

VEGETATION COMMUNITIES OF ZION
NATIONAL PARK

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Objectives

The overall objectives of this study are to (1) provide a map of the current vegetation of Zion National Park (ZNP), (2) provide a listing of all vascular plants known for the park, (3) list all rare, endangered, and exotic plant species growing within the park and describe the distribution and habitat preferences of each as fully as possible, (4) list representative locations for examples of undisturbed stands of each of the major vegetational types, and (5) present our basic field data to the park on computer disks with software programs that will permit employees to access data files easily and systematically. These objectives will be satisfied using field data collected in the growing seasons of 1987, 1988, and 1989 at 0.01 ha survey plots. Those plots were laid out at the intersections of a grid with intersections 1.6 km apart. Ideally, the samples should have been taken at all section corners using cadastral survey maps, but some remote areas in the park have not been surveyed. As a consequence, the Universal Transverse Mercator grid system is used as the reference system for describing plot locations. A total of slightly over 310 survey plots have been sampled in the park.

The survey plots have been sampled using a procedure developed by the Zurich-Montpellier School of Phytosociology. At each plot a worker recorded all species rooted in the plot and assigned a foliage cover value (projected crown) and a sociability value (a quantified estimate of the degree to which individuals of a species are aggregated in space) to each species. Total living cover of all species combined is recorded as is the proportional contribution of the various

plant life-form groups (i.e., trees, shrubs, graminoids, forbs, and nonvascular plants) to that total. Surface covered by plant litter, rock, or bare soil but not overtopped by living cover is also estimated at each plot. Each plot was marked at its center with a steel marker peg, photographed with color print film, and pin-pricked onto a low level, aerial photograph to provide a file record of the plot's exact location in the landscape. An aluminum tag is secured to each plot-center peg: the plot number, sampling date, and project name appears on that tag.

Environmental data recorded at each plot included elevation, slope aspect and steepness, geologic parent material, apparent history of the site (previously logged over, abusively grazed in the past, successional developmental stage, or previously burned), and current condition and trend of the vegetative cover. These data are all entered into a microcomputer file and software prepared by one of us (SCS) is available to permit one to print out the entire file on any given plot on command. The printed file for each plot is confined to a single page of systematically organized data.

Results

Vegetational Sampling. Our 1989 sampling season was spent in the Kolob section of ZNP where about 100 plots were inventoried. Soil samples were collected from several representative plots in each vegetational type from throughout the park. Finally, intensive work was done on the essential mineral content and basic metabolic rates of the major vascular plants of crevices in the Navajo Sandstone within ZNP. For comparative purposes, mineral content and metabolic results for rock crevice plants were contrasted with comparable values for species confined to sandy soils derived from Navajo Sandstone and deposited adjacent to the rock faces sampled for crevice plants. Data for this portion of the study were collected near checkerboard Mesa and near the east portal of the long tunnel on Highway 15 through ZNP.

We will briefly recap results for the rock crevice study here as an example of the general approach that will be taken in synthesis of data for each of the other vegetational types in the park. A total of 57 study plots are available for the rock crevice plant communities. Following the lead of Curtis (1959), we base our description of the community on prevalent species only. Curtis determined the average number of vascular species per survey plot. After arranging all species encountered in decreasing order of abundance in the full

sample, he counted down that list to a number equivalent to the average number of species per survey plot. Those species were designated as "prevalent species" and were indeed the most commonly encountered taxa in the community.

The rock crevice plant prevalents for this study are reported in Table 1. Twenty-two species are recognized including one tree, seven shrubs, four graminoids and ten forbs. The commonest species in the community is Cercocarpus intricatus, an evergreen shrub belonging to a genus known to fix nitrogen. Twelve of the species are evergreen, a characteristic that permits the species to reduce the frequency with which foliage and scarce essential mineral elements are replaced. Only one annual (Festuca octoflora) is listed among the prevalents.

Plants adapted for life on rock have significantly less of the essential elements N, P, K, Ca, and Mg in their foliage than occurs in leaves of plants adapted to soils derived from the same rock material (Table 2). In contrast to the five macroelements noted above, essential trace elements are usually more abundant in the foliage of rock plants than in plants of adjacent sandy soils (Table 2). Observed differences for trace elements in foliage of rock versus soil plants were statistically different only for iron.

Metabolic rates of plants adapted for life on rock or soil do not differ at 15C, but the rates for those two groups do differ significantly at 25C and 35C (Table 3). Thus at cooler temperature such as prevail when most of the plant growth occurs on rock faces, metabolic processes are not significantly impeded in plants adapted to rock crevices. Slower metabolic rates of rock plants at higher temperatures would slow the loss of respirable organic matter from tissue and leave a greater fraction of the total photosynthate supply available for growth of roots and above-ground parts. Such an adaptation would seem to be desirable for rock species which must be too stressed for water to experience net gains in carbon during most of the latter part of the growing season.

Conclusions

The rock crevice community is a highly distinctive assemblage of plants adapted for life in a harsh environment in which water and essential minerals are deficient and wind and high temperatures regularly acerbate evapotranspiration stress. Plants prevalent in this community are small, slow growing species that make metabolic ends meet by having low

Table 1. Prevalent vascular plant species for the rock crevice plant community on Navajo Sandstone, Zion National Park, Utah. Species are arranged in decreasing order of frequency of occurrence in 57 study plots. Nomenclature follows Welsh et al. (1987).

Prevalent Species	Common Name	Percentage Occurrence ¹	Percentage Frequency Crevices ²
<u>Cercocarpus intricatus</u>	(dwarf Mt. Mahogany)	100	22.0
<u>Poa fendleriana</u>	(muttongrass)	82	10.3
<u>Castilleja scabrida</u>	(Eastwood paintbrush)	82	1.3
<u>Arenaria fendleri</u>	(Fendler sandwort)	77	3.2
<u>Heterotheca villosa</u>	(hairy goldenaster)	71	21.0
<u>Pinus ponderosa</u>	(ponderosa pine)	71	3.5
<u>Arctostaphylos patula</u>	(greenleaf manzanita)	59	0.8
<u>Carex rossii</u>	(Ross sedge)	59	1.3
<u>Solidago sparsiflora</u>	(alcove goldenrod)	53	8.7
<u>Opuntia macrorhiza</u>	(plains pricklypear)	53	1.0
<u>Penstemon laevis</u>	(smooth penstemon)	53	2.8
<u>Stephanomeria tenuifolia</u>	(slender wirelettuce)	47	3.2
<u>Holodiscus dumosus</u>	(mt. oceanspray)	41	3.3
<u>Petrophytum caespitosum</u>	(rock spiraea)	41	13.8
<u>Muhlenbergia pauciflora</u>	(New Mexican muhly)	41	9.7
<u>Cryptantha confertiflora</u>	(golden cryptanth)	41	0.2
<u>Ivesia sabulosa</u>	(Sevier Ivesia)	41	9.5
<u>Penstemon humilis</u>	(low penstemon)	41	2.8
<u>Senecio multilobatus</u>	(Uinta groundsel)	41	0.8
<u>Amelanchier utahensis</u>	(Utah serviceberry)	35	4.0
<u>Arenaria macradenia</u>	(shrubby sandwort)	35	1.7
<u>Festuca octoflora</u>	(sixweeks fescue)	35	5.3

¹ % occurrence in 0.01 ha survey plots

² % frequency in 600 random lengths (each 1.0 m long) of rock crevice

Table 2. Foliage tissue content of selected essential elements for rock crevice prevalent species and species common on deep sandy soils derived from and adjacent to the rock faces sampled for crevice plants. Six species and 13 separate analyses are considered for crevice plants. Eight species and 20 analyses are included for soil plants. Analyses are based on foliage tissue only collected on 15 June 1989.

Element	Rock Faces	Adjacent Soils	Significance of Difference
Nitrogen (%)	1.483±0.188	1.674±0.482	p<.01
Phosphorus (%)	0.110±0.027	0.175±0.111	p<.05
Potassium (%)	0.825±0.429	1.143±0.500	p<.001
Calcium (%)	0.840±0.528	1.085±0.494	p<.001
Magnesium (%)	0.150±0.065	0.277±0.126	p<.01
Iron (ppm)	265.9±158.1	163.0±67.8	p<.05
Copper (ppm)	41.7±60.1	12.4±5.8	NS ¹
Manganese (ppm)	82.2±63.6	51.1±40.1	NS
Zinc (ppm)	30.8±18.6	47.8±33.5	NS

¹ not significant

Table 3. Average respiration rates of current year foliage tissue at three different temperatures. Tissue for analysis was collected on 15 June 1989. Stem tips of species sampled were transported with the stem base immersed in distilled ice water in a dark, humid chamber. Analyses were run the following day in microcalorimeters in the laboratory of Dr. Lee Hansen, Department of Chemistry, Brigham Young University. Six species and 16 separate samples were analyzed from rock faces. Seven species and 20 separate samples were analyzed from adjacent soils. Mean values are followed by their standard deviation.

Temperature	Rock Faces	Adjacent Soils	Significance of Differences
15C	1.44±1.06	1.65±0.64	NS
25C	3.18±2.20	3.78±1.59	p<.01
35C	5.37±3.37	6.54±2.53	p<.01

requirements for the essential macroelements and lower than normal metabolic rates at elevated temperatures. Most of the individuals are further specialized by being evergreen, an adaptation that has value for both the photosynthetic process and efficient use of deficient essential macronutrients on habitats such as that considered here.

Literature Cited

Curtis, J. T. 1959. The vegetation of Wisconsin. University of Wisconsin Press, Madison

Welsh, S. L., N. D. Atwood, L. C. Higgins, and S. Goodrich. 1987. A Utah flora. Great Basin Naturalist Memoir, No. 9. 894 pp.