

# Floristic Habitats of the White Mountains, California and Nevada: A Local Approach to Plant Communities

JAMES D. MOREFIELD  
Rancho Santa Ana Botanic Garden  
Claremont, California 91711-3101

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## Abstract

An effort is underway to classify each of the nearly 1,100 vascular plant taxa now known to occur in the White Mountains under a system of descriptive, semi-qualitative habitat-controlling factors readily observed in the field (examples: altitude, moisture availability, soil/parent-rock chemistry). Factors used are those that collectively appear necessary and nominally sufficient to predict taxon occurrence based upon the bulk of accumulated field observations. The data are maintained on a computer database for ease of updating and manipulation. Multi-variate analysis of this system of plant-habitat correlations will provide a basis for hypotheses of vegetation/habitat structure (if any) in the White Mountains, which then can be subjected to more detailed quantitative field testing. Any consistently recognizable plant "communities" to be revealed by such analysis are likely to be based upon several environmentally restricted "definitive" taxa, rather than upon their associated dominant "characteristic" taxa, the latter of which commonly recur over much broader environmental limits. A preliminary hypothesis of community structure in the White Mountains is presented. Below the Alpine Zone, the four strongest habitat controls appear to be (in descending order of importance): moisture availability, substrate chemistry, altitude-related factors, and substrate texture.

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## Introduction

Renewed field and herbarium work on the flora of the White Mountains of eastern California and western Nevada [Taylor and DeDecker, 1982; Morefield *et al.*, 1983, 1986, 1987a,b] has generated much new information on the occurrence and distribution of vascular plants since the work of Lloyd and Mitchell [1973]. This includes numerous observations on the correlation (or lack thereof) of individual plant taxa with the apparent environmental conditions of their respective habitats throughout the White Mountains. Two taxa can have simi-

lar or very different nominal habitat requirements, their tolerance of environmental variability can be very narrow or very broad, and different environmental factors can vary (commonly widely so) in importance in controlling the distribution of a given taxon. These environmental factors commonly are readily observed in the field on a qualitative basis without immediate need for detailed quantitative measurement. For example *Petrophytum caespitosum* (Nuttall) Rydberg is almost always limited to barren dolomite outcrops at elevations from 6,000 to 10,000 feet (1,830 to 3,050 m) in the White Mountains.

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Bristlecone Pine (*Pinus longaeva* D. K. Bailey) and several other taxa [Wright and Mooney, 1965; Mooney, 1966] are known to occur in a similarly predictable fashion.

This paper reports the beginning and prospects of an experiment to record information on the apparent environmental controlling factors of each vascular plant taxon in the White Mountains in a systematic way--along with qualitative assessments of frequency, density, and abundance, and data on geographic distribution, life form, and reproductive season--and to make this information available for preliminary analysis until more quantitative information on vegetation and habitat is available for this region. In many cases such preliminary analysis may suggest the direction for further measurement to proceed. The database will be updated as field work continues, and new information provided by other investigators will be welcomed. In general, its data represent a systematized version of the incomplete and anecdotal notes on plant occurrence found in most other floristic treatments.

When completed, the habitat data will provide a concise and qualitatively accurate description of a multidimensional "niche" for each taxon. By performing multivariate analyses of this plant-habitat correlation data in the White Mountain floristic database (WMFD), I hope to begin addressing two questions of long standing: do relatively distinct and predictable floristic assemblages (plant communities) exist, at least in the White Mountains; and, if so, what are their contents and limits. If vegetation patterns are determined largely by several environmental factors acting at least partially independently of one another, such

analyses should provide a direct route to preliminary hypotheses (either positive or negative) bearing on these questions. Initial computer sorts of the WMFD have provided some positive evidence for plant communities in the White Mountains, and the remainder of this paper will address this approach to White Mountain plant communities. It should first be pointed out, though, that this is only one of numerous potentially informative analyses that could be performed using the WMFD once it is complete.

### **Previous Local Vegetation Work**

The only previous attempt to treat the entire diversity of vegetation in the White Mountains was that of Mooney [1973], who recognized four broad zones (Desert Scrub, Pinyon Woodland, Subalpine Forest, and Alpine Tundra). There was little further attempt formally to subdivide these vegetation zones; only limited quantitative plot and transect data were (and remain) available. Most taxa examined in the present study appear to encounter their distribution limits at or near some of the boundaries of Mooney's zones (though frequently spanning two or more such zones), and with some modification these zones should remain excellent broad predictors of vegetation and of individual taxa.

Broader regional classifications such as those of Beatley [1976], Thorne [1982], and Holland [1986], though generally useful, are somewhat less helpful in understanding local White Mountain vegetation. Thorne [1982] apparently has spent the most time in the White Mountains and provides the most accurate picture of the floristic composition of vegetation occurring there. Much of the

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White Mountain vegetation, however, still fits poorly into any existing classification. I believe that this is because the plant communities of these workers, in the absence of clearly predominant habitat controls, typically are defined by the presence of certain abundant and dominant taxa whose ranges commonly extend far beyond the communities they define. Holland's [1986] work defines nearly every combination of dominant taxa in California as a community.

Dominant taxa quite probably are dominant and widespread because their environmental tolerances are exceptionally flexible. The presence or absence of such a eurytopic taxon seems *a priori* a poor criterion for defining a repeatably recognizable vegetation unit, if the latter is to have any meaning beyond the unique distribution limit of the defining taxon itself. A dominant taxon is by definition important in any of the several communities in which it may occur, and its presence should always be noted, but it is important in terms of biomass and physical structure and not necessarily as a tool for defining natural units of vegetation. With respect to the vegetation in which they occur, such taxa will be termed "characteristic taxa" for the remainder of this paper. This will be in contrast to "definitive taxa," which are perhaps less apparent to our senses, but are more useful for predicting the boundaries of repeatably recognizable units of vegetation.

As an illustration, the Desert Scrub of Mooney [1973] appears to correspond most closely in floristic composition to the Blackbrush Scrub of Thorne [1982] and many previous workers--minus the Blackbrush (*Coelogyne ramosissima* Torrey) and several other characteristic associates.

This formation is everywhere typified by a great diversity of shrubby taxa between the *Larrea* and *Artemisia* zones, Blackbrush among them, each of which can become locally dominant. In the White Mountains, *Menodora spinescens* A. Gray appears to be the ecologic and physiognomic counterpart of Blackbrush, but numerous other shrubby taxa are usually present there.

Analysis of the WMFD may reveal a set of definitive taxa whose limits correlate closely among themselves and together correspond more closely to the boundaries of Mooney's [1973] Desert Scrub than do the limits of any individual shrubby taxa previously used in combination to recognize this formation. In this case the same formation could be recognized as a plant community defined by the presence of the definitive taxa and characterized additionally by the several shrubby co-dominants and other associated taxa. Alternatively, the same analysis might suggest a still better-defined community (meaning more correlated taxa) with different limits, or it might find no significant correlation at all among the environmental limits of different plant taxa.

### Methods

The entire White Mountain flora of nearly 1,100 vascular taxa [Lloyd and Mitchell, 1973; Taylor and DeDecker, 1982; Morefield *et al.*, 1983, 1986, and 1987a,b] has been entered into a computer database (dBASE III) with fields available for assigning coded habitat controls. In order to make general but precise predictive statements regarding the distribution of White Mountain taxa, a finite number of controlling factors (primary among which were moisture availability, substrate chemistry, ele-

**Table 1**  
Qualitative habitat-controlling factors used to  
classify the White Mountain flora.

Symbol	Habitat Controls
MO	MOISTURE SUPPLY
E	CLIMATIC REGIME: Elevation-temperature-rainfall gradient
TX	SUBSTRATE TEXTURE
C	SUBSTRATE CHEMISTRY
H	SOIL COHESION
S	SLOPE
A	ALBEDO of substrate/surroundings
X	EXPOSURE
O	SOCIABILITY relative to other proximal taxa
SP	ADDITIONAL HABITAT SPECIALIZATIONS
F	FIDELITY to other habitat controls

vation-temperature-precipitation gradient, and soil texture--see Table 1) and conditions (examples respectively: saturated soil, carbonate rock, Subalpine Zone, sod) were found necessary and sufficient for the great majority of White Mountain taxa. Each of these conditions was assigned a numeric code for entry into the WMFD with each appropriate taxon. If the condition of a given habitat factor for a given taxon matched one already assigned to another taxon, the same code was used; otherwise, additional categories and codes were defined until all the taxa were accommodated.

Habitat data for White Mountain taxa are derived from direct field observation whenever possible. Data are also taken from Lloyd and Mitchell [1973] and other published sources, herbarium sheets, etc., when considered reliable. The number of data "samples" varies among taxa and thus so does the quality of the information in the WMFD. The primary purpose is to reflect current knowl-

edge of each taxon, however scanty or complete. Quality will improve with further field work. In some cases the data for taxa rare in the White Mountains were augmented from closely adjacent areas. The appendix to this paper gives the habitat factors and conditions currently in use. The actual assignments for each taxon and recognized taxon names are given in the working floristic checklist elsewhere in this symposium volume. Some habitat factors have yet to be assigned for all taxa, and some categories may be changed or added as field observations provide new insight. Computerized storage of these data make changes relatively easy.

No attempt is made here to define the habitat categories in any rigorous way. The categories used are entirely dependent on the observed requirements of the plant taxa, and more rigorous definitions must await the completion of field work. The descriptive terms used in the appendix are intended to provide a sufficient basis for interpretation.

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Nearly all controlling factors have been provided with a condition called "indeterminate," used where the range of the taxon is too broad to be described reasonably by any single condition, where the factor is not applicable (as in the case of "soil cohesion" for aquatic taxa), or where the condition is unknown for that taxon. In addition, certain conditions within each factor are provided with various hierarchic levels depending on the inclusiveness of a plant's requirements. A field for "additional habitat specializations" is provided for taxa whose occurrence could not be described adequately among the other factors. Parasitic taxa are described as having the habitat requirements of their host taxa, unless specifically observed to be different.

Assignment of habitat data to each taxon is nominal, intended to reflect the predominant tendencies of a taxon when such are apparent, and not intended to include every single observation. Nearly every taxon is occasionally found in an unusual habitat situation relative to its norm, and no concise systematic treatment could cover all such exceptions. Examples of highly predictable taxa were given earlier. An example of the opposite extreme would be *Castilleja linariaefolia* Bentham, which occurs in the White Mountains (1) on open slopes and swales in the subalpine on chemically diverse substrata, and (2) in silty, moist, alkaline soil about desert springs. (The possibility that two cryptic taxa are involved should be considered.) Other relatively ubiquitous taxa in the White Mountains include *Artemisia tridentata* Nuttall, *A. dracunculus* Linnaeus, *Sitanion hystrix* (Nuttall) J. G. Smith, and *Juncus balticus* Willdenow. In order to provide for this dimension of variation among taxa, a category called

"fidelity" is included in the WMFD. It contains a relative assessment of a taxon's degree of adherence to the habitat correlations assigned, however broad or narrow.

In addition to habitat factors, other fields have been assigned to facilitate analysis of the White Mountain flora. These accommodate qualitative observations on the frequency, density, and abundance of each taxon, geographic restriction within the White Mountains, floristic center of distribution, life form, and reproductive season (see Table 2 and appendix). These data will permit, for example, further analysis of the ecologic and geographic derivation of the White Mountain flora and of the ecogeographic tendencies of specific taxonomic groups or vegetation associations seen there.

Simple sorting and selective extraction of data currently in the WMFD has provided preliminary insight into the possible existence of distinct floristic habitats in the White Mountains, discussed further below. Once the data become relatively stable and complete, the next step will be to perform multivariate analyses of the primary plant-habitat correlation data. Any resulting secondary correlations among taxa will suggest repeatably recognizable plant communities for more detailed quantitative testing.

### **Discussion of Methods**

Multivariate analysis of the WMFD will group taxa sharing the most similar sets of habitat correlations and will separate such groups collectively from each other in a hierarchic system of decreasing group similarities. The most strongly supported natural community will consist of a group of plant taxa that meets the

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**Table 2**  
Summary of non-habitat data available from the  
White Mountain flora database

Symbol	Distribution Controls
Q	FREQUENCY of presence in habitat
D	DOMINANCE/DENSITY within habitat
U	UBIQUITY of habitat in region (percent cover)
G	GEOGRAPHIC RESTRICTION in region
FL	FLORISTIC CENTER OF DISTRIBUTION
<b>Lifeform Controls</b>	
LF	LIFEFORM
N	SEASON of reproductive activity
<b>Miscellaneous Data</b>	
L	FLORISTIC LIST of first report

following criteria: (1) the number of included definitive taxa (with coincident or nearly coincident environmental limits as encoded in the database) will be relatively high in proportion to the number of characteristic taxa that co-occur in nature with the definitive taxa, (2) the habitat similarity between the two least-related taxa in the group will be high relative to the similarity between the group as a whole and the next group most closely related to it, and (3) the group will represent a plant association (or part thereof) that occurs repeatedly in nature as a relatively distinct unit or set of units. This latter criterion must be tested by quantitative field measurements. It is my prediction (not yet tested) that communities that are most strongly supported by the first two criteria above will also be those most easily and repeatably recognized in the field.

No attempt is made here to define the exact proportion of definitive to characteristic taxa that should

be called a community. There is probably continuous variation between these extremes in any given flora, and the first criterion above will likely have to be applied on a relative basis to each region considered.

If hypotheses of vegetation structure derived from multivariate analysis of the WMFD and similar data sets are supported by subsequent, more detailed quantitative field and analytic work, this method might then be used with some confidence to classify vegetation of any given area once its flora and the nominal habitat requirements of the taxa therein are known. (Though environmental limits are most apparent in relatively severe regions such as the White Mountains, limits of taxa in more mesic situations probably can be discerned with careful field observation.) Vegetation units of local areas might be linked on the basis of habitat requirements to form more broadly applicable classifications, even though the plant taxa correlated with these ha-

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bitats might change with geographic position. This would be analogous to a simple geologic example where a single contiguous rock formation might vary laterally as several different lithologic facies. Several "floristic facies" might comprise a single extensive plant community.

Quantitative field tests should employ phytosociologic methods similar to those used in Braun-Blanquet's [1964] work, now in wide use among European workers. See Koenigs *et al.* [1982] or Haase [1987] for modern application of phytosociologic methods to North American vegetation. Such directly empirical, descriptive methods perform multivariate analysis on quantitative vegetation plot/transect data (rélévés) and provide perhaps the most accurate picture of a given local vegetation. It might thus be argued that the method I am suggesting is needlessly indirect in its predictive approach to vegetation, an argument that would have support should the result of the two different methods not correspond closely. Preliminary analysis suggests that the results will correspond closely (see below). The predictive approach will then permit broader and more rapid assessments of vegetation structure based directly on plant-habitat interrelations. These relationships are the roots of all natural vegetation patterns and are addressed only incidentally by present descriptive approaches.

Several attributes inherent in the WMFD data will have to be compensated for, or at least recognized, before the results of multivariate analysis can be interpreted correctly. The data are qualitative and therefore discontinuous. Multivariate analysis thus will always reveal distinct groups of taxa, even if all possible

combinations of the data are present. The meaning of these groups will have to be assessed using other criteria already discussed. Not all of the habitat categories are independent of one another. A slope condition of "2. flat (0-2°)" will commonly accompany a moisture condition of "46. poorly drained flats and ephemeral pools." Such dependent correlations can be compensated in some algorithms [Sneath and Sokal, 1973]. Finally, it was already mentioned that there are always unaccounted exceptions when taxa are classified using a finite set of habitat categories. Plants do not obey strict laws of distribution, exhibiting at best only patterns and trends. Classification of vegetation will thus remain imprecise and partially subjective regardless of the methods employed, and all results must be interpreted with this in mind.

### **Preliminary Results and Discussion**

The process of working with the data in the WMFD, including the extraction of lists of taxa based upon certain specified combinations of habitat controls, has provided some preliminary insight into the predictive potential of the data, possible natural plant communities, and the relative importance of various habitat controls in the White Mountains. As might be expected in an arid region, the single strongest habitat control for the White Mountain flora appears to be moisture availability, and it seems likely that major vegetation units will be divided along such lines (Fig. 1). Thus, the "azonal" riparian or wetland communities of other workers will be set off as a primary group from the dryland communities.

Within the dryland vegetation, and especially at lower elevations in

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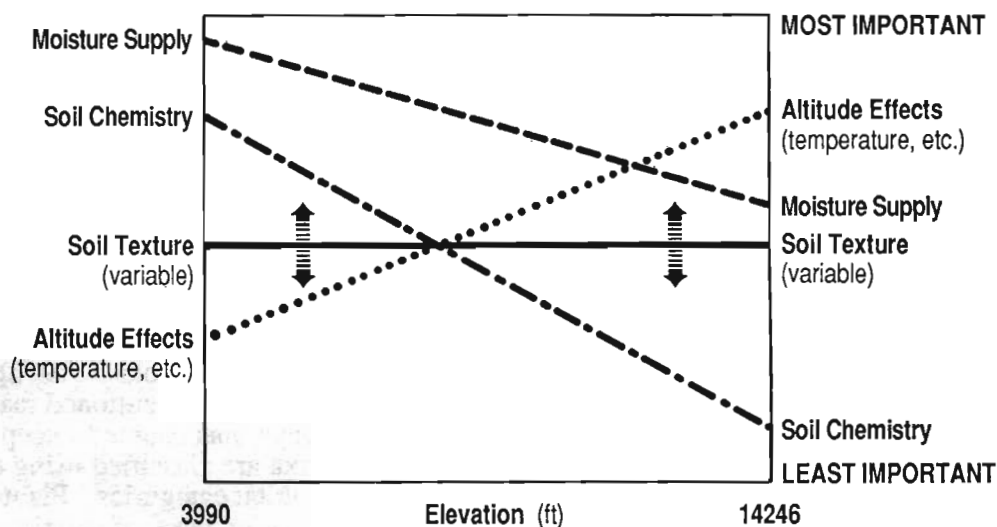


Figure 1. Schematic diagram of the apparent relative importance of four primary floristic habitat controls along the altitude gradient in the White Mountains of California and Nevada.

the White Mountains, substrate chemistry appears to be the second strongest controlling factor. Dryland taxa restricted to carbonate outcrops or soils appear to form a second "azonal" series cutting across typical elevational limits, as do those restricted to granite crevices. However, this chemical effect appears to decrease in importance with increasing altitude (see Fig. 1). Though the alpine "dolomite barrens" described by Mooney [1973] are visually distinctive, the majority of taxa occurring thereon also occur on non-calcareous substrata with equal frequency; there are relatively few taxa restricted to, and thereby definitive of, the dolomite barrens (see Table 3).

Almost by definition, the next most important factors outside the azonal divisions appear to be altitude-related, followed closely by substrate texture. Within the chemically azonal vegetation just mentioned, the effects of altitude-related factors and sub-

strate texture appear to dominate increasingly at higher altitudes, as opposed to the hydrologically azonal vegetation where such effects do not appear to vary significantly with altitude. The effects of substrate texture (particle size and associated cohesion) appear variable and of uncertain overall importance at present and require further analysis. At highest altitudes the combined effects of altitude-related factors themselves appear to dominate all other habitat controls, and a primary alpine vegetation zone is recognized easily. Relatively few taxa span the entire subalpine-alpine gradient.

Tables 3-9 list taxa extracted from the database based upon different combinations of habitat restrictions. These lists resemble closely actual plant associations commonly encountered in the field. They correspond closely with much of my own field experience and notes though in originally entering the data, I con-

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sidered each taxon individually without regard to its association with other taxa. The use of standardized habitat controls as floristic data is clearly of predictive value, at least in a limited region.

### Acknowledgements

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**Tables 3 and 4.** Elements of two alpine habitats in the White Mountains. Lists contain some taxa present in, but not definitive of, the habitats. Refer to appendix for habitat control codes.

**Table 3**  
Database extraction for Alpine Dolomite Barrens Habitat

MO	E	C	TX	SP	TAXON
50	7	5	20	02	<i>ARENARIA kingii</i> ssp. <i>compacta</i>
60	7	5	11	02	<i>ERIOGONUM gracilipes</i>
50	7	5	20	02	<i>DRABA oligosperma</i>
50	7	5	30	02	<i>POTENTILLA drummondii</i> ssp. <i>bruceae</i>
50	7	3	32	00	<i>ASTRAGALUS kentrophyta</i> var. <i>implexus</i>
50	7	4	30	02	<i>OXYTROPIS parryi</i>
50	8	3	30	00	<i>LINUM lewesii</i> var. <i>alpicola</i>
50	7	5	32	02	<i>CASTILLEJA nana</i>
50	8	5	30	02	<i>ERIGERON pygmaeus</i>
50	8	3	32	00	<i>TOWNSENDIA condensata</i>

**Table 4**  
Database extraction of High-alpine Habitat

MO	E	C	TX	SP	TAXON
31	9	7	22	00	<i>CERASTIUM beeringianum</i>
50	9	7	10	08	<i>ANELSONIA eurycarpa</i>
50	9	7	10	00	<i>POLEMONIUM viscosum</i> ssp. <i>chartaceum</i>
50	9	7	31	08	<i>ERIGERON vagus</i>
50	9	7	21	00	<i>POA lettermannii</i>
44	9	7	20	00	<i>POA suksdorfii</i>
44	9	7	10	00	<i>AGROPYRON scribneri</i>

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Table 5

Elements of the azonal rupicolous calcicole habitat extracted from the White Mountain flora database. Some taxa listed are present in, but not definitive of, the habitat. Refer to appendix for habitat control codes.

MO	E	C	TX	SP	TAXON
44	2	3	13	00	<i>CHEILANTHES parryi</i>
44	2	3	13	00	<i>ARGYROCHOSMA jonesii</i>
50	2	4	10	02	<i>ARENARIA macradenia</i> ssp. <i>macradenia</i> var. <i>parishii</i>
50	2	3	13	00	<i>ERIOGONUM heermannii</i> var. <i>argense</i>
50	2	5	50	02	<i>ERIOGONUM kearneyi</i> var. <i>monoense</i>
60	2	3	12	00	<i>ERIOGONUM shockleyi</i>
50	3	3	13	00	<i>GLOSSOPETALON nevadense</i>
50	3	3	13	00	<i>GLOSSOPETALON stipuliferum</i> (?)
40	2	3	30	00	<i>MENTZELIA oreophila</i>
44	2	4	10	02	<i>PETALONYX nitidus</i>
60	5	5	32	02	<i>LESQUERELLA kingii</i> var. <i>kingii</i>
44	3	3	10	00	<i>RIBES velutinum</i> var. <i>gooddingii</i>
50	4	3	10	00	<i>CERCOCARPUS intricatus</i>
50	4	3	12	00	<i>PETROPHYTUM caespitosum</i>
44	3	3	10	00	<i>PURSHIA stansburiana</i>
50	2	4	10	02	<i>ASTRAGALUS coccineus</i>
40	2	3	10	00	<i>CAMISSONIA walkeri</i> ssp. <i>tortilis</i>
50	5	3	10	06	<i>OENOTHERA caespitosa</i> var. <i>crinita</i>
50	5	5	30	03	<i>LINUM lewisii</i> var. <i>lewisii</i>
50	3	4	10	02	<i>CYMOPTERUS aboriginum</i>
50	5	7	32	03	<i>IPOMOPSIS congesta</i> ssp. <i>montana</i>
44	1	5	10	03	<i>EUCRYPTA chrysanthemifolia</i> var. <i>bipinnatifida</i>
44	4	4	10	02	<i>PHACELIA peirsoniana</i>
44	2	3	13	00	<i>PHACELIA perityloides</i>
44	2	4	10	02	<i>PHACELIA rotundifolia</i>
44	2	5	32	02	<i>CRYPTANTHA barbigerata</i>
50	3	5	10	02	<i>CRYPTANTHA confertiflora</i>
50	1	3	11	00	<i>CRYPTANTHA decipiens</i>
50	5	5	30	03	<i>CRYPTANTHA flavoculata</i>
44	2	3	13	00	<i>CRYPTANTHA racemosa</i>
50	4	4	32	02	<i>CRYPTANTHA virginensis</i>
50	1	3	11	00	<i>PECTOCARYA recurvata</i>
44	2	5	30	02	<i>ANTIRRHINUM kingii</i>
50	5	3	30	00	<i>PENSTEMON scapooides</i>
60	2	3	10	00	<i>ENCELIOPSIS nudicaulis</i> var. <i>nudicaulis</i>
44	3	4	10	02	<i>PERITYLE megalcephala</i> var. <i>megalcephala</i>
44	2	3	13	00	<i>PERITYLE megalcephala</i> var. <i>oligophylla</i>
50	3	4	10	02	<i>ARTEMISIA nova</i>
40	2	4	10	02	<i>SENECIO douglasii</i> var. <i>monoensis</i>
50	2	4	10	02	<i>CHRYSOTHAMNUS nauseosus</i> ssp. <i>leiospermus</i>
50	5	3	31	00	<i>CHRYSOTHAMNUS parryi</i> var. <i>asper</i>
50	4	3	30	00	<i>ERIGERON argentatus</i>
60	4	3	50	00	<i>ERIGERON compactus</i>
44	4	5	10	02	<i>LEUCELENE ericoides</i>
50	4	5	31	02	<i>TOWNSENDIA scapigera</i>
44	2	4	10	02	<i>ARISTIDA purpurea</i> var. <i>glauca</i>

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Tables 6 and 7. Two phases of the azonal granitic rupicole habitat in the White Mountains. Lists contain some taxa present in, but not definitive of, the habitats. Refer to appendix for habitat control codes.

**Table 6**  
Database extraction for Subalpine Granitic Rupicolous Habitat

MO	E	C	TX	SP	TAXON
44	7	8	10	04	<i>SELAGINELLA watsonii</i>
44	6	8	10	00	<i>PELLAEA breweri</i>
50	6	5	00	04	<i>PINUS flexilis</i>
50	5	5	10	04	<i>EPHEDRA viridis</i>
50	6	8	10	00	<i>ARABIS drummondii</i>
44	6	8	13	00	<i>JAMESIA americana</i> var. <i>californica</i>
50	5	7	10	04	<i>RIBES cereum</i>
44	5	8	13	04	<i>HEUCHERA rubescens</i> var. <i>pachypoda</i>
41	5	5	10	04	<i>ACER glabrum</i> var. <i>diffusum</i>
50	5	5	10	04	<i>LEPTODACTYLON pungens</i> var. <i>hallii</i>
50	7	7	10	04	<i>LEPTODACTYLON pungens</i> var. <i>pungens</i>
44	5	0	10	04	<i>SCROPHULARIA desertorum</i>
44	7	8	10	04	<i>GALIUM multiflorum</i> var. <i>subalpinum</i>
44	6	8	10	04	<i>SPHAEROMERIA cana</i>
44	6	8	13	04	<i>ERIGERON tener</i>
44	7	8	13	00	<i>HAPLOPAPPUS eximius</i> ssp. <i>peirsonii</i>
44	6	8	13	00	<i>HIERACIUM horridum</i>
44	6	8	13	00	<i>CAREX occidentalis</i>
44	6	7	10	04	<i>CALAMAGROSTIS purpurascens</i>
44	6	8	13	04	<i>ORYZOPSIS micrantha</i>

**Table 7**  
Database extraction for Lowland Granitic Rupicolous Habitat

MO	E	C	TX	SP	TAXON
50	5	5	10	04	<i>EPHEDRA viridis</i>
50	2	8	10	04	<i>ECHINOCEREUS triglochidiatus</i> var. <i>mohavensis</i>
50	4	8	10	04	<i>ERIOGONUM saxatile</i> (?)
44	3	5	13	04	<i>HALIMOLOBOS diffusa</i> var. <i>jaegeri</i>
50	4	6	10	07	<i>PHILADELPHUS microphyllus</i> ssp. <i>stramineus</i>
50	5	7	10	04	<i>RIBES cereum</i>
44	3	5	10	04	<i>RIBES velutinum</i> var. <i>glanduliferum</i>
44	5	8	13	04	<i>HEUCHERA rubescens</i>
44	3	8	13	04	<i>POTENTILLA saxosa</i> ssp. <i>sierrae</i>
50	2	8	10	00	<i>PURSHIA tridentata</i> var. <i>glandulosa</i>
41	5	5	10	04	<i>ACER glabrum</i> var. <i>diffusum</i>
44	3	5	10	04	<i>CYMOPTERUS petraeus</i>
44	2	8	13	00	<i>NICOTIANA trigonophylla</i>
50	5	5	10	04	<i>LEPTODACTYLON pungens</i> var. <i>hallii</i>
44	5	0	10	04	<i>SCROPHULARIA desertorum</i>
50	2	8	13	04	<i>GALIUM mathewsii</i>
44	3	5	10	04	<i>ERIGERON breweri</i> var. <i>porphyreticus</i>
44	3	8	13	04	<i>HAPLOPAPPUS cuneatus</i> var. <i>cuneatus</i>
44	3	8	10	00	<i>BRICKELLIA californica</i>
44	3	8	13	04	<i>POA fendleriana</i>
50	2	7	10	04	<i>MUHLENBERGIA porteri</i>

James D. Morefield

Tables 8 and 9. Elements of two desert scrub phases in the White Mountains. Lists contain only definitive taxa, except for *Sitanion hystrix*. Taxa excluded occurred beyond the bounds of the habitat (upper only). Refer to appendix for habitat control codes.

Table 8  
Database extraction for Desert Alluvial Mixed Shrubland

MO	E	C	TX	SP	TAXON
50	2	5	20	08	<i>EPHEDRA nevadensis</i> var. <i>nevadensis</i>
50	2	4	21	08	<i>MIRABILIS bigelovii</i> var. <i>aspera</i>
50	2	4	21	08	<i>MIRABILIS bigelovii</i> var. <i>bigelovii</i>
50	2	4	21	08	<i>MIRABILIS bigelovii</i> var. <i>retrorsa</i>
50	2	5	40	00	<i>OPUNTIA basilaris</i> var. <i>basilaris</i>
50	2	5	40	04	<i>OPUNTIA echinocarpa</i> var. <i>echinocarpa</i>
50	2	5	20	00	<i>ATRIPLEX canescens</i>
50	2	0	21	08	<i>ATRIPLEX confertifolia</i>
50	2	5	42	04	<i>ARABIS glaucovalvula</i>
50	2	5	20	04	<i>PSOROTHAMNUS arborescens</i> var. <i>minutifolius</i>
50	2	5	42	09	<i>PSOROTHAMNUS polydenius</i> var. <i>polydenius</i>
50	2	5	20	00	<i>LYCIUM andersonii</i>
50	2	5	21	14	<i>MENODORA spinescens</i>
50	2	4	22	00	<i>PENSTEMON monoensis</i>
50	2	5	22	00	<i>AMBROSIA dumosa</i>
50	2	5	40	00	<i>ARTEMISIA spinescens</i>
50	2	5	40	00	<i>TETRADYMIA axillaris</i>
50	2	5	22	04	<i>TETRADYMIA glabrata</i>
50	2	4	21	00	<i>ACAMPTOPAPPUS shockleyi</i>
50	2	5	40	04	<i>HAPLOPAPPUS cooperi</i>
50	2	4	21	00	<i>XYLORHIZA tortifolia</i>
50	0	5	20	00	<i>SITANION hystrix</i> var. <i>brevifolium</i>
50	2	5	42	00	<i>BLEPHARIDACHNE kingii</i>
50	2	4	42	00	<i>ERIONEURON pulchellum</i>

Table 9  
Database extraction for Nevadan phase of Desert Alluvial Mixed Shrubland

MO	E	C	TX	SP	TAXON
50	2	5	52	00	<i>KOCHIA americana</i>
50	2	8	42	00	<i>SARCOBATUS baileyi</i>
50	2	5	50	02	<i>ERIOGONUM kearneyi</i> var. <i>monoense</i>
50	2	7	20	00	<i>LYCIUM shockleyi</i>

## Floristic Habitats of the White Mountains

### Plant Communities in the White Mountains: A Preliminary Hypothesis

A preliminary classification of White Mountain vegetation, based upon presently accumulated data and experience, is presented below. Both definitive and characteristic taxa are listed, but none of the listings is intended to be exhaustive of either.

**HIGH-ALPINE** - *Cerastium beeringianum*, *Anelsonia eurycarpa*, *Polemonium viscosum*, *Erigeron vagus*, *Poa suksdorfii*, *Agropyron scribneri*.

#### **ALPINE**

AQUATIC - *Callitriche palustris*.

MEADOW - *Antennaria alpina*, *Ivesia lycopodioides*, *Carex subnigricans*, *Arenaria rossii*, *Lewisia pygmaea*.

FELLFIELD TUNDRA - *Ivesia shockleyi*, *Phlox pulvinata*, *Erigeron pygmaeus*, *Androsace septentrionalis*, *Draba oligosperma*, *Castilleja nana*, *Eriogonum ovalifolium* var. *nivale*, *Trifolium andersonii* ssp. *monoense*, *Potentilla drummondii*, *Carex* spp., *Poa rupicola*.

RUPICOLOUS/TALUS - *Hulsea algida*, *Ranunculus eschscholzii*, *Oxyria digyna*, *Silene sargentii*, *Ribes cereum*

PSAMMOPHYTIC ANNUALS - *Gymnosteris parvula*, *Mimulus suksdorfii*, *Cryptantha glomeriflora*, *Gayophytum racemosum*.

#### **NON-ALPINE**

##### AZONAL MCISTURE-DEPENDENT VEGETATION

AQUATIC - *Lemna minuta*, *Zannichellia palustris*, *Ranunculus aquatilis*, *Potamogeton foliosus*.

MOIST SHELTERED ORGANIC LITTER - *Maianthemum stellatum*, *Pyrola asarifolia*, *Corallorhiza maculata*, *Silene mensiesii*.

RIPARIAN - Grading insensibly from a low-elevation phase with such taxa as *Phragmites australis*, *Oenothera elata*, *Rorippa nasturtium-aquaticum*, *Typha* spp., *Cirsium mohavense*, *Epilobium ciliatum*, *Salix exigua*, *S. lasiolepis*, and *Solidago spectabilis* through middle elevations with such characteristics as *Benula occidentalis*, *Populus balsamifera*, *Urtica dioica*, *Agrostis scabra*, *Veronica americana*, *Sphenosciadum capitellatum*, *Thalictrum sparsiflorum*, *Ribes inerme*, *Mertensia ciliata*, *Polemonium occidentale*, *Epilobium angustifolium*, *Castilleja miniata*, *Geum macrophyllum*, and *Aconitum columbianum*, to a high-elevation phase with *Dodecatheon redolens*, *Stellaria calycantha*, *Barbarea orthoceras*, *Epilobium saximontanum*, *Eleocharis pauciflorus*, and *Phleum alpinum*.

MARGINAL (Meadow) - *Rosa woodsii*, *Juncus balticus* throughout.

- **Alkaline** - *Cleomella* spp., *Nitrophila occidentalis*, *Anemopsis californica*, *Aster adscendens*, *Suaeda moquinii*, *Sarcobatus vermiculatus*, *Aster intricatus*, *Spartina gracilis*, *Distichlis spicata*, *Sporobolus airoides*, *Atriplex torreyi*, etc.
- **Montane** - *Carex* and *Juncus* spp., *Cirsium congdonii*, *Erigeron lonchophyllus*, *Eleocharis rostellata*, *Potentilla gracilis*, *Stellaria longipes*, *Achillea millefolium*, *Arnica* spp., *Salix pseudocordata*,

*Aster occidentalis*, *Platanthera hyperborea*.

**Subalpine** - *Salix geyeriana*, *S. orestera*, *Agrostis idahoensis*, *Delphinium polycladon*, *Trifolium monanthum*, *Mimulus primuloides*, *Potentilla fruticosa*, *Lupinus lepidus*, *Artemisia cana*.

#### DRYLAND VEGETATION

##### AZONAL RUPICOLOUS

- **Calicolous** - *Cheilanthes parryi*, *Argyrochosma jonesii*, *Eriogonum heermannii* var. *argense*, *E. shockleyi*, *Glossopetalon nevadense*, *Cercocarpus intricatus*, *Petrophytum caespitosum*, *Purshia stansburiana*, *Camissonia walkeri*, *Oenothera caespitosa* var. *crinita*, *Phacelia perityloides*, *Enceliopsis nudicaulis*, *Chrysothamnus parryi* var. *asper*, *Artemisia nova*.

- **Granitic** - *Leptodactylon pungens*, *Ephedra viridis*, *Scrophularia desertorum* throughout.

Lowland phase - *Halimolobos diffusa*, *Philadelphus microphyllus*, *Ribes velutinum*, *Potentilla saxosa*, *Purshia tridentata* var. *glandulosa*, *Cymopterus petraeus*, *Galium mathewsii*, *Erigeron breweri*, *Haplopappus cuneatus*, *Brickellia californica*, *Poa fendleriana*, *Trifolium dedeckerae*.

Subalpine phase - *Pellaea breweri*, *Jamesia americana*, *Galium multiflorum* var. *subalpinum*, *Sphaeromeria cana*, *Erigeron tener*, *Haplopappus eximius*, *Hieracium horridum*, *Carex occidentalis*, *Oryzopsis micrantha*, *Holodiscus dumosus*, *Chamaebatiaria millefolium*, *Juniperus occidentalis*, *Woodsia scopulina*, *Dryopteris filix-max*, *Polypodium hesperium*, *Chrysothamnus nauseosus* ssp. *albicaulis*.

**MONTANE VEGETATION** - *Purshia tridentata* X *P. glandulosa*, *Chrysothamnus viscidiflorus* ssp. *viscidiflorus*, *Artemisia tridentata* throughout.

- **Lower Montane** ("Pinyon-Juniper") Zone - *Pinus monophylla*, *Juniperus osteosperma*, *Opuntia erinacea*, *Eriogonum umbellatum* var. *nevadense*, *E. caespitosum*, *E. kennedyi*, *Salvia dorrii*, *Penstemon rostriflorus*, *Townsendia scapigera*, *Astragalus inyoensis*, *Stipa thurberiana*, etc.

Nevadan clay hill phase - *Polygala acanthoclada*, *Asclepias crypteoceras*, *Arenaria nuttalli* ssp. *fragilis*, *Phacelia lutea*, *Streptanthus oliganthus*, *Phoenicaulis cheiranthoides*.

- **Subalpine zone** (communities doubtful)

Sandy phase - *Eriogonum cernuum*, *E. spergulinum*, *Gayophytum* spp., *Muhlenbergia richardsonis*, *Arabis platysperma*.

Cercocarpus ledifolius phase

Sagebrush scrub phase

Swales - *Symphoricarpos* spp., *Artemisia tridentata* ssp. *vaseyana*, *Lupinus argenteus*, *Bromus ciliatus*, *Leucopoa kingii*, *Monardella odoratissima*, *Angelica lineariloba*, *Wyethia mollis*, *Stephanomeria tenuifolia*, *Stipa* spp., *Castilleja linariaefolia*, *Eriogonum latens*.

Exposed - *Artemisia arbuscula*, *Chrysothamnus parryi* var. *monocephalus*, *Tetradymia canescens*.

High - *Artemisia rothrockii*, *Haplopappus suffruticosus*.

## Floristic Habitats of the White Mountains

### Rupicolous coniferous forest

Calcicolous phase - *Pinus longaeva*, etc.

Granitic phase - *Pinus flexilis*, etc.

DESERT VEGETATION - *Atriplex confertifolia*, *A. canescens*,

*Ephedra nevadensis*, *Mirabilis bigelovii*, *Grayia spinosa* in all.

**Colluvial basic** - *Oenothera caespitosa* var. *marginata*, *Hecastocleis shockleyi*, *Petalonyx nitidus*, *Dedeckera eurekensis*, *Mimulus bigelovii* var. *cuspidatus*, *Emmenanthe penduliflora*, *Stipa speciosa*, *S. parishii*, *Chrysothamnus teretifolius*, *Brickellia microphylla*, *Lepidium fremontii*, *Camissonia chamaenerioides*.

**Colluvial granitic** - see azonal rupicoles.

**Alluvial** - *Opuntia echinocarpa*, *Psoralea polydenius*, *Lycium andersonii*, *Menodora spinescens*, *Artemisia spinescens*, *Tetradymia axillaris*, *T. glabrata*, *Sitanion hystrix*, *Blepharidachne kingii*, *Erioneuron pulchellum* in all

Nevadan - *Sarcobatus baileyi*, *Lycium shockleyi*, *Kochia americana*, *Eriogonum kearneyi*, *Chrysothamnus greenii*.

Mojavean - *Opuntia basilaris*, *Psoralea arborescens*, *Ambrosia dumosa*, *Acamptopappus shockleyi*, *Haplopappus cooperi*, *Xylorhiza tortifolia*.

Desert Washes and Roadsides - *Brickellia multiflora*, *Hymenoclea salsola*, *Mirabilis pumila*, *Lepidospartum latisquamum*, *Chrysothamnus nauseosus* ssp. *hololeucus*, *Encelia virginensis*.

(Note: desert scrub assemblages are somewhat doubtful. All taxa share close upper elevation limits, but none reaches its lower limits within our range, and those could vary from taxon to taxon, rendering the correlation less exact.)

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# *Floristic Habitats of the White Mountains*

## APPENDIX: White Mountain Floristic Data Codes

- NOMINAL HABITAT CONTROLS
- MOISTURE SUPPLY (MO)**
00. Indeterminate
  10. Aquatic (obligately submerged or floating)
  20. Wet (saturated soil or emergent; proximal riparian)
  30. Moist - indeterminate
  31. marginal (wetland, meadow, distal riparian)
  32. phreatic (at depth) or hypermarginal
  40. Accumulative drainage - indeterminate (floodland)
  41. swales/depressions/protected slopes/canyons
  42. washes and roads
  43. tree driplines
  44. rupicolous runoff (rocks in soil, talus, crevices)
  45. clays or fine sands (low porosity)
  46. poorly drained flats/ephemeral pools
  50. Passive drainage (open soil)
  60. Dispersive drainage (well-drained topographic highs, etc.)
- CLIMATIC REGIME: Elevation-Temperature-Rainfall gradient. (E)**  
 [NOTE: elevations are NOT definitive, but for approximate reference only]
0. Ubiquitous (elevation range > ca. 7000 ft [2135 m])
  1. Hottest (lowest desert) 3990-4500 ft [1216-1370 m]
  2. Hot (desert) 4000-6500 ft [1220-1980 m]
  3. Warm 4000-9500 ft [1220-2895 m]
  4. Warm-mesic (lower montane) 6500-9500 ft [1980-2895 m]
  5. Mesic 6500-11500 ft [1980-3505 m]
  6. Cool-mesic (subalpine) 9500-11500 ft [2895-3505 m]
  7. Cool 9500-13500 ft [2895-4115 m]
  8. Cold (alpine) 11500-13500 ft [3505-4115 m]
  9. Frigid (highest alpine) 13000-14246 ft [3960-4342 m]
- SUBSTRATE TEXTURE (TX)**
00. Indeterminate
  10. Rupicolous (general crevice/talus/coarse detritus)
  11. surficial
  12. crevices
  13. residual (thin autochthonous soils; see also 50 & 60)
  20. Detrital (indeterminate allochthonous rubble)
  21. Coarse (indeterminate, pebbles to boulders)
  22. Fine (indeterminate, gravel and finer)
  30. Colluvial (mixed, incl. talus/scree)
  31. Coarse only (incl. talus)
  32. Fine only (incl. scree)
  40. Alluvial (mixed)
  41. Coarse (pebbles and larger)
  42. Fine (gravel and finer)
  50. Disintegral (indeterminate, rupicolous or detrital)
  51. Gravel/Grus
  52. Sand
  53. Silt
  60. Decompositional (Clay)
  61. Sandy -
  62. Mud/Sod
  70. Organic (incl. rich sod, litter)
  80. Water (aquatics)
- SUBSTRATE CHEMISTRY (C)**
0. Indeterminate
  1. Saline (not present in White Mts.)
  2. Alkaline
  3. Basic (Limestone, Dolomite, Gypsum)
  4. Mixed basic (often includes basalt)
  5. Facultative basic/non-basic
  6. [not used]
  7. Silicate (non-basic, incl. indeterminate sod)
  8. Quartzose (felsic granitics, sandstone, quartzite)
  9. Hyperacidic (organic: rich sod, litter)
- SOIL COHESION (H)**
0. Indeterminate
  1. Loose (indeterminate)
  2. migrating (at or near repose)
  3. disturbed/disrupted (roads, washes etc.)
  4. Cohesive/metastable (most natural soils)
  5. sod-bound
  6. Stabilized (compacted, deflated)
  7. Lithified (rupicolous or cemented)
- SLOPE (approximate range in degrees given for reference) (S)**
0. Indeterminate
  1. Gentle (0-10)
  2. flat (0-2)
  3. shallow (2-10)
  4. Moderate (10-30)
  5. weak (10-20)
  6. strong (20-30)
  7. Repose (30-40)
  8. High (40-70)
  9. Vertical (or near) (>70)
- ALBEDO of substrate/surroundings (A)**
0. Indeterminate
  1. Bright (reflective)
  2. Dark (absorptive)
- EXPOSURE (X)**
0. Indeterminate
  1. Exposed (high south slopes/ridges)
  2. Open
  3. Protected (north slopes/canyons)
  4. Sheltered (under ledges or dense vegetation)
- SOCIABILITY relative to other proximal taxa (O)**
0. Indeterminate
  1. Hypocompetitive (often in barren places)
  2. Hypercompetitive (sod, thickets)
- ADDITIONAL HABITAT SPECIALIZATIONS (SP)**
00. None
  01. Alkaline soils
  02. Carbonate substrata
  03. Carbonate substrata with altitude depression
  04. Granite areas
  05. Acid soils (organic)
  06. Barren clay slopes
  07. Talus
  08. Scree
  09. Loose sand
  10. Disturbed places
  11. Hanging gardens
  12. Protected places
  13. Dark rocky pavement
  14. Dark rocky soils
  15. Deflated gravels
  16. Sod
  17. Near Packrat middens
  18. Open mud
  19. Within tree/shrub driplines
  20. Rosette leaves appressed
  21. Appearing only in exceptionally wet years
  22. Meadow hummocks
- FIDELITY to other habitat controls (F)**
0. Indeterminate (mesotypic)
  1. Restricted (stenotopic)
  2. Ubiquitous (eurytopic)

(continued)

# Floristic Habitats of the White Mountains

## APPENDIX: White Mountain Floristic Data Codes

### NOMINAL HABITAT CONTROLS

#### MOISTURE SUPPLY (MO)

00. Indeterminate
10. Aquatic (obligately submerged or floating)
20. Wet (saturated soil or emergent; proximal riparian)
30. Moist - indeterminate
31. marginal (wetland, meadow, distal riparian)
32. phreatic (at depth) or hypermarginal
40. Accumulative drainage - indeterminate (floodland)
41. swales/depressions/protected slopes/canyons
42. washes and roads
43. tree driplines
44. rupicolous runoff (rocks in soil, talus, crevices)
45. clays or fine sands (low porosity)
46. poorly drained flats/ephemeral pools
50. Passive drainage (open soil)
60. Dispersive drainage (well-drained topographic highs, etc.)

#### CLIMATIC REGIME: Elevation-Temperature-Rainfall gradient. (E)

[NOTE: elevations are NOT definitive, but for approximate reference only]

0. Ubiquitous (elevation range > ca. 7000 ft [2135 m])
1. Hottest (lowest desert) 3990-4500 ft [1216-1370 m]
2. Hot (desert) 4000-6500 ft [1220-1980 m]
3. Warm 4000-9500 ft [1220-2895 m]
4. Warm-mesic (lower montane) 6500-9500 ft [1980-2895 m]
5. Mesic 6500-11500 ft [1980-3505 m]
6. Cool-mesic (subalpine) 9500-11500 ft [2895-3505 m]
7. Cool 9500-13500 ft [2895-4115 m]
8. Cold (alpine) 11500-13500 ft [3505-4115 m]
9. Frigid (highest alpine) 13000-14246 ft [3960-4342 m]

#### SUBSTRATE TEXTURE (TX)

00. Indeterminate
10. Rupicolous (general crevice/talus/coarse detritus)
11. surficial
12. crevices
13. residual (thin autochthonous soils; see also 50 & 60)
20. Detrital (indeterminate allochthonous rubble)
21. Coarse (indeterminate, pebbles to boulders)
22. Fine (indeterminate, gravel and finer)
30. Colluvial (mixed, incl. talus/scree)
31. Coarse only (incl. talus)
32. Fine only (incl. scree)
40. Alluvial (mixed)
41. Coarse (pebbles and larger)
42. Fine (gravel and finer)
50. Disintegral (indeterminate, rupicolous or detrital)
51. Gravel/Grus
52. Sand
53. Silt
60. Decompositional (Clay)
61. Sandy -
62. Mud/Sod
70. Organic (incl. rich sod, litter)
80. Water (aquatics)

#### SUBSTRATE CHEMISTRY (C)

0. Indeterminate
1. Saline (not present in White Mts.)
2. Alkaline
3. Basic (Limestone, Dolomite, Gypsum)
4. Mixed basic (often includes basalt)
5. Facultative basic/non-basic
6. [not used]
7. Silicate (non-basic, incl. indeterminate sod)
8. Quartzose (felsic granitics, sandstone, quartzite)
9. Hyperacidic (organic: rich sod, litter)

#### SOIL COHESION (H)

0. Indeterminate
1. Loose (indeterminate)
2. migrating (at or near repose)
3. disturbed/disrupted (roads, washes etc.)
4. Cohesive/metastable (most natural soils)
5. sod-bound
6. Stabilized (compacted, deflated)
7. Lithified (rupicolous or cemented)

#### SLOPE (approximate range in degrees given for reference) (S)

0. Indeterminate
1. Gentle (0-10)
2. flat (0-2)
3. shallow (2-10)
4. Moderate (10-30)
5. weak (10-20)
6. strong (20-30)
7. Repose (30-40)
8. High (40-70)
9. Vertical (or near) (>70)

#### ALBEDO of substrate/surroundings (A)

0. Indeterminate
1. Bright (reflective)
2. Dark (absorptive)

#### EXPOSURE (X)

0. Indeterminate
1. Exposed (high south slopes/ridges)
2. Open
3. Protected (north slopes/canyons)
4. Sheltered (under ledges or dense vegetation)

#### SOCIABILITY relative to other proximal taxa (O)

0. Indeterminate
1. Hypocompetitive (often in barren places)
2. Hypercompetitive (sod, thickets)

#### ADDITIONAL HABITAT SPECIALIZATIONS (SP)

00. None
01. Alkaline soils
02. Carbonate substrata
03. Carbonate substrata with altitude depression
04. Granite areas
05. Acid soils (organic)
06. Barren clay slopes
07. Talus
08. Scree
09. Loose sand
10. Disturbed places
11. Hanging gardens
12. Protected places
13. Dark rocky pavement
14. Dark rocky soils
15. Deflated gravels
16. Sod
17. Near Packrat middens
18. Open mud
19. Within tree/shrub driplines
20. Rosette leaves appressed
21. Appearing only in exceptionally wet years
22. Meadow hummocks

#### FIDELITY to other habitat controls (F)

0. Indeterminate (mesotypic)
1. Restricted (stenotopic)
2. Ubiquitous (eurytopic)

(continued)