

Endemic and Endangered Plants of Pinyon-Juniper Communities

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Abstract—Habitat relations between pinyon-juniper and narrow endemic plants of Utah and management implications of these relations are evaluated.

For this paper a narrow endemic plant is considered to be one that is restricted to one or a few counties in one or perhaps two States. Some of these are known from only a few populations while others are known from many. Nearly all plants of Utah and other Western States that have been listed as threatened or endangered by the U. S. Fish and Wildlife Service and those listed as sensitive by other agencies are narrow endemics. Ute ladies tresses (*Spiranthes diluvialis*), which is listed as threatened, is a notable exception with distribution including Colorado, Utah, Wyoming, Montana, and, at least historically, Nevada. That species is included in this paper based on its threatened status. Consideration of biological diversity, scientific interest including potential medicinal uses, and other features of these relatively rare or at least restricted plants is important to land use planning and management.

Colorado pinyon (*Pinus edulis* Engelm.), singleleaf pinyon (*Pinus monophylla* Torr. & Frem. in Frem.), and Utah juniper (*Juniperus osteosperma* [Torr.] Little) are the common trees of the pinyon/juniper thermal belt of Utah. Within their thermal belt, these generalists are found on nearly all geologic strata and soil types. Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) does not seem as thermal-sensitive as the above species, and it is more common at higher elevations. It is less common on exposed geologic strata than the above species, and it is not so commonly found in closed stands. It is also more common where the soil mantle is well covered with vegetation and litter. Atwood and others (1991) listed nearly 70 taxa of narrow endemic plants for pinyon-juniper communities of Utah, and 22 species for juniper communities, and two for Rocky Mountain juniper communities. Many of these endemics have been listed as threatened, endangered, or sensitive or have

been considered for listing. When plant communities are compared for presence of narrow endemic plants, it is clear that pinyon-juniper and desert shrub communities support most of these in Utah (Welsh 1979).

Because many of these plants are known within the pinyon-juniper thermal belt and sometimes coexist with these trees, the assumption might be made that some or many of these could be pinyon-juniper obligates or at least benefited by pinyon-juniper association. This paper provides an evaluation of relationships between pinyon-juniper and many of the narrow endemic plants known from the pinyon-juniper thermal belt of Utah. This evaluation is quite restricted to narrow endemic plants. There are other plants of wider distribution that might show a positive relationship with pinyon-juniper and be indicators of community type or seral status such as pinyon-juniper lousewort (*Pedicularis centranthera* Gray).

Sources of Information and Concepts

Much of the information known about narrow endemic plants is a function of botanical collections. Information taken with botanical collections often includes plant community, soil texture, geologic formation, elevation, and other habitat features. Numerous collections with this information become the foundation for written floras including *A Utah Flora* (Welsh and others 1993), which includes geologic information for many of the narrow endemic plants of Utah. It is a major source of information for this paper.

The inclusion of geologic information in that work is largely a function of observations of close relationships between plants and geology made by Dr. Stanley L. Welsh beginning with his survey of Dinosaur National Monument (Welsh 1957). From this point, Welsh continued to observe these relationships throughout Utah and sought help from geologists in recognizing geologic strata (Welsh 1978; 1984). His interest and knowledge became infectious, and his students caught the fascination of the strong relationships between narrow endemic plants and geologic substrate. Use of geological maps and observations for exposed geologic strata became standard tools in surveys for endemic plants as well as more common plants (Goodrich 1981; Goodrich 1984; Goodrich and Neese 1986; Huber 1995). Looking for these unusual habitats yields new species and range extensions of other species, and contributes greatly to the knowledge of the flora of Utah.

Surveys conducted specifically for plants listed or considered for threatened and endangered status such as those of Neese and Smith (1982), Petersen and Baker 1982, Shultz

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(1982), Shultz and Mutz (1979), Fertig (1995), and Heil and Melton (1995) are greatly facilitated by recognizing and searching on appropriate exposed geologic strata. The above and several other publications and surveys are major sources of information for this paper, including Franklin (1989, 1992, 1993). In addition, numerous collections of these species have been made by the authors of this paper, and field experience while making those collections are part of the information provided here.

Edaphic control by geological formations is greatest in areas where the strata are exposed (Welsh 1979). For geologic substrates to be controlling, in Utah at least, the area must be xeric. Desiccation is apparently a necessity for ultimate expression of edaphic control of vegetation (Welsh 1984). On geologic badlands or semibarrens, the interaction of various substrates with low annual precipitation through long periods has led to the demonstration of edaphic differences on a grand scale. Soil formation is minimal. The substrate surface is often merely residual parent material only slightly modified from that of a few inches below the surface where conditions for plant growth are often rigorous at best.

Geologic or edaphic control of plants is not as common in areas of high precipitation. Where precipitation is abundant, the influence of water has a strong tendency to override the influence of geology. However, xeric conditions are not only associated with low precipitation. They are also associated with steep slopes and cliff faces, and with wind swept slopes and ridges, especially where geologic substrates with features that shed water quickly are exposed. Thus, some higher elevations in Utah with relatively high precipitation provide xeric or at least desiccating habitats where plant specialists are protected from competition of generalists. Plants capable of establishment and reproduction in these harsh conditions are few in number. Competition is therefore limited (Welsh 1978). Thus Utah, with much exposed geology under xeric conditions, supports numerous relatively narrow endemic plants.

The concept that narrow endemic plants are favored by exposed geology under xeric conditions is well supported by the large number of such taxa found in such habitats, and relatively few that have been found where the geology is well mantled by vegetation. Viewing the photographs of habitats of the threatened, endangered, and sensitive species provided in Atwood and others (1991) provides an excellent array of semibarrens or badlands of Utah. There are a few plants listed in that work for which the habitat is shown to be well mantled by vegetation. With few exceptions, these plants are broadly distributed and are included in that work based on a narrow range known in Utah. Examples are *Potentilla palustris* (L.) Scop., which has circumboreal distribution, and *Carex leptalea* Wahl., which is known from Alaska to Labrador and south to California and Florida.

Also, viewing the photographs of rare plants of Wyoming as provided in Fertig (1994) and endangered and sensitive plants of Idaho and Wyoming as provided by U.S. Department of Agriculture, Forest Service (without date of publication) shows a similar theme. However, the works from these States seem to show more species in areas of dense vegetation. Once again, however, several of these taxa from well-vegetated habitats are not narrow endemics but are listed in these works based on narrow distribution within the state

only. Examples are *Carex bauxbaumii* Wahl. with circumboreal distribution and *Salix candida* Fluegge ex Willd., which is known from Alaska to Labrador and south to British Columbia and Indiana.

The photographs of habitat for sensitive plants of the Humboldt National Forest, NV, which are mostly narrow endemics (U.S. Department of Agriculture, Forest Service 1991), show a propensity of these plants for open, sunny sites free of trees. Where pinyon-juniper are present, the endemic plants often grow in rock outcrops or talus within pinyon-juniper communities.

Plants that occupy well-developed soils tend not to be specialists, and they are broadly distributed (Welsh 1984). The Duchesne River Formation of the Uinta Basin, Utah, provides an example. At lower elevations this formation weathers to badlands or semibarrens as seen along U.S. Highway 40 between Roosevelt and Vernal and along Utah Highway 121 between Lapoint and Vernal. At higher elevations (around Strawberry Reservoir) under higher precipitation much of this formation is comparatively well mantled by vegetation. At the lower elevations where the formation has weathered to semibarrens, at least 17 taxa of narrow endemic plants have been found. None are known from the upper elevations of the formation where it is well mantled by vegetation.

The propensity of narrow endemic specialists for open sites of badlands or semibarrens with little competition from generalists is critical to understanding their relationships with pinyon and juniper.

Relation Between Narrow Endemic Plants to Pinyon and Juniper

The list of plants treated below was derived mostly from Atwood and others (1991). However, other narrow endemics listed by Welsh and others (1993) for pinyon or juniper communities of Utah are included. Page limitations for this paper prevent a discussion of each of the numerous narrow endemic plants of Utah found within the pinyon-juniper belt. The representative taxa discussed below are arranged in three categories of apparent relationship to pinyon-juniper. These categories are obligatory, apparent associate, and incidental. An expanded list of taxa for each of these categories without discussion is also provided below.

Obligatory or Semiobligatory

Arabis vivariensis Welsh Park rockcress—**Geology/soils:** sandstone and limestone outcrops and sandy soil. **Plant Communities:** Mixed desert shrub, pinyon-juniper. **Notes:** Presence on sandstone and limestone outcrops, and in mixed desert shrub communities indicates no obligatory relationship with pinyon or juniper. However, this plant does grow under the canopy of and in the duff of these trees on sandy soil, and apparently it is more abundant and vigorous in shade including that provided by pinyon or juniper. A positive relationship is strongly indicated between this plant and pinyon-juniper.

Camissonia exilis (Raven) Raven Meager camissonia—**Geology/soils:** Gypsiferous **Plant communities:** sagebrush, galleta, pinyon-juniper. **Notes:** This species seems to

have a true affinity for growth under the canopy of other vegetation. Most often the other vegetation is either pinyon or juniper. However, on some occasions it grows under the canopy of bitterbrush and rarely in the open. The presence of duff is not a deterrent to its growth. It is unknown if there is dependence on canopy cover or duff or both, but a strong relationship to pinyon-juniper is evident.

Echinocereus triglochidiatus var. *inermis* (K. Schum) Rowley Spineless hedgehog cactus—**Geology/soils:** Brushy Basin and Saltwash Formations, and sandstone members of the Morrison Formation, shallow, rocky soils. **Plant communities:** Pinyon-juniper/galleta grass, pinyon-juniper/yucca/black sagebrush. **Notes:** This plant shows affinity for shade of pinyon-juniper trees and tall mountain brush.

Penstemon pinorum L. Shultz & J. Shultz Pinyon penstemon—**Geology/soils:** Often on Claron Limestone or its gravels. **Plant communities:** Pinyon-juniper, mountain mahogany, ephedra, oak, sagebrush, and less commonly greasewood. **Notes:** The specific epithet for this species is definitely descriptive of its habitat. Although it has been found in shrubby communities, it is most often found in duff directly under pinyon-juniper canopy and becomes increasingly less common into open interspaces. When found in association with shrubs, it is often not far from thick pinyon-juniper cover. In such instances, it is again found in the litter underneath woody species, becoming uncommon in the open. It is unclear whether the association is a function of the duff or the protection of the canopy cover or both, but a dependency is indicated. Removal of pinyon-juniper canopy has been associated with reduction of the species.

Apparent Associates

Allium geoyeri var. *chatterlyi* Welsh Chatterley's onion—**Geology/soils:** Soils are mostly fine textured sandy loams, found in small pockets, protected depressions, and cracks in open slick rock of the Navajo Sandstone Formation. **Plant communities:** Ponderosa pine/Manzanita/Western wheatgrass, Ponderosa pine/Oak brush/Ross sedge. **Notes:** Although this plant is found in association with ponderosa pine and pinyon, it prefers the more unshaded sites.

Astragalus desereticus Barneby Desert milkvetch—**Geology/soils:** Sandy to clay soils of the Moroni Formation (ash flow tuff) and occasionally on a sandy member of the North Horn Formation located just above the Moroni Formation. **Plant communities:** Pinyon-juniper (mostly Utah juniper) with an understory including bitterbrush and Indian ricegrass. Some plants have been found in a basin big sagebrush community adjacent to the pinyon-juniper type. **Notes:** This plant has a strong affinity for the Moroni formation and pinyon/juniper/bitterbrush communities.

Draba pectiniphila Rollins Woods draba—**Geology/soils:** Sandy and other soils underlain by Weber Sandstone, Park City, and other formations. **Plant communities:** Big sagebrush, black sagebrush, mountain brush, ponderosa pine, Douglas-fir, pinyon-juniper. **Notes:** This plant grows in shade of pinyon and juniper and some tolerance of pinyon-juniper cover is evident. However, it is found in vigorous form outside duff and shade associated with these trees. Its abundance in black sagebrush and mountain brush communities indicates no obligatory relationship with pinyon or juniper.

Lepidium barnebyanum Reveal Barneby peppergrass—**Geology/soils:** White shale outcrops of the Uinta Formation where most common on ridge crests. **Plant communities:** Pinyon-juniper and mound plant communities. **Notes:** Although known from within the pinyon-juniper belt, the plant is most common on ridge crests where semibarrens or mound plant communities have developed in sparse or open pinyon-juniper communities. Presence of this plant in open pinyon-juniper but not closed pinyon-juniper communities indicates tolerance of pinyon-juniper presence but intolerance of crown closure of these trees.

Lesquerella tumulosa (Barneby) Reveal Kodachrome bladderpod—**Geology/soils:** White, bare shale knolls of Winsor Member of the Carmel Formation. **Plant Communities:** Among scattered juniper in a gramma grassland. **Notes:** While this species seems to be correlated with geologic strata, it is only found amongst scattered juniper. Typical habitat is bare shale knolls where any other vegetation is quite uncommon. While most often found in the bare inner spaces between juniper, plants are also be found directly in duff under the canopy of individual trees. Growth of individual plants does not seem to be influenced by presence or absence of duff and/or canopy.

Pediocactus despainii Welsh Despain footcactus—**Geology/soils:** Limestone gravels. **Plant communities:** Open pinyon-juniper. **Notes:** The distribution of this species being largely limited to within the pinyon-juniper belt might indicate a positive relationship to these trees. This species is found scattered within pinyon-juniper communities. However, it does not seem to be dependent on either of these tree species. It is often found in open, unvegetated spaces, on gravelly substrate. It is not found in thick canopy cover, nor directly under canopy of woody species. A negative relationship is indicated for pinyon-juniper canopy closure.

Pediomelum epiasilum (Barneby) Welsh Kane breadroot—**Geology/soils:** Chinle and Moenkopi Formations. **Plant communities:** Sparse sagebrush and pinyon-juniper. **Notes:** This species occurs with sparse sagebrush and pinyon-juniper. It often found growing in desert pavement within the open spaces of pinyon-juniper. This hardy species has also been observed growing through eroding highway gravels. Decline in numbers of this species has been concurrent with loss of pinyon-juniper. While no definite relationship is known to exist, there is an indication that this species survives best in pinyon-juniper openings.

Penstemon atwoodii Welsh Atwood penstemon—**Geology/soils:** Kaiparowits, Wahweap, and Straight Cliffs Formations on grayish sand and clay loam soils. **Plant communities:** Ponderosa pine and pinyon-juniper. **Notes:** Presence of this species in both ponderosa pine and pinyon-juniper indicates no obligatory relationship to either one. However, with its range essentially limited to pinyon-juniper and ponderosa pine communities a positive relationship to these trees is indicated.

Penstemon bracteatus Keck. Red Canyon beardtongue or platy penstemon—**Geology/soils:** Pink and white limestone members of the Wasatch Formation. **Plant communities:** Ponderosa pine, pinyon-juniper, limber pine, and bristlecone pine-manzanita. **Notes:** This species is found within exposed strata of the Wasatch Formation. It commonly occurs in sparsely vegetated areas within many different woody communities. It does not seem to

demonstrate an obligatory relationship with any one of these tree covered communities, but it is geologically selective. However, a secondary relationship to trees is indicated by the distribution being essentially limited to tree covered communities.

Penstemon concinnus Keck. Elegant penstemon or Tunnel Springs beardtongue—**Geology/soils:** Calcareous or igneous gravels usually of pale limestone parent materials. **Plant communities:** Pinyon-juniper and sagebrush. **Notes:** This species commonly occurs within a moderate canopy cover of pinyon-juniper and does not seem deterred by the presence of duff or litter. It is most often not found directly under canopy of pinyon-juniper, but within the small inner spaces between trees. However, canopy cover is not a deterrent to its occurrence. In rare circumstances it can be found in sagebrush communities at the edge of pinyon-juniper communities.

Townsendia aprica Welsh & Reveal Last chance townsendia—**Geology/soils:** Clay or claysilt soils of Arapien and Mancos Shale Formations. **Plant communities:** Salt desert shrub and pinyon-juniper. **Notes:** This species is most commonly found within the pinyon-juniper belt where it occurs in open to moderately dense cover. Although it does grow directly under pinyon-juniper, it is just as easily found in vast open areas within the pinyon-juniper belt. A positive relationship between tree cover, duff, or other habitat feature that is a function of pinyon-juniper is not apparent.

Incidental

Aquilegia barnebyi Munz Shale columbine—**Geology/soils:** Semibarren slopes, ridges, cliffs, ledges, and talus of Douglas creek and Parachute members of the Green River Formation and Uinta Formation. **Plant communities:** Mixed desert shrub, Salina wildrye, pinyon-juniper, Douglas-fir. **Notes:** This is a plant of open sites. It is not favored by shade nor duff or any other microsite feature that is a function of pinyon or juniper. Its association with these trees is incidental to its affinity for the Green River and Uinta Formations. Its independence from habitat features that are a function of pinyon or juniper is verified by its abundance in mixed desert shrub and Salina wildrye communities and by populations of high numbers on high elevation, wind swept ridges beyond the influence of pinyon and juniper.

Astragalus chloodes Barneby Grass milkvetch—**Geology/soils:** Outcrops of Entrada, Navajo, Frontier, Dakota, and other sandstone hogbacks and cuerdas. **Plant Communities:** Mixed desert shrub, mountain brush, and pinyon-juniper. **Notes:** A strong propensity for sandstone barrens in full sun without litter or shade indicates the association of this species with juniper is incidental. The association is a function of the ability of pinyon-juniper to tolerate sandstone barrens and the propensity of this species for these barrens.

Astragalus hamiltonii C. L. Porter Hamilton milkvetch—**Geology/soils:** Heavy clay soils and road cuts in the Duchesne River and perhaps Wasatch Formations. **Plant communities:** Road cut, sparsely vegetated desert shrub and juniper. **Notes:** This uncommon plant is often favored by road cuts where robust specimens produce abundant flowers and fruit. It is found on badlands of inherently high

erosion rates in full sun. Associated vegetation is sparse. There is no indication this species is favored by shade or duff or any other habitat feature that could be a function of pinyon or juniper. Indeed the distribution of this species indicates it would be adversely effected by increasing density of these trees. The association of this plant with juniper and perhaps rarely with pinyon is a function of the ability of these trees to occupy the badlands of the Duchesne River Formation to which this plant has a strong affinity. The inference by Davidson and others (1996) that this plant would be favored by wilderness status (designated wilderness as an act of congress) demonstrates a misconception of many narrow endemic plants which are well adapted to disturbance. The propensity of *A. hamiltonii*, *A. saurinus*, *Eriogonum viridulum*, and many other endemic species for road cuts, roadsides, and other disturbance does not support the concept that wilderness status is necessary or even helpful for the perpetuity of many of these plants.

Astragalus iselyi Welsh Isely milkvetch **Geology/soils:** Heavy clay derived from shale members of the Morrison and Paradox Formations. **Plant communities:** Salt desert shrub/blackbrush/greasewood and Utah juniper/galleta grass communities. **Notes:** This plant is widely scattered around the LaSal Mountains where it seems to be more restricted by the geological strata on which it grows than by plant type association.

Astragalus lutosus Jones Dragon milkvetch—**Geology/soils:** Green River Shale barrens. **Plant communities:** Desert shrub, mountain brush, limber pine, Douglas-fir, pinyon-juniper. **Notes:** Although reported for the above communities, this plant is one of barrens where pinyon, juniper, and other trees occur as scattered individuals. The affinity of this species for the Green River Shale is evident across a wide elevational range from 1,570 to 2,870 m (5,150 to 9,400 ft). That the range of the species includes elevations both below and above the pinyon-juniper belt demonstrates no obligatory relationship with these trees. The strong affinity for geologic substrate indicates little or no response of this species to habitat conditions that could be a function of pinyon or juniper. Association of pinyon and juniper with this plant is a function of the common ability of these plants to occupy this harsh substrate. In the case of *Astragalus lutosus*, the geology is obligatory. In the case of pinyon and juniper, this substrate is just one of many that these species tolerate.

Perhaps as well as any Utah endemic specialist, the Dragon milkvetch demonstrates an affinity for specific geologic strata. This plant is known from Rio Blanco County, Colorado to Utah County, Utah on the Tavaputs Plateau where it is most common in the White River drainage including the Pieance Basin and Two Waters drainage. The total range of the species is over 200 km long. Toward the west, known populations are isolated and separated by as many as 50 km. These isolated population are found on barrens or semi barrens of exposed Green River Shale. No population of this plant is known from this or any other substrate where the geologic strata is well mantled by vegetation.

Astragalus pattersonii Gray ex Brand. Patterson milkvetch—**Geology/soils:** Seleniferous soils of Blue Gate member of the Mancos Shale Formation and other formations that tend to weather to badlands. **Plant**

communities: Mixed desert shrub, pinyon-juniper/black sagebrush/galleta grass. **Notes:** This plant is sometimes found under shade of juniper and other overstory plants. Its presence in mixed desert shrub communities does not indicate an obligatory relationship with pinyon or juniper. However, its presence in shade of overstory indicates tolerance or perhaps a beneficial relationship.

Cryptantha brevifolia (Osterh.) Payson Short-flower cryptanth—**Geology/soils:** Mostly heavy clay soils of the Morrison and Duchesne River Formations. **Plant communities:** road-cut, salt desert shrub, sagebrush, rabbitbrush, pinyon-juniper, mountain brush **Notes:** The presence of this species in desert shrub and road-cut communities where it is found in full sun indicates no obligatory relationship with pinyon-juniper. Where it is found with pinyon-juniper, the trees are mostly scattered and of little influence on habitat conditions.

Cryptantha creutzfeldtii Welsh Creutzfeldt-flower—**Geology/soils:** Seleniferous soils of Mancos Shale. **Plant communities:** Mat saltbush and scattered Utah juniper/salina wildrye. **Notes:** This plant is restricted by geologic substrate. Its presence in mat saltbush communities indicates shade, duff, or other habitat feature that is a function of Utah juniper is not critical to the species.

Erigeron maguirei Cronq. Maguire daisy—**Geology/soils:** Rocky canyon bottoms of Wingate and Navajo sandstone, rim rock and other slick rock of Navajo sandstone **Plant communities:** Mountain brush, pinyon-juniper, ponderosa pine, and Douglas-fir. **Notes:** No specific associations occurs with any plant community. Plants occur on open windswept outcrops and under shaded canopy within deep canyon bottoms. Although associated with pinyon-juniper, this plant is quite limited to cracks and crevices in rock outcrops. The association with pinyon-juniper is indicated to be incidental.

Gilia caespitosa Gray Rabbit Valley gilia—**Geology/soils:** Carmel and Navajo Formations. **Plant communities:** Pinyon-juniper. **Notes:** This species occurs in crevices, sand, and open rocky outcrops associated with Navajo Sandstone. Other vegetation is sparse and includes ponderosa pine. Known populations are from semibarrens where there is no indication of obligatory relationship with pinyon-juniper.

Lomatium latilobum (Rydb.) Mathias Canyonlands lomatium or broad-leaved biscuitroot—**Geology/soils:** Mainly on Entrada Sandstone and Navajo Sandstone on fine textured loose sand. **Plant communities:** Pinyon-juniper/Blackbrush/Indian ricegrass, Pinyon-juniper/Mixed mountain brush/Needlegrass and desert shrub. **Notes:** Plants are mostly found in crevices of rock and on sandy deposits. Although found within pinyon-juniper woodlands, they are more common on open exposed, sunny (hot) sites where there is no indication that they are dependent on pinyon-juniper.

Penstemon grahamii Keck in Graham Graham penstemon—**Geology/soils:** White to tan semi-barren, shaley slopes, ridges and knolls of the Parachute member of the Green River Formation. **Plant communities:** Shadscale, greesebush, Salina wildrye, and pinyon-juniper. **Notes:** Habitat affinity for this species is exposed geologic strata with comparatively little soil development. Presence in shrub and grass communities indicates no dependency on shade or duff or other habitat feature that is a function of pinyon-juniper. Where associated with pinyon-juniper, the

trees are scattered. It is not found in stands of trees with moderate or high crown closure indicating tolerance of limited presence of these trees but intolerance of crown closure or intolerance for soil conditions that allow for closure of pinyon-juniper canopy.

Penstemon idahoensis Atwood & Welsh Idaho penstemon—**Geology/soils:** Barrens, semi-barrens, and road cuts in white tuffaceous outcrops. **Plant Communities:** Sagebrush and scattered juniper. **Notes:** Habitat propensity of this species is for exposed tuffaceous materials. Association with juniper is incidental and a function of juniper to tolerate this material as well as nearly every exposed geologic strata within the pinyon-juniper belt of Utah.

Phacelia argillacea Atwood Clay phacelia—**Geology/soils:** Semi-barrens of the Green River Formation. **Plant communities:** Rocky mountain juniper/Gambel oak sites **Notes:** Although within the range of the pinyon-juniper belt, this plant is not dependent on or obligate to pinyon-juniper. It is in no way associated with the trees. It is found on open, actively eroding Green River Shale slopes with only limited vegetation. This species does not do well in competition with any other vegetation.

Spiranthes diluvialis Shev. Ute lady's tresses—**Geology/soils:** Moist to wet soils of wetlands and riparian areas. **Plant communities:** Riparian, meadow, wetland areas within cottonwood, tamarix, willow, and pinyon-juniper communities. **Notes:** This species is obligate to moist soils of riparian or wetland communities. The association with pinyon-juniper is accidental, and the listing of this species for pinyon-juniper communities is mostly based on riparian inclusions within the pinyon-juniper belt. However, the ecological amplitude of pinyon-juniper includes riparian settings. Ute lady's tresses is more common in open grass and forb dominated communities than where shrub and tree density or canopy closure is high. A negative relationship is indicated for this species with pinyon-juniper crown closure.

Talinum thompsonii Atwood & Welsh Thompson talinum—**Geology/soils:** Silicious conglomeratic gravels of the North Horn Formation. **Plant communities:** Pinyon-juniper/cliffrose/needlegrass, pinyon-juniper/alder-leaf mountain-mahogany/Salina wildrye. **Notes:** The most vigorous populations of this plant occur in the cracks and crevices of the conglomerate rock outcrops without pinyon-juniper cover which is primary habitat for the species. A small population occurs in a dense stand of mature pinyon-juniper trees with an understory of cryptogams which is marginal habitat.

Summary List of Taxa

A list of taxa for each of these categories without discussion is provided below. For brevity neither authors nor common names are given in these lists. For the most part, nomenclature follows that of Welsh and others (1993) and Atwood and others (1991) where authors and common names are provided.

Obligatory or Semiobligatory

These plants are found in shade and/or duff of pinyon-juniper more commonly than not, and they appear to be

either dependent upon or at least greatly favored by habitat features that are a function of pinyon and/or juniper.

Arabis vivariensis
Camissonia exilis
Echinocereus triglochidiatus var. *inermis*
Penstemon pinorum

Apparent Associates

These plants are known only, or mostly, from within pinyon and/or juniper communities but are mostly found in inner spaces of the trees and often on exposed geologic substrate where substrate more than trees could be the habitat feature these plants respond to most.

Allium geyeri var. *chatterlyi*
Astragalus desereticus
Cryptantha jonesiana
*Draba pectiniphila*²
Lepidium barnebyanum
Lesquerella tumulosa
Pediocactus despainii
Pediomelum epipsilum
*Penstemon atwoodii*¹
*Penstemon bracteatus*¹
Penstemon concinnus
Townsendia aprica
Trifolium friscanum

¹Although known from other tree dominated communities, this is mostly known where trees are present, and it could be positively related to pinyon-juniper as well as other trees.

²Although known from habitats without pinyon-juniper, this plant appears to do well under pinyon-juniper. Although not necessary for the plant, habitat created by pinyon-juniper is favorable to the plant.

Incidental

These are species known from within the pinyon-juniper belt, but which also extend below the belt into salt desert shrub communities or above the belt and often to open wind swept slopes and ridges of exposed geology where geology is clearly the feature to which these species respond. Their association with pinyon and/or juniper is incidental and often a function of the ability of pinyon and juniper to inhabit a broad range of exposed geological strata without substantially modifying the environment of the exposed strata.

Aquilegia barnebyi
Artemisia nova var. *duchesnicola*
Asclepias cutleri
Asclepias welshii
Aster kingii var. *barnebyana*
Astragalus ampullarius
Astragalus anserinus
Astragalus barnebyi
Astragalus chloodes
Astragalus coltonii var. *moabensis*
Astragalus consobrinus
Astragalus duchesnensis
Astragalus eastwoodii
Astragalus equisolensis
Astragalus hamiltonii
Astragalus henrimontanensis

Astragalus iselyi
Astragalus lutosus
Astragalus monumentalis
Astragalus musiniensis
Astragalus oophorus var. *lonchocalyx*
Astragalus pattersonii
Astragalus saurinus
Astragalus serpens
Astragalus subcinereus var. *basalticus*
Cirsium ownbeyi
Chrysothamnus nauseosus var. *uintahensis*
Cryptantha brevifolia
Cryptantha cinerea var. *arenicola*
Cryptantha creutzfeldii
Cryptantha johnstonii
Cryptantha ochroleuca
Cryptantha paradoxa
Cryptantha witherillii
Cycladenia humilis var. *jonesii*
Cymopterus beckii
Cymopterus coulteri
Cymopterus duchesnensis
Draba kassii
Epilobium nevadense
Erigeron maguirei
Erigeron untermanii
Eriogonum aretioides
Eriogonum batemanii var. *eremicum*
Eriogonum batemanii var. *ostlundii*
Eriogonum brevicaule var. *ephedroides*
Eriogonum brevicaule var. *viridulum*
Eriogonum corymbosum var. *cronquistii*
Eriogonum soredium
Festuca dasyclada
Gilia caespitosa
Gilia stenothyrsa
Gilia tenuis
Gutierrezia pomariensis
Hedysarium occidentale var. *canone*
Hymenoxys acaluis var. *nana*
Hymenoxys lapidicola
Lepidium montanum var. *stellae*
Lepidium ostleri
Lomatium latilobium
Lygodesmia grandiflora var. *entrada*
Mentzelia argillosa
Mentzelia goodrichii
Mentzelia multicaulis var. *librina*
Mentzelia multicaluis var. *multicaluis*
Oreoxis trotteri
Pediocactus winkleri
Pediomelum pariense
Penstemon acaulis var. *acaulis*
Penstemon ammophilus
Penstemon angustifolius var. *dulcis*
Penstemon duchesnensis
Penstemon fremontii
Penstemon goodrichii
Penstemon grahamii
Penstemon idahoensis
Penstemon nanus
Penstemon pachyphyllus

Penstemon parvus
Penstemon scariosus var. *albifluvis*
Penstemon tidesstromii
Penstemon wardii
Phacelia argillacea
Selaginella utahensis
Schoenocranbe suffrutescens
Sclerocactus pubispinus var. *pubispinus*
Sclerocactus wrightiae
Silene petersonii
Sphaeralcea caespitosa
Spiranthes diluvialis
Talinum thompsonii
Thelesperma subnudum var. *alpinum*
Thelesperma subnudum var. *caespitosum*
Townsendia jonesii
Townsendia mensana
Xylorhiza cronquistii

Discussion

Many of the narrow endemic plants of Utah including those of the pinyon-juniper belt are found on semibarrens or badlands where geologic strata are exposed or on wind deposited sands. These relationships are repeated in so many taxa that it is apparent that these plants have evolved where geology and erosion are primary drivers of plant community composition and dynamics. Chemical and water relations are closely allied to geological formations. Ecology of most endemic plants of Utah indicate an inability of these plants to occupy well-developed soils, inability to compete for resources with the generalists that are commonly found there, or they are suppressed by shading of shrubs and trees (comparatively few endemic plants of Utah are shrubs and none are trees). The implication is strong that the open sites of harsh substrates and special conditions provide opportunities for development for specialists that have not developed the ability to compete with aggressive generalists. Aggressiveness of generalists such as pinyon and juniper is evident in the wide range of these species and the super dominance (West and Van Pelt 1987) they are capable of expressing. Even on sites where endemics are the most common plants, plant density often remains low. Here survival appears more a function of adaptation to harsh substrates and dry conditions than an ability to compete with other plants.

Colorado pinyon, singleleaf pinyon, and Utah juniper each have a broad ecological amplitude, and they are capable of colonizing on all, or nearly all, exposed geologic strata within their thermal belt. However, their presence on many of these substrates is often limited to depauperate, scattered individuals that are obviously stressed by the harsh conditions where they do little to modify the environment. Such harsh environments are open to colonization by narrow endemic specialists. In contrast to the depauperate and stressed nature of generalists that do exist on these harsh sites, many of the specialists flower and fruit in profusion with appropriate timing and amounts of precipitation, and they have developed mechanisms which enable them to survive through times without favorable moisture.

Layers of alluvium, which represent mixtures of materials from different sources tend to insulate vegetation from

peculiar chemical and water relations of exposed geologic strata (Welsh 1979). With increasing depth of alluvium and increasing soil profile development, conditions become increasingly favorable for plant growth and greater productivity. Generalists such as big sagebrush, Colorado pinyon, Utah juniper, and common widespread grasses occupy such sites. Here competition among different species and among individual plants drives plant community dynamics where the most aggressive species express high percent crown cover in the absence of disturbance. In such highly competitive environments, most narrow endemic specialists are excluded.

A concept of dependency on pinyon or juniper for narrow endemic specialists is contrary to the concept of specialization. The propensity of narrow endemic specialists for open sites in contrast to the paucity of occurrences within pinyon-juniper communities with high crown closure supports the concept of specialization on open habitats and not dependency on pinyon or juniper. The occurrence in desert shrub communities of many of the narrow endemics that are reported for pinyon-juniper communities is additional, and quite conclusive, evidence that many of these taxa are not dependent on shade, duff, or any other habitat feature that is a function of pinyon or juniper.

The coexistence of Colorado pinyon and Utah juniper with narrow endemic specialists throughout Utah is evidence of the potential of pinyon and juniper to occupy or at least exist on nearly all (if not all) exposed geologic strata within their thermal belt. Their general occurrence on alluvial surfaces within their thermal belt is additional evidence of their broad ecological amplitude. These highly competitive species, which are capable of near complete dominance on many sites and which can effectively eliminate such highly competitive species as sagebrush and perennial grasses, can hardly be expected to be nurse plants for many narrow endemic specialists.

This concept is supported by the few species listed by Atwood and others (1991) for aspen communities of Utah. Of the seven species listed for aspen, five are indicated to be specific for rocky open places. Botanical collections from sagebrush communities are mostly not specific to the dominant sagebrush taxon at a site. Thus, it is not possible to compare endemic plants with habitat as indicated by different sagebrush taxa. However, it is the experience of the authors that relatively few endemic species are found in mountain big sagebrush communities, which tend to be on Mollisols. Relatively few are found in Wyoming big sagebrush communities with high crown closure. A greater number seem to be associated with black sagebrush, which indicates less favorable conditions for plant growth.

In general, endemic plants are few on soils of the Mollisol, Alfisol, or other orders indicating high degree of soil profile development. Many endemic species are found on cliff faces, talus slopes, and semibarrens of exposed geologic strata where soils of the Inceptisol and Entisol Orders are indicated.

The harsh exposed unfavorable habitats presented by exposed geologic strata under xeric conditions provide a refuge for narrow endemic specialists against the competitive and often dominating influence of pinyon and juniper. With the exceptions of four species listed above as obligatory or semiobligatory and the possible exceptions of

14 species listed above as apparent associates, a neutral or negative relationship with pinyon-juniper crown closure is suggested for most narrow endemic species of the pinyon-juniper thermal belt of Utah. Of the 14 apparent associates, woods draba and a few other species show considerable tolerance to pinyon-juniper cover without being dependent on pinyon-juniper cover. For these species a negative or positive relationship is not clear.

Management Implications

The nature of narrow endemic specialists to occupy semibarren habitats indicates low potential for vegetation manipulation projects on these sites. Indeed, the presence of many of these species could be used as an indicator of low potential. However, the more obvious barren nature of many of their habitats should be indicator enough that these are not appropriate sites for forage improvement projects. There are a few exceptions, and generalized conclusions are not an appropriate substitute for specific surveys and specific data bases for local areas. However, from data available in 1979, Welsh (1979) concluded it was possible to prepare a model with predictive capability that could aid in the search for these plants. Information gained since 1979 supports this concept. Sites with alluvial soils or where soil profiles are well developed, or where dense stands of pinyon-juniper with high percent canopy closure are present are indicated to be better sites for projects for high production of shrubs and herbaceous species. These habitats provide sites for such projects with low potential for narrow endemic plants.

Distribution of rare species is not equal. Certain areas appear to lack them while other areas support concentrations of several species. Unless a specific mineral to be exploited is located within an outcrop that supports one or more narrow endemic species, or unless the area to be occupied by a particular development is large, there seems little reason why activities should impress known endangered or threatened plant species. Even in these two exceptional instances there should be opportunity for mitigation. The best site for industrial development is not always the only good alternative (Welsh 1979). In some cases, narrow endemic plants of threatened or endangered status do come into conflict with development. An example is the low bearcaw-poppy (*Arctomecon humilis* Cov.) and urban development in and around the city of St. George, UT, where economic values for semibarrens or badlands are high. Such economic values are driven by urban development. No such value is indicated for cultural practices such as burning or chaining for forage or watershed improvement projects. The nature of the habitat should serve to protect many of these plants from these kinds of projects. The remainder can be addressed and protected by referring to well-documented inventories. Where such inventories are lacking, management should place high priority for achieving such inventories.

The habitat for many narrow endemic specialists might be considered at less than desired condition because of low production or high rates of erosion and delivery of salts to rivers. This might be suspected to be a function of use of the land by non-Native Americans and their livestock. However, the strong relationship between highly erosive,

exposed geologic strata and narrow endemic specialists indicates an evolutionary ecology dependent on harsh conditions and high rates of erosion that predates the advent of European settlers and their livestock by thousands of years.

The comparatively rare nature of these plants indicates their high value for biodiversity and for the study of speciation, evolutionary biology, reproductive ecology, biogeography, taxonomy, species interactions and species rarity (Heil and Melton 1995). Additionally some of these plants, such as the several penstemons, contribute to aesthetics of semibarren landscapes. Some have potential for flower gardens. Also some, such as the Duchesne buckwheat (*Eriogonum brevicaulle* var. *viridulum* [Reveal] Welsh), offer some potential to greatly soften the visual aspects of road cuts.

Maintenance of these plants is dependent on semibarrens or badlands with high rates of erosion and sometimes high delivery of salts. Attempts to alter these habitats by structures or establishing highly competitive plants that are capable of slowing erosion can be expected to have a high rate of failure. Any such project that might be successful would likely be highly detrimental to narrow endemic plants present in the project area.

As dense pinyon-juniper stands develop on sites, ground cover is often reduced as a function of bearing of interspaces where rill and sheet erosion increase with increasing pinyon-juniper cover. This relationship might be suspected of creating habitat for narrow endemic specialists that are often favored by erosion and bare surfaces. However, this is not indicated to be a major source of habitat for narrow endemics. Sites favorable enough for pinyon and juniper to achieve high cover are not indicated to be sites of evolutionary development of many rare species. Dense cover of these species is indicative of plant competition far beyond the tolerance of many narrow endemic specialists.

A concept labeled "properly functioning condition" is currently of high profile in some Federal agencies. Under this concept, narrow endemic plants and the badlands on which they have evolved present some different values to consider compared to those of landscapes that have the potential to be well mantled by vegetation. One of the functions of badlands in Utah is production of narrow endemic plant specialists including most of those listed as threatened and endangered. The evolutionary ecology of these plants indicate these badlands have been so for thousands of years. They have been highly erosive. They have contributed salts to drainage. These are inherent functions of these lands. Difficulty in applying the term "proper function" to this scenario demonstrates values of questionable application to badlands or semibarrens where geologic strata are exposed or where they are near the surface or where xeric conditions prevent development of dense vegetative cover.

Inherently highly erosive geologic substrates are well accepted as national treasures inside National Parks. There are reasons to accept these conditions as inherent on lands administered by other agencies. Narrow endemic plants are one of those reasons. Indeed production of these plants should be a measure of proper function.

There seems to be a tendency for those opposed to hands-on management of pinyon-juniper ecosystems to look at

threatened and endangered species as a reason to stop projects designed to manage vegetation. Also, it seems those who support practices used to manage vegetation sometimes demonstrate an attitude of resentment toward threatened and endangered plant species. Neither of these attitudes seem appropriate for narrow endemic plants of Utah. Holmgren (1979) advised against taking a strong stand pro or con without sufficient knowledge. He also warned against advocacy for preservation by those who might view these plants mainly as instruments for political strategy. In view of the value of these rare or restricted plants and in view of the laws and regulations dealing with some of them, continued botanical surveys that lead to well-documented inventories are appropriate. Planning and management based on such inventories also seem appropriate. In the case of pinyon-juniper, it seems highly likely that most potential conflicts between vegetation management and narrow endemic plants can be rather easily resolved with well-documented inventories and an understanding of the habitat and biology of these species.

Using geologic maps, recognizing geologic strata, recognizing soils that tend to repel water and are inherently sparsely vegetated can facilitate inventory for many of these plants.

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