

FINAL DRAFT
RESEARCH STUDY PLAN

**CHARACTERIZATION AND IDENTIFICATION OF WATER QUALITY
AND BIOTIC COMPONENTS IN ISOLATED SPRINGS ALONG THE
COLORADO RIVER DRAINAGE SYSTEM, UTAH AND ARIZONA:
CANYONLANDS NATIONAL PARK, GRAND CANYON NATIONAL PARK,
AND GLEN CANYON NATIONAL RECREATION AREA.**

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SEEDS ARCH. 044-24
CANY. 344-24
Did 4/10
project Nippon?
A LITTLE BIT W/ 1998 -
3 DAYS.
Are there seeds
in CANY?
YUP. CANY + ARCH

January 15, 1997

PROBLEM STATEMENT: A significant portion of the Colorado River drainage system occurs on the Colorado Plateau. The distance from Canyonlands National Park to Lake Mead is c. 850 km, all administered by the National Park Service. Three park units administer this river corridor, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park. Numerous springs and seeps occur along the river corridor. Most of these water sources exist as isolated sites in arid or semi-arid climates, surrounded by arid-adapted communities. Baseline characterization of water quality has been accomplished for a limited number of springs in all three park units.

The Colorado River corridor parks support one of the most diverse floras and faunas in the U.S. Southwest. Grand Canyon NP, because of its great elevational relief and diverse geological strata, has a particularly rich biota. Much of the biodiversity in the river corridor parks centers around the permanent springs. Despite this, very little work has been done inventorying the biota associated with these sites. The floras and faunas associated with springs and seeps has never been adequately surveyed for any park unit.

Currently there are a variety of threats that could seriously impact the biota and water quality of isolated spring/seep sites. One of the most urgent threats is ongoing and increasing impacts of recreational activity. Trampling and swimming at springs can damage vegetation, increase erosion, allow exotic species to invade, interfere with animal life cycles, and even eliminate aquatic life. Exotic riparian species, in particular tamarisk (*Tamarix chinensis*), can invade and completely change the biotic community. Many spring/seep sites in the study area have already been severely impacted by recreational activity and invasion of exotics. Impacts of climate change, such as global warming, on the biota of springs and seeps is not well understood. Declines in regional precipitation could potentially eliminate many of the obligate wetland plant and animal species at these sites. Ground water pumping and water diversion projects could also affect springs and seeps. The ongoing regional drought may have already reduced water flows and affected biotic communities at many sites along the river corridor. With a continuation of this drought, many plants and animals may become locally extinct before they can be discovered, identified and evaluated for significance. Baseline characterization of these systems is needed in order to properly evaluate the significance of any losses resulting from global climate change.

Many benefits to the individual park units will be derived from this project. Since virtually nothing is known about the biota of springs and seeps, valuable baseline data will be collected. Additional locations of the endangered Kanab Ambersnail may be found. The potential for species new to science is high, particularly in the aquatic macroinvertebrates. The baseline data will produce an evaluation of the ecological status of spring and seep sites, and provide information on human-caused recreational impacts, as well as the presence of exotic and undesirable plant species. Geographic components of water quality, geological aquifers, trace elements, native biotas, exotic species, and recreational and development impacts along a 850 km corridor of the Colorado River, from Canyonlands NP to Lake Mead, will be documented. The baseline data on water (especially quantity) and biota will be useful for future comparisons in the event of any changes in regional aquifers related to global warming, other climatic changes in the region, or water-pumping and related water developments. The results of this project will be invaluable in the develop of proper management programs for these fragile and important resources.

OBJECTIVES: The principal objectives of this study are:

1. Inventory aquatic macroinvertebrate species and abundance;

2. Inventory vascular plant and bryophyte species and abundance;
3. Describe vegetation communities;
4. Document recreational and other impacts on sites;
5. Inventory exotic species presence and abundance;
6. Quantify water quality parameters, including trace elements;
7. Describe geological and geomorphological settings of study sites;
8. Georeference all data and enter into relational databases;
9. Provide information on suitable sites for long-term monitoring to each NPS unit.

BACKGROUND: Canyonlands NP has an ongoing water quality monitoring program that involves sampling at some spring sites, most of which are not directly associated with the Colorado River (NPS 1994; Long and Smith 1996). Glen Canyon NRA has recently completed an extensive sampling program of selected springs in side canyons around Lake Powell which includes seasonal variation (Berghoff 1996). Lively-Schall and Foust (1988) also characterized water quality at numerous springs in Glen Canyon NRA. Brown and Moran (1979) identified the principal water sources in Grand Canyon NP, identifying 36 spring sites. Grand Canyon NP has ongoing studies at spring sites on the South Rim, including cooperative work with researchers at the University of Nevada at Las Vegas.

Limited floristic work has been done. Phillips et al. (1980) investigated the floras at a few of the larger karstic springs, in particular Roaring Springs. Spence (1993) investigated a series of spring-associated hanging gardens along the Colorado River through Marble and Grand Canyons. However, this project only sampled ten sites out of literally hundreds along this stretch of the Colorado River. In that report it was suggested that spring-associated hanging garden vegetation at higher elevations between the Colorado River and the rims should be investigated, as these sites would be most likely to hold the clues to the origins, development and recent history of the Grand Canyon spring and seep biota. Spence (1996a,b) has also investigated spring-associated woodlands and hanging gardens in Glen Canyon NRA. Very little information is available on bryophytes (e.g., Haring 1946) at springs and seeps on the Colorado Plateau.

Virtually no baseline data on the aquatic macroinvertebrates of springs/seeps has been collected. Only Canyonlands NP has completed some preliminary work on aquatic macroinvertebrates associated with water sources (Wolz and Shiozawa 1995). Stevens et al. (1995) discussed the ecology of the federally endangered Kanab Ambersnail (*Oxyloma haydenii kanabensis*), which occurs at the spring at Vasey's Paradise in Marble Canyon. Currently, the U.S. Fish & Wildlife Service, Grand Canyon NP, and Arizona Game & Fish Department are investigating the ecology of sites in the Grand Canyon for re-introduction of the snail. The U.S. Fish and Wildlife Service recovery plan calls for a minimum of 10 sites for the Ambersnail, including sites where the species occurs naturally as well as new sites where it has been introduced. There is good potential for the discovery of new populations of this species during this project.

METHODS:

Study Area Stratification and access

The study area is the Colorado River corridor. Of the c. 850 kms of Colorado River corridor, 50% occurs in Grand Canyon NP, 35% in Glen Canyon NRA, and 15% in Canyonlands NP. Field work and sites selected for the study will be sampled at approximately this intensity for each NPS unit.

In general sites will be selected within c. 10 kms of the river. Springs at a variety of elevations will be

sampled, from river level to ca. 2600 m (at or below the North Rim of Grand Canyon NP). Some additional sites may be selected from major tributaries, such as the Green River, Escalante River, San Juan River, Paria River, Little Colorado River, and Kanab Creek. Preliminary fixed-wing overflights will identify principal study sites. Site access will be by a variety of means. In more remote areas, especially in the Grand Canyon, helicopters will be needed. One and possibly two river trips will be conducted to sample sites accessible from the Colorado River. Boats will also be used to sample sites on Lake Powell. Some sites can be reached by backpacking or four-wheel drive vehicle.

Sites

A site is defined as either a spring or seep, with associated obligate wetland vegetation. Springs are defined as water sources which flow year round, although some seasonal variation in quantity may occur. Seeps are defined as water sources that stop emerging aboveground for at least a portion of the year. Sites will be selected based on the following criteria:

- isolation from riparian zones
- relatively constant and well-developed water flows (not ephemeral)
- well developed vegetation (see below)
- geological formation (as many strata as possible will be sampled)
- accessibility

Major spring sites will be sampled first, then springs or seeps with smaller flows. Vegetation at springs and seeps in the study area is very complex, and can comprise either predominantly herbaceous species, woody species, or a mixture of the two. Many springs have associated with them woodlands of deciduous tree or shrub species. However, the emphasis of this project will be on the herbaceous vegetation component at sites, and woodland vegetation will only be described if is directly adjacent to and closely associated with the spring. Sites from a wide range of geological strata will be sampled to provide details on how various strata affect water chemistry and in turn plants and aquatic macroinvertebrates.

Preliminary Planning and Literature Search

A preliminary planning meeting will be held at Page, prior to the 1997 field season. At this meeting the following aspects of the project will be determined: collation of available data on water, aquatic invertebrates, and plants; site selections for 1997; specific assignment of duties for project; discussion of timing for field work and logistics involved; and equipment purchases. Each park will provide a short presentation on work to date that is related to the project, including sampling methods, literature and data available, as well specific park needs and suggestions. It is anticipated that an additional meeting will be held after the 1997 field work.

Water Quality

Water samples will be collected using ultra-pure techniques. A disposable sterilized syringe will be used to collect water samples from cracks or other locations where water is issuing. The water will be stored in pre-cleaned plastic bottles. Using a syringe minimizes possible contamination that could occur as the water flows over vegetation, soil or other materials. Data collected on site using hand held meters or portable hydrolabs will include pH, temperature, conductivity, and dissolved oxygen.

The water will be analysed at the USGS lab in Denver, Colorado. Dissolved component analyses of

trace elements include sodium, potassium, magnesium, calcium, strontium, iron, aluminum, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, vanadium, zinc, silica, alkalinity, chloride, sulfate, bromide, fluoride, nitrate, nitrite, ammonium, phosphate, carbonate, and bicarbonate. Because of holding time problems, some analyses cannot be done for samples from remote sites accessed by backpacking or by boat along the Colorado River. Hand-held test kits for selected elements may be used in these situations. Organic carbon will require special collection techniques, and will not be collected unless it is economically feasible, as there is a contamination problem from roots and other organic materials at the sites. Standard techniques will be used throughout (Standard Methods 1992).

Water flow (quantity) will be determined by one of several methods. Where possible, a pygmy water meter will be used. In some situations, where the water is constrained into a channel, filling a standard volume over a specified time can be used, either by building a temporary dam or installing a weir plate. In many situations, however, the water will be issuing from a variety of sources, such as a wet wall. In these cases a photograph will be taken of the wetted area, with a meter stick for scale in the photo. Total wetter surface area can then be calculated.

Data will be compared between sites, and correlated with geological strata. All data will be maintained in Microsoft ACCESS databases, and water quality data will be transferred and archived in the national STORET database.

Flora and Vegetation

The flora of each site will be described, and specimens of unknown or un-identified species collected. A complete voucher set of all species will also be collected as part of the project. The vegetation at the site will be described using the prominence scale developed by Spence (1993, 1996a):

- 6=dominant (> 95% canopy cover)
- 5=abundant (51-95% canopy cover)
- 4=common (11-50% canopy cover)
- 3=uncommon (1-10% canopy cover)
- 2=occasional (< 1% canopy cover)
- 1=rare (< < 1% canopy cover, few individuals)

In addition to prominence, the vegetation will be described by measures of species richness, diversity (Shannon Index), and evenness (Pielou's J). All vegetation data will be entered into a Microsoft ACCESS database. Each species will be classified according to life form, geographic distribution, and dispersal category. Life forms (vascular plants) include annual forb, annual graminoid (grass, sedge or rush), perennial forb, perennial graminoid, shrub, tree, or vine. Seed/spore dispersal categories are those found in Spence and Henderson (1993), and include:

Megawind	Nut
Miniwind	Sticktight
Megasmooth	Ballistic
Minismooth	Myrmecoid
Fleshy	Floater

Geographic distributions will include the following floristic elements, based on the work of

McLaughlin (1992):

Southwestern U.S./N. Mexico
Colorado River (endemics)
Mohave
Sonoran

Colorado Plateau
Boreal-montane
Widespread NA temperate
Cosmopolitan

As part of the project collections of bryophytes (liverworts, hornworts and mosses) will be made. Rough abundances will be determined for species that can be reliably identified in the field. In principal sites where accessibility is not a major problem, periphyton (primarily diatom) collections will be made. Diatoms are good indicators of biotic health and water quality, and indices of water quality can be developed using periphyton (Dr. Joe Shannon, pers. comm., 1996).

Invertebrates

Aquatic macroinvertebrates will be collected at each study site. Timed searches, or numbers or biomass per area, will be used to sample available microhabitats at each site. The exact method(s) will be selected at the preliminary planning meeting. Standard collecting equipment, including dip nets and surber samplers, will be used. A rough abundance scale will be used to quantify selected groups in order to make comparisons between sites. Whenever possible this will be done in the field during the timed searches. This scale is based on log10:

- 1 = 1 individual seen/collected within timed search,
- 2 = 2-10 individuals,
- 3 = 11-100 individuals,
- 4 = 101-1000 individuals
- 5 = > 1000 individuals

Other comparisons between sites will include diversity and abundance analyses for microhabitats which are shared. Species will be classified by habitat preferences, dispersal mode, life-form, and geographic distribution. Collections will be sorted by family and genus and sent to specialists for identification (see list of participants below). The data forms and sampling protocol developed for the Kanab Ambersnail project in the Grand Canyon will be utilized in this study. All macroinvertebrate data will be entered into a Microsoft ACCESS database.

Other Site Components

The geological strata and associated geomorphological landforms at each site will be identified and described. Other site features recorded include elevation, aspect, exposure, any obvious natural disturbances, anthropogenic impacts, and presence of vertebrate species, in particular amphibians. Photographs will be taken of each site from permanent photo points. Sites will be georeferenced and mapped onto USGS 7.5 minute topographic maps.

Data Analysis, Specimen Processing and Storage

Sites will be classified and compared using standard multivariate techniques, including TWINSpan, SAHN clustering, DECORANA, PCA. Comparisons between data sets (eg., water, macroinvertebrates, and plants) will be made using canonical correlation analysis (CCA). Correlations between specific taxa and site characteristics will be performed using Spearman's or Pearson's

correlations. PCORD 2.0, SX4.1 and JMP 3.1 will be used to analyse the data. Data will be stored in Microsoft ACCESS databases.

Preliminary sorting, processing and identification of plant specimens will be done at Glen Canyon NRA. Mounting and preparation of specimen labels will be done at the Deaver Herbarium for vascular plants. Bryophytes will be prepared at Glen Canyon NRA. Sorting and preliminary identification (family/genus) of invertebrates will be done at the Department of Biology at Northern Arizona University and in the labs of SWCA, Inc. Specialists will be consulted for identification below the family/genus level for select groups. All specimens will be housed in the park where they were collected, and will be stored and cataloged according to standard NPS natural history procedures.

PRODUCTS:

Products will include yearly progress reports, a final technical report, recommendations for monitoring to each NPS unit, copies of all data, including data on vascular plants, bryophytes, water quality and quantity, geology, and disturbances, in electronic and hard copy form, specimens of plants and animals for each NPS unit, and one or more technical peer-reviewed papers to be submitted to biological or water quality journals.

IDENTIFICATION OF RESEARCHERS AND DUTIES (*to attend scoping meeting in Page if possible):

Principal Investigator: Dr. John R. Spence (GLCA).

Budget: Dr. John R. Spence (GLCA).

Responsibilities for data analysis and reports:

- *Dr. John R. Spence (general, plants)
- *Dr. William Leibfried (aquatic macroinvertebrates)
- *Dr. Joe Shannon (aquatic macroinvertebrates)
- *Dr. Howard E. Taylor (water quality)
- *Kevin Berghoff (water quality)

Local contact-park coordination:

- *Dr. John R. Spence (GLCA)
- *Nancy Brian (GRCA)
- *Charles Schelz (CANY)

Research and collection permitting:

Norm R. Henderson (GLCA)

Database design and statistical advice:

*Jim Petterson, GRCA

Plants:

*Dr. John R. Spence, GLCA (vascular plants, bryophytes, field work, id of general flora and

*Nancy Brian, GRCA (vascular plants, field work).

Dr. Tina Ayers, NAU (general vascular flora id, field work).

Dr. Randy Scott, NAU (Asteraceae id, field work).

Aquatic Macroinvertebrates (because macroinvertebrate identification is a specialist field it is anticipated that a variety of researchers will be involved, and will be paid by negotiating personal services contracts for time to identify taxa):

*Dr. William Leibfried, SWCA (collections processing and sorting, some id, field work).

*Dr. Joe Shannon, Dr. Dean Blinn, NAU (specimen id, field work).

Dr. Gary Vinyard, University of Nevada at Reno (specimen id, field work).

Dr. Saxon Sharpe, Desert Research Institute, Reno (snail/ostracode id).

Dr. John MacDonald, Department of Entomology, Purdue University (specimen id).

Dr. Boris Kondratieff, Colorado State University (field work, specimen id).

Water Quality:

*Kevin Berghoff, GLCA (sample processing, field work).

*John Rihs, GRCA (sample processing, field work)

Dr. Howard E. Taylor, USGS, Denver (water quality analyses)

Geological and Geomorphological Descriptions:

Dr. Ned Andrews, USGS, Denver.

GIS Support:

*Lex Newcomb, GLCA

*Dan Spotesky, GRCA

Coordination on Kanab Ambersnail work:

*Jeff Sorenson, AGFD

Other possible cooperators and pending in-kind support:

National Biological Service, Grand Canyon Monitoring and Research Center (GCMRC): logistics support and possible water quality analysis support.

Grand Canyon Natural History Association: \$13,000 proposal pending.

Bureau of Reclamation, Boulder City: additional personnel, equipment, and other support pending (see budget).

BUDGET (FY97 & FY98 combined):

Personnel (personal services contracts, seasonal positions)\$22,000
 Helicopter Time (@\$600/hr for 15 hrs)\$9,000
 Water Samples (@\$60/sample for 100 samples)\$6,000
 Travel and logistics (incl. boat travel)\$10,000
 Equipment (lab, collections and office supplies)\$3,000

Total\$50,000

Lower Colorado Office, Bureau of Reclamation, Boulder City
 Helicopter time (@\$650/hr for 10 hrs for FY97)\$6,500

Total to date committed for FY97\$31,500

Total to date continuing support (FY98)\$25,000

The budget includes ca. 4,500\$ per year for helicopter access. This translates to ca. 7.5 hours, which is probably inadequate for the project. However, The Bureau of Reclamation is willing to provide ca. 10 additional hours of helicopter time in 1997 using their helicopter for work principally in the western Grand Canyon region.

Some of the money in the personnel section will be used to provide equipment, field support and salary (through small personal service contracts) to the invertebrate specialists to conduct field work as well as to identify and process collections.

WORK SCHEDULE:

Field work will commence in the spring of 1997. A tentative work schedule is presented below. Most site visits will be conducted in spring (April-May) through fall (September-October). Late summer or fall will probably be best for most taxonomic groups other than some vascular plant taxa. Final choice of times for field work will be made at the preliminary meeting to be conducted in Page in the winter of 1997.

1997

February	Scoping meeting (all * participants), preliminary site selections, preparation of data forms
March	Overflights, site selections (continued)
April	Calibration of field techniques, field work (GRCA)
May	Field Work (GRCA, GLCA, CANY)
June	Field Work (GLCA, CANY)
July	Collections processing and id
August	Collections processing and id
September	Field work [tentative Colorado River-level trip (GRCA)]
October	Field work (GRCA)
November	Data analysis and collections processing
December	Project participants meeting; yearly report write-up (due 1/15/98)

1998

January	Methods refinement/collections id
February	Collections id

March	Collections id
April	Field work (GRCA)
May	Field Work (GRCA, GLCA, CANY)
June	Field work (GLCA, CANY)
July	Collections processing and id
August	Collections processing and id
September	Field work, Cataract Canyon river-level trip (tentative)
October	Field work (GRCA)
November	Data analysis
December	Yearly report and Final report write-up (due 1/15/99 & 3/15/99).

PERMITS:

All necessary permits will be obtained from the U.S. Fish & Wildlife Service (Kanab Ambersnail) and Grand Canyon Science Center (research and general collection permits), National Park Service.

LITERATURE CITED:

Berghoff, K. 1996. Inventory of water quality of selected seeps and springs in Glen Canyon National Recreation Area. Final Report in preparation.

Brown, B.T. and Moran, S. 1979. An Inventory of Surface Water Resources in Grand Canyon National Park, Arizona. Unpublished Final Report to the Division of Resource Management Grand Canyon National Park Part I (Water Resources Inventory) of the 208 Water Quality Project. 60 pp.

Haring, I.M. 1946. Mosses of the Grand Canyon National Park, Arizona, II. Bryologist 49: 90-96.

Long, B.A. and Smith, R.A. 1996. Water quality data analysis and interpretation for spring monitoring sites, Southeast Utah Group. National Park Service Draft Tech. Rep. NPS/NRWRD/NRTR-96/77.

National Park Service. 1994. Southeast Utah Group water quality monitoring plan. National Park Service, SEUG, Moab, UT.

Phillips, B.G., Johnson, R.R., Phillips, A.M. III, and Bowers, J.E. 1980. Resource values of the aquatic and riparian vegetation of Roaring Springs, Grand Canyon. Proceedings of the Second Conference on Research in National Parks. National Park Service, Washington, D.C.

Spence, J.R. 1993. A preliminary survey of hanging gardens and related vegetation along the Colorado River, Grand Canyon National Park. Report to Glen Canyon Environmental Studies and Grand Canyon National Park. Resource Management Division, Glen Canyon National Recreation Area. 15 pp.

Spence, J.R. 1996a. Riparian vegetation in side canyons of Lake Powell: community structure, species diversity and site relationships. Final report, National Park Service, Resource Management Division, Glen Canyon N.R.A. 90 pp.

Spence, J.R. 1996b. Hanging garden vegetation of Glen Canyon National Recreation Area, Utah. Draft report in preparation.

Spence, J.R. and Henderson, N.R. 1993. Tinaja and hanging garden vegetation of Capitol Reef National Park, southern Utah, U.S.A. J. Arid Environments 24: 21-36.

Standard methods for the examination of water and wastewater, 18th ed. 1992. American Public Health Association, Washington, DC.

Stevens, L.E., Protiva, F., Kubly, D., Meretsky, V.J., and Petterson, J. 1995. The ecology of the Kanab Ambersnail (Succineidae: Oxyloma haydeni kanabensis Pilsbry) at Vasey's Paradise, Grand Canyon, Arizona. Draft Final Report submitted to Glen Canyon Environmental Studies Program. 34 pp.

Wolz, E.R. and Shiozawa, D.K. 1995. Aquatic macroinvertebrates of the Needles District, Canyonlands National Park, Utah. Report to the national Park Service. Brigham Young University. 25 pp.

Species List 7/13-15/98		J. Spence					
		SITES					
SPECIES	ACRONYM	Sleepy Hollow	Seven Mile S	Seven Mile NW	Freshwater Spring	Cabin Spring	Big Springs
Acer negundo	ACNE	X	X	X			
Adiantum capillus-veneris	ADCA			X			X
Agrostis stolonifera*	AGST	X			X	X	X
Amalanchier alnifolia	AMAL					X	
Apocynum cannabinum	APCA			X		X	X
Aquilegia micrantha	AQMI	X	X	X	X	X	X
Artemisia ludoviciana	ARLU		X				
Asparagus officinalis*	ASOF	X					
Aster glaucodes	ASGL				X		
Berberis fendleri	BEFE					X	
Betula occidentalis	BEOC					X	
Briellia longifolia	BRLO		X	X			X
Calamagrostis scopulorum	CASC	X	X			X	
Carex aquatilis	CAAQ	X					
Carex aurea	CAAU	X	X		X	X	X
Carex cf hassei	CAHA					X	X
Carex hystericina	CAHY	X					
Castilleja exilis	CAEX				X		
Celtis reticulata	CERE	X		X			
Cirsium rydbergii	CIRY	X	X	X	X		
Clematis ligusticifolia	CLLI	X					X
Convolvulus arvensis*	COAR	X					
Cornus sericea	COSE	X				X	
Elymus canadensis	ELCA		X				X
Elymus trachycaulis	ELTR					X	
Epilobium ciliatum	EPCI					X	
Epipactus gigantea	EPGI	X		X	X		X
Equisetum hyemale	EQHY	X		X			X
Euphorbia brachycera	EUBR				X		
Forestiera pubescens	FOPU						X
Fraxinus anomala	FRAN	X					
Glyceria striata	GLST	X		X			
Habenaria zothecina	HAZO	X	X			X	
Hedeoma drummondii	HEDR				X		

SPECIES	ACRONYM	SITES (cont.)					
		Sleepy Hollow	Seven Mile S	Seven Mile NW	Freshwater Spring	Cabin Spring	Big Springs
<i>Juncus balticus</i>	JUBA	X					
<i>Juncus ensifolius</i>	JUEN	X					X
<i>Melilotus alba</i> *	MEAL	X	X		X		
<i>Mimulus eastwoodiae</i>	MIEA	X	X				
<i>Muhlenbergia asperifolia</i>	MUAS	X		X	X	X	
<i>Oenothera elata</i>	OEEL			X			
<i>Oxytenia acerosa</i>	OXAC						
<i>Panicum acuminatum</i>	PAAC	X					X
<i>Panicum virgatum</i>	PAVI			X	X		X
<i>Phragmites australis</i>	PHAU	X					
<i>Plantago major</i> *	PLMA	X					X
<i>Polypogon monspeliensis</i> *	POMO	X					X
<i>Populus fremontii</i>	POFR	X				X	
<i>Primula specuicola</i>	PRSP	X					
<i>Quercus gambelii</i>	QUGA	X	X	X	X		X
<i>Ranunculus cymbalaria</i>	RACY						
<i>Rhamnus betulifolia</i>	RHBE						
<i>Rhus trilobata</i>	RHTR	X	X	X	X	X	
<i>Rosa woodsii</i>	ROWO	X	X				X
<i>Salix exigua</i>	SAEX	X					
<i>Salix gooddingii</i>	SAGO	X				X	
<i>Schizachyrium scoparium</i>	SCSC						
<i>Smilacina stellata</i>	SMST				X		X
<i>Solidago canadensis</i>	SOCA	X	X	X			
<i>Solidago sparsiflora</i>	SOSP			X			
<i>Sonchus asper</i> *	SOAS	X			X		
<i>Stephanomeria tenuifolia</i>	STTE					X	
<i>Tamarix chinensis</i> *	TACH	X			X		
<i>Taraxacum officinale</i> *	TAOF	X					
<i>Toxicodendron rydbergii</i>	TORY	X	X				
<i>Typha domingensis</i>	TYDO	X		X			X
<i>Viola nephrophylla</i>	VINE						
<i>Xanthium strumarium</i> *	XAST	X	X				
<i>Zigadenus vaginatus</i>	ZIVA	X	X	X		X	