	*Limenitus weidemeyerii nevadae*	1			1			1		
Carole's silverspot butterfly	*Speyeria zerene carolae*	1			1					

Common Name	Scientific Name		Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
Mojave silver-spotted skipper					1		1		
Rocky Mountain duskywing					1		1		
MacNeil's desert sootywing			1						1
Southern Yuma skipper									1
Western great purple hairstreak			1		1				
Leda hairstreak									
Mojave ellis blue					1				
Eastern Mojave blue					1				
Western Palmer's metalmark									
Satyr angelwing					1				
Kingston checkerspot								1	
Arizona viceroy									1
Western hackberry butterfly					1				
Western canyonland satyr					1				
Great Basin ringlet					1				
Evaluation									
Bret's blue butterfly	*Euphilotes battoides sp.*	2							
MacNeil sooty wing skipper	*Hesperopsis gracielae*	2							1
Bees									
Covered									
none									
Evaluation									
Dalea blister bee	*Ancylandrena koebelei*	2							
Mojave gypsum bee	*Andrena balsamorhizae*	2							
Mojave poppy bee	*Perdita meconis*	2							
Red-legged beardtongue bee	*Atoposmia rufifemur*	2							
Virgin River globmallow bee	*Diadasia proridens*	2							
Red-tailed blazing star bee	*Megandrena mentzeliae*	2							
Two-tone Perdita	*Perdita bipicta*	2							
Mojave twilight bee	*Perdita celadona*	2							
Big-headed Perdita	*Perdita cephalotes*	2							

Geographic Aggregates

Common Name	Scientific Name		Flanks	Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead	Upland	Riverine
			Geographic Aggregates								
Las Vegas Perdita	*Perdita crasens*	2									
Virginia River Perdita	*Perdita crotonis caerulea*	2									
Spurge-loving Perdita	*Perdita euphorbiana*	2									
Tiquilia Perdita	*Perdita exusta*	2									
Apache Plume Perdita	*Perdita fallugiae*	2									
Yellow-headed Perdita	*Perdita flaveceps*	2									
Moapa Perdita	*Perdita fulvescens*	2									
Unadorned Perdita	*Perdita inornata*	2									
Mojave poppy bee	*Perdita meconis*	2									
Valley of Fire Perdita	*Perdita nevediana*	2									
Virgin River twilight bee	*Perdita vespertina*	2									
Mojave mountain Perdita	*Perdita vicina*	2									
Desert-loving Perdita	*Perdita xeropila discrepans*	2									
	Atposmia n. sp.	2									
	Hesperapis (Carinapis) n. sp.	2									
	Hesperapis aff. elegantula n. sp.	2									
	Hesperapis aff. kayella n. sp.	2									
	Hoplitis (Proteriades) n. sp.	2									
	Megachile aff. umaitillensis n. sp.	2									
	Osmia aff. giffardi n.sp.	2									
	Perdita (Epimacrotera n.sp.	2									
	Perdita (Glossoperdita) n.sp.	2									
	Perdita (Heteroperdita) n.sp.	2									
	Perdita dicksoni	2									
	Perdita aff. megapyga n.sp.	2									
	Perdita aff. namatophila n.sp. 9	2									
	Perdita aff. rhodogastoa n.sp. 7	2									
	Perdita aff. rhodogastoa n.sp. 8	2									
Watch List											
Red-legged lava bee	*Ashmeadiella picticrus sp. nov.*	3									
Flat-faced cactus bee	*Lithurge listrota*	3									

Common Name	Scientific Name		Geographic Aggregates						
			Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
Beck's perdita	*Perdita becki*	3							
Rock nettle perdita	*Perdita eucnides eucnides*	3							
Banded perdita	*Perdita vittata conformis*	3							
Koso phacelia bee	*Protodufourea koso sp. nov.*	3							
Michener's phacelia bee	*Xeroheriades michener*	3							
Other insects									
Covered									
none									
Evaluation									
Spring Mountains ant	*Lasius nevadensis*	2							
Moapa riffle beetle		2							
Moapa skater/waterstrider	*Rhagovellia becki*	2							
Naucorid bug	*Usingerian moapensis*	2							
Crawling water beetle	*Haliplus eremicus*	2							
Moapa riffle beetle	*Microcylloepus moapus moapus*	2							
Amargosa (Pahranagat naucorid	*Pelocoris shoshone shoshone*	2							
Other invertebrates									
Covered									
Spring Mountains springsnail	Pyrgulopsis deaconi	1	1		1				
Southeast Nevada springsnail	Pyrgulopsis turbatrix	1			1				
Evaluation									
Moapa pebble snail	*Pyrgulopsis avernalis*	2							
Moapa turban snail	*Pyrgulopsis carinefera*	2							
Grated tryonia	*Tryonia clathrata*	2							
Undescribed tryonia	*Tryonia sp.*	2							
Dry lake bed species		2							
Watch List									
Corn Creek springsnail	*Pyrgulopsis sp.*	3							
Blue Point springsnail	*Pyrgulopsis sp.*	3							
Undescribed Blue Point tryonia	*Tryonia sp.*	3							
Vascular Plants									

Common Name	Scientific Name		Geographic Aggregates						
			Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
Covered									
Blue Diamond cholla	*Opuntia whipplei var. multigeniculata*	1	1						
Rough angelica	*Angelica scabrida*	1			1				
Sticky ringstem	*Anulocaulis leisolenus*	1				1		1	
Charleston-pussytoes	Antennaria soliceps	1			1				
Las Vegas bearpoppy	*Arclomecon californica*	1	1	1		1		1	
White bearpoppy	*Arctomecon merriamii*	1	1	1					
Rosy King sandwort	*Arenaria kingii ssp. rosea*	1			1				
Clokey milkvetch	*Astragalus aequalis*	1			1				
Threecorner milkvetch	*Astragalus geyeri var. triquetrus*	1		1		1		1	1
Clokey eggvetch	*Astragalus oophorus var. clokeyanus*	1				1			
Spring Mountain milkvetch	*Astragalus remotus*	1	1	1					
Alkali mariposa lily	*Calochortus striatus*	1	1						
Clokey paintbrush	*Castelleja martinii var. clokeyi*	1			1				
Clokey thistle	*Cirsium clokeyi*	1			1				
Jaeger whitlowgrass	*Draba jaegeri*	1			1				
Charleston draba	*Draba paucifructa*	1			1				
Inch high flebane	*Erigeron uncialis ssp. conjugans*	1			1				
Forked buckwheat	*Eriogonum bifurcatum*	1	1						
Sticky buckwheat	*Eriogonum viscidulum*	1				1		1	
Clokey greasebush	*Glossopetalon clokeyi*	1			1				
Pahrump Valley buckwheat									
Smooth pungent greasebush	*Glossopetalon pungens var. glabra*	1		1	1				
Pungent dwarf greasebush	*Glossopelalon pungens var. pungens*	1			1				
Red Rock Canyon aster	*Ionactis caelestis*	1			1				
Hidden ivesia	*Ivesia cryptocaulis*	1			1				
Jaegar ivesia	*Ivesia jaegeri*	1		1	1				
Hitchcock bladderpod	*Lesquerella hitchcockii*	1			1				
Charleston pinewood lousewort	*Pedicularis semibarbata var. charlestonensis*	1			1				
White-margined beardtongue	*Penstemon albomarginatus*	1		1					
Charleston beardtongue	*Penstemon thompsoneae var. keckii*	1			1				

Common Name	Scientific Name		Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
			Geographic Aggregates						
Jaegar beartongue	*Penstemon thompsoneae var. jaegeri*	1			1				
Parish's phacclia	*Phacelia parishii*	1	1						
Clokey mountain sage	*Salvia dorrii var. clokeyi*	1			1				
Clokey catchfly	*Silene clokeyi*	1		1	1				
Charleston tansy	*Sphaeromeria compacta*	1			1				
Charleston kittentails	*Synthyris ranunculina*	1			1				
Charleston grounddaisy	*Tounsendia jonesii var. tumulosa*	1	1	1	1				
Limestone violet	*Viola purpurea var. charlestonensis*	1	1						1
Evaluation									
Black wooly-pod	*Astragalus funereus*	2							
Triangle lobe moonwort	*Botrychium ascendens*	2							
Dainty moonwort	*Botrychium crenulatum*	2							
Silverleaf sunray	*Enceliopsis argophylla*	2							
Nevada willowherb	*Epilobium nevadense*	2							
Las Vegas Valley buckwheat	*Eriogonum corymbosum var. aureum*	2							
Yellow twotone beardtongue	*Penstemon bicolor ssp. Bicolor*	2							
Curve-podded Mojave (halfring) milkvetch	*Astragalus mojavensis var. hemigryus*	2							
Meadow Valley sandwort	*Arenaria stenomeres*	2							
Ackerman milkvetch	*Astragalus ackermanii*	2							
Sheep Mountain milkvetch	*Astragalus amphioxys var. musimonum*	2							
Mokiak milkvetch	*Astragalus mokiacensis*	2							
Remote rabbitbrush	*Chrysothamnus eremobius*	2							
Unusual catseye	*Cryptantha insolita*	2							
Ripley's biscuitroot	*Cymopterus ripleyi var. saniculoides*	2							
Sheep fleabane	*Erigeron ovinus*	2							
Desert (Clark) parsley	*Lomatium graveolens var. clarkii*	2							
Pygmy poreleaf	*Porophyllum pygmaeum*	2							
Virgin River thistle	*Circium virginense*	2							
Clokey buckwheat	*Eriogonum heermannii var. clokeyi*	2							
Amargosa beardtongue	*Penstemon fruticiformis ssp. Amargosae*	2							
Watch List									

Common Name	Scientific Name		Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine
			Geographic Aggregates						
One-leaflet Torrey milkvetch	*Astragalus calycosus var. monophyllidius*	3							
Clokey pincushion	*Coryphantha vivipara ssp. Rosea*	3							
Hoffman's cryptantha	*Cryptantha hoffmannii (=C. virginesis)*	3							
New York Mountains catseye	*Cryptantha tumulosa*	3							
Chalk liveforever	*Dudleya pulverulenta*	3							
Clokey fleabane	*Erigeron clokeyi*	3							
Barrel cactus	*Ferocactus acanthoides vcar. Lecontei*	3							
Nevada greasebush	*Glossopetalon nevadensis*	3							
Beaver Dam scurfpea (breadroot)	*Pediomelum castoreum*	3							
Rosy twotone beardtongue	*Penstemon bicolor ssp. Roseus*	3							
Utah spikemoss	*Selaginella utahensis*	3							
Non Vascular Plants									
Covered									
Anacolia menziesil	*Anacolia menziesii*	1			1				
Claopodium whippleanum	*Claopodium whippleanum*	1			1				
Syntrichia princeps	*Dicranoweisia crsipula*	1							1
Dicranoweisia crispula	*Syntrichia princeps*	1			1				
Evaluation									
Pseudocrossidium moss	*Pseudocrossidium crinitum*	2							
Undescribed targionia liverwort	*Targionia sp. nov.*	2							
Nevada didymodon	*Didymondon nevadensis*	2							
Crossidium moss	*Crossidium seriatum*	2							
American grimmia	*Grimmia americana*	2							
Trichostomum moss	*Trichostomum sweetii*	2							
	Distichium inclinatum	2							
Undescribed syntrichia moss	*Syntrichia spp.*	2							
Watch List									
	Fissidens sublimbatus	3							
	Splachnobryum obtusum	3							
		Totals =	34	19	60	18	23	21	32

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Mammals												
Covered												
Silver-haired bat	*Lasionycteris noctivagans*	1			1	1			1		1	1
Long-eared myotis	*Myotis evolis*	1			1	1	1		1		1	1
Long-legged myotis	*Myotis volans*	1			1	1	1					
Palmer's chipmunk	**Tamias palmeri**	1			1	1						
Evaluation												
Pale Townsend's big-eared bat,	*Corynorhinus townsendii pallescens*	2					1	1		1	1	1
Kit fox,	*Vulpes macrolus arsipus*	2				1	1	1	1	1	1	1
Desert kangaroo rat,	*Dipodomys deserti*	2						1	1	1		
Desert pocket mouse,	*Chaetodipus penicillalus sobrinus*	2							1	1	1	
Inyo shrew	*Sorex tenellus*	2										
Small-footed *myotis*	*Myotis ciliolabrum_*	2										
Fringed myotis	*Myotis thysanodes*	2										
Golden-mantled ground squirrel	*Spermophihis laleralis certus*	2										
Hidden Forest Uinta chipmunk	*Tamias umbrinus nevadensis*	2										
Panamint kangaroo rat	*Dipodomys panamintinus caudatus*	2										
Bushy tail woodrat	*Neotoma cinerea lucida*	2										
Short-tailed weasel	*Mustela erminea*	2										
Long-tailed weasel	*Mustela frenata*	2										
Nuttall's cottontail	*Sylvilagus nuttalli*	2										
Chisel-toothed kangaroo rat	*Dipodomys microps occidentalis*	2										
Watch-List												
California leaf-nosed bat	*Macrotus californicus*	3										
Spotted bat		3										
Allen's big-eared (lapped-browed) bat	*Idionycteris phyllotis*	3										
Southwestern cave myotis	*Myotis velifer brevis*	3										
Yuma myotis	*Myotis yumanensis*	3										
Greater western mastiff-bat	*Eumops perotis californicus*	3										
Big free-tailed bat	*Nyctinomops macrotis*	3										
Spiny pocket mouse	*Chaetodipus spinatus spinatus*	3										

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Desert bighorn sheep	*Ovis canadensis nelsoni*	3										
Birds												
Covered												
Southwestern willow flycatcher	*Empidonax traillii extimus*	1										1
American peregrine falcon	*Falco peregrinus anatum*	1			1	1	1					1
Yellow-billed cuckoo	*Coccyzus americanus*	1										1
Blue grosbeak	*Guiraca caerulea*	1										1
Phainopepla	*Phainopepla nitens*	1									1	1
Summer tanager	*Piranga rubra*	1										1
Vermillion flycatcher	*Pyrocephalus rubinus*	1									1	1
Arizona Bell's vireo	*Vireo bellii arizoniae*	1										1
Evaluation												
Western hurrowing owl	*Athene cunicularia hypugea*	2				1	1			1		
Bendire's thrasher	*Toxosroma bendirei*	2										
LeConte's thrasher	*Toxostoina lecontei*	2										
Gray vireo	*Vireo vicinior*	2										
Loggerhead shrike	*Lanius Indovicianus*	2										
Crissal thrasher	*Toxostoina (lorsale*	2										
Western bluebird	*Sialia mexicana*	2										
Watch List												
Green-backed heron	*Butorides striatus*	3										
Western least bittern	*Ixobrychus exilis hesperis*	3										
White-faced ibis	*Plegadis chihi*	3										
Yuma clapper rail	*Rallus longirostrus yumanensis*	3										
Northern goshawk	*Accepiter gentilus*	3										
Ferruginous hawk	*Buteo regalis*	3										
Golden eagle	*Aquila chrysaetos*	3										
Bald eagle	*Haliaeetus leucocephalus*	3										
Flammulated owl	*Otus flammeolus*	3										
Northern saw-whet owl	*Aegolius acadius*	3										
Northern pygmy owl	*Glaucidium gnoma*	3										

Common Name	Scientific Name		Vegetation									
			Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Western screech owl	*Otus kennicotti*	3										
Cactus wren	*Campylorhynchus brunneicaptillus*	3										
Canyon wren	*Catharpes mexicanus*	3										
Scott's oriole	*Lcterus parisorum*	3										
Reptiles/Amphibians												
Covered												
Desert tortoise	*Gopherus agassizii*	1					1	1	1	1	1	
Glossy snake	*Arizona elegans*	1				1			1	1		
Banded gecko	*Coleonyx variegatus*	1				1	1	1		1	1	1
Sidewinder	*Crotalus cerastes*	1							1	1	1	
Speckled rattlesnake	*Crotalus mitchelli*	1				1	1	1		1		
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*	1						1		1		
Great Basin collared lizard	*Crotaphytus insularis bicintores*	1				1	1	1	1	1	1	1
Desert iguana	*Dipsosaurus dorsalis*	1							1	1	1	
Western chuckwalla								1	1	1	1	
Western red-tailed skink	*Eumeces gilberti rubricaudatus*	1			1	1	1	1			1	1
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*	1				1	1	1	1	1		
California (common) king snake	*Lampropeltis getulus californiae*	1							1	1		
Western leaf-nosed snake	*Phyllorhynchus decurtatus*	1							1	1		
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	1							1	1		
Sonoran lyre snake	*Trimorphodon biscutatus lambda*	1			1	1				1		
Relict-leopard frog	*Rana onca*	1										1
Evaluation												
Banded Gila monster	*Heloderma suspectum cinctum*	2				1		1		1	1	1
Southern desert horned lizard	*Phrynosoma platyrhinos calidiarum*	2				1	1	1	1	1	1	
Arizona (Southwestern) toad	*Bufo microscaphus microscaphus*	2										1
Desert night lizard	*Xantusia vigilis*	2										
Sonoran mountain kingsnake	*Lampropeltis gyromelana*	2										
Regal ringneck snake	*Diadophus punctatus regalis*	2										
Sidewinder	*Crotalus cerastes*	2										
Western Diamondback	*Crotalus atrox*	2										

Common Name	Scientific Name		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
			Vegetation									
Red-spotted toad	*Bufo punctatus*	2										
Southern plateau lizard	*Sceloporus undulatus tristichus*	2										
Watch List												
Zebra-tailed lizard												
Pacific tree frog												
Plains toad												
Woodhous toad												
Fish												
Covered												
none												
Evaluation												
Moapa dace	*Moapa coriacea*	2										1
Woundfin	*Plagopterus argentissimus*	2										1
Virgin River chub	*Gila seminuda*	2										1
Virgin River chub (Muddy River population)	*Gila seminuda*	2										1
Desert sucker	*Catastomus clarki utahensis*	2										1
Flannelmouth sucker	*Catostomus latipinnis*	2										1
Moapa White River springfish	*Crenichthys baileyi moapae*	2										1
Moapa speckled dace	*Rhinichthys osculus moapae*	2										
Watch List												
Virgin spinedace	*Lepidomeda mollispinus mollispinus*	3										
Butterflies												
Covered												
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*	1			1	1	1					
Dark blue butterfly	*Euphilotes enoptes purpurea*	1			1	1	1					
Morland's checkerspot butterfly	*Euphydryas anicia morandi*	1		1	1	1						
Spring Mountains comma skipper	*Hesperia comma mojavensis*	1		1	1	1	1					
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*	1		1	1	1	1					
Mt. Charleston blue butterfly	*Icaricia shasta charlestonensis*	1		1	1							
Nevada admiral	*Limenitus weidemeyerii nevadae*	1		1	1	1						
Carole's silverspot butterfly	*Speyeria zerene carolae*	1		1	1	1	1					

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Mojave silver-spotted skipper												
Rocky Mountain duskywing												
MacNeil's desert sootywing												
Southern Yuma skipper												
Western great purple hairstreak											1	
Leda hairstreak											1	
Mojave ellis blue												
Eastern Mojave blue												
Western Palmer's metalmark											1	
Satyr angelwing												1
Kingston checkerspot												
Arizona viceroy												
Western hackberry butterfly												
Western canyonland satyr												
Great Basin ringlet												
Evaluation												
Bret's blue butterfly	*Euphilotes battoides sp.*	2										
MacNeil sooty wing skipper	*Hesperopsis gracielae*	2										1
Bees												
Covered												
none												
Evaluation												
Dalea blister bee	*Ancylandrena koebelei*	2										
Mojave gypsum bee	*Andrena balsamorhizae*	2										
Mojave poppy bee	*Perdita meconis*	2										
Red-legged beardtongue bee	*Atoposmia rufifemur*	2										
Virgin River globmallow bee	*Diadasia proridens*	2										
Red-tailed blazing star bee	*Megandrena mentzeliae*	2										
Two-tone Perdita	*Perdita bipicta*	2										
Mojave twilight bee	*Perdita celadona*	2										
Big-headed Perdita	*Perdita cephalotes*	2										

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Las Vegas Perdita	*Perdita crasens*	2										
Virginia River Perdita	*Perdita crotonis caerulea*	2										
Spurge-loving Perdita	*Perdita euphorbiana*	2										
Tiquilia Perdita	*Perdita exusta*	2										
Apache Plume Perdita	*Perdita fallugiae*	2										
Yellow-headed Perdita	*Perdita flaveceps*	2										
Moapa Perdita	*Perdita fulvescens*	2										
Unadorned Perdita	*Perdita inornata*	2										
Mojave poppy bee	*Perdita meconis*	2										
Valley of Fire Perdita	*Perdita nevediana*	2										
Virgin River twilight bee	*Perdita vespertina*	2										
Mojave mountain Perdita	*Perdita vicina*	2										
Desert-loving Perdita	*Perdita xeropila discrepans*	2										
	Atposmia n. sp.	2										
	Hesperapis (Carinapis) n. sp.	2										
	Hesperapis aff. elegantula n. sp.	2										
	Hesperapis aff. kayella n. sp.	2										
	Hoplitis (Proteriades) n. sp.	2										
	Megachile aff. umaitillensis n. sp.	2										
	Osmia aff. giffardi n.sp.	2										
	Perdita (Epimacrotera n.sp.	2										
	Perdita (Glossoperdita) n.sp.	2										
	Perdita (Heteroperdita) n.sp.	2										
	Perdita dicksoni	2										
	Perdita aff. megapyga n.sp.	2										
	Perdita aff. namatophila n.sp. 9	2										
	Perdita aff. rhodogastoa n.sp. 7	2										
	Perdita aff. rhodogastoa n.sp. 8	2										
Watch List												
Red-legged lava bee	*Ashmeadiella picticrus sp. nov.*	3										
Flat-faced cactus bee	*Lithurge listrota*	3										

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Beck's perdita	*Perdita becki*	3										
Rock nettle perdita	*Perdita eucnides eucnides*	3										
Banded perdita	*Perdita vittata conformis*	3										
Koso phacelia bee	*Protodufourea koso sp. nov.*	3										
Michener's phacelia bee	*Xeroheriades michener*	3										
Other insects												
Covered												
none												
Evaluation												
Spring Mountains ant	*Lasius nevadensis*	2										
Moapa riffle beetle		2										
Moapa skater/waterstrider	*Rhagovellia becki*	2										
Naucorid bug	*Usingerian moapensis*	2										
Crawling water beetle	*Haliplus eremicus*	2										
Moapa riffle beetle	*Microcylloepus moapus moapus*	2										
Amargosa (Pahranagat naucorid	*Pelocoris shoshone shoshone*	2										
Other invertebrates												
Covered												
Spring Mountains springsnail	Pyrgulopsis deaconi	1										
Southeast Nevada springsnail	Pyrgulopsis turbatrix	1										
Evaluation												
Moapa pebble snail	*Pyrgulopsis avernalis*	2										
Moapa turban snail	*Pyrgulopsis carinefera*	2										
Grated tryonia	*Tryonia clathrata*	2										
Undescribed tryonia	*Tryonia sp.*	2										
Dry lake bed species		2										
Watch List												
Corn Creek springsnail	*Pyrgulopsis sp.*	3										
Blue Point springsnail	*Pyrgulopsis sp.*	3										
Undescribed Blue Point tryonia	*Tryonia sp.*	3										
Vascular Plants												

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Covered												
Blue Diamond cholla	*Opuntia whipplei var. multigeniculata*	1								1		
Rough angelica	*Angelica scabrida*	1			1							
Sticky ringstem	*Anulocaulis leisolenus*	1							1	1		
Charleston-pussytoes	Antennaria soliceps	1	1	1								
Las Vegas bearpoppy	*Arclomecon californica*	1							1	1		
White bearpoppy	*Arctomecon merriamii*	1						1	1	1		
Rosy King sandwort	*Arenaria kingii ssp. rosea*	1		1	1							
Clokey milkvetch	*Astragalus aequalis*	1			1	1	1					
Threecomer milkvetch	*Astragalus geyeri var. triquetrus*	1								1		
Clokey eggvetch	*Astragalus oophorus var. clokeyanus*	1			1	1						
Spring Mountain milkvetch	*Astragalus remotus*	1				1	1	1		1		
Alkali mariposa lily	*Calochortus striatus*	1								1		
Clokey paintbrush	*Castelleja martinii var. clokeyi*	1		1	1							
Clokey thistle	*Cirsium clokeyi*	1	1	1	1							
Jaeger whitlowgrass	*Draba jaegeri*	1	1	1								
Charleston draba	*Draba paucifructa*	1	1	1								
Inch high flebane	*Erigeron uncialis ssp. conjugans*	1		1	1	1	1					
Forked buckwheat	*Eriogonum bifurcatum*	1							1			
Sticky buckwheat	*Eriogonum viscidulum*	1								1		
Clokey greasebush	*Glossopetalon clokeyi*	1			1							
Pahrump Valley buckwheat											1	
Smooth pungent greasebush	*Glossopetalon pungens var. glabra*	1				1	1					
Pungent dwarf greasebush	*Glossopelalon pungens var. pungens*	1				1	1					
Red Rock Canyon aster	*Ionactis caelestis*	1			1							
Hidden ivesia	*Ivesia cryptocaulis*	1	1									
Jaegar ivesia	*Ivesia jaegeri*	1		1	1							
Hitchcock bladderpod	*Lesquerella hitchcockii*	1	1	1	1							
Charleston pinewood lousewort	*Pedicularis semibarbata var. charlestonensis*	1		1	1							
White-margined beardtongue	*Penstemon albomarginatus*	1						1		1		

			Vegetation									
Common Name	**Scientific Name**		Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Charleston beardtongue	*Penstemon thompsoneae var. keckii*	1	1	1								
Jaegar beartongue	*Penstemon thompsoneae var. jaegeri*	1			1	1						
Parish's phacclia	*Phacelia parishii*	1							1			
Clokey mountain sage	*Salvia dorrii var. clokeyi*	1		1	1	1						
Clokey catchfly	*Silene clokeyi*	1	1	1								
Charleston tansy	*Sphaeromeria compacta*	1	1	1								
Charleston kittentails	*Synthyris ranunculina*	1	1	1	1							
Charleston grounddaisy	*Tounsendia jonesii var. tumulosa*	1	1	1	1							
Limestone violet	*Viola purpurea var. charlestonensis*	1		1	1							
Evaluation												
Black wooly-pod	*Astragalus funereus*	2										
Triangle lobe moonwort	*Botrychium ascendens*	2										
Dainty moonwort	*Botrychium crenulatum*	2										
Silverleaf sunray	*Enceliopsis argophylla*	2										
Nevada willowherb	*Epilobium nevadense*	2										
Las Vegas Valley buckwheat	*Eriogonum corymbosum var. aureum*	2										
Yellow twotone beardtongue	*Penstemon bicolor ssp. Bicolor*	2						1		1		
Curve-podded Mojavemilkvetch	*Astragalus mojavensis var. hemigryus*	2				1	1	1				
Meadow Valley sandwort	*Arenaria stenomeres*	2										
Ackerman milkvetch	*Astragalus ackermanii*	2										
Sheep Mountain milkvetch	*Astragalus amphioxys var. musimonum*	2										
Mokiak milkvetch	*Astragalus mokiacensis*	2										
Remote rabbitbrush	*Chrysothamnus eremobius*	2										
Unusual catseye	*Cryptantha insolita*	2										
Ripley's biscuitroot	*Cymopterus ripleyi var. saniculoides*	2										
Sheep fleabane	*Erigeron ovinus*	2										
Desert (Clark) parsley	*Lomatium graveolens var. clarkii*	2										
Pygmy poreleaf	*Porophyllum pygmaeum*	2										
Virgin River thistle	*Circium virginense*	2										
Clokey buckwheat	*Eriogonum heermannii var. clokeyi*	2										
Amargosa beardtongue	*Penstemon fruticiformis ssp. Amargosae*	2										

Common Name	Scientific Name		Vegetation									
			Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian
Watch List												
One-leaflet Torrey milkvetch	*Astragalus calycosus var. monophyllidius*	3										
Clokey pincushion	*Coryphantha vivipara ssp. Rosea*	3										
Hoffman's cryptantha	*Cryptantha hoffmannii (=C. virginesis)*	3										
New York Mountains catseye	*Cryptantha tumulosa*	3										
Chalk liveforever	*Dudleya pulverulenta*	3										
Clokey fleabane	*Erigeron clokeyi*	3										
Barrel cactus	*Ferocactus acanthoides vcar. Lecontei*	3										
Nevada greasebush	*Glossopetalon nevadensis*	3										
Beaver Dam scurfpea (breadroot)	*Pediomelum castoreum*	3										
Rosy twotone beardtongue	*Penstemon bicolor ssp. Roseus*	3										
Utah spikemoss	*Selaginella utahensis*	3										
Non Vascular Plants												
Covered												
Anacolia menziesil	*Anacolia menziesii*	1				1	1					
Claopodium whippleanum	*Claopodium whippleanum*	1				1						
Syntrichia princeps	*Dicranoweisia crsipula*	1				1						
Dicranoweisia crispula	*Syntrichia princeps*	1			1	1						
Evaluation												
Pseudocrossidium moss	*Pseudocrossidium crinitum*	2										
Undescribed targionia liverwort	*Targionia sp. nov.*	2										
Nevada didymodon	*Didymondon nevadensis*	2										
Crossidium moss	*Crossidium seriatum*	2										
American grimmia	*Grimmia americana*	2										
Trichostomum moss	*Trichostomum sweetii*	2										
	Distichium inclinatum	2										
Undescribed syntrichia moss	*Syntrichia spp.*	2										
Watch List												
	Fissidens sublimbatus	3										
	Splachnobryum obtusum	3										
	Totals =		11	23	33	36	25	18	21	31	20	27

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Mammals											
Covered											
Silver-haired bat	*Lasionycteris noctivagans*	1		1							
Long-eared myotis	*Myotis evolis*	1		1			1				
Long-legged myotis	*Myotis volans*	1									
Palmer's chipmunk	*Tamias palmeri*	1									
Evaluation											
Pale Townsend's big-eared bat,	*Corynorhinus townsendii pallescens*	2		1			1				
Kit fox,	*Vulpes macrolus arsipus*	2		1			1				
Desert kangaroo rat,	*Dipodomys deserti*	2									
Desert pocket mouse,	*Chaetodipus penicillalus sobrinus*	2					1				
Inyo shrew	*Sorex tenellus*	2									
Small-footed *myotis*	*Myotis ciliolabrum_*	2									
Fringed myotis	*Myotis thysanodes*	2									
Golden-mantled ground squirrel	*Spermophihis laleralis certus*	2									
Hidden Forest Uinta chipmunk	*Tamias umbrinus nevadensis*	2									
Panamint kangaroo rat	*Dipodomys panamintinus caudatus*	2									
Bushy tail woodrat	*Neotoma cinerea lucida*	2									
Short-tailed weasel	*Mustela erminea*	2									
Long-tailed weasel	*Mustela frenata*	2									
Nuttall's cottontail	*Sylvilagus nuttalli*	2									
Chisel-toothed kangaroo rat	*Dipodomys microps occidentalis*	2									
Watch-List											
California leaf-nosed bat	*Macrotus californicus*	3									
Spotted bat		3									
Allen's big-eared (lapped-browed) bat	*Idionycteris phyllotis*	3									
Southwestern cave myotis	*Myotis velifer brevis*	3									
Yuma myotis	*Myotis yumanensis*	3									
Greater western mastiff-bat	*Eumops perotis californicus*	3									

			Limited/Isolated/ Fragmented Habitats								
Common Name	Scientific Name		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Big free-tailed bat	*Nyctinomops macrotis*	3									
Spiny pocket mouse	*Chaetodipus spinatus spinatus*	3									
Desert bighorn sheep	*Ovis canadensis nelsoni*	3									
Birds											
Covered											
Southwestern willow flycatcher	*Empidonax traillii extimus*	1		1							
American peregrine falcon	*Falco peregrinus anatum*	1		1							
Yellow-billed cuckoo	*Coccyzus americanus*	1	1	1			1				
Blue grosbeak	*Guiraca caerulea*	1		1							
Phainopepla	*Phainopepla nitens*	1		1			1				
Summer tanager	*Piranga rubra*	1		1							
Vermillion flycatcher	*Pyrocephalus rubinus*	1		1			1				
Arizona Bell's vireo	*Vireo bellii arizoniae*	1		1							
Evaluation											
Western hurrowing owl	*Athene cunicularia hypugea*	2									
Bendire's thrasher	*Toxosroma bendirei*	2									
LeConte's thrasher	*Toxostoina lecontei*	2									
Gray vireo	*Vireo vicinior*	2									
Loggerhead shrike	*Lanius Indovicianus*	2									
Crissal thrasher	*Toxostoina (lorsale*	2									
Western bluebird	*Sialia mexicana*	2									
Watch List											
Green-backed heron	*Butorides striatus*	3									
Western least bittern	*Ixobrychus exilis hesperis*	3									
White-faced ibis	*Plegadis chihi*	3									
Yuma clapper rail	*Rallus longirostrus yumanensis*	3									
Northern goshawk	*Accepiter gentilus*	3									
Ferruginous hawk	*Buteo regalis*	3									
Golden eagle	*Aquila chrysaetos*	3									
Bald eagle	*Haliaeetus leucocephalus*	3									

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Flammulated owl	*Otus flammeolus*	3									
Northern saw-whet owl	*Aegolius acadius*	3									
Northern pygmy owl	*Glaucidium gnoma*	3									
Western screech owl	*Otus kennicotti*	3									
Cactus wren	*Campylorhynchus brunneicaptillus*	3									
Canyon wren	*Catharpes mexicanus*	3									
Scott's oriole	*Lcterus parisorum*	3									
Reptiles/Amphibians											
Covered											
Desert tortoise	*Gopherus agassizii*	1				1	1				
Glossy snake	*Arizona elegans*	1									
Banded gecko	*Coleonyx variegatus*	1		1			1				
Sidewinder	*Crotalus cerastes*	1			1		1				
Speckled rattlesnake	*Crotalus mitchelli*	1							1		
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*	1									
Great Basin collared lizard	*Crotaphytus insularis bicintores*	1		1			1				
Desert iguana	*Dipsosaurus dorsalis*	1					1				
Western chuckwalla							1				
Western red-tailed skink	*Eumeces gilberti rubricaudatus*	1		1			1				
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*	1									
California (common) king snake	*Lampropeltis getulus californiae*	1							1		
Western leaf-nosed snake	*Phyllorhynchus decurtatus*	1									
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	1									
Sonoran lyre snake	*Trimorphodon biscutatus lambda*	1									
Relict-leopard frog	*Rana onca*	1	1								
Evaluation											
Banded Gila monster	*Heloderma suspectum cinctum*	2		1			1				
Southern desert horned lizard	*Phrynosoma platyrhinos calidiarum*	2					1				
Arizona (Southwestern) toad	*Bufo microscaphus microscaphus*	2		1							
Desert night lizard	*Xantusia vigilis*	2					1				

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Sonoran mountain kingsnake	*Lampropeltis gyromelana*	2									
Regal ringneck snake	*Diadophus punctatus regalis*	2									
Sidewinder	*Crotalus cerastes*	2									
Western Diamondback	*Crotalus atrox*	2									
Red-spotted toad	*Bufo punctatus*	2									
Southern plateau lizard	*Sceloporus undulatus tristichus*	2									
Watch List											
Zebra-tailed lizard											
Pacific tree frog											
Plains toad											
Woodhous toad											
Fish											
Covered											
none											
Evaluation											
Moapa dace	*Moapa coriacea*	2	1								
Woundfin	*Plagopterus argentissimus*	2									
Virgin River chub	*Gila seminuda*	2									
Virgin River chub (Muddy River population)	*Gila seminuda*	2									
Desert sucker	*Catastomus clarki utahensis*	2									
Flannelmouth sucker	*Catostomus latipinnis*	2									
Moapa White River springfish	*Crenichthys baileyi moapae*	2	1								
Moapa speckled dace	*Rhinichthys osculus moapae*	2									
Watch List											
Virgin spinedace	*Lepidomeda mollispinus mollispinus*	3									
Butterflies											
Covered											
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*	1									
Dark blue butterfly	*Euphilotes enoptes purpurea*	1	1								
Morland's checkerspot butterfly	*Euphydryas anicia morandi*	1									

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Spring Mountains comma skipper	*Hesperia comma mojavensis*	1	1								
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*	1	1								
Mt. Charleston blue butterfly	*Icaricia shasta charlestonensis*	1									
Nevada admiral	*Limenitus weidemeyerii nevadae*	1	1								
Carole's silverspot butterfly	*Speyeria zerene carolae*	1									
Mojave silver-spotted skipper											
Rocky Mountain duskywing											
MacNeil's desert sootywing											
Southern Yuma skipper											
Western great purple hairstreak											
Leda hairstreak											
Mojave ellis blue											
Eastern Mojave blue											
Western Palmer's metalmark											
Satyr angelwing											
Kingston checkerspot											
Arizona viceroy											
Western hackberry butterfly											
Western canyonland satyr											
Great Basin ringlet											
Evaluation											
Bret's blue butterfly	*Euphilotes battoides sp.*	2									
MacNeil sooty wing skipper	*Hesperopsis gracielae*	2		1							
Bees											
Covered											
none											
Evaluation											
Dalea blister bee	*Ancylandrena koebelei*	2									
Mojave gypsum bee	*Andrena balsamorhizae*	2				1					
Mojave poppy bee	*Perdita meconis*	2				1					
Red-legged beardtongue bee	*Atoposmia rufifemur*	2									

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Virgin River globmallow bee	*Diadasia proridens*	2									
Red-tailed blazing star bee	*Megandrena mentzeliae*	2									
Two-tone Perdita	*Perdita bipicta*	2									
Mojave twilight bee	*Perdita celadona*	2									
Big-headed Perdita	*Perdita cephalotes*	2									
Las Vegas Perdita	*Perdita crasens*	2									
Virginia River Perdita	*Perdita crotonis caerulea*	2									
Spurge-loving Perdita	*Perdita euphorbiana*	2									
Tiquilia Perdita	*Perdita exusta*	2									
Apache Plume Perdita	*Perdita fallugiae*	2									
Yellow-headed Perdita	*Perdita flaveceps*	2									
Moapa Perdita	*Perdita fulvescens*	2									
Unadorned Perdita	*Perdita inornata*	2									
Mojave poppy bee	*Perdita meconis*	2									
Valley of Fire Perdita	*Perdita nevediana*	2									
Virgin River twilight bee	*Perdita vespertina*	2									
Mojave mountain Perdita	*Perdita vicina*	2									
Desert-loving Perdita	*Perdita xeropila discrepans*	2									
	Atposmia n. sp.	2									
	Hesperapis (Carinapis) n. sp.	2									
	Hesperapis aff. elegantula n. sp.	2									
	Hesperapis aff. kayella n. sp.	2									
	Hoplitis (Proteriades) n. sp.	2									
	Megachile aff. umaitillensis n. sp.	2									
	Osmia aff. giffardi n.sp.	2									
	Perdita (Epimacrotera n.sp.	2									
	Perdita (Glossoperdita) n.sp.	2									
	Perdita (Heteroperdita) n.sp.	2									
	Perdita dicksoni	2									
	Perdita aff. megapyga n.sp.	2									
	Perdita aff. namatophila n.sp. 9	2									

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
	Perdita aff. rhodogastoa n.sp. 7	2									
	Perdita aff. rhodogastoa n.sp. 8	2									
Watch List											
Red-legged lava bee	*Ashmeadiella picticrus sp. nov.*	3									
Flat-faced cactus bee	*Lithurge listrota*	3									
Beck's perdita	*Perdita becki*	3									
Rock nettle perdita	*Perdita eucnides eucnides*	3									
Banded perdita	*Perdita vittata conformis*	3									
Koso phacelia bee	*Protodufourea koso sp. nov.*	3									
Michener's phacelia bee	*Xeroheriades michener*	3									
Other insects											
Covered											
none											
Evaluation											
Spring Mountains ant	*Lasius nevadensis*	2									
Moapa riffle beetle		2									
Moapa skater/waterstrider	*Rhagovellia becki*	2									
Naucorid bug	*Usingerian moapensis*	2									
Crawling water beetle	*Haliplus eremicus*	2									
Moapa riffle beetle	*Microcylloepus moapus moapus*	2									
Amargosa (Pahranagat naucorid	*Pelocoris shoshone shoshone*	2									
Other invertebrates											
Covered											
Spring Mountains springsnail	Pyrgulopsis deaconi	1									
Southeast Nevada springsnail	Pyrgulopsis turbatrix	1									
Evaluation											
Moapa pebble snail	*Pyrgulopsis avernalis*	2									
Moapa turban snail	*Pyrgulopsis carinefera*	2									
Grated tryonia	*Tryonia clathrata*	2									
Undescribed tryonia	*Tryonia sp.*	2									
Dry lake bed species		2									

Common Name	Scientific Name		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
			Limited/Isolated/ Fragmented Habitats								
Watch List											
Corn Creek springsnail	*Pyrgulopsis sp.*	3									
Blue Point springsnail	*Pyrgulopsis sp.*	3									
Undescribed Blue Point tryonia	*Tryonia sp.*	3									
Vascular Plants											
Covered											
Blue Diamond cholla	*Opuntia whipplei var. multigeniculata*	1				1					
Rough angelica	*Angelica scabrida*	1	1	1							
Sticky ringstem	*Anulocaulis leisolenus*	1				1					
Charleston-pussytoes	Antennaria soliceps	1									
Las Vegas bearpoppy	*Arclomecon californica*	1				1					
White bearpoppy	*Arctomecon merriamii*	1									
Rosy King sandwort	*Arenaria kingii ssp. rosea*	1									
Clokey milkvetch	*Astragalus aequalis*	1									
Threecomer milkvetch	*Astragalus geyeri var. triquetrus*	1							1		
Clokey eggvetch	*Astragalus oophorus var. clokeyanus*	1									
Spring Mountain milkvetch	*Astragalus remotus*	1									
Alkali mariposa lily	*Calochortus striatus*	1									
Clokey paintbrush	*Castelleja martinii var. clokeyi*	1									
Clokey thistle	*Cirsium clokeyi*	1	1								
Jaeger whitlowgrass	*Draba jaegeri*	1						1			
Charleston draba	*Draba paucifructa*	1						1			
Inch high flebane	*Erigeron uncialis ssp. conjugans*	1									
Forked buckwheat	*Eriogonum bifurcatum*	1			1		1				
Sticky buckwheat	*Eriogonum viscidulum*	1			1					1	
Clokey greasebush	*Glossopetalon clokeyi*	1									
Pahrump Valley buckwheat											
Smooth pungent greasebush	*Glossopetalon pungens var. glabra*	1									
Pungent dwarf greasebush	*Glossopelalon pungens var. pungens*	1									
Red Rock Canyon aster	*lonactis caelestis*	1							1		

			Limited/Isolated/ Fragmented Habitats								
Common Name	**Scientific Name**		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
Hidden ivesia	*Ivesia cryptocaulis*	1						1			
Jaegar ivesia	*Ivesia jaegeri*	1							1		
Hitchcock bladderpod	*Lesquerella hitchcockii*	1						1			
Charleston pinewood lousewort	*Pedicularis semibarbata var. charlestonensis*	1									
White-margined beardtongue	*Penstemon albomarginatus*	1									
Charleston beardtongue	*Penstemon thompsoneae var. keckii*	1									
Jaegar beartongue	*Penstemon thompsoneae var. jaegeri*	1									
Parish's phacclia	*Phacelia parishii*	1								1	
Clokey mountain sage	*Salvia dorrii var. clokeyi*	1									
Clokey catchfly	*Silene clokeyi*	1						1			
Charleston tansy	*Sphaeromeria compacta*	1						1	1		
Charleston kittentails	*Synthyris ranunculina*	1	1					1			
Charleston grounddaisy	*Tounsendia jonesii var. tumulosa*	1							1		
Limestone violet	*Viola purpurea var. charlestonensis*	1									
Evaluation											
Black wooly-pod	*Astragalus funereus*	2									
Triangle lobe moonwort	*Botrychium ascendens*	2									
Dainty moonwort	*Botrychium crenulatum*	2									
Silverleaf sunray	*Enceliopsis argophylla*	2									
Nevada willowherb	*Epilobium nevadense*	2									
Las Vegas Valley buckwheat	*Eriogonum corymbosum var. aureum*	2									
Yellow twotone beardtongue	*Penstemon bicolor ssp. Bicolor*	2									
Curve-podded Mojave (halfring) milkvetch	*Astragalus mojavensis var. hemigryus*	2									
Meadow Valley sandwort	*Arenaria stenomeres*	2									
Ackerman milkvetch	*Astragalus ackermanii*	2									
Sheep Mountain milkvetch	*Astragalus amphioxys var. musimonum*	2									
Mokiak milkvetch	*Astragalus mokiacensis*	2									
Remote rabbitbrush	*Chrysothamnus eremobius*	2									
Unusual catseye	*Cryptantha insolita*	2									
Ripley's biscuitroot	*Cymopterus ripleyi var. saniculoides*	2									

Common Name	Scientific Name		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
			Limited/Isolated/ Fragmented Habitats								
Sheep fleabane	*Erigeron ovinus*	2									
Desert (Clark) parsley	*Lomatium graveolens var. clarkii*	2									
Pygmy poreleaf	*Porophyllum pygmaeum*	2									
Virgin River thistle	*Circium virginense*	2									
Clokey buckwheat	*Eriogonum heermannii var. clokeyi*	2									
Amargosa beardtongue	*Penstemon fruticiformis ssp. Amargosae*	2									
Watch List											
One-leaflet Torrey milkvetch	*Astragalus calycosus var. monophyllidius*	3									
Clokey pincushion	*Coryphantha vivipara ssp. Rosea*	3									
Hoffman's cryptantha	*Cryptantha hoffmannii (=C. virginesis)*	3									
New York Mountains catseye	*Cryptantha tumulosa*	3									
Chalk liveforever	*Dudleya pulverulenta*	3									
Clokey fleabane	*Erigeron clokeyi*	3									
Barrel cactus	*Ferocactus acanthoides vcar. Lecontei*	3									
Nevada greasebush	*Glossopetalon nevadensis*	3									
Beaver Dam scurfpea (breadroot)	*Pediomelum castoreum*	3									
Rosy twotone beardtongue	*Penstemon bicolor ssp. Roseus*	3									
Utah spikemoss	*Selaginella utahensis*	3									
Non Vascular Plants											
Covered											
Anacolia menziesil	*Anacolia menziesii*	1									
Claopodium whippleanum	*Claopodium whippleanum*	1									
Syntrichia princeps	*Dicranoweisia crsipula*	1									
Dicranoweisia crispula	*Syntrichia princeps*	1									
Evaluation											
Pseudocrossidium moss	*Pseudocrossidium crinitum*	2									
Undescribed targionia liverwort	*Targionia sp. nov.*	2									
Nevada didymodon	*Didymondon nevadensis*	2									
Crossidium moss	*Crossidium seriatum*	2									
American grimmia	*Grimmia americana*	2									

Common Name	Scientific Name		Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist
			Limited/Isolated/ Fragmented Habitats								
Trichostomum moss	*Trichostomum sweetii*	2									
	Distichium inclinatum	2									
Undescribed syntrichia moss	*Syntrichia spp.*	2									
Watch List											
	Fissidens sublimbatus	3									
	Splachnobryum obtusum	3									
	Totals	=	11	19	3	6	18	7	7	2	0

Summary of Hot Spot Analyses

Vegetation										
Alpine	Bristlecone	Mix Conifer	P-J	Sagebrush	Blk Brush	Salt Desert	Mojave Des	Mesquite/Cat	Riparian	total
11	23	33	36	25	18	21	31	20	27	245
4.49%	9.39%	13.47%	14.69%	10.20%	7.35%	8.57%	12.65%	8.16%	11.02%	

Geographic Aggregates							
Flanks Springs	I-15 Corridor	Mtns w/ Conifers	N & E CC	Piute/Eldor	U L. Mead Upland	Riverine	total
34	19	60	18	23	21	32	207
16.43%	9.18%	28.99%	8.70%	11.11%	10.14%	15.46%	

Limited/Isolated/Fragmented Habitats									
Springs	Riparian	Dunes	Gypsum	Mesquite/Catclaw	Alpine	Rock outcrop	Playas	Specialist	total
11	19	3	6	18	7	7	2	0	73
15%	26%	4%	8%	25%	10%	10%	3%	0%	

Species to be considered for coverage

We have been studying species to prescribe adaptive management allowing more species to be covered in the MSHCP. The first of these is the Gila Monster. Below is a preliminary report.

ECOLOGY AND NATURAL HISTORY OF THE GILA MONSTER IN NEVADA: PRELIMINARY REPORT

Introduction

The Gila monster (*Heloderma suspectum*) is a conspicuous, but infrequently encountered species distributed across the hot deserts of the American southwest. It's infrequent activity and low population densities make intensive field study difficult, and information regarding this species is limited. In Nevada, it is in fact only known from twelve museum records and 65 field observations.

In order to better understand the ecology of Gila monsters in Nevada and address the conservation needs of the species we undertook an intensive study and survey of Gila monsters near Overton Nevada. Museum records indicate that this area was one where the species was historically found. We used radio telemetry to monitor activity and habitat use of ten individuals.

To determine patterns of geographic variation in this species we also gathered over 1000 collection records from 35 museums and natural history collections and compare them to field data from our field study and previously published reports from Utah, Arizona, and New Mexico. We also used the records to develop a landscape level predictive model of suitable Gila monster habitat in Clark and Lincoln Counties.

Methods

We collected and surgically implanted radio transmitters into ten individuals in April and May 2001. Mass and size (snout to vent length) were recorded and lizards were returned to the field within 48 hours of surgery and monitored with radio telemetry daily to weekly thereafter. Refuge shelters and underground burrows used by each lizard were marked and home ranges were calculated from the different shelter sites using the convex polygon method (Jennrich and Turner 1969). Activity patterns were determined from direct visual observations of surface activity and from indirect observations of lizards changing refuge sites between tracking days.

We also developed a model of potential habitat for Gila monsters in southern Nevada. We used Weights of Evidence Modeling in Arcview GIS to predict possible habitat from existing museum and agency records. We used surface geology and elevation as predictor variables, and the model was created by weighting the variables to maximize the communality between observations (Bonham-Carter 1994).

Results

Gila monsters captured during field survey averaged 286.4 mm in snout to vent length (range 210-324 mm) and 351.3 g in mass (range 150-501 g). This is significantly smaller than lizards captured during previous field studies in Utah, Arizona, and New Mexico (Figure 1).

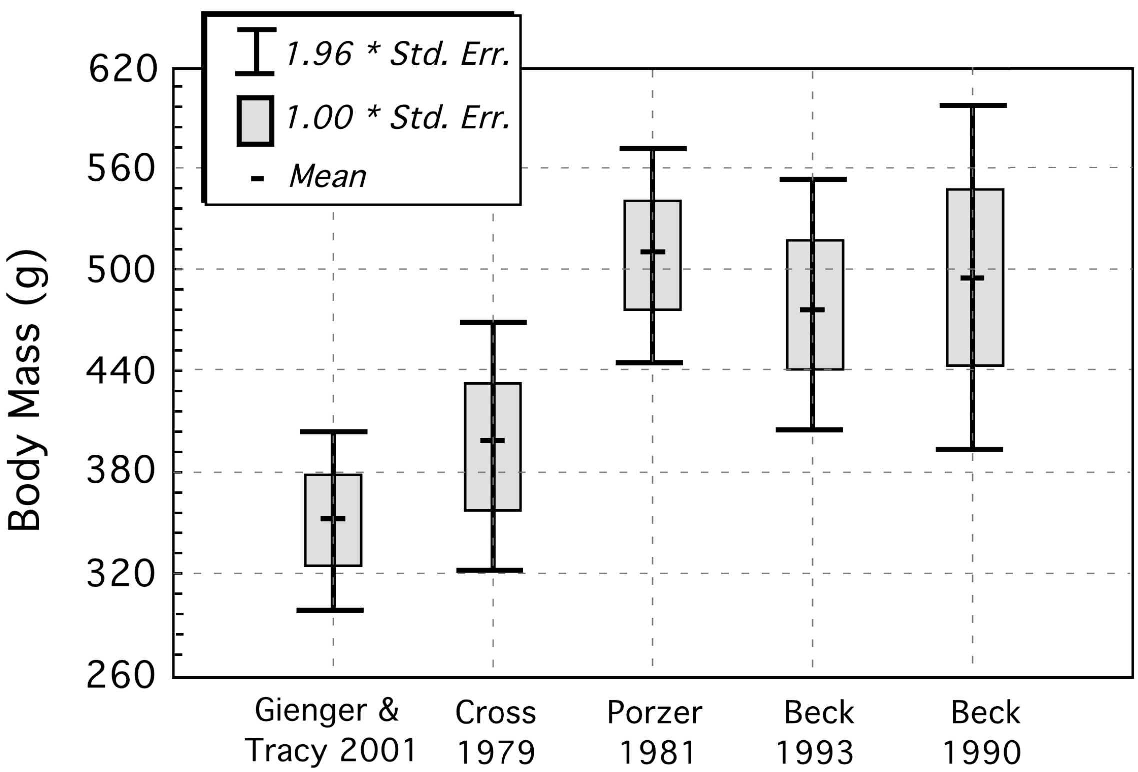


Fig. 1. Distribution of body size (mass) of Gila monsters across their geographic range in the U.S. Data were taken from published studies (Cross, Porzer, and Beck) and current field work by Gienger and Tracy. ANCOVA (site-fixed; snout to vent length covariate) $F_{(4, 60)} = 3.196$, $P = 0.019$.

Nevada Gila monsters overall have less mass per unit of length than other populations, indicating that they may perhaps be more vulnerable to dry years and food scarcity than other populations because they have lower fat reserves.

Surface activity for radio tracked lizards peaked in June with approximately 50 percent of all yearly activity occurring between April and June (Figure 2). This matches closely with previous field observations from Utah, Arizona, and New Mexico (Lardner 1969, Beck 1990, Beck and Jennings 2001) as well as data from museum collections.

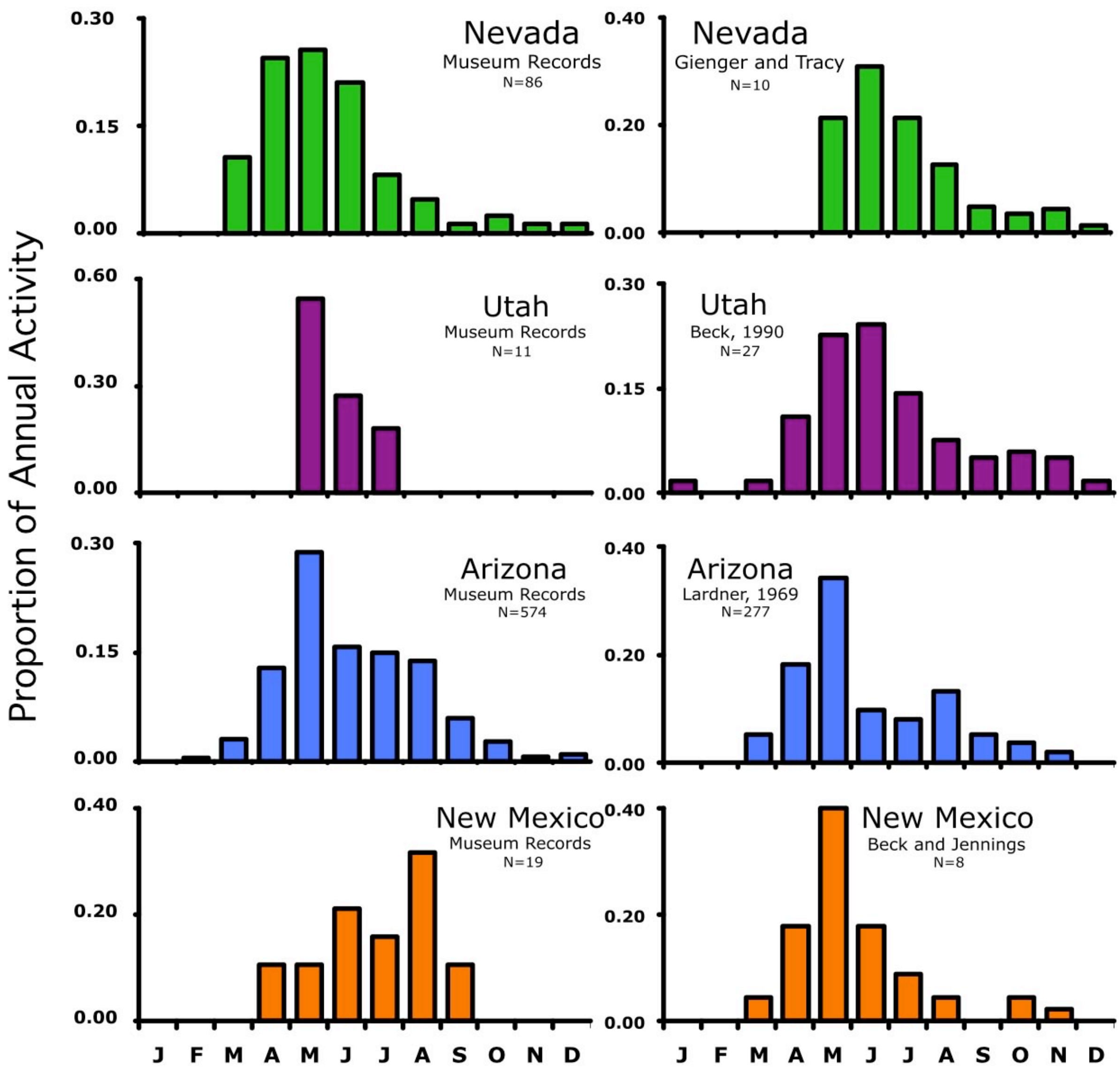


Fig. 2. Distribution of annual activity of Gila monsters across their geographic range in the U.S. Data were collected from over 40 natural history museums, published studies and ongoing field work.

Home ranges averaged 30.4 ha and ranged from 5.7 to 70.5 ha (Figures 3 and 4). This as well is similar to other studies (Porzer 1981, Beck 1990, Beck 1993), but interpretation is difficult due to the small number of individuals other workers have used to calculate home ranges.

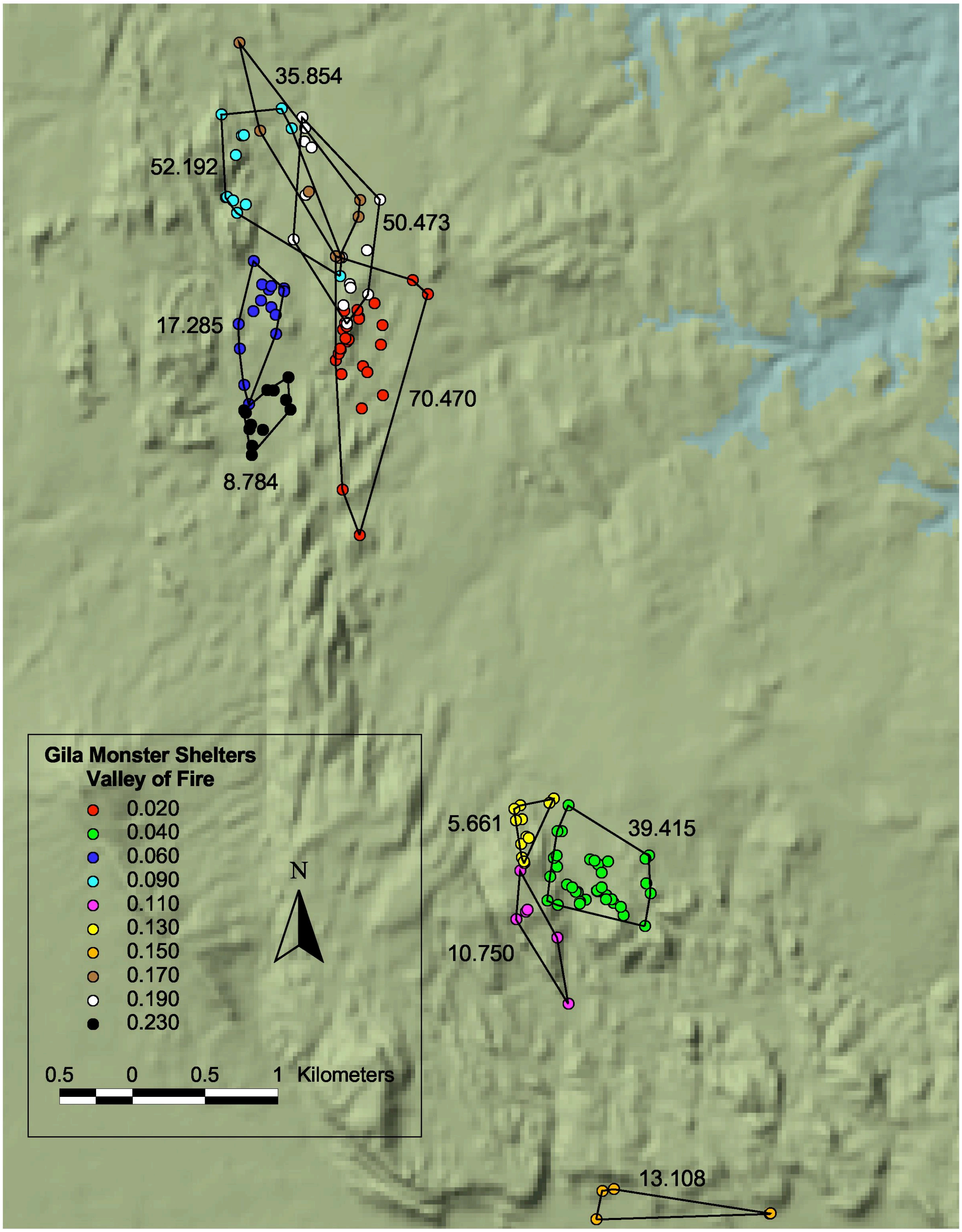


Fig. 3. Home ranges of 10 Gila monsters (coded by color) currently under study in southern Nevada. Numbers outside each polygon indicate home range area in hectares.

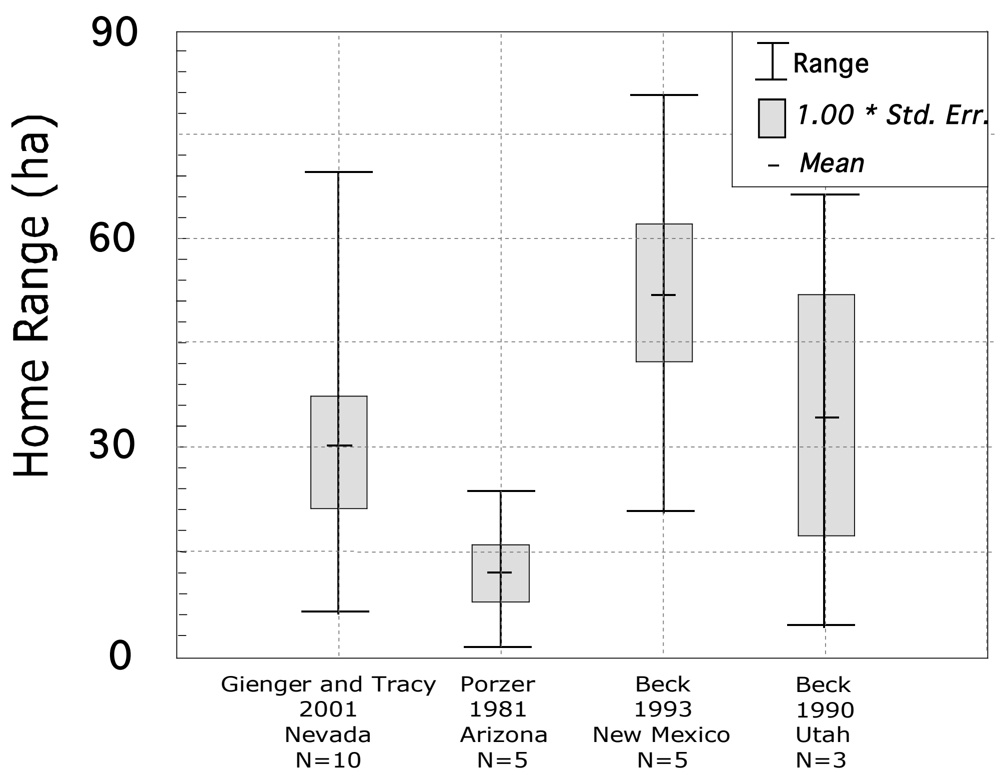


Fig. 4. Distribution of Gila monster home ranges across their geographic range in the U.S. Data were taken from published studies (Porzer and Beck) and current field work by Gienger and Tracy. ANOVA $F_{(3, 19)} = 2.96$, $P > 0.05$

Our habitat model (Figure 5) indicates that suitable habitat for this species may be limited but definable. The model predicts that areas of relative high structural (geologic) complexity and low elevation (e.g. areas adjacent to Lake Mead and Meadow Valley Wash system) may be most suitable for the species in southern Nevada. Although the model may be an over simplification, it may become an important tool for use in survey and evaluating potential habitat. However, field testing is needed to confirm it's utility as a conservation and management tool.

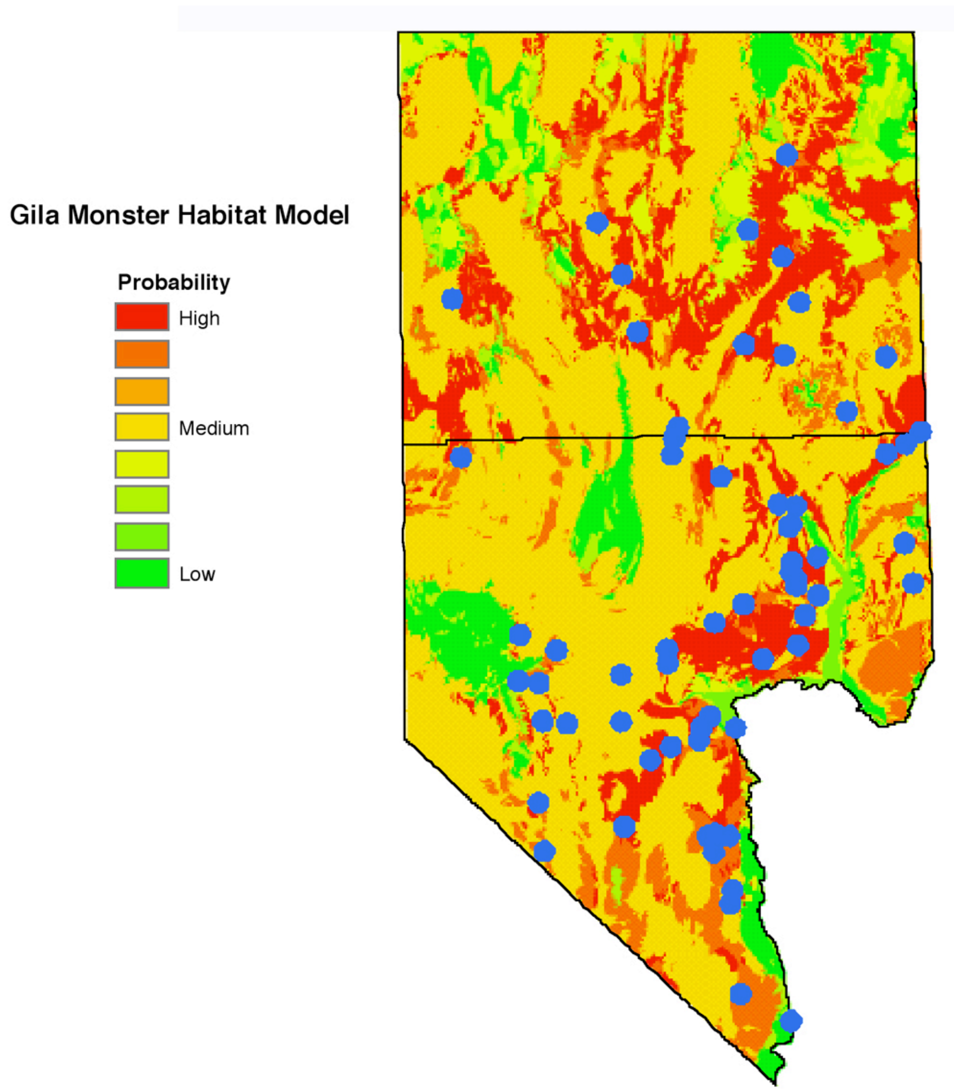


Fig. 5. Predictive habitat model for Gila monsters in Clark and lower Lincoln counties. The model was developed using elevation and structural geology to predict suitable habitat from existing museum and agency records (blue dots) using Weights of Evidence modeling in Arcview GIS.

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Evaluation of Means to Enhance Cost-effectiveness in Existing Species and Habitat Management Actions (Muddy River Demonstration Project)

Proposed activities along the Muddy River initially focused on a disturbing trend toward hybridization between two closely related species of toads, one that exhibits a narrow geographic distribution and one that has expanded rapidly into the locations occupied by the first species. However, upon initiation of data collection it became clear that a much more pressing ecosystem-wide phenomenon and management response present a direct challenge to the Clark County HCP. In substantial portions of the riparian corridor along the Muddy River, the invasion of non-native salt-cedar has replaced virtually all native vegetation. Furthermore, intensive efforts to eradicate the salt-cedar result, at least in the short term, in a vegetation community heavily dominated by native, but weedy, saltbush. With encouragement from the County, USFWS, and The Nature Conservancy, UNR scientists undertook an intensive analysis of the effects of salt-cedar invasion and eradication on the Muddy River ecosystem.

Both salt-cedar and saltbush tend to exclude other native riparian vegetation. It has been assumed that the myriad animal species native to the Muddy River ecosystem, including a number of species of concern to conservation planners, likewise are excluded by salt-cedar and saltbush. As discussed below, although full analysis of the currently accruing data set awaits completion of ineventories in early April 2002, clear patterns are emerging. In near-monocultures of salt-cedar and saltbush, native plant and animal diversity does indeed diminish. But even in areas dominated by invasive, weedy species (either native or non-native) both before and after eradication efforts, residual native plant diversity appears to sustain high animal diversity. This and related findings should have great value to planners strategizing future weed eradication and riparian restoration efforts, as well as land acquistion schemes.

Field Methods

Butterflies. We established 85 sampling locations for butterflies. All were delineated with differentially corrected global positioning systems. The sites collectively spanned the existing gradient of vegetation associations and human disturbance in the Muddy River drainage, ranging from native cottonwood (*Populus fremontii*), willow (*Salix* spp.), and mesquite (*Prosopis* spp.) to near-monocultures of non-native salt-cedar (*Tamarix* spp.). Butterfly sampling was initiated in April 2000. Site visits were conducted twice per month. Sampling was conducted when weather conditions were most conducive to flight (e.g. mostly sunny skies, light winds, warm temperatures). During each site visit, one observer identified and recorded all butterflies seen within 10 minutes in a 10 m radius from the center of the site. Butterfly species believed to complete their entire life in the study area were categorized as residents. Species whose larval hostplants grow largely or exclusively in mesic areas—including riparian corridors, permanently wet meadows, and seasonal wetlands—were defined as riparian obligates. Riparian obligacy refers to the populations found in the Muddy River drainage only; in other locations, populations of these species may be less dependent on mesic areas.

Birds. We established 33 sampling locations for birds. All were delineated with differentially corrected global positioning systems. Each of the bird sampling locations circumscribed from one to six of the butterfly sampling locations; 69 of the 85 butterfly sampling locations were included within an individual bird sampling location. Bird sites were grouped into four distinct clusters—California Wash, Dairy Ditch, Lewis Ranch, and Warm Springs—on the basis of geographic location. The California Wash cluster included 4 sites, Dairy Ditch included 16 sites, Warm Springs included 8 sites, and Lewis Ranch included 5 sites. Although vegetation structure and composition were somewhat heterogeneous within each cluster, broad qualitative differences among clusters could be distinguished. Much of California Wash had a higher water table, and riparian areas were dominated by salt-cedar. Current human activity in the vicinity was minimal. Dairy Ditch had some mesquite, with a narrow linear corridor of salt-cedar along much of the Muddy River, but otherwise was fairly open and dominated by halophytic plants such as *Atriplex* spp. and, to a lesser extent, *Distichlis* spp. Lewis Ranch included lush, wide stands of salt-cedar interspersed with coyote willow (*Salix exigua*) along the Muddy River, large stands of *Phragmites* spp. and *Atriplex* spp., and some agricultural activity. Warm Springs had the greatest diversity of vegetation types, including mesquite, cottonwood stands of varying density, and areas dominated by grasses and forbs. Portions of Warm Springs were grazed by livestock in previous years but not during our study period.

Birds were sampled using one or two fixed-radius point counts per sample day in each site. At Warm Springs, the points had a radius of ~125 m. The radius of all other points was ~100 m. Each site was visited ≥ 7 times between 2 May and 29 June 2001. During each visit, we recorded all birds seen or heard during 30 minutes in each point. Bird species were categorized as either locally breeding (including both year-round residents and migratory species) or non-breeding and as either riparian obligates (species that rely upon riparian areas for at least some of their critical resources, such as food or nesting sites) or non-obligates.

Vegetation. Although the general resource requirements of birds and butterflies in the Mojave Desert overlap (e.g., both groups exploit riparian areas for food and shelter), some of their specific needs differ. For instance, species richness of birds frequently corresponds to vegetation structure, while species richness of butterflies and occurrence patterns of both taxonomic groups may be more closely associated with vegetation composition. In order to collect information most relevant for interpreting distribution patterns of each taxonomic group, we used different vegetation sampling methods in the butterfly sites and in the bird sites.

In each butterfly site, we established from one to four line transects. The number of transects corresponded to the apparent heterogeneity of vegetation structure and composition in the site as perceived by an experienced observer. Each transect extended 10 m from the center of the site. The compass orientations of the transects were selected at random. We measured percent cover of all species of plants (shrubs, trees, grasses, and forbs) and of bare ground that intercepted each transect. All plant species were categorized as native or non-native to the Muddy River drainage.

At three randomly selected points in each bird site, we extended a 20-foot pole vertically through the vegetation. We recorded the species identity of all vegetation contacts in each 1-foot interval (Rottenbery 1985, Mills et al. 1991). Species identification focused on shrubs and trees; although some grasses and forbs were recorded, there was less focus on these groups in the bird sites than in the butterfly sites.

Analyses

Butterflies. Measures of butterfly diversity, especially in desert and riparian ecosystems, can be significantly affected by seasonal and annual variation in weather conditions such as precipitation patterns (e.g., Fleishman et al. 1999). Drought or good rainfall conditions may differentially impact vegetational and butterfly communities in areas that support high weed and low weed conditions, therefore confounding spatial effects. We plan to complete two full years of sampling in early April, 2002, before conducting detailed analyses to test whether vegetation diversity and composition have significant effects on butterfly distributions. However, as an initial step, we have compiled summary statistics on butterfly assemblages in the Muddy River drainage after our first 18 months of sampling (April 2000—October 2001). These summary data include information on species richness (number of species per site), abundance (number of individuals per site), and evenness (the extent to which individuals in each site are equally partitioned among species; Magurran 1988, Hayek and Buzas 1997). To quantify evenness, we used the diversity index E (Hayek and Buzas 1997). E is calculated as $E = e^H/S$. $H = -Sp_i ln(p_i)$, where p_i = the proportion of individuals found in the ith species, and S = the number of species in the site (Magurran 1988, Hayek and Buzas 1997). E ranges from 0 to 1, approaching 1 when individuals are partitioned equally among species.

We used analysis of variance to test whether species richness, abundance, or evenness of butterflies was a significant ($P < 0.05$) linear function of species richness of plants, percent native plants (i.e., number of native plant species divided by the total number of plant species), percent cover of native plants, or evenness of plants (all species, native species, or non-native species).

The following tests are among the suite of analyses we will perform after two years of sampling have been completed. We test whether dominant vegetation type, plant species richness, plant species evenness, relative proportion of native and non-native plant species, presence of salt-cedar, or year affects species richness, total abundance, and the abundance of individual butterfly species. We also will test whether the latter measures of vegetation or year affect species evenness of butterflies.

Further, we will test whether differences in vegetation and year affect butterfly species composition of our study sites. We will calculate dissimilarity of species composition between pairs of sites using Bray-Curtis distances. We will use non-parametric multivariate analysis of variance (NPMANOVA, Anderson 2001, McArdle and Anderson 2001) to test whether community dissimilarity differs among sites with different vegetation characteristics and among years.

Birds. Initially, we were most interested in testing whether there were differences in bird communities among site clusters that potentially could be related to broad differences in vegetation structure and composition. Because sampling effort (number of visits per site) was not equal among clusters ($F_{3,32} = 205.19$, $P < 0.001$), we used analysis of covariance to test whether species richness (mean number of bird species per site) differed significantly among clusters if sampling effort was kept constant. We used analysis of variance to test whether abundance (mean number of individual birds per site per visit) and species evenness differed significantly among clusters. When there was a significant experimentwise effect, we used Tukey-Kramer HSD tests (a = 0.05) to compare all pairs of clusters.

We used analysis of variance to test whether breeding bird community similarity of sites within clusters varied by cluster. We measured similarity within each cluster with the Jaccard index, $C_J = j/(a+b-j)$, where j is the number of species found in all sites and a and b are the number of species in sites A and B, respectively. C_J approaches 1.0 when species composition is identical among sites and 0.0 when sites have no species in common (Magurran 1988).

Based on the results of these initial analyses, we plan to conduct a more detailed evaluation of how vegetation structure and composition affect distribution patterns of birds in the Muddy River drainage. These analyses are described more fully in the next section.

Vegetation. While all of the vegetation data in our butterfly sites have been collected, we plan to complete two full years of sampling before conducting detailed analyses to test whether vegetation diversity and composition have significant effects on butterfly distributions. To date, therefore, our analyses of vegetation in the butterfly sites have been restricted to summary statistics.

To obtain a relative estimate of percent cover of each species in the site, we divided the area covered by each species by the total area sampled in the site. We calculated species richness and evenness of all plants, native plants, and non-native plants in each butterfly site. Evenness was calculated as the extent to which percent cover in each site was equally partitioned among species.

For the bird sites, we have calculated a suite of variables related to vegetation; we plan to test whether these variables explain significant explain significant variation in species richness, abundance, and evenness both within and among clusters. To date, we have estimated species richness of plants in each site, compiled summary information on community similarity of pairs of sites in each cluster, and estimated the total vegetation volume (TVV, Mills et al. 1991) of each site. We calculated TVV as h/10p, where h = the total number of 'hits' (intervals that contained vegetation) and p = the number of points at which vegetation volumes were measured (21 in this case). We estimated TVV for each site as the mean TVV of the three sampling points.

Researchers in some studies of bird communities studies have calculated foliage height diversity (FHD, MacArthur and MacArthur 1961). Foliage height diversity essentially is a measure of evenness—the extent to which foliage (or, more broadly, vegetation) at each sampling point is equally partitioned among sampling intervals. We calculated this metric but chose not to use it for further analysis because in our study system, it was identical to TVV in all but 4 sites (5 sampling points).

RESULTS

Butterflies. During the first 18 months of our butterfly surveys, we recorded a total of 48 species of butterflies from our 85 study sites (Table 1). Twenty species are believed to be resident (complete their entire life cycle in the study area). Of the resident species, four were categorized as riparian obligates (i.e., probably could not maintain viable populations in the absence of a functional riparian area) (see Table 1). We recorded a total of 17,347 individual butterflies. Summary data values for species richness, abundance, and evenness are presented in Table 2. The number of sites in which individual species were present varied widely, from 1 to 85 (25.8 ± 26.1, mean ± SD). Abundances of individual species spanned three orders of magnitude, from 1 to 5657 (361.4 ± 1023.8, mean ± SD).

Our preliminary analysis (again, note, without analysis of temporal variation) indicates that species richness of butterflies (both all species and residents) increased significantly as species richness of plants increased (Table 3). Species richness of butterflies decreased as evenness of plants (both all species and natives) increased (Table 3).

Abundance of butterflies (all species and residents) increased as species richness of plants increased. Abundance of resident butterflies also increased as percent cover of native plants increased. Abundance of butterflies (all species and residents) decreased as evenness of plants (all species and natives) increased. Abundance of butterflies (all species) also decreased as percent of native plants increased.

Evenness of butterflies (all species) increased as percent cover of native plants increased. None of the variables we tested was a significant predictor of evenness of resident butterflies.

Birds. We recorded a total of 125 species of birds from our 33 study sites (Table 4). Seventy-six of the species are believed to breed in the Muddy River drainage. Of the breeding species, 33 were categorized as riparian obligates (i.e., probably could not maintain viable populations in the absence of a functional riparian area) (see Table 4). Thirty-one species (13 breeding, 6 of which were riparian obligates) were restricted to Warm Springs, 11 species (6 breeding, 3 riparian obligate) were recorded from California Wash only, and 8 species (2 breeding) were restricted to Dairy Ditch. No species were recorded only from Lewis Ranch.

All eight species of birds recognized by the Clark County Multiple Species Habitat Conservation Plan were recorded during our surveys: Peregrine Falcon (*Falco peregrinus*), Yellow-billed Cuckoo (*Coccyzus americanus*), Willow Flycatcher (*Empidonax trailii*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Bell's Vireo (*Vireo bellii*), Phainopepla (*Phainopepla nitens*), Blue Grosbeak (*Guiraca caerulea*), and Summer Tanager (*Piranga rubra*).

We also recorded several additional species of particular interest. For example, we documented breeding by species that are typically found at low densities in the region, such as Anna's Hummingbird (*Calypte anna*), Brown-crested Flycatcher (*Myiarchus tyrannulus*), Cassin's Kingbird (*Tyrannus vociferans*), and Hooded Oriole (*Icterus cucullatus*). In addition, we documented the occurrence of a number of species rarely found in the region, including Green Heron (*Ardea herodia*), Missisipi Kite (*Ictinia mississippiensis*), Red-eyed Vireo (*Vireo olivaceus*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*), and Indigo Bunting (*Passerina cyanea*).

Summary data values (means and standard errors) are presented in Table 5; experimentwise F-statistics and significance values are presented in Table 6. Cluster had a significant effect on species richness when sampling effort was kept constant. Clusters decreased in species richness from Warm Springs to California Wash, Dairy Ditch, and Lewis Ranch.

We recorded a total of 3627 birds. Abundance differed significantly among clusters, but evenness did not differ among clusters. Mean community similarity at the site level was significantly different among clusters ($F_{3,163} = 37.71$, $P < 0.001$). Mean community similarity was significantly greater within Warm Springs than within California Wash or Dairy Ditch, and Lewis Ranch had greater community similarity than Dairy Ditch.

Vegetation. We recorded a total of 53 species of plants (32 native) from the butterfly sites. Summary data values for species richness and evenness are presented in Table 7. Individual plant species were present in 1 to 59 sites (8.3 ± 11.5, mean ± SD).

We recorded a total of 27 species of plants from the bird sites. Individual species were present in 1 to 13 sites (2.9 ± 2.9, mean ± SD). Species richness of each site ranged from 0 (i.e., no live vegetation was present) to 6 (2.4 ± 1.2, mean ± SD). Total vegetation volume of each site ranged from 0 to 0.270 (0.091 ± 0.063, mean ± SD).

Mean plant community similarity of pairs of sites within each cluster ranged from 0.093 (Dairy Ditch) to California Wash (0.289). Mean community similarity of sites within the Lewis Ranch and Warm Springs clusters was 0.207 and 0.224, respectively. The difference in community similarity among clusters was statistically significant ($F_{3,163} = 6.93$, $P < 0.001$). Community similarity of sites within California Wash and Warm Springs was significantly greater than within Dairy Ditch. We may conclude at this point that areas dominated by invasive, weedy species of plants, whether native or non-native, have lower diversity of native birds than areas with more heterogeneous vegetation.

NOTES ON PRELIMINARY ANALYSES

We are continuing to collect data that will allow us to discriminate between the effects of vegetational diversity and temporal variation on butterfly diversity, especially with respect to invasion of weedy plant species and actions to control those invasions. Until we are able to test whether temporal variation in butterfly distributions affects the response of butterflies to various measures of vegetational diversity, the above results should be regarded strictly as preliminary. An additional confounding factor that will be incorporated into future analyses is land management. A subset of our butterfly study sites recently have been subjected to either removal of salt-cedar or cattle grazing. In some cases, the abundance and dominance of non-native plant species increased markedly after cessation of grazing.

Note that many of the R^2 values associated with the preliminary butterfly results above are fairly low (e.g., < 0.15)—although our results were statistically significant, the predictor variables often explained relatively little of the deviance in the dependent variables; therefore, the ecological significance of the preliminary results may be viewed as equivocal. We suspect that variation in precipitation during the first 23 months of the study will explain a considerable proportion of the deviance in species richness, abundance, and evenness of butterflies.

Measures of vegetational diversity that appear to have a desirable effect on butterfly diversity include (1) increasing species richness of plants, which is positively associated with species richness and abundance of butterflies, including resident butterflies, and (2) increasing percent cover of native plants, which is positively associated with species richness of resident butterflies. But, surprisingly, measures of butterfly diversity appeared to be negatively correlated with percent cover of native plants and evenness of all species of plants or native plants.

Again, we note a very low R^2 associated with the latter unexpected results. Abundance of all species of butterflies, but not of resident butterflies, decreased as percent of native plants increased. It is possible that a few sites with low percentages of native plants had high abundance of migratory butterflies. The result largely may be coincidental; concentrations of migratory species often have a stochastic component that cannot be explained by (i.e., be caused by) local species composition of plants. Furthermore, it is possible that sites with greater evenness of plants, especially native plants, have greater structural complexity than sites in which relatively few species of plants account for the majority of the percent cover. Butterfly diversity often is greatest in early-successional sites. Over time, the presence of an overstory created by many trees and/or shrubs may render local conditions less suitable for the forbs and grasses that butterflies use as larval hostplants or adult nectar sources. Potential effects of plant growth form represent a new hypothesis that will be tested in subsequent analyses.

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Table 1. Residency status and riparian obligacy of butterfly species present in the Muddy River drainage, April 2000—October 2001. Species whose larval hostplants grow largely or exclusively in mesic areas were defined as riparian obligates. Nomenclature follows Austin (1998).

species	**resident**	**riparian obligate**
Erynnis funeralis		
Pyrgus scriptura		
Pyrgus albescens/communis	x (*albescens*)	
Heliopetes ericetorum		
Hesperopsis libya	x	
Hesperopsis gracielae	x	
Copaeodes aurantiaca	x	
Hylephila phyleus	x	
Atalopedes campestris	x	
Polites sabuleti	x	x
Ochlodes yuma	x	x
Lerodea eufala	x	
Battus philenor		
Papilio polyxenes		
Pontia beckerii		
Pontia protodice		
Pieris rapae		
Colias eurytheme		
Zerene cesonia		
Phoebis sennae		
Eurema nicippe		
Nathalis iole		
Lycaena helloides	x	
Atlides halesus	x	
Ministrymon leda	x	
Strymon melinus		
Leptotes marina	x	
Brephidium exilis	x	
Everes amyntula		
Lycaeides melissa	x	
Icaricia texana	x	
Hemiargus ceraunus	x	
Hemiargus isola	x	
Calephelis nemesis	x	x
Apodemia mormo		
Apodemia palmerii	x	
Libytheana carinenta		
Euptoieta claudia		
Chlosyne lacinia		
Chlosyne acastus neumoegeni		
Nymphalis californica		
Nymphalis antiopa	x	
Aglias milberti		
Vanessa virginiensis		
Vanessa cardui		
Vanessa annabella		
Vanessa atalanta		
Junonia coenia		

Limenitis archippus	x	x
Danaus plexippus		
Danaus gilippus		

Table 2. Summary data values for diversity of butterflies in 85 study sites in the Muddy River drainage, April 2000—October 2001.

	minimum	maximum	mean	standard deviation
Species richness per site				
all species	6	26	14.5	4.6
resident species	2	13	7.4	2.8
Abundance per site				
all species	31	460	204.1	84.7
resident species	4	300	88.9	56.3
Evenness per site				
all species	0.207	0.727	0.428	0.094
resident species	0.267	0.990	0.578	0.152

Table 3. Effect of measures of plant diversity on measures of butterfly diversity. *E*, evenness. *, P < 0.05; **, P < 0.01; ***, P < 0.001.

	Butterfly diversity			
	species richness, all species		species richness, residents	
Plant diversity	R2	F	R2	F
species richness	0.26	28.46 ***	0.23	25.49 ***
E, all species	0.14	13.23 ***	0.11	10.30 **
E, natives	0.13	12.07 ***	0.13	12.33 ***
	abundance, all species		abundance, residents	
	R2	F	R2	F
species richness	0.14	13.34 ***	0.10	9.09 **
% native species	0.07	6.03 *		
% cover, natives			0.05	4.62 *
E, all species	0.10	9.33 **	0.09	7.83 **
E, natives	0.08	6.86 **	0.14	13.66 ***
	evenness, all species			
	R2	F		
% native species	0.09	8.02 **		

Table 4. Life history status and presence of bird species in the Muddy River watershed in 2001. B, breeding; R, riparian obligate; CW, California Wash; DD, Dairy Ditch; LR, Lewis Ranch; WS, Warm Springs. Nomenclature follows AOU (1998).

species	B	R	CW	DD	LR	WS
Double-crested Cormorant	x		x	x		
Phalacrocorax auritus						
Great Blue Heron			x	x		x
Ardea herodias						
Green Heron			x	x	x	
Butorides virescens						
Black-crowned Night-Heron	x	x	x	x	x	
Nycticorax nycticorax						
White-faced Ibis			x	x		x
Plegadis chihi						
Turkey Vulture	x		x	x		x
Cathartes aura						
Canada Goose				x		
Branta canadensis						
Mallard	x		x	x	x	x
Anas platyrhynchos						
Cinnamon Teal	x		x			
Anas cyanoptera						
Osprey						x
Pandion haliaetus						
Mississippi Kite						x
Ictinia mississippiensis						
Northern Harrier			x			x
Circus cyaneus						
Accipiter sp.	x					x
Sharp-shinned Hawk			x	x		x
Accipiter striatus						
Swainson's Hawk						x
Buteo swainsoni						
Red-tailed Hawk	x		x	x		x
Buteo jamaicensis						
American Kestrel	x		x	x		x
Falco sparverius						
Peregrine Falcon			x			
Falco peregrinus						
Ring-necked Pheasant	x	x	x	x		x
Phasianus colchicus						
Wild Turkey	x				x	x
Meleagris gallopavo						
Gambel's Quail	x	x	x	x	x	x
Callipepla gambelii						
Sora	x					x

Porzana carolina						
American Coot	x			x		
Fulica americana						
Killdeer	x		x	x	x	x
Charadrius vociferus						
Black-necked Stilt			x	x		
Himantopus mexicanus						
American Avocet			x			
Recurvirostra americana						
Greater Yellowlegs				x		
Tringa melanoleuca						
Spotted Sandpiper	x			x		
Actitis macularia						
Marbled Godwit			x			
Limosa fedoa						
Ring-billed Gull			x			
Larus delawarensis						
Rock Dove	x		x	x	x	
Columba livia						
White-winged Dove				x		x
Zenaida asiatica						
Mourning Dove	x		x	x	x	x
Zenaida macroura						
Yellow-billed Cuckoo	x	x	x		x	x
Coccyzus americanus						
Greater Roadrunner	x		x	x	x	
Geococcyx californianus						
Barn Owl	x	x	x			
Tyto alba						
Great Horned Owl	x					x
Bubo virginianus						
Lesser Nighthawk	x			x	x	x
Chordeiles acutipennis						
White-throated Swift	x		x	x	x	x
Aeronautes saxatalis						
Black-chinned Hummingbird	x			x		x
Archilochus alexandri						
Anna's Hummingbird	x	x	x	x		
Calypte anna						
Belted Kingfisher	x	x	x	x		
Ceryle alcyon						
Lewis's Woodpecker						x
Melanerpes lewis						
Ladder-backed Woodpecker	x	x				x
Picoides scalaris						
Olive-sided Flycatcher				x		x
Contopus cooperi						
Western Wood-Pewee			x	x		x

Contopus sordidulus						
Empidonax sp.						x
“Western” Flycatcher						x
Empidonax “difficilis”						
Willow Flycatcher	x	x	x			
Empidonax traillii						
Dusky Flycatcher			x			
Empidonax oberholseri						
Gray Flycatcher						x
Empidonax wrightii						
Black Phoebe	x	x	x	x		x
Sayornis nigricans						
Say’s Phoebe	x		x	x	x	x
Sayornis saya						
Vermilion Flycatcher	x	x				x
Pyrocephalus rubinus						
Ash-throated Flycatcher	x		x	x	x	x
Myiarchus cinerascens						
Brown-crested Flycatcher	x	x		x		x
Myiarchus tyrannulus						
Cassin’s Kingbird	x	x				x
Tyrannus vociferans						
Western Kingbird	x		x	x	x	x
Tyrannus verticalis						
Loggerhead Shrike	x		x		x	x
Lanius ludovicianus						
Bell’s Vireo	x	x		x		x
Vireo bellii						
Cassin’s Vireo						x
Vireo cassinii						
Plumbeous Vireo			x	x		x
Vireo plumbeus						
Warbling Vireo			x	x		x
Vireo gilvus						
Red-eyed Vireo						x
Vireo olivaceus						
Western Scrub-Jay						x
Aphelocoma californica						
American Crow	x		x		x	
Corvus brachyrhynchos						
Common Raven	x		x	x	x	x
Corvus corax						
Tree Swallow	x	x				x
Tachycineta bicolor						
Violet-green Swallow			x	x	x	x
Tachycineta thalassina						
Northern Rough-winged Swallow	x		x	x	x	x

Stelgidopteryx serripennis						
Barn Swallow	x		x	x		x
Hirundo rustica						
Cliff Swallow	x		x	x	x	x
Petrochelidon pyrrhonota						
Verdin	x	x	x	x	x	x
Auriparus flaviceps						
Red-breasted Nuthatch			x			
Sitta canadensis						
Canyon Wren	x		x	x		
Catherpes mexicanus						
Bewick's Wren	x	x	x	x	x	x
Thryomanes bewickii						
House Wren	x					x
Troglodytes aedon						
Marsh Wren	x					x
Cistothorus palustris						
Ruby-crowned Kinglet				x		x
Regulus calendula						
Blue-gray Gnatcatcher	x		x	x		x
Polioptila caerulea						
Black-tailed Gnatcatcher	x	x	x	x	x	x
Polioptila melanura						
Townsend's Solitaire						x
Myadestes townsendi						
American Robin			x	x		x
Turdus migratorius						
European Starling	x			x		
Sturnus vulgaris						
Northern Mockingbird	x		x	x	x	x
Mimus polyglottos						
Crissal Thrasher	x		x	x	x	x
Toxostoma crissale						
Cedar Waxwing						x
Bombycilla cedrorum						
Phainopepla	x	x	x	x	x	x
Phainopepla nitens						
Orange-crowned Warbler				x		
Vermivora celata						
Nashville Warbler						x
Vermivora ruficapilla						
Virginia's Warbler						x
Vermivora virginiae						
Lucy's Warbler	x	x	x	x	x	x
Vermivora luciae						
Yellow Warbler	x	x	x	x	x	x
Dendroica petechia						
Black-throated Grey Warbler						x

Dendroica nigrescens						
Townsend's Warbler						x
Dendroica townsendi						
Common Yellowthroat	x		x	x		x
Geothlypis trichas						
Wilson's Warbler			x	x		x
Wilsonia pusilla						
Yellow-breasted Chat	x	x	x	x	x	x
Icteria virens						
Summer Tanager	x	x				x
Piranga rubra						
Western Tanager			x	x		x
Piranga ludoviciana						
Green-tailed Towhee			x			
Pipilo chlorurus						
Abert's Towhee	x	x	x	x	x	x
Pipilo aberti						
Chipping Sparrow			x			x
Spizella passerina						
Brewer's Sparrow			x			
Spizella breweri						
Lark Sparrow	x					x
Chondestes grammacus						
Black-throated Sparrow	x					x
Amphispiza bilineata						
Song Sparrow	x		x	x	x	x
Melospiza melodia						
Lincoln's Sparrow						x
Melospiza lincolnii						
White-crowned Sparrow			x	x		x
Zonotrichia leucophrys						
Rose-breasted Grosbeak			x			x
Pheucticus ludovicianus						
Black-headed Grosbeak	x	x				x
Pheucticus melanocephalus						
Blue Grosbeak	x	x	x	x	x	x
Guiraca caerulea						
Lazuli Bunting	x	x	x	x		x
Passerina amoena						
Indigo Bunting						x
Passerina cyanea						
Red-winged Blackbird	x		x	x	x	x
Agelaius phoeniceus						
Western Meadowlark	x		x	x	x	x
Sturnella neglecta						
Yellow-headed Blackbird				x	x	x
Xanthocephalus xanthocephalus						
Brewer's Blackbird	x		x			x

Euphagus cyanocephalus						
Great-tailed Grackle	x	x	x	x	x	x
Quiscalus mexicanus						
Brown-headed Cowbird	x	x	x	x	x	x
Molothrus ater						
Hooded Oriole	x	x	x	x		x
Icterus cucullatus						
Bullock's Oriole	x	x	x	x	x	x
Icterus bullockii						
House Finch	x	x	x	x	x	x
Carpodacus mexicanus						
Lesser Goldfinch	x	x	x	x		x
Carduelis psaltria						
House Sparrow	x		x	x	x	x
Passer domesticus						

Table 5. Summary data values for diversity of birds in the Muddy River drainage, 2001. Means and standard errors (in parentheses). CW, California Wash; DD, Dairy Ditch; LR, Lewis Ranch; WS, Warm Springs.

	Cluster			
	CW	DD	LR	WS
Number of site visits	13.0 (0)	11.6 (0.54)	6.8 (0.20)	26 (0)
Species richness				
all species	42.0 (2.1)	27.0 (1.7)	23.6 (4.1)	50.8 (5.7)
breeding species	34.0 (1.7)	23.1 (1.4)	22.0 (3.2)	40.1 (4.4)
Total abundance				
all species	31.8 (4.2)	20.9 (2.9)	23.0 (3.9)	32.8 (2.4)
breeding species	30.5 (4.3)	19.9 (2.9)	22.2 (3.4)	31.4 (2.3)
Evenness				
all species	0.67 (0.06)	0.70 (0.03)	0.76 (0.03)	0.69 (0.03)
breeding species	0.67 (0.07)	0.69 (0.03)	0.77 (0.03)	0.73 (0.03)
Community similarity	0.53 (0.02)	0.48 (0.01)	0.61 (0.03)	0.70 (0.01)

Table 6. Effect of geographic cluster on bird community measurements. *, P < 0.05; **, P < 0.01; ***, P < 0.001.

	F-statistics
Species richness (sampling effort kept constant)	
all species	11.27***
breeding species	10.41***
Total abundance	
all species	3.11*
breeding species	3.04*
Evenness	
all species	0.72
breeding species	0.97

Table 7. Summary data values for diversity of plants in the 85 butterfly study sites in the Muddy River drainage.

	minimum	maximum	mean	standard deviation
Species richness per site				
all species	1	14	5.2	2.5
native species	1	10	3.8	2.1
non-native species	0	6	1.4	1.4
Evenness per site				
all species	0.412	0.996	0.684	0.140
native species	0.394	1.000	0.740	0.170
non-native species	0.455	1.000	0.858	0.174

RIPARIAN PLANT DECOMPOSITION AND STREAM MACRO-INVERTEBRATES: IMPLICATIONS OF NONNATIVE PLANTS.

Introduction

Energy dynamic theories in aquatic ecology are based on mesic woodland streams. Mesic woodland streams are characterized by uniform, continuous riparian vegetation and a low disturbance regime. Allochthonous input is a major energy source for riverine biotic communities (Stewart and Davies 1990, Fisher and Likens 1973). In contrast, in Sonoran Desert streams are characterized by severe flash flood events (Baker 1977) and spatially heterogeneous, patchy riparian vegetation. Allochthonous input is not an important energy source for the riverine biotic communities (Schade and Fisher 1997). Many desert streams in the Great Basin and Mojave Desert are subject to varying degrees of disturbance and have a range of riparian vegetation communities incorporating both native and nonnative plant species. This study looked at how a heterogeneous, continuous riparian vegetation community influenced the stream macroinvertebrate community. Within the context of energy dynamics, I investigated the spatial and temporal changes in benthic macroinvertebrate communities in a warm stream with a riparian community containing both native and nonnative riparian plant species distributed continuously along the stream channel. I determined differences in contribution of native and nonnative riparian plant community to a warm river (allochthonous input) and differences in the use of allochthonous input by macroinvertebrates.

In this project, I addressed several questions, which fall into two ecological categories: plant community structure and macroinvertebrate community structure (dynamics).

Plant community structure

- What proportion of energy are native and nonnative plant species contributing to a warm river?
- Do native and nonnative plant species have different rates of in-stream retention?
- Is there a difference in native and nonnative plant decomposition in a warm river?

Macroinvertebrate community structure

- Are macroinvertebrates using all plant species?
- Are shifts in macroinvertebrate community structure spatial or temporal – does colonization of nonnative plant leaves by macroinvertebrates lag behind colonization of native plant leaves (temporal difference), or is there a loss of macroinvertebrate diversity in nonnative plant leaves (spatial difference).

Materials and Methods

The Muddy River is the lower portion of the Pluvial White River on the northern edge of the Mojave Desert. It is a warm river fed by springs originating in Paleozoic carbonate rocks (Garside and Schilling 1979). With the completion of Hoover Dam on the Colorado River, the length of the Muddy River decreased from 48 km (Hubbs and Miller 1948) to 40 km. It flows southeast and currently drains to the Overton arm of Lake Mead. Native riparian vegetation included *Salix* sp., *Prosopis* sp., and *Populus* sp. (Carpenter 1915, Harrington 1930). Current riparian vegetation at the headwaters area of the Muddy River include *Salix* sp., *Prosopis* sp., *Franzinus* sp., *Pluchea* sp., *Baccharis* sp., *Tamarix* sp., and *Washingtonia filifera*. The major land uses along the Muddy River are agriculture, pasture, coal-fired power plant, dairy farm, and urban developments. *Tamarix* sp. dominates the riparian corridor of the lower two-thirds of the river and is present throughout the system. The instream habitat in the lower part of the river is composed of steep banks, sandy/muddy bottom sediments and a uniform water velocity.

A 1500 m study reach was chosen on the upper portion of the river in order to minimize outside influences (e.g. man-made dams, organic input from irrigation canals, side channels) and disturbance regimes. Within the 1500 m study reach, one riffle area was chosen for the leaf bag experiment. This riffle area was chosen to maximize diversity of upstream riparian vegetative community and to minimize the potential of stream bank failure.

Plant community structure

Leaf litter fall into the stream was measured by randomly placing 45, 0.25 m^2 litterfall traps in the study site. Traps were placed adjacent to the bank parallel to water flow to catch plant material falling from vegetation canopy. Lateral traps were not employed due to the overgrown condition of the stream, and bank incision.

Direct litter fall traps consisted of 1x1 inch pine frames and three-ply 3mm plastic liner stapled to the frame. Traps were suspended parallel to the water surface with 1.5-meter metal stakes driven into the bank soil or stream sediment. Litter fall traps were emptied every 14-30 days for one year. Material was dried and stored in plastic zippered bags until plant species were identified, separated, and weighed. Percent composition of plant species was determined from dry weight.

In-stream leaf retention was determined by mark release methods described by Prochazka, et al. (1991).

Plant decomposition was determined by weight loss of leaf species in leaf bags. 24 hr dry weight and AFDM was determined for each plant species.

Macroinvertebrate community structure

Chlorotic leaves on trees or shrubs were collected from *Prosopis glandulosa*, *Baccharis* sp., *Pluchea* sp., *Salix* sp., *Tamarix* sp., and *Washingtonia filifera*. Leaves were air dried for 24 hrs at room temperature and stored in Ziploc plastic bags. Composite leaf bags were constructed of fine (185 μm) nylon mesh on bottom and coarse (5 mm) nylon mesh on top 20x20 cm: Seven different leaf bag combinations were used: six single species bags and one mixed bag (*Tamarix* sp. + *Baccharis* sp.). Five (5.00) grams of each plant species were used for the single species leaf bag and 2.50 grams of each plant species were used for mixed bags. Empty bags were used to determine rates of particulate matter retention. At each removal date, three replicates of each leaf-mesh combination were removed from the stream. 23 bags were removed on each removal date (7 leaf combinations + 1 empty bag × 3 replicates). In order to minimize confounding habitat variables, all leaf bags were placed in one riffle. Leaf bags were grouped in the riffle by removal date: groups were removed from the stream starting at downstream locations and moving upstream.. Leaf bags within each group were randomly arranged. Removal dates were designated as number of days after placement in the stream and were: 14, 21, 28, 35, 49, 63, 77, 91, 121, 151 days. An additional set of leaf bags was removed from the stream after 24 hours to determine weight loss from handling and leaching. This was the initial AFDM and dry weight that subsequent leaf weights were compared with.

On removal dates, leaf bags were removed from the stream, sealed in a Ziploc bag and frozen. Invertebrates were removed from each leaf bag and preserved in 90% ethanol for identification (Merritt and Cummins 1996). Invertebrate species composition, abundance, and diversity was determined for each removal date.

Samples of benthic macroinvertebrates were taken from the riffle area adjacent to the leaf bags at each removal date. A modified Surber sampler, 12 x 10 cm, was used to collect three random samples. Samples were composited and stored in 90% ethanol. These samples were used to compare differences in actual (leaf bag) and potential (Surber sample) macroinvertebrate colonization of leaf bags.

Shifts in macroinvertebrate community structure - Macroinvertebrate data from leaf bags were analyzed for temporal and spatial differences in invertebrate structure in relation to available plant material.

Water chemistry

pH, conductivity, dissolved oxygen, and temperature were determined on the day of leaf bag placement in the stream and on each removal date. Air and water temperature were continually monitored in the area of the leaf bag experiment and at random locations throughout the stream with Orion HoboTemps□.

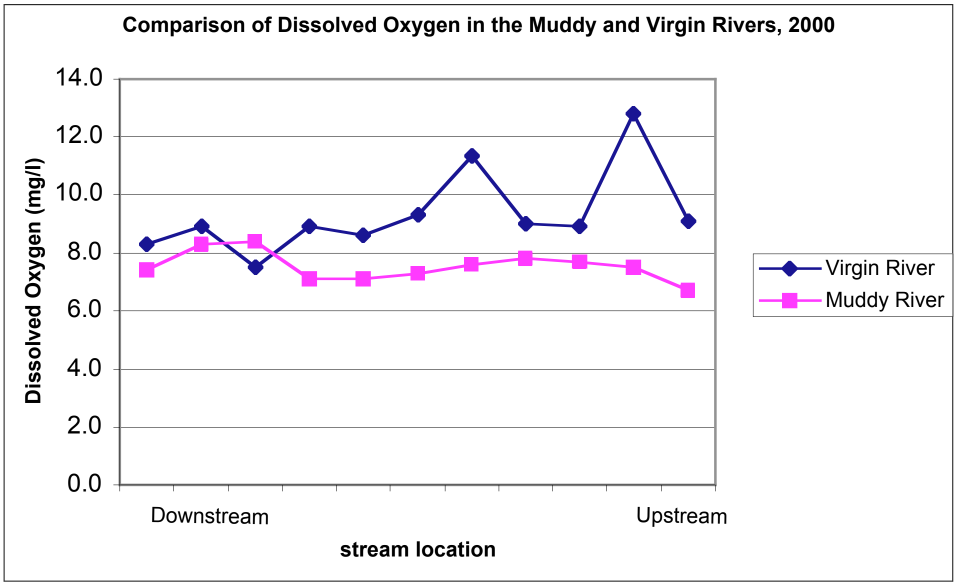
Physical habitat

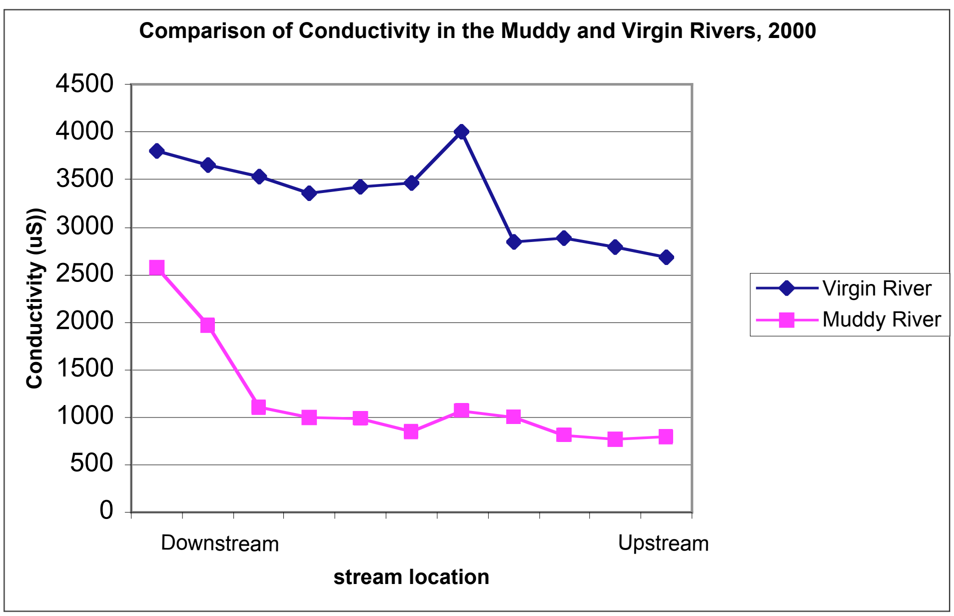
Microhabitat (width, depth, degree of bank slope, discharge, substrate size, embeddedness, and canopy cover) of the leaf bag study area was measured. Instream habitat (width, depth, canopy cover) was also measured at each leaf litter trap.

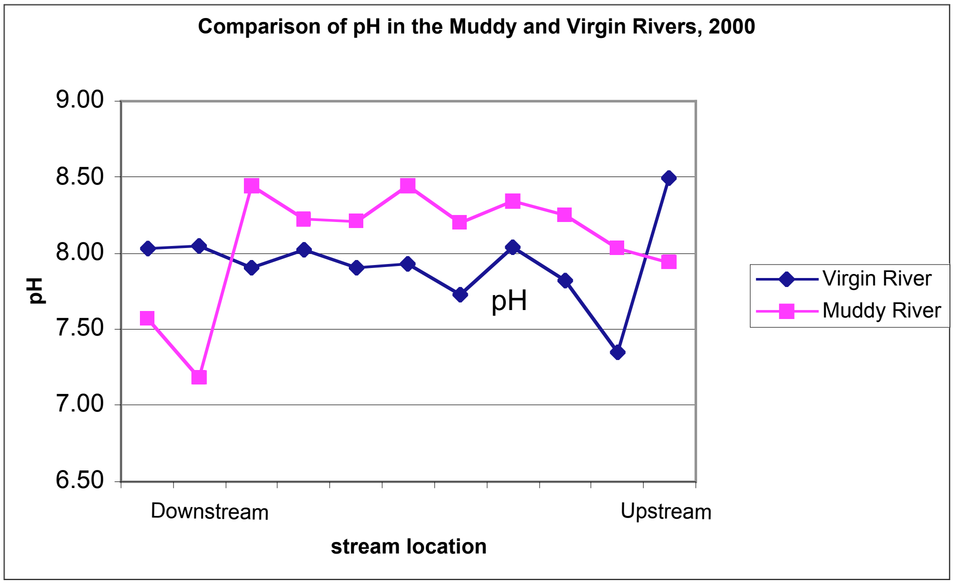
Status of research

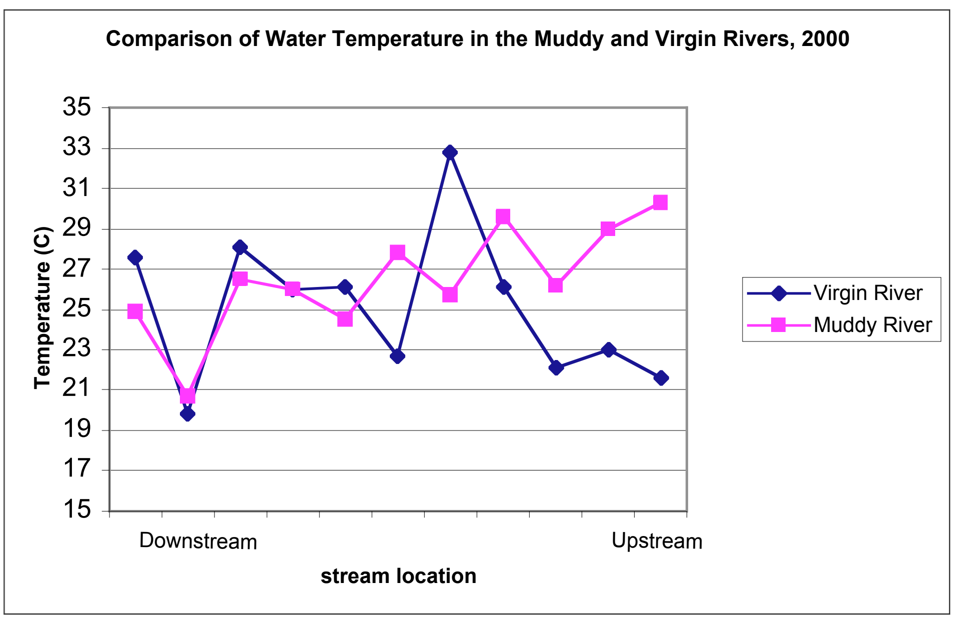
Field data collection is complete and the project is in the laboratory phase. Invertebrate data is incomplete, thus no results will be discussed. Initial results on the vegetation data indicate that *Washingtonia filifera* decomposed slowest and *Baccharis* sp. fastest. *Washingtonia filifera*'s rate of decomposition differed significantly from all other leaf species. *Baccharis* sp. had the highest rate of retention, while *Pluchea* sp. had the lowest. *Washingtonia filifera* was not included in the retention experiment.

Laboratory phase of research is expected to be completed by 01 May. Final report will be completed by August 2002.


Comparison of Dissolved Oxygen in the Muddy and Virgin Rivers, 2000
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Dissolved Oxygen (mg/l)
Downstream
Upstream
stream location
Virgin River
Muddy River


Comparison of Conductivity in the Muddy and Virgin Rivers, 2000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Conductivity (uS))
Downstream
Upstream
stream location
Virgin River
Muddy River


Comparison of pH in the Muddy and Virgin Rivers, 2000
9.00
8.50
8.00
7.50
7.00
6.50
pH
pH
Downstream
Upstream
stream location
Virgin River
Muddy River


Comparison of Water Temperature in the Muddy and Virgin Rivers, 2000
35
33
31
29
27
25
23
21
19
17
15
Temperature (C)
Downstream
Upstream
stream location
Virgin River
Muddy River

Comprehensive Ecosystem Analysis Along RRTTS (Red Rocks to the Summit)

STATUS OF SPRINGS IN THE SPRING MOUNTAINS: PRELIMINARY RESULTS AND A PROPOSAL FOR FUTURE RESEARCH

Introduction

With the incursion and expansion of humans across previously uninhabited landscapes, the composition and persistence of local ecosystems have become threatened. Urban sprawl consumes relatively undisturbed habitats that are bastions for local flora and fauna, and in some cases, these species assemblages are unique to a particular geographic location. While habitat modification is a threat for many species, other species are at risk due to the introduction of and competition with exotic species. Whether due to habitat modification or to the introduction of exotics, frequently, human expansion results in losses of biodiversity and degradation in local biological resources.

The considerable growth in Clark County offers an example of problems related to rapid urban expansion and the conservation of biological resources. With growth, the introduction of exotics often threatens the condition of local communities; the introduction of horses, burros, and elk in the Spring Mountains are a good case in point.

The objectives of this study were to evaluate the current status of springs in the Spring Mountains and define management and research goals for the future.

Methods

Study areas. During the months of July and August 2001, springs in the Spring Mountains and Red Rock Conservation Area (Clark Co., NV) were visited to assess the condition of the springs and the riparian areas surrounding the springs. Springs visited were restricted to more lowland areas located in desert scrub (DS), pinyon-juniper (PJ), or mixed conifer (MC) communities. Locations (UTMs) of springs were obtained either by digitizing known springs from topographic maps (iGage 1999) or obtained from UTMs listed in a report to the Bureau of Land Management (Sada 199X). UTMs of springs have been verified on site (except where noted) and are reported in NAD27 (Table 1). Springs visited during this study are shown in Fig. 1.

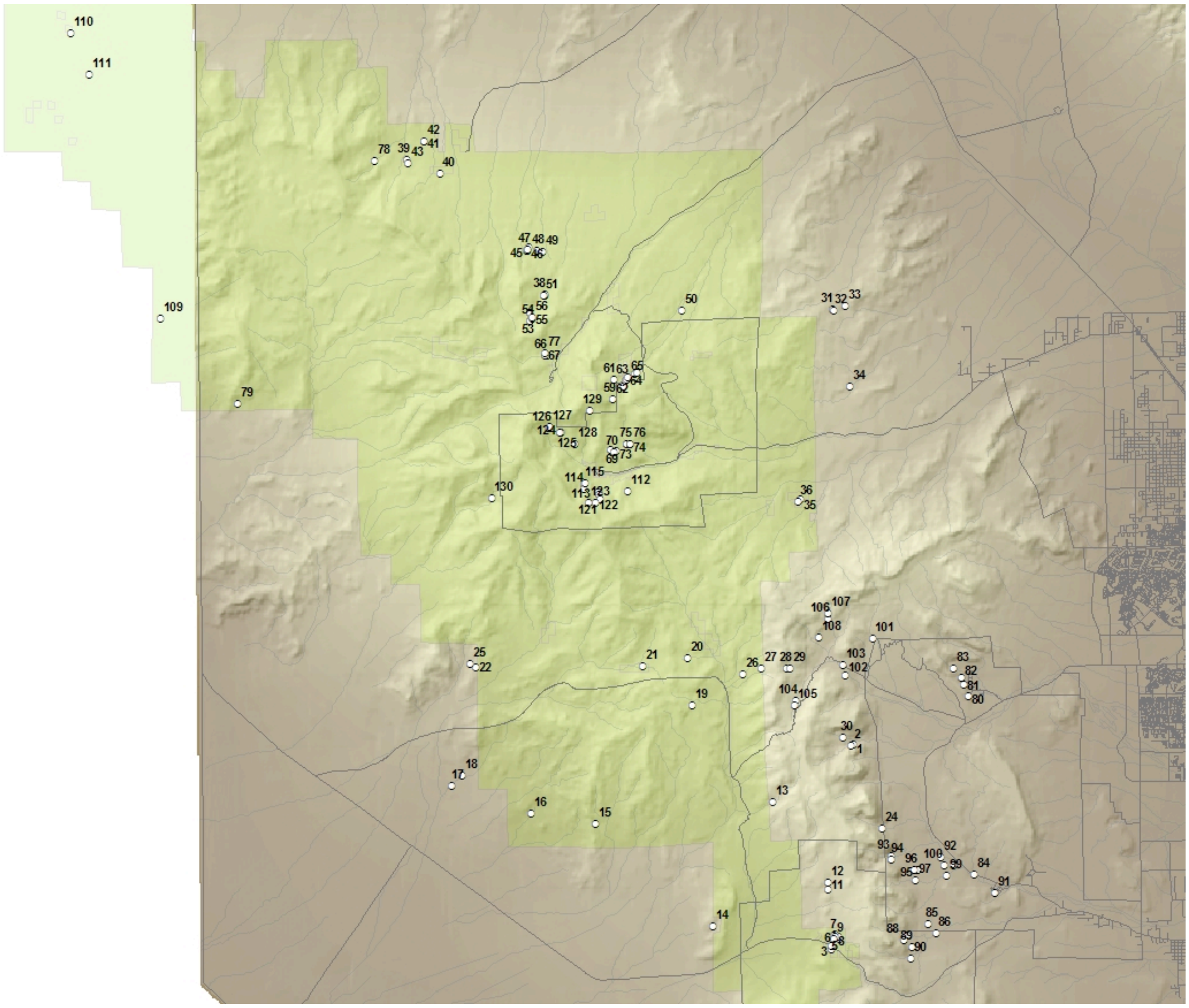


Fig. 1. Map of springs sampled in the Spring Mountains and Red Rocks.

Classification of disturbance. Disturbance around springs was classified among different sources attributable to humans, burros and horses, and elk. Human disturbances included trails, roads, fences, diversion pipes, and troughs, each of which were recorded as present or absent for each spring. Burro and horse disturbances included trails, feces, browsing of flora, and soil compaction. Equine disturbances were recorded in a graded fashion for all disturbance types as follows: a score of 0 denotes an absence of disturbance, a score of 1 denotes one or two instances of a particular disturbance, and a score of 2 denotes three or more instances of the disturbance type. Elk disturbances were recorded in the same manner as equine disturbance.

Statistical analysis. Cluster analyses were performed to summarize how disturbances are distributed among springs and to group springs into disturbance categories. Tree clustering analyses were performed on disturbance scores for each spring to illustrate how disturbance variables cluster. Euclidean distances were used as the distance measure and unweighted pair-group averages were used for amalgamation of resulting clusters. K-means clustering analyses were performed to classify springs into categories of ranked disturbance. All analyses were performed with the Cluster Analysis module in Statistica for Windows (StatSoft, Inc. 2000).

Results

Clustering of disturbance variables. The clustering of disturbance variables is presented in a hierarchical tree plot (Figure 2). The two primary branches neatly divide human disturbances from equine disturbances. With respect to human disturbance, roads and trails are distinct; while fences, pipes, and troughs are represented in a smaller group. Fences are built to exclude horses and burros, and pipes and troughs are built to divert water from these spring areas to areas where horses and burros will have lower impacts on springs. With respect to equine disturbance, secondary branches denote trails and feces as related clusters, while more impacting disturbances are grouped as related clusters. Elk disturbances were not included in this analysis because elk sign (pellets) was on found in only 5 of the 105 springs visited.

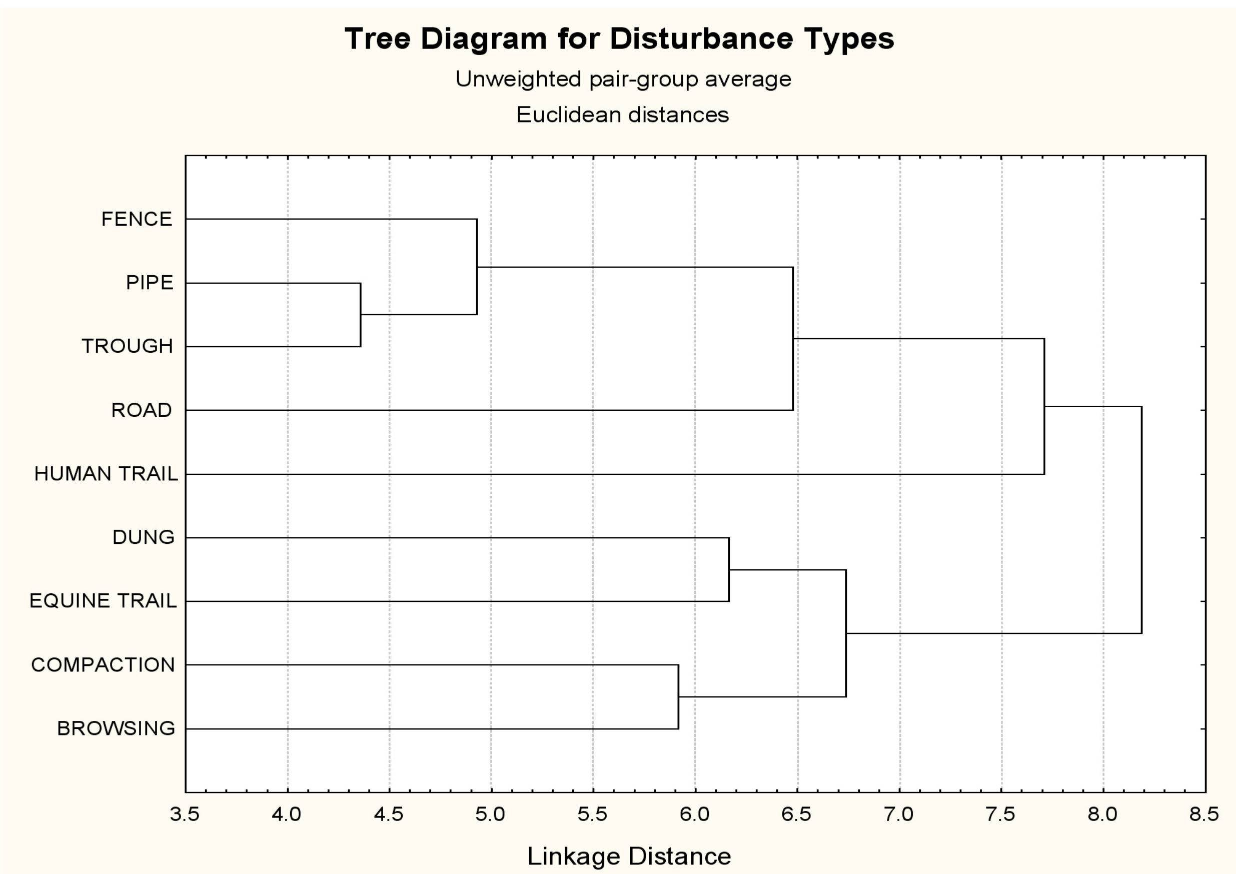


Fig. 2. A hierarchical tree plot shows that disturbance can be grouped largely into two types, human and equine. Unweighted pair-group averages were used for amalgamation. Euclidean distances were used for joining.

Ranking springs with respect to disturbance. Springs were separated into three distinct clusters with respect to equine-induced disturbances (Figure 3). Springs were ranked as low (n=58), moderate (n=24), or high disturbance springs (n=23). Low disturbance springs exhibit few, if any, trails, feces, browsed vegetation, or areas of compacted soil. Moderately disturbed springs had an intermediate frequency of trails and feces, and relatively low amounts of browsing and compaction. Highly disturbed springs had the highest frequency of trails, feces, browsing, and soil compaction.

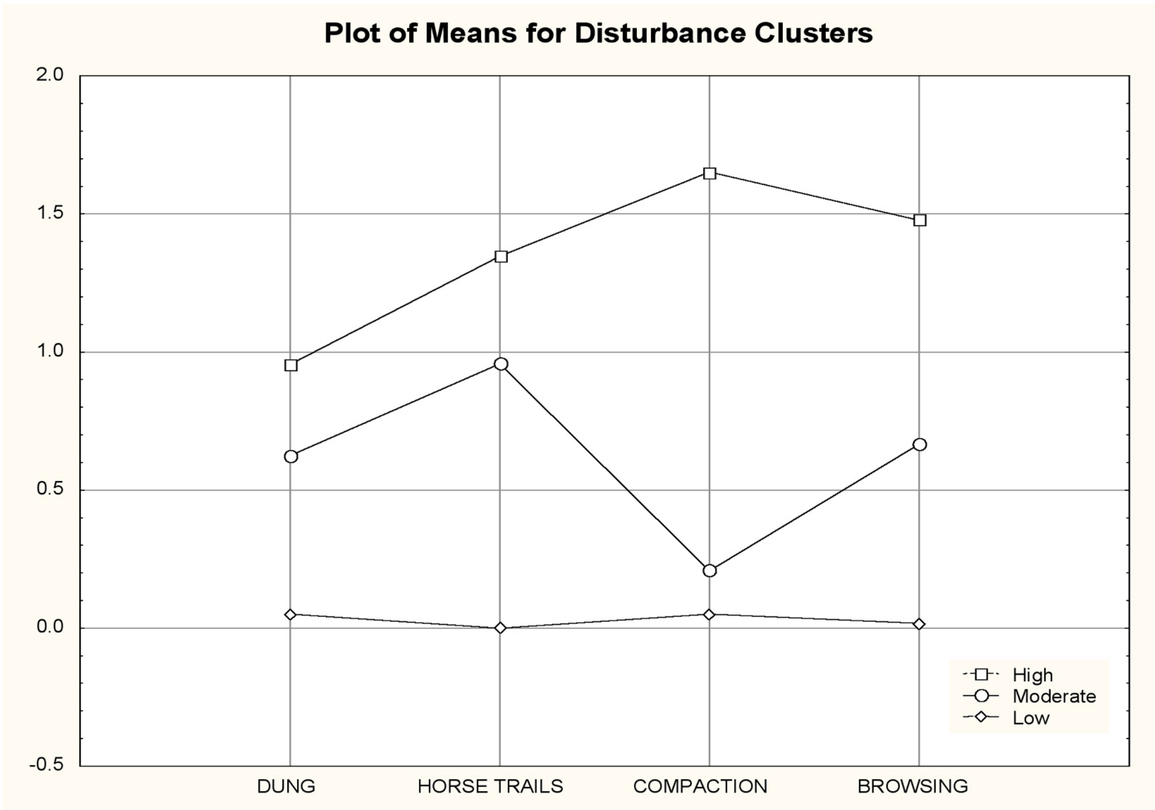


Fig. 3. Using equine disturbance types, springs can be clustered into three distinct levels of disturbance: low, moderate, and high.

Since k-means cluster analysis allows for an arbitrary number of clusters to be set, I tried varied numbers of clusters to determine the most distinct groupings. Adding a fourth cluster could not be accomplished, as an additional cluster would contain no members. Using only two clusters clumped the highly and moderately disturbed springs, without altering the membership of the low disturbance spring cluster. An analysis of variance for three clusters indicates that the clusters are significantly different from one another with respect to all disturbance types: trails ($F_{2,102}$=40.26, p<0.001), feces ($F_{2,102}$=151.01, p<0.001), soil compaction ($F_{2,102}$=185.95, p<0.001), and browsing ($F_{2,102}$=102.18, p<0.001), though these results should be viewed cautiously as they are based on qualitative scores.

Discussion

The condition of springs varies considerably across the Spring Mountains and Red Rock Conservation Area. While human 'footprints' are evident at many of the springs through the presence of trails and roads, human disturbance would appear to have less detrimental effects on springs than the damage created by horses and burros. Springs receiving high usage by horses and burros—as evident by feces, trails, soil compaction, and browsing of vegetation—are often simply decimated. Decimation of springs is a likely outcome from these animals given that water resources are scarce and spring areas are often small compared to the number of animals using the springs. Indeed, groups of five or more burros or horses are not uncommon in the Spring Mountains or Red Rock Conservation areas. Furthermore, population estimates of horse herds in the Spring Mountains are on the order of 200-300 animals. To make matters worse, elk herd population estimates are on the same order of magnitude as horses.
To alleviate the effects of horses and burros on springs, federal agencies have built fences to exclude these animals from the springheads and riparian areas that surround the springs. To varying degrees, the installation of fences has had beneficial effects on spring condition. Areas that were previously stripped of vegetation and experienced high degrees of soil compaction have been revegetated and are beginning to take on the character of a riparian area. Other springs, though, are dominated by a smaller number of dominant species that were able to take hold due to the eradication of competitor species (*sensu* Grimes197X), and these springs may need further human intervention through reseeding or replanting native species to these areas if these springs are to recover. The re-establishment of plant communities is important because these riparian plants are responsible for most of the primary productivity in spring areas, which can give rise to diverse invertebrate communities and thus support higher-order grazers and predators such as mammals and lizards.

Whether or not fences are on average beneficial has not been demonstrated to date. Ideally, with time, fenced spring areas would progress from overgrazed, highly-compacted areas with few (or no) plant species to areas that resemble the original communities that thrived before their destruction by horses. Unfortunately, due to the eradication of many plants at a given spring, and the lack of seed dispersal to these springs due to the large distance between riparian areas in arid habitats, many of the fenced springs may become dominated by a fraction of the species that formerly inhabited the spring area. Species inventories and monitoring efforts need implementation before the efficacy of fences can be evaluated.

For the fencing of springs to be effective, their successional progression from barren areas to near-original spring communities should mimic the diversity of unfenced springs (Figure 4). Unfenced springs are affected by the frequency of disturbance that they receive, and the relative effect of this disturbance is dampened as the spring areas become larger. For example, the diversity of undisturbed unfenced springs should be low compared to that of unfenced springs that receive heavy usage by horses and burros. Furthermore, the same level of animal use should affect larger springs less than at smaller springs as it becomes more difficult for horses and burros to graze the entire area, and larger areas provide a greater opportunity for neighboring plants to recolonize overgrazed areas. The analogy between the time progression of fenced spring recovery to original spring communities produces a set of hypotheses that can be tested through the species inventories: 1) newly fenced springs should resemble highly disturbed natural springs of similar size, 2) as time progresses, fenced springs should resemble moderately-disturbed springs of similar size, and 3) at some point in time, fenced springs should resemble unfenced springs that receive little or no disturbance. Furthermore, long-term monitoring of newly fenced springs should reveal a gradual increase in species diversity over time, or currently fenced springs should reveal a trend of higher species diversity with the time since fencing. The accordance of patterns of diversity among fenced and unfenced springs described above will reveal the efficacy of the fencing of springs.

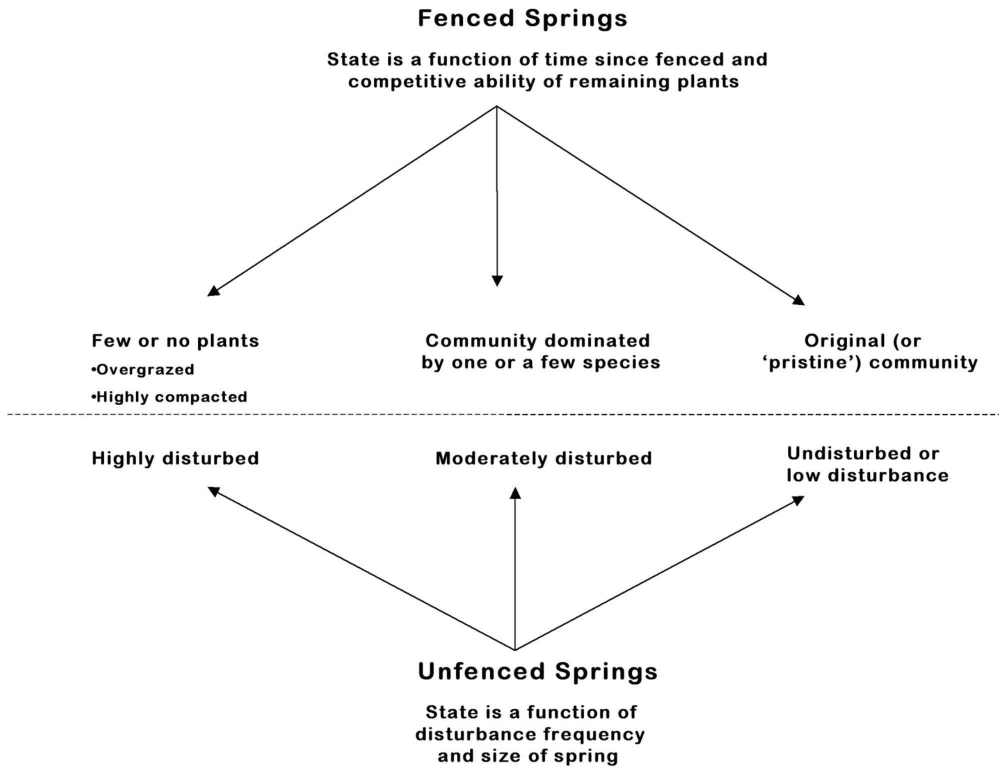


Fig. 4. A heuristic model relating natural disturbance and recovery of fenced springs

To determine the effect of disturbance on springs caused by horses and burros, and to determine the efficacy of fencing springs as a means of remediation, I propose a two-phased approach for adaptive spring management. First, baseline species inventories of springs need to be collected. Plant species lists should be given priority as plant composition and abundance will likely determine, to a large extent, the animal communities around springs. Additional priority should be given to aquatic invertebrates, lepidopterons, bats, amphibians, and small mammals because the presence of these species is likely indicative of spring condition and recovery beyond the initial recovery of the plant community. Such baseline information would allow the preliminary testing of the hypotheses stated in the last paragraph. Table 2 shows a list of proposed springs for monitoring. These springs were chosen based on their level of disturbance, location with respect to surrounding vegetation, and size of the spring area. In the second phase, a subset of springs from the initial monitoring efforts—both disturbed and undisturbed—should be fenced and subsequently monitored to fully understand successional changes induced by fencing. An additional step could be taken by de-fencing currently-fenced springs to determine the time course of species loss. Both aspects of the second research phase would be highly informative as to the dynamics of springs to horse and burro use.

Definitions of Success of Conservation Actions for Marginal Species

This project was developed in response to a direct request for help from BLM. BLM is responsible for managing various mesquite and catclaw woodlands and the birds that use them, particularly phainopepla, which is a Covered Species under the Plan. We have taken the request and combined it with other needs of the MSHCP to produce a project that will yield results that may be more generally useful for all of the agencies and for the Plan.

Several species included in the Plan as Covered or Evaluation Species (e.g., phainopepla, summer tanager, blue grosbeak, Arizona Bell's vireo) are highly vagile, and they are also at the margins of their geographic distributions. Definition of success for conservation actions may be elusive for these species. Investigation is necessary to define what can be expected as a best response to conservation actions for these marginal species.

We are using the phainopepla as a model for definition of these difficult species. Phainopeplas are not present on BLM lands in the Las Vegas District in all years. Additionally, this species depends upon mistletoe berries for food, and mistletoe fruiting is a phenomenon that varies from year-to-year and place-to-place due to natural conditions. Currently, this variability confounds understanding of the effects of management actions. Our approach has been to study the presence and abundance of mistletoe throughout Clark County and make a GIS coverage for this resource. Additionally, we are assessing the extent to which mistletoe produces berries each year for several years. Moreover, we have been surveying for nesting success in phainopepla to determine the temporal and spatial distribution of nesting by this species.

We expect that these data will allow us to identify how much fruiting mistletoe is required to sustain a breeding population of phainopepla in Clark County. We also expect that we will be able to determine the temporal and spatial patterns of occurrence and abundance of mistletoe berries, and the same type of information on reproduction in phainopepla. Our prediction is that it is not reasonable to expect animals at the limits of their geographic distribution to be present and reproducing every year in all places in Clark County. Therefore, how can we determine when we have done conservation well? We assert that only by knowing what one can expect under the best of circumstances, what the biology of the species will allow in terms of presence and abundance, can we ever assess the efficacy of conservation actions for marginal species. Our studies of phainopepla will allow us to determine what can be expected from solid conservation actions with this species. We anticipate that the approach will help us to determine whether we can define the efficacy of conservation actions for other marginal species.

What follows is a report on a study of phainopepla which is not complete.

DETERMINANTS OF PHAINOPEPLA DISTRIBUTION AND ABUNDANCE IN SOUTHERN NEVADA

Abstract

In southern Nevada, phainopeplas and their principal food, desert mistletoe, are at the edge of their range, where cold and drought may produce fluctuations in bird and mistletoe berry abundance not observed at the range core. The objective of this study is to determine the influence of food availability and various habitat and landscape parameters on the distribution and abundance of over-wintering and breeding phainopeplas in this region from 2000-2003; presented here is the first season's research. From Oct 2000-June 2001, phainopepla presence and mistletoe abundance in mesquite and catclaw acacia patches were recorded at each site several times several times annually. Phainopeplas were found throughout the study area, but they were significantly scarcer in the western part of the study area. They were significantly more likely to be present in areas with high mistletoe infection; and absent from sites with low infection. They did not appear to discriminate between patches based on patch area or dominant tree species. Occupation of some sites changed over the year; the distribution and abundance of phainopeplas among habitat patches is dynamic, even within years. During the breeding season, 52 nests were found at a total of 12 sites and fledglings were seen at an additional two sites. At four of these sites, intensive nest searches were conducted, nest success was estimated, and measured nest site characteristics. Fifteen of the 28 nests (53%) that contained eggs were successful (fledged $\geq$ 1 young; clutch size = 2-3 eggs). Within sites, the proportion of successful nests ranged from 0.20-0.71. Nest predation and abandonment was seen, but not parasitism. Many pairs apparently started two nests, even if the first was successful, and several pairs may have raised two successful broods. Results to date suggest that mistletoe abundance strongly influences phainopepla abundance and perhaps breeding success, but that among sites with berries, other factors may also influence phainopepla abundance and breeding.

Introduction

Phainopeplas are the only representatives of the silky flycatchers (Family - Ptilogonatidae) in the United States; the other species in this family are found in Mexico and Central America. Their closest relatives in the USA are the Cedar and Bohemian waxwings. Phainopeplas are only found in the American Southwest and Mexico. They are relatively common in Mexico, Arizona and southern California, and are scarcer in northern California, southern Nevada and Utah, and western Texas and New Mexico (BBS 1999; Figure 1).

Within this range, phainopeplas occupy two very distinct habitats – woodlands and deserts - and to some extent, regions, at different times of year. Unusually, these shifts in distribution and habitat both coincide with distinct socioecology and breeding periods; breeding phainopeplas occur both in spring in one habitat and summer in the other (Walsberg 1977). It is not known if the same phainopeplas breed twice, once in each habitat, or if phainopeplas that breed in one habitat are non-breeders in the other (Chu and Walsberg 1999).

In summer (May/June-Sept/Oct, depending on the region), phainopeplas most commonly inhabit montane or coastal woodlands in Mexico, Arizona and the Central Valley of California and coastal California as far north as Marin Co. (Cottam 1936, Crouch 1943). There are also scattered records from Utah (Tanner 1927, Behle and Perry 1977), New Mexico (Bailey 1928) and Nevada (Ridgeway 1877, Van Rossem 1936, Alcorn 1988, Chu and Walsberg 1999). In the core regions, phainopepla often favor riparian cottonwood (Rand 1943, Behle and Perry, 1975, Chu and Walsberg 1999) or mesquite-elder (Phillips et al. 1983) associations, or semi-arid oak-sycamore canyons (Crouch, 1943, Walsberg 1977, Small 1994, Chu 2001) and pinyon-juniper woodlands (Weathers 1983). They breed in these habitats from late June-August. In Nevada, breeding phainopeplas have not been seen in summer. Non-breeding phainopeplas have been reported in cottonwoods in SE Lincoln Co. (Chu and Walsberg 1999) and in a plum thicket near Alamo. They have also been reported in pinyon-juniper in the Soda Lakes near Fallon (Ridgeway 1877) and in Cold Creek, Clark Co. (Van Rossem 1936).

In fall, phainopeplas move to the desert. From fall to spring, they are most abundant in the US in the Sonoran and Colorado Deserts and in the Mojave Desert as far north as Inyo Co., CA (Chu and Walsberg 1999). They also occur less commonly during this period as far east as New Mexico and Texas (Crouch 1943) and as far north as Clark Co., NV and southwestern UT (Van Rossem 1936, Krueger 1998). In the desert, phainopeplas are limited to stands of arborescent legumes such as mesquite, acacia, palo verde, ironwood and smoke tree. They breed in these stands from February – June, then leave the desert for their summer habitat in May-June. Phainopeplas are rarely seen in desert habitats from mid-June-September. Conversely, they are rarely seen in riparian elder/oak/cottonwood or pinyon-juniper habitats during the winter.

The distribution of phainopepla in both of their major habitat types closely mirrors the temporal and spatial availability of berries, as they are highly specialized frugivores (Walsberg 1975). The adults eat berries almost exclusively, catching insects only during the nesting season. Nestlings eat both insects and berries (Walsberg 1977, Small 1994). The summer diet of phainopeplas consists of the fruits of plants such as elder, buckthorn, redberry, pepperberry (Bent 1965, Crouch 1943, Walsberg 1977), juniper, wild grape (Bent 1965), sumac and oak mistletoe (Crouch 1943). They forage colonially, moving from plant to plant as berries ripen (Walsberg 1977). Socially monogamous pairs defend small territories immediately around nest sites, but do not defend food (Walsberg 1977). Clutches usually contain 2-3 eggs, and sometimes four eggs, with a mean of 2.46 eggs/clutch (Chu and Walsberg 1999, Walsberg 1977)

In the desert, phainopeplas are closely tied to desert mistletoe (*Phoradendron californicum*), which is a hemiparasite on the above-mentioned arborescent legumes (Crouch 1943, Chu and Walsberg 1999), and produces berries from October to May (Cowles 1936, Walsberg 1977, Anderson and Ohmart 1978). As nothing else is fruiting at this time, phainopeplas subsist almost entirely on mistletoe berries (Crouch 1943, Rand and Rand 1943, Bent 1965, Walsberg 1975 and 1977, Anderson and Ohmart 1978, Laudenslayer 1981, Phillips et al. 1983, Weathers 1983, Small 1994, Chu and Walsberg 1999). They also often build nests in mistletoe clumps. In turn, desert mistletoe relies heavily on phainopeplas for seed dispersal (Larson 1996), creating a positive feedback. Compared to their summer habitat, phainopeplas in the desert maintain larger territories (mean area=0.4 ha) around both food resources and nest sites (Walsberg 1977). In the desert, two egg clutches are more common than in summer habitats, with a mean clutch size of 2.0 eggs/clutch in Nevada (Krueger 1998) and in the Colorado Desert (Walsberg 1977), and 2.35 eggs/clutch in the Sonoran Desert (Chu and Walsberg 1999). However in wet years in the Colorado Desert, mean clutch size can be as high as 2.5 eggs/clutch (Walsberg 1977). The studies proposed here are concerned only with the habitat requirements, resource use, and breeding success of phainopepla in the desert. A major objective of this proposal is to determine the spatial and temporal patterns and determinants of woodland occupancy and breeding success of phainopepla in their desert habitat.

The objectives of the proposed research are:

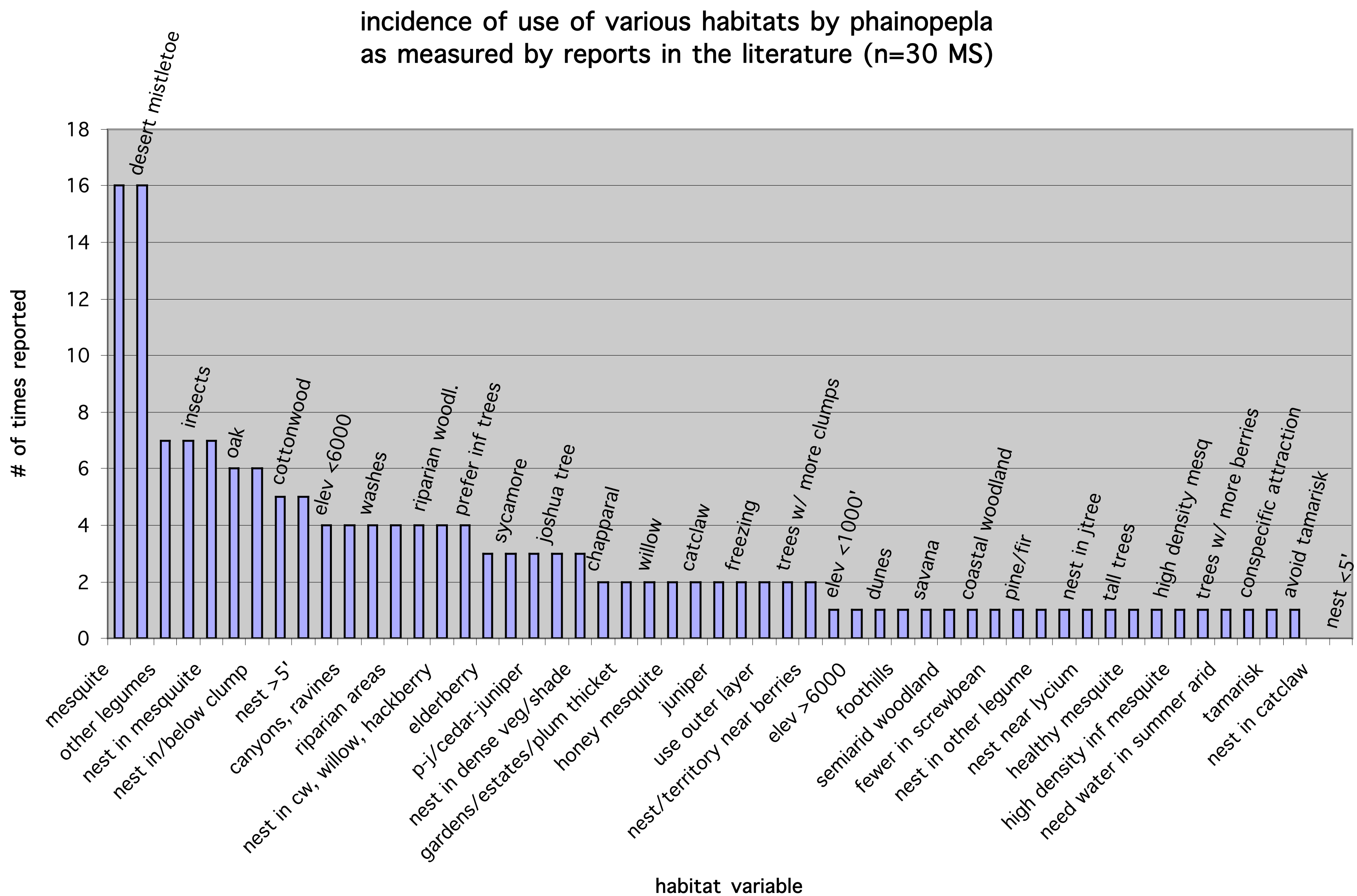
1. to establish the determinants of phainopepla presence, abundance and breeding success along the northern edge of their desert breeding range. In particular I will examine their:
   a) habitat requirements
   b) response to spatial and temporal differences in resource availability,
   c) response to patch size and isolation
   d) movements among patches
2. to investigate the probability that phainopepla populations will persist at the edge of their range in the face of habitat loss/degradation, natural variability in resources, and climate change
3. to recommend measures to preserve and improve phainopepla habitat and protect phainopepla populations, especially regarding the area and spatial configurations of mesquite and catclaw acacia that should be protected

"Meta-analysis" of the existing literature

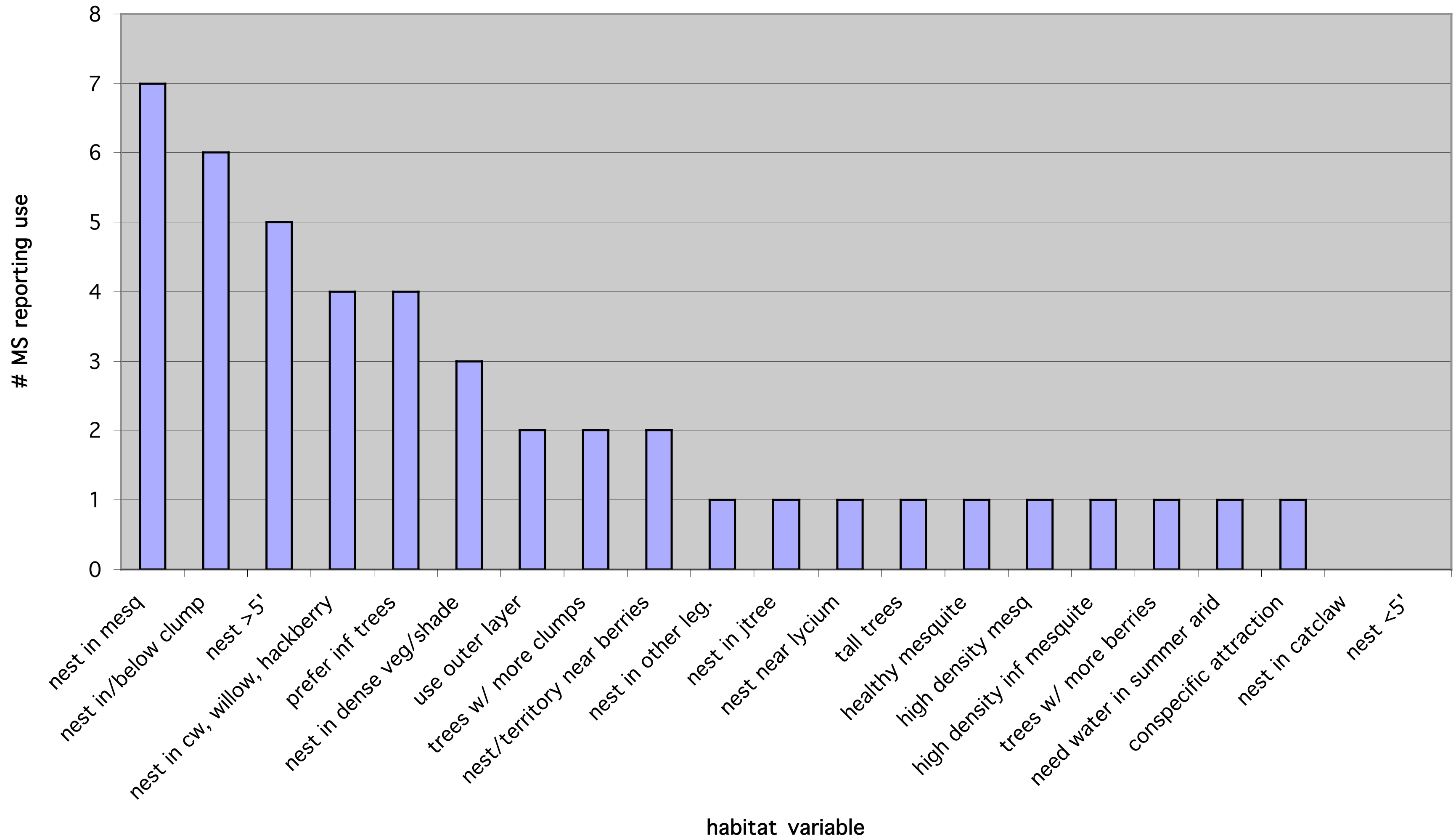
In an attempt to understand the potential determinants of phainopepla abundance and breeding success better, The existing literature on habitat use and dietary items of phainopeplas was surveyed. Unfortunately, little primary literature on phainopeplas exists, and much of the survey consists of habitat associations described in bird guides of the southwestern states.

A score of "1" was given for a particular habitat or diet parameter, if it was mentioned in a literature source. All papers for each parameter were summed and a frequency distribution was constructed of the number of papers in which habitat and diet parameters were mentioned. An overall frequency distribution for all habitat parameters (in both summer and winter ranges) was constructed, and that was decomposed into "macro"- scale and "micro"- (within patch) scale variables, and "desert" variables (restricted to those found only in the desert range of phainopeplas).

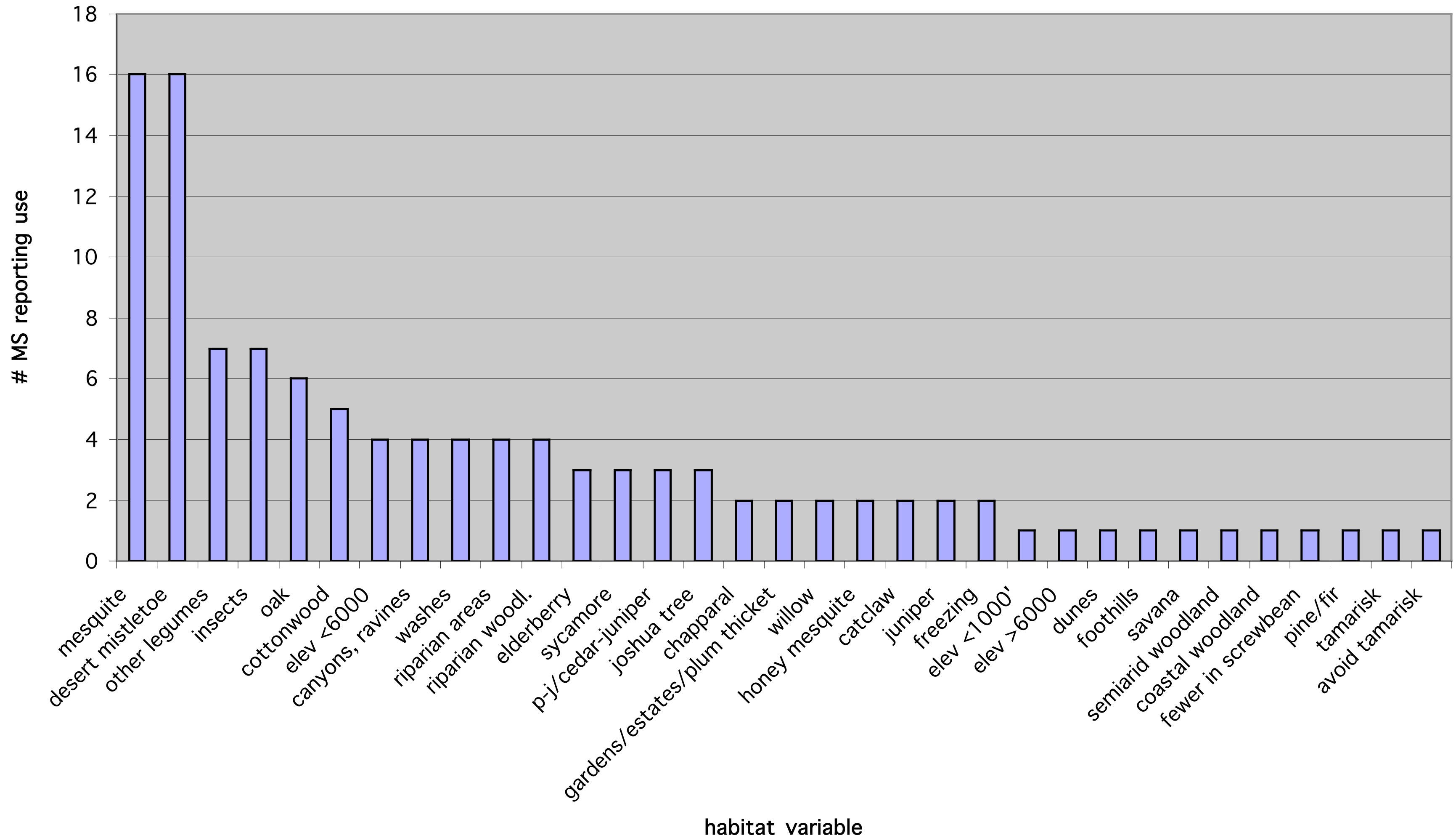
Mesquite and desert mistletoe were the most frequently mentioned variables in all habitat analyses (except the small scale analysis; Figures 2-5). In the overall and desert macro-scale analyses, other leguminous tree species that host mistletoe and insects (which are fed to young) were the next most frequently mentioned variables (Figures 2 and 3). Oak is commonly mentioned in terms of summer habitat, but is not associated with desert phainopepla habitat (Figure 4). Cottonwood, however, is moderately commonly associated with phainopeplas in the desert. In terms of micro-scale variables, several sources mentioned that phainopeplas nest in mesquite, in or below mistletoe clumps greater than 5 ft from the ground (Figure 5). The most common dietary item associated with phainopeplas is desert mistletoe followed by insects, berries of *Sambucus* and *Rhamnus*, and mistletoes in general (Figure 6).


incidence of use of various habitats by phainopepla
as measured by reports in the literature (n=30 MS)
# of times reported
0
2
4
6
8
10
12
14
16
18
habitat variable
mesquite
desert mistletoe
other legumes
insects
nest in mesquite
nest in/below clump
oak
nest >5'
cottonwood
canyons, ravines
elev <6000
riparian areas
washes
nest in cw, willow, hackberry
riparian woodl.
elderberry
prefer inf trees
p-j/cedar-juniper
sycamore
nest in dense veg/shade
joshua tree
gardens/estates/plum thicket
chapparal
honey mesquite
willow
juniper
catclaw
use outer layer
freezing
nest/territory near berries
trees w/ more clumps
elev >6000
elev <1000'
foothills
dunes
semiarid woodland
savana
fewer in screwbean
coastal woodland
nest in other legume
pine/fir
nest near lycium
nest in jtree
healthy mesquite
tall trees
high density inf mesquite
high density mesq
need water in summer arid
trees w/ more berries
tamarisk
conspecific attraction
nest in catclaw
avoid tamarisk
nest <5'

Incidences of use of "micro" scale habitat variables by phainopepla, as measured by reports in the literature



Incidence of use of "macro" scale habitat features by phainopepla, as measured by reports in the literature



Several sources also mentioned that the quantity of food resources available during the breeding season and the weather influenced breeding success (Figure 7). The amount of available berries was cited in three sources as influencing the number of fledglings/nest and once as affecting the number of nesting pairs. The abundance of spring insects was mentioned once as affecting the number of eggs/nest, and once as determining the initiation of courtship behavior by males.

Field surveys

<u>Study Sites</u>

From October 2000 to May 2001, as many mesquite and catclaw acacia "woodlands" were identified as could be found within and along the borders of Clark Co., NV. Several of these woodlands had been mapped by the BLM, but others were located by talking to local agency people and birders, and by driving around Clark Co. In total, 41 sites were identified, 31 of which were located in Clark Co. As many of these woodlands were visited as possible, concentrating on those in Clark Co.

These woodlands vary widely in size, shape and isolation, and in the growth form of their dominant host species. Much of the catclaw acacia is found along washes and in shallow ravines, and is thus very narrow, but some of it occurs in series of stringers in floodplains (e.g. North Las Vegas Site). Some of the honey mesquite also occurs along washes, but at many more of the sites, honey mesquite occurs in stringers across floodplains and is thus wider in coverage. At several sites, honey mesquite is found on the edges of dry lakes, and at other sites, particularly in western Clark Co., it grows on the tops of series of sandy dunes. Screwbean mesquite is common only at a few wetter sites, such as Warm Springs Ranch, Blue Point Springs and Big Bend State Park, where it grows in quite dense associations. The smallest woodland is approximately 25 ha, and the largest, approximately 5000 ha. The longest wash is 38 km long, and the shortest, 1 km.

Some of the woodlands exhibit within site variability in host species, growth form and topography. I divided these sites into subsites for sampling purposes. For example, at Corn Creek, I have two subsites: one for the dunes, and one for the area around the spring.

The density and productivity of mistletoe plants also greatly differs within and among woodlands. For example, at the low end of the scale, in one woodland, 4 small plants in 4 km were counted, whereas in another woodland, more than 100 plants on one tree were counted. Differences in productivity within sites also resulted in subsite designation.

Survey Effort

During the survey period, I conducted 71 bird transects at 25 sites (40 subsites). On 43 of those transects at 15 of those sites, I also counted the number of mistletoe plants/tree. Some of these sites and transects were surveyed twice or more; once or twice during the winter, and once during the breeding season. All but three of these sites were surveyed during the breeding season (March 8-June 6, 2001).

Spot surveys were conducted at an additional seven sites; surveys at three sites were conducted during the breeding season. These spot surveys involved walking or driving portions of the site listening and looking for phainopeplas. When phainopeplas were easily found, I usually stayed no more than 30-60 minutes at these sites. When phainopeplas were not easily found, I spent 1-2 hours and tried to cover more ground, looking for sites of mistletoe infection where phainopeplas were most likely to be. In this manner, I visited the Stewart Valley site three times, and am quite confident that phainopeplas are not found there. I visited the flats west of Pahrump twice, and covered perhaps a 1/4-1/3 (both visits combined) of the total area; I am reasonably sure that phainopeplas do not occur on the flats except right on the edge of town. I thoroughly combed Dry Lake once; there are no mistletoe or phainopeplas at that site. Only at Toquop did I feel that I did not spend enough time to state with confidence that phainopeplas were absent.

I received reports from local birders that phainopeplas were present at five of the remaining nine sites (Las Vegas Wash, Red Rock Canyon, Sunrise Mountain, the Reservation near Laughlin and the Henderson Bird Preserve). Phainopeplas were present at the first two sites during the breeding season. I have no information concerning phainopeplas from four of the 41 sites I identified. Only one of these, Gold Butte, is in Clark Co.; the rest are in Nye Co. and California.

<u>Methods</u>

Occurrence of phainopeplas along transects

From mid-November – early May, I monitored phainopepla occurrence along transects. Each transect began at a random point within a portion of the site that was covered by host-tree woodland at least 500 m long. In washes and stringers, transects ran down the middle of the wash. In sites composed of mesquite dunes, which often occur in a near-linear fashion, the direction of the transect followed the long axis of the dunes nearest the random point. I maintained this direction as long as a mesquite-bearing dune was within 50 m. If not, I moved to the nearest dune and then continued in the same direction.

Until the end of December, transects varied in length from 500-1500m, depending on the shape and size of the woodland. In each site I sampled a total of 1500-2000m depending on the area of the site. The number of transects/site varied from 1-3 depending on the shape and area of the site. In other words, in washes < 5000 m long, I conducted 1 long transect of 1500-2000m. In very long washes, I conducted 2 transects of 1000m each. In woodlands of more breadth or composed of a number of stringers or dunes, I conducted 2-3 transects of 500-1000m.

From January-May, I standardized all transects to a length of 500m. I conducted 1-5 transects/site depending on the shape and area of the site. Sites were categorized as very small (1 transect), small (2 transects), medium-sized (3 transects), large (4 transects), and very large (5 transects). Long, narrow washes were categorized as very small if they were less than 50 ha and 2km long, small if they were 50-100 ha and 3-5km long, medium if they were 100-175 ha and 5-7 km long, large if they were 175-500 ha and 7km-15km long, and very large if they were over 500 ha and 15 km long. Woodlands that were not long and narrow (e.g. sets of stringers, dunes) were classified as very small if they were less than 100 ha, small if they were 100-300 ha, medium if they were 300-700 ha, large if they were 600-1200 ha and very large if they were over 1200 ha.

The approximate distance was measured from the transect (to the nearest 10 m) of each phainopepla seen or heard along the transect. At each site, I estimated the greatest distance at which I could detect vocal and non-vocal birds. In most sites, my ability to detect birds was 50-60 m on each side of the line, if they were perched on top of the tree, even if they were not calling. If birds called, I detected them up to 100 m away. Thus transects sampled an area 100m-200m wide over 1500-2000m/site, or 15-40 ha/site. The detection distance depended on width of site, the growth form of the trees, the amount of sun, and the behavior of the bird.

Abundance of desert mistletoe along transects

To sample the availability of mistletoe to phainopeplas in the vicinity of the transects, I generated eight random points that fell within the area I sampled for phainopeplas. I used a T^2 sampling method (Krebs 1989), which generated up to two "random infected trees"/random point. From each random point, I located the nearest infected tree (A) to the point, and the nearest infected tree (B) to A, with the provision that B be in the opposite direction from A than the random point. I added an additional provision that each tree must be within a 30-m radius of the point or A. If there was no infected tree within 30 m, I moved on to the next point. At most sites, this method produced 14-16 trees/500 m transect, but at sites with a low density of infected trees, it produced as few as 8 trees/500 m. On each tree, I counted the number of clumps that were producing berries (present resources) and the number of clumps with flowers (future resources).

Nest searches and observations

I selected six sites at which to conduct exhaustive nest searches from mid-March – early-June such that sites were distributed throughout the study area (south, central north), represented large and small site areas and represented the two host tree species (mesquite, acacia or a mix of both). At one of the six sites, Cactus Springs (a small, northern mesquite site), phainopeplas were exhibiting courtship behavior on 22 February, but when I returned on 4 April, no phainopeplas remained. In each of the two remaining small sites (Roman: a southern acacia site; and Big Springs: a mixed host tree site in Las Vegas), I searched an area of about 10 ha for phainopepla nests. In each of the large sites (Coyote Springs: a mixed tree, northern site; Ranch: a mesquite/mixed, northern site; and Piute: a southern catclaw site), I searched two ~10ha sites for nests. Each nest searching area was centered on an existing transect.

I attempted to visit each site every 3-5 days, but due to a shortage of person-hours during the early part of the season, I visited some sites only once a week. When I found a nest, I noted the contents, briefly described the nest tree, including the number of mistletoe plants on it, and recorded the location with GPS. On subsequent visits, I quickly checked nest contents when the parents were absent. I also observed parent behavior from a distance before and after I checked the nest. When I found an empty nest, I assessed whether or not the nest appeared damaged (e.g. by predators) and searched for nest and egg fragments in the vicinity of the nest.

Once young had left the nest, I measured nest and tree height. I counted the number of trees within 30m that had berry-producing mistletoe plants on them, and counted the number of mistletoe clumps on the nearest infected tree in each of the four quadrants (defined by the cardinal directions) from the nest tree.

In addition to these focused nest searches, I also recorded the location and general characteristics of any nests found on transects conducted during the breeding season.

Results

Presence/Absence surveys-general trends

Phainopeplas were present in the majority of sites surveyed during the fall and winter (Appendix 1). While they were also present in the majority of sites during the breeding season, they were present in fewer sites, abandoning three sites entirely. Furthermore, phainopeplas were not uniformly present in all subsites or on all transects on any given survey. At two sites during the breeding season, they disappeared from subsites (Meadow Valley Wash, Fire Canyon) in which they formerly had been present.

Phainopeplas were equally likely to be present in honey mesquite, catclaw acacia and mixed mesquite/acacia woodlands throughout the year and in the breeding season (logistic regression, $p>0.3$). They were present in all regions, although sites in the west were significantly less likely to be occupied than sites elsewhere in the study area (logistic regression, $p=0.022$). In general, sites comprised of mesquite-covered dunes, or the portions of such sites comprised of dunes, were significantly less likely to be occupied than non-dune areas (logistic regression, $p=0.027$). Many of these dune sites are located in the western portion of the study area.

The southern portion of the study area had the highest number, and the third highest proportion, of occupied patches. In almost all catclaw acacia sites in the south, phainopeplas were present throughout the winter and breeding season, although they were absent from some transects and subsites. During the breeding season, only one male and no females were detected at Empire and El Dorado Washes. The only mesquite site in the south, Big Bend, had a low density of very localized phainopepla in the mixed mesquite/tamarisk of the headquarters subsite.

Phainopeplas were present throughout the winter and breeding season in all sites that I surveyed in the Las Vegas area, although they were absent from the dunes at Sunset Park. Additionally, birders reported seeing a male on the Las Vegas Wash, and pairs in Red Rock Canyon during the breeding season.

In the northeast, phainopeplas were absent from all catclaw acacia sites along SR163 and I15 except where acacia was mixed with mesquite at the Warm Springs Ranch. However, they were present at catclaw acacia sites in Pahranagat, Valley of Fire and Blue Point/Rogers Springs. They were present at all of the Moapa subsites that I surveyed (mostly dominated by mesquite), although they abandoned Meadow Valley Wash during the breeding season. They were also present during the breeding season at all the other mesquite-dominated sites I surveyed.

Both of the two sites northwest of Vegas on highway 93 were occupied by phainopeplas during the fall and winter. At Corn Creek, phainopeplas were localized around the spring, and birders reported seeing them there during the breeding season. During the fall I saw one female in the

dunes, but during the breeding season, I did not detect any phainopeplas in the dunes. Cactus Springs was abandoned during the breeding season, although phainopeplas present there in late February were exhibiting courtship behavior.
All of the western sites except one small portion of Franklin, the areas of Pahrump east of (Kellog subsite), and in the town of, Pahrump, and near the town of Sandy were not occupied by phainopeplas. Phainopeplas remained in the first two of these occupied areas throughout the breeding season; the latter was not surveyed during the breeding season. Many of the western sites had large areas of mesquite-covered dunes, which as noted, were not usually occupied by phainopeplas.

Relationship between patch area/shape and phainopepla presence in sites

Occurrence of phainopeplas in patches throughout the year and during the breeding season was not related to patch area (logistic regression, $p>0.6$) and/or patch geometry (long and narrow washes vs. wider sites (woodlands, stringers and dunes); logistic regression, $p>0.7$). Qualitatively, however, patches that had moderately low mistletoe abundance and contained phainopeplas (see below), were larger than those that had low mistletoe abundance and no phainopeplas.

Relationship between mistletoe abundance and phainopepla presence on transects

Mistletoe abundance (measured in terms of total number of clumps counted on the random trees on the transect) is a very good predictor of presence of phainopeplas on transects (logistic regression, $p<0.001$). Phainopeplas were not present when there were fewer than, and usually present when there were more than, 46 clumps/transect, although they were absent from one transect with 50 clumps and one with 100 clumps (Figure 8). The number of clumps/transect ranged from 9-486. The number of clumps/transect is highly correlated with the mean number of clumps/tree and the mean number of clumps with berries/tree.

Nesting attempts and nest success

I found a total of 44 nests across all of the intensive nest searching sites, 29 of which were completed and contained eggs. Of these 29 nests, 15 produced at least one fledgling, for an overall nest success rate of 53%. Most nests contained two or three eggs or nestlings when I found them, although one nest contained only one nestling. I have no positive evidence that any nest fledged three nestlings, but I am certain that some nests fledged two nestlings. In total, a minimum of 68 eggs were laid, and a minimum of 25 young fledged (36%).

The number of nests that I found in each site varied from 4 nests/20 ha at Coyote Springs to 18 nests/20 ha at the Ranch site (Table 1). However, at the Ranch, only nine nests were completed. At Coyote Springs, one nest failed, one was never completed, and two may have produced fledglings, but I cannot be certain given that I did not visit those nests for more than one week. Nest success at the other four sites varied from 20-71%. At Roman, only 1/5 nests fledged young. At both Big Springs (n=7 nests) and the Ranch, 57% of the nests fledged young. 71% of seven nests fledged young at Piute, the biggest site. The ratio of eggs laid to young fledged varied from 0.08 at Roman to 0.52 at Piute.

Most nests that apparently failed were empty when I found them, suggesting predation, but few appeared disturbed. In one case, just as I found a nest for the first time, I detected a coachwhip snake poised 45cm over the nest, so I did not check the nest contents. However, earlier in the day, the female was carrying food to the nest, so it seems likely that she had nestling(s). On my next visit, the nest was empty but undisturbed. I assume that the snake killed the nestling(s). In two instances, I found dead nestlings in the nest, apparently abandoned. However, in one nest, small red ants were crawling over the nestling; according to S. Small (pers. com.), such ants can actually kill nestlings. I saw no evidence of cowbird nest parasitism.

Table 1. Phainopepla nest success at four sites in Clark County, Spring 2001. Nests from Coyote Springs and random finds are not included. Bold numbers are actual observed numbers; numbers in regular font are maximums based on max. clutch size (3 eggs) (#laid, #hatched), #eggs seen at last visit (#hatched) and #nestlings seen at last visit (#fledged). Bold proportions were the result of dividing bold numbers only. The range of proportions in normal type is: minimum = bold #chicks/max #eggs and maximum = max #chicks/bold #eggs.

Site (Host sp, size)	#nests with eggs	# successful nests	% successful nests	# eggs laid	#chicks hatched	#hatched/#laid	#chicks fledged	#fledged/#laid
Ranch (Mesq, big)	**9**	Prob. **5** (poss. 7)	**56** (78)	**22** (poss. 27)	**18** (poss. 24)	**0.82** (0.67-0.88)	**9** (poss. 13)	**0.41** (0.33-0.59)
Big Spr (Mesq, sm)	**7**	**4**	**57**	**14** (poss. 21)	**9** (poss. 13)	**0.64** (0.42-0.92	5 (poss. 8)	**0.36** (0.24-0.57
Piute (CC, huge)	**7**	**5**	**71**	**19** (poss. 24)	**18** (poss. 22)	**0.95** (0.75)	**10** (poss. 13)	**0.52** (0.42-0.68)
Roman (CC, sm)	**5***	**1** (prob. 2)	**20** (40)	**13** (poss.15)	**10**	**0.77** (0.67)	**1** (poss. 3)	**0.08** (0.07-0.23)
Total	**28**	**15**	**54**	**68**	**55**	**0.81**	**25**	**0.36**

*Doesn't include young of the year fledged before nest found

The first egg was laid approximately 9 March and the last nest fledged approximately 6 June. Within this three-month period, it appeared as though there were two general laying events, the first centered on the second week of March, and the second around the fourth week of April. It also appeared as though many phainopeplas started second nests, even when the first nest had been successful. Many of these putative second nests were not completed, but in several cases, laying did occur, and in at least three instances, it appeared as though parents raised two successful broods. For example, at two nests, I observed a young-of-the-year in close association with a breeding pair that had eggs in the nest on a territory that had an earlier successful nest. However, without color banding individuals, I cannot be certain that both nests belonged to the same pair.

In addition to nests found during nest searches, I found by chance 12 nests at seven other sites (for a total of 12 sites with confirmed breeding in the study area; Table 2). Ten of these nests contained eggs or nestlings. Also, young-of-the-year were seen at the Virgin River and at Corn Creek, but these sightings do not mean that phainopeplas bred at these sites.

Characteristics of nest trees

Phainopeplas nested in a variety of plants, including honey and screwbean mesquite, catclaw acacia, cholla, juniper, desert willow and cottonwood. At one site, of four nests, three were located in cholla and one in juniper, despite the availability of acacia, honey mesquite and cottonwood.

Other than the two nests in cottonwood, which were 7 – 9 m high, nests were generally low, about half to two-thirds of the way up the nest "tree". Across sites, mean nest height was 1.75 m and mean nest tree height was 2.9 m (n=23; Table 3). Nest height and nest tree height were lower at the two catclaw acacia-dominated sites than at the two sites where mesquite was dominant (Table 3). Nests were usually nearer the trunk of the tree than the edge of the canopy, although nests in cottonwood were in the smaller branches at the edge of the tree.

Many nest trees were not or were scarcely infected with mistletoe, and only a few clumps bore berries (Table 3). The mean number of mistletoe clumps/nest tree was 10.0; the mean number with berries was 3.4 clumps (n=23). On average, the nearest infected tree to the nest tree had 8.0 clumps, 3.67 of them bearing fruit. In contrast, the average number of clumps/tree on the random trees along the nearest transect usually was higher than that of nest trees and their nearest neighbors. For example, the two corresponding transects at Piute had averages of 5.7 and 28.1 clumps/tree. However, at Roman, nest trees were on average more infected than random trees, which had a mean of 5.0 clumps/tree.

Table 3. Characteristics of nests and nest trees (means are shown; n=23 nest trees but only 18 nearest neighbors (NN))

Site	Nest Ht (m)	Tree Ht (m)	# clumps w/ berries	# clumps w/o berries	Distance to berries (m)	Distance to nearest inf. Tree (m)	# clumps w/ berries on NN	# clumps w/o berries on NN	# trees w/ berries in 30 m	# inf. Trees in 30 m
Big Springs	2.6	3.3	3.5	9.9	0	--	--	--	6	10.3
Piute	1.6	2.9	4.1	4.4	1.8	--	--	--	8.7	10.7
Roman	1.3	2.5	2.0	5.8	2.6	--	--	--	15	--
Ranch	2.3	4.2	3.4	14.4	0.33	--	--	--	7.0	12.5
Overall	1.75	2.9	3.4	6.6	1.6	4.8	3.7	3.8	10.2	11.8

Despite these low infection rates, nests were never far from a source of berries. Many nest trees hosted a berry-producing mistletoe, and/or were close to a tree with mistletoe berries. The mean distance to the nearest tree with berries was 1.6m. On average, 10.2 trees with berries were found within a 30m radius of nest trees.

Discussion

Phainopepla occurrence

Phainopeplas occurred in mesquite and catclaw acacia patches throughout the study area, but were not present in all patches or in all parts of all patches. Of the factors examined by this study, only the amount of mistletoe, the region in which the patch was situated, and whether or not mesquite was growing on dunes were correlated with phainopepla occurrence. Given that desert mistletoe was one of the variables most frequently mentioned in association with phainopeplas in my literature review, and that phainopeplas subsist almost exclusively on this food during the winter, it is not surprising that phainopepla occurrence is well predicted by mistletoe abundance. This close relationship is underscored by the fact that within sites, phainopeplas are absent from transects with little mistletoe and present on transects with a greater abundance of mistletoe. Both of the other two factors may predict phainopepla occurrence because they themselves are correlated with mistletoe abundance and with each other. Mistletoe is less abundant in many sites in the west, where sites are more likely to experience a hard frost (Krueger 1998) and where dunes are more common. Mesquite on dunes is more water stressed than mesquite in riparian areas (D. Charlet, pers. comm.) and therefore a less suitable host for mistletoe (Lei, 1999). Additionally, suitable nest sites may be less common in the west and on dunes; in both cases, there are fewer clumps in which to hide nests, and on dunes, the mesquite is short and scrubby, and it may not be possible to place nests out of the reach of predators.

At the scale of patch size and isolation examined in the first year of this study, these two variables were not correlated with phainopepla occurrence. In many respects, this finding is not surprising. The natural habitat of both phainopeplas and desert mistletoe is highly fragmented and contains a large proportion of "edge", so it is unlikely that phainopeplas would be affected by many of the factors that negatively impact songbirds in other, artificially-fragmented ecosystems (e.g. increased predation and nest parasitism). Low songbird densities and reproductive success have also been attributed to diminished food resources (i.e. invertebrates) in small patches with large proportions of edge (e.g. Huhta et al. 1998, Zanette et al. 2000). However, given the natural configuration of much of its host tree habitat, it is unlikely that desert mistletoe similarly declines in response to increased proportion of edge.

On the other hand, if patches become small and/or isolated enough, other factors might negatively impact phainopepla presence and abundance. First, small, isolated patches may be less likely to be detected by phainopeplas than large or less isolated patches. Second, according to Hinsley (2000), once patches become so small that territories must comprise several patches, birds experience costs in terms of time and energy expenditure that may reduce reproductive potential. Third, the availability of mates (Huhta et al. 1998) or the opportunity for extra-pair copulations (Norris and Stutchbury 2001) may decline with patch size and isolate. Phainopeplas, like other birds (e.g. Lane et al. 2001) bustard paper), may be more likely to in habitat patches occupied by conspecifics. Fourth, the positive feedback between phainopeplas and desert mistletoe by which desert mistletoe accumulates in areas frequented by phainopeplas (which in turn respond to higher levels of mistletoe) may require a threshold number of phainopeplas to get started/be maintained. Small, isolated patches may not contain the critical number of phainopeplas for either of these last two processes to occur. During the next two years of the study, I will attempt to include patches that are smaller and more isolated than those studied this year, should such patches currently exist in my study area.

Phainopepla breeding behavior

Phainopeplas bred at a number of sites throughout Clark Co. (including the western portion) and neighboring counties, and I confirmed phainopepla breeding in some areas where Nevada Breeding Bird Atlas had been unable to confirm breeding (GBBO 2001). They appeared not to discriminate between mesquite- and catclaw acacia-dominated sites.

Of the patches abandoned during the breeding season, several had little mistletoe, and may have been abandoned due to a lack of resources. One such site was the site studied by Krueger (1998), in which phainopeplas had bred in the mid-late 1990s. However, others patches apparently had lots of mistletoe. These latter patches were typically quite small and contained few phainopeplas pre-abandonment. It is possible that the arrival of a predator such as a hawk could have caused all pairs to leave the patch.

Nesting success

In all of my intensive nest study sites except Roman, nesting success was high for a passerine bird. Even the smallest site, Big Springs, had high nest success. Furthermore, it appears that many breeding adults attempted two broods; this behavior has not been previously documented, and in fact a recent author suggested that it was not possible (Chu 1999).

There are several possible explanations for this high success and productivity. First, it may be related to the quantity of available resources. Given the warm, wet spring weather in the study area, berries were abundant and lasted for a long period, and insects were likely also abundant. Both of these factors have been correlated with the number of brooding pairs, the clutch size, and the number of fledglings (Walsberg 1977). In particular, the favorable spring weather, via its effect on resources, may have been responsible for the high proportion of nests with three eggs in my study. Krueger (1998) found only one three-egg nests at her Clark Co. study site, and Walsberg (1977) reports that three-egg nests are very uncommon in the desert. Abundant resources may have allowed parents to raise two broods. The 2001 breeding season lasted several weeks longer than those of 1997 and 1997 (Krueger 1998). Interestingly, of all the sites, Roman had the lowest average clumps/transect of all the breeding sites and the lowest nesting success, further supporting the resource availability explanation.

Second, the timing of breeding may also have been influenced by the warm weather. The emergence of volant insects in the spring apparently triggers courtship (Walsberg 1977); this emergence may have been earlier this year, further contributing to the length of the breeding season. In general, phainopeplas in southern Nevada breed several weeks prior to the emergence of reptilian predators and the arrival of many migrant songbirds (including cowbirds); the lack of predators and nest parasites during the early nesting stage may help explain phainopeplas' high productivity relative to other songbirds.

However, while high for passerines in general, the nesting success at all of my sites was lower than that reported by Krueger (1998). At her mesquite study site, approximately 80% of nests fledged at least one young (Kreuger 1998). The reasons for this difference are unclear, but I can suggest several differences between her site and mine that might bear further investigation. First, her site was entirely honey mesquite, whereas mine contained at least some (if they were not dominated by) catclaw acacia. Second, two of my sites were impacted by urban and agricultural development, which may have been correlated with higher incidences of predation and nest abandonment.

Characteristics of nest trees

Phainopeplas nested in a variety of trees and shrubs, including several that were not mistletoe host species and were relatively rare in the study site (e.g. desert willow). In my survey of the literature, I found references to phainopeplas nesting in all of the plant species used in the present study except cholla. I did not find any nests in *Yucca* spp., although they do nest in this genus elsewhere.

As expected from my survey of the literature, most nests were higher than 1.5m. Nest heights in the mesquite sites were similar to those found by Krueger (1998; mean heights of 2.6 m for nests and 4.8 m for trees respectively), but nest tree heights were a little shorter, perhaps reflecting the youth of trees at the Ranch site, and the fact that I could not measure the height of the huge cottonwoods used at the Big Springs site. Nest heights in catclaw acacia were about 1 m lower than those of Krueger's (1998) study, not surprisingly since catclaw acacia nest trees were shorter. The particularly low nest heights at Roman may have meant the nests were more vulnerable to predation, and may help explain the low nest success at that site.

At the two mesquite-dominated sites, phainopeplas sometimes nested in relatively large trees, in dense vegetation, with berries nearby, as described by Anderson and Ohmart (1978) and Krueger (1998). However, in the catclaw acacia-dominated sites, and even in portions of the mesquite sites, phainopeplas also nested in small, isolated trees, which were often at least partly dead. Furthermore, contrary to the findings of Krueger (1998), nest trees in most catclaw acacia and mesquite-dominated sites were on average less infected than randomly selected trees the same site. At Roman, however, they were relatively more infected than random trees, yet the mean number of clumps at this site was still lower than other sites. Phainopeplas may prefer trees that have a few clumps that offer food and nest concealment, but avoid trees with a lot of clumps (especially those with berries) that would attract large numbers of foragers. If this is the case, one would predict that sites with relatively low levels of mistletoe (such as Roman and Krueger's site), nest trees have greater than the average number of clumps, whereas at sites with abundant mistletoe, nest trees would have less than the average number of clumps.

Summary

Phainopepla overwintering and breeding habitat exists throughout Clark Co. and neighboring counties, but the most suitable habitat appears to be located in the northeastern, central and southern parts of the county. Phainopeplas overwinter and breed in both mesquite- and catclaw acacia-dominated sites. The high densities and breeding success of phainopeplas in many catclaw acacia sites suggest that more research management attention needs to be paid to these sites. In particular, while the breeding habits of phainopeplas in mesquite habitat have been documented by several authors, they have not been investigated in catclaw acacia habitat and may differ considerably. The response of phainopeplas to within- and among-site differences in mistletoe abundance highlight the need to define phainopepla habitat in terms of mistletoe, not just mistletoe host trees. I will continue to investigate these issues during the next two years of the study.

Some additional questions require further investigation. No effect of patch size or isolation on phainopepla presence was detected in this study, but it could be that the patches studied this year were not small enough to produce an effect. During the remaining years of the study, I will specifically address this use. The effect of food resources and predation on nesting success and productivity will also be a focus of investigation. Finally, phainopeplas appeared to move considerably within and among patches such that some patches were abandoned during the field season and others received an influx of phainopeplas. I will attempt to discern variables that are correlated with these movements.

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Adaptive Management of Desert Tortoise Management Actions

In February of 1996, Clark County contracted with BRD and UNR to develop and implement an experimental desert tortoise translocation program. The translocation program has been controversial and expensive. The controversy has resulted from an overwhelming public sentiment opposed to euthanasia of displaced and surplus tortoises and a lack of options for disposition of those tortoises. The expense has resulted from the necessity of properly and humanely housing these tortoises and the cost of conducting credible research into translocation. The USFWS allowed the programmatic translocation of tortoises by Clark County only as part of a credible scientific study. Preliminary results indicate higher than anticipated survivorship of translocated tortoises. The translocation study has resulted in a number of recommendations that will be presented to the USFWS that should streamline the handling of tortoises that, if adopted, would result in further savings. Finally, successful completion of the first phase of the translocation study should result in additional cost savings to Clark County.

Continued translocation of tortoises may depend, in part, on containing the cost. It is thus imperative that the Large-Scale Translocation Study Site (LSTS) be used as a cost-effective way to support as many tortoises as is consistent with sound management and humane treatment of the animals. Results of these studies will enable decisions to be made that may help control or reduce costs.

While a final conclusion is still premature, the Clark County Translocation Program seems to be a resounding success and will significantly expand knowledge of tortoise translocation, handling, housing, and maintenance. However, several critically important questions have arisen during the course of the Tortoise Translocation Project that require answers before a final conclusion on the success and future of tortoise translocation can be drawn. The following component projects will attempt to answer some of those questions.

Experimental Density Studies

The desert tortoise translocation program in Clark County, Nevada has placed over 2000 tortoises into the LSTS, a fenced sanctuary of 88 km2. This area now has an average density of 28.5 tortoises/km^2 (73.8/mi^2). The Service has asked us to determine the density at which the LSTS will reach its carrying capacity, and hence, how many more tortoises can be added to the LSTS. Desert tortoises are found in natural populations at densities as high as 110/km^2 (275/mi^2) and controversial anecdotal evidence suggests densities may have been as high as 770/km^2 (2000/mi^2) in some places of the Western Mojave. To persist after declines due to stochastic events such as drought, fire, and disease, local tortoise populations may need to attain such high densities, but it is not known whether high densities are sustainable without health risk to the tortoises. What follows is a preliminary report on our density study.

Introduction

Since the late 1980s, the Las Vegas Valley in southern Clark County Nevada has had one of the highest rates of urban growth. To accommodate this growth, new construction has destroyed millions of acres of desert tortoise habitat. When the desert tortoise was listed as a threatened species in 1989, Clark County faced an economic disaster if development was halted. To avoid this possibility and as part of a lawsuit settlement, Clark County wrote a short-term Habitat Conservation Plan (HCP) to protect large areas of desert habitat while still allowing others areas to be developed. The plan became effective in 1991 and was funded through mitigation fees paid by development companies on a per acre basis for all new developed land in the county. Tortoises displaced by urban sprawl were collected and placed in a holding and research facility, the Desert Tortoise Conservation Center (DTCC), funded by these fees. The 88 ha facility southwest of Las Vegas, NV has several sizes of pens used for maintaining tortoises and for research and is administered by Southern Nevada Environmental, Inc. (SNEI). In 1995 a long-tern HCP was approved, providing funds to implement conservation measures for the desert tortoise for a term of 30 years.

Nearly 2000 desert tortoises and resultant offspring were housed at the DTCC by early 1996, more than the facility was designed to accommodate and desert tortoises are still brought in to the facility. All tortoises that come into the facility are assigned a unique number. A red tag (~1 cm x 0.25 cm) with this number is attached with epoxy onto the carapace. Animals are placed in quarantine until results are returned from a blood sample that is tested for upper respiratory tract disease (URTD) via an ELISA screen. This quarantine can last up to six months. Tortoises that test positive for URTD are euthanized unless needed for research purposes.

Through 1996, several hundred healthy and URTD positive animals were used in research projects at the DTCC (e.g., Alberts *et al*., 1994; Niblick *et al*., 1994; O'Connor *et al*., 1994; Rostal *et al*., 1994a; Rostal *et a*l., 1994b; Ruby and Niblick, 1994; Ruby *et al*., 1994a; Ruby *et al*., 1994b; Spotila *et al*., 1994; Zimmerman *et al*., 1994). The majority of the remaining animals were eventually released back into the desert starting in the spring of 1997. Land administered by the U.S. Department of the Interior Bureau of Land Management was set aside as a translocation site for those remaining animals. The Large Scale Translocation Study Site (LSTS) is a fenced sanctuary of 88 km^2 along the west side of interstate 15 south of Jean, NV, and north of the resort area known as Primm on the California-Nevada border. Another small-scale translocation study site on the southern end of Las Vegas Valley, Bird Spring Valley, was used in 1997 through 1999.

As of November 1999, the desert tortoise translocation program in Clark County placed over 2000 tortoises into the LSTS. This resulted in an average density of 28.5 tortoises/km^2 (73.8/mi^2). The original density (for tortoises over 180mm MCL) was 18.8/km^2 (48.6/mi^2) and 9.7/km^2 (25.2/mi^2) were added (again tortoises over 180mm). The Fish and Wildlife Service (FWS) asked that the University of Nevada in cooperation with the U.S. Geological Survey, develop a study to determine what density levels the LSTS could support without resulting in deleterious impacts. Outbreak of symptoms of URTD may be related to stress such as overcrowding. This preliminary study addressed the Fish and Wildlife Service's questions concerning the carrying capacity of the LSTS.

Desert tortoises are found in natural populations at densities as high as 110/km^2 (275/mi^2; Berry 1978) and according to Berry (1979, 1984) densities may have been as high as 770/km^2 (2000/mi^2) in some places of the western Mojave. To persist after declines due to stochastic events such as drought, fire, and disease, local tortoise populations might need to attain such high densities (Fish and Wildlife Service 1994). If densities occur as high as 770/km^2, then the LSTS is far from capacity. However, the density of 770/km^2 is not supported by any hard data, just anecdotal evidence (Berry 1984). Also, LSTS is in the Eastern Mojave and carrying capacity may be lower than in the Western Mojave. Densities of 33-40/ km^2 were recorded at a nearby study site at Arden, Nevada, (Burge and Bradley 1976). We used fenced pens at the DTCC stocked with varying densities of desert tortoises for a preliminary study to test the main hypothesis that desert tortoises can survive and maintain good health status at relatively high population densities. The results of this study are intended to support the determination of appropriate tortoise population densities in preserves.

HYPOTHESES:

Annual Plant Production. H_{O1}: Mean above ground annual plant biomass does not vary among pens of different densities.

Almost all of the tortoises living in the pens used in this study were removed over two years ago, therefore, the annual biomass before adding tortoises should be similar. We expect that under crowded conditions, tortoises may consume all available food. This will be realized by a greater relative decrease in annual plant biomass in the pens with the highest densities. Therefore, H_{O1} should be rejected.

Mass. H_{O2}: Mean mass of animals does not vary among pens of different densities over time.

If under the higher densities the tortoises consume all available forage, then these tortoises will lose mass faster than less crowded populations and wild populations. Increased stress due to fighting and disease could also lead to lower masses in higher density pens. Thus, we expect to reject H_{O2}.

Health Status. H_{O3}: The incidence of URTD symptoms does not vary among pens of different densities.

We expect that under crowded conditions tortoises may experience higher stress levels, social interaction, and aggression. Increased stress may result in greater incidence of URTD symptomatic tortoises. Also, the increased social interaction and contact at higher densities may result in increased incidence of URTD symptomatic tortoises and tick infestations. Tortoises that have less to eat and are losing mass may be more susceptible to disease. Thus, pens with higher densities may exhibit a higher proportion of tortoises with disease symptoms and external parasites and we therefore expect to reject H_{O3}.

Behavior. H_{O4}: Behavior does not vary among pens of different densities.

We expect that under crowded conditions tortoises may experience higher levels of social interaction and contact. There may be increased fighting among males and perhaps females. Increased levels of aggression may influence normal behavior. Anecdotal information suggests that in pens and backyards or other confined areas the presence of two or more large males results in higher levels of aggressive social interactions. Subordinate males, and even some females, may retreat to burrows and lose foraging opportunities. Data from temperature data loggers may indicate that animals in the higher density pens have higher body temperatures and have different daily patterns than animals in the lowest density pens. Thus, we expect to reject H_{O4}.

Mortality. H_{O5}: Mortality rate does not vary among pens of different densities.

We expect that under crowded conditions, tortoises may experience higher levels of indirect mortality due to starvation or stress induced disease processes or tortoises may experience increased aggression resulting in direct mortality. Therefore, we expect to reject H_{05}.

Reproduction. H_{O6}: Clutch size, clutch frequency, and annual egg production do not vary among pens of different densities in the second year of the study.

In the first year, we do not expect there to be any differences among the pens in the average clutch size, clutch frequency or annual egg production. Most of these females entered hibernation in good physiological condition and therefore should be able to produce at least one clutch of eggs. Therefore, reproduction was not studied in the first year. In future years, we expect that the females in the higher density pens may produce smaller clutches (or none) and fewer clutches either due to higher social interactions or reduced forage availability. Therefore, we expect to reject H_{O6}.

Methods

This study was designed to encompass a range of densities rather than use replicates of lower densities. A sound statistical practice is to have at least four replicates if analysis of variance is to be used. With the current pen configuration, this was not possible. However, when the analysis is to be regression, replicates are not necessary but a large range in levels of the independent variable (density) is desirable. Small holding pens at the DTCC are at densities much higher that at the LSTS and the densities of tortoises in three 0.09 km^2 enclosures in Rock Valley are as high as 133/km^2 (345/mi^2). The minimum density that would have at least two adult males and two adult females in a pen (250/km2) determined the lowest density for our study. We also wanted the range to encompass 750/km^2 (the anecdotal highest known density).

We chose the upper level of 2500/km^2 so that the range of densities would be over an order of magnitude, making regression a more robust test of the data.

Pens. There are nine fenced pens at the DTCC ranging in size from 0.03-0.05 km^2 (0.013-0.019 mi^2). These pens are in a 3 x 3 square (Figure 1). The fences between the pens have fiberglass attached to inhibit contact between the adjacent pens. The mesh fencing extends 45 cm below ground in most areas to prevent a tortoise from digging under the fence and escaping. Cohorts of tortoises ranging in density from 250/km^2 to 2500/km^2 (648 to 6475/mi^2) were randomly assigned to a pen.

Tortoises. A total of 728 tortoises at the DTCC were available for this study. The majority of these tortoises were at the DTCC for one year or less. Less than one third were wild tortoises removed from areas slated for development and many of the adult animals were former captives (pets) or were of unknown origin. In general, three adults (two females and one male) were held in one small holding pen. Males that could not be accommodated with one or two females were alone in a pen. Smaller tortoises were held at higher densities.

The size distribution of tortoises in each of the treatments was determined from percentages derived from the average values in numerous annual reports from square mile plots studied from the 1970s through the 1990s. These reports characterized the size distribution of tortoises based on maximum midline carapace length (MCL). These figures were from locations in the eastern and western Mojave Desert habitats (California, Nevada and southern Utah) and Sonoran habitat (Arizona). However, the habitats in the Arizona sites were not similar to southern Nevada and the Utah distributions were not similar to the rest of the sites, so data from these study plots were not included. Percentages used were: 47.1% adults (>215 mm MCL), 20.2% subadults (170-215 mm MCL), 25.0% juveniles (100-170 mm MCL), 6.7% very small (60-100 mm MCL), and 1.9% hatchling (40-60 mm MCL). The average ratio of male to female adults was 1:1. Because the small-sized animals are difficult to observe, the numbers of hatchlings and very small tortoises are usually underestimated in reports. To correct for this, we placed additional small-sized and hatchling tortoises in each pen. Based on the average reproductive output from 1997 through 1999 in Bird Spring Valley and assuming 75% mortality, 1.8 small tortoises per adult female in the pen were added. Only healthy animals were used. A healthy animal was one that has tested negative for URTD via an ELISA screen **and** had no outward symptoms of illness (runny or occluded nares, wheezing, moist eyes). The total numbers of tortoises needed to achieve the densities assigned to each pen are shown in Table 1. Using the distribution given above and rounding to whole animals, the numbers of tortoises needed for each size class in each pen are also listed in Table 1.

In addition to placement of tortoises into the pens at the predetermined densities this study involved six major tasks. The majority of the tasks were repeated on a monthly or bimonthly schedule. An additional task, pen characterization, was performed only once during the first year.

Set-up Procedures. Before any animals were released into the pens, all of the pens were searched for tortoises left from earlier studies and for any fence needing to be repaired. The pens were not uniform in topography with four of the pens having a large wash passing through the pens. The remaining pens had either no wash area (one pen), minimal wash area (one pen), or moderate wash area (three pens). The larger washes had several large caliche overhangs that could serve as shelter sites. Since not all of the pens had this feature, the caliche dens were checked with a fiber optic scope to ensure that there were no tortoises inhabiting them and large rocks were placed in the openings so that the shelters could not be used. All of the pens had artificial burrows that were either removed or blocked so that the tortoises could not use them unless the animals cleared the entrances.

By 27 April 2000, all tortoises to be used for this study were transferred to the pens. Animals from each size class were randomly assigned to a treatment pen until the target number was reached. The MCL means for adult females assigned to the pens (Table 2) were not significantly different among pens ($F_{8,129} = 0.836$, $P = 0.4334$) nor were means for adult males ($F_{8,130} = 0.284$, $P = 0.9703$).

For initial processing, animals were removed from holding pens by SNEI personnel, placed in a plastic storage bin and brought to a shaded area. Animal numbers were checked against the list of assigned pens and the animal number and assigned pen were recorded on a data sheet. MCL to the nearest 1 mm (slide caliper) and mass to the nearest 1 gram (electronic balance) were measured and a check for URTD symptoms was performed. Animals that had symptoms of URTD were returned to SNEI personnel. All ticks were removed at this time. On animals >150 mm MCL a unique mark consisting of a combination of one to four colored dots was painted on the first and second left costals and third and fourth right costals (approximately 5 mm diameter) with non-toxic paint. The pattern was visible from a distance of 100 m with binoculars. A pattern was read from left to right and could therefore be interpreted from either side of the animal and was at least partially visible when an animal was in a burrow. When the animal was finished with processing it was returned to the bin and the data sheet was clipped to the bin. Tortoises were sorted by pen and transported to the pens where they were given an opportunity to drink water. Tortoises were weighed again before being released into the center of the assigned pens during the early morning or late afternoon. Placement was under the shaded side of a shrub. Tortoises were monitored during and immediately after the release for signs of overheating. Tortoises rarely remained in the shade.

Annual Plant Biomass. No supplemental food was added to the pens. Irrigation also was not used to stimulate germination and growth of annual plants so that forage availability in the pens was comparable to that in the LSTS. To assess the availability of food, primary production of annual plants was sampled for each pen. Originally, this was to occur before animals were placed into the pens and then on a monthly basis until October. However, not enough personnel were available for preparing pens, processing animals, and pre-release vegetation. Therefore, annual plant biomass was not measured until early June of 2000.

The technique for estimating biomass was adapted from Andariese and Covington (1986) and Catchpole and Catchpole (1993). Five random points with a random compass direction were chosen in each pen for each month of data collection. Each point was the beginning of a 50-meter transect. If the compass direction sent the line through a fence, the direction was shifted +/-90°. For each transect, 15 random points were selected. Each of these points was the corner of a 0.1 m² quadrat (75 quadrats per pen). If the point landed in the middle of a shrub, the quadrat was moved to under the edge of the canopy. Percent cover by perennial vegetation and perennial species were recorded. The amount of vegetation within each quadrat was estimated by categorizing quadrats from 0 to 10, where 0 was no measurable plant biomass and 10 had the most abundant annual plant biomass. Data on the substrate (*e.g.*, cobble, sand, desert pavement, wash, disturbed) for each quadrat were also recorded. Annuals were categorized into wet and dry (standing only) for each quadrat. At the same time, outside of the pens, similar transects were sampled. However, on these transects two representative quadrats from each category, 1 through 10, were clipped to calibrate estimation values. Plants were sorted into bags for standing green and standing dry annuals. Each bag was labeled with the date, transect number, and rank. Plants were dried in a drying oven for 48 hours at 50°C and then weighed. For each, wet or dry vegetation, a regression analysis was performed for category (1 to 10) versus biomass, yielding a regression equation. The ranking values for each quadrat in each pen were then inserted into the regression equation to generate a biomass equivalent for both wet and dry samples per pen. A mean for wet and dry vegetation in each pen was calculated by taking the mean of all quadrat estimates.

Mass. During year one of the study (2000), tortoises were weighed monthly until tortoises became inactive in the fall. During year 2 (2001), tortoises were weighed in April, May and June. The greatest amount of effort was placed on finding and weighing tortoises $\geq$150 mm MCL (*N*=320). However, any tortoise encountered was weighed and inspected for disease. Pens were intensively searched during the morning from sunrise until ambient temperature reached 32°C (90°F) at waist level.

Each searcher carried a list of tortoises residing in the pen to be searched and the corresponding sex and paint pattern. Searchers checked the number tag on the animal against the list and made sure the paint pattern was correct. Paint patterns were touched-up at this time. The sex of the animal was recorded and checked against the list. Any discrepancies were noted and evidence of why a sex was assigned was recorded (e.g., concave plastron, mating position). The quadrant in the pen was noted as well as if the animal was along the fence or within ten meters of the fence. Location (under vegetation, in the sun, in the shade, in a burrow) was also noted and activity when first observed (walking, mating, fighting, eating, drinking) was recorded. Any other tortoises within one meter were recorded. A plastic cup, such as one of a large cottage cheese or yogurt container (or casino change cup) was placed on top of the weighing pan of a portable electronic balance to immobilize the animal. The animal was then placed on the balance to take mass in grams at the point of location. A small dot of paint was placed on the 5th vertebral scute to indicate that the tortoise had been measured for the month. Dot colors changed monthly. Once processing was finished, the animal was returned to its burrow or placed in the nearest shade. Scales were tared monthly. A body condition index (CI; Table 2) was calculated for each time a tortoise was measured by dividing the body mass (g) by the cube of the MCL (volume in cm^3). Fluctuations in this parameter allow for more accurate indications of hydration status of an animal than do changes in biomass.

Health Status. Health status data were collected monthly. At the same time that mass data were collected, the health status was evaluated based on outward symptoms of URTD. Nasal exudate, wet eyes, occluded nares, and wheezing were symptoms noted on data sheets. Presence of ticks was also noted but ticks were not removed. Signs of heat stress such as salivating were also noted.

Behavior. During the first week after release the perimeter of the pen areas were walked daily to count tortoises that were following the fence. At least one day per week was designated as an observation day. Observers arrived at their starting point at sunrise and walked a set pattern that covered all fences and crossed the diagonals of each pen. Patterns and starting points varied among days so that no area was always observed early or late during the observation time. When a corner was reached, observers spent five minutes searching the area. Observations were simultaneous: an observer did not start the five -minute bouts until all four observers reached the corner. To increase the observable area, ladders were used at each corner to observe the inner areas. The observable area was searched with and without the aid of binoculars. Any surface-active tortoises were noted on data sheets. Pen, paint pattern, time, quadrant of pen, type of activity, other tortoises in close proximity, and distance from fence were noted on the data sheet. Data on social interaction such as fighting, courtship, and mating included identity of tortoises involved. General behavior such as digging, basking, eating, and drinking were noted. Comparisons among the pens included the total incidences of fighting and fence pacing.

Mortality. During observation sessions and monthly mass collection any carcass was removed from the pens. Pen number, animal number, paint pattern, location in the pen and general description of the tortoise's condition (near fence, upside down, in a burrow, on desert pavement, etc.) were noted on the data sheet.

Reproduction. Five pens (lowest density, middle density, highest density, and two others) were used to determine reproductive output over the entire range of densities. All three of the females in the lowest density pen were chosen and six females were randomly chosen from the remaining four pens. Radiotransmitters (AVM Instrument Co., SB2 model) were attached to females that were at least 200 mm-maximum carapace length and packages did not exceed 5% of the mass of the tortoise. Transmitters were attached to the anterior carapace using two-part putty epoxy with the antennas secured in several places to the lower edge of the costal scutes. No epoxy was placed over the scute seams. Silicone sealant was used to protect antennas and the transmitters were covered with the putty epoxy.

Female tortoises were located at 14-day intervals from April 23, 2001 though July 30, 2001 to determine the presence of successive clutches. All of the tortoises were located with radiotelemetry. At the point of location, data collected included time, temperature, behavior and pen quadrant (southeast, northeast, southwest, northwest). The area was flagged to facilitate returning the animal. All flagging was removed when the tortoise was returned. Once all pertinent data were collected, tortoises were handled with latex gloves, with new gloves used for each animal handled. Tortoises that were deep in burrows and did not respond to tapping (Medica *et a*l. 1986) were left in place. Tortoises available for capture were placed in a sterilized container and transported to the x-ray staging area by hand or transported in an air-conditioned vehicle.

At the staging area, tortoises were kept in a shaded area until processed. Every time a tortoise was retrieved for x-raying, it was weighed on a portable electronic balance, inspected for ticks, and examined for signs of upper respiratory tract disease and shell lesions. During the first capture of the year, measurements of midline plastron length, midline carapace length (MCL), carapace width, and shell height to the nearest 1 mm were taken with a caliper. Animals were then returned to the tote and taken to the portable x-ray machine. The date, pen number, and animal identification number were written on X-ray labeling tape that was then placed on the film cassette. A dime was taped next to the label. The film cassette was positioned under a portable x-ray machine suspended from a tripod and the tote with the tortoise was placed on top of the cassette. Using film cassettes with rare earth screens that amplify the amount of energy recorded on x-ray film, the exposure with the Minxray 80 was 60 kV for 0.06 seconds. This is not expected to have any adverse impacts on the health of the tortoise or on the development of the eggs (Hinton *et al*., 1997).

Following x-raying, animals were returned to the point of capture and released under the nearest shade or in their burrows. No animals were handled when air temperature was 32°C (90°F) at waist level as outlined in the protocols developed by the Desert Tortoise Council (Desert Tortoise Council, 1999). All transportation totes were sterilized with a 10% solution of bleach prior to subsequent use. The electronic balance and calipers were also sterilized.

X-ray films were developed before the next x-ray session. Egg widths were measured with a dial caliper. The dime image was also measured and compared to the original dime to determine if there was any magnification of objects. Successive clutches were usually separated by one or more sessions without eggs. In instances where this was not the case, thickness of shells and width and shape of eggs were used to indicated different clutches.

To minimize the impact of this study and to protect the welfare of the tortoises, once an individual had no eggs for 2 consecutive x-raying sessions in July, it was no longer transported to be x-rayed. The end of the reproductive season was indicated when all tortoises had been found without having eggs present in the x-rays for two consecutive sampling periods in July (4 weeks).

Pen Characterization. Perennial cover was estimated using a line-intercept method on six 50-meter transects per pen. To determine percent cover by perennials, start and end meter for each perennial plant crossing the measuring tape were recorded. Species, greatest width, perpendicular width, and height were also measured. Start and stop meters were also collected for desert pavement, wash, and disturbance. Each transect was characterized for general topography such as percent of wash area, desert pavement, and disturbance. The pens were not uniform in these attributes, which could impact any results.

Analyses. Change in mass, prevalence of sickness, aggressive behaviors, and survival-to-hibernation were compared among treatments using regression analyses. Annual plant production was compared using regression analysis and single factor analysis of variance. Reproductive parameters were analyzed using regression analysis and multi-factorial analysis of covariance with MCL as the covariate.

Reproduction studies are ongoing at two sites in southern Nevada, Bird Spring Valley and Piute Valley. Bird Spring Valley is located one valley west of the DTCC and has similar physiographic features. Piute Valley is in the Piute-Eldorado DWMA to the east of the DTCC and is sandier. Both of these sites were used as standards of reproduction in unmanipulated areas.

Results

Pen Characterization. There were no significant differences in percent cover of perennial vegetation among the nine pens ($F_{8,63}$ = 1.402, P = 0.2133). There were, however, significant differences among pens in the amount of disturbed soil present ($F_{8,63}$ = 1.402, P = 0.2133) with Pen 9 (1500/km^2) having a significantly greater amount of disturbance along the transects than all other pens except pen 7 (500/km^2). The main source of disturbance was related to fence building and installation of irrigation lines.

Annual Plant Biomass. Due to time constraints, annual plant biomass was measured during June and July in 2000 and June in 2001 (Table 3). The winter of 1999-2000 was one of below average precipitation. As a result of this, annual plant production was minimal and plants that did germinate either died before fruiting or fruited at a small size. Only three annual plants were observed on the transects: *Plantago* spp., *Eriogonum* spp. and *Allionia* spp. *Plantago* was the most abundant in all pens.

Mean total biomass in June 2000 was significantly different among the pens ($F_{8,666}$ = 3.128, P = 0.0018). A *post hoc* test (Scheffe's, □ = 0.05) revealed that the lowest density pen of 250 animals/km^2 had a significantly higher mean annual plant biomass than the means in the pens containing 750 and 1250 animals/km^2 (Table 3). No other pair-wise comparisons were significant at this time. Regression analysis showed a slight negative but not significant trend between density and mean biomass (r^2 = .005, P = 0.774, N = 975). Mean total biomass decreased in all pens from June to July (Table 3) but there were no longer any significant differences among pens ($F_{8,666}$ = 1.792, P = 0.0755), nor was any trend evident (r^2 < 0.001, P = 0.9669, N = 675).

Annual plant production increased ten-fold in all pens from 2000 to 2001 (Table 3). The winter of 2000-2001 had sufficient precipitation such that annual plants germinated in large quantities. While *Plantago* spp. was still the predominant species, additional species such as the exotic grasses *Bromus madritensis* and *Schismus barbatus* were found on transects in all of the pens. The exotic forb *Erodium cicutarium* was also present. There were no significant differences in mean annual plant biomass among pens in 2001 ($F_{8,666}$ = 1.796, P = 0.0747), nor was any trend evident (r^2 = .001, P = 0.4301, N = 675.

Mean annual plant biomass at Bird Spring Valley was approximately 20 times greater than the mean biomass for all pens in 2000 (4.22 $\pm$ 0.31) and 2001 (46.96 $\pm$ 3.54). Bird Spring Valley has considerably less disturbed area than the pens. The 2000 and 2001 biomasses included several more species of native forbs and two exotic species, *Bromus madritensis* and *Erodium cicutarium*.

Mass. During 2000, pens were searched in May, June, July, August, September, and October (one through six months after release in April. During 2001, pens were searched in April, May, and June (12 through 14 months after release).

Because capture probabilities were low for small tortoises, only animals greater than 170 mm were used in mass analyses. Mean masses at the start of the study did not differ significantly (ANCOVA, $F_{8,274}$ = 0.623, P = 0.7579) and animals in all nine pens lost mass from the initial release through July 2000 (Figure 2). There was a rain event in August (month 4 since release) during the afternoon of the first day of searching. Those two pens were therefore searched another day. After the rain, tortoises in all of the pens had greater mean masses than when they were initially placed into the pens (Figure 2). Mean masses were higher at the start of 2001 than at the start of 2000 (Figure 3) and while most means declined through June 2001, this decline was not as great as in 2000. The mean mass in the lowest pen actually increased during this time (Figure 3).

A body condition index value (CI) was used for all remaining analyses among pens. There was no difference in CI between males and females ($F_{1,281}$ = 0.191, P = 0.6625) so these data were pooled. There was no trend between density and CI at the initiation of the study (r^2 = 0.002, P = 0.4094, N = 281) and while the mean CI in each pen declined until the summer rain, this lack of trend continued throughout 2000. At the start of 2001 there also was no significant relationship (r^2 <<0.001, P = 0.9272, N = 221). There was however, a negative relationship during May 2001 (CI = 0.194 - 4.243E-6 * density; r^2 = .021, P = 0.0515, N = 240). A similar relationship was found in June 2001 (CI = 0.187 - 4.085E-6 * density; r^2 = .010, P = 0.0763, N = 222).

At the start of 2001, tortoises in all pens except pen #7 had greater mean masses than when the animals were placed in the pens. May of 2001 mean masses were also higher than were those of 2000 except for pen #7. This pattern held for June of 2001 and June of 2000. Due to the physical topography, vegetation cover, and a constant rotation of field personnel, pen #7 was the most difficult pen to search during monthly mass collection. Even with added personnel and search days, only two of the ten animals over 170 mm MCL were found every month in 2000 and this most likely biased the results. In 2001, capture rates were improved with six found every month. This may be because the field crew working in 2001 consisted of the same personnel every month.

Health Status. None of the animals that were placed into the pens showed any symptoms of URTD and all ticks had been removed. In 2000, during the 1572 occasions that tortoises were handled to collect mass data, 20 tortoises were observed with mildly runny noses or runny eyes (Table 4). An additional four animals had wheezing or labored breathing in 2000. The highest density pen, 2500/km^2, had the most tortoises with these symptoms at eight (9.2 % of observed animals). Only the second lowest density pen, 500/km^2, had no symptomatic tortoises. There was no trend between density and presence of URTD symptoms in 2000 (r^2 = 0.41, P = 0.6006).

In 2001, 46 tortoises exhibited URTD symptoms. Forty of those animals had runny eyes and/or runny nares and seven exhibited wheezing or labored breathing. (Table 4). Again, there was no trend evident (r^2 = 0.015, P = 0.7547).

The exhibition of URTD symptoms appeared to be transient as most animals that showed symptoms in one month did not present symptoms the next month and only six of the 24 animals with symptoms in 2000 showed symptoms in 2001. Of those animals with symptoms, only those with runny eyes or nares shoed symptoms in more than one month. Animals with only labored breathing were never symptomatic a second month, indicating that this is not a reliable indicator of disease but more likely an indication of recent strenuous activity.

During 2000, the second highest density pen, 2000/km^2, had ten tortoises with ticks (Table 4). The middle density, 1250/km^2, had three, the highest density had two, and the second lowest, 500/km^2, and third highest, 1750/km^2, each had one tortoise with ticks.

Ticks were not as prevalent in 2001. During the 1304 handling occasions, a total of seven animals were observed with ticks in 2001. The second highest density had three tortoises with ticks, the highest density had two (one with over 50 ticks), the third highest density had one animal and the second lowest density had one tortoise with ticks. None of the animals with ticks in 2001 were the same as had ticks in 2000.

Behavior. This data has not been analyzed.

Mortality. A total of 30 animals died between time of release through winter dormancy (Table 5). Throughout 2000, the only pen with no mortality was the lowest density pen. Within the first 30 days after being released into the pens, four tortoises were found dead. All four were >280 mm MCL and three of the four were males >310 mm MCL. Two were found upside down next to the fence (males) and the other two were in the open and one was inverted. Signs of scavenging were evident on two of the carcasses. Over the next 30 days, three animals were found dead: one 167 mm MCL upright next to the fence, one 97 mm MCL upright in the center of the pen, and one 237 mm MCL in a burrow. The animal found in the burrow was never found more than 1 meter from the burrow on 13 of its 16 observations.

During July (61 - 90 days after release) seven additional carcasses were found. Four of these were adults (two male, two female) and three were very small (<100 mm MCL). The three largest adults (>260 mm MCL) were all found upright and in or near a shelter. One female (340 MCL) found near a shelter was found next to a burrow it had been using that had collapsed.

With the exception of three tortoises, the remaining 16 deaths in 2000 were all tortoises less than 150 mm MCL. Nine of those 13 animals had not been observed since being released and two had not been observed since June. One tortoise was last observed alive on 15 September 2000. No animal number could be recovered from one individual. Of the three larger tortoises (230 mm MCL found in August, 222 mm MCL found in March 2001 and 264 mm MCL found in April 2001), the two found dead in 2001 were found in burrows and had been dead for several months. Both were last observed alive on 17 October 2000 and both animals were observed several times with runny noses in 2000.

Although there was a positive trend between density and mortality rates in 2000 (arcsine percent of total observed), this relationship was not significant ($r^2 = 0.118$, $P = 0.3662$). There were no deaths reported from winter emergence in 2001 through the end of July 2001.

Reproduction. Midline carapace length of females chosen for the reproduction study did not vary significantly among pens ($F_{4,22} = 0.489$, $P = 0.7440$). X-raying commenced on 23 April 2001. Three females had eggs on this date and each was located in a different pen (Table 6). First clutches appeared on x-rays from 23 April through 18 June. One female laid her first clutch (nine eggs) by 7 May while one female held on to her first clutch (one egg) until after 16 July. Second clutches first appeared on x-rays taken 21 May and all second clutches were laid by 2 July (Table 6).

Only one animal produced eggs in the lowest density pen (pen 1, 33%) while all six had eggs in the second highest density pen (pen 2, 100%). The remaining three pens had five females producing at least one clutch of eggs (pens 3, 5, and 8, 83%). The female in pen 1 that had eggs produced only one clutch of 6 eggs. One female in each of pens 5 and 3 (the next highest densities) produced a second clutch (0.17%). Two animals in pen 2 had two clutches (the second highest density, 33%) while 3 females in pen 8 produced two clutches (the highest density, 50%). One animal in pen 2 produced a third clutch of one egg.

Clutch and egg parameters for each pen are listed in Table 7. Although a positive trend was evident among the five pens in size of first clutch, this was not significant (clutch size = 0.001

density + 4.764; r^2 = 0.031, P = 0.4357, N = 22) and there was no significant difference among pens in size of first clutch ($F_{4,16}$ = 0.455, P = 0.7676). The positive trend was also not significant for the second clutch (clutch size = 0.001 density + 2.091; r^2 = 0.186, P = 0.3333, N = 7). There was a significant difference in size of second clutch ($F_{3,2}$ = 48.280, P = 0.0204). However, because the sample size was low for this comparison, the result is not statistically sound. Clutch frequency and annual egg production also showed positive trends among the pens but neither was significant (CF = 0.001 density + 4.710, r^2 = 0.031, P = 0.4357, N = 22; AEP =0.001 density + 4.710, r^2 = 0.093, P = 0.1670, N = 22). Clutch frequency ($F_{4,15}$ = 0.555, P = 0.6983) and annual egg production ($F_{4,16}$ = 0.670, P = 0.6222) were not significant among pens.

Of the females that had eggs in all five pens, the average size for the first clutch (mean $\pm$ one standard error) was 5.6 $\pm$ 0.5 eggs (range 1-10) and for the second clutch was 3.6 $\pm$ 1.6 eggs (range 1-6). Mean size of the first clutch was significantly greater than that of the second clutch (ANCOVA, $F_{1,26}$ = 9.158, P = 0.0055). The average total number of eggs or annual egg production (first plus second clutch) was 6.8 $\pm$ 0.7 eggs. Overall clutch frequency was 1.4 $\pm$ 0.6 clutches. As expected, there was a significant positive relationship between annual egg production and MCL (AEP = 0.99 MCL - 18.348; r^2 = 0.333, P = 0.0049, N = 22). There was also a correlation between number of eggs in first clutch and MCL (Clutch size = 0.072 MCL - 12.737; r^2 = .363, P = 0.0030, N = 22) and number of eggs in second clutch and MCL (Clutch size = 0.071 MCL - 14.536; r^2 = 0.603, P = 0.0399,N = 7).

After adjusting for the effect of body size (MCL), the mean width of eggs in the first clutch (38.1 $\pm$ 0.5) was not significantly different from the mean width of eggs in the second clutch (39.7 $\pm$ 0.5) or third clutch (36.5; ANCOVA, $F_{1,27}$ = 2.918, P = 0.0991). There was a significant relationship between egg width of the first clutch and MCL of female tortoises (EW = 0.55 MCL + 24.094; r^2 = .248, P = 0.183, N = 22), but not between egg width of the second clutch and MCL (EW = 44.743 - 0.019 MCL; r^2 = 0.099, P = 0.4477, N = 8).

Mean MCL was significantly greater at DTCC (250 $\pm$ 45 mm) than at BSV (229 $\pm$ 2 mm; t = 3.768, P = 0.0006). However, after correcting for MCL, clutch parameters in Bird Spring Valley in 2001 were similar to the overall mean values in the pens with regards to average clutch size for first clutches (5.2 $\pm$ 0.2 eggs; ANCOVA, $F_{1,40}$ = 3.545, P = 0.0670) and clutch frequency (1.6 $\pm$ 0.1; $F_{1.40}$ = 1.997, P = 0.1653). The average size of second clutches in Bird Spring Valley (4.3 $\pm$ 0.4 eggs) was significantly greater than that at the DTCC ($F_{1,17}$ = 5.778, P = 0.0279) as was mean annual egg production (7.9 $\pm$ 0.5 eggs; $F_{1,40}$ = 10.776, P = 0.0021).

Discussion

We cannot accept H_{O1} (mean above ground annual plant biomass does not vary among pens of different densities) for June 2000. However, after three months and again after one year, there were no significant differences among the pens. That the aboveground annual plant biomass was nearly 20 times greater at Birds Spring Valley on both years may be due to the amount of disturbed area in the pens. Also, biomass was measured one month earlier in Bird Spring than at the DTCC in both years and consisted of mostly wet vegetation while the DTCC plants had dried by the time biomass was measured.

We can reject H_{O2} (mean mass of animals does not vary among pens of different densities over time). No significant differences emerged until the second year of this study. Year one was an extremely poor year for forage in all pens and therefore tortoises in all pens would appear to have been affected by this in a similar fashion. After the late summer rainfall, tortoises in all pens also were able to improve their body condition (*i.e.*, hydration state) by drinking the available water. Tortoises then entered winter dormancy with a body condition better than when first released in the pen. Food availability in 2001 was adequate in all pens but not particularly abundant when compared to similar areas in years with better than average winter rainfall. It would appear that in marginal years, tortoises in the higher density pens may not fare as well as tortoises in the lower density pens.

We fail to reject H_{O3} (the incidence of URTD symptoms does not vary among pens of different densities). The presence of one tortoise in the lowest density pen with a runny nose in both years (a high percentage of the few animals present in the pen) was the possible reason for any lack of relationship. While we were diligent when placing tortoises into the pens, it is likely that some animals placed into the pens, while supposedly having a negative test for URTD and were asymptomatic, may have tested falsely negative.

We must accept H_{O5} (mortality rate does not vary among pens of different densities). Mortality in the highest density pen was the greater than in any other pen in 2000 and there were no deaths in the lowest density pen during this time. There did appear to be a plateau effect of density on mortality but further polynomial regression was also not significant ($r^2 = 0.132$, $P = 0.6541$). It is possible that the relatively high incidence of death in the second lowest density pen may be influencing this lack of relationship.

Although there were some positive trends in clutch and egg parameters, none were significant and therefore we fail to reject H_{O6} (clutch size, clutch frequency, and annual egg production do not vary among pens of different densities in the second year of the study). The failure to produce eggs by the largest female is of some concern. The body condition index for this animal was consistently greater than that of the female that did produce eggs (267 mm MCL). The only other female in this pen (206 mm MCL) had an even better condition index and also failed to produce eggs. A female of 210-mm MCL in the 750/km^2 pen also did not produce eggs. It is possible that the largest female, 311-mm MCL, may be too old to reproduce. Additional years of reproductive data may answer this question. The smallest female with eggs (one clutch of two eggs) in Bird Spring Valley was 212 mm MCL and at Piute Valley a female of 202 mm MCL had two clutches of five eggs each.

The density of tortoises currently in the LSTS are well within historical densities of tortoises in other populations in the Eastern Mojave. The current density does not include very small tortoises (60-120 mm) that are not normally included in density estimates because they are difficult to find. However, these animals do consume vegetation and therefore contribute to decreases in forage due to possible overgrazing. Small-sized tortoises were included because they were released into the LSTS even though they have not been encountered during subsequent transects. It is probable that there is no reason to be concerned about the current density in the LSTS since it is well below 250/km^2, the lowest density of this study with no mortality or significant disease symptoms. To support this, we have detected no mortality events that are different from those in populations throughout the Eastern Mojave.

The range of densities established in the experimental pens provided some evidence of the possible densities that can be sustained in the LSTS. However, the pen situation at the DTCC is an artificial environment and the walls of the pens and their small size relative to normal tortoise activity areas impose some additional stress on the tortoises in those pens. It is possible that these conditions and not the actual densities, may bias the data to show a negative impact of density or crowding in the pens when such impact would be less or undetectable in a more natural environment. This bias, if present, will simply make application of the results of this experiment more conservative, erring on the side of concern for the welfare of the tortoises in the LSTS.

This set of experiments has allowed us to predict conservatively safe tortoise density levels that can be achieved at the LSTS and thus the number of tortoises that can be safely translocated into the LSTS. There is no evidence that the current density levels are deleterious.

Conclusions and Future Studies

On a short-term basis, it appears that high densities such as those used in this study are not detrimental to tortoises with the exception of very large (<280 mm MCL) animals. Very small animals (<100 mm MCL) also appear to be at risk for mortality.

This pilot study has helped narrow the range of densities where tortoises can be expected to exist in the wild with no adverse effects. Once a reasonable target density has been determined, a large-scale study should follow using larger enclosures. No proposals are ready at the present time.

The cost of translocating tortoises has been significantly decreased because of studies conducted by the Clark County Conservation Program. Those studies have demonstrated that in some circumstances translocation provides a reasonable and relatively safe, humane management option for disposition of displaced tortoises. Establishing the LSTS as a site to accommodate translocated tortoises has been expensive. Continued translocation of tortoises may depend, in part, on the cost remaining constant or decreasing. It is imperative that the LSTS be used in the most cost-effective way to accommodate as many tortoises as is consistent with sound management and humane treatment of the animals.

The results of this preliminary study indicate that translocation can continue at LSTS, and additional tortoises have already been released into the LSTS. We expect that a monitoring program will be in place to follow density trends.

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Table 1. Size of pen, assigned density, number per size class, and total number of tortoises placed into each pen.

Pen #	1	2	3	4	5	6	7	8	9
Size (km^2)	.0380	.0457	.0492	.0460	.0381	.0326	.0428	.0402	.0413
Assigned density (N/km^2)	250	1750	1250	2000	750	1000	500	2500	1500
Total Animals to reach density	9.6	80.0	61.5	92.0	28.6	32.6	21.4	100.5	62.0
Male	2	19	14	21	7	8	5	24	15
Female	2	19	14	21	7	8	5	24	15
Subadult	2	16	12	19	6	7	4	19	13
Juvenile	3	19	16	23	7	8	6	25	15
Very small	1	5	4	6	2	2	1	7	4
Hatchling	0	2	1	2	1	1	0	2	1
Added small	4	35	26	38	12	15	9	43	27
Total Animals	14	115	87	130	41	49	30	144	90

Table 2. Mean MCL (mm) $\pm$ 1 SE and body condition index (g/cm^3) $\pm$ 1 SE for males and female tortoises placed into each pen.

Pen #	1	7	5	6	3	9	2	4	8
density (N/km^2)	250	500	750	1000	1250	1500	1750	2000	2500
Mean MCL Males	250.7 ± 35.5	251.3 ± 12.6	245.5 ± 12.0	238.8 ± 12.1	240.8 ± 7.4	237.9 ± 7.6	236.1 ± 5.8	238.4 ± 5.4	237.0 ± 5.6
Mean MCL Females	259.0 ± 34.3	257.4 ± 18.4	256.0 ± 14.2	241.1 ± 10.1	238.0 ± 8.6	237.2 ± 8.6	230.9 ± 5.9	233.2 ± 6.6	239.0 ± 6.4
Mean Body Index Males	0.155 ± 0.015	0.176 ± 0.006	0.180 ± 0.004	.0181 ± 0.005	0.183 ± 0.006	0.173 ± 0.005	0.175 ± 0.004	0.175 ± 0.003	0.179 ± 0.004
Mean Body Index Females	0.164 ± 0.007	0.174 ± 0.006	0.166 ± 0.008	0.182 ± 0.004	0.182 ± 0.004	0.181 ± 0.004	0.173 ± 0.004	0.174 ± 0.003	0.176 ± 0.004

Table 3. Mean total annual biomass (g dry matter/m^2) $\pm$ 1 SE by pen in 2000 and 2001.

Pen #	1	7	5	6	3	9	2	4	8
density (N/km^2)	250	500	750	1000	1250	1500	1750	2000	2500
June 2000	2.56 $\pm$ 0.21	1.90 $\pm$ 0.19	1.54 $\pm$0.19	1.90 $\pm$.015	1.54 $\pm$ 0.13	1.93 $\pm$0.15	1.65 $\pm$0.17	1.97 $\pm$ 0.19	1.81 $\pm$ 0.15
July 2000	1.42 $\pm$ 0.19	1.21 $\pm$ 0.12	0.86 $\pm$ .015	1.13 $\pm$ 0.14	1.30 $\pm$ 0.14	1.48 $\pm$ 0.12	1.31 $\pm$ 0.21	0.98 $\pm$ 0.11	1.28 $\pm$ 0.15
June 2001	13.58 $\pm$ 3.50	20.38 $\pm$ 2.90	19.16 $\pm$ 3.05	25.63 $\pm$ 3.68	23.73 $\pm$ 4.44	18.55 $\pm$ 1.61	12.97 $\pm$ 1.90	19.13 $\pm$ 4.21	14.99 $\pm$ 2.52

Table 4. Number of animals that showed URTD symptoms (runny or occluded nares, runny eyes, wheezing, labored breathing) or had external parasites in 2000 and 2001. Numbers in parentheses are percent of total animals observed in a pen in a year. * Indicates one animal died; ** indicates two animals died.

Pen #	1	7	5	6	3	9	2	4	8
density (N/km^2)	250	500	750	1000	1250	1500	1750	2000	2500
Sympt. 2000	1 (10.0)	0	3* (11.1)	1 (3.6)	1 (1.8)	4 (7.4)	3 (4.3)	3 (4.7)	8** (9.2)
URTD 2001	1 (14.3)	4 (26.7)	4 (15.4)	1 (3.7)	1 (2.1)	8 (15.7)	10 (18.9)	4 (5.9)	13 (16.9)
Sympt. 2000 & 2001	1 (14.3)	0	1 (4.2)	0	0	1 (2.1)	0	0	3 (4.1)
Ticks 2000	0	1 (7.9)	0	0	3 (5.5)	0	1 (1.4)	10 (15.6)	2 (0.1)
Ticks 2001	0	1 (6.7)	0	0	0	0	1 (1.9)	3 (4.4)	2 (2.6)

Table 5. Mortality in 2000. Numbers in parentheses are percent of total age class released.

	Age class					
density (N/km^2)	Hatchling <60 mm	Very small 60 - <100 mm	Juvenile 100 - <170 mm	Subadult 170-215 mm	Adult >215 mm	Total
250	0	0	0	0	0	0
500	0	0	0	0	2 (20.0)	2 (8.0)
750	0	0	0	0	1 (7.7)	1 (2.6)
1000	0	1 (33.3)	0	0	1 (6.7)	2 (4.8)
1250	0	0	1 (6.7)	0	2 (7.7)	4 (5.1)
1500	0	2 (18.2)	0	0	0	2 (2.5)
1750	1 (4.2)	1 (6.7)	1 (6.3)	0	1 (2.8)	4 (3.8)
2000	2 (8.3)	2 (11.1)	1 (5.6)	0	0	5 (1.8)
2500	0	4 (17.4)	1 (5.6)	0	5 (11.9)	10 (7.5)

Table 6. Date ranges when clutches appeared and were laid.

	Pen 1	Pen 5	Pen 3	Pen 2	Pen 8
Density (#/km^2)	250	750	1250	1750	2500
Dates first clutch appears	21 May	23 April - 18 June	23 April - 21 May	7 May - 4 June	23 April - 21 May
Dates first clutch laid by	18 June	21 May - 30 July	21 May - 2 July	21 May - 2 July	7 May - 4 June
Dates second clutch appears	None	21 May	4 June	4 June	21 May - 4 June
Dates second clutch laid by	None	18 June	2 July	18 June - 2 July	2 July
Date third clutch appears	None	None	None	18 June	None
Date third clutch laid by	None	None	None	2 July	None

Table 7. Means ± 1 SE for midline carapace length, clutch parameters and egg parameters of egg laying females at the DTCC.

	Pen 1	Pen 5	Pen 3	Pen 2	Pen 8
Density (#/km^2)	250	750	1250	1750	2500
Number	3	6	6	6	6
Egg layers	1	5	5	6	5
MCL (mm)	261 ± 30	246 ± 10	256 ± 11	241 ± 3	253 ± 8
Clutch frequency	1	1.2 ± 0.2	1.2 ± 0.2	1.5 ± 0.3	1.6 ± 0.2
Clutch 1 size	6	4.8 ± 1.1	6.8 ± 1.0	4.5 ± 0.6	6.4 ± 1.3
Clutch 2 size	None	6	1	3.0 ± 0	4.0 ± 0.6
Clutch 3 size	None	None	None	1	None
Eggs produced per tortoise	6	6.0 ± 1.8	7.0 ± 1.0	5.7 ± 1.0	8.8 ± 2.0
Egg width, clutch 1	36.3 ± 0.2	38.1 ± 1.4	38.1 ± 1.1	38.0 ± 0.5	38.5 ± 0.9
Egg width, clutch 2	None	39.8 ± 0.2	40.0	39.9 ± 1.1	40.4 ± 0.6
Egg width, clutch 3	None	None	None	36.5	None

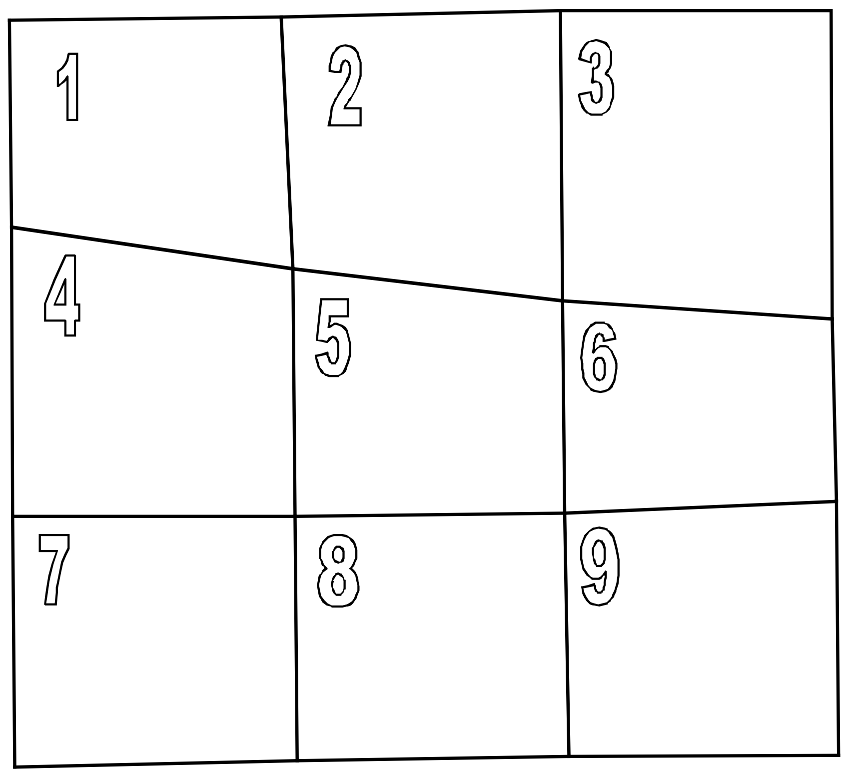

Fig. 1. Diagram of the pens at the DTCC with plot number designation.

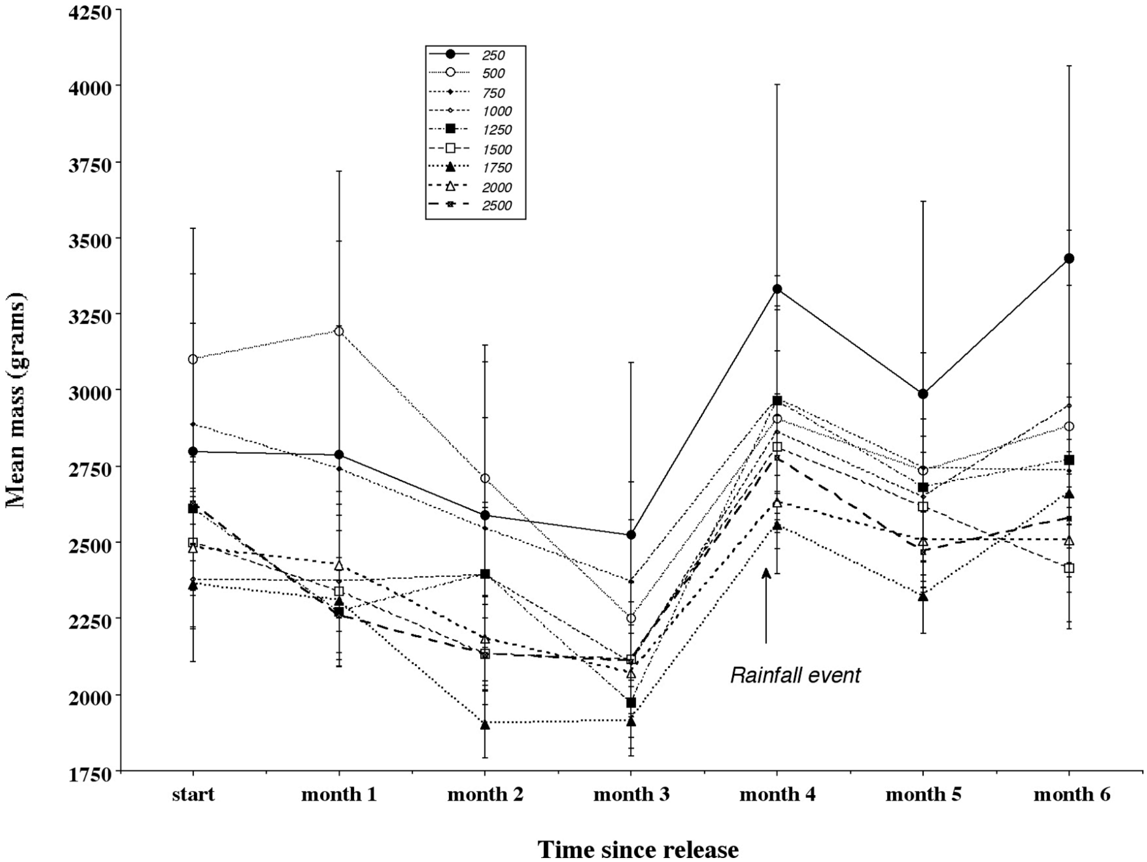

Fig. 2. Changes in mass in 2000. Error bars are one standard error.

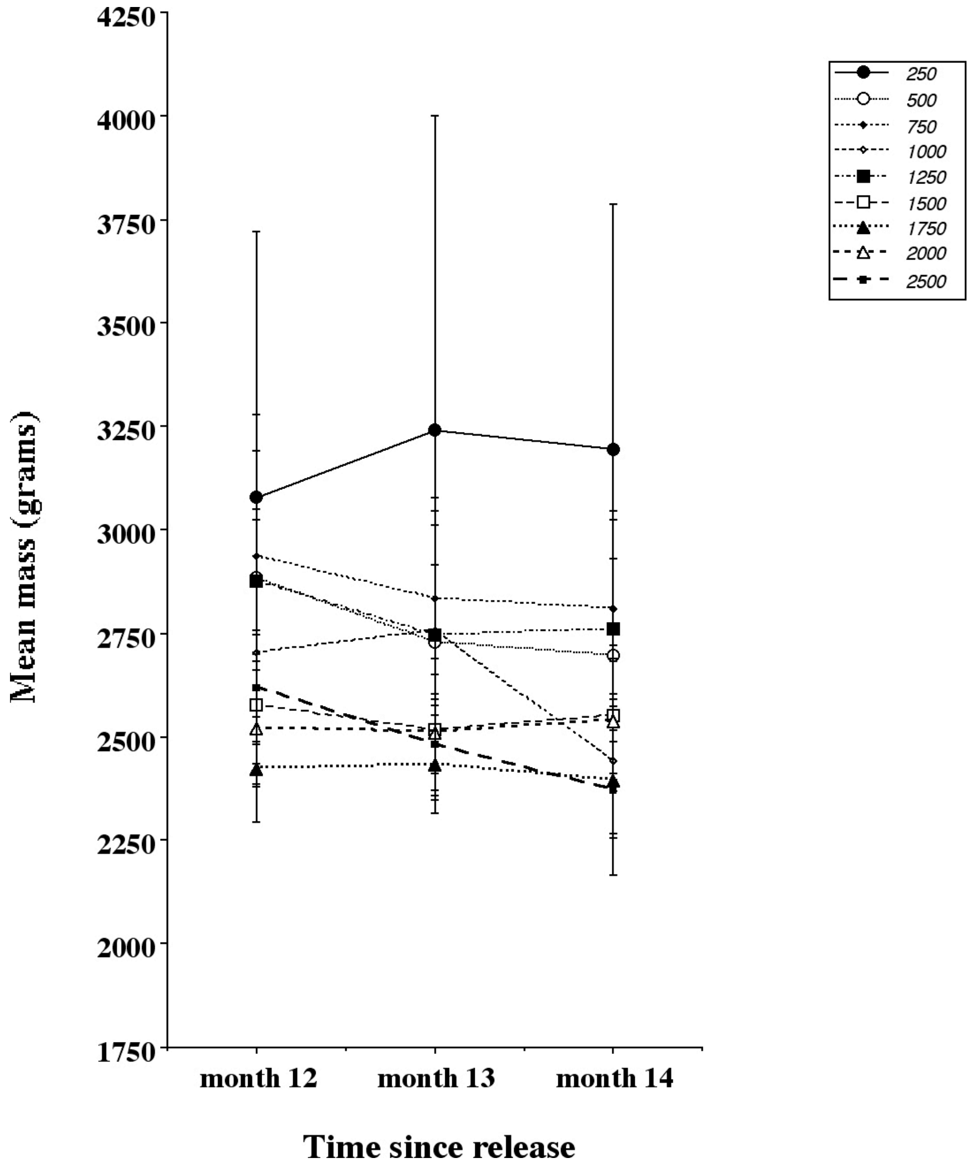

Figure 3. Changes in mass in 2001. Error bars are one standard error.

Monitor LSTS Population Health in Light of High Density

The experimental density studies at the DTCC are only a first step that must lead to tests at a higher scale. We have been conducting translocations to the LSTS for three years, and the densities there are higher than those in other parts of the Mojave Desert in Nevada. To understand the population health in the LSTS, and how it relates to density, comparable techniques must be used to examine populations both within the LSTS and "natural" populations outside the LSTS.

The Service, in consultation with the Desert Tortoise Management Oversight Group (MOG) and tortoise experts have determined that tortoise density and trend estimates range wide will be made using a type of line transect sampling called "distance sampling." Distance sampling requires that tortoise surveys be conducted by walking known transects during the active season for tortoises and during the times of the day in which tortoises can be observed. Survey crews, consisting of two or three searchers walk along a transect line and record all tortoises found on or near the line. The transects are randomly distributed throughout the Clark County in Desert Wildlife Management Areas (DWMAs). The technique requires that all tortoises located exactly on the transect must be observed (without failure) and recorded. To determine the proportion of the population of tortoises available to be observed it is necessary to study tortoise behavior. This is done using radio telemetry of focal animals to determine what proportion of the population is active, on the surface or available to be observed at any time. This monitoring effort will allow us to estimate regional tortoise density for establishing trends. We will also be estimating the number of dead tortoises in the region to determine regional mortality rates. This technique will not allow us to estimate tortoise reproduction or recruitment.

To estimate any effects of high density in the LSTS, we will conduct distance sampling in the LSTS. For comparison, sampling will also be done within the Piute/Eldorado DWMA, Coyote Springs-Upper Mormon Mesa DWMA and Gold Butte DWMA. Approximately 20 Y-shaped transects (9 km in length) will be established in the LSTS and each DWMA. Additional transects will be installed, if stratification of the DWMAs requires additional coverage. Each transect consists of three arms radiating from a central point. Each arm has a 1400m outbound segment, a 200m end segment and a 1400m inbound segment for a total transect arm length of 3000m. The total length of the transect composed of three arms is 9000m or 9km, approximately the distance a survey team can cover early in the season when tortoises are active for most of the day. Tortoise density monitoring will be initiated in the early spring and continue for approximately 6-12 weeks, depending on local weather conditions.

Because more than half of the animals in the LSTS have been marked (because they were placed there as part of translocation), it will be possible to estimate the population density in the LSTS using mark-recapture techniques which are not practical in other situations. Thus, we will have two methods by which we can estimate population size in the LSTS. This should be helpful for further refining the distance sampling techniques for estimating population size in desert tortoise.

To measure the above-ground visibility of tortoises, we need to observe behavior of focal animals. Focal animals in the Piute-Eldorado DWMA are on or near the Piute Valley Permanent Study Plot (PSP) site and we will establish focal populations in the Coyote Springs-Upper Mormon Mesa and Gold Butte DWMAs. Each focal animal team will consist of a technician or graduate student and one volunteer from the Student Conservation Association. These individuals will work closely together each day to document tortoise activity. The same 15 female tortoises used as part of the reproductive study on the Piute PSP and the higher elevation site along with 20 males, 10 in each strata will serve as focal animals upon which to base activity estimates.

Spatial/Temporal Patterns of Recruitment and Analysis of Mechanisms

The criteria for delisting the desert tortoise requires a stable or statistically significant upward trend for at least 25 years within a recovery unit. The Service in consultation with the Desert Tortoise Management Oversight Group (MOG) and tortoise experts have indicated that monitoring tortoise reproduction and recruitment is a high priority for management. It is important to know if management actions are promoting population recruitment and subsequent increases in density and an upward trend. We have collaborated with the U.S. Geological Survey in a range wide survey of reproduction by tortoise populations. The current work extends that study to the specific concerns of desert tortoise populations in Clark County. This will create a necessary foundation upon which a future decision to delist the tortoise might be made. What follows is a preliminary report on research so far.

Executive Summary

This collaborative research project was designed to test multiple hyptheses with respect to the reproductive capacity of the federally Threatened desert tortoise. It has long been recognized that worthwhile attempts to understand relationships between reproductive output of long-lived desert vertebrates such as the desert tortoise will require that data be collected across the range of environmental conditions occurring at any site. We specifically tailored this project to tease out the the ways desert tortoise respond to environmental variables at sites with relatively good overall conditions with native tortoises and translocated individuals, as well as at a site inhabited by native tortoises experiencing chronically bad environmental conditions. Three sites were selected: Bird Spring Valley (BSV), Piute Valley (PV) and Cottonwood Cove (CC). The Cottonwood Cove site was new to this project and since it was started late, we did not get an adequate sample size of tortoises. We agreed to add this site in cooperation with other USGS researchers and the National Park Service at Lake Mead National Recreation Area specifically because of the large mortality experienced there by tortoises during previous studies. That mortality was thought to be linked to severe drought.

In spite of the small sample size, interesting behavioral observations were made at the Cottonwood Cove site. We found that tortoises inhabiting the most severe environment engage in some nocturnal aboveground activity. Their use of this time could be an interesting off-shoot from this project. Other results, although preliminary, are also interesting. The following comparisons include the Bird Springs Valley and Piute Valley Sites in 1998 through 2001. The average annual egg output for tortoises at BSV and PV were not significantly different. However, the way tortoises achieved this level of reproduction varied significantly. Average clutch size and frequency were significantly different between sites. There were also significant differences in egg production parameters among years. Direct correlations between winter precipitation were not strong, however winter precipitation and spring plant production are linked. We found that early measures of plant production may ultimately represent the most efficient way to predict reproductive output, based on these preliminary data.

We consider all of the data to be preliminary until we have collected data in relatively good versus bad years at all sites and across a gradient of conditions. The results reported here, therefore, are preliminary and interpretation of such results should be used in light of the fact that additional years of data with adequate sample sizes could change the results of the hypothesis tests. There are some particular challenges related to the success of this research project. The Cottonwood Cove site is represented by only 3 adult tortoises to date. This is insufficient to make meaningful

conclusions. We will require a minimum of 6 adult female desert tortoise, twelve would be better and a comparable amount as found at other sites would be best. Unless we can increase the sample size at this site, the success on the experiment may be inadequate to warrant continued work there. We should determine this during the 2002 field season.

Abstract

We report reproductive output for the desert tortoise at sites in southern Nevada in relation to site, year, precipitation, annual vegetation production and whether or not sample populations were translocated or native. Analyses of translocated animals occur elsewhere. Three sites were investigated: Bird Spring Valley (BSV), Piute Valley (PV) and Cottonwood Cove (CC), all in Clark County Nevada. Reproductive data were collected from 1997 through 2001. In 2001, there were 22, 19 and 3 desert tortoises studied at BSV, PV and CC, respectively. This work was completed as one of the requirements of the Clark County Multi-species Habitat Conservation Plan in Nevada and reported to the US Fish and Wildlife Service as a requirement of our Endangered Species collecting permit. In 1997 there was a late start and some of the variables were not represented by enough data for statistical analysis. At CC the same was true for the startup year of 2001. In 2001 we added a study plot to the research project that is designed to compare reproductive output between a site that is considered to have a relatively mild Mojave Desert climate (PV) and a site that has a chronically harsh climate (CC) as demonstrated in a previous USGS report by Kathleen Longshore. Total mean annual egg production was 7.9 ± 0.5 at BSV and 7.5 ± 0.07 for PV in 2001 and these values were not significantly different. The first cluctch detected at BSV was on 19 April, 2001 and on 5 May, 2001 at PV. Last clutches were detected by 15 June at both sites. No more than two egg clutches were detected at any of the study sites. The first clutch was significantly larger than the second clutch at each site in 2001.There was not a significant relationship betwen body size and clutch frequency at either site. There was not enough yearly precipitation data to analyze relationships to egg production at PV from 1998 to 2001, and there was no significant relationship between precipitation and egg production at BSV from 1997 to 2001. When data from BSV were compared to PV, the total average first clutch size per tortoise was greater at BSV than PV, but not significantly different for the second clutch. The clutch frequency was significantly greater at PV than at BSV. Average first clutch egg width was not significantly different between BSV and PV, but second clutches were significantly smaller at PV and BSV. Most of that variation was due to differences in 2000 and 2001. Combined data from 1998 through 2001 for BSV and PV resulted in a significant relationship between average clutch frequency and the log of annual plant production. There were no significant differences between the log of annual plant production and total average egg production, or the number of eggs in the first or second clutches. There were also no significant differences between precipitation and clutch frequency, total annual egg production, or the size of the first and second clutches.

Introduction

The desert tortoise (north and west of the Colorado River) was listed as a federally threatened species in 1990 based on perceived rapid population declines that were largely attributed to human-caused perturbations in tortoise habitat in the Mojave Desert (Fish and Wildlife Service 1994). The Recovery Plan prepared by the U.S. Fish and Wildlife Service defined six distinct recovery units. Within each unit, Desert Wildlife Management Areas (DWMAs) were identified as areas critical for implementing recovery actions. Research deemed necessary to monitor and guide the recovery effort included the development of a model of desert tortoise demography. The model was to cover desert wide variations and account for environmental fluctuations within each DWMA and be based on at least 25 years of data. To complete this model, research on the reproductive output of desert tortoises was included as one of the high priority tasks for land management agencies. In addition, Clark County, Nevada funded a study of the efficacy of translocating desert tortoises that had been displaced by construction in the Las Vegas Valley.

In 2001, the U.S. Geological Survey and the University of Nevada Reno, Biological Resources Research Center studied reproduction of female desert tortoises (*Gopherus agassizii*) at three sites in Clark County, Nevada. This is a continuation of research that was initiated in 1997. The objective of the reproduction study is to gain information on the reproductive ecology of the desert tortoise by documenting the number of clutches and the number of eggs per clutch that female tortoises produce during a reproductive season. We also document vegetation and rainfall conditions and how these relate to tortoise reproduction within sites, between sites, and among years.

Our research is aimed at testing the specific hypotheses:
H_{o1}: Mean clutch size and clutch frequency do not vary significantly with respect to the study site.
H_{o2}: Mean clutch size and clutch frequency do not vary significantly with respect to year.
H_{o3}: Mean clutch size and clutch frequency do not vary significantly with respect to amount of winter precipitation.
H_{o4}: Mean clutch size and clutch frequency do not vary significantly with respect to amount of annual plant production.
H_{o5}: Mean clutch size and clutch frequency do not vary significantly with respect to translocated versus resident origin.

Although the three study sites are in different valleys in Clark County, all three are at similar UTM northing coordinates. Soil, perennial vegetation cover, and elevation vary among the three sites. Annual precipitation and therefore annual plant production also differ among the sites and years. Thus, we expect to reject at least the first four of the above hypotheses.
The results from this research may be used, along with data from studies in California, Utah, and Arizona, to facilitate conservation management within DWMAs. Through development of a more accurate demographic model based on environmental variation and reproductive output, land managers may be provided with a regionally specific tool to assist in the recovery of the desert tortoise.

Study area

Bird Spring Valley. Bird Spring Valley (BSV) is approximately 78 km^2 and located south of the city of Las Vegas, Nevada and east of the Bird Spring Range in Clark County, Nevada. This area is outside of the designated recovery units. The study site encompasses approximately 7 km^2 of the northeast portion of the valley and tortoises were located at elevations ranging from 900 m to 1050 m. The northeast corner of where tortoises are located is along the foothills and is at UTM coordinates 651783 E, 3984432 N. The terrain at BSV consists of a large wash with smaller washes and bajadas. The soil type is mainly sandy loam with large areas of desert pavement. Vegetation is mixed shrubs of mostly *Larrea tridentata*, *Ambrosia dumosa*, *Lycium andersonii*, *Grayia spinosa*, and *Ephedra* spp. This site has been part of the Clark County translocation study since 1996 and female reproduction has been studied since 1997. Tortoises were translocated from the Desert Tortoise Conservation Center to this site in 1997 and 1998. Transmitters were removed from most tortoises in the fall of 1999. Transmitters were left on 25 female tortoises in order to continue assessing reproduction.

Piute Valley. The Piute Valley (PV) study site is in the Piute-Eldorado DWMA of the Eastern Mojave Recovery Unit (Fish and Wildlife Service 1994) and is divided into two areas: southwest of Cal-Nev-Ari on Homestead Road and east of Cal-Nev-Ari on the Loran Road. The northern most tortoise was located along a power line perpendicular to Loran Road at UTM 3916065 N. The two sites are similar in soil type (sandy) and vegetation (*Larrea/Ambrosia* with *Acacia greggii* along the washes). The elevation where tortoises were found at Homestead ranged from 700 m to 820 m and at Loran the elevation ranged from 780 to 860 m. Female tortoise reproduction has been studied at these two sites since 1998. Through 2000, there were no significant differences between the two sites in annual plant biomass, rainfall, or clutch size. Therefore, in 2001 annual biomass was collected from only one site (Homestead) and the clutch size and total eggs per female were combined for the two sites for all years.

Cottonwood Cove. The National Park Service established a study site at Cottonwood Cove and a second site at Grapevine Canyon in1992. The objective of this study was to look at the survival of adult desert tortoises equipped with radiotransmitters at these two areas in the Lake Mead National Recreation Area. These study sites are within areas identified by the U.S. Fish and Wildlife Service as critical tortoise habitat and recognized as conserved habitat within the Piute-Eldorado DWMA. The Cottonwood Cove site (NW corner 706631E, 3928706N) was located on an undulating, alluvial bajada that descends gradually eastward toward Lake Mojave, about 1.5 km southwest of the Cottonwood Cove Marina. The study site is approximately 2.5 km^2 and consists of deep sandy washes separated by gravel bajadas with an elevation range from 250 m to 350 m. The Grapevine canyon site (NW corner 709984E, 3900010N) is located on the east slope of the Newberry Mountains less than 0.5 km south of the Grapevine Canyon petroglyph site and about 8 km west of Lake Mojave. This study was completed in 2000. The Cottonwood Cove area had an adult mortality rate of 30% and 22% in the summers of 1996 and 1997 respectively (unpublished data). This coincided with severe drought conditions and no annual plant biomass production in either year. Nearby, at the Grapevine Canyon study site there was no adult mortality during those years. The loss of adult animals at Cottonwood Cove was also higher than that found at Bird Spring Valley (0% and 2% of transmitter equipped tortoises in summers of 1996 and 1997 respectively). If the loss of adults is widespread in the Cottonwood Cove area, then recovery of this population may depend more on recruitment of hatchlings than on immigration of adults and subadults. To determine the fecundity of the females at Cottonwood Cove, we added this site to our ongoing reproductive study. Because the Federal Permit did not arrive until late May, too late for any conclusive results, 2001 was used to collect data from females already equipped with transmitters, search the area for additional females, collect annual plant biomass data, and to become familiar with the site.

Methods

A total of 22 females were equipped with radiotransmitters in Bird Spring Valley prior to the 2001 field season. Therefore, no new animals were needed at this location. At the Piute Valley site, however, only eleven animals remained from the 2000 field season. Eight additional animals were equipped with transmitters in 2001 to bring the total to 19 at this site. We were able to locate three females already equipped with transmitters (Telonics Co.) at the Cottonwood Cove Site. These animals were part of the Park Service study. Because the Federal Permit did not arrive until late May, it was too hot at this site to search for additional females.

Transmitters (AVM Instrument Co., Model SB2) were attached to females that were at least 180 mm-maximum carapace length and packages did not exceed 5% of the mass of the tortoise. Transmitters were attached to the anterior carapace with the antenna attached to the lower edge of the costal scutes. No epoxy was placed over the scute seams. A small number was epoxied on the dorsal surface of the right 4th costal scute to facilitate field identification.

Female tortoises were located at 14-day intervals from April 17, 2001 though July 26, 2001 to determine the presence of successive clutches. All of the tortoises were located using radiotelemetry. At the point of location, data collected included time, temperature, behavior and GPS location. The area was flagged to facilitate returning the animal. All flagging was removed when the tortoise was returned. Once all pertinent data were collected, tortoises were handled with latex gloves, with new gloves used for each animal handled. Tortoises that were deep in burrows and did not respond to tapping (Medica *et al*. 1986) were left in place. Tortoises available for capture were placed in a sterilized container and transported to the x-ray staging area by hand or transported in an air-conditioned vehicle.

At the staging area, tortoises were kept in a shaded area until processed. Every time a tortoise was retrieved for x-raying, it was weighed on a portable electronic balance, inspected for ticks, and examined for signs of upper respiratory tract disease and shell lesions. During the first capture of the year, measurements of midline plastron length, midline carapace length (MCL), carapace width, and shell height were taken with a caliper. Animals were then returned to the tote and taken to the portable x-ray machine. The date, site, and animal identification number were written on X-ray labeling tape that was then placed on the film cassette. A dime was taped next to the label. The film cassette was positioned under a portable x-ray machine suspended from a tripod and the tote with the tortoise was placed on top of the cassette. Using film cassettes with rare earth screens that amplify the amount of energy recorded on x-ray film, the exposure with the Minxray 80 was 60 kV for 0.06 seconds. This is not expected to have any adverse impacts on the health of the tortoise or on the development of the eggs (Hinton *et al*., 1997).

Following x-raying, animals were returned to the point of capture and released under the nearest shade or in their burrows. No animals were handled when air temperature was 32°C (90°F) at waist level as outlined in the protocols developed by the Desert Tortoise Council (Desert Tortoise Council, 1999). Because of the extreme heat at the Cottonwood Cove Study Site, we located, transported, and x-rayed the females there after sunset or before sunrise. To minimize the impact of our study and to protect the welfare of the tortoises, once an individual had no eggs for 2 consecutive x-raying sessions in July, it was no longer transported to be x-rayed. The end of the reproductive season was indicated when all tortoises had been found without having eggs present in the x-rays for two consecutive sampling periods in July (4 weeks). All transportation totes were sterilized with a 10% solution of bleach prior to subsequent use. The electronic balance and calipers were also sterilized.

X-ray films were developed before the next x-ray session. Egg widths were measured with a dial caliper. The dime image was also measured and compared to the original dime to determine if there was any magnification of objects. Successive clutches were usually separated by one or more sessions without eggs. In instances where this was not the case, thickness of shells, width and shape of eggs and relative locations of eggs were used to indicate different clutches.

Because the Piute Valley tortoises were smaller in MCL than those at Bird Spring Valley, we used analysis of covariance (ANCOVA) for all between site comparisons. Within the Bird Spring Valley site, translocated animals had significantly greater MCL than resident animals ($F_{1,57} = 9.278$, $P = 0.0035$). Therefore, ANCOVA was used for comparisons within this site among years. A repeated-measures analysis was not possible for the Piute Valley data because only three animals were x-rayed in all years. Although 20 of the animals at Bird Spring were x-rayed in every year, to simplify the analysis for this report, standard ANCOVA was used. Unless otherwise stated, analyses were only for tortoises with eggs. ANCOVA was used to analyze egg width of first and second clutches between and within years. Simple linear regression was used to analyze the relationship between egg width and MCL.

The technique for estimating annual aboveground biomass in 2001 was adapted from Andariese and Covington (1986) and Catchpole and Catchpole (1993). Ten, 200-meter transects were randomly placed in each of the study areas. During peak biomass, 20 random points were sampled per transect (200 total points). Each point was the corner of a 0.1 m^2 quadrat. If the point landed in the middle of a shrub, the quadrat was moved to under the edge of the canopy. The amount of vegetation within each quadrat was estimated by categorizing quadrats from 0 to 10, where 0 was no measurable plant biomass and 10 had the most abundant annual plant biomass. Data on the substrate (e.g., cobble, sand, desert pavement), percent cover by perennial vegetation, and cover species for each quadrat were also recorded. Annuals were categorized into wet and dry (standing only) for each quadrat. Among the ten transects per site, two representative quadrats from each category, 1 through 10, were clipped to calibrate estimation values (20 total quadrats). Clipped plants were sorted into paper bags labeled standing wet and standing dry. Each bag was also labeled with the site, date, transect number, and quadrat number. Plants were dried in a drying oven for 48 hours at 50°C and then weighed (to the nearest 0.001 g for 1997 through 2000 and nearest 0.0001 g for 2001). For each, wet or dry vegetation, a regression analysis was performed for category (1 to 10) versus biomass, yielding a regression equation. The quadrat estimate values were then inserted into the regression equation to generate a biomass equivalent for both wet and dry values. The technique for all previous years had ten-100 meter transects with ten quadrats points per transect. At each of the points, a 10-meter tape was stretched perpendicular to and randomly left or right of the line. At the end of this tape, one quadrat was placed in the open and one was placed under the nearest shrub. Plants in all quadrats were harvested and divided into five categories: native forb, native grass, exotic forb, exotic grass and standing dead. This technique required more field days per site and the ability to identify the plants. More time was also needed to weigh the plants.

Rainfall data were collected from rain gauges at the Bird Spring Valley and the Piute Valley study sites. October through March rainfall is considered important for germination of annual plants (Beatley 1974). Therefore, this period of rainfall was of particular interest.
To analyze the relationship between annual plant biomass and egg parameters, we used simple linear regression and the base 10 logarithm of winter annual plant biomass (Turner *et al.*, 1986). Linear regression was also used to analyze the relationship between winter precipitation and egg parameters.

Results

Bird Spring Valley. We x-rayed 22 females biweekly in BSV in 2001 (Table 1). Eggs were observed in the x-rays of two animals taken on 19 April and no eggs were observed after 14-15 June. First clutches were first observed on x-rays taken on 19 April through 31 May. Second clutches appeared from 17 May through 14-15 June. The two animals with a first clutch appearing on 31 May did not have a second clutch of eggs. Only one animal had no eggs (5%),

eight had only one clutch (36%) and 13 animals had two clutches (59%). The single animal that did not produce eggs in 2001 had an MCL of 229 mm, no different from the mean of the females that produced eggs (229.3 ± 2.1, mean ± one standard error). Eleven females with shorter MCL produced eggs. Of the females that had eggs, the average size for the first clutch in 2001 was 5.2 ± 0.2 eggs (range 4-7) and for the second clutch was 4.3 ± 0.3 eggs (range 2-7). Mean size of the first clutch (Table 1) was significantly greater than that of the second clutch (ANCOVA, $F_{1,31}$ = 5.599, P= 0.0244). Mean size of first clutch for tortoises laying only one clutch (5.4 ± 0.4) was not significantly greater than that of tortoises laying two clutches (5.1 ± 0.2; $F_{1,18}$= 0.684, P= 0.4189). The average total number of eggs or annual egg production (first plus second clutch) was 7.9 ± 0.5 eggs. Although showing a positive trend, there was no significant relationship between annual egg production and MCL (Figure 1). There was also no correlation between number of eggs in first clutch and MCL (r^2= .089, P= 0.1896) and number of eggs in second clutch and MCL (r^2= 0.035, P= 0.5377).

After adjusting for the effect of body size (MCL), the mean width of eggs in the first clutch (Table 1) was not significantly different from the mean width of eggs in the second clutch (ANCOVA, $F_{1,31}$= 0.284, P= 0.598). There was a significant relationship between egg width of the first clutch and MCL of female tortoises in 2001 (Figure 2), but not between egg width of the second clutch and MCL (r^2= 0.039, P= 0.519).

Translocated tortoises were x-rayed only in 1997, 1998, and 1999. Because some animals were not x-rayed until after late May, died, or were lost, 18 translocated tortoises and seven resident tortoises were

not included in the analysis in 1997. Likewise, four translocated and three residents were excluded in 1998 and two translocated and one resident were excluded in 1999. Although translocated tortoises always produced more eggs on average per year (Table 2), once means were adjusted for MCL, there was no significant difference between mean annual egg production of translocated and resident tortoises in any year ($F_{1,102}$= 0.105, P= 0.746). Similar results were shown for first clutch ($F_{1,102}$= 0.018, P= 0.892) and second clutch ($F_{1,25}$= 0.438, P= 0.5142). There was also no significant difference in clutch frequency between translocated and resident tortoises in any year ($F_{1,102}$= 0.357, P= 0.5516). Mean egg width was not significantly different between translocated and resident tortoises ($F_{1,128}$= 0.770, P= 0.3819). Because there were no significant differences between resident and translocated tortoises, we combined these data for analyses among years.

A comparison of mean total eggs among all years with ANCOVA using MCL as the covariate was significant ($F_{4,146}$= 8.948, P< 0.001). A post hoc comparison using the Tukey test showed that significantly fewer total eggs were produced in 1997 than in 1998, 1999, 2000, and 2001, while mean total eggs in 1999 were significantly fewer than in 2001 (Figure 3). There was also a significant result among years in mean numbers of eggs in the first clutch (ANCOVA, $F_{4,146}$= 2.739, P= 0.031). A post hoc Tukey test, however, failed to show any significant differences for any pair-wise comparison. Mean numbers of eggs in the second clutch were not significantly different among years (ANCOVA, $F_{4,51}$= 0.579, P= 0.679).

While the size of first and second clutches did not vary among years, average egg production was higher in years of good winter rainfall due to increased clutch frequency (Table 1, Figure 4). Clutch frequency was significantly lower in 1997 than in 1998, 2000, and 2001 and lower in 1999 than in 2000 and 2001 (ANCOVA, $F_{4,146}$= 6.795, P< 0.0001). Mean egg widths varied significantly among years ($F_{1,198}$= 12.250, P< 0.0001) with 1997 and 1998 mean widths significantly smaller than those in 1990, 2000, and 2001 (Tukey test, □ = 0.05).

Rainfall at Bird Spring Valley in 2001 was greater than in 1997, 1999, and 2000 but lower than in 1998 (Table 3). A simple regression to look for a trend in percent of females that reproduce in a year and that year's winter precipitation was not significant (Figure 5). There was no significant relationship between mean total eggs produced (annual egg production) and winter precipitation (r^2= 0.290, P= 0.349). There was a similar lack of relationships between winter precipitation and size of first clutch (r^2= 0.090, P= 0.624), size of second clutch (r^2= 0.036, P= 0.761), and clutch frequency (r^2= 0.524, P= 0.167). In all cases, the 1997 data point was an outlier.

A simple linear regression of annual plant biomass versus winter precipitation showed a positive trend that was significant (Y = -29.59 + 0.64*precipitation, r^2= 0.964, P= 0.0029). There were no significant relationships found between the log of annual plant biomass and size of first clutch (r^2= 0.030, P= 0.7802), size of second clutch (r^2= 0.046, P= 0.7300, or clutch frequency (r^2= 0.180, P= 0.4767). There was also no significant relationship between mean total eggs produced (annual egg production) and log biomass (r^2= 0.071, P= 0.6640). As in the precipitation regressions, the 1997 data points were outliers.

Piute Valley. We x-rayed 19 females in 2001 (Table 4). Four animals were not included in the analysis for this year: two females that were not x-rayed until late June, one tortoise that was lost (no transmitter signal) in mid-June, and one tortoise found dead on May 29. Of the remaining 15 females, 14 produced eggs in 2001 (93%). Three produced only one clutch (20%) and 11 (73%) produced two clutches. Eggs were first observed on x-rays taken on 5 May and no eggs were observed after 12-13 June. First clutches were first

observed from 5 May through 12-13 June. The single animal with a first clutch on 12-13 June had only two eggs and did not have a second clutch. Second clutches first appeared on x-rays taken 29-30 May.

Of the females producing eggs, the mean number of eggs in the first clutch (Table 4) at Piute Valley was 4.1 ± 0.5 eggs (mean ± one standard error) with a range of 2-9 eggs, and for the second clutch was 4.3 ± 0.5 eggs (range 2-9 eggs). Mean size of the first clutch was not significantly different from that of the second clutch (ANCOVA, $F_{1,22}$= 0.012, P= 0.9137). Mean size of first clutch for tortoises laying only one clutch (5.3 ± 2.0) was not significantly greater than that of tortoises laying two clutches (3.8 ± 0.4; $F_{1,11}$= 2.062, P= 0.1789). The mean total number of eggs was 7.5 ± 0.7 eggs (range 2-13 eggs). There was no significant relationship between annual egg production and MCL (Figure 6). There was also no correlation between number of eggs in first clutch and MCL (r^2= 0.007, P= 0.783) and number of eggs in second clutch and MCL (r^2= 0.041, P= 0.551).

After adjusting for the effect of body size (MCL), the mean width of eggs in the first clutch (Table 4) was significantly greater from the mean width of eggs in the second clutch (ANCOVA, $F_{1,23}$=

4.826, P= 0.0384). There was no significant relationship between egg width of the first clutch and MCL of female tortoises in 2001 (r^2= 0.009, P= 0.7275), nor between egg width of the second clutch and MCL (r^2= 0.010, P= 0.7834).

The comparison of total eggs produced among all years (Figure 7) was significant (ANCOVA, $F_{3,64}$= 6.940, P<0.001), with fewer eggs produced on average in 1999 than in 1998, 2000, and 2001 (Tukey test, □ = 0.05). There were no differences in number of eggs in first clutch among years ($F_{3,64}$= 0.402, P= 0.752) nor in number of eggs in the second clutch (ANCOVA, $F_{3,40}$= 1.964, P= 0.135). The greater number of total eggs produced was achieved by increasing clutch frequency (Figure 4) and not clutch size (Figure 7) with clutch frequency differing significantly among years (ANCOVA, $F_{3,64}$= 8.866, P< 0.0001). Clutch frequency in 1999 was significantly lower than the other three

years (Tukey test, □ = 0.05). After adjusting for body size, the width of eggs from the first clutch were significantly different among years ($F_{3,70}$= 3.459, P= 0.209) but not for the second clutch ($F_{3,38}$= 0.257, P= 0.855). A post hoc test revealed that egg width of first clutch eggs in 1998 was significantly smaller than widths in 1999, 2000, and 2001.

Winter rainfall data at Piute Valley were available only for 2000 and 2001 (Table 3). Thus, we could not perform any meaningful regression analyses using this regressor. There were no significant relationships found between the log of annual plant biomass and size of first clutch (r^2= 0.117, P= 0.658), size of second clutch (r^2= 0.509, P= 0.287, or clutch frequency (r^2= 0.738, P= 0.141). There also was no significant relationship between mean total eggs produced (annual egg production) and log biomass (r^2= 0.766, P= 0.125).

Cottonwood Cove. There were only three females at Cottonwood Cove that were already equipped with working transmitters. We were able to start x-raying at this site on May 31. Because of the extreme heat at this site, animals were active only in the late evenings and early mornings. One female was found walking around three hours after sunset. During the day, all three females retreated into deep burrows and were inaccessible. It was also difficult to retrieve animals every other week so that no animal was ever x-rayed more than twice. Animal number 400 was x-rayed only on July 9th (no eggs), while number 204 was x-rayed on June 13th (3 eggs) and June 25th (no eggs). Animal 33 was x-rayed on May 31st (2 eggs) and on June 25th (no eggs). Because this site is at a lower elevation than Piute and Bird Spring Valleys, animals probably emerge from winter dormancy earlier and begin producing eggs earlier than at the other two sites. Annual plant productivity in 2001 at Cottonwood Cove was 32.23 $\pm$ 2.03 g dry matter/m^2.

Bird Springs Valley vs Piute Valley. After adjusting for body size, the average number of eggs in the first clutch was significantly greater at BSV than PV ($F_{1,189}$= 6.785, P= 0.0099) while average size of second clutch remained relatively constant among years and between the sites ($F_{1,90}$= 0.081, P= 0.7766). Clutch frequency was significantly higher at PV than at BSV ($F_{1,189}$= 5.384, P= 0.0214). However, the average annual egg production between sites did not differ significantly ($F_{1,189}$= 0.064, P= 0.8011).

Although slightly smaller in all years, the average width of eggs in the first clutch at Piute Valley were not significantly different from those at Bird Spring Valley (F= 1.598, P= 0.2077). Mean width of second clutch eggs were significantly smaller at Piute Valley than at Bird Spring Valley (F= 3.980, P= 0.0491). A post hoc test revealed that the only year where there was a significant difference was in 2001 (Tukey test, α = 0.05), although mean widths of second clutch eggs in 2000 were marginally significant (*P*= 0.0574).

Combining the sites for 1998 through 2001, the relationship between clutch frequency (CF) and the log of annual plant biomass, CF = 1.40 + 0.196*(log biomass) was significant (r^2= 0.631, *P*= 0.0330). There was no relationship between total eggs produced and log biomass (r^2= 0.493, *P*= 0.0787), between number of eggs in first clutch and log biomass (r^2= 0.034, *P*= 0.942), or between number of eggs in second clutch and log biomass (r^2= 0.300, *P*= 0.5128). There was no significant relationship between clutch frequency and winter precipitation (r^2= 0.095, *P*= 0.6143), annual egg production and winter precipitation (r^2= 0.481, *P*= 0.4119), size of first clutch and winter precipitation (r^2= 0.002, *P*= 0.9435), or size of second clutch and winter precipitation (r^2= 0.028, *P*= 0.7877).

Discussion

The 2001 reproductive season was the second year in a row of relatively good egg production. A high percentage of both BSV and PV females had at least one clutch of eggs in 2001 (95% and 93% respectively). Well over half of the females x-rayed in 2001 produced two clutches of eggs (64% at BSV and 73% at PV).

We rejected hypothesis H_{o1} (mean clutch size and clutch frequency do not vary significantly with respect to the study site). It was desirable to compare these two sites as one is inside a DWMA (Piute Valley) and one is outside (Bird Spring Valley). Environmental variation should impact both sites in a similar fashion. If results do not follow a similar trend, differences may be due to other factors such as human uses of DWMAs that are influencing reproduction. The average annual egg production between sites did not differ significantly, however, indicating that animals at the sites achieved the same annual egg output through different strategies: the greater number of eggs in the first clutch at BSV balanced the greater number of clutches produced at PV. The most obvious reason for the different strategies is the larger MCL of females at BSV.

We can reject the part of H_{o2} that states clutch frequency does not vary significantly with respect to year. At both Bird Spring Valley and Piute Valley the clutch frequency varied significantly with respect to year, with 1999 significantly lower than 1998, 2000, and 2001 at both sites. In addition, 1997 was significantly lower than 1998, 2000, and 2001 at the BSV site. We failed to reject the portion of H_{o2} dealing with clutch size with respect to year.

We fail to reject Hypotheses H_{o3} as there were no significant results from linear regression analyses of clutch parameters and amount of winter precipitation. We can, however, reject H_{o4} as there was a significant result from linear regression analysis of clutch frequency and amount of annual plant production. The resulting equation was similar to the equation CF = 1.42 + 0.294 (logP) that described the relationship between clutch frequency and log biomass at two sites in California over five years reported in Turner *et al*. (1986). Turner *et al.* found a highly significant relationship between clutch frequency and log plant production (r^2= 0.88). When the data from Turner *et al*. are combined with the data from the two sites in this report, the equation is CF = 1.41 + 0.225 * log biomass, (r^2= 0.701, *P*= 0.0007, N = 12).
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After adjusting for MCL, there were no significant differences in clutch size and clutch frequency between resident and translocated tortoises. Thus, we cannot reject H_{o5} (mean clutch size and clutch frequency do not vary significantly with respect to translocated versus resident origin).

It appears that when the annual biomass is known, the only reproductive parameter for any site that can be predicted with any regularity is clutch frequency. This is not a useful parameter to know since it only indicates how many clutches are laid on average and not the average annual egg output. However, there was a significant relationship between average annual egg production (AEP) and clutch frequency for combined data from Bird Spring Valley and Piute Valley (AEP = 1.560 + 3.311 * CF; r^2= 0.541, P= 0.0239, N = 9). This may be helpful when there are time or money constraints that prevent actual measuring of reproductive output. If that is the case, then the relatively inexpensive technique that we used to collect annual plant biomass may be used as a proxy for annual egg production.

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Tables

Table 1. Mean (± 1 SE) midline carapace length, clutch parameters, and egg parameters of egg-laying females at Bird Spring Valley in 1997-2001.

	1997	1998	1999	2000	2001
Number	38	59	59	25	22
Egg layers	23	48	38	22	21
MCL (mm)	237 ± 3	237 ± 3	236 ± 3	232 ± 2	229 ± 2
Clutch frequency	1.04 ± 0.04	1.46 ± 0.07	1.21 ± 0.07	1.55 ± 0.11	1.62 ± 0.11
Clutch 1 size	4.4 ± 0.3	5.2 ± 0.3	5.3 ± 0.2	5.2 ± 0.3	5.2 ± 0.2
Clutch 2 size	3	4.2 ± 0.4	4.4 ± 0.6	4.7 ± 0.3	4.3 ± 0.4
Eggs produced per tortoise	4.6 ± 0.3	7.1 ± 0.5	6.2 ± 0.4	7.7 ± 0.5	7.9 ± 0.5
Egg width, clutch 1	36.0 ± 0.3	36.6 ± 0.3	38.4 ± 0.3	38.4 ± 0.4	38.4 ± 0.4
Egg width, clutch 2	35.7 ± 0	36.9 ± 0.4	38.0 ± 0.5	38.4 ± 0.4	38.1 ± 0.3

Table 2. Mean (± 1 SE) midline carapace length, clutch parameters, and egg parameters of translocated (Trans) and resident (Res) female tortoises in Bird Spring Valley in 1997-1999.

	1997		1998		1999	
	Trans	Res	Trans	Res	Trans	Res
Number	12	26	29	30	27	32
Egg layers	7	16	20	28	14	24
MCL (mm)	247 + 7	233 + 3	249 + 5	229 + 2	245 + 6	230 + 2
Clutch frequency	1.0 ± 0	1.1 ± 0.1	1.4 ± 0.1	1.5 ± 0.1	1.2 ± 0.1	1.2 ± 0.9
Clutch 1 size	5.0 ± 0.9	4.2 ± 0.2	5.9 ± 0.6	4.7 ± 0.2	5.7 ± 0.4	5.0 ± 0.2
Clutch 2 size	None	3.0 ± 0	5.1 ± 0.9	3.8 ± 0.3	4.3 ± 0.9	4.4 ± 0.9
Eggs produced per tortoise	5.0 ± 0.9	4.4 ± 0.3	7.7 ± 0.9	6.8 ± 0.4	6.6 ± 0.5	5.9 ± 0.4
Egg width, clutch 1	36.2 ± 0.5	36.0 ± 0.4	37.1 ± 0.5	36.2 ± 0.4	38.8 ± 0.8	38.2 ± 0.3
Egg width, clutch 2	None	35.7 ± 0	37.6 ± 0.6	36.6 ± 0.5	37.9 ± 0.9	38.1 ± 0.7

Table 3. Winter (October to March) and summer precipitation (June to September, in mm) and productivity (g dry matter/m2 + 1 SE) of winter annual plants from 1997 to 2001 at BSV and 1998 to 2001 at PV. Rain gauges were not established in Piute Valley until January 1999.

		1996-97	1997-98	1998-99	1999-00	2000-01
BSV	Winter	56	155	44	68	122
	Summer	16	84	78	50	30
	Productivity	12.15 ± 0.61	70.90 ± 3.06	0.50 ± 0.31	4.22 ± 0.31	49.96 ± 3.54
PV	Winter				58	138
	Summer				30	27
	Productivity		67.96 ± 10.02	0.12 ± 0.07	13.13 ± 4.52	23.74 ± .78

Table 4. Mean (+ 1 SE) midline carapace length, clutch parameters, and egg parameters of egg-laying females at Piute Valley in 1998-2001. *4 animals were excluded from statistical analysis.

	1998	1999	2000	2001
Number	19	19	18	15*
Egg layers	19	18	18	14
MCL (mm)	215 ± 3.3	215 ± 3.1	217 ± 3.0	216 ± 2.5
Clutch frequency	1.68 ± 0.11	1.22 ± 0.10	1.89 ± 0.08	1.79 ± 0.11
Clutch 1 size	3.7 ± 0.3	3.7 ± 0.3	3.8 ± 0.2	4.1 ± 0.5
Clutch 2 size	4.0 ± 0.5	3.0 ± 0	3.1 ± 0.4	4.3 ± 0.5
Eggs produced per tortoise	6.5 ± 0.7	4.3 ± 0.4	6.8 ± 0.4	7.5 ± 0.7
Egg width, clutch 1	35.8 ± 0.5	37.3 ± 0.4	37.5 ± 0.4	37.7 ± 0.4
Egg width, clutch 2	36.3 ± 0.5	37.2 ± 1.1	36.6 ± 0.4	36.4 ± 0.4

Figures

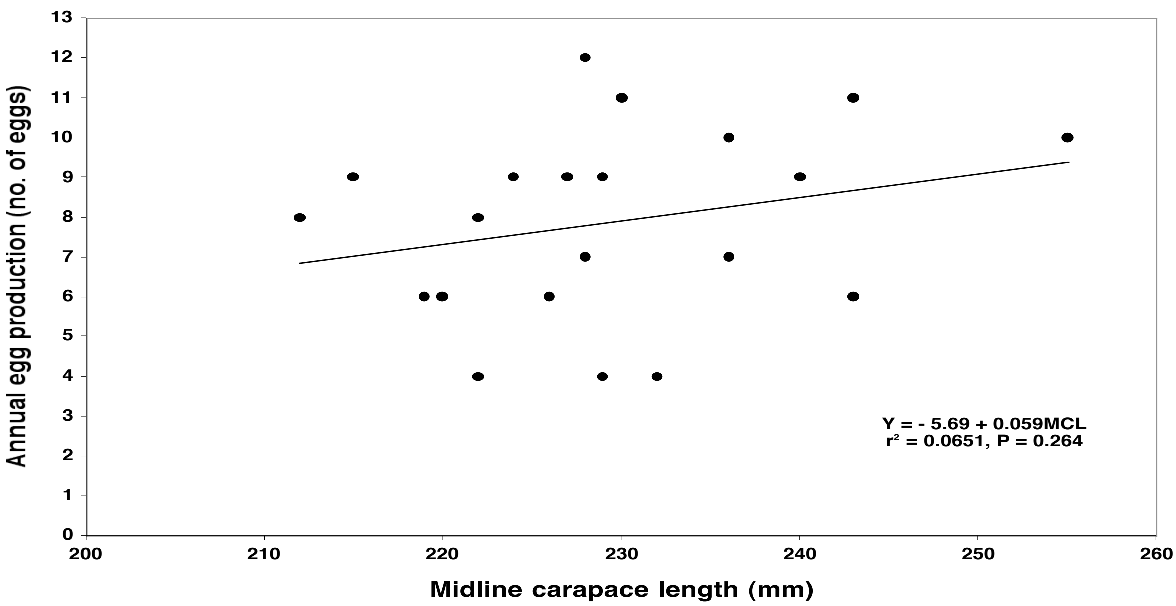

Fig. 1. **Relationship between annual egg production and body size (MCL) of female tortoises at BSV in 2001. Neither the size of first clutch nor the size of second clutch was correlated to MCL.**

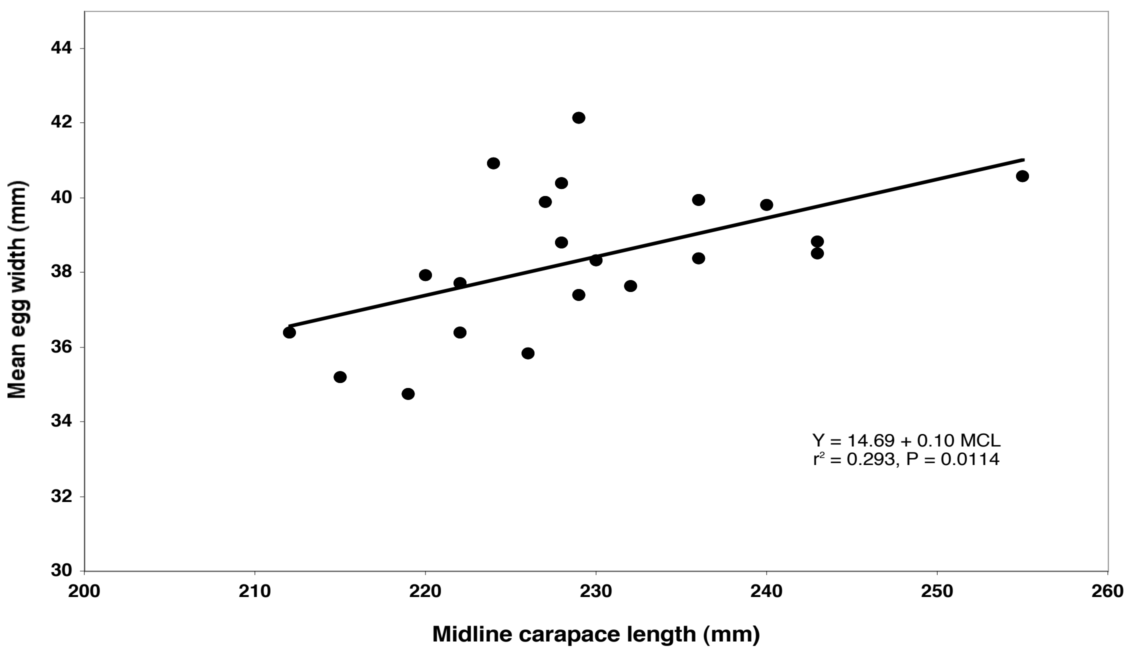

Fig. 2. Relationship between egg width of first clutch and body size (MCL) of female tortoises at BSV.

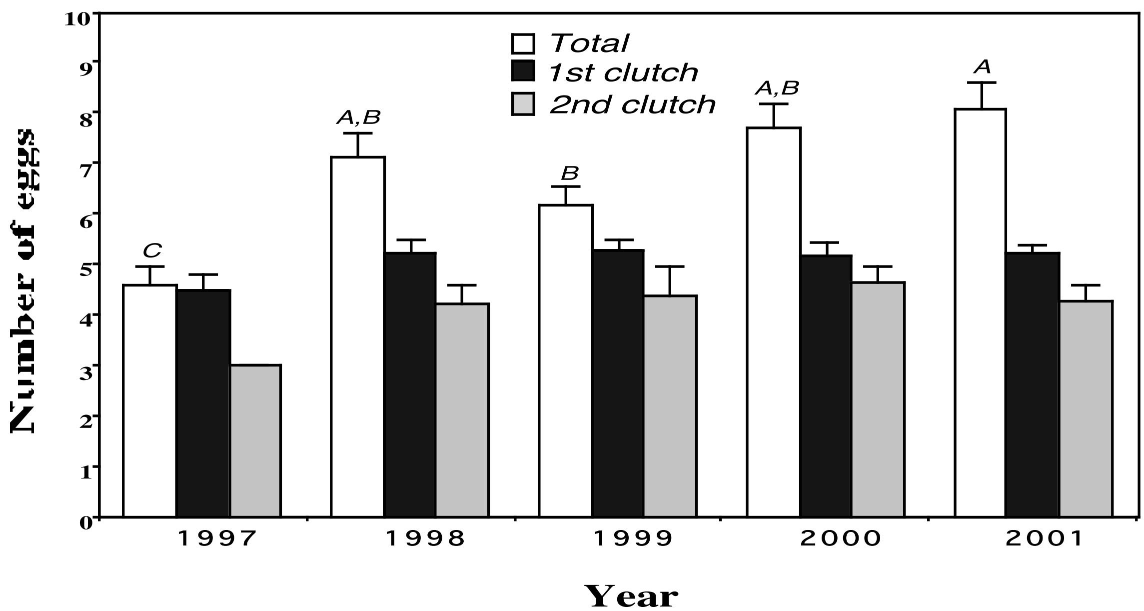

Fig. 3. Average annual egg production, size of first and second clutch for females producing eggs in Bird Spring Valley, 1997-2001. Error bars are one standard error. Total eggs bars with different letters are significantly different. There were no significant differences among years in number of eggs in the first clutch or in number of eggs in the second clutch.

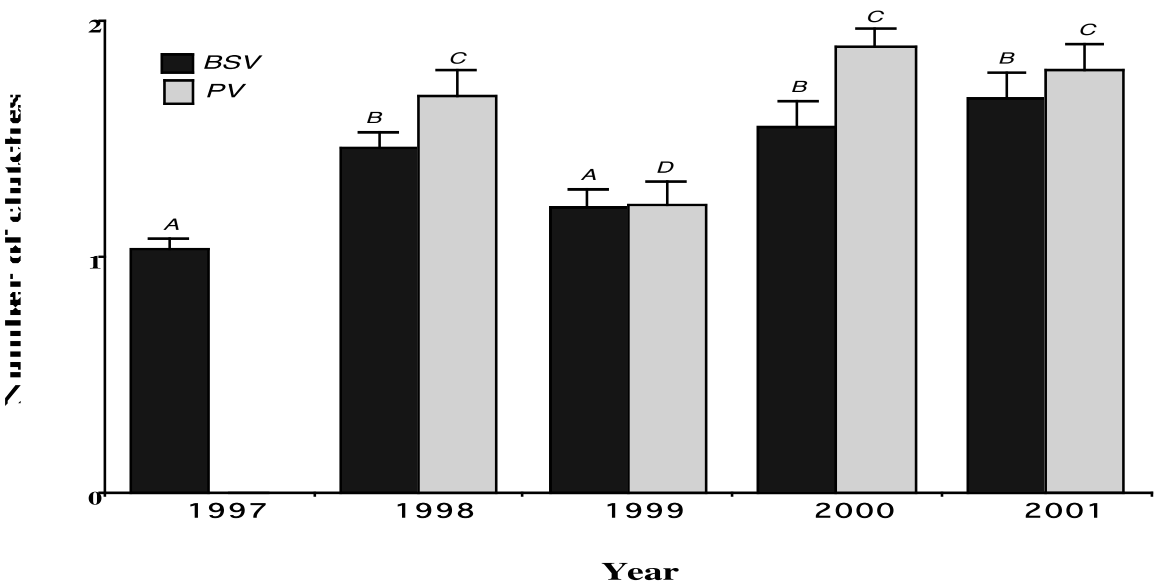

Fig. 4. Average clutch frequency of egg-laying females at Bird Spring Valley (1997-2001) and Piute Valley (1998-2001). Bars within the same site with different letters are significantly different.

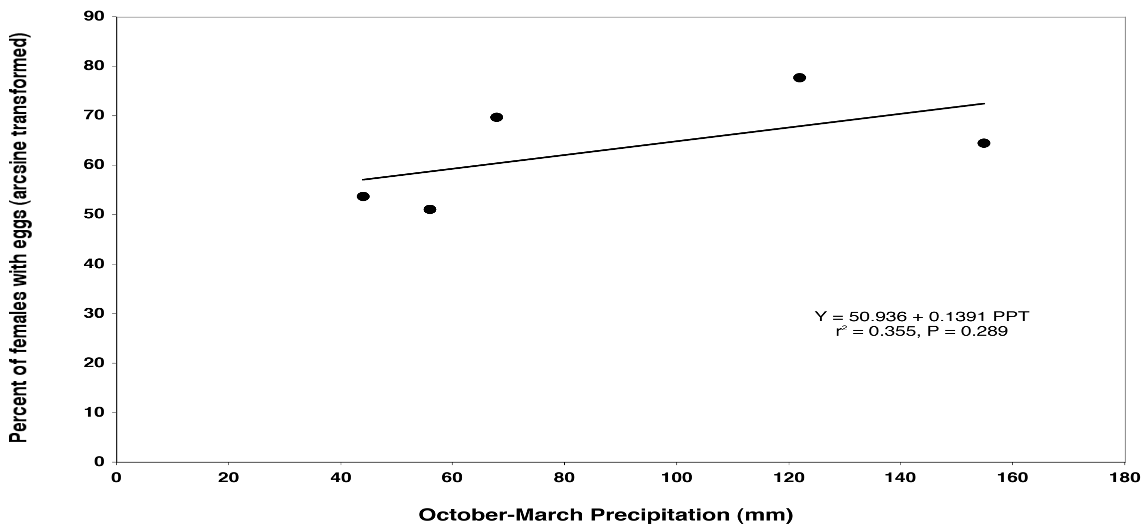

Fig. 5. Relationship between percent of females reproducing in a year and precipitation at Bird Spring Valley in 1997-2001.

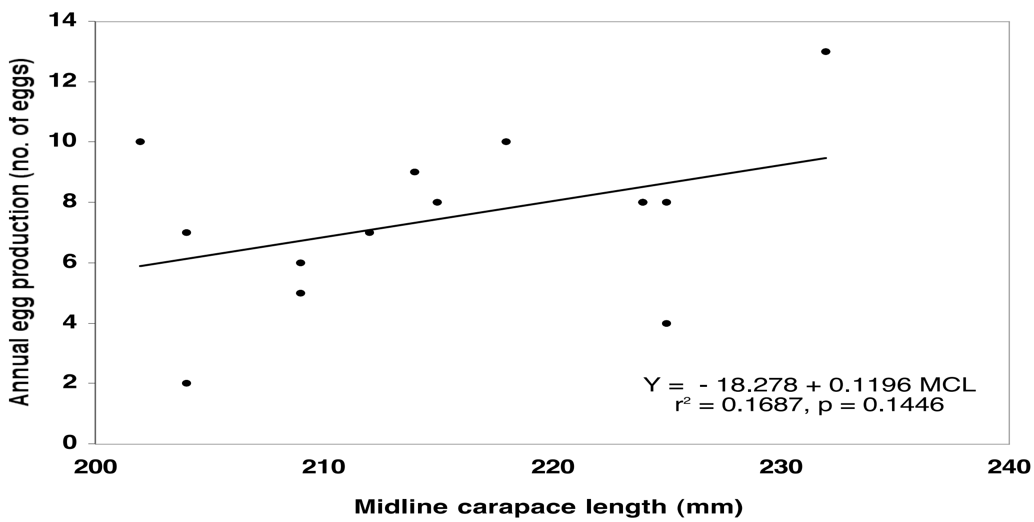

Fig. 6. Relationship between annual egg production and body size (MCL) of female tortoises at Piute Valley in 2001. Neither the size of first clutch nor the size of second clutch was correlated to MCL.

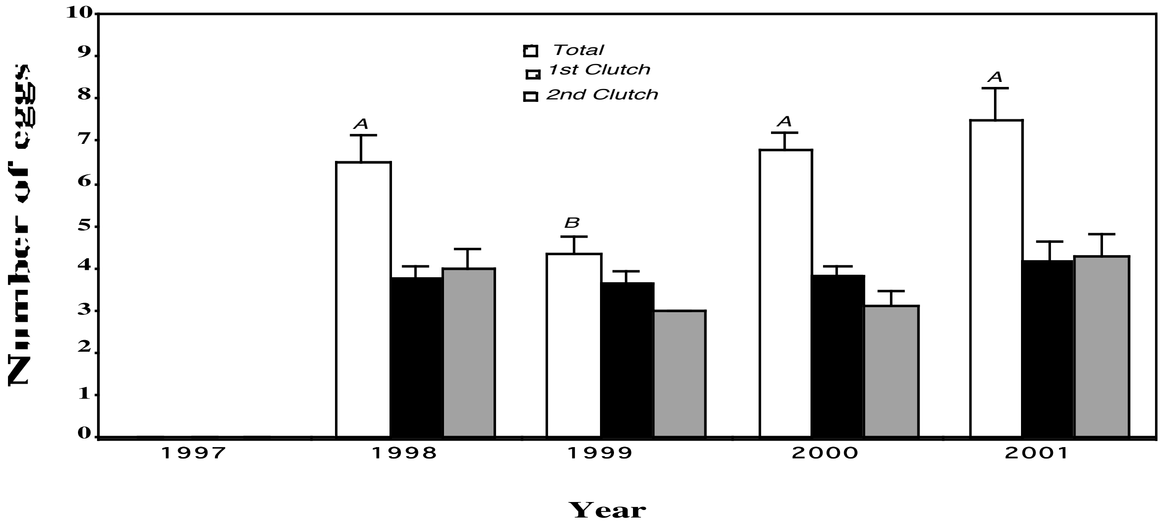

Fig. 7. Average annual egg production, size of first and second clutch for females producing eggs in Piute Valley, 1998-2001. Error bars are one standard error. Total egg bars with different letters are significantly different.

Experimental Epidemiology of Translocated Groups

One the most vexing issues surrounding recovery of the desert tortoise is that of dealing with the Upper Respiratory Tract Disease. This disease was responsible for the emergency listing of the desert tortoise a decade ago. Now after many hundreds of thousands of dollars have been spent on aspects of the disease, we are no closer to understanding that which is necessary to manage desert tortoise in the face of the disease. As a result, we are killing literally hundreds of tortoises annually as we adhere to the untested prescriptions that originated at the University of Florida. However, those prescriptions are known to be seriously flawed for several reasons:

(a) they are not based on the biology of tortoises infected with the pathogen,

(b) the tests to determine whether the tortoise has the disease is flawed in that it produces false positives (meaning that many tortoises are condemned to death even though they do not have the disease - and may never get it),

(c) the population biology of a recovering population may suggest that there is more to be gained from the recruitment from ELISA-positive animals than that which can be lost from the potentially infectious animals, and

(d) other technical reasons.

No appropriate biological investigation has been conducted to assess the importance of ELISA positiveness. No appropriate investigation has been conducted to assess the dangers - or lack thereof - of a population with animals infected with URTD. There has been no biological investigation of the dangers - or lack thereof - of translocation of ELISA positive animals or translocation of animals with symptoms of URTD. We propose to conduct a factorial design experiment (with replication) of the importance of ELISA positiveness and of infection with URTD in translocation of desert tortoise. Currently, Clark County translocates desert tortoises only when they are ELISA negative (all other tortoises are killed).

We propose to translocate and study three groups of tortoises into secure corrals that we will use as experimental blocks. The three groups are:

(a) ELISA positive tortoises with no symptoms of URTD,
(b) tortoises exhibiting symptoms of URTD, and
(c) tortoises that both are ELISA positive and show symptoms of URTD

We have begun construction of experimental corrals at the DTCC (it has been a long road getting permissions from BLM and contracting for fence building). We are making 24 1-hectare, doubly-fenced corrals into which we will introduce these three different treatment groups. The ELISA positive group will consist of six replicates of eight ELISA positive animals and eight ELISA negative animals (total of 16 animals per corral). The URTD group will consist of six replicates of eight symptomatic animals and eight ELISA negative animals. The "both" group will consist of six replicates of four ELISA positive but asymptomatic animals, four symptomatic animals, and eight ELISA negative animals. One control will be a corral containing 16 ELISA negative animals exclusively. Another comparison group will be the LSTS outside of the corrals.

We intend to monitor physiological condition of all animals in treatment corrals by measuring changes in body mass, and we will assess health status by checking animals for symptoms. We will assess ELISA status twice annually. We will assess the same variables in the comparison group by sampling animals in the LSTS (as part of the density study in LSTS). We will produce a report that reviews and analyzes the data and offers a discussion and evaluation of the meaning of the data from this study in terms of management of translocated tortoises.

Temperature Sensitivity of Mycoplasma agassizii

We have also begun a second experiment on the temperature sensitivity of *Mycoplasma agassizii* to bear on the hypothesis that recent outbreaks are caused by global climate change. We will be proposing greater effort on this next biemnium.

DESERT TORTOISE MONITORING PROGRAM

Introduction

The Clark County Short-Term Desert Tortoise Habitat Conservation Plan, the Desert Conservation Plan and the Multiple-Species Habitat Conservation Plan all identify monitoring desert tortoise populations as an essential element of desert tortoise conservation. The Desert Tortoise Recovery Plan has recommended that monitoring desert tortoise populations is an essential part of any sound conservation or management plan. We have collaborated with the Fish and Wildlife Service, the United States Geological Survey and colleagues at St. Andrews University in conducting tortoise monitoring in Southern Nevada, improving monitoring techniques and in evaluating and developing new and better monitoring techniques.

Density Estimation Monitoring

Tortoise density monitoring in Southern Nevada is initiated in the early spring and continues for approximately 2--3 months. Sampling is initiated within some or all of the Piute Desert Wildlife Management Area (DWMA), the Cottonwood DWMA, the Eldorado Valley DWMA, Coyote Spring DWMA, Mormon Mesa DWMA, Gold Butte DWMA, the Pakoon DWMA, the Large-Scale Translocation Study Site (#1, South), the Large-Scale Translocation Study Site (#2) and throughout areas of the Lake Mead National Recreation Area. The sampling techniques currently followed are those discussed at the "Monitoring Workshop" held in Laughlin, NV in November l996, and a variety of subsequent meetings including the most recent MOG-TAC meeting December 11, 2000. Transect surveys have consisted of lines 1600 m. or 3200 m. in length arranged in squares. As a result of evaluation of past monitoring efforts this year transects will be 4000 m long (final protocol and techniques are continuing to be refined by us and approve by the Desert Tortoise Coordinator). The location of the transect start points within the DWMAs has been determined randomly. Currently, we are measuring encounter rates in all of the proposed Desert Wildlife Management Areas (DWMA) in Nevada. It is necessary to estimate encounter rates in order to plan the monitoring effort in each DWMA necessary to obtain an adequate sample size to statistically estimate density.

Tortoise observers navigate to the start points form the nearest road using Global Positioning System (GPS) instruments. At the start point a 100 m. tape will be stretched along the ground and a 2-person team will thoroughly search along the tape. Tortoise encountered will be weighed, measured, have sex determined, have health assessed and location recorded. The stretching and searching of the line will continue until the transect length has been completed.

Focal Animals

While the transect teams search for tortoises an additional 1 or 2-person team will monitor radio transmitter equipped tortoises, “focal animals” to determine tortoise activity. This value allows the density estimate to be calibrated for variations in tortoise activity levels. A sample of approximately 10-20 tortoises will be equipped and monitored in each of the DWMAs.

To calibrate the transect sampling technique we observe behavior of focal animals.
Focal animals in each DWMA. Each focal animal team consists of a technician or graduate student and one Student Conservation Association volunteer. These individuals work closely

together each day using two radio receivers to document tortoise activity. Presently, we have focal tortoise samples in Paiute Valley, Bird Springs Valley, the Large Scale translocation Study Site (South). Additional focal tortoises may need to be located and equipped with transmitters. Current transmitters will need to be maintained, replaced when nearing the end of their battery life and refurbished for future use.

The monitoring of tortoise activity through focal tortoises is expensive and time consuming. We believe that tortoise activity can be modeled to provide the Program DISTANCE with the necessary calibration. We have discussed with the FWS the need for a Post-Doctoral level research effort to analyze our data and that of other researchers to model tortoise activity. We will develop a proposal for the FWS to address this need.

Desert Tortoise Monitoring Training

Our program has developed efficient and comprehensive training procedures. We have trained more than 120 interns and more than 50 consultant contractors working on FWS approve contracts to follow tortoise monitoring procedures. At the request of the FWS we have assisted in demonstrating the tortoise monitoring protocols for agency biologists, managers, other researchers and consultants. This training has included weeklong seminars and field exercises in Las Vegas and at Jean, Nevada on our field training facility. We will continue to provide reasonable training opportunities, workshops, seminars and exercises for tortoise monitoring field workers from throughout the desert tortoise range.

Our training procedures include classroom and field exercises. The field exercises are conducted under realistic conditions using tortoise models. In additions we use live tortoises that are a part of other research projects we are conducting to refine the field worker's search image. The use of our training procedures allows us to evaluate the effectiveness of each observer team as to compliance with FWS protocols.

The expansion of our training facilities to accommodate all tortoise monitoring field workers will require that we have new tortoise models produced and a sufficient number to allow for wear and tear and loss and we have taken steps to have these models produced. We will require upgraded field logistic facilities such as installation of a fenced yard and trailer at Jean for conducting field briefings and housing trainees from outside the area. We are discussing the use of Bureau of Land Management land in the vicinity of Jean to provide a logistical base for training and short-term housing of trainees. In addition we will require additional training lines for training the increasing number of tortoise monitors and for improving the effectiveness of training. We will need the cooperation of the Bureau of Land Management in identifying suitable locations for additional training lines.

At the request of the FWS we have already undertaken the training and evaluation of all desert tortoise monitoring field workers and will continue this at a reasonable level.

Data Management and Evaluation

The FWS has requested that we monitor range-wide compliance with protocols and that we evaluate data as it is collected. This requires that we receive data electronic files and hard copies as they are collected, or within a few days. The protocols currently being followed are sensitive to certain types of observer error. This type of error can, in some cases, be detected by ongoing evaluation of data collection and corrected. We proof and evaluate the data sets forwarded to us by other field workers and report the results to the FWS.

We maintain electronic records of all tortoise monitoring data and archive hard copies of all data sheets for the FWS.

Development of New Monitoring Techniques

At the request of the FWS we have undertaken an evaluation of current monitoring techniques. We have developed and exciting new approach to monitoring tortoise population density. This new technique was presented to the Technical Advisory Committee of the Desert Tortoise Management Oversight Group (MOG-TAC) in the fall, 2001. We proposed that a revolutionary approach to monitoring procedures and a new approach to data evaluation might lead to improvements in the accuracy of density estimates and a significant decrease in cost. Simulations of these techniques have shown great promise. The MOG-TAC enthusiastically approved field evaluations of this new approach.

We hope to begin field evaluations of these new techniques in spring 2002. For this to happen we will require the assistance of the Las Vegas office of the Bureau of Land Management in approving installation of additional tortoise training lines in the vicinity of Jean. We are waiting for this approval.

What follows is a Powerpoint presentation on the new monitoring technique we are developing; "Transect Probability Method."


"Monitoring the desert tortoise"
Is there a better method than Distance Sampling?

Equation for Distance Sampling

$$D = \frac{n}{(L*w) * Pa * Go}$$

Distance Sampling requires finding tortoises along a transect, and measuring the distance perpendicular to the transect to each tortoise in order to estimate the probability of detecting tortoises along the transect.

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Equation for Distance Sampling

$$D = \frac{n}{(L*w) * Pa * Go}$$

The rule of thumb is that the transect should be long enough to encounter approximately 60 tortoises.

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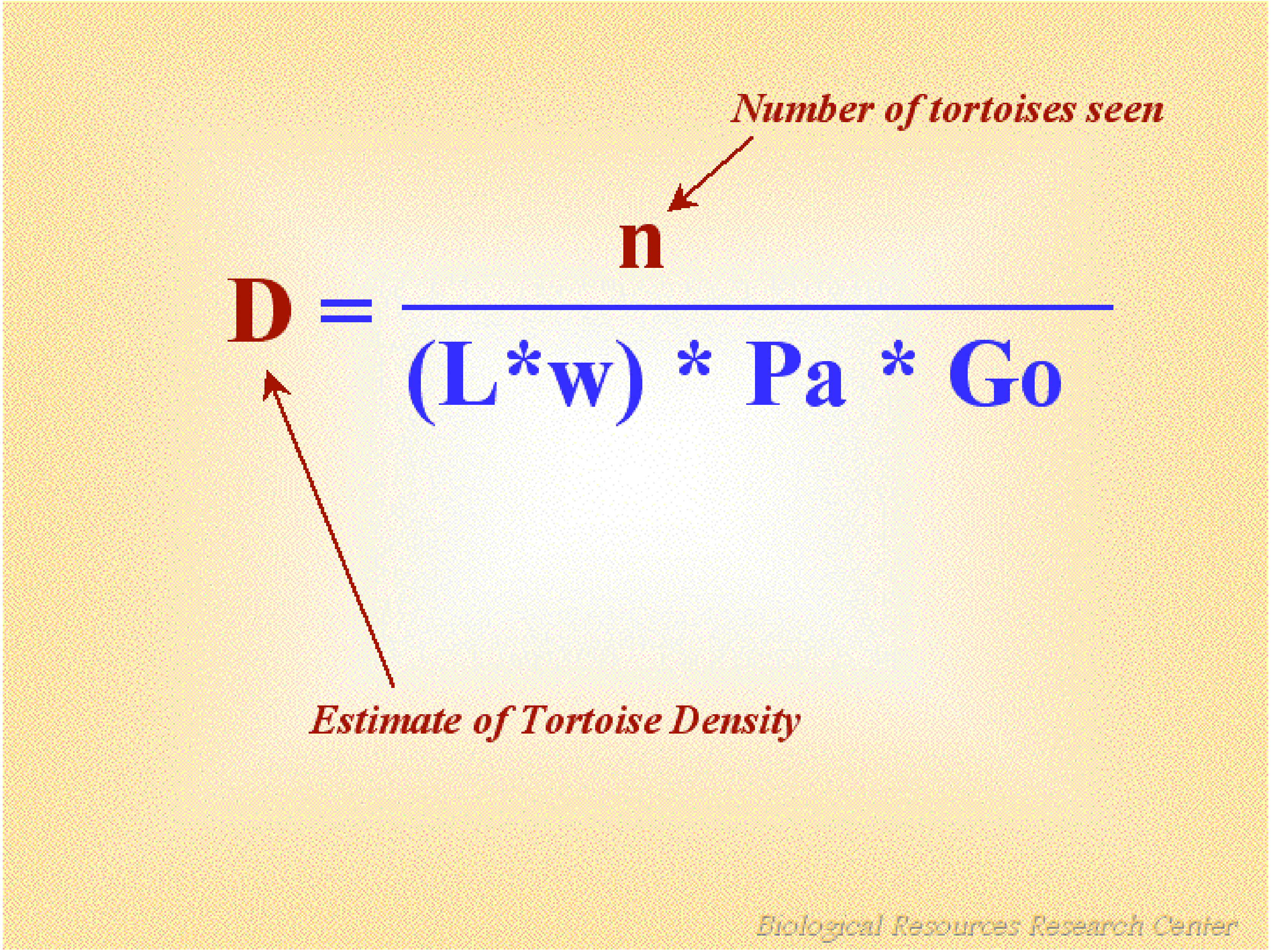
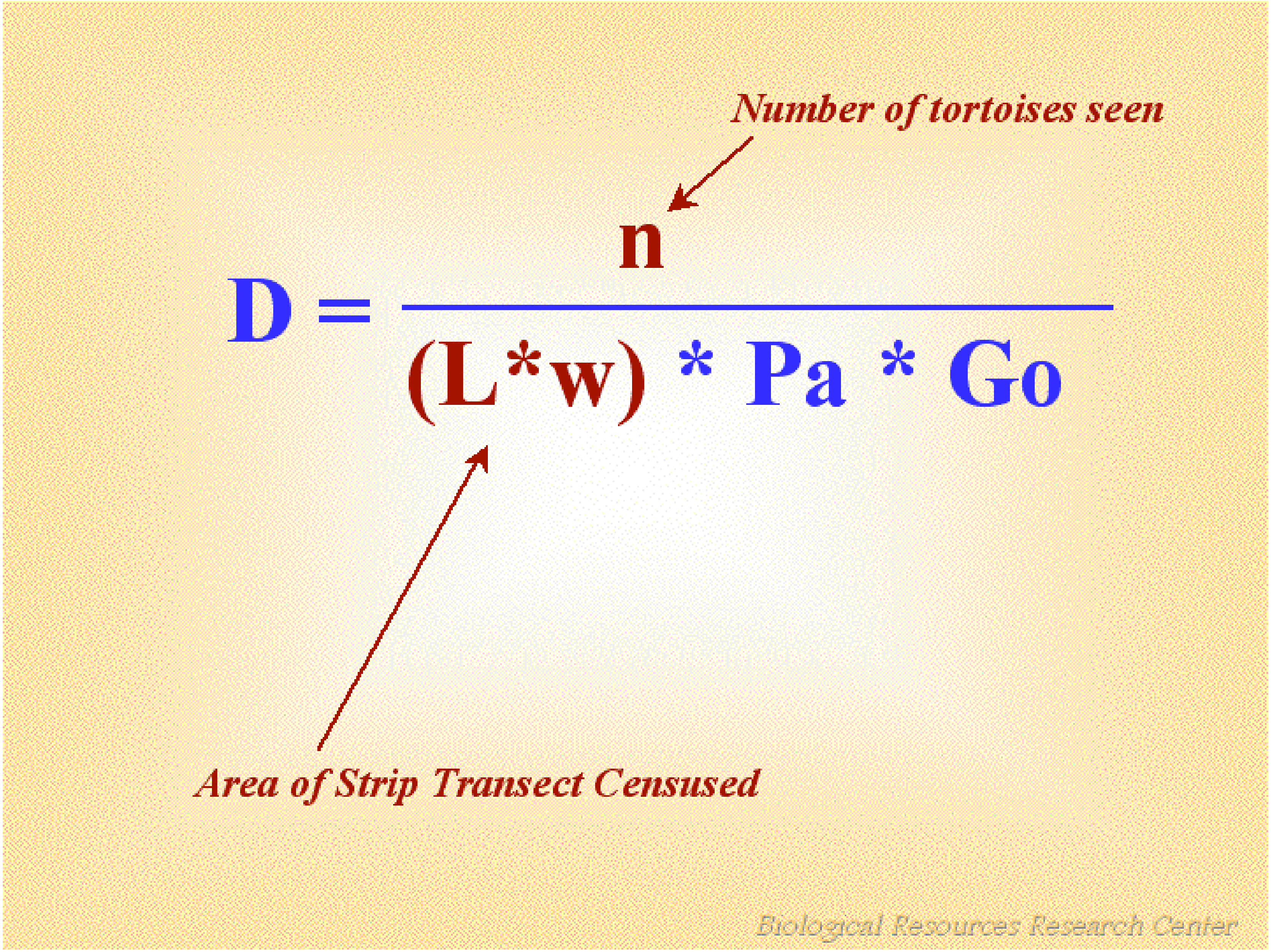
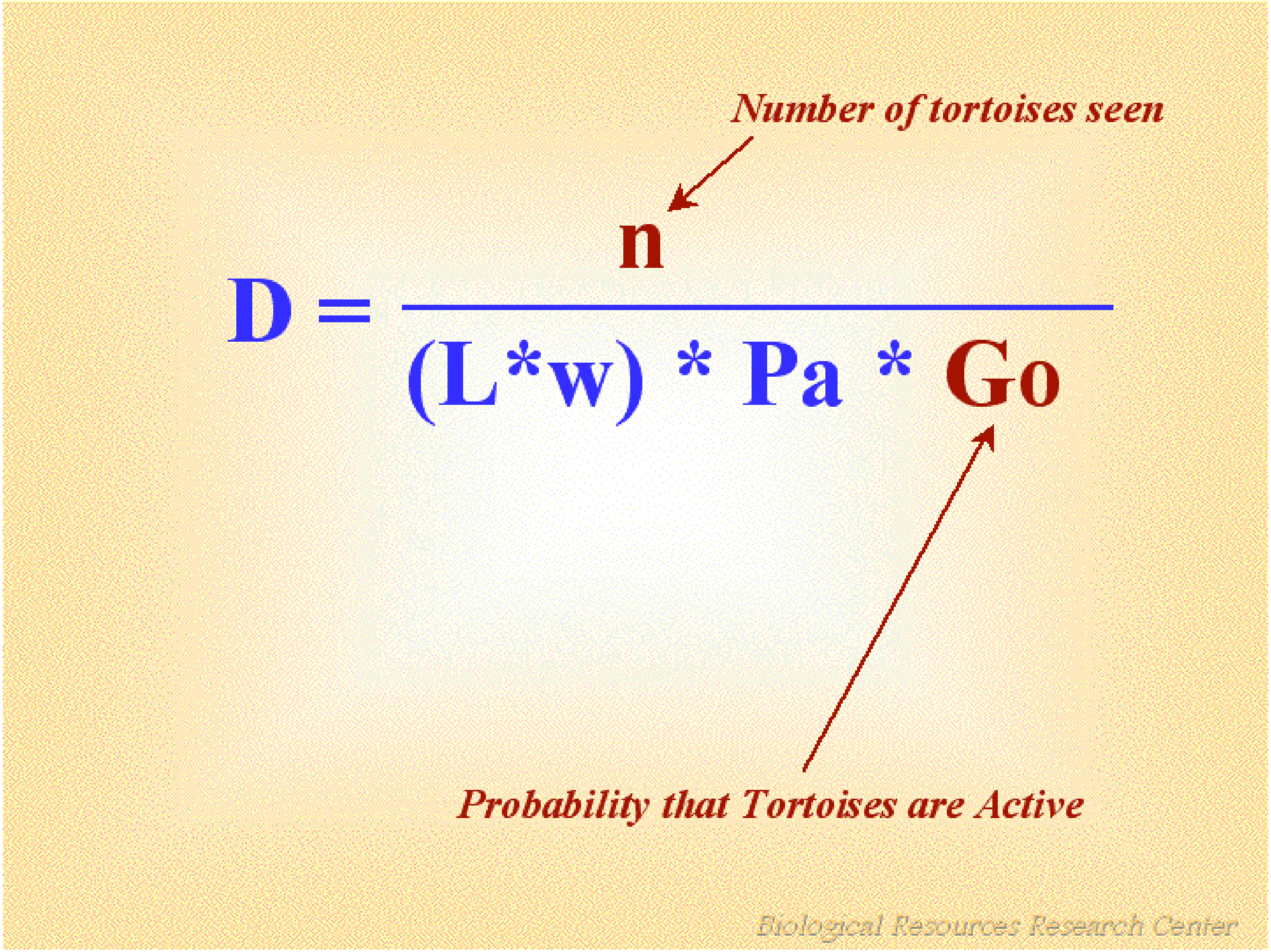
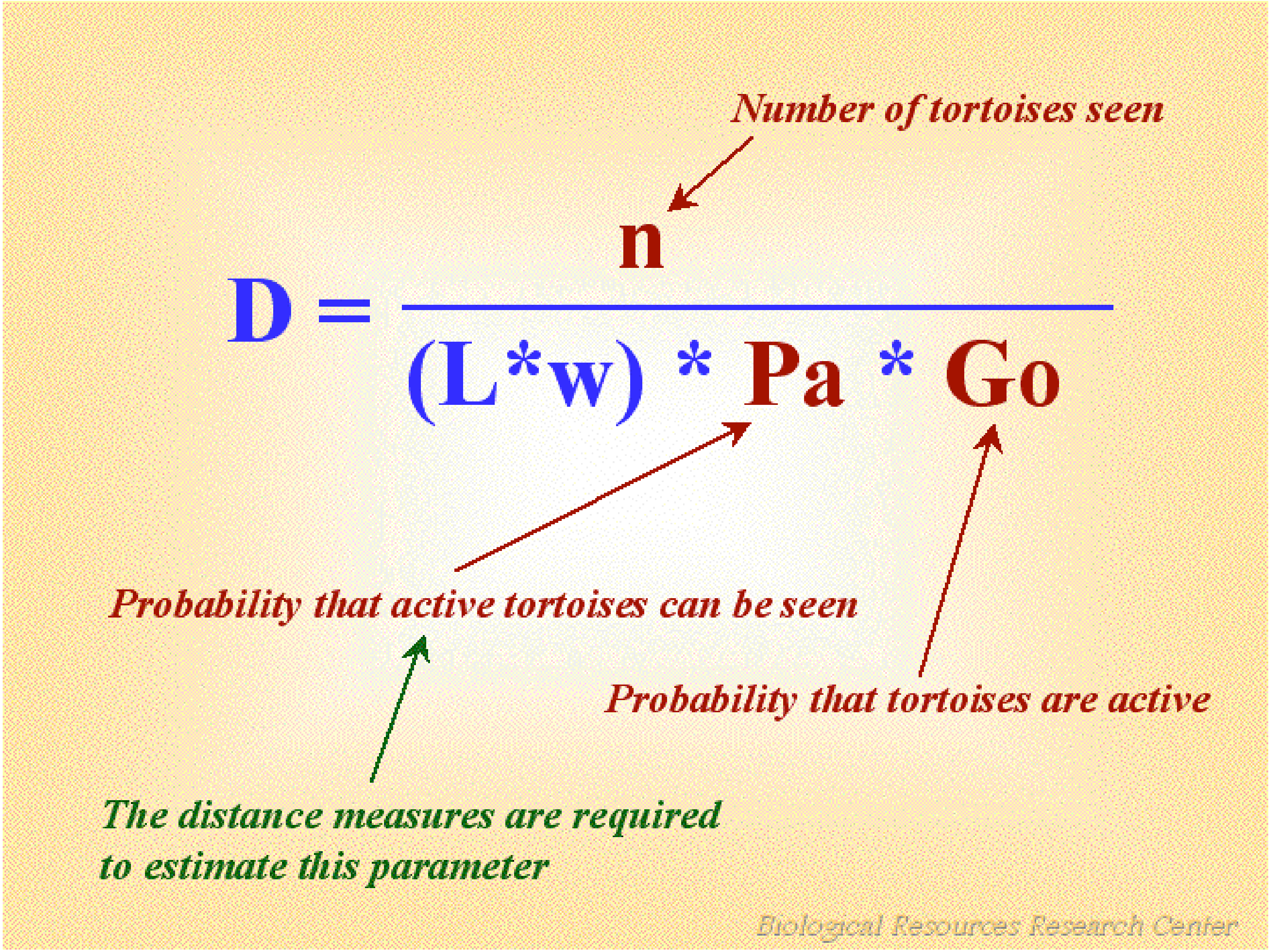
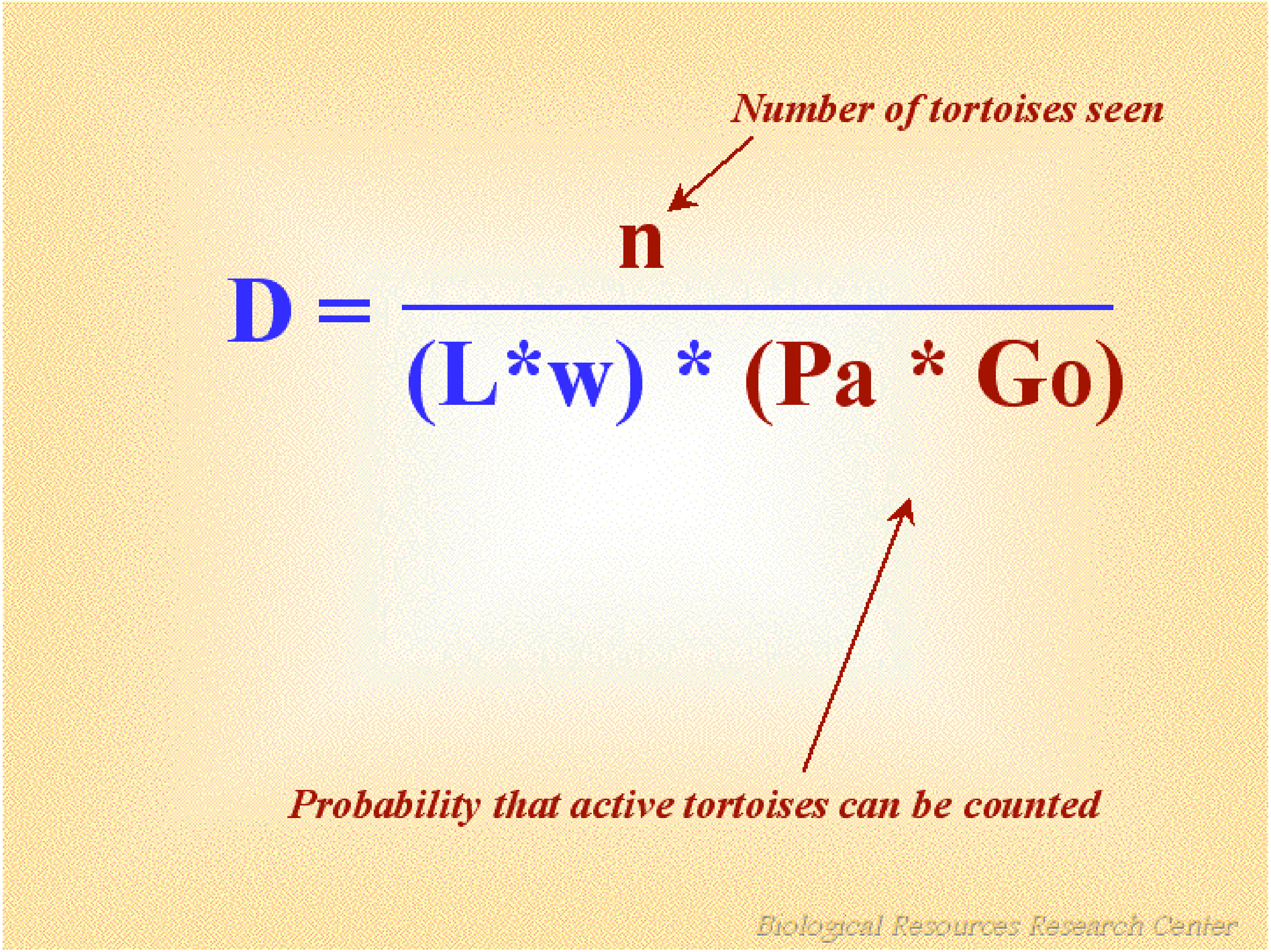

Number of tortoises seen
$$D = \frac{n}{(L*w) * Pa * Go}$$
Estimate of Tortoise Density
Biological Resources Research Center


Number of tortoises seen
D = n / ((L*w) * Pa * Go)
Area of Strip Transect Censused
Biological Resources Research Center


Number of tortoises seen
D = n / (L*w) * Pa * Go
Probability that Tortoises are Active
Biological Resources Research Center


Number of tortoises seen
D = n / ((L*w) * Pa * Go)
Probability that active tortoises can be seen
Probability that tortoises are active
The distance measures are required
to estimate this parameter
Biological Resources Research Center


Number of tortoises seen
D = n / ((L*w) * (Pa * Go))
Probability that active tortoises can be counted
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Go

Go = f(day of year,
rainfall, operative
temperature, other)

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Study Sites

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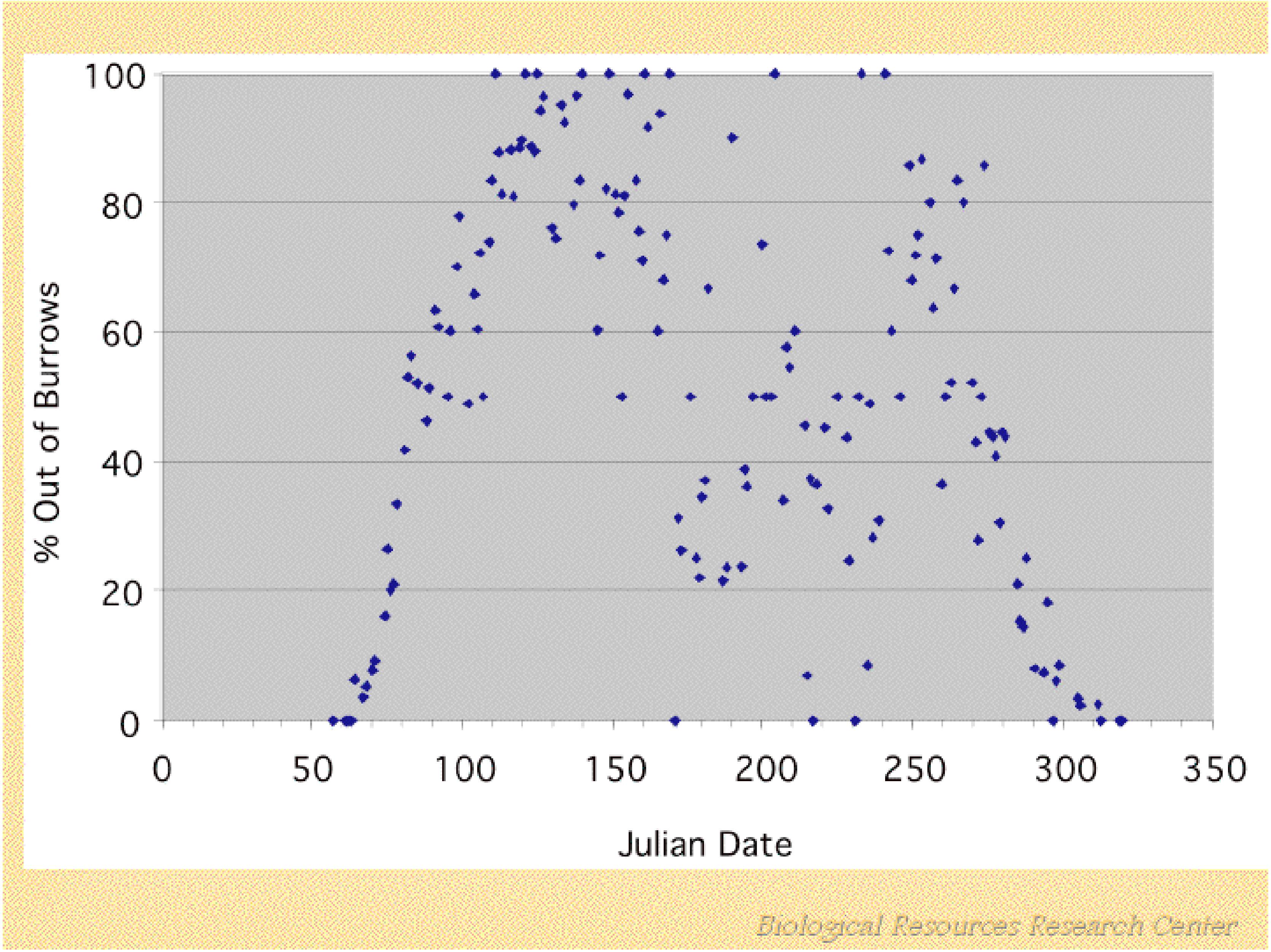
Bird Spring Valley
Elevation 997 m


% Out of Burrows
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Julian Date
Biological Resources Research Center

Clearly the best approach is to develop a technique that allows population estimation on the day in which Go is known instead of averaging over many dissimilar days.

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Pa

Pa = f(observer, vegetation,
habitat physiognomy,
other)

This parameter can be estimated by distance sampling or directly.

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Pa

Pa = f(observer, vegetation, habitat physiognomy, other)

This parameter can be estimated by distance sampling or directly.

Study Sites

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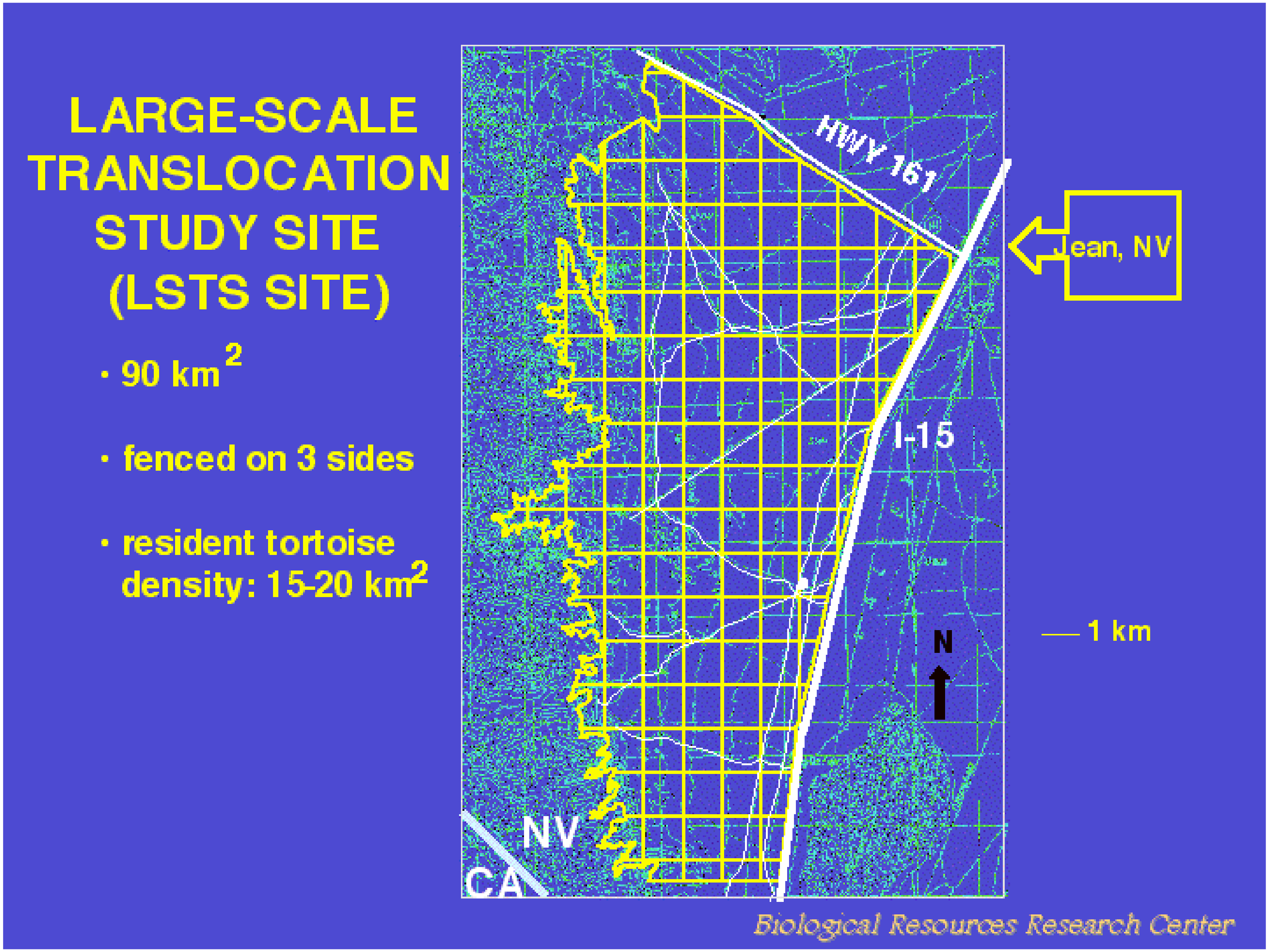
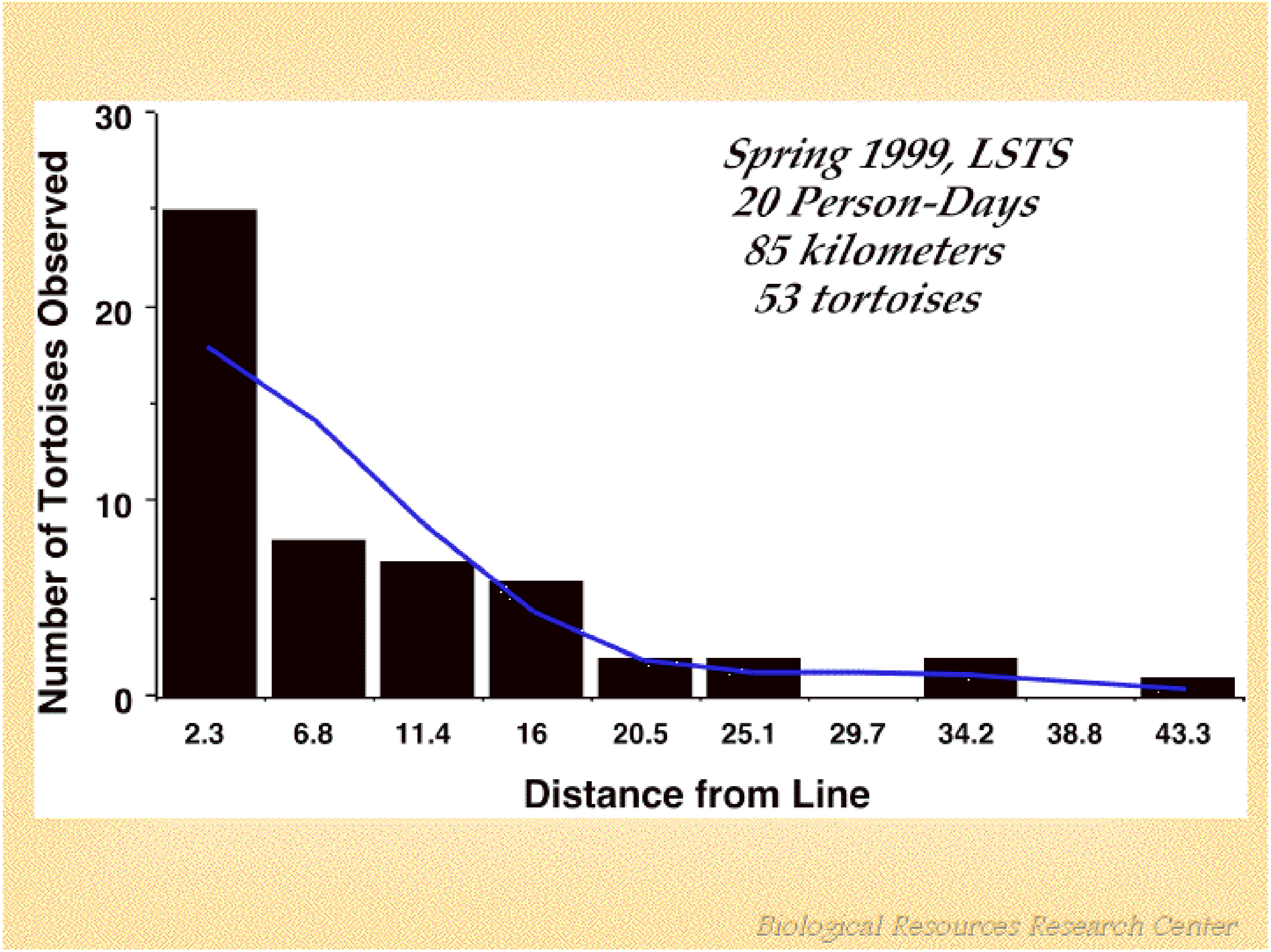
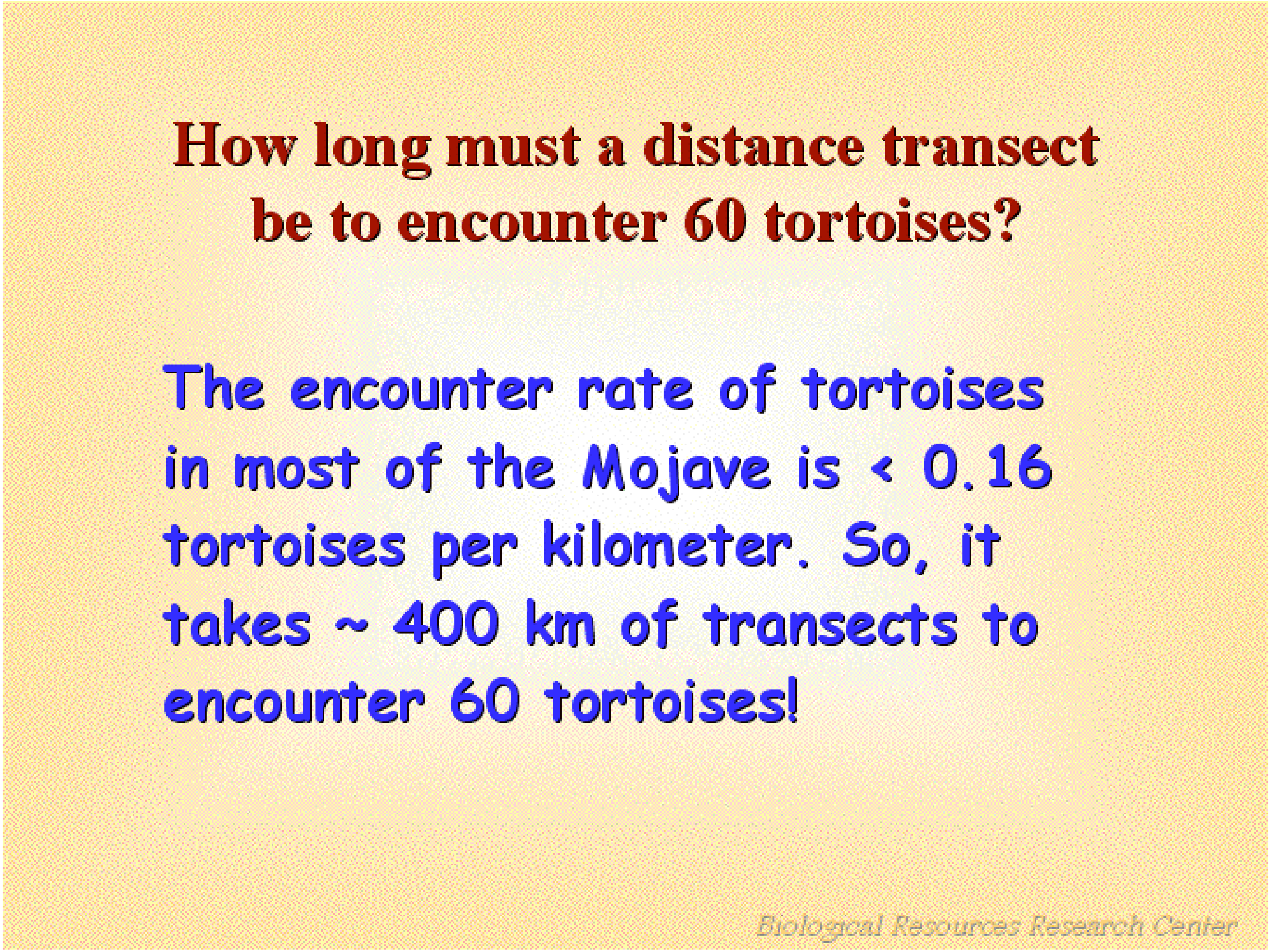

LARGE-SCALE TRANSLOCATION STUDY SITE (LSTS SITE)
• 90 km2
• fenced on 3 sides
• resident tortoise density: 15-20 km2
HWY 161
Jean, NV
I-15
N
1 km
NV
CA
Biological Resources Research Center


Spring 1999, LSTS
20 Person-Days
85 kilometers
53 tortoises
Number of Tortoises Observed
0
10
20
30
2.3
6.8
11.4
16
20.5
25.1
29.7
34.2
38.8
43.3
Distance from Line
Biological Resources Research Center


How long must a distance transect
be to encounter 60 tortoises?
The encounter rate of tortoises in most of the Mojave is < 0.16 tortoises per kilometer. So, it takes ~ 400 km of transects to encounter 60 tortoises!
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Remember - regardless of how it is estimated,

Pa = f(observer, vegetation, habitat physiognomy, other)

Suppose we estimated Pa more directly?

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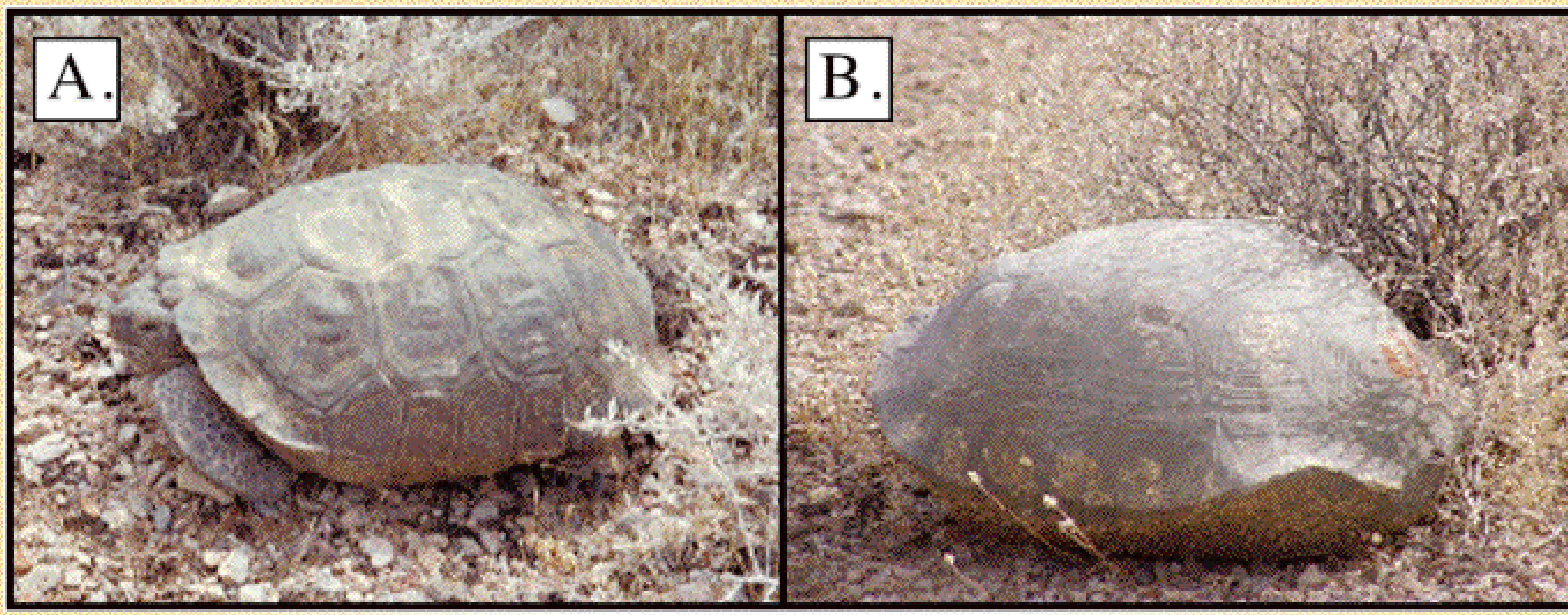
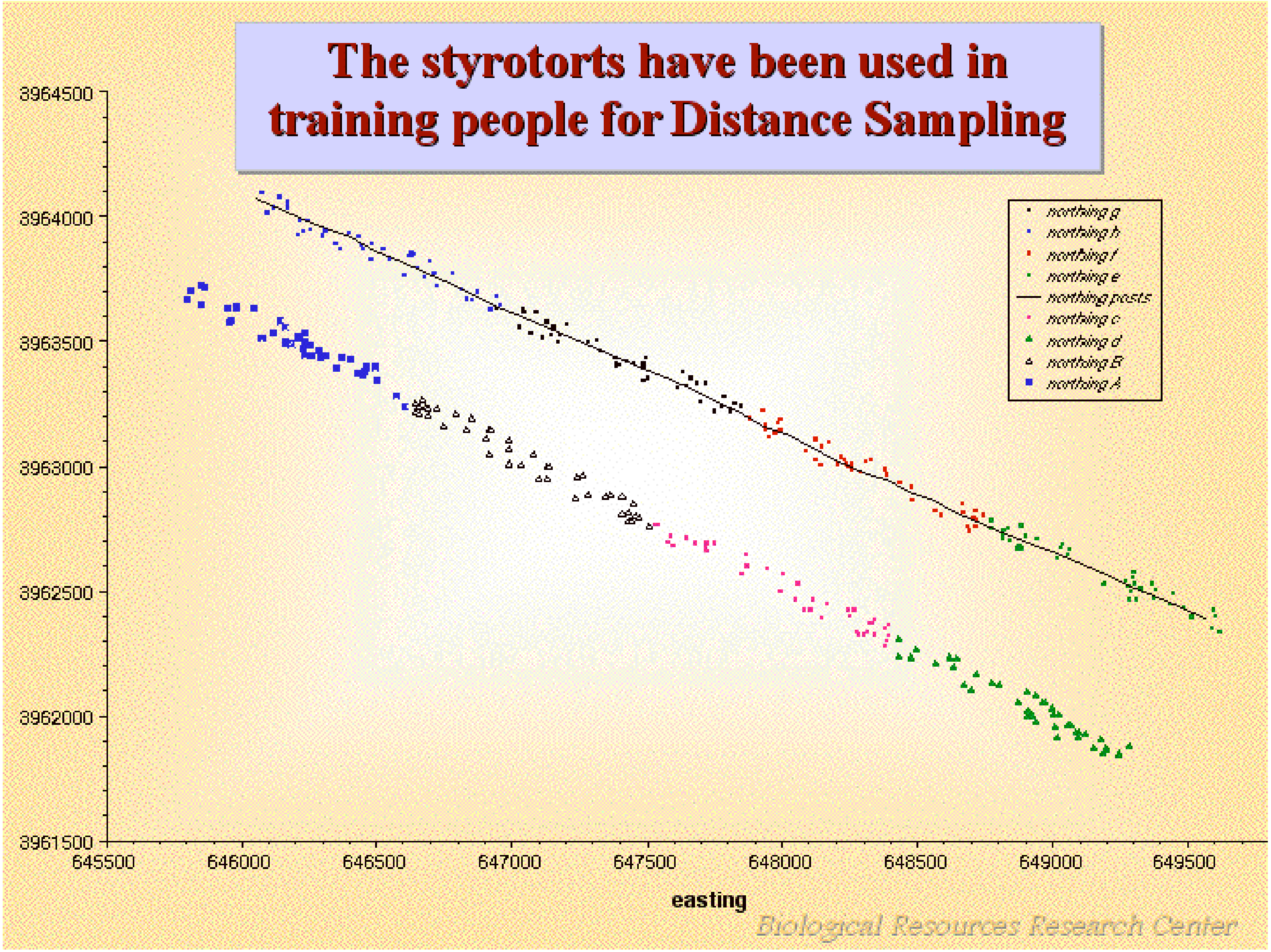
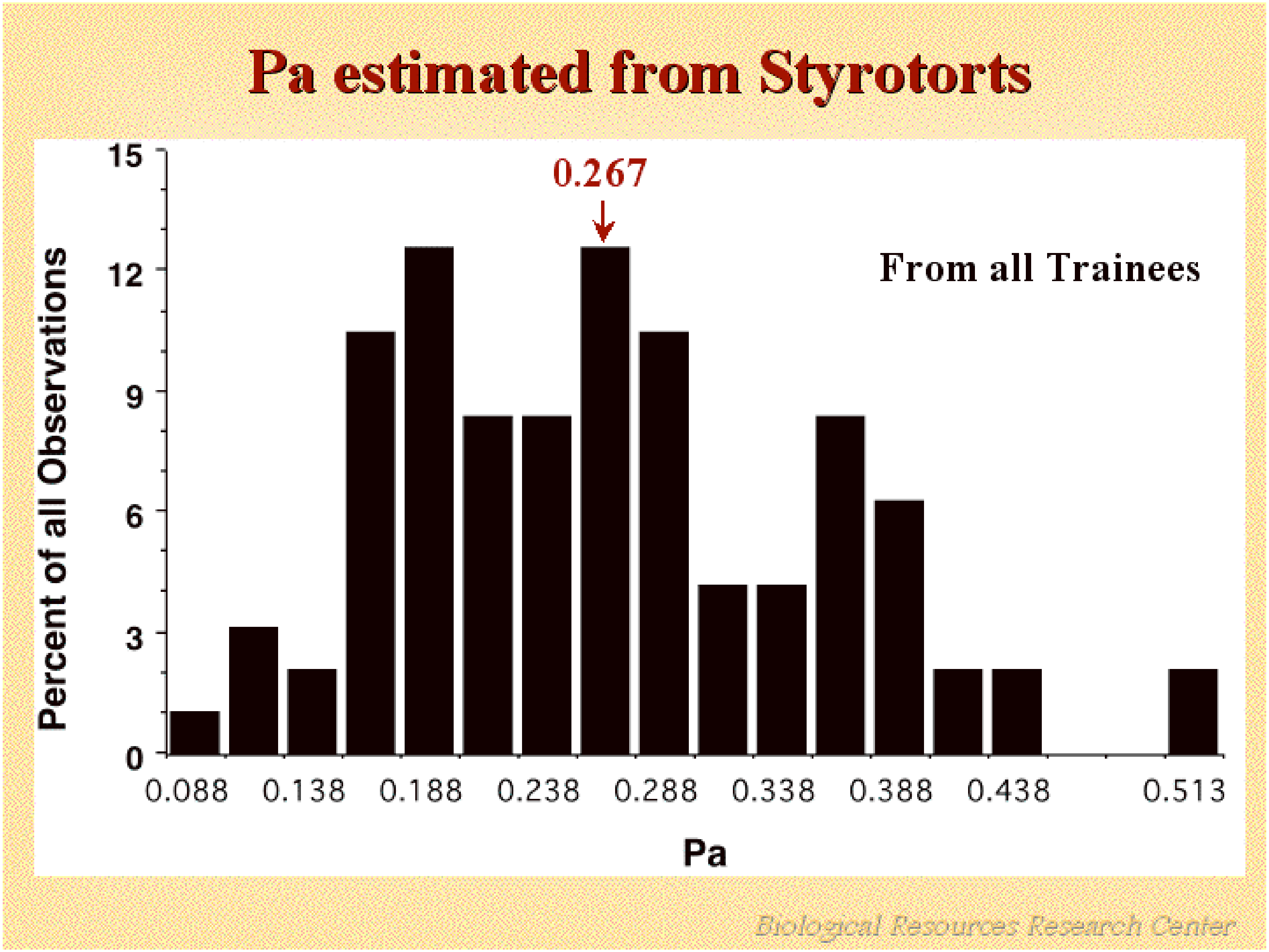


We have been able to manufacture styrofoam tortoises that look remarkably like real tortoises.

Biological Resources Research Center


The styrotorts have been used in training people for Distance Sampling
northing g
northing h
northing f
northing e
northing posts
northing c
northing d
northing B
northing A
3964500
3964000
3963500
3963000
3962500
3962000
3961500
645500
646000
646500
647000
647500
648000
648500
649000
649500
easting
Biological Resources Research Center


Pa estimated from Styrotorts
0.267
From all Trainees
Percent of all Observations
15
12
9
6
3
0
0.088
0.138
0.188
0.238
0.288
0.338
0.388
0.438
0.513
Pa
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$$D = \frac{n}{(L*w) * Pa * Go}$$

We can estimate population density using this equation, but using Pa measured directly using Styrotorts, We'll call this approach the **Transect Probability Method**.

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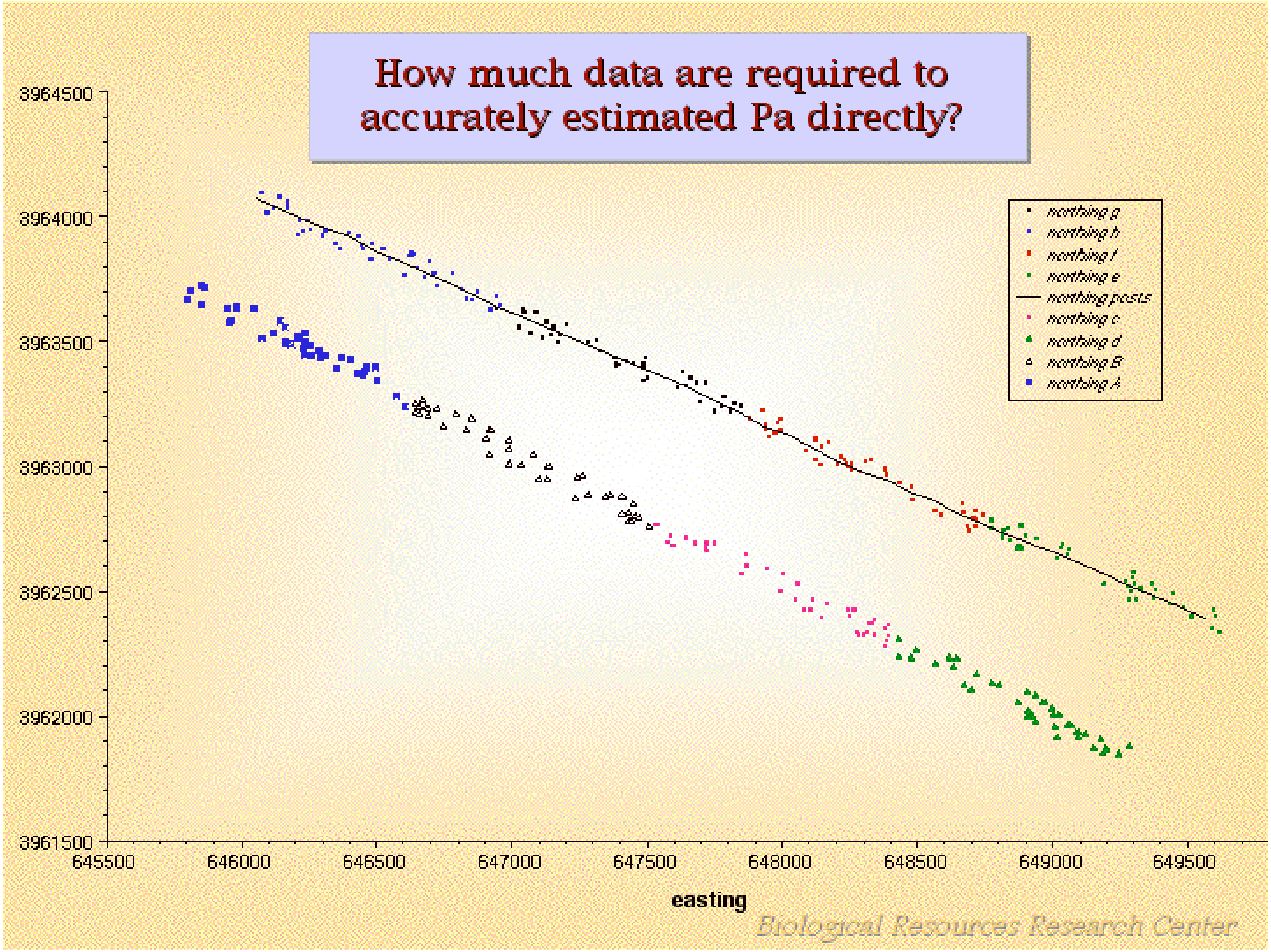
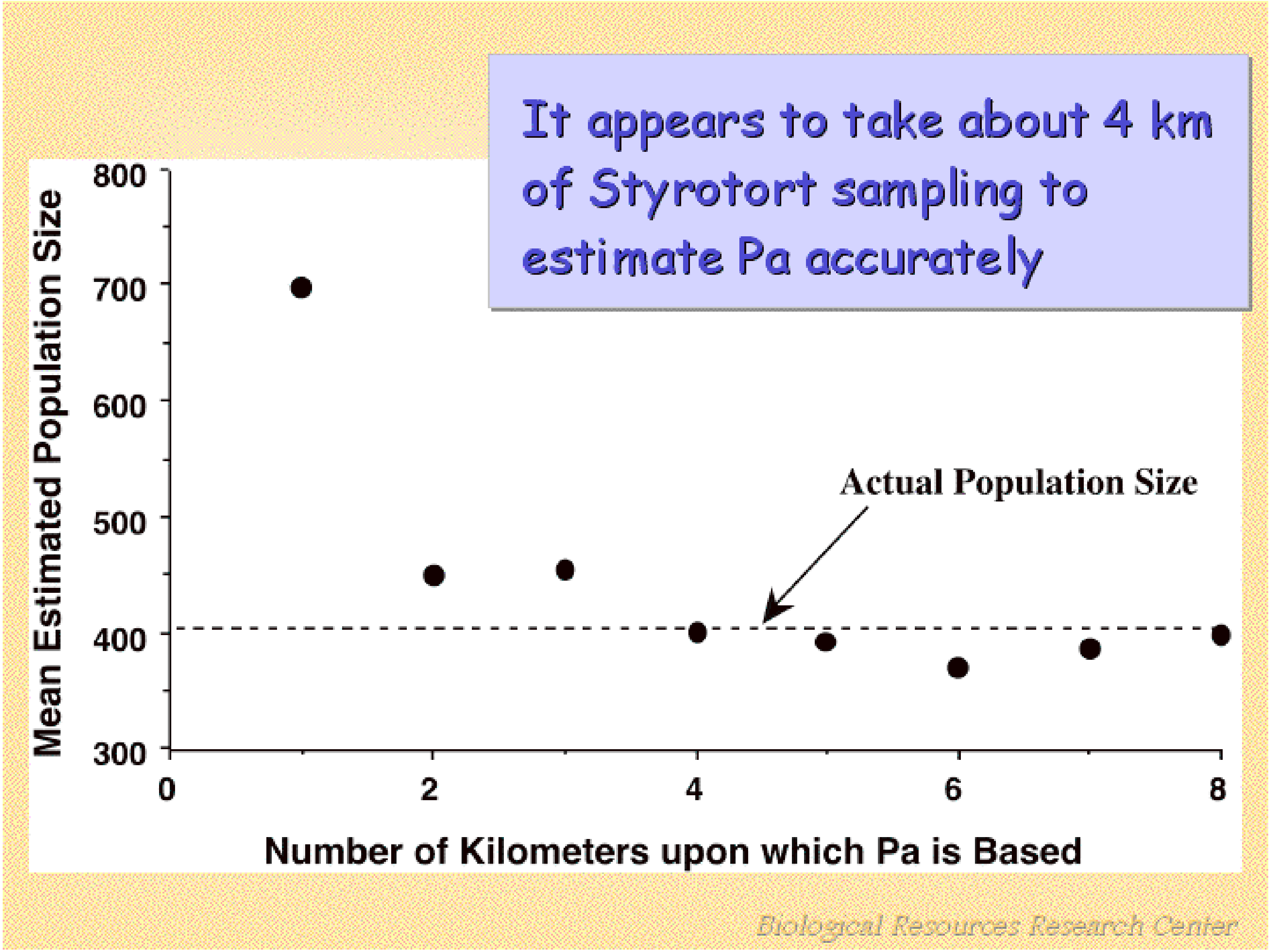
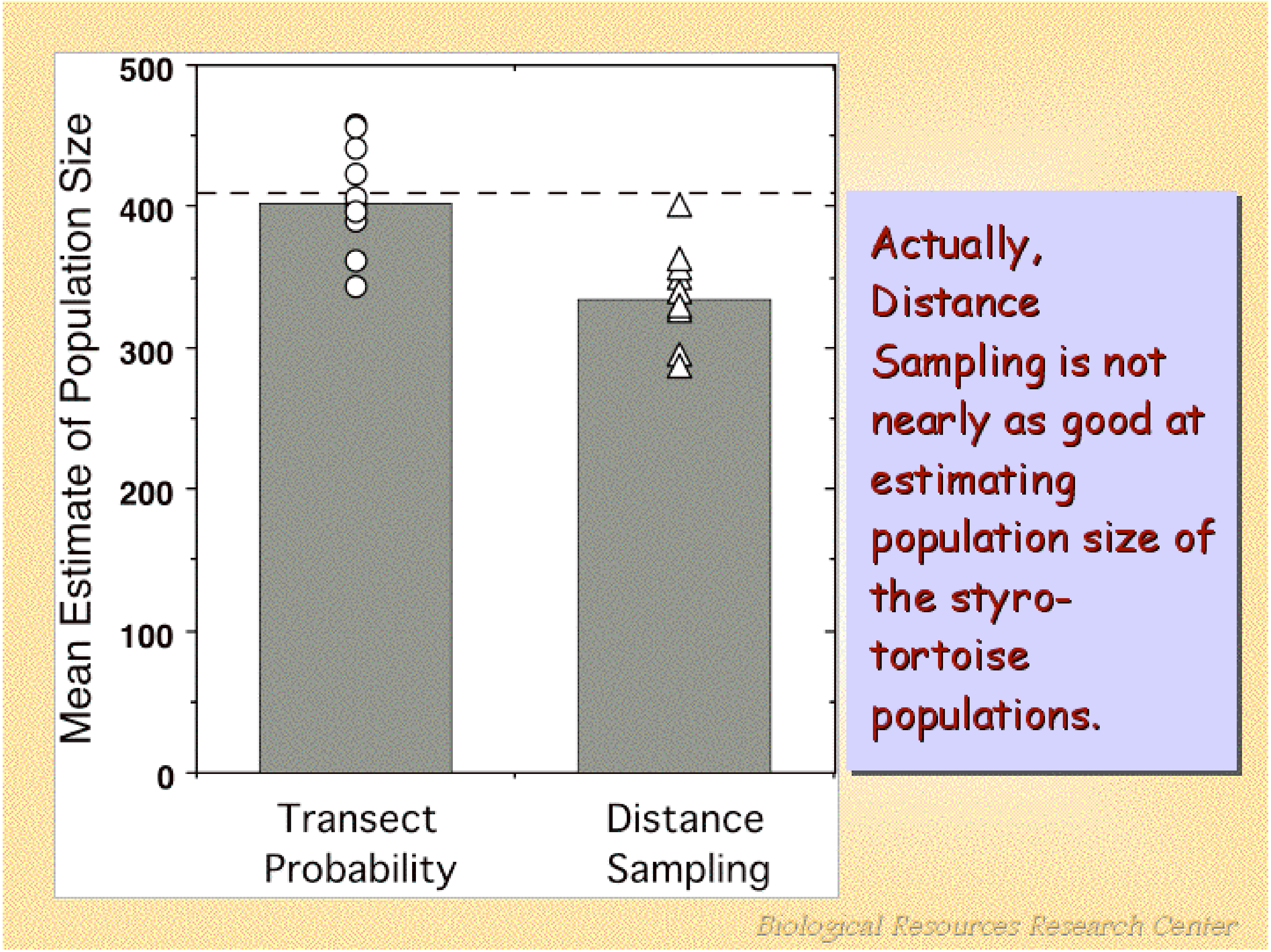
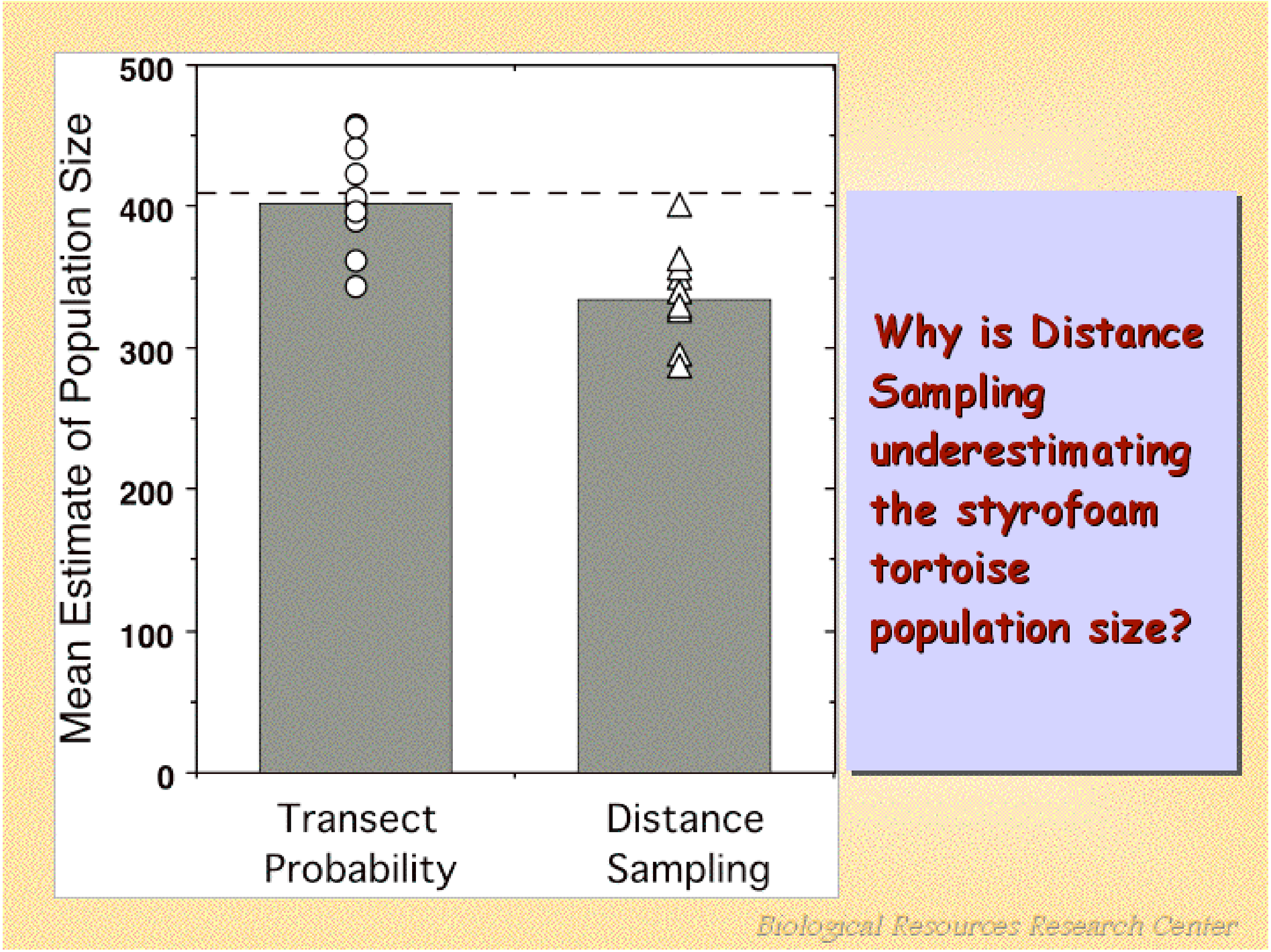

How much data are required to accurately estimated Pa directly?
3964500
3964000
3963500
3963000
3962500
3962000
3961500
645500
646000
646500
647000
647500
648000
648500
649000
649500
easting
northing g
northing h
northing f
northing e
northing posts
northing c
northing d
northing B
northing A
Biological Resources Research Center


It appears to take about 4 km of Styrotort sampling to estimate Pa accurately
Mean Estimated Population Size
800
700
600
500
400
300
0
2
4
6
8
Actual Population Size
Number of Kilometers upon which Pa is Based
Biological Resources Research Center


Mean Estimate of Population Size
500
400
300
200
100
0
Transect Probability
Distance Sampling
Actually, Distance Sampling is not nearly as good at estimating population size of the styro-tortoise populations.
Biological Resources Research Center


Mean Estimate of Population Size
500
400
300
200
100
0
Transect Probability
Distance Sampling
Why is Distance Sampling underestimating the styrofoam tortoise population size?
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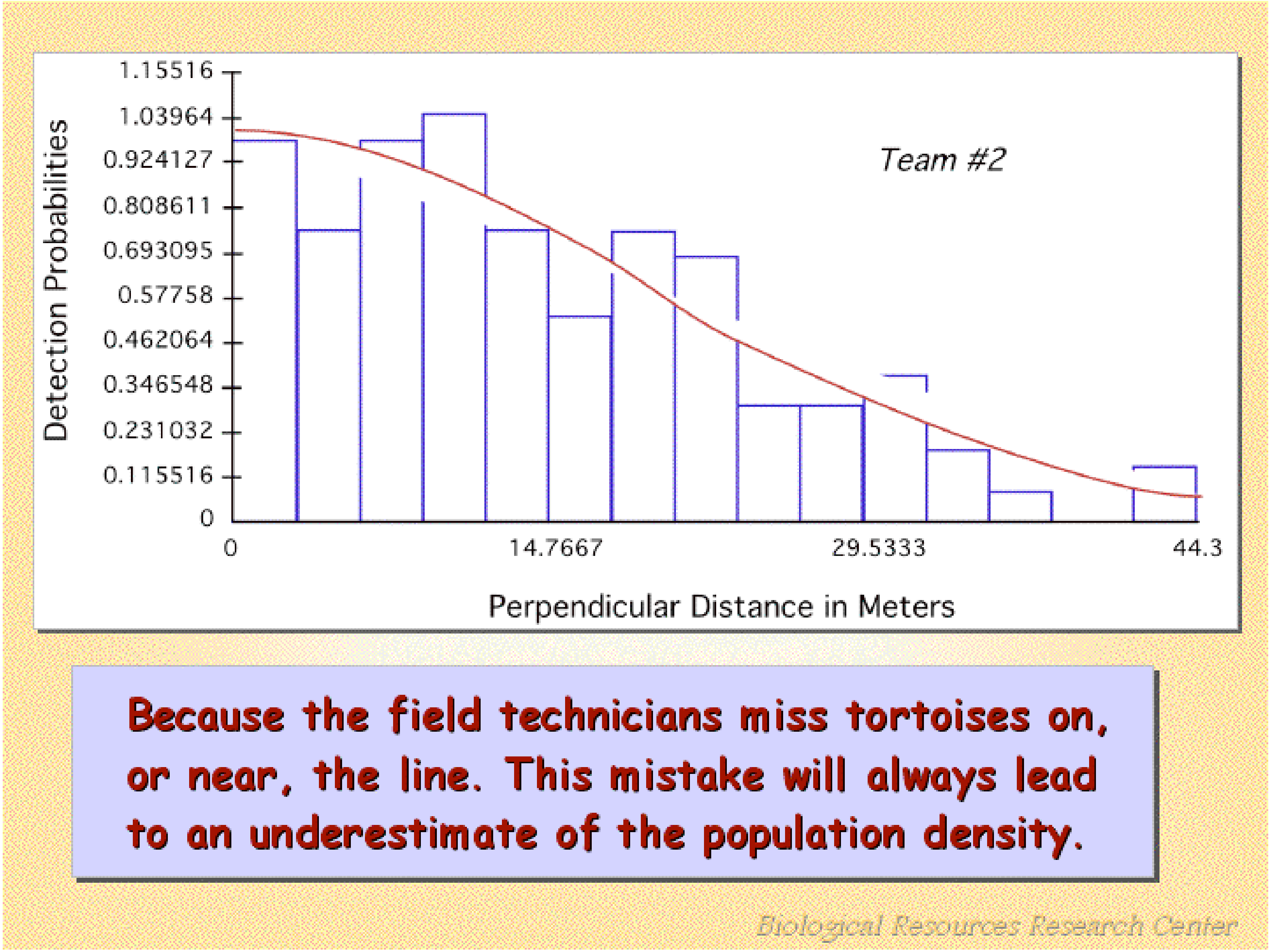
Detection Probabilities
1.15516
1.03964
0.924127
0.808611
0.693095
0.57758
0.462064
0.346548
0.231032
0.115516
0
0
14.7667
29.5333
44.3
Perpendicular Distance in Meters
Team #2
Because the field technicians miss tortoises on, or near, the line. This mistake will always lead to an underestimate of the population density.
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How does Distance Sampling compare with Transect Probability in real tortoise populations?

Transects have been conducted in the LSTS between 1999-present allowing us to compare Distance Sampling and Transect Probability.

How do estimates from each method differ?

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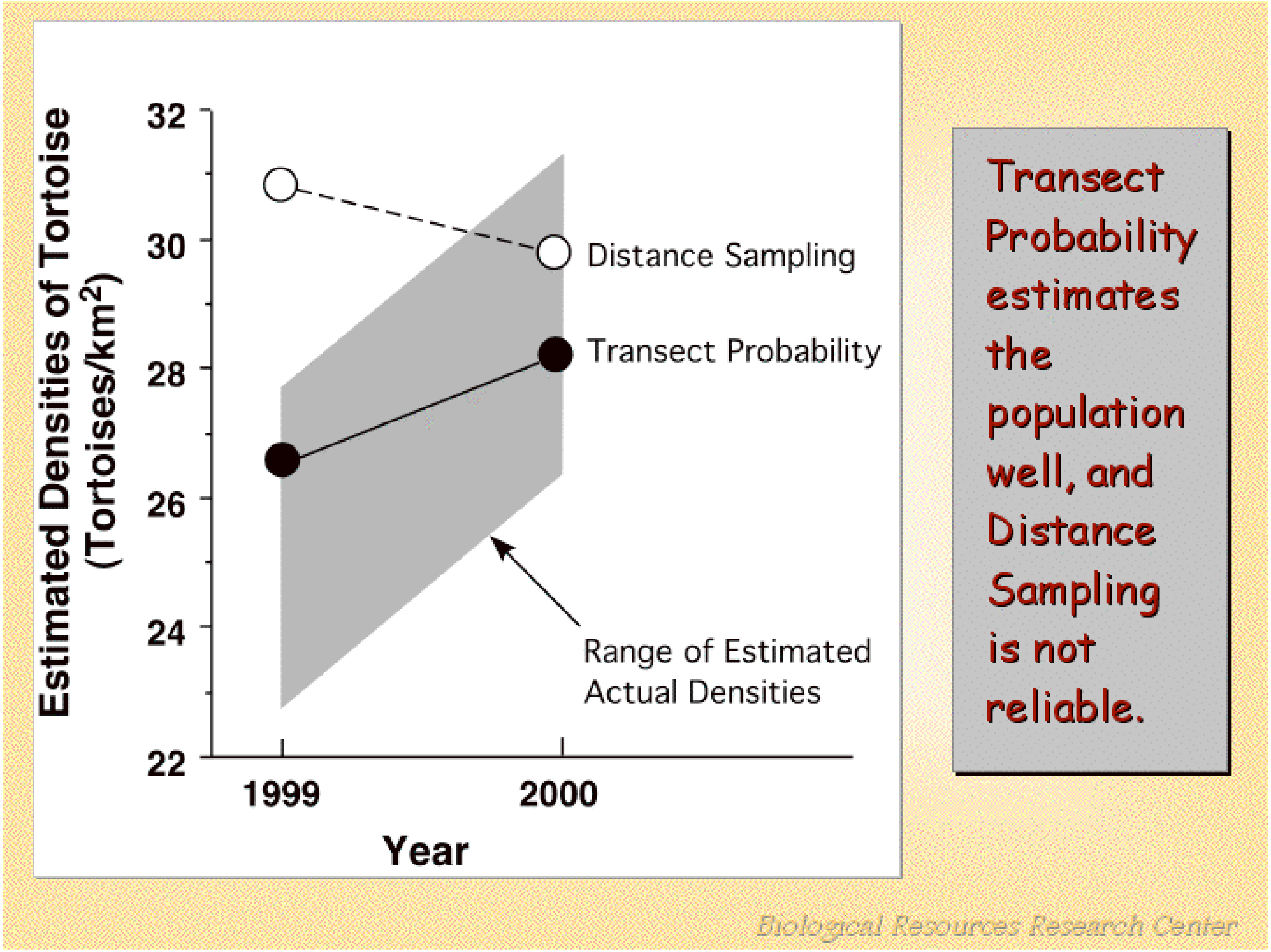
Estimated Densities of Tortoise (Tortoises/km²)
32
30
28
26
24
22
1999
2000
Year
Distance Sampling
Transect Probability
Range of Estimated Actual Densities
Transect Probability estimates the population well, and Distance Sampling is not reliable.
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With Transect Probability, the work load is much less:

a. Only one person is needed to run the transects because distances are not needed.

b. Fewer tortoises need be observed.

How many fewer?

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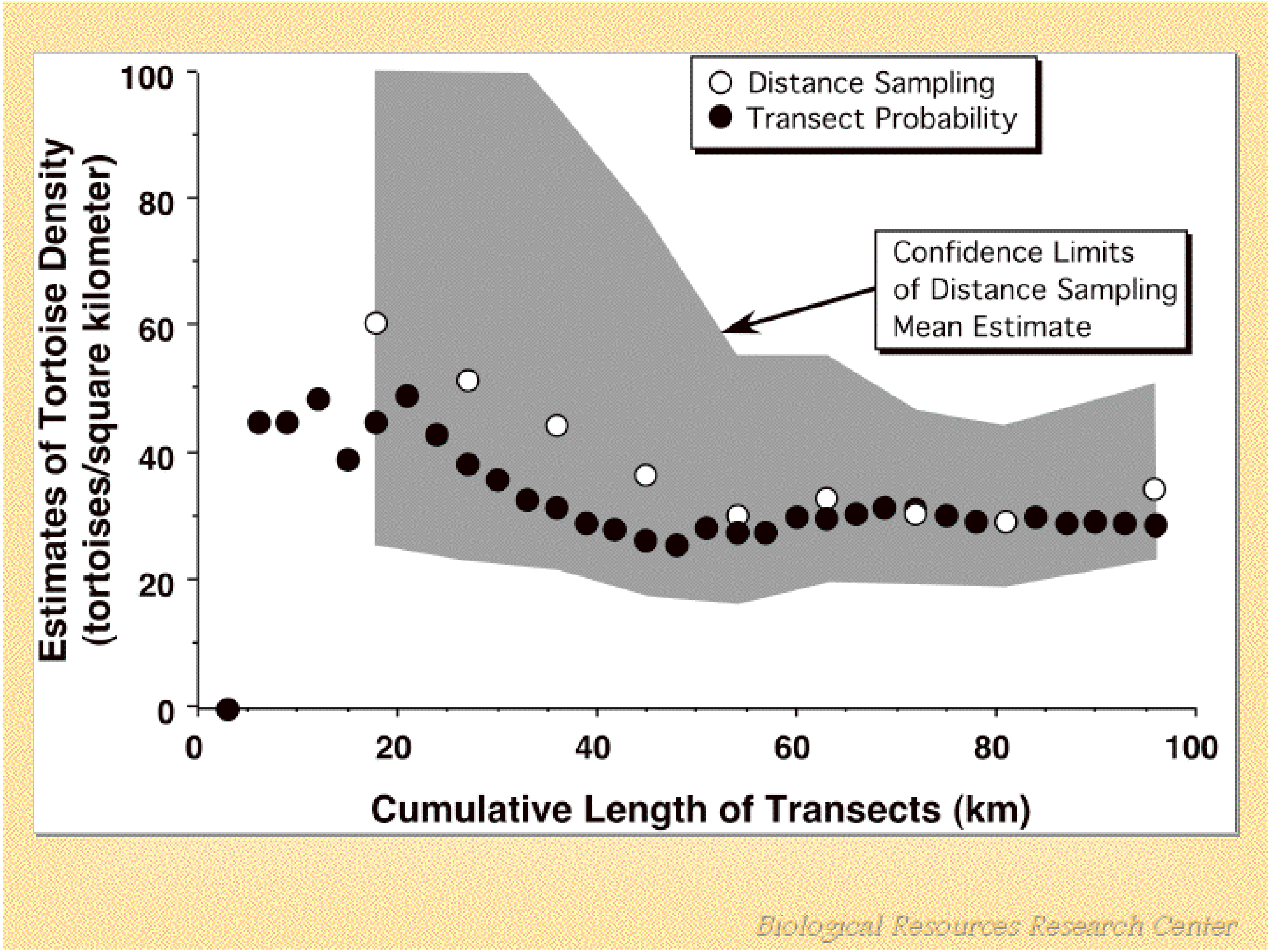
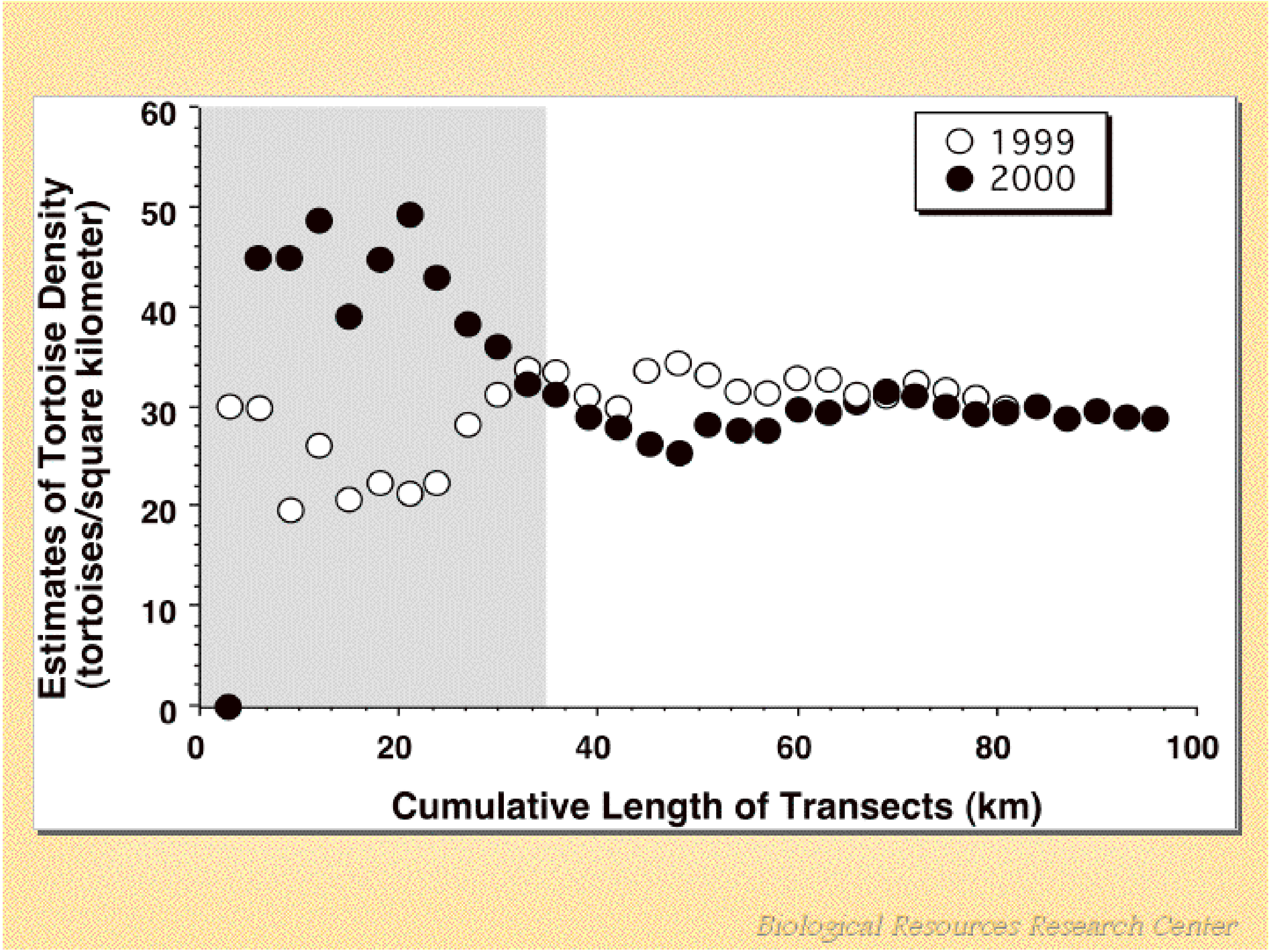

Estimates of Tortoise Density
(tortoises/square kilometer)
100
80
60
40
20
0
0
20
40
60
80
100
Cumulative Length of Transects (km)
Distance Sampling
Transect Probability
Confidence Limits
of Distance Sampling
Mean Estimate
Biological Resources Research Center


Estimates of Tortoise Density
(tortoises/square kilometer)
60
50
40
30
20
10
0
0
20
40
60
80
100
Cumulative Length of Transects (km)
1999
2000
Biological Resources Research Center

Summary of Important Points

- The Transect Probability method measures Pa directly using models placed in the stratum of interest.
- The population estimates can be accomplished in a much shorter time with 1-2 persons (depending upon the density of tortoises).

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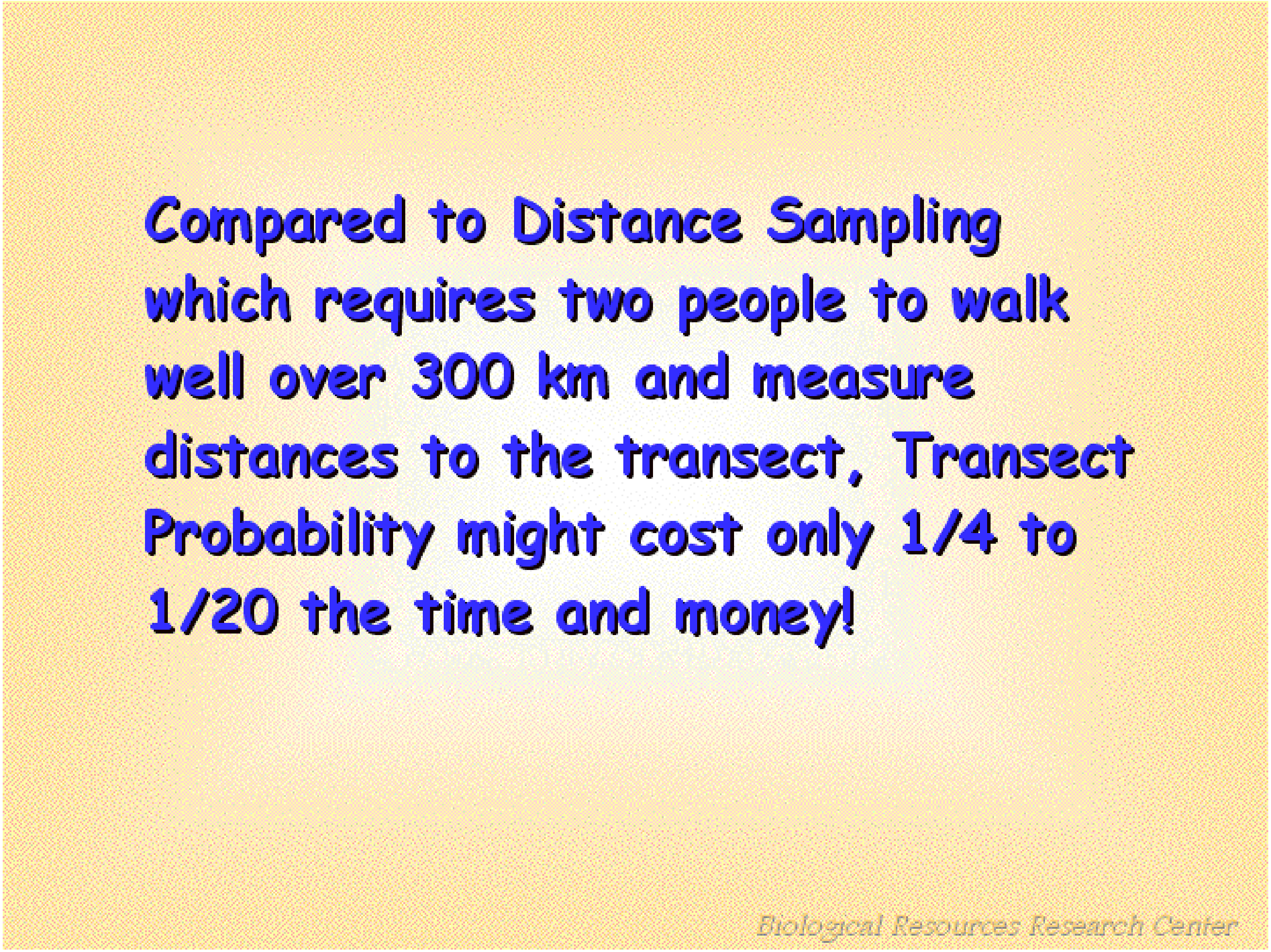
Compared to Distance Sampling which requires two people to walk well over 300 km and measure distances to the transect, Transect Probability might cost only 1/4 to 1/20 the time and money!
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What's next?
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There is much to be tested before we commit fully to Transect Probability. We were tricked into thinking that Distance Sampling was the most appropriate approach to estimate tortoise densities. Now we need to avoid rash decisions as we consider changing our approaches to monitoring.

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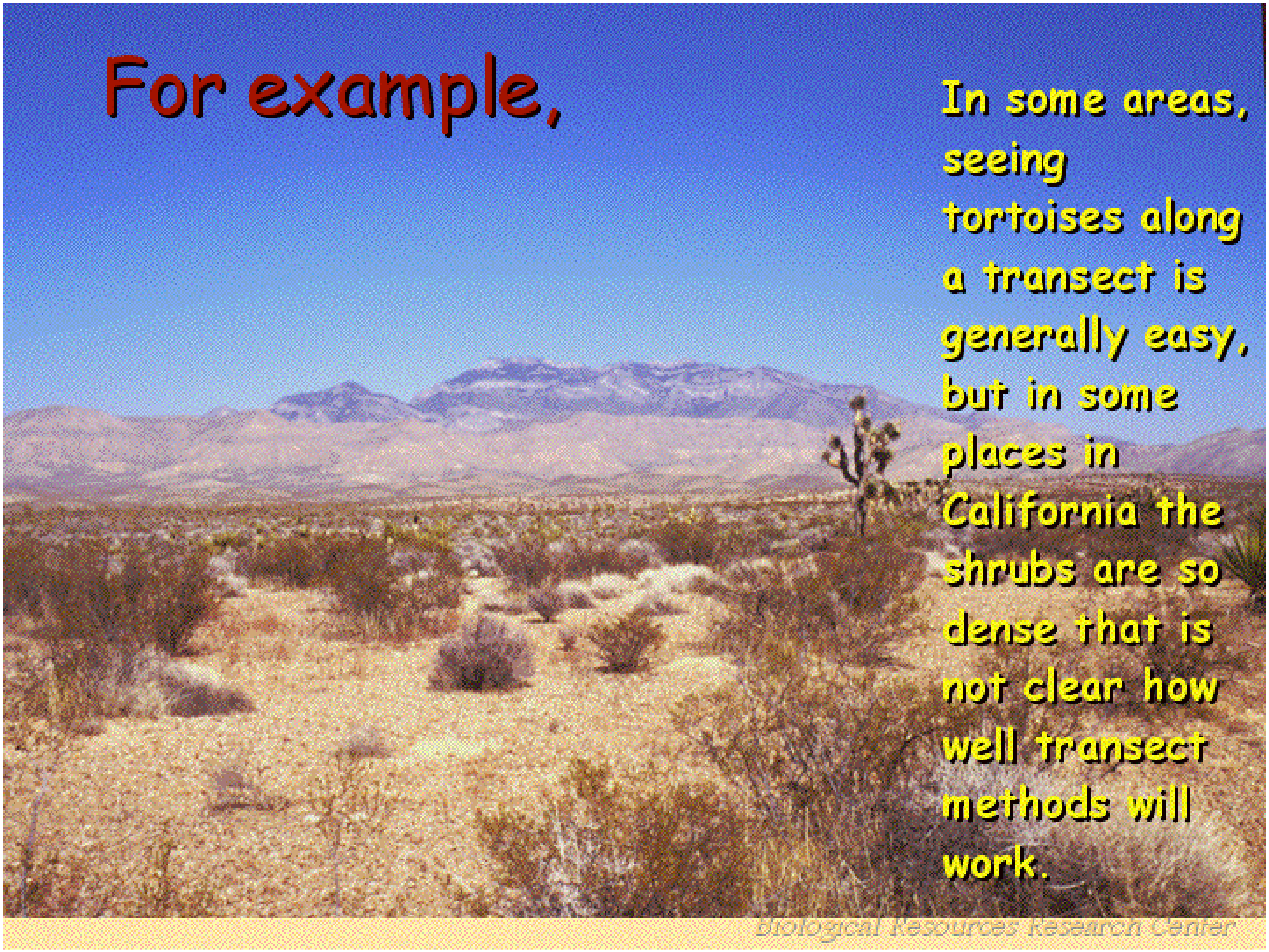
For example,
In some areas, seeing tortoises along a transect is generally easy, but in some places in California the shrubs are so dense that is not clear how well transect methods will work.
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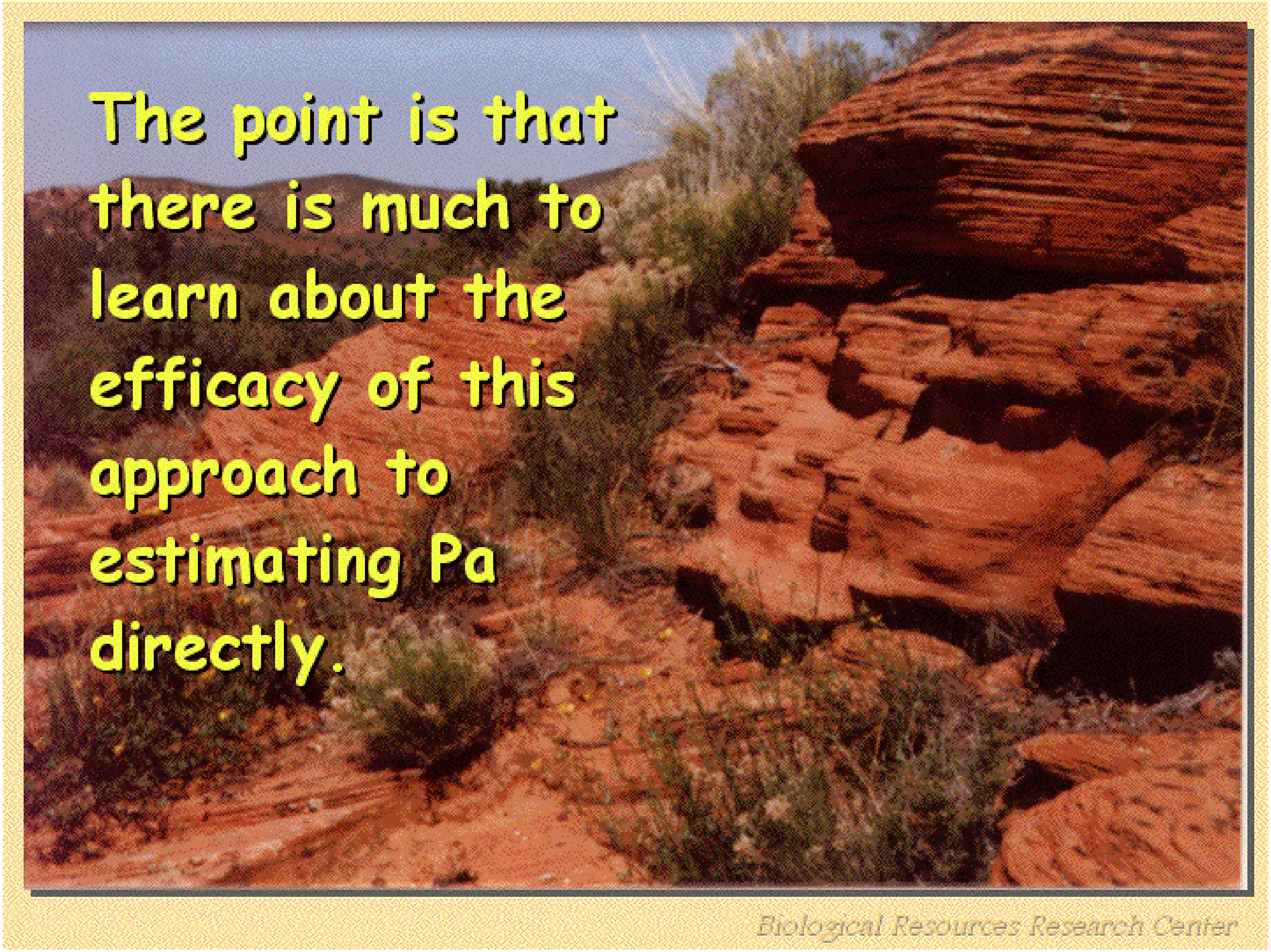
The point is that there is much to learn about the efficacy of this approach to estimating Pa directly.
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Adaptive Management

Adaptive management is a scientifically sound approach preferred by many resource managers when funding and scientific resources are available. Adaptive management provides resource managers with objective scientific data and analysis upon which to base management decisions as well as scientifically valid evaluation of management actions. Adaptive management provides those who fund resource management and conservation actions with objective and scientifically valid evaluations of the need for various actions and assessment of the effectiveness of those actions. From the beginning of the efforts to obtain a permit for a multiple species habitat conservation plan in Clark County, the BRRC has been called upon to help in developing an adaptive management plan for the Clark County MSHCP.

In 1996, BRRC hosted a panel of internationally well-known experts on the subject of adaptive management of conservation plans. This was an extremely productive workshop, which resulted in ideas contained in the MSHCP document under the subject of Adaptive Management. Additionally, BRRC has regularly suggested action plans and institutional relationship models that are known to work well for adaptive management of conservation plans elsewhere. We have archived our many suggestions, which have differed little in general, but differed substantially in some particulars over the years.

Our earliest models of action plans and institutional relationships were proposed using the players in the MSHCP process at that time. The beginning efforts to obtain a permit for a multiple species HCP included institutional elements no longer in existence in the MSHCP. In particular, the implementation and monitoring committee from the Desert Conservation Plan (the desert tortoise HCP) remained the forum directing the development of the MSHCP, but two additional elements were added to facilitate development of the plan: (1) a Biological Advisory Committee (BAC), and (2) a consultant (RECON). Supporting the BAC was still another institutional level which included several specialist groups (e.g., herpetologists, entomologists, etc.) which provided technical guidance to the BAC as the BAC developed proposals for an MSHCP to the Implementation and Monitoring Committee. Thus, the BRRC proposed organizational schemes for adaptive management that used the same elements used to develop the MSHCP. The first scheme developed (Fig. 1) was very similar to the current MSHCP organized with the IMC as the principal decision arena. The main difference between the current organization of the MSHCP, and the proposed organization in 1997 was the proposed retention of the BAC as a committee (made up of agencies, interest groups, and BRRC) to help the IMC by developing proposals for adaptive management which would then be brought to the IMC for discussion. Currently, the adaptive management MOA working group serves the same role as the proposed role for the BAC, and all other elements currently are as portrayed in Fig. 1.

Some members of the IMC wanted clarification about the different roles of research relative to inventory and monitoring in adaptive management, so the BRRC developed a scheme to clarify the relative roles of these AMP activities (Fig. 2).

These two diagrams (Fig. 1 and 2) were taken to be too controversial, so they were edited out of the original MSHCP document. The only diagram used in the MSHCP document was a diagram simplified to exclude all mention of people or groups, or their roles in adaptive management, while identifying the different kinds of monitoring, research, and modeling in meeting stated objective goals of adaptive management (Fig. 3).

Administrative Decisions (solid arrows) and Action (dashed arrows) Organizational Scheme

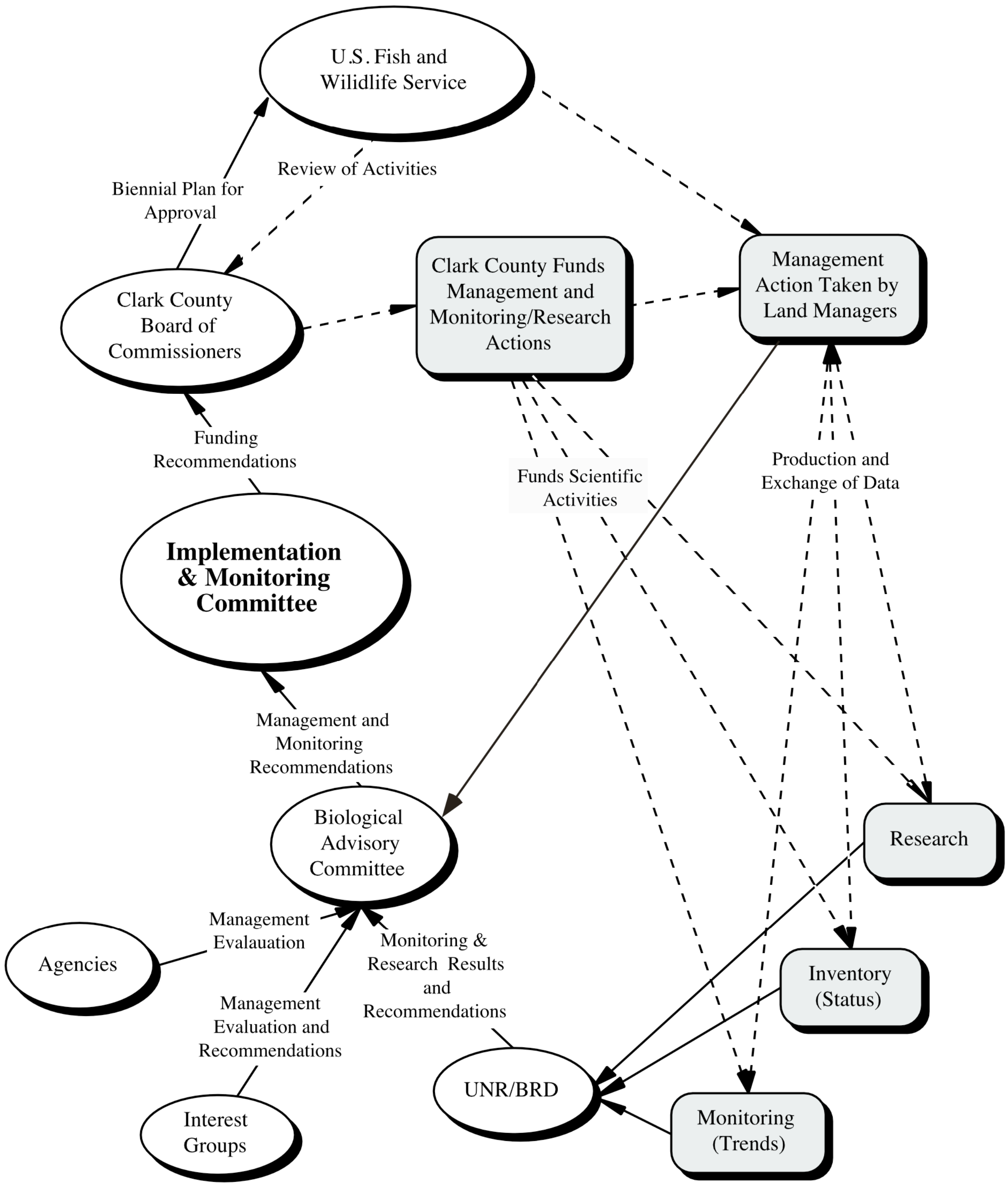


Fig. 1 Original BRRC proposal for an organizational scheme for AMP within the CC MSHCP.

MONITORING, INVENTORY, AND RESEARCH

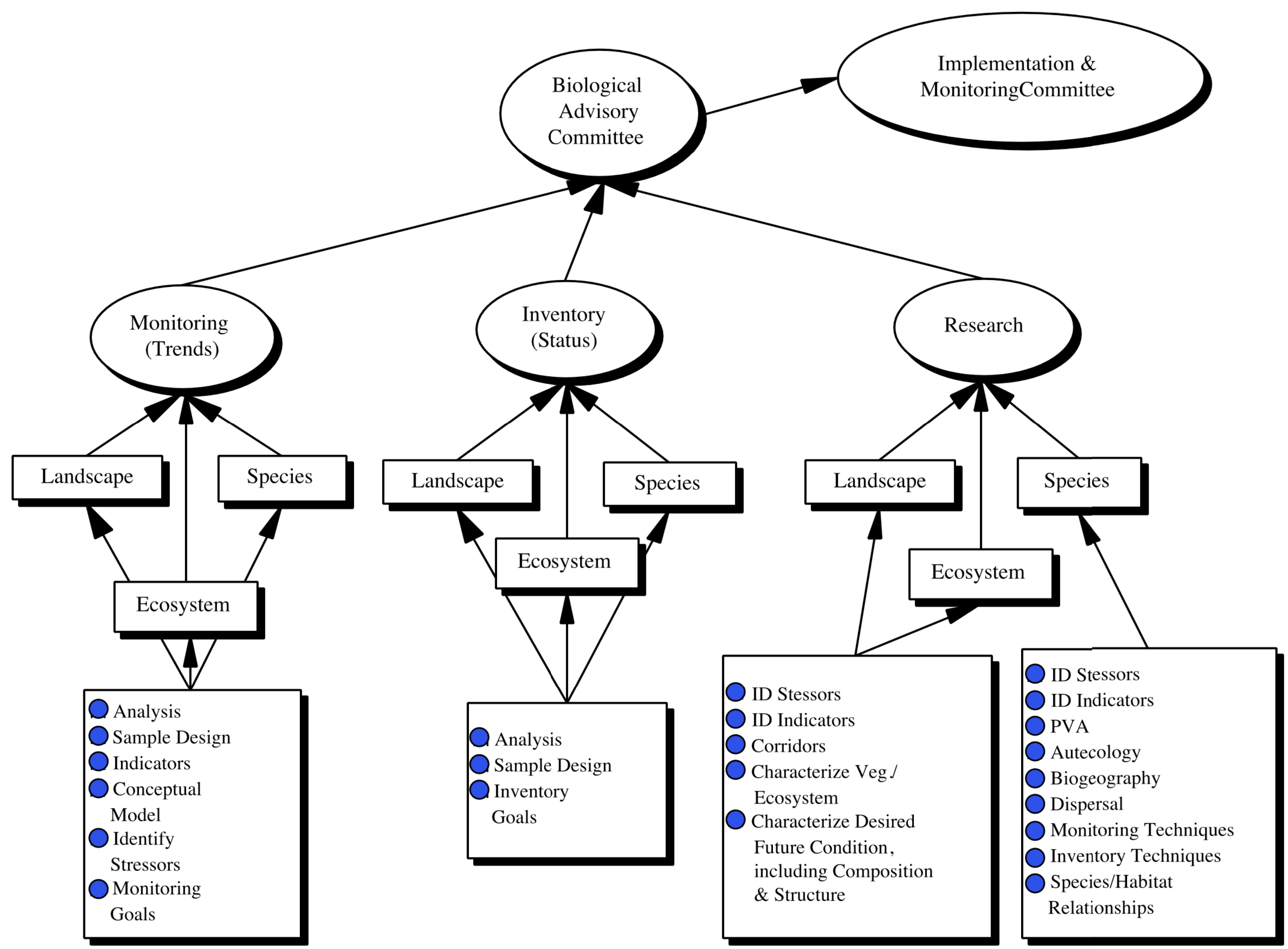


Fig. 2. The different roles among monitoring, inventory, and research to adaptive management decisions by the IMC.

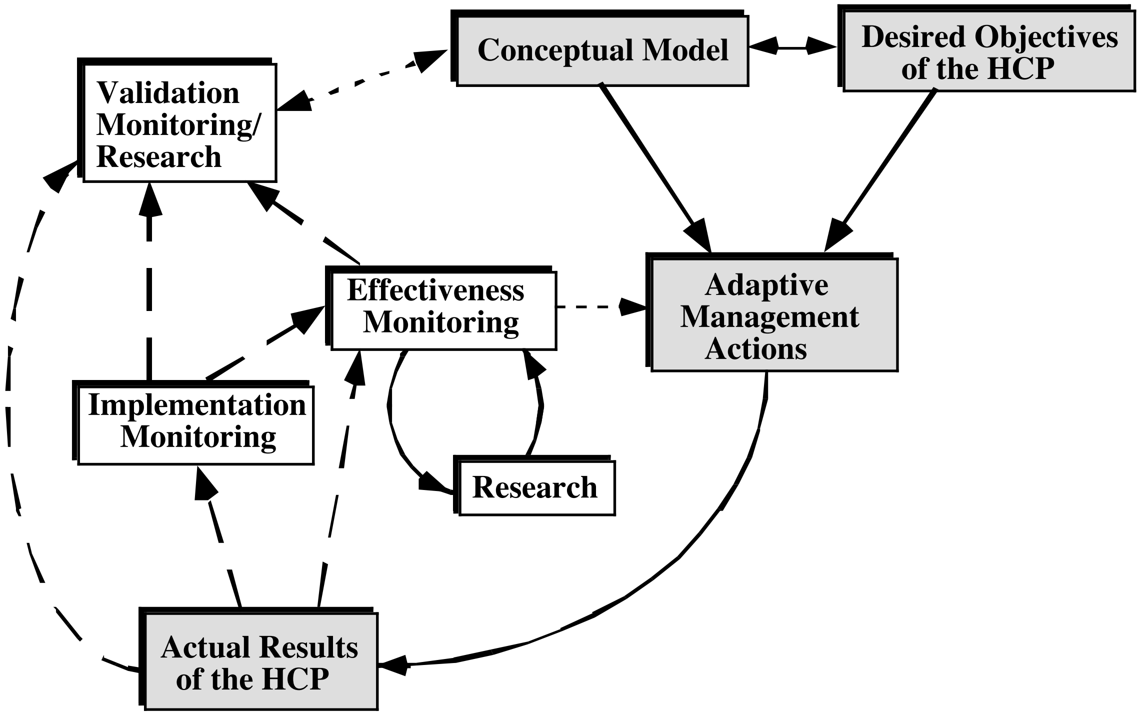


Fig. 3. Relationships among the desired objectives of the HCP, a conceptual model of the functional relationships among species, and monitoring activities in the adaptive management of the HCP.

The exercise of building organizational models for adaptive management caused us to realize that the action pathways were different from the administrative pathways in the function of adaptive management in the MSHCP. Working with Cindy Truelove, we proposed schemes illustrating those differences (Fig. 4). This too was seen as controversial, so the schemes were not presented to the IMC.

Each time a new attempt was made to outline an adaptive management program, we have proposed appointing a committee that would help in synthesizing the enormous complexity of actions and evaluations as part of adaptive management so that the IMC would have a manageable task in evaluating adaptive management for the MSHCP. A scheme developed in collaboration with Cindy Truelove included appointing a new committee of the IMC (including stake holders, agencies, and the university) which would serve as an executive committee called the Adaptive Management Executive Committee (AMEC). This committee would be served by a new committee called the Adaptive Management Working Group (AMWG), which would synthesize information from technical working groups, agencies, and other sources (Fig. 5). The role of the AMWG is really the same as that originally proposed for the BAC, and newly proposed Technical Working Groups (TWGs) would serve the same role as the technical groups and RECON which served the BAC in creating recommendations for the IMC while developing the MSHCP. The roles and responsibilities of each of these entities are given in Fig. 6. This scheme was seen to be elitist by those who wanted all tasks of the MSHCP to be accomplished in the IMC forum. Indeed, in retrospect, the AMEC represented a level that would have been charged with decision making that traditionally has been the domain of the IMC, so this scheme also was killed before being presented to the IMC, and, in fact, was too deep in hierarchy to work in the current political climate in Clark County.

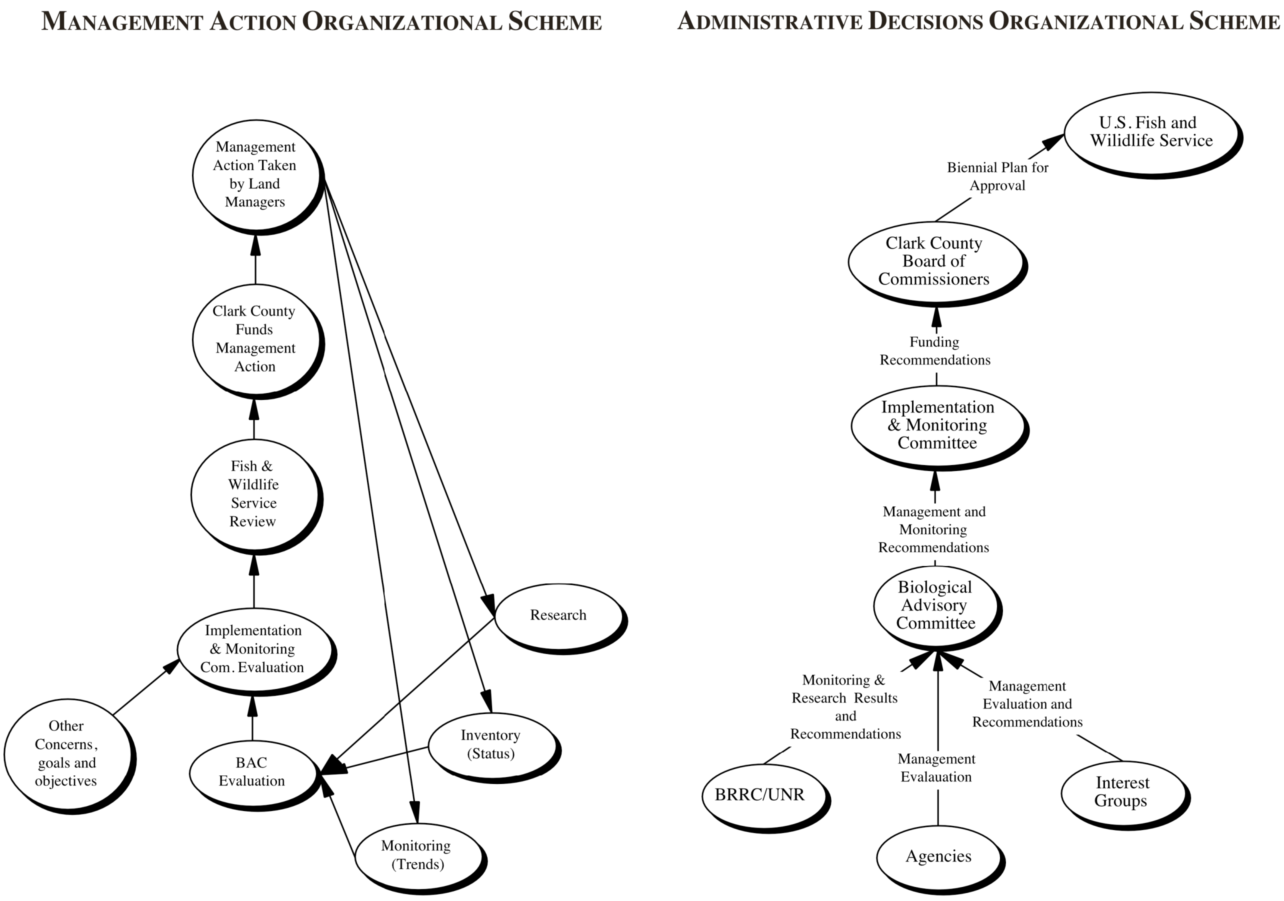


Fig. 4 Schemes illustrating the difference between management actions and administrative decisions as part of adaptive management in the MSHCP.

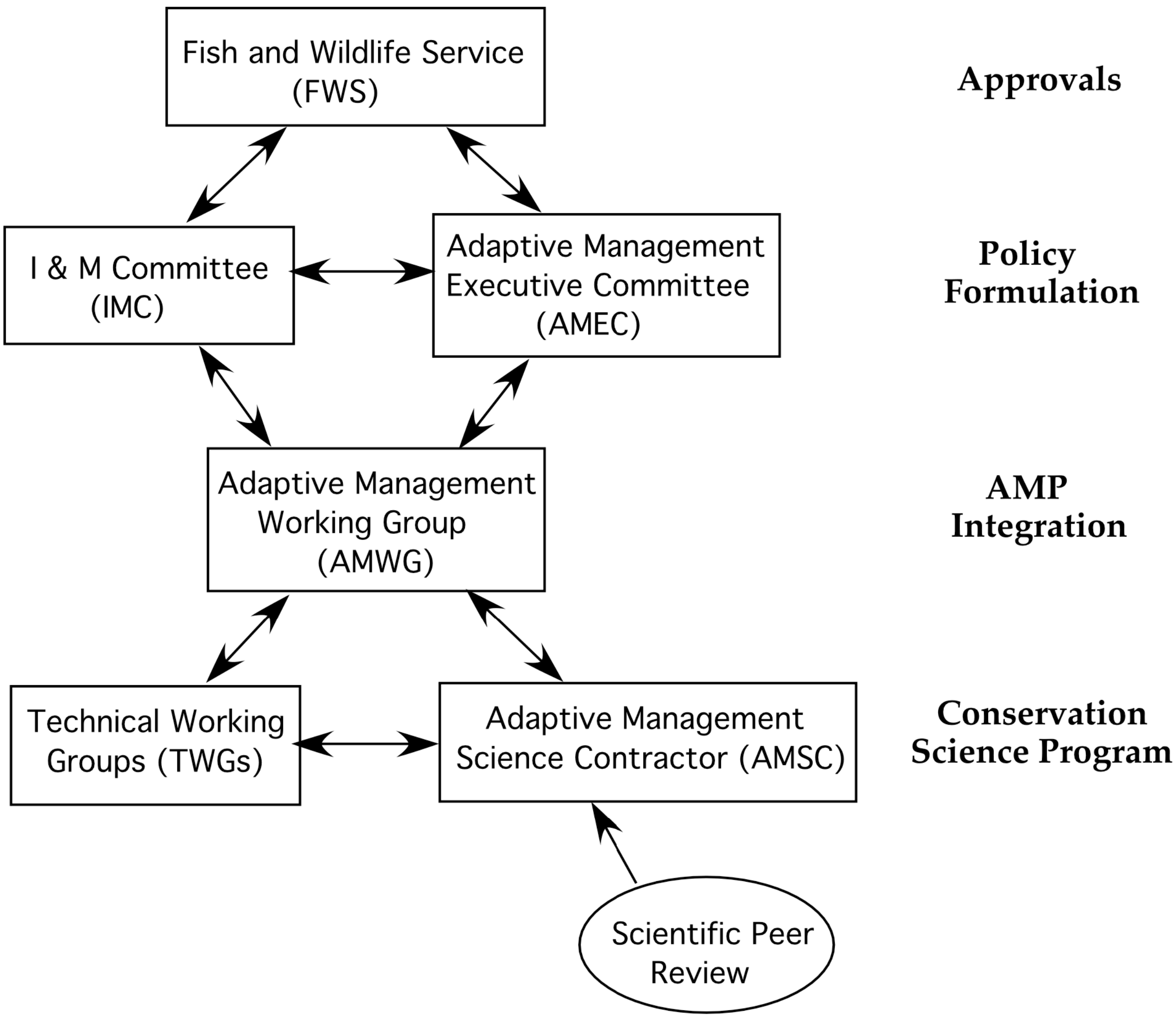


Fig. 5. Possible organizational scheme for adaptive management for the MSHCP defining an AMWG and Technical Working Groups.

FWS
Approves Adequacy of AMP and Budget per Permit Requirements

AMEC
Reviews recommendations of the AMWG regarding research, monitoring, and conservation actions; and makes final decisions regarding funding per the Funding MOU

IMC
Reviews AMP

AMWG

- Develops Annual Goals and suggested AMP biennial work plan
- Reviews conservation measures, results of implementation, and suggests amendments to conservation measures
- Reviews results and reports of previous activities
- Develops, per AMP Funding MOU, coordinated federal land manager biennial budgets, and AMP contractor biennial budgets related to MSHCP development activities
- Develops long term monitoring and science program, with AMP contractor coordination and science partners
- Reports every five years on status of covered species
- Develops suggested AMP RFP process

TWG

- Receives inputs from sub-committees and develops coordinated recommendations of AMP needs
- Prepares suggested AMP goals and biennial AMP workplan
- Prepares initial coordinated federal land manager budgets and AMP budget related to MSHCP development activities per the AMP Funding MOU
- Reviews individual conservation measures and results of implementation
- Reviews individual monitoring protocols; adequacy, effectiveness of monitoring
- Reviews individual research or monitoring proposals received from science partners or other research entities
- Reviews adequacy of regional conservation plans to protect covered species
- Develops regional conservation strategies

Working Groups

- Special Area Planning: e.g. Virgin R, Muddy R, Spring Mountains
- Protection and Conservation Measures: e.g. SNRT, Rural Roads
- Covered Species or Taxa: e.g. relict leopard frog, bats, bear poppy

Prepare regional applications, regional conservation strategies, suggest conservation measures, develop regional conservation plans and agreements

Science Partners

- University of Nevada System: UNR, UNLV, DRI, CCSN
- USGS
- OLVF

Provide For:

- Broad Science Delivery System
- Public Education
- Peer Review
- Partnerships
- Public Education

Fig. 6. Definitions and explanations of roles for the entities in Fig. 5.

Current recommendations

Recently, technical working groups have been appointed by the IMC, and they function to assemble information and recommendations for the IMC. One of those working groups, the implementation monitoring database working group, has proposed monitoring "indices of success" as information to be input in the implementation database. Additionally, a working group has been appointed to develop an MOA outlining the rules of engagement for the adaptive management program. As part of the MOA activities, UNR and FWS were to develop a proposal for implementing adaptive management. This task group amended recent models from existing HCPs to articulate new models presented below in two new graphics. These graphics build upon our ideas dating back to 1996, they incorporate ideas generated from the implementation database working group, and they incorporate ideas from successful adaptive management programs nationwide.

The first graphic (Fig. 7) describes the monitoring responsibilities of HCP participants in the adaptive framework. Importantly, **compliance** monitoring is differentiated from **effectiveness** monitoring; the latter (along with focused research) provide information important to adaptive management. This differentiates the current proposal for the structure of adaptive management from previous structures, which did not differentiate "milestones" from "success of actions" (previously, success of management actions was measured simply as spending required funds, so "success" of management actions was measured through milestones instead of indeces of success). Figure 7 simplifies the annual cycle of management action, data collection, reporting, and decision making in a seven-step model.

Authority for adaptive management resides with the County, land managers, FWS, the AMP contractor, and stakeholders, represented as the Implementation and Monitoring Committee (IMC). IMC recommends conservation management actions and approves funding (1). Information flows from three contemporaneous efforts -- data gathered from monitoring of federal and non-federal management actions, and from research (2). Monitoring in these contexts can be viewed as two distinct efforts supporting the HCP (3 & 4). Compliance monitoring (e.g., did the funded entity plant 500 willow stems along the riparian corridor as contractually obligated) and effectiveness monitoring (e.g., how many of those stems appear to be surviving, and which aspects of the out planting strategy appear to contribute to success). Clark county (or their proxy) is responsible for compliance monitoring (3). The land managers (federal agencies or their designees, and private managers such as MRREIAC or their designees) collaborate with the AMP contractor to design and implement the effectiveness-monitoring program (4).

Data on compliance monitoring are submitted to the AMP database, and become the material for a collaborative dialogue between the land managers, the AMP contractor, and the county (5). Syntheses of these data are prepared in a form facilitating decision making by the IMC (6). Information transfer to the IMC (7) can be facilitated through a technical subcommittee, generally not different from the current MOA subcommittee, which can not only report results, but also propose new or amended conservation strategies (8).

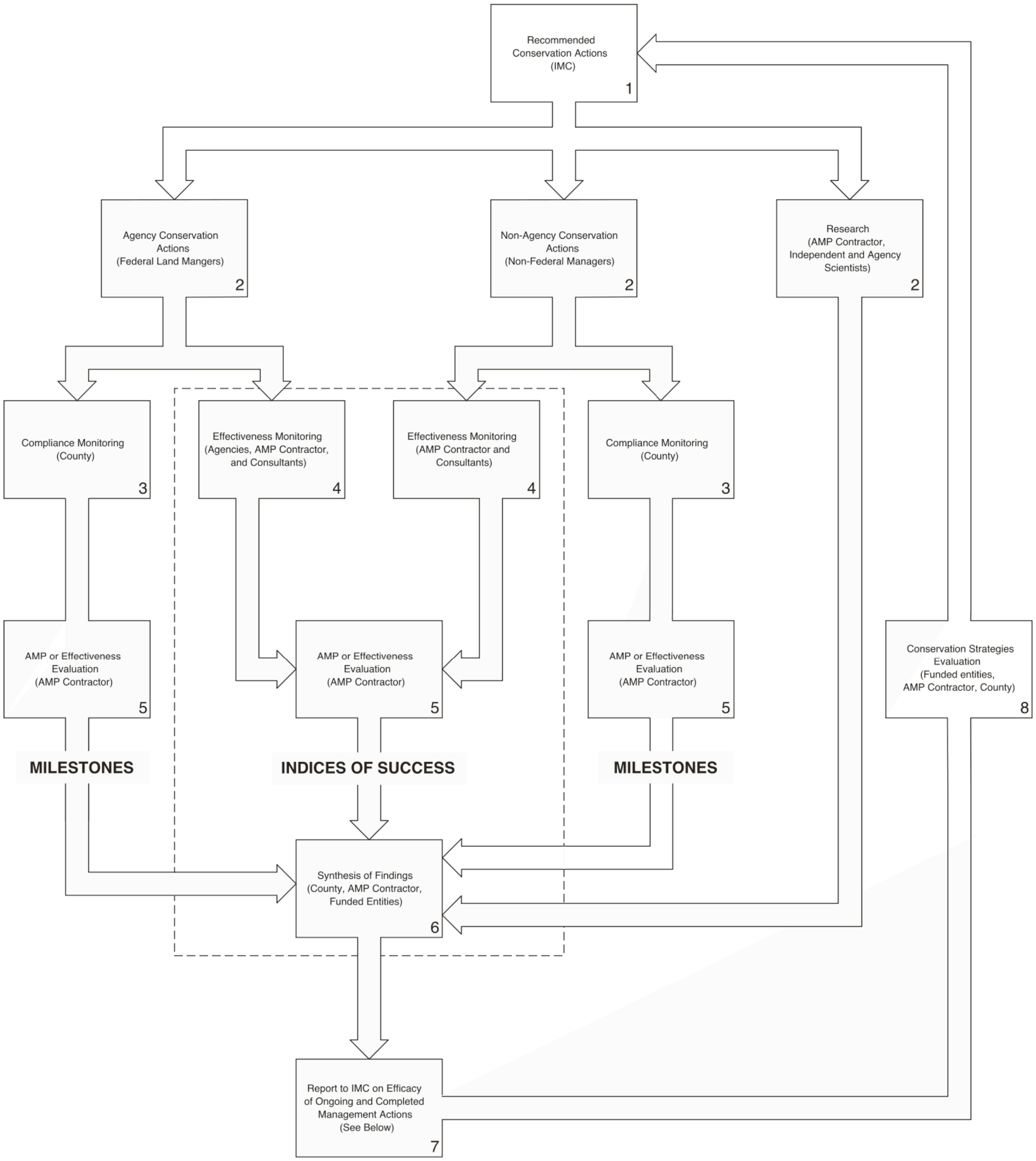
A second graphic (Fig. 8) clarifies and articulates the flow of information through the AMP process, describing obligatory steps, responsibilities, and authorities. Again, the IMC and its participants are responsible for the conservation action plan, turning recommendations from adaptive management into program priorities and funding actions (1). Working groups review and develop HCP goals and milestones, where necessary translating HCP intent into on-the-ground plans (2). Working groups annually revisit HCP goals and milestones which are interpreted into management efforts (3). The working groups evaluate knowledge and data on species and ecosystems including ecosystem linkages and threats to species and ecosystems. The discussion (4) guides management actions on the ground, monitoring that assess the efficacy of those actions, and research which can further inform the conservation plan (4). Land managers, the AMP contractor, and other involved parties collaborate through working groups to initiate management actions while concurrently gathering monitoring data and carrying out field experimentation and resource inventory (5,6). All funded entities gathering data commit to timely delivery of those data in compatible formats to the AMP database (7). The AMP contractor inputs the data (8), and in collaboration with working groups, analyzes and interprets the data into reports (9). Results of the subsequent interpretation and synthesis of reports (10) by working groups is reported to the IMC (11).

These graphics and the ideas they portray, are presented to the MOA working group for further development before presenting them to the IMC for final development of the required adaptive management program of the MSHCP.

Bottom line

The current ideas concerning how the Clark County MSHCP should conduct adaptive management have developed over time since 1996. The most recent ideas have matured in parallel with the MSHCP. In particular, the original idea within the (desert tortoise) DCP was to structure the HCP to be deemed successful by virtue of meeting agreed-upon goals to expend funds on management activities. The MSHCP has, more recently recognized that this measure of "success" represents tracking "milestones" rather than success of the HCP. The proposed changes to AMP are to track "indices of success" as well as milestones, and this requires assessing the ways in which management actions benefit covered species and their ecosystems as well as monitoring promises to complete actions within management. Adapting management to maximize success is, thus, the basis for efficacious adaptive management.

The proposed models herein reflect the evolution in the MSHCP. Specifically, working groups and the group appointed to develop the AMP MOA have assumed the workloads of former groups like the original BAC and working specialty groups by providing technical information and synthesis for the IMC. These elements are necessary for the very complex processes required to satisfy the FWS and retain the Section 10A permit for covered species. Importantly, tracking indices of success through monitoring allows the MSHCP to adapt management to maximize its own effectiveness in promoting success of the MSHCP. The scheme presented is a logical parsing of responsibilities for adapting management of the MSHCP, and we present this to the IMC for discussion and modification.



HCP Conservations Actions Efficacy Analysis --

Project is said to be in **compliance**, if milestones are met; project is then subject to effectiveness monitoring outcome.

Project is deemed **effective** if indices of success (goals) are achieved; project continues to completion.

When a project is deemed not to be effective, management actions are amended (monitoring protocols also may need to be adjusted, program goals may be revisited).

Note: Areas inside broken lines are adaptive management actions articulated in next figure.

Fig. 7. Monitoring responsibilities of HCP participants in the adaptive framework as well as the monitoring signals used to indicate the needs for adaptive management.

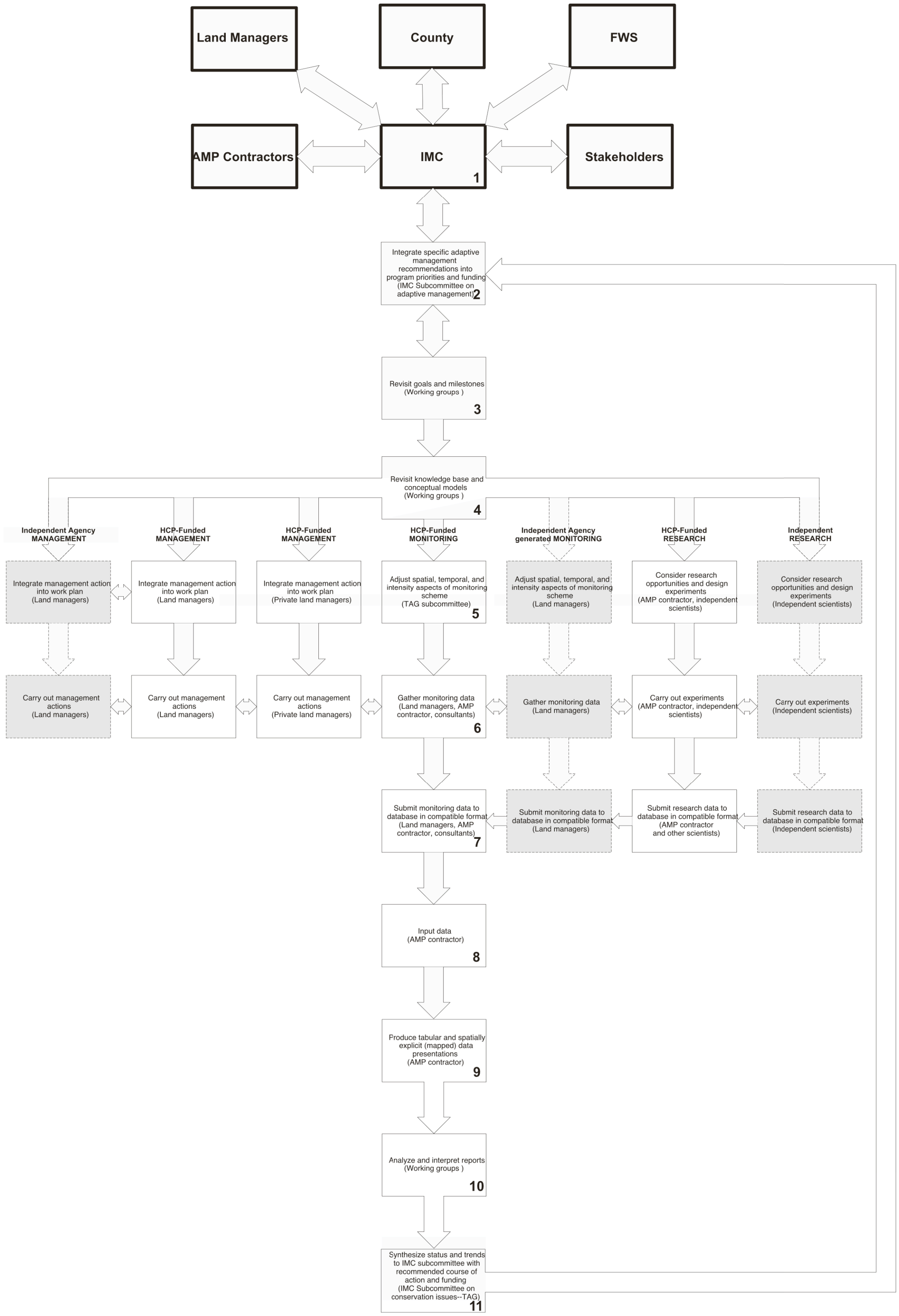


Fig. 8. Diagram indicating the flow of information through the AMP process as well as describing obligatory steps, responsibilities, and authorities associated with the AMP process.

Concluding remarks

Presented herein are activities of the AMP contractor in support of adaptive management of the MSHCP. These activities include develping necessary knowledge and techniques for the MSHCP as well as a draft organizational scheme for conducting adaptive management. This organizational scheme is presented for consideration by the IMC.

The AMP contractor has begun dialog with land-management agencies to discuss management actions to be proposed in the 2003-2004 biennium. This dialog has used the hot-spot analysis and discussions of indices of success to promote proposals that will maximize the success of the MSHCP. It appears that the elements are gradually getting implemented that will allow the MSHCP to have a functioning and efficacious adaptive management program.