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PLANT COMMUNITIES AND GEOLOGICALLY SIGNIFICANT PLANTS OF THE FOUR CORNERS AREA

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Abstract—Plant communities on the Colorado Plateau include Desert Scrub, a vegetational type of the Lower Sonoran Life Zone; Desert Grassland and Juniper Savanna, both components of the Upper Sonoran Life Zone; Coniferous and Mixed Woodland of the Transition Zone; and Montane Coniferous Forest of the Canadian Zone. Riparian zones also act as narrow corridors supporting floral diversity in this mostly arid landscape. Botanical prospecting for uranium in the Colorado Plateau has involved two methods, indicator plant and plant analysis prospecting. The best indicator plants for uranium are species of the genus *Astragalus* that thrive in selenium-rich soils. The most commonly used plants for plant analysis prospecting are small trees, typically junipers, which have roots that may extend to depths of more than 30 ft. The indicator-plant prospecting method is limited by the fact that many of the best indicator plants are components of the desert scrub community and do not occur at higher elevations of the plateau.

INTRODUCTION

Plants have played a significant role in our understanding of paleoenvironments, including the late Paleozoic and Mesozoic environments of the Colorado Plateau. Plants and plant communities have also affected geologic processes such as weathering (Knoll and James, 1987) and erosion and, to a lesser extent, geology affects the distribution of plant species. This paper provides an introduction to the extant vegetational communities of the Colorado Plateau and briefly reviews the ways that specific plants have been utilized in prospecting for ore deposits, i.e., botanical prospecting.

PLANT COMMUNITIES OF THE FOUR CORNERS AREA

The Colorado Plateau Geologic Province, centered on the Four Corners area, contains at least six distinct vegetational communities. Because of the limited latitudinal range, elevation and rock type are the major factors that determine the extent and distribution of each vegetation type. The effect of 1000 ft gain in elevation is equivalent to traveling northward about 300 mi, resulting in a temperature drop of about 5°F (Epple and Epple, 1995) and an increase in precipitation. The major vegetational communities in the vicinity of the field trip route, in order of occurrence from lower to higher elevations, include Great Basin Desert Scrub, Desert Grassland, Juniper Savanna, Coniferous and Mixed Woodland, and Montane Coniferous Forest (Dick-Peddie, 1993).

Life Zones

The vegetation communities listed above are components of four different Life Zones. The Upper Sonoran Zone, between about 4000 and 6000 ft, supports a mixture of grasslands, scrublands, and savannas of oak (*Quercus* sp.), juniper (*Juniperus* sp.) and pinyon pine (*Pinus edulis*) (Fig. 1). Typical shrubs in the zone include saltbush (*Atriplex* sp.), greasewood

FIGURE 1. View northeast of the La Plata Mountains from Mesa Verde showing grassland and Montane Forest vegetational communities.

FIGURE 2. View of ridges along road in Mesa Verde National Park. Note greater density of juniper and pinyon trees along crest of ridges relative to small valleys which have a greater density of deciduous vegetation (oaks and skunkbush).

(*Sarcobatus vermiculatus*), and big sagebrush (*Artemisia tridentata*). The presence of ponderosa pine (*Pinus ponderosa*) signals the presence of the Transition Zone, at elevations of 6000 to 8000 ft. Pinyon pine (*Pinus edulis*) may be present in the understory of these pine forests. The Canadian Zone is typified by the presence of fir and spruce, dominantly Colorado blue spruce (*Picea pungens*), Engelmann spruce (*P. engelmannii*), and Douglas fir (*Pseudotsuga menziesii*). Mountain peaks in the area, snow-covered for most of the year, lie in the Hudsonian and Alpine Life Zones. In addition, riparian (stream-side) habitats provide narrow corridors of floral diversity along stream courses between and within the life zones. Within a life zone, availability of water, soil development, and exposure may determine the distribution of different species in a small area (Fig. 2).

Great Basin Desert Scrub

This vegetational community is one of the most widespread in the Four Corners area. It has also been called Great Basin Microphyll Desert (Kearney and Peebles, 1951). It covers large areas of the Navaho Reservation in northeastern Arizona and adjacent portions of New Mexico, Utah and Colorado. Small shrubs such as big sagebrush, four-wing saltbush (*Atriplex canescens*), greasewood, blackbrush (*Coleogyne ramosissima*) and shadscale (*Atriplex confertifolia*) characterize this vegetation type (Fig. 3). Dick-Peddie (1993) considered shadscale, which can survive on soils up to 1000 times more alkaline than normal soils (Kricher and Morrison, 1993), the best indicator of this vegetational community. Four-wing saltbush is used in reclamation projects and is an important browse plant for both wildlife and domestic livestock (Welsh et al., 1987). Mormon tea (*Ephedra* sp.) is also common. Less than 10 in. of precipitation per year falls mostly as snow during the winter (Kricher and Morrison, 1993). A subtype of this vegetational community are "badlands" or "barrens," terms used to describe "sparsely vegetated shale outcrops or shale-derived soils" (Colorado Native Plant Society, 1989, p. 11). Barrens are most common in areas with low rainfall (less than 10 in./yr) and on south-facing slopes. In the field trip area these areas occur principally on, or on soils developed on, the Mancos Shale. The Mancos Shale and soils harbor the greatest number of species endemic to the Four Corners area (Table 1).

Desert Grassland

This vegetational regime has been called simply grassland (Kearney and Peebles, 1951), or desert scrub grassland or desert plains grassland (Dick-Peddie, 1993). These areas are used intensively for grazing and hay production, resulting in native species being replaced by introduced grasses (Colorado Native Plant Society, 1989). Species of fescue (*Festuca* sp.), wheat-grass (*Agropyron* sp.), dropseed (*Sporobolus* sp.) and grama (*Bouteloua* sp.) are common here. The ecologically fragile grasslands are susceptible to shrub invasion because grasslands typically border desert scrub and because of human suppression of fire. Also, some land use practices, such as intensive grazing, often initiate and/or accelerate the invasion of grasslands by shrubs.

Juniper Savanna and Coniferous and Mixed Woodland

The Juniper Savanna community consists of a grassland with widely scattered, generally low trees (Dick-Peddie, 1993). Different kinds of juniper may be present, as well as oaks. Pinyon pine is also typical. The savanna is a transition between grassland and woodland. Coniferous and mixed woodlands in this area typically include pinyon pine, Rocky Mountain (*Juniperus scopulorum*) or Utah juniper (*Juniperus osteosperma*), Ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*) mixed in with Gambel oak (*Quercus gambelii*).

Montane Coniferous Forest

The species composition may vary due to the introduction of some species used for reseeding old burns, such as at Molas Pass (Komarek, 1994) where Lodgepole pine (*Pinus contorta*), naturally occurring in cen-

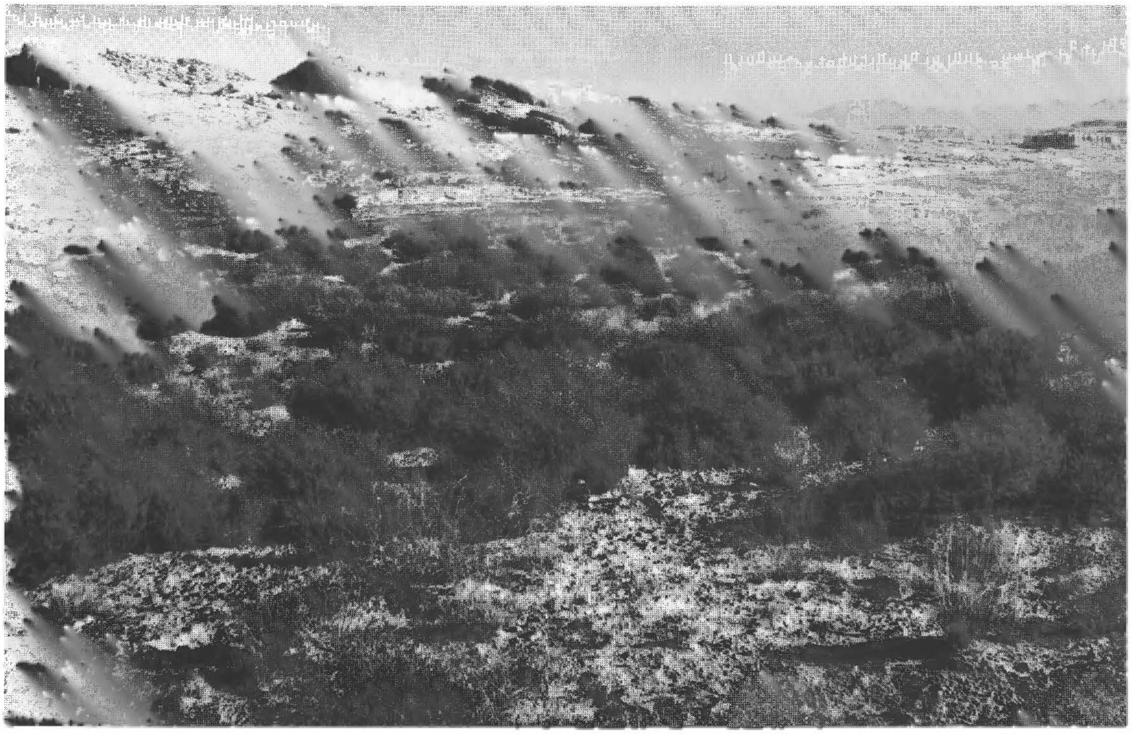

FIGURE 3. Desert scrub on the Carmel Formation (foreground) along Butler Wash, east of Comb Ridge between Bluff and Mexican Hat, Utah. View is NNW.

TABLE 1. List of Plants endemic to the Four Corners region.

Common Name	Scientific Name	Occurrence	Habitat
Knowlton's Cactus	*Pediocactus knowltonii*	San Juan (NM) and adjacent counties	Alluvial hills (2).
Hardwall Cactus	*Sclerocactus whippleii*	San Juan county, NM	Gravelly or sandy ground in Pinyon-juniper association (2).
-------------	*Sclerocactus terrae-canyonae*	San Juan county, UT	Rocky, sandy soil in Pinyon-juniper woodland (4).
Mesa Verde Cactus	*Sclerocactus mesae-verdae*	Montezuma and San Juan (NM) counties	Barren clay hills underlain by Mancos Shale or Fruitland Formation (1,2).
Mancos Saltbush	*Atriplex pleiantha*	Montezuma and San Juan (NM) counties	On barren, Mancos-shale derived clay soils (1).
Schmoll's Milkvetch	*Astragalus schmolliae*	Mesa Verde N.P.	Thin, aeolian soils (1).
Mancos Milkvetch	*Astragalus humillimus*	San Juan (NM) and Montezuma counties	In sandy soil pockets in woodlands (1,2)
Monument Valley Milkvetch	*Astragal usmonumentalis var. monumentalis*	McKinley and San Juan (NM), SE UT, and NE AZ.	Sandy ledges and slopes in Pinyon-juniper association (2).
Cottams Milkvetch	*Astragalus monumentalis var. cottamii*	McKinley and San Juan(NM) and SE Utah	Weathered depression and sandstone crevice of rimrock (2).
Arborales Milkvetch	*Astragalus oocalycis*	San Juan(NM) and SW CO	Alkaline, usually selenium-rich, clay soils (2).
Naturita Milkvetch	*Astragalus naturitensis*	San Juan (NM) and adjacent CO	Known only from sandstones of the Mesa Verde Group (2).
Sleeping Ute Milkvetch	*Astragalus tortipes*	Sleeping Ute Mountain	On barrens developed on Mancos Shale (3).
Cronquist's Milkvetch	*Astragalus cronquistii*	San Juan (UT) and Montezuma counties	In desert scrub communities dominated by Atriplex (1).
Cliff Palace Milkvetch	*Astragalus deterior*	Mesa Verde N.P.	On sandy pockets and talus on the Upper Cliff House Sandstone (1).
Beautiful Gilia	*Gilia formosa*	San Juan county, NM	Sandstone outcrops (2).
Small-flowered Penstemon	*Penstemon parviflorus*	Near Mancos, Montezuma county	Last collected July, 1890, believed extinct.1
Frosty Bladderpod	*Lesquerella pruinosa*	Archuleta county,CO	In oak brush or Ponderosa pine stands on soils derived from the Mancos Shale (1).
Mesa Verde Stickseed	*Hackelia gracilenta*	Mesa Verde N.P.	In dense litter beneath oaks, Pinyon pines or junipers

FIGURE 4. Herbarium specimen of *Astragalus pattersonii*, collected by L. C. Higgins from a *Sarcobatus* sp. community developed on Mancos Shale in Uintah County, Utah. WTAMU Herbarium specimen no. 41239.

FIGURE 5. *Astragalus preussi*, collected April 1977. WTAMU Herbarium specimen no. 32699.

tral Colorado and northward to Montana, was seeded. Typically this forest includes subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmanii*), and aspen (*Populus tremuloides*). On exposed rocky ridges or shallow soils, limber (*Pinus flexilis*) or bristlecone pine (*Pinus aristata*) may occur.

EVOLUTION OF PRESENT ENVIRONMENTS

It is not clear how long the present environments have existed in their present locations, but evidence from packrat middens in Arizona and Utah suggests that the present climatic and vegetational patterns were established as recently as 8000 yrs B.P. (Van Devender and Spaulding, 1979). The evidence suggests a change from woodland to desert or grassland about 10,000 to 8000 yrs B.P. in the Chihuahuan, Sonoran and Mohave deserts (Van Devender, 1977; West, 1979). Dick-Peddie (1993) further noted a marked reduction in winter precipitation about 8000 yrs B.P., and the palynological evidence in New Mexico suggests an increase in grasslands and desert scrub and a decrease in woodlands since that time. The use of fire by native Americans may also have influenced these changes.

DEVELOPMENT OF THE BOTANICAL PROSPECTING CONCEPT

Geochemical dispersion patterns associated with ore deposits may be formed at the time of the formation of the deposit or secondarily by weathering at or near the surface. That plants which thrive in specific metal-rich environments can be used as a clue to the existence of subsurface mineral deposits was recognized hundreds of years ago. Sanders (1967) noted that as far back as the 1400s alum deposits in the vicinity of Rome were located by the realization that a type of holly plant growing above the deposits also flourished above alum mines in Syria. Modern, widespread application of the concept began with early experiments by Soviet geologists about 1932 (Hawkes, 1949). Swedish investigators in the middle 1930s independently developed geobotanical techniques, although Hawkes (1957) noted that the 1938 publication date of the first Soviet paper on use of vegetation for prospecting predates the earliest Scandinavian reports by about a year. Other plant species have been used in other countries to locate copper, zinc, nickel-cobalt, and other ores (Cannon, 1960a). Plants that grow in selenium-rich soils have been used successfully to locate uranium deposits on the Colorado Plateau (Cannon, 1952, 1960b).

BOTANICAL PROSPECTING ON THE COLORADO PLATEAU

The U.S. Geological Survey pioneered the use of methods for botanical prospecting on the Colorado Plateau and described the techniques and results in a series of bulletins published during the 1950s and 1960s. The work of the U.S.G.S. built on previous work done during the 1930s by the U.S. Department of Agriculture. The common factor in both sets of studies was the presence of selenium and the recognition that many selenium-indicator plants—plants present in soils with above-average selenium concentrations—are also significantly radioactive (Cannon, 1960b). Selenium occurs in association with uranium and vanadium and, thus, selenium-indicator plants serve as good indicators of uranium and vanadium mineralization, provided the deposit is at a relatively shallow depth (less than 40 to 60 ft). The geobotanical prospecting methods used on the Colorado Plateau were indicator-plant and plant analysis prospecting (Cannon, 1960b;

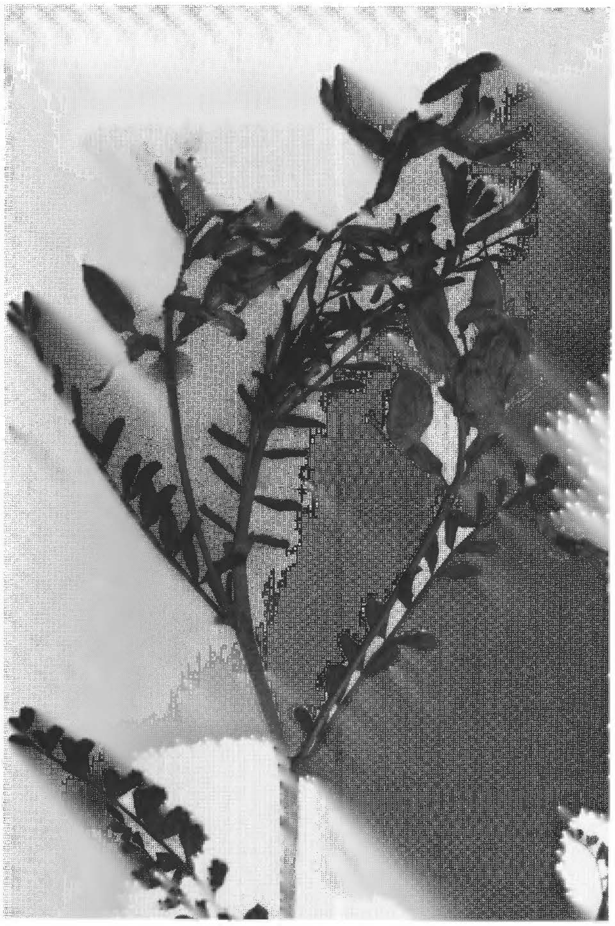

FIGURE 6. *Astragalus cobrensis*, collected in Gila County, Arizona. WTAMU Herbarium specimen no. 24721.

Kleinhampl, 1962). Indicator plants are those which have been shown to indicate mineralization. In a mineralized area their population densities may be much greater than that in unmineralized areas (Rockwell Corp., 1964). Plant analysis prospecting involves collection of plant parts, most commonly leaves, and chemical analyses of these parts for specific elements.

Plants used for botanical prospecting

Indicator plants used to prospect for uranium on the Colorado Plateau belong mostly to the genus *Astragalus*, known commonly as locoweed, milkvetch or poisonvetch. Species of *Astragalus* vary considerably in their ability to take up and concentrate selenium and as reliable indicators of uranium ore bodies. The single most effective indicator (Cannon, 1960a) is *Astragalus pattersonii* (Patterson's locoweed). Cannon reported that the species is widespread and has been useful in prospecting throughout the southwestern part of the Plateau. Cowgill (1990) found that *A. pattersonii* concentrated selenium as much as 250 times that of the soil concentration. Other species of *Astragalus* effective in prospecting are (Figs. 4–6) *A. preussi*, *A. thompsonae*, *A. confertiflorus*, *A. cobrensis*, and *A. aculeatus* (Cannon, 1960a).

Astragalus species are not the only useful indicator plants. Other indicators of uranium include *Aster venustus* (Woody aster), *Oryzopsis hymenoides* (Indian ricegrass), *Grindelia* sp. (gumweed), *Stanleya* sp. (Desert plume) and others. *Eriogonum inflatum*, a member of the wild buckwheat family (Fig. 7), is considered a gypsum indicator (Cannon, 1960a). Cannon reported that multiple indicator species with high population densities provide the most reliable indication of mineralization.

Woody plants are most commonly used in plant analysis prospecting because they possess deeper root systems. The most widespread tree or shrub on the plateau is the juniper and several varieties of juniper have been used to successfully locate deposits that may be at depths of 100 ft or more (Cannon, 1960b).

FIGURE 7. *Eriogonum inflatum*, a striking member of the wild buckwheat family, growing on Permian redbeds near Mexican Hat, Utah. This species is characterized by swollen stems and is a gypsum indicator.

A geobotanical survey for uranium on South Elk Ridge in San Juan County, Utah, in the lower part of the Chinle Group (Kleinhampl, 1962) utilized only plant analysis prospecting because the ridge lies above 7000 ft, too high for *Astragalus* species. Using plant analysis prospecting, 110 localities were identified and subsequent analysis of drill core data indicated that plant analysis prospecting proved twice as successful as drilling in locating mineralization (Kleinhampl, 1962).

A geobotanical survey in the Circle Cliffs area, Garfield County, Utah, in the Shinarump Member revealed that *Astragalus pattersonii* and *Stanleya pinnata* delineated, in a general way, uranium-rich localities (Kleinhampl and Koteff, 1960). However, the sparseness of *A. pattersonii* in the area limited the usefulness of this species.

SUMMARY AND CONCLUSIONS

The diverse habitats of the Colorado Plateau, ranging from Desert Scrub to Montane Forest, provide a variety of indicator plants that can be used for botanical prospecting. The elevation and soil types are the major determinant of the varieties of indicator plants that may be useful in botanical prospecting. At elevations above 6500 ft, few indicator plants may be present and plant analysis prospecting is the only geobotanical method that may be useful.

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REFERENCES

Anderson, J.L. and Porter, M. J., 1994, *Astragalus tortipes* (Fabaceae), a new species from desert badlands in southwestern Colorado and its phylogenetic relationships within *Astragalus*: Systematic Botany, v. 19, p. 116–125.

Cannon, H.L., 1952, The effect of uranium-vanadium deposits on the vegetation of the Colorado Plateau: American Journal of Science, v. 250, p. 735–770.

Cannon, H.L., 1960a, Botanical prospecting for ore deposits: Science, v. 132, p. 591–598.

Cannon, H.L., 1960b, The development of botanical methods of prospecting for uranium on the Colorado Plateau: U.S. Geological Survey, Bulletin 1085-A, p. 1–50.

Colorado Native Plant Society, 1989, Rare plants of Colorado: The Rocky Mountain Nature Association, 73 p.

Cowgill, U.M., 1990, The selenium cycle in three species of Astragalus: Journal of Plant Nutrition, v. 13, p. 1309–1318.

Dick-Peddie, W.A., 1993, New Mexico vegetation: past, present and future: Albuquerque, University of New Mexico Press, 244 p.

Epple, A.O. and Epple, L.E., 1995, A field guide to the plants of Arizona: Mesa, Arizona, LewAnn Publishing Company, 347 p.

Froelich, A.J. and Kleinhampl, F.J., 1960, Botanical prospecting for uranium in the Deer Flat area, White Canyon District, San Juan County, Utah: U.S. Geological Survey, Bulletin 1085-B, p. 51–84.

Hawkes, H.E., 1949, Geochemical prospecting for ores: a progress report: Economic Geology, v. 44, p. 706–712.

Hawkes, H.E., 1957, Principles of geochemical prospecting: U.S. Geological Survey, Bulletin 1000-F, p. 225–355.

Heil, K.D., 1979, Three new species of Cactaceae from southeastern Utah: Cactus and Succulent Journal, v. 51, p. 25–30.

Kearney, T.H. and Peebles, R.H. and collaborators, 1951, Arizona flora: Berkeley, Univesity of California Press, 1085 p.

Kleinhampl, F.J., 1962, Botanical prospecting for uranium on South Elk Ridge, San Juan County, Utah: U.S. Geological Survey, Bulletin 1085-D, p. 105–188.

Kleinhampl, F.J. 1960, Botanical prospecting for uranium in the Circle Cliffs Area, Garfield County, Utah: U.S. Geological Survey, Bulletin 1085-C, p. 85–104.

Knoll, M.A. and James, W.C., 1987, Effect of the advent and diversification of vascular land plants on mineral weathering through geologic time: Geology, v. 15, p. 1099–1102.

Komarek, S., 1994, Flora of the San Juans: a field guide to the mountain plants of SW Colorado: Durango, Colorado, Kivaki Press, 244 p.

Kricher, J.C. and Morrison, G., 1993, A field guide to the ecology of western forests: New York, Houghton Mifflin, 554 p.

New Mexico Native Plants Protection Advisory Committee, 1984, Handbook of rare and endemic plants of New Mexico: Albuquerque, University of New Mexico Press, 291 p.

Rockwell Corporation, 1964, Application of biogeochemistry to mineral prospecting: a survey: National Aeronautics and Space Administration SP-5056, 134 p.

Sanders, H.J., 1967, Chemistry and the solid earth: Chemical and Engineering News, Special Report, p. 1a–57a.

Van Devender, T.R., 1977, Holocene woodlands in the southwestern deserts: Science, v. 198, p. 189–192.

Van Devender, T.R. and Spaulding, W.G., 1979, Development of vegetation and climate in the southwestern United States: Science, v. 204, p. 701–710.

Welsh, S.L., Atwood, N.D., Goodrich, S. and Higgins, L.C., eds., 1993, A Utah flora, 2nd Edition, revised: Provo, Utah, Brigham Young University, 986 p.

West, N.E., 1979, Basic synecological relationships of sagebrush-dominated lands in the Great Basin and the Colorado Plateau: The Sagebrush Ecosystem, A symposium held at Utah State University, April, 1978, p. 33–41.