

Bibkey 10: 9427
Drawer #1
INVEST

Vis,
Theresa 15 day 10.
Official copy, etc.
some 12 copies of
the report 10/10/91
and 10/10/91

ANNUAL REPORT for
BIOGEOGRAPHY OF INVERTEBRATES
AND PLANTS IN
HANGING GARDENS OF THE COLORADO
PLATEAU

Includes Zion

Nancy L. Stanton, Steven J. Buskirk, James F. Fowler

Department of Zoology and Physiology

University of Wyoming

Laramie

UW-NPS Budget Number 32752

May 15, 1992

For period covering May 1, 1991 to May 15, 1992

ABSTRACT

Twenty seven, mesic hanging garden habitats in Zion National Park and Glen Canyon National Recreation Area were surveyed for vascular plant, small mammal, and insect species distribution and abundance. Each hanging garden was separated into wet wall, backwall, ledge, and ledge - colluvial soil slope microhabitats with the former two usually being located on the Navajo sandstone and the latter two developing from weathering of the Kayenta formation. Small mammals trapped on hanging gardens were similar in species composition and abundance to the surrounding xeric habitat community. Plant species assemblages were distinct on each microhabitat but showed little seasonal change from June to August on two sites with replicate sampling periods. Plant species distribution patterns on these hanging gardens do not support the prediction of the core - satellite hypothesis. Many rarely occurring species (satellite) are present, but there is not a large mode of widely occurring (core) species and moderately well distributed species occupy a similar number of sites.

INTRODUCTION

Hanging gardens of the Colorado Plateau are small mesophytic habitats of herbaceous plants (Tuhy and MacMahon 1988) surrounded by more xerophytic desert vegetation (Welsh 1989, Malanson 1980, Welsh and Toft 1972). There is a sharp contrast between the microclimate associated with hanging gardens and the surrounding high desert climate: water is abundant; soils are moist; and shade from canyon walls, and in some cases an alcove roof, offers protection from summer sun. Various sandstone formations, such as the Navajo in Glen Canyon NRA and Zion NP, serve as aquifers which produce permanent seeps or springs when underlain by impervious layers or formations (Welsh and Toft 1972). These reliable sources of water near the base of canyon walls allow the formation of mesic biotic communities. These relatively well defined communities provide an opportunity to investigate various hypotheses of community structure, insular ecology, historic biogeography,

speciation, extinction, and niche theory.

Welsh (1989) indicates that many of the plant species found in hanging gardens have biogeographic affinities with more mesophytic regions such as the boreal forest and prairie biomes. Especially intriguing are the endemic taxa which may be present in hanging garden communities. Several endemic plant species have been found in Utah hanging garden surveys (Welsh 1989, Loope 1977, Welsh and Toft 1972) and Dinosaur NM (T. Naumann, personal comm.). Virtually nothing is known about the invertebrate fauna. Our specific research objectives for the first year of this three year project were to (1) survey the plant and invertebrate animal communities of hanging gardens in Zion National Park (ZION) and part of Glen Canyon National Recreation Area (GLCA) and (2) determine levels of similarity between each sampled hanging garden plant and insect community.

STUDY AREA

Most of the hanging gardens we sampled (Table 1) were chosen during a reconnaissance trip to Zion National Park (ZION) in southwestern Utah and Glen Canyon National Recreation Area (GLCA) located above the Glen Canyon Dam on the Colorado River near Page, Arizona on May 14 - 18, 1991. We centered our work on the larger distinct hanging gardens which Welsh (1984, 1989) and Tuhy and MacMahon (1988) had previously surveyed for plant species during NPS sponsored research. The ZION hanging gardens we sampled were located within Zion Canyon with the exception of Pine Creek and

Canyon Overlook I and II hanging gardens. Pine Creek hanging garden is located just upstream of the Zion - Mt. Carmel highway bridge across Pine Creek. Both Canyon Overlook hanging gardens are located along the short Canyon Overlook Trail just above the tunnel on the Zion - Mt. Carmel highway. In GLCA we chose hanging gardens in three main areas. Pedestal, Graffiti, and Zephyr hanging gardens are located on the southeast flank of Pollywog bench near the mouth of the Escalante River arm of Lake Powell. Upper and Lower Three Garden are located near the mouth of the San Juan River arm, and the remaining hanging gardens are located near the Great Bend area of the San Juan River arm of Lake Powell. Geographic Information System maps are currently being prepared to illustrate more detailed locations.

METHODS

Tuhy and MacMahon (1988) described hanging garden vegetation as typically herbaceous. Along this theme, we define a hanging garden community as the area of mesophytic, mainly herbaceous vegetation surrounding a perennial spring or seep originating from a canyon wall. The boundary with surrounding xeric vegetation is placed at the point where the more xeric vegetation begins even if it would not be there without hanging garden influence but would be found in other dry, protected alcoves or canyons. The boundary with the riparian community is placed at the point where colluvial soils stop and alluvial soils begin. Colluvial soils develop on deposits accumulated by gravitational downslope movement whereas

alluvial soils develop on water transported deposits as in a floodplain (Brady 1974). The previous plant work allowed us to concentrate on measuring the community importance of plant species in these gardens, especially the endemics; to expand to nearby smaller hanging gardens; and to increase our effort on invertebrate surveys.

Each hanging garden was visually separated into the following microhabitats: wet walls, backwalls, ledges, and colluvial soil slopes associated with some ledges. Wet walls were covered with thin sheet flow of water and were dominated by prokaryotic and protistan communities with scattered patches of vascular plants. Protected backwalls at the back of wet alcoves in GLCA allow the development of fern communities against the dry alcove floor in some hanging gardens. Ledges were of sufficient width and length to support linear plant communities growing on shallow soils. Most of the vascular plant communities were found on colluvial soils which develop just down slope of ledges or on the talus/scree underneath an alcove stabilized by a downslope ledge.

Our sampling intensity was hierarchically arranged with hanging garden size (Table 2). For the largest hanging gardens, such as Upper Three Garden at GLCA or Grotto Hanging Garden at ZION, we used pitfall and malaise traps for insects as well as general sweep netting of the vegetation. Off garden controls were

set on dry slopes for malaise and pitfall traps. We also collected flower feeders and pollinators when the plants were in flower. Wet walls and floors were visually examined to collect insects by hand or aspirator. Insect collections are currently being processed and identified to Family prior to shipment to the USDA Bee Laboratory at Utah State University and the Systematic Entomology Laboratory at Oregon State for species identification.

Vegetation was systematically sampled (Manly 1989) by 20 cm x 50 cm quadrat frames to estimate herbaceous canopy cover by species for each microhabitat present on each hanging garden when accessible. Cover classes for the Daubenmire method (1959) are: 1 = 0-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-95%, 6 = 95-100%. Voucher specimens were collected for each species. The above specimens were identified by Dr. Hartman at the Rocky Mountain Herbarium at the University of Wyoming and will be stored there. Systematically placed line transects (MacDonald 1990) were also used in GLCA when woody plants were an important component of the community. Hanging garden vascular plant community similarities were calculated using Sorensen's (1948) coefficient for binary (presence - absence) data and the simplified Morisita - Horn coefficient (Horn 1966) for canopy coverage data.

Malaise traps were set only on the largest hanging gardens in order to minimize the collection of off site insects. However, pitfall traps were placed on all but the smallest hanging gardens. In addition, for the smallest hanging gardens only plant species lists were compiled. Small mammal presence - absence data was

collected on three hanging gardens in both ZION and GLCA. Seasonal effects will be examined from plant and insect data collected in June, July, and August from ZION's two largest hanging gardens - Upper Emerald Hanging Garden and Grotto Hanging Garden. These gardens received the full treatment each month (Table 2).

Small mammals were sampled using eight No. 11 Havahart and two larger wire mesh live traps baited with "lab chow" pellets dotted with anise oil. During June trapping in Zion for Upper Emerald, Pine Creek, Menu Falls, and Grotto hanging gardens, two hanging gardens per night were sampled with two Havaharts and one larger trap on the garden and two Havaharts off the garden site (Table 3). All later trapping periods were on one garden per night with four Havaharts and one larger wire mesh live trap on and off each hanging garden site. In addition, field notes were made for all visual sightings of mammals and tracks on each garden.

RESULTS

Geology

In GLCA and ZION, many hanging gardens appear to be located on the contact between the Navajo sandstone and the Kayenta formation, at an approximate elevation of 4160-4200 and 4500-4700 feet respectively. These gardens straddle the contact and have distinct geomorphic microhabitats. The wet walls are in the cliff forming Navajo sandstone while the ledges and colluvial soil slopes develop in the siltstone and mudstone layers of the Kayenta.

Our plan to use low altitude stereo paired color photography

to locate hanging gardens at GLCA was abandoned after an overflight of the hanging gardens in May. While the green islands representing hanging gardens could be seen from directly overhead, a more horizontal angle was required to separate hanging gardens from the deep ravines with protected north and east aspects which supported dense stands of woody vegetation.

Small mammals

There was no difference in small mammal trapping success between on and off garden sites (paired t-test, $p=0.44$) (Table 2A). Therefore we must reject our original hypothesis of hanging gardens having more dense small mammal populations. There was a slight trend for *Peromyscus crinitus*, Canyon mouse, to be found on the hanging gardens and for *Peromyscus truei*, Pinyon mouse, to be found in the surrounding dryer vegetation (Table 3) but neither trend was statistically significant ($p=0.11$ and $p=0.24$ respectively). Other species observed on site or tracks observed are as follows:

Grotto HG - *Ovis canadensis*, bighorn sheep, tracks; *Tamias minimus*, least chipmunk, on site.
 Upper Emerald - *Bassariscus astutus*, ringtail cat, tracks; *T. minimus*, least chipmunk, on site.
 Upper Three Garden - unknown chipmunk *Tamias* on site.
 Hardwood - *Erethizon dorsatum*, porcupine, and *T. minimus*, least chipmunk, on site.
 Rattlesnake - *T. minimus*, least chipmunk, on site.

Vascular plants

Adiantum capillus-veneris was found in most ZION hanging gardens (Table 4) predominantly on the wet wall microhabitats where it occupied 5 - 95% of the plant canopy, e.g. Fall hanging garden (Table 4h). In addition to *Adiantum capillus-veneris*, *Mimulus cardinalis* and *Aquilegia chrysantha* were dominant components of the

wet wall microhabitat plant community, e.g. Menu Falls and Weeping Rock hanging gardens (Table 4d and 4i respectively). Ledge - colluvial soil slope microhabitats were dominated by *Dodecatheon pulchellum*, *Smilacina stellata*, *Calamagrostis scopulorum*, *Carex aurea*, and *Carex haysii* (Table 4). Ledge microhabitat plant communities were intermediate in species composition having species more typical of both wet walls and colluvial slopes (Table 4). *Mimulus cardinalis* was more abundant on wet walls and ledges with abundant surface water as shown in Grotto hanging garden (table 4b). With the exception of *Carex haysii*, the above species were also the most widely distributed within ZION hanging gardens occupying 8 - 12 of the hanging gardens surveyed (Table 4). *Aralia racemosa* was found on only three hanging gardens (table 4b,h,j), but this extended the previous range of Grotto hanging garden and the Narrows noted by Nelson (1976).

Pine Creek hanging garden was the most dissimilar as indicated by both binary and canopy coverage plant species data (Tables 5 and 6 respectively) due to its low species richness. Distinctive plant assemblages on wet wall, ledge, and ledge - colluvial soil microhabitats are indicated by the simplified Morisita - Horn coefficient of community similarity (table 6). Within Grotto hanging garden for example, the similarity coefficients between ledge and ledge - colluvial soil slope ranged from 0.41, 0.07, and 0.12 during June, July, and August respectively. A coefficient of 1.00 indicates completely similar canopy coverage values for each

species while 0.00 indicates complete dissimilarity (Krebs 1989?). Analogous coefficients for Upper Emerald hanging garden are 0.34 and 0.66 for June and July respectively and 0.33 for Kayes hanging garden in July. June data from Menu Falls also indicates that the ledge - colluvial soil plant community is distinct from wet walls with coefficients of 0.27 and 0.51, with the latter value corresponding to the calcareous deposit wet wall.

June to August seasonal change on the vascular plant community at Grotto hanging garden was minimal on both ledge - colluvial soil slope (0.96 - 0.98 similarity coefficients) and ledge (0.82 - 0.97 similarity coefficients) microhabitats (table 6). More season effects were detected on the Upper Emerald plant community, with coefficients from 0.61 - 0.91 on the large ledge - colluvial soil slope to 0.61 on the smaller ledge microhabitat.

Adiantum capillus-veneris was also found in most GLCA hanging gardens (table 7) being the most important component of the backwall and wet wall vascular plant community (table 7b, c, d, & g). In addition to *Adiantum capillus-veneris*, *Primula specuicola*, *Cirsium rydbergii*, *Carex curatorum*, and *Schizachyrium scoparium* were important plant community components of backwall microhabitats at GLCA (table 7b, c, & d). Ledge microhabitats were dominated by *Adiantum capillus-veneris* in Hardwood hanging garden (table 7f) and by *Andropogon glomeratus*, *Schizachyrium scoparium*, and *Petrophytum caespitosum* on Dune and Crossbed hanging gardens (table 7h, i).

The ledge - colluvial soil slope microhabitats were dominated by *Cirsium rydbergii*, *Adiantum capillus-veneris*, *Schizachyrium scoparium*, *Petrophytum caespitosum*, *Calamagrostis scopulorum*, and *Carex* sp. (table 7). *Panicum virgatum*, *Cladium callifornicum*, and *Juncus arcticus* were important components of the Hardwood hanging garden plant community. With the exception of the latter three species, the above plants also occupied the most hanging garden sites within GLCA. The woody plant, *Rhamnus betulifolia*, was also consistently present in most GLCA hanging gardens.

No distinctively dissimilar hanging garden could be detected within GLCA with plant species presence - absence data (table 8), but Hardwood hanging garden's large ledge - colluvial soil slope is unlike all others sampled with canopy coverage techniques (table 9). Simplified Morisita - Horn similarity coefficients range from 0.00 to 0.11. Microhabitat plant communities within individual hanging gardens were also distinct at GLCA (table 9). Similarity coefficients between ledge and ledge - colluvial soil slopes ranged from 0.11 at Hardwood to 0.70 at Crossbed, while the similarity coefficients between backwall and ledge - colluvial soil slopes ranged from 0.26 to 0.73 at Zephyr hanging garden.

The predictions of the core - satellite hypothesis (Hanski 1982) were not supported with plant distribution data for either park (Table 11). The distribution pattern for number of sites occupied appears to be more of a negative exponential shape than

the predicted bimodal distribution which would have large modes at the low and high proportional ends of the sites occupied scale.

Insects

Most of the sweep netted, hand, and flower pollinator/feeder insect collections and some of the pitfall collections have been processed and shipped for identification. Over 1500 specimens in 105 families have been cataloged so far. However, only the bees have been identified to species by our consultants.

Species identification for most families of bees is complete (Table 12). The remaining unknown specimens of Family Halictidae will be examined by a specialist in these genera this fall. No species were found in both ZION & GLCA hanging gardens, but the plant species sampled were not found in both parks. Only two species of bee were found on the endemic *Cirsium rydbergii* in GLCA while the disjunct population of *Aralia racemosa* in ZION had eight species of floral bee visitors. Both plant species were sampled intensively when flowers were available. *Bombus occidentalis* was netted from flowers of four plant species which are all characteristic of ZION hanging garden vegetation; *Aralia racemosa*, *Dodecatheon pulchellum*, *Aquilegia chrysantha*, and *Mimulus cardinalis*. No new species have been noted, but the population of *Bombus melanopygus* is atypical in elevation and habitat. This species has a more northerly distribution but also occurs in the mountains of northern New Mexico at higher elevations (Vince Tepidino, personal communication). It was found exclusively on *Dodecatheon pulchellum* in Grotto hanging garden at ZION.

DISCUSSION

The trend for *P. crinitus* to be found on hanging gardens could be investigated further with longer trapping periods and/or more gardens per night. Most gardens are not large enough to significantly increase trapping intensity; however, its normal habitat in Zion is low and middle elevations (Anon.) where other mesic habitats are common. This would necessitate a third trapping grid along a riparian zone before a definitive statement about hanging garden selection could be made. In any case, no unexpected or endemic mammal species appeared on hanging gardens.

Some endemic plant species of the Colorado Plateau are both widespread and abundant components of hanging garden communities. *Cirsium rydbergii* was found in 6 of the 13 gardens surveyed in GLCA and comprised 1 -56% of the canopy cover when present (Table 7). The same pattern is true for *Dodecatheon pulchellum* var. *zionense* and *Aquilegia chrysantha* in ZION. There should be little management concern for the future of these species. However, other endemics such as *Erigeron sionis*, *Perityle tenella* (both in ZION), and *Habenaria zothecina* (in GLCA) were found in only one hanging garden community and are not dominant components of the plant canopy (Tables 4 & 7). If these species are indeed rare in occurrence and rare in abundance within the hanging garden community, they would be likely candidates for local extinction due to natural or man - caused disturbances. Our future work in CARE and CANY where *Habenaria zothecina* is also supposed to occur may

provide a clearer picture of its status.

There were a larger number of plant species that occur in only one or two hanging gardens in both parks than we expected from consulting previously published species lists (Tuhy and MacMahon 1988, Welsh 1984, 1989) and various unofficial sources. This was in spite of our relatively narrow definition of hanging garden extent to exclude riparian and mesic hanging garden influence zones. We plan to devote more survey time to document these occurrences in the next two years.

The large number of rarely occurring plant species within hanging gardens (Table 11) was partially predicted by the core-satellite hypothesis (Hanski 1982). However, the small number of widely distributed plant species and larger number of species occupying an intermediate number of sites do not match the core-satellite predictions. One of Hanski's (1982) assumptions for the core-satellite hypothesis was that of similarity of sites. This assumption would appear to have been met at least for ZION hanging gardens. This trend runs counter to most other plant studies (Collins and Glenn 1990, 1991, Gotelli and Simberloff 1987) but agrees with an insect test of the core-satellite hypothesis (Gaston and Lawton 1989).

We plan to wait until our GLCA work is completed this coming field season before attempting to compare the ZION & GLCA hanging garden plant communities. A quick look at tables 6 and 9 indicates that ZION hanging gardens are much more similar to each other while the gardens within GLCA are more diverse.

The vast number of insects collected demands a lot of preparation time, and we are behind schedule for the first year insect collections. The large number of small Diptera in the malaise trap samples may prove to be the most difficult. Another potential problem may exist in getting most specimens identified to species within the proposed three year time frame for project funding. This will be especially true if a significant number of specimens prove to be endemic to hanging gardens. If this is the case, the final report at the end of three year may have to be amended as the insect specimens are authoritatively described in the following years.

ACKNOWLEDGEMENTS

Our thanks go to Rick Harris (GLCA), Vic Vieira (ZION), and Frank Hayes (ZION) for access to NPS reports and logistical support. Thanks also go to our technicians Cathleen May and Jon Hak for their dedication to the project.

LITERATURE CITED

- Brady, N. C. 1974. The nature and properties of soils, 8th ed. MacMillan Publishing Co., Inc. New York.
- Collins, S. L., and S. M. Glenn. 1990. A hierarchical analysis of species' abundance patterns in grassland vegetation. *Am. Nat.* 135:633-648.
- _____. 1991. Importance of spatial and temporal dynamics in species regional abundance and distribution. *Ecology* 72:654-664.

- Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-64.
- Gaston, K. J., and J. H. Lawton. 1989. Insect herbivores on bracken do not support the core - satellite hypothesis. Am. Nat. 134:761-777.
- Hanski, I. 1982. Dynamics of regional distribution: the core and satellite species hypothesis. Oikos 38:210-221.
- Horn, H. S. 1966. Measurement of "overlap" in comparative ecological studies. Am. Nat. 100:419-424.
- Loope, W. L. 1977. Relationships of vegetation to environment in Canyonlands National Park. Unpublished Ph.D. Diss. Utah State University.
- MacDonald, L. L. 1990. Line intercept sampling for two dimensional particles. Unpublished manuscript, ver. 7-90.
- Manly, B. F. J. 1989. Stratified and systematic sampling. Unpublished manuscript, ver. 11-89.
- Malanson, G. P. 1980. Habitat and plant distribution in hanging gardens of the narrows, Zion National Park, Utah. Gt. Basin Nat. 40:178-182.
- Nelson, R. A. 1976. Plants of Zion National Park.
- Sorensen, R. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Kong. Dan. Vidensk. Selsk, Biol. Skr. 5:1-34.
- Tuhy, J. S., and J. A. MacMahon. 1988. Vegetation and relict communities of Glen Canyon National Recreational Area, Final report NPS contract CX1200-6-B076.

- Welsh, S. L. 1984. Flora of Glen Canyon National Recreation Area,
Unpub. mss. Glen Canyon National Recreation Area.
- _____. 1989. On the distribution of Utah's hanging gardens.
Gt. Basin Nat. 49:1-30.
- _____, and C. A. Toft. 1972. Biotic communities of hanging
gardens in southeastern Utah. Nat. Geo. Soc. Res. Report
13:663-681.

Table 1. Hanging gardens (HG) sampled in summer 1991.

Dates	Glen Canyon NRA	Zion National Park
June 3-9, 1991		Upper Emerald HG Lower Emerald HG Grotto HG Menu Falls HG Pine Creek HG
June 10-16, 1991	Upper Three Garden Lower Three Garden Pedestal HG Graffiti HG Zephyr HG	
July 8-14, 1991		Court of Patriarchs HG Kayes HG Upper Emerald HG Grotto HG Fall HG Weeping Rock HG

Table 1. Hanging gardens (HG) sampled in summer 1991.

Dates	Glen Canyon NRA	Zion National Park
July 26-31, 1991	Hardwood HG	
	Rattlesnake HG	
	Crossbed HG	
	Dune HG	
	Surprise HG	
	Ivy HG	
	Baby HG	
	Baby Too HG	
August 1-6, 1991		Upper Emerald HG
		Grotto HG
		Trail HG
		Falling Water HG
		Snail HG
		Canyon Overlook HG
		Trail's End HG

Table 2. Sampling intensity by relative hanging garden size.

Sampling Treatment	Large	Medium	Small
Vegetation			
Canopy coverage	x	x	
Species list only			x
Insects			
Malaise trap	x		
Pitfall trap	x	x	
Sweep netting	x	x	
Hand/aspirator	x	x	
Pollinators/feeders	x	x	
Small mammals			
Live traps	x ¹	x ¹	

¹ selected HGs only

Table 3. Small mammal species trapping success for Zion and GLCA, 1991.

Hanging Garden	Date	Number & species	
		On garden	Off garden
Upper Emerald	June 3-5	1 <i>Peromyscus</i> <i>maniculatus</i>	1 <i>Peromyscus</i> <i>truei</i>
Pine Creek	June 3-7	1 <i>Dipodomys ordi</i>	none
Menu Falls	June 5-9	3 <i>Peromyscus</i> <i>crinitus</i>	1 <i>P. crinitus</i> 1 <i>P. maniculatus</i>
	July 8-10	3 <i>P. maniculatus</i> 3 <i>P. crinitus</i>	none
	Aug. 1-6	1 <i>P. crinitus</i> 1 <i>P. maniculatus</i>	4 <i>P. truei</i>
Grotto	June 7-9	none	none
Upper Three Garden	June 10-12	2 <i>Neotoma lepida</i>	none
Pedestal	June 13-15	none	1 <i>P. maniculatus</i> 1 <i>N. lepida</i>
Hardwood	July 26-31	none	none

Table 4a. Vascular plant species on Upper Emerald hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12		
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1 1-2	l ls
<i>Aquilegia formosa</i>	7	0		
Cyperaceae				
<i>Carex aurea</i>	8	5	1-3*	l
<i>Carex haysii</i>	3	0	1	ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2	1-ls
<i>Elymus canadensis</i>	1	2	1	ls
<i>Muhlenbergia andina</i>	5	2	1	ls
Liliaceae				
<i>Smilacina stellata</i>	12	1	2-3	ls
Orchidaceae				
<i>Epipactus gigantea</i>	7	9	1	ls
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	2 2-3	l ls
Onagraceae				
<i>Oenothera longissima</i>	1	1		
Anacardiaceae				
<i>Toxicodendron rydbergii</i>	6	2		
Umbelliferae				
<i>Angelica pinnata</i>	1	0	1	ls
Apocynaceae				
<i>Apocynum cannabinum</i>	2	0	1	1-ls
Asclepiadaceae				
<i>Asclepias hallii</i>	1	0		
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0		

Table 4b. Vascular plant species on Grotto hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1-2	l-ls
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1-2	l-ls
<i>Aquilegia formosa</i>	7	0		
Berberidaceae				
<i>Mahonia repens</i>	4	0		
Violaceae				
<i>Viola nephrophylla</i>	2	0	1	l-ls
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	2	l-ls
Saxifragaceae				
<i>Heuchera rubescens</i>	2	0		
<i>Jamesia americana</i>	1	0		
Anacardiaceae				
<i>Toxicodendron rydbergii</i>	6	2		
Araliaceae				
<i>Aralia racemosa</i>	3	0	2	l
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0	2-3	l
Rubiaceae				
<i>Galium triflorum</i>	1	0		
Liliaceae				
<i>Smilacina stellata</i>	12	1	1	ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1 3	l ls
<i>Bromus ciliatus</i>	2	0		

Table 4c. Vascular plant species on Trail hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1 1-2 2-3	l ls w
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1	1-ls
<i>Aquilegia formosa</i>	7	0		
<i>Clematis ligusticifolia</i>	2	3	1	ls
Berberidaceae				
<i>Mahonia repens</i>	4	0		
Cannabaceae				
<i>Humulus americanus</i>	1	0		
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	2 1	1-ls w
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Vitaceae				
<i>Vitis arizonica</i>	2	3	1 2 3	ls l w
Anacardiaceae				
<i>Toxicodendron rydbergii</i>	6	2	1	ls
Aceraceae				
<i>Acer negundo</i>	3	0	1-2	ls
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0	1	1-ls
Compositae				
<i>Cirsium wheeleri</i>	1	0		
<i>Cirsium neomexicanum</i>	1	0		
Cyperaceae				
<i>Carex aurea</i>	8	5	1	l

Graminae				
<i>Calamagrostis scopulorum</i>	10	7	3 2-3 1	1 ls w
<i>Muhlenbergia andina</i>	5	2		
Liliaceae				
<i>Smilacina stellata</i>	12	1	2-3 3 2	ls 1 w
Orchidaceae				
<i>Epipactus gigantea</i>	7	9		

Table 4d. Vascular plant species on Menu Falls hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2 1-3	ls w
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1 2	ls w
<i>Aquilegia formosa</i>	7	0		
<i>Clematis ligusticifolia</i>	2	3		
Apocynaceae				
<i>Apocynum cannabinum</i>	2	0		
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0	2	w-ls
Cyperaceae				
<i>Carex aurea</i>	8	5	1	ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1 2	ls w
<i>Agrostis exarata</i>	4	1		
<i>Bromus diandrus</i>	1			
Liliaceae				
<i>Smilacina stellata</i>	12	1		

Table 4e. Vascular plant species on Lower Emerald hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1	ls
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1	ls
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	2-3	ls
Compositae				
<i>Aster glaucodes</i>	3	0	2	ls
Cyperaceae				
<i>Carex aurea</i>	8	5		
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2-3	ls
<i>Agrostis exarata</i>	4	1		
Orchidaceae				
<i>Epipactus gigantea</i>	7	9	1	ls
Liliaceae				
<i>Smilacina stellata</i>	12	1	1	ls

Table 4f. Vascular plant species on Kayes hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1	l-ls
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1	ls
<i>Aquilegia formosa</i>	7	0		
Anacardiaceae				
<i>Toxicodendron rydbergii</i>	6	2	1	l-ls
Hydrophyllaceae				
<i>Phacelia heterophylla</i>	1	0		
Oleaceae				
<i>Fraxinus velutina</i>	3	0		
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0	1	l
Compositae				
<i>Artemisia ludoviciana</i>	2	1	1	l
<i>Cirsium arizonicum</i>	2	0		
<i>Taraxacum officinale</i>	1	0	1	l
Juncaceae				
<i>Juncus ensifolius</i>	2	1	1	ls
Cyperaceae				
<i>Carex aurea</i>	8	5	2*	l-ls
<i>Carex haysii</i>	3	0		
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1 3	l ls
<i>Agrostis exarata</i>	4	1		
<i>Danthonia californica</i>	1	0	1	l
<i>Muhlenbergia andina</i>	5	2	1	ls
<i>Panicum acuminatum</i>	1	8	1 2	ls l
<i>Phragmites australis</i>	1	1	1	ls
<i>Poa pratensis</i>	2	0	2	l
Liliaceae				
<i>Smilacina stellata</i>	7	9	1	l

Table 4g. Vascular plant species on Pine Creek and Court of the Patriarchs hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Pine Creek hanging garden:				
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	2	1s
Compositae				
<i>Aster glaucodes</i>	3	0	2	1s
Court of the Patriarchs hanging garden:				
Equisetaceae				
<i>Equisetum laevigatum</i>	1	0	1	1s
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2	1s
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Aceraceae				
<i>Acer negundo</i>	3	0	1	1s
Oleaceae				
<i>Fraxinus velutina</i>	3	0		
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0		
Rubiaceae				
<i>Galium trifidum</i>	1	0		
Cyperaceae				
<i>Carex aurea</i>	8	5	1	1s
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2	1s
<i>Agrostis exarata</i>	4	1		
<i>Poa pratensis</i>	2	0	1	1s
Liliaceae				
<i>Smilacina stellata</i>	12	1	1	1s

Table 4h. Vascular plant species on Fall hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2 6	ls w
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1	ls
<i>Aquilegia formosa</i>	7	0		
Cruciferae				
<i>Nasturium officinale</i>	1	0		
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	3	ls
Araliaceae				
<i>Aralia racemosa</i>	3	0		
Juncaceae				
<i>Juncus ensifolius</i>	2	1	1	ls
Liliaceae				
<i>Smilacina stellata</i>	12	1	2	ls
Orchidaceae				
<i>Epipactus gigantea</i>	7	9		

Table 41. Vascular plant species on Weeping Rock hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2	w
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	2	w
<i>Aquilegia formosa</i>	7	0		
Primulaceae				
<i>Dodecatheon pulchellum</i>	8	0	1	w
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	1	w
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0	4	w
Cyperaceae				
<i>Carex haysii</i>	3	0	1	w
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	3	w
Liliaceae				
<i>Smilacina stellata</i>	12	1		

Table 4j. Vascular plant species on Falling Water hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1	ls
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	2	ls
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Aceraceae				
<i>Acer negundo</i>	3	0		
Anacardiaceae				
<i>Toxicodendron rydbergii</i>	6	2		
Araliaceae				
<i>Aralia racemosa</i>	3	0		
Oleaceae				
<i>Fraxinus velutina</i>	3	0		
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0		
Cyperaceae				
<i>Carex aurea</i>	8	5	1	ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2	ls
Liliaceae				
<i>Smilacina stellata</i>	12	1		

Table 4k. Vascular plant species on Snail hanging garden, ZION. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope.

Family - species	Sites occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	3	ls
Ranunculaceae				
<i>Aquilegia chrysantha</i>	11	0	1	ls
Scrophulariaceae				
<i>Mimulus cardinalis</i>	10	0		
Compositae				
<i>Aster glaucodes</i>	3	0		
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2	ls
Liliaceae				
<i>Smilacina stellata</i>	12	1	1	ls
Orchidaceae				
<i>Epipactus gigantea</i>	7	9		

Table 41. Vascular plant species on Trail's End (TE), Canyon Overlook I (COI), and Canyon Overlook II (COII) hanging gardens. Sites occupied is number of hanging gardens in which species was found.

Family - species	Sites Occupied		TE	COI	COII
	ZION	GLCA			
Polypodiaceae					
<i>Adiantum capillus-veneris</i>	14	12	x	x	x
Ranunculaceae					
<i>Aquilegia chrysantha</i>	11	0	x	x	
Berberidaceae					
<i>Mahonia repens</i>	4	0	x		x
Fagaceae					
<i>Quercus turbinella</i>	1	0			x
Salicaceae					
<i>Populus fremontii</i>	1	0			x
<i>Salix gooddingii</i>	1	0			x
Primulaceae					
<i>Dodecatheon pulchellum</i>	8	0	x		
Saxifragaceae					
<i>Heuchera rubescens</i>	2	0		x	x
Rosaceae					
<i>Petrophytum caespitosum</i>	6	10		x	x
Onagraceae					
<i>Zauscheria latifolia</i>	1	0			x
Celastraceae					
<i>Paxistima myrsinites</i>	1	0			x
Vitaceae					
<i>Vitus arizonica</i>	2	3	x		
Anacardiaceae					
<i>Toxicodendron rydbergii</i>	6	2	x		
Scrophulariaceae					
<i>Mimulus cardinalis</i>	10	0	x		

Compositae					
<i>Artemisia ludoviciana</i>	2	1			x
<i>Brickellia grandiflora</i>	2	3		x	x
<i>Erigeron sionis</i>	1	0			x
<i>Eupatorium herbaceum</i>	1	0		x	
<i>Heterotheca villosa</i>	1	1			x
<i>Perityle tenella</i>	1	0		x	
<i>Solidago sparsiflora</i>	1	3			x
<i>Stephanomeria pauciflora</i>	1	0			x
Graminae					
<i>Bromus ciliatus</i>	2	0			x
<i>Calamagrostis scopulorum</i>	10	7	x		
<i>Poa fendleriana</i>	1	0		x	
Liliaceae					
<i>Smilacina stellata</i>	12	1	x	x	
Orchidaceae					
<i>Epipactus gigantea</i>	7	9		x	x

Table 6. ZION hanging garden vascular plant community similarity by the simplified Morisita - Horn coefficient (Horn 1966). See table 5 for hanging garden legend. Microhabitat legend: ww = wet wall, ls = ledge with colluvial soil below, l = ledge without colluvial soil below.

[illegible]

Table 6. (continued) ZION hanging garden vascular plant community similarity by the simplified Morisita - Horn coefficient (Horn 1966). See table 5 for hanging garden legend. Microhabitat legend: ww = wet wall, ls = ledge with colluvial soil below, l = ledge without colluvial soil below.

[illegible]

Table 7a. Vascular plant species on Lower Three Garden hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Cyperaceae				
<i>Carex aurea</i>	8	5	2*	ls
<i>Carex curatorum</i>	0	4		
Primulaceae				
<i>Primula specuicola</i>	0	7	1	ls
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	2	ls
Scrophulariaceae				
<i>Castilleja linariifolia</i>	0	7	1	ls
Compositae				
<i>Cirsium rydbergii</i>	0	6	2	ls

Table 7b. Vascular plant species on Upper Three Garden hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2 1	bw ls
Cyperaceae				
<i>Carex aurea</i>	8	5	1-3* 1	ls bw
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1 1-2	bw ls
<i>Panicum acuminatum</i>	1	8		
<i>Schizachyrium scoparium</i>	0	5	1-2	ls
Orchidaceae				
<i>Epipactis gigantea</i>	7	9	1	ls
Fagaceae				
<i>Quercus gambelii</i>	0	4	1	ls
Primulaceae				
<i>Primula specuicola</i>	0	7	2	bw
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Leguminosae				
<i>Cercis occidentalis</i>	0	4		
Asclepiadaceae				
<i>Asclepias latifolia</i>	0	1		
Scrophulariaceae				
<i>Mimulus eastwoodiae</i>	0	3	1	bw
<i>Castilleja linariifolia</i>	0	7		
Compositae				
<i>Cirsium rydbergii</i>	0	6	2-4 2	ls bw
<i>Solidago sparsiflora</i>	1	3		

Table 7c. Vascular plant species on Graffiti hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	5	bw
Orchidaceae				
<i>Epipactis gigantea</i>	7	9	1	ls
Ranunculaceae				
<i>Aquilegia micrantha</i>	0	4		
Ulmaceae				
<i>Celtis reticulata</i>	0	8		
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11		
Compositae				
<i>Brickellia longifolia</i>	0	3		

Table 7d. Vascular plant species on Zephyr hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	3 1-2	bw ls
Cyperaceae				
<i>Carex curatorum</i>	0	4	1-2* 3	ls bw
Graminae				
<i>Andropogon glomeratus</i>	0	6		
<i>Schizachyrium scoparium</i>	0	5	1-4 2	ls bw
Orchidaceae				
<i>Epipactis gigantea</i>	7	9	1	bw
Ranunculaceae				
<i>Aquilegia micrantha</i>	0	4	1	bw-ls
Ulmaceae				
<i>Celtis reticulata</i>	0	8		
Urticaceae				
<i>Parietaria pennsylvanica</i>	0	1	1	ls
Fagaceae				
<i>Quercus gambelii</i>	0	4		
Primulaceae				
<i>Primula specuicola</i>	0	7	1	bw
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	1	ls
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11	1	ls
Anacardiaceae				
<i>Rhus aromatica</i>	0	7	1	ls
Scrophulariaceae				
<i>Castilleja linariifolia</i>	0	7	1	ls
Compositae				
<i>Cirsium rydbergii</i>	0	6	1-3 1	ls bw

Table 7e. Vascular plant species on Pedestal hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1-3	ls
Cyperaceae				
<i>Carex curatorum</i>	0	4	2*	ls
<i>Carex aurea</i>	8	5		
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1	ls
<i>Schizachyrium scoparium</i>	0	5	1-4	ls
Orchidaceae				
<i>Epipactis gigantea</i>	7	9	1	ls
Ranunculaceae				
<i>Aquilegia micrantha</i>	0	4	1	ls
<i>Clematis ligusticifolia</i>	2	3	1	ls
Juncaceae				
<i>Juncus arcticus</i>	0	2	1	ls
Fagaceae				
<i>Quercus gambelii</i>	0	4		
Onagraceae				
<i>Oenothera longissima</i>	1	1	1	ls
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11	1	ls
Anacardiaceae				
<i>Rhus aromatica</i>	0	7		
Compositae				
<i>Cirsium rydbergii</i>	0	6	1-2	ls
<i>Heterotheca villosa</i>	1	1	1	ls

Table 7f. Vascular plant species on Hardwood hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	3	l
			1	ls
Juncaceae				
<i>Juncus arcticus</i>	0	2	2	ls
Cyperaceae				
<i>Carex aurea</i>	8	5		
<i>Cladium californicum</i>	0	1	2	ls
			1	l
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	2	l
<i>Elymus canadensis</i>	1	2	1	l-ls
<i>Panicum acuminatum</i>	0	8	1	ls
<i>Panicum virgatum</i>	1	2	2	ls
<i>Schizachyrium scoparium</i>	0	5	1	ls
<i>Muhlenbergia andina</i>	5	2		
<i>Sphenopholis obtusata</i>	0	1		
<i>Phragmites australis</i>	1	1		
Orchidaceae				
<i>Epipactis gigantea</i>	7	9		
Ranunculaceae				
<i>Clematis ligusticifolia</i>	2	3	1	l-ls
Ulmaceae				
<i>Celtis reticulata</i>	0	8		
Fagaceae				
<i>Quercus gambelii</i>	0	4	1	ls
Cruciferae				
<i>Thelypodium integrifolium</i>	0	1		
Primulaceae				
<i>Primula specuicola</i>	0	7	1	l
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	1	l
Leguminosae				
<i>Cercis occidentalis</i>	0	4		

Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11	1	1
Vitaceae				
<i>Vitus arizonica</i>	2	3	1	1s
Anacardiaceae				
<i>Rhus aromatica</i>	0	7	1	1s
Oleaceae				
<i>Forestiera pubescens</i>	0	2	2	1s
Scrophulariaceae				
<i>Mimulus eastwoodiae</i>	0	3	1	1
<i>Castilleja linariifolia</i>	0	7		
Compositae				
<i>Cirsium rydbergii</i>	0	6		
<i>Baccharis emoryi</i>	0	1	2	1s
			1	1
<i>Erigeron utahensis</i>	0	2		

Table 7g. Vascular plant species on Rattlesnake hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): w = wet wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	3 2	w ls
Juncaceae				
<i>Juncus ensifolius</i>	2	1		
Cyperaceae				
<i>Carex aurea</i>	8	5	1	ls-w
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	4 3	ls w
<i>Elymus canadensis</i>	1	2	1	ls-w
<i>Agrostis exarata</i>	4	1		
Liliaceae				
<i>Smilicina stellata</i>	12	1	1	ls-w
Orchidaceae				
<i>Epipactis gigantea</i>	7	9	1	ls-w
<i>Habenaria zothecina</i>	0	1	1	w
Ranunculaceae				
<i>Aquilegia micrantha</i>	0	4	1	ls-w
Fagaceae				
<i>Quercus gambelii</i>	0	4	1	ls
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10		
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11		
Vitaceae				
<i>Vitus arizonica</i>	2	3	1 2	ls w
Oleaceae				
<i>Forestiera pubescens</i>	0	2	2	w
<i>Fraxinus anomala</i>	0	3		
Scrophulariaceae				
<i>Mimulus eastwoodiae</i>	0	3	1	w

Compositae				
<i>Cirsium rydbergii</i>	0	6	1	w
<i>Brickellia longifolia</i>	0	3	1	w

Table 7h. Vascular plant species on Crossbed hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	1	1-ls
Cyperaceae				
<i>Carex curatorum</i>	0	4	1	1-ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1	1
<i>Panicum acuminatum</i>	0	8		
<i>Schizachyrium scoparium</i>	0	5	2	ls
			3	1
<i>Andropogon glomeratus</i>	0	6		
Orchidaceae				
<i>Epipactis gigantea</i>	7	9		
Ulmaceae				
<i>Celtis reticulata</i>	0	8		
Polygonaceae				
<i>Eriogonum corymbosum</i>	0	1		
Loasaceae				
<i>Mentzelia cronquisti</i>	0	1		
Primulaceae				
<i>Primula specuicola</i>	0	7	1	1-ls
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	2	1-ls
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11		
Anacardiaceae				
<i>Rhus aromatica</i>	0	7		
Oleaceae				
<i>Fraxinus anomala</i>	0	3		
Scrophulariaceae				
<i>Castilleja linariifolia</i>	0	7		

Compositae

<i>Cirsium rydbergii</i>	0	6	2	1s
<i>Gutierrezia sarothrae</i>	0	1	1	1
<i>Erigeron utahensis</i>	0	2		
<i>Brickellia longifolia</i>	0	3	1	1
<i>Hymenoxys acaulis</i>	0	1		
<i>Solidago sparsiflora</i>	1	3		

Table 71. Vascular plant species on Dune hanging garden, GLCA. Sites occupied is number of hanging gardens in which species was found in ZION & GLCA. For sampled portions, community importance (CI) values are Daubenmire canopy cover classes by microhabitat (MH): bw = back wall, l = ledge, ls = ledge plus colluvial slope. * = *Carex* species combined.

Family - species	Sites Occupied		CI	MH
	ZION	GLCA		
Polypodiaceae				
<i>Adiantum capillus-veneris</i>	14	12	2	ls
Graminae				
<i>Calamagrostis scopulorum</i>	10	7	1	1-ls
<i>Panicum acuminatum</i>	0	8		
<i>Bromus tectorum</i>	0	1	1	l
<i>Andropogon glomeratus</i>	0	6	2	l
<i>Muhlenbergia andina</i>	5	2	1	l
Orchidaceae				
<i>Epipactis gigantea</i>	7	9		
Ulmaceae				
<i>Celtis reticulata</i>	0	8		
Salicaceae				
<i>Salix ligulifolia</i>	0	2	2	ls
Primulaceae				
<i>Primula specuicola</i>	0	7	1	ls
Rosaceae				
<i>Petrophytum caespitosum</i>	6	10	2	l
Rhamnaceae				
<i>Rhamnus betulifolia</i>	0	11	2	ls
Anacardiaceae				
<i>Rhus aromatica</i>	0	7	1	1-ls
Oleaceae				
<i>Fraxinus anomala</i>	0	3		
Scrophulariaceae				
<i>Castilleja linariifolia</i>	0	7	1	l
Compositae				
<i>Cirsium rydbergii</i>	0	6	2	ls
			1	l
<i>Aster chilensis</i>	0	3	1	ls
<i>Solidago sparsiflora</i>	1	3	1	1-ls

Table 7j. Vascular plant species present in Baby (Ba), Baby Too (BT), Surprise (Su), and Ivy (Iv) hanging gardens, GLCA. Sites occupied is number of hanging gardens in which species was found.

Family species	Sites Occupied		Ba	BT	Su	Iv
	ZION	GLCA				
Polypodiaceae						
<i>Adiantum capillus-veneris</i>	14	12	x	x	x	x
Gramineae						
<i>Andropogon glomeratus</i>	0	6	x	x		x
<i>Calamagrostis scopulorum</i>	10	7		x		
<i>Panicum acuminatum</i>	1	8	x	x	x	x
<i>Panicum virgatum</i>	0	2	x			
Orchidaceae						
<i>Epipactis gigantea</i>	7	9	x			
Ranunculaceae						
<i>Clematis ligusticifolia</i>	2	1			x	
Ulmaceae						
<i>Celtis reticulata</i>	0	8	x		x	x
Primulaceae						
<i>Primula specuicola</i>	0	7		x		
Rosaceae						
<i>Petrophytum caespitosum</i>	6	10		x		x
Leguminosae						
<i>Cercis occidentalis</i>	0	4			x	
Rhamnaceae						
<i>Rhamnus betulifolia</i>	0	11	x	x	x	x
Vitaceae						
<i>Vitis arizonica</i>	2	3			x	
Anacardiceae						
<i>Rhus aromatica</i>	0	7	x		x	
<i>Toxicodendron rydbergii</i>	6	2			x	x
Scrophulariaceae						
<i>Castilleja linariifolia</i>	0	7		x		
Compositae						
<i>Artemisia dracunculus</i>	0	1	x			
<i>Artemisia ludoviciana</i>	2	1		x		
<i>Aster chilensis</i>		3	x	x		

Table 8. Sorensen's (1948) binary similarity coefficients for GLCA hanging garden vascular plant communities. U3 = Upper Three Garden, L3 = Lower Three Garden, Ze = Zephyr, Pd = Pedestal, Hw = Hardwood, Rs = Rattlesnake, Cb = Crossbed, BT = Baby Too, Ba = Baby, Su = Surprise, Iv = Ivy, Du = Dune, Gf = Graffiti.

[illegible]

Table 9. GLCA hanging garden vascular plant community similarity by the simplified Morisita - Horn coefficient (Horn 1966). See table 8 for hanging garden legend and table 7 for microhabitat legend.

[illegible]

Table 10. Frequency distribution of number of vascular plant species occupying up to 1 - 14 hanging gardens in ZION and 1 - 12 hanging gardens in GLCA.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ZION	31	10	5	2	1	2	2	2	0	2	1	1	0	1
GLCA	20	9	8	4	2	2	4	2	1	1	1	1		

Table 11. Floral visiting bee species on hanging garden vascular plants in ZION & GLCA in summer 1991. Species identification not complete on *Dialictus* and *Evyllaesus*. Hanging garden (HG) codes as in tables 4 & 7.

Family - species	N	Park	HG	Plant species or substrate
Apidae				
<i>Bombus morrisoni</i>	11	GLCA	Rs	<i>Cirsium rydbergii</i>
	4	GLCA	L3	<i>Cirsium rydbergii</i>
	1	GLCA	U3	general
<i>Bombus huntii</i>	5	ZION	Gr	<i>Aralia racemosa</i>
	2	ZION	Gr	<i>Dodecatheon pulchellum</i>
<i>Bombus centralis</i>	1	ZION	Gr	<i>Aralia racemosa</i>
	1	ZION	UB	general
<i>Bombus melanopygus</i>	4	ZION	Gr	<i>Dodecatheon pulchellum</i>
<i>Bombus occidentalis</i>	7	ZION	Gr	<i>Aralia racemosa</i>
	1	ZION	Gr	<i>Dodecatheon pulchellum</i>
	1	ZION	UB	<i>Aquilegia chrysantha</i>
	3	ZION	MF	<i>Mimulus cardinalis</i>
<i>Apis melanifera</i>	3	ZION	Gr	<i>Aralia racemosa</i>
Megachilidae				
<i>Ashmeadiella cactorua</i>	1	GLCA	Ze	near temporary pool
<i>Megachile lippae</i>	1	GLCA	Hw	<i>Thelypodium integrifolium</i>
<i>Megachile texana</i>	1	GLCA	Hw	<i>Thelypodium integrifolium</i>
Halictidae				
<i>Augochlorella pomoniella</i>	2	GLCA	Rs	<i>Cirsium rydbergii</i>
<i>Halictus tripartitus</i>	1	ZION	Gr	<i>Aralia racemosa</i>
<i>Dialictus</i> spp.	6	ZION		
<i>Evyllaesus</i> sp. 1	15	ZION		
<i>Evyllaesus</i> sp. 2	2	ZION		