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Study
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VEGETATION OF THE CITY OF BOULDER, COLORADO OPEN SPACE LANDS

prepared for
CITY OF BOULDER, REAL ESTATE/OPEN SPACE
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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

1.0 INTRODUCTION

1.1 PURPOSE

The overall purpose of the research reported here is to provide the basis for improving the management and preservation of the City of Boulder Open Space lands. The continuing growth of the Colorado Front Range urban population presents a challenge of providing good management of the Open Space lands in the face of large potential human-related disturbances. Management for the preservation of native or unique flora is one goal of the Open Space system. Most of the City of Boulder Open Space system, which was established in 1967, is vegetated with natural plant communities rather than communities that are the product of human manipulation or disturbance. Thus the emphasis of the research reported here is on natural plant communities.

Effective management of natural vegetation is based upon a sound understanding of the characteristics of the natural plant communities and of their environments as well as an understanding of the changes in the communities that follow disturbance. The plant communities on the City of Boulder Open Space lands had not been the subject of a thorough ecological inventory prior to this study and that of Thompson and Strauch (1985). As requested by the City's Real Estate/ Open Space Department, this study was initiated in April, 1984 to study the vegetation of the parcels that had been acquired by that time. See Figure 1-1 for the location of the parcels.

Objectives of this study were to: 1) identify, characterize and describe the

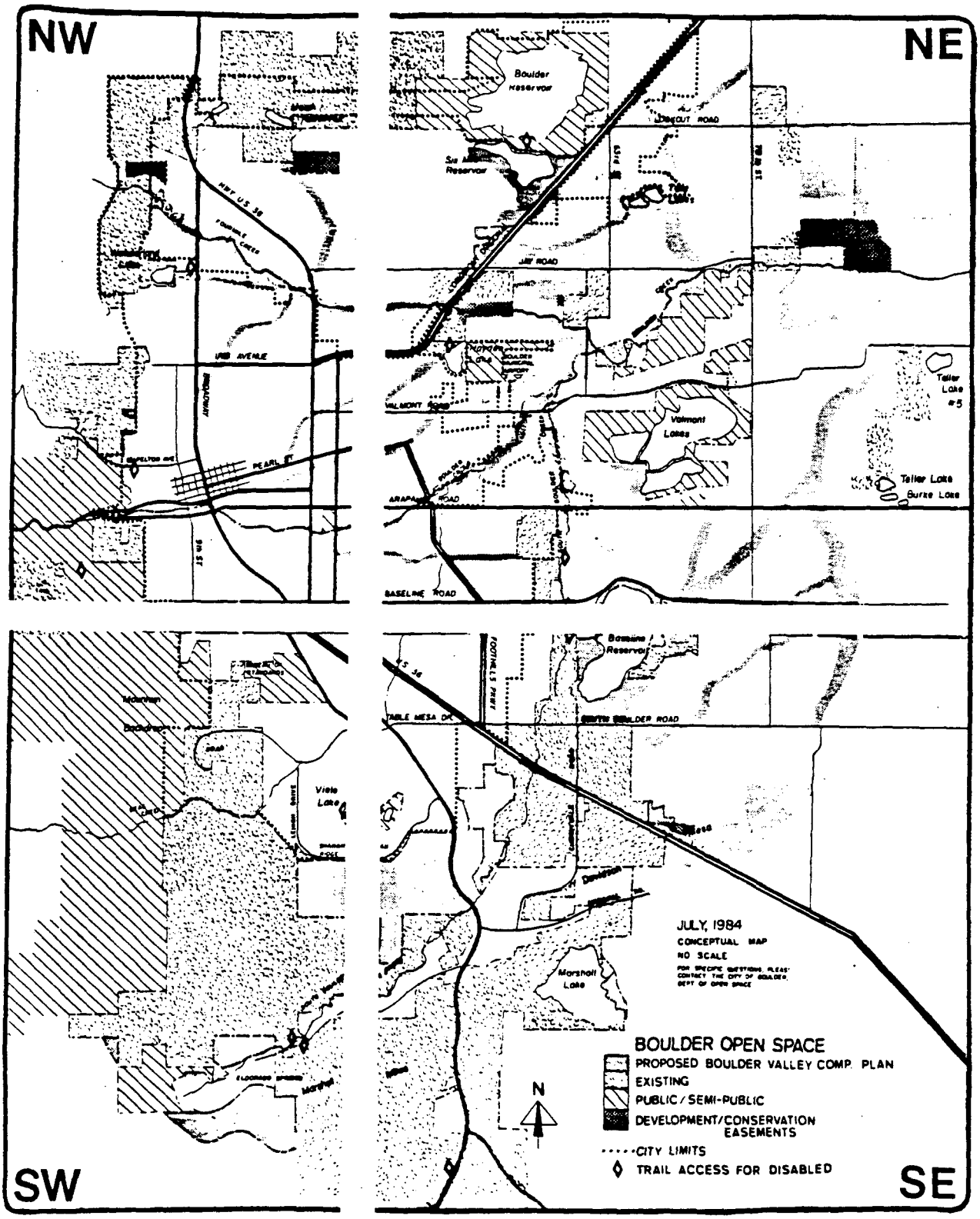

Figure 1-1. 1984 City of Boulder Open Space map. See Plates 1-4 for the detailed property locations and vegetation map.

vegetation types; 2) describe the relationships of the vegetation to environmental factors, including soils and disturbance factors; 3) map the existing vegetation; 4) determine the potential natural vegetation insofar as possible; 5) compare historic with existing treeline; 6) carry out a floristic inventory, including collection of voucher specimens; 7) provide the basis for management recommendations; and 8) gather in one document the floristic and vegetation references most useful for understanding and managing the City of Boulder Open Space lands.

1.2 STUDY AREA

The Open Space lands studied cover about 11,475 acres (4645 hectares) in the vicinity of the City of Boulder, Boulder County, Colorado. The parcels are located between $40^{o}5'$ to $39^{o}55'$N latitude and $105^{o}19'$ to $105^{o}8'$W longitude and extend over a 120 square mile area. Elevations range from 5070 ft (1545 m) on the Ertl property to 7490 ft (2283 m) on the Campbell property, spanning 2420 ft (738 m) of elevation in a horizontal distance of 10 mi (16 km). A number of the properties are adjacent to City of Boulder Mountain Parks property, particularly along the western extent of the Open Space lands. See Figure 1-1.

The natural floristic and vegetation patterns are complex due to existing climatic, topographic and soil factors as well as the climatic changes that have occurred in recent geological time. Superimposed upon this already complex natural mosaic are additional vegetation patterns that have resulted from the long and diverse disturbance history of the region. For example, changes in the natural vegetation patterns relate particularly to changes in

elevation (affecting precipitation and temperature), slope position, slope steepness, aspect, soil texture, soil depth, and site drainage, which together create the pattern of plant-available moisture at each site. Soils in the study area are diverse. Existing plant species and communities have affinities to geographical areas in all directions and within the Rocky Mountain region, as well as to Asia. Both natural and human-related disturbances are diverse and widespread in the study area. Natural disturbances include fires, floods, erosion, slumping, windstorms and infestations. Human-related disturbances that are of concern to Open Space vegetation stem primarily from livestock grazing, logging, forest management, mining, quarrying, agriculture, mowing for hay, irrigation, fire management, construction of trails, roads and structures, and recreational uses. Intense human use of the Boulder area dates from approximately the 1850s (see section 2.2).

An overview of the natural vegetation of the study area reveals grasslands at elevations below about 6000 ft (1830 m), lower montane forests typically dominated by ponderosa pine (Pinus ponderosa) above this elevation, and an intermediate belt with common shrubs and scattered trees that is variably present between approximately 5700 and 6200 ft (1737 and 1890 m) elevation.

2.0 BACKGROUND

2.1 ECOLOGICAL BACKGROUND

2.1.1 Climate and Soils

The climate of the Open Space lands is continental and more similar to tha the plains than the high mountains. Daily and seasonal temperature ranges large, radiation receipts are high, humidity is low, the relatively l precipitation is concentrated in the fall and spring, and it is windy. Average annual precipitation at Boulder is about 18 inches (45 cm) (Paddock 1964). In such a semiarid climate, patterns of plant-available moisture exert a large influence on vegetation patterns.

Surficial geology and soils show important correlations with the natural vegetation patterns, often through their effects on plant-available moisture. As an example, consider one typical set of patterns: the resistant Dakota sandstone hogbacks that form the prominent easternmost north-south ridges are vegetated with ponderosa pines, while adjacent valleys underlain by shale or colluvium (recent deposits of debris locally derived via gravitational processes) are vegetated with midgrass or tallgrass communities. The rocky hogbacks provide a substrate favoring the pines, i.e., with ample plant-available moisture but very well drained, whereas the usually finer substrates in the valleys favor grasses. Another typical set of patterns is for mesic tallgrass vegetation to be situated on poorly drained alluvium, e.g., Niwot soils, while adjacent xeric tallgrass vegetation is on well

drained alluvium, e.g., Nederland very cobbly sandy loams.

The surficial geology of the Open Space lands has been mapped at a scale of 1:24,000 (1" = 2000') in the Niwot Quadrangle (Trimble 1975), the Louisville Quadrangle (Malde 1955), the Eldorado Springs Quadrangle (Wells 1967), and the Boulder Quadrangle (Wrucke and Wilson 1964).

The oldest rocks are exposed in the mountains west of Boulder and are Precambrian igneous and metamorphic rocks. Hogbacks of sedimentary rocks occur along the east edge of the mountains, dating back to times ranging from the Pennsylvanian to the Cretaceous. The plains are underlain by sedimentary deposits variously covered with alluvial (stream deposited), colluvial (moved by gravity), and eolian (windblown) deposits. The former two types of deposits also are common above the plains. In the higher mountains well above the elevations of Open Space, glacial deposits are extensive (Knight 1964).

Soils of the Boulder County Area have been mapped by the U. S. Soil Conservation Service (SCS) at a scale of 1:20,000 (1" = 1667') (Moreland and Moreland 1975), although more recent work has revealed some unspecified inclusions and lumping of map units in the original survey (H. Sprock 1985, personal communication). Most soils are mollisols (with a surface horizon that is thick, dark, soft when dry, and dominated by divalent cations), with smaller areas of dry entisols (very young soils), alfisols (forested soils with a clay layer), and aridisols (dry grassland soils).

Range site descriptions that are relevant to the Open Space lands were published by the SCS between 1975 and 1984 and are being updated. However, correspondence between range site descriptions and specific soil map locations

have not yet been fully worked out. Range sites applicable to Open Space lands include: Loamy Foothill # 202, Rocky Foothill # 206, Clayey Foothill # 208, Cobbly Foothill # 213, Wet Meadow #38, Salt Flat # 34, Shallow Loam # 230 and Shallow Foothill # 204. Possibly applicable are Shaly Foothill # 212, Sandstone Breaks # 53, and Overflow # 36. Woodland/Forest descriptions relevant to Open Space lands are Riverbottom #73, Ponderosa Pine and Douglas-fir.

2.1.2 Vegetation and Flora

The general vegetation patterns of the Boulder area have been the subject of floristic and ecological interest for many decades (Daniels 1911; Marr 1964, 1967; Mutel 1976; Ramaley and Kelso 1931; Vestal 1913, 1914, 1917, 1919; Weber 1964, 1976). A full catalog of the Boulder County flora is in preparation by Dr. W. A. Weber of the University of Colorado Herbarium. In 1983(a) and 1984(a), Baker listed over 120 references to the vegetation of Boulder County. The compilations of literature in this chapter include the literature compiled by The Nature Conservancy (1983).

Prior studies of Open Space and Mountain Parks lands concern tall grassland (Colorado Natural Heritage Inventory 1982, 1982a; Moir 1969, 1971, 1972), the Marshall Mesa area (Biggins and Dodson 1970; Komarkova and Gordon 1982), the Long and Horse Mesa areas (James 1930; Komarkova and Gordon 1982; Roach 1948; Robbins 1908; Robbins and Dodds 1908), the Sawhill Ponds area (Beidleman 1948, 1954), a general vegetation map of the southern part of the Open Space lands (Marr and Boyd 1979), and the White Rocks area or Ertl property (Environmental Analysts Inc. 1972; Gage Davis Associates 1982; MacPhail et al. 1970;

Keammerer and Keammerer 1983). Several studies of riparian areas are being carried out by faculty at the University of Colorado Department of EPO Biology and by consultants to the City.

Overviews of the vegetation of the Boulder Mountain Parks (Cooper 1984) and the flora of the Mountain Parks (Weber 1984; Wittmann 1984; Cooper 1984) are found in Cooper ed., 1984. Vegetation categories identified by Cooper (1984) that would be applicable to Open Space properties are: ponds and reeds, grasslands, plains riparian, foothills riparian, grassland-forest ecotone, ponderosa pine forest, mixed ponderosa pine-Douglas-fir forest, and rock faces and rock canyons. Thompson and Strauch (1985) mapped the wildlife habitats on the City of Boulder Open Space lands using 12 map units (in order of descending acreage): grassland, conifer, agricultural grassland, mountain shrub, agriculture, riparian, disturbed, wetland, buildings, lakes & ponds, cliffs, and talus.

Rare plants are known to occur at several localities on Open Space lands. The White Rocks area supports the very rare fern, Andrews' spleenwort (Asplenium andrewsii), and the regionally rare American ground-nut (Apios americana) and three-awn (Aristida basiramea) (Keammerer 1983; Weber 1976). Bell's twin-pod (Physaria bellii) has been found on shale outcrops on the Mann property (Colorado Natural Heritage Inventory 1984b). Small-leaved false indigo (Amorpha nana) was once considered very rare (Weber 1976) but has been found in the vicinity of the National Center for Atmospheric Research, on Mountain Parks lands (R. Wittmann 1985, personal communication), and on Open Space properties including Stengel 1, Erni (J. Scholl 1985, personal communication; B. Peck 1985, personal communication), and Abbey. Of these five rare plant

species, two have Federal status - the spleenwort and Bell's twin-pod. Both are Category 2, or candidates for listing as threatened or endangered, but with current data not sufficient to support listing at this time (Colorado Natural Heritage Inventory 1984a; U. S. Fish and Wildlife Service 1980, 1983). Other unusual plants are discussed in Weber (1984).

Vegetation studies on neighboring lands concern Rocky Flats (Branson et al. 1961, 1964, 1965; Clark 1977; Clark et al. 1980; Hadley and Branson 1965), Gregory Canyon (McHenry 1929, 1930), Lefthand Creek (Beidleman 1954), and Haystack Mountain (Ulman and Young 1970). Relevant ecological studies carried out in Larimer County just to the north of Boulder County include Hanson 1953; Hanson and Dahl 1956; Hess 1981; Kovacic 1983; Peet 1975, 1978, 1978a, 1980, 1981). Farther south along the Front Range, Livingston (1952) described tall grassland "remnants" that resemble tall grasslands near Boulder.

Two comprehensive classifications of the natural vegetation of Colorado are available: Baker (1984) and Johnston (1984). The former includes all known presettlement types in the Boulder area and is under revision. Johnston covers five states, including those that border Colorado on the north and east. An overview of Colorado vegetation patterns is found in Armstrong 1972; Costello 1954; Dix 1974; Mutel and Emerick 1984; and Ramaley 1927. A floristic inventory of Colorado has been prepared by Drs. W. A. Weber and B. Johnston (1979, 1981), which is the basis for the nomenclature used here.

2.2 DISTURBANCE OF VEGETATION

The disturbance and recovery of plant communities in the vicinity of Boulder was the subject of a recent study by Komarkova and Gordon (1982). Following

the 1859 discovery of gold ore in the Gold Hill area and lasting about until the turn of the century, logging, human-related fires and other human activities resulted in substantial deforestation. Roads and railroads were constructed. The leading disturbance on the rangeland prairies was grazing. Komarkova and Gordon (1982) note that "while natural disturbances are part of the dynamics of Colorado ecosystems, their incidence is relatively low ... in the Front Range. During the period of exploration and initial settlement, the incidence, extent and intensity of disturbances is greatly increased." They concluded that recovery is occurring at a very slow rate due to the dry, continental climate.

No Open Space properties are known to be free from disturbance by European peoples and almost all are known to have been logged or grazed by livestock before they were acquired by the City of Boulder (e.g., Colorado State Forest Service 1982; Komarkova and Gordon 1982). Due to their steepness and rockiness, possibly parts of Barute, Campbell and McCann were not so affected. Furthermore, many Open Space properties were overgrazed or substantially disturbed by recent logging or other recent human use before the time of acquisition. Exceptions to this were found on Abbey, Barute, Brammiar, Campbell, Culberson, Debacker, Dunn 1, Erni, Kassler and adjacent properties, Moore, and Wells (A. Wichmann 1985, personal communication).

Although winter grazing is not the only practice that sustains tallgrass communities, several properties that have been winter grazed have sustained healthy natural plant communities of tallgrasses; notably, parts of Church, THP, and Yunker. These properties include areas now designated as Colorado Tallgrass Natural Areas by the State Department of Natural Resources and the

City of Boulder.

2.2.1 Grazing

Range condition data collected between 1976 and 1983 document improving trends on most acquired Open Space rangelands, apparently as a result of management techniques aimed at improving the native species (B. Peck and A. Wichmann 1976 through 1983). Exceptions to the improving trends were caused by poor management techniques that were not in the control of the City (C. Wilson 1985, personal communication).

In 1984, the City Open Space Department hired an agricultural manager who is utilizing a holistic approach for planning and implementing range and pasture land management programs. The programs consider ecosystem and species characteristics, limitations, maintenance, and health, as well as multiple use demands, such as livestock grazing and recreation. The programs are planned to include monitoring of soils and plant community changes so that management practices can be evaluated (D. Antonio 1986, personal communication).

The range site descriptions of the SCS include discussions of vegetation changes that result from poor management of livestock grazing. If overgrazed sufficiently, soil compaction and erosion may also occur. In general, in the Boulder area, poor management of livestock grazing leads to a decline in tallgrasses, if present, and eventually to a decline in midgrasses, with green needlegrass (Stipa viridula) being particularly sensitive to grazing pressure. On well drained sites, common increasers or invaders include the shortgrasses blue grama (Bouteloua gracilis), red three-awn (Aristida longiseta), and buffalo grass (Buchloe dactyloides) on fine soils; the shrubs

snakeweed (Xanthocephalum sarothrae) and rubber rabbitbrush (Chrysothamnus nauseosus); the annuals cheatgrass (Bromus tectorum), Japanese brome (Bromus japonicus), curlycup gumweed (Grindelia squarrosa), and others; and the herbs pasture sagebrush (Artemisia frigida) and golden aster (Heterotheca villosa).

On moist or wet, poorly drained sites, common increasers or invaders include redtop (Agrostis gigantea), Kentucky bluegrass (Poa pratensis), Canada bluegrass (Poa canadensis), smooth brome (Bromopsis inermis), and common timothy (Phleum pratense) (H. Sprock 1985, personal communication; SCS 1975 through 1984).

2.2.2 Forest management

Parts of the following properties have been considerably disturbed by recent forest management activities aimed at controlling pathogens: Brammiar, Culberson, Debacker, Dunn 1, Stengel 1, Schnell, Wells and Whittemyer. Forest management programs have been carried out on City of Boulder Open Space lands since about 1973 in order to control forest pathogens, and also have substantial effects on forest understory.

From 1977 to 1982 a massive interagency effort was organized in Boulder County to control mountain pine beetle (Dendroctonus ponderosae). Most forested Open Space lands had been affected by the mountain pine beetle with the exception of Flatirons Vista, where preventive thinning is currently occurring (C. Wilson 1985, personal communication). Other goals of the tree cutting program were to reduce the danger of wildfire, develop wildife habitat and, in some cases, improve scenic quality. Effects on understory typically include increased exotics and weeds, caused by two factors: opening of the tree layer,

which decreases competition for root moisture and increases sunlight incident on the understory; and surface soil and vegetation disturbance from the physical processes of clearing timber trails and from tree cutting and the resulting woody debris. Also, soil compaction from vehicular operation may affect the vegetation.

Forest management activities continue as needed in order to control the mountain pine beetle and other pathogens, such as the Ips beetle (Ips sp.), twig beetles (Pityophorus spp.), the ponderosa pine needleminer (Coleotechnites ponderosae), western spruce budworm (Choristoneura occidentalis), and dwarf mistletoe (Arceuthobium vaginatum ssp. cryptopodum) (Colorado State Forest Service 1982).

2.2.3 Treeline

Komarkova and Gordon's (1982) review of disturbance in the Boulder area and their study of vegetation changes over the last 80 years at selected sites shows that forests are apparently recovering from past deforestation initiated by miners and early settlers of the Boulder area. Their comparisons of recent and early 1900s photographs just south of Eldorado Springs show very apparent increases in density within tree stands as well as migration outward into grasslands. The changes are similar but less marked in pairs of photographs taken 34 years apart on the Flatirons Vista property. Study of photographs taken 60 and 90 years apart at a drier location to the east of the preceding (on Rocky Flats) showed no advance of the trees into the dry prairie area.

Komarkova and Gordon's results agree with other observations of tree advancement for the Boulder area (Beckmann 1977; Robbins and Dodds 1908; Roach

1948) as well as vegetation changes seen in other western states. Veblen (1985, personal communication) also reported that the reforestation rates around Boulder are highly variable and apparently related to soil factors.

Several authors favor the hypothesis that the advance of lower treeline downslope in the Boulder area is due to factors other than recovery after drastic disturbance, for example, due to chronic disturbance from mismanagement of livestock grazing, which decreases competition from herbaceous plants (Cooper 1985; Komarkova and Gordon 1982; Roach 1948; Robbins and Dodd 1908; The Nature Conservancy 1983). Weber (1965, 1976) and Weber et al. (1974) note that the Boulder area was more densely forested in the past, and that Rocky Flats has not revegetated as fully as surrounding lands because of overgrazing, timber cutting, burning and winter winds.

Another possible reason for the advance of treelines is the change in fire regime since the arrival of European settlers and the demise of the native Americans. It appears that native Americans were responsible for many fires throughout the Interior West for a millenium before Euro-American settlement (e.g., Arno 1985; Gruell 1985). Natural pre-settlement fire firequencies are probably 35 to 45 years (Crane 1984). Comparisons of century-old with recent photographs show successional patterns differing significantly -- shrubs and trees now invade where graminoids and herbs had dominated (Gruell 1985).

2.2.4 Fire

Current knowledge of the fire characteristics of grasses, herbs, shrubs and conifers supports the hypothesis that recent fire suppression may explain the advancing treeline in many western localities (Arno 1985; Wright and Bailey

1980). In general, frequent, light fires help to maintain mid-height or tallgrass dominance since they regenerate readily from buds near the soil surface. Longer intervals between fires favor most coniferous trees (Arno 1985; Martin 1982). Fire characteristics of ponderosa pine are reviewed by Fischer and Clayton (1983) and of grassland species by Wright and Bailey (1980). Alexander (1979, 1980) and Martin (1982) review a number of fire history studies and Lotan et al. (1985) and Wright and Bailey (1982) report on many aspects of fire ecology.

Laven et al. (1980) and Rowdabaugh (1978) describe work on fire frequencies in the Colorado Front Range montane zone, but well above the elevations of the City of Boulder Open Space lands. Both papers found the mean fire interval to be longer than that in other parts of ponderosa pine's geographical range, where the interval is roughly 5-20 years. Laven at al. (1980) estimated that small fires, including human-caused ones, have occurred on the average every 20.9 years and large ones every 41.7 years. Mean intervals between fires were 66 years in the pre-settlement era (pre-1840), 17.8 years in the settlement period (1840-1905), and 27.3 years in the fire suppression era (post-1905).

The only recent fire over about 5 acres area that was found during this work on City of Boulder Open Space lands occurred in 1980 on the Erni property (A. Wichmann 1985, personal communication).

The City of Boulder Parks department has attempted to improve an overutilized mesic tall grassland on Open Space lands, on the Gebhart property, by several burns that aimed to eliminate redtop (A. Wichmann 1985, personal communication). Use of fire as a management tool in tall grasslands has been

the subject of work at the Konza Prairie Research Natural Area in Kansas, where research is being carried out by biologists from Kansas State University in Manhattan. Restoration of overgrazed or mowed tall grassland requires cessation of the disturbance, and can require removal of undesirable species by burning or mechanical means as well as the planting of desirable ones (e.g., Hurlbert 1973; The Nature Conservancy 1983).

2.2.5 Other Disturbance

The activities of Euro-Americans have also changed some aspects of the hydrology of the Boulder area, particularly flooding from creeks and water distribution from irrigation ditches. Some human activities such as dumping residues into creeks and building on and the paving of substantial lands tend to increase peak floods with greater resultant destruction of bridges and floodplains (Madole 1973; Schoolland 1980). In contrast, water diversions and dams tend to interrupt flood cycles that are apparently needed for perpetuation of riparian ecosystems such as cottonwood groves (Crouch 1961, 1978, 1979). Observations made in this work indicate that leakage from irrigation ditches may be supporting some mesic tall grassland remnants (cf. The Nature Conservancy 1983). Many ditches were constructed early in the settlement period. For example, Farmers Ditch dates from 1862.

Prairie dog (Cynomys ludovicianus) activity on several of the Open Space parcels has been present for some time and is associated with significant vegetation disturbance. Armstrong and Freeman (eds. 1985) suggest that prairie dogs are more a symptom than a cause of poor range condition because the prairie dogs prefer over perennials the more productive annuals that

result from overgrazing. On the other hand, prairie dogs themselves disturb the vegetation, maintain or favor annuals, and favor hardy perennials such as inland saltgrass (Distichlis spicata ssp. stricta) and buffalo grass (Agnew 1983; Detling and Painter 1983; Uresk 1984; H. Sprock 1985, personal communication). However, inland saltgrass is typically found on wetter sites than those preferred by prairie dogs.

Recreational use of the City of Boulder Open Space lands is having increasing impacts on the natural vegetation. For example, Dr. Will Moir, ecologist with the U. S. Forest Service, has studied Boulder's remnant tall grasslands and has expressed concern about an exotic, smooth brome, invading into tallgrass areas that are used for recreation, e.g., in the Chautauqua area (Moir 1982, personal communication, reported in The Nature Conservancy 1983). Dr. W. A. Weber, Professor of Natural History and Curator of the Herbarium at the University of Colorado Museum, has expressed concern about impacts on natural vegetation from recreational use of the Boulder Open Space and Mountain Parks (Weber 1976; Weber 1984).

Management problems associated with recreational use of public lands have been studied by researchers and public agencies and include economic and human behaviorial aspects as well as vegetation, wildlife and soil aspects (e.g., Stankey and McCool compilers 1985). The U. S. Forest Service has an active recreation research program that is being carried out by several Forest and Range Experiment Stations. Their recreation publications, as well as others concerned with natural resources, may be accessed by Westfornet, a computerized bibliography that is publicly available, for instance, at the Boulder County District Ranger Office.

3.0 METHODS

3.1 ECOLOGICAL TERMINOLOGY

The City of Boulder Real Estate/Open Space department asked that this study address presettlement, historic, and potential natural vegetation as well as existing vegetation. Clarification of these terms is necessary in order for the City to comprehend the possible utility of these approaches to vegetation, especially in view of the fact that various definitions of these terms are utilized by different ecologists. The definitions used here are widely accepted in the western United States and serve the purposes of this project.

The concept of potential natural vegetation (PNV) is widely applied in the western United States (e.g., Küchler 1964; Daubenmire and Daubenmire 1968; Pfister and Arno 1980; Johnston 1984). The approach is to identify units of PNV, or plant associations (P.A.s), which are climax community types represented by stands occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all layers. A plant association is the community at climax, which is the culminating stage in plant succession for a given environment, that develops and perpetuates itself in the absence of disturbance. Indicators of disturbance or lack of disturbance are used in the field to identify plant associations since the existing or actual vegetation is rarely climax.

While a plant association is a climax plant community, a plant community type or C.T. is a unit of existing vegetation, which is an assemblage of plants

living together, reflecting no particular successional status. A vegetation type as used here is a generic term referring to either plant associations or plant community types. A vegetation map unit (M.U.) may be one or a group of vegetation types or it may represent unvegetated lands, e.g. buildings.

The advent of Europeans in this country created numerous plant communities as a result of domestic grazing, water impoundments, logging, mining, fires, protection from fire, and other disturbances. Such activities do not affect plant associations since these represent PNV (cf. Baker 1984), while at the same time such activities greatly affect existing distribution of plant communities and our knowledge of them.

The concept of potential natural vegetation has strengths and weaknesses.

> Potential natural vegetation can only be constructed. ... This is because potential natural vegetation is a conceptual abstraction that is established from a knowledge of the existing vegetation, its developmental tendencies, and its site relationships. Therefore, a potential natural vegetation map provides a mirror-image of the current state of knowledge with respect to the present vegetation potential of a region. If these restrictions are clear in one's mind, such maps can be used to advantage, either for practical purposes or as starting bases for other research. (Mueller-Dombois & Ellenberg 1974).

Because PNV synthesizes so much knowledge, it can be a very valuable interpretive tool for land managers. The U. S. Forest Service has been inventorying its western lands for approximately the last thirteen years using the habitat type, and thus utilizing the concept of PNV. A habitat type is an aggregation of lands potentially capable of producing the same plant association at climax, i.e., the same PNV.

Potential natural vegetation is defined differently than either presettlement or historic vegetation. Historic vegetation that was once present on a given area at an earlier time (regardless of successional status) is generally hard to reconstruct accurately. However, historic treeline can be determined from old aerial photographs rather easily. Presettlement or "original" vegetation is the particular historic vegetation that was present in an area before humans had any influence on it. It is not necessarily PNV because natural disturbances such as lightning-caused fires or grazing by native animals such as bison would have affected it. In the Boulder area and in this work, presettlement refers to the time before Europeans settled here, or, before the 19th Century. However, native Americans had lived in the region and apparently influenced the vegetation for a millenium, albeit at a low level of disturbance compared to Euro-Americans (see preceding chapter). Thus pre-human influenced vegetation in the Boulder area lies so far back in history that at that time, there may have been a different climate and floristic assemblage.

The problems with applying the preceding concepts of vegetation are accounted for in the concept of natural vegetation (NV) utilized by the Colorado Natural Heritage Inventory (Baker 1984), which recognizes that although possibly affected by natural disturbances and activities of native Americans, presettlement vegetation was not dramatically altered by humans and serves as a good reference point for understanding subsequent changes. The concept and field identification of natural vegetation resemble PNV, but include as plant associations those vegetation types maintained by periodic natural disturbance. In this work, vegetation types relatively undisturbed by

Europeans and fitting the definition of natural vegetation are discussed as plant associations.

3.2 DATA COLLECTION

An initial survey of published and unpublished literature led to a tentative list of vegetation types with data on their expected characteristics and distribution. This list was refined in late summer after several months of field studies of the Open Space properties and after reexamination of the literature. The assistance of the following people in making available unpublished information is greatly appreciated: Bill Baker, Jane Bock, Colorado Natural Heritage Inventory staff, Debbie Keammerer, Warren Keammerer, Vera Komarkova, Barry Johnston, Harvey Sprock, Maureen O'Shea Stone, Rick Thompson, Ann Wichmann, and Chris Wilson. Special acknowledgement is due to Dr. Barry Johnston, who was also very helpful in reviewing the draft report.

The procedures used in this research were designed to accomplish a thorough inventory and mapping of the diverse vegetation on 11, 475 acres (4645 hectares) in one field season. A baseline vegetation study of an area as complex as the Boulder Open Space lands is ideally carried out over more than one field season. During the first year, extensive floristic collections are made, and field and office data are collected on the existing vegetation, and the distribution and environments of the vegetation types. The data is analyzed, the vegetation types are identified and characterized, map units are determined and initial maps are drafted. The mapping is field checked in the second year, when additional floristic collections and verifications of the plant communities, plant associations and map units are made. However, in

order to meet the schedule for this project, all of the field studies were carried out in one year, between April and December, 1984. Field mapping was accomplished after August.

Time limitations did not allow quantitative samples that are customary in plant association studies (Daubenmire and Daubenmire 1968; Pfister and Arno 1980). Instead the approach was to collect methodical, qualitative data that would allow accomplishment of all the goals of the project. More detailed data were taken on relatively undisturbed vegetation than on disturbed vegetation. Some of the procedures used here resemble the reconnaissance survey methods of Baker (1982). The data collection methods described below allowed identification and characterization of plant associations as well as mapping of existing vegetation.

Use of methodical, qualitative methods allowed enough time for on-the-ground surveys of every parcel within the 11,475 acres (4645 hectares) of Open Space lands by December, 1984, as well as providing enough data to relate existing vegetation to already known plant associations of the region (Baker 1984; Johnston 1984) and to initially characterize several plant associations not previously described.

In order to accomplish all the tasks of the baseline vegetation inventory in one field season, a data collection system was designed as follows. Three sets of field sheets were made up for each of the Open Space properties: a data sheet, a copy of an aerial photograph, and a topographic basemap, with the property boundaries drawn in on the latter two sheets. The aerial photographs were 1:12,000 (1" = 1000') black and white, 1979 photos borrowed

from the City of Boulder Engineering Department. Their resolution was fair to good. The topographic basemaps were 1:12,000 (1" = 1000') maps obtained from the City of Boulder Engineering Department, which had been adapted from U. S. Geological Survey 1:24,000 (1" = 2000') topographic maps. The general procedure was to record data on a data sheet with a location code that corresponded to a specified location recorded on the basemap or photo. Thus information useful for mapping was gained at the same time that earlier phases of the research were accomplished.

Floristic collections were taken fairly continuously throughout the 1984 field season, with notes recorded on the data sheet. Searches specifically directed at threatened or endangered species were beyond the scope of work. Through the cooperation of Dr. William A. Weber, Professor of Natural History and Curator of the Herbarium at the University of Colorado, Mr. Ronald Wittmann identified some and verified many of the specimens with final verification to be done by Dr. W. A. Weber. Mr. Ron Wittmann was extremely helpful and provided assistance invaluable in accomplishing the field studies within one field season. Voucher specimens are being deposited at the Herbarium of the University of Colorado Museum. Nomenclature follows Weber (1976) and Weber and Johnston (1979). Because much taxonomic reevaluation is now occurring, post-1979 nomenclatural changes are not included in this report.

Kentucky bluegrass and native Kentucky bluegrass Poa agassizensis were not distinguished from each other and both are referred to here as Kentucky bluegrass.

The relatively undisturbed examples of vegetation found, i.e., plant

associations, were not presettlement remnants; however they were recognized by reference to the following features or indicators of remnant vegetation (Baker 1982, 1983; Daubenmire 1970): 1) absence or little sign of livestock grazing, such as trails, cowpies, or compacted or terraced soils; and little sign of logging, such as stumps, access roads or cut debris; 2) absence or low coverage by exotics, weeds, or indicators of overgrazing as noted in section 2.2; 3) presence of healthy, large native plants, and generally abundant native grass cover; 4) general absence of excessive or accelerated erosion, such as rilling orgullying; 5) absence of signs of human disturbance, such as quarrying, garbage, trails, etc.

Field data collected for relatively undisturbed vegetation included information on location, environment, the vegetation, and any disturbance signs. Environmental data taken were: elevation, aspect, slope steepness, slope position, landform, obvious soil features such as surface texture, moistness and rockiness, and adjacent vegetation. Environmental data on soils were also obtained in the office from the SCS Soil Survey (Moreland and Moreland 1975).

Vegetation community data were: cover data for major and selected minor species -- by categories of dominant, common, scattered, or widely scattered; ocular estimates of total vegetation or cover by layers, and of bare soil, rock, and litter; if trees present, description of cover or density and sizes. Descriptors of canopy cover for trees are closed, open, and very open, referring, respectively, to three classes of tree canopy cover: over 60%, between 25 and 60%, and under 25%. Descriptors of total canopy cover for shrub and herbaceous layers are reported in six classes: very high (greater than

90%), high (75 to 90%), moderate (50 to 75%), low (25 to 50%), very low (10 to 25%), and extremely low (under 10%).

Disturbance signs were noted as described in the preceding paragraph, with descriptions of type, amount and likely time of disturbance. Records of any photographs were made.

Field data at a given location were all of or a subset of the preceding data. If the plant community or map unit was fairly clear and had already been described, little data was recorded. If not clear, which was the case in much disturbed vegetation, then a fuller set of data was recorded so that the location would not require another field visit in order to map accurately.

Aerial photographs taken in 1937 and 1938 were obtained from the U. S. Forest Service in order to study historic treeline on the Open Space properties. The photographs were at a scale of 1:24,000 (1" = 2000') or 1:20,000 (1" = 1600'). Their resolution was fair to good.

3.3 DATA ANALYSIS AND SYNTHESIS

In late summer, after several months of field surveys, data were summarized on the vegetation, site, and disturbance characteristics of the plant associations and plant communities on the tentative list. Along with a second review of relevant literature, this summary of the field notes allowed the preparation of a working list of about 45 plant associations and plant communities. From this list was derived a working list of 28 map units that was used in the field and in 1985 streamlined down to the final 18 map units.

Considerable care was taken so that the definitions of the map units

integrated customary vegetation mapping procedures (e.g., UNESCO 1973) with the needs of the City Open Space for information that would be useful in managing the lands. For example, even if vegetation was very disturbed, it was mapped as a plant community or plant association rather than "Disturbed" as long as one of the former could be identified, with the subscript d used to indicate conspicuous disturbance of the vegetation. Similarly, plant associations rather than plant community types were mapped whenever they were identifiable.

Final mapping of existing vegetation was carried out in the office using field notes and field mapping, and where necessary, the 1979 1:12,000 (1"= 1000') air photos. The smallest area mapped is about one acre. Unmapped inclusions can cover up to about 20% (usually less) of a map unit. Unmapped inclusions are necessary due to the scale of the map and particularly, where the inclusions are too narrow, small or interdispersed to be individually mapped. Mosaics are shown (by a slash, /) where two map units are interdispersed and the minor unit comprises more than 20% of a mapped area. In a few cases an area that is intermediate between two map units is best described as a mosaic. Boundaries between adjacent map units are necessarily shown as a line, but were sometimes gradual or unclear. In this case, the boundary was located at what was judged to be the most appropriate place in the transition zone.

After final mapping, characteristics of the vegetation types were summarized. Site factors were synthesized by use of a single estimate of site moisture regime, which was made using an eight (8) part subjective scale ranging from very wet to very dry (Clark et al. 1980). The estimate was based on field

observations, supplemented by information from the literature. Summary of the vegetation characteristics was the basis for naming the plant associations. Procedures for naming follow the practices of Baker (1984) and Johnston (1984). A P.A. is named for the dominant species (based on greatest percent canopy cover) in each stratum (layer) of most of the stands of the P.A. A slash (/) separates species in different strata (trees/shrubs/grasses) whereas a dash (-) separates species that are codominant within the same stratum. A parenthesis () indicates that the species is often but not constantly a dominant.

Patterns of natural vegetation were inferred by synthesis of several sources of data: my field notes; vegetation and soils literature, especially Baker (1984) and Johnston (1984), the SCS Boulder area soil survey (Moreland and Moreland 1975), SCS range site descriptions, and information from SCS Range Conservationist Harvey Sprock; and comparisons of the existing vegetation map with the same scale U. S. Geological Survey topographic maps.

4.0 RESULTS AND DISCUSSION: THE VEGETATION TYPES

4.1 OVERVIEW

The following summary of the natural vegetation patterns on Open Space lands utilizes data from past research (see section 2.1) although it is based primarily on data from the research carried out for this study. Baker (1984) and Johnston (1984) have reviewed the literature pertaining to the plant associations (P.A.s) that are discussed here. Therefore reference will be made here to their synonymous or similar P.A.s and only selected additional literature will be cited.

Following a brief overview is a more detailed discussion of map units (M.U.s). Less disturbed M.U.s are discussed first, then disturbed and cultivated M.U.s. Within each major group of natural vegetation (i.e., grassland, savannah, forest/shrubland), the M.U.s are discussed from drier to wetter types. Likewise, within each M.U., the P.A.s are discussed from drier to wetter types. The discussion for each M.U. first characterizes the M.U., then lists synonymous P.A.s and then summarizes the vegetation, site, and disturbance and distribution data for the M.U. and the P.A.(s), as appropriate. A "Cf." in the list of synonymous P.A.s indicates that noteworthy vegetation or site characteristics differ from those reported here.

Plates 1 through 4 (in pocket) show the existing vegetation as mapped on the City of Boulder Open Space properties. Section 5 summarizes the vegetation patterns by property. The Appendix contains a species list.

Patterns of Vegetation

Natural vegetation patterns in the Boulder area are complex. Grasslands are diverse and include widespread Mid-height and Xeric Tallgrass Grasslands as well as Mixed-height Grassland, Short Grassland, Mesic Tall Grassland, and Steep/Sparse vegetation. Wetlands are found on poorly drained sites at bottom slope positions.

On Open Space lands, codominance by shrubs and grasses and the presence of scattered trees characterize many areas intermediate between grasslands and forests (i.e., the forest-grassland ecotone), usually between the elevations of about 5700 and 6200 ft (1737 and 1890 m). However, a sub-forest altitudinal zone dominated by xeric-site shrub thickets is absent from the study area.

Ponderosa Pine Forests are the predominant vegetation of the lower montane zone above the plains grasslands, with Douglas-fir (Pseudotsuga menziesii) on the moister forested sites. Talus vegetation resembles that of Douglas-fir Forest whereas Cliff vegetation resembles that of Mountain Shrub or Ponderosa Pine Forest or Savannah.

Mountain Shrub thickets are found on some mesic uplands as well as in minor drainages. Riparian, deciduous tree and shrub communities are found along the creeks and many of the irrigation ditches in the study area and undergo changes in species composition and structure with increasing altitude.

Four map units that represent unvegetated, disturbed or cultivated lands cover minor areas of the Open Space lands: Open Water, Building, Agricultural Field,

and Disturbed Land.

4.2 GRASSLAND

4.2.1 Steep/Sparse Vegetation (Map Unit E)

This map unit is typically sparsely vegetated, steep, and has at least one of the following species common: Indian ricegrass (Oryzopsis hymenoides), New Mexico feathergrass (Stipa neomexicana) and sunflower (Helianthus pumilus). It is located on shale or steep sandstone slopes that are found below the coniferous forest zone primarily on the northwest Open Space properties.

Synonymy

For the Indian ricegrass Shale Barrens P.A.
(Oryzopsis hymenoides Shale Barrens P.A.):

Indian ricegrass Shale Barrens P.A. (Oryzopsis hymenoides Shale Barrens P.A.)	Baker (1984)
Cf. New Mexico feathergrass Mixed Prairie P.A. (Stipa neomexicana Mixed Prairie P.A.)	Baker (1984) Moir (1969)

Moir (1969) studied New Mexico feathergrass communities north of Boulder that were situated on shale derived soils, had a higher canopy cover than Sparse Vegetation, and could be treated as a blue grama-needlegrass community (Johnston 1984).

For the Skunkbrush/Needlegrass Sandstone Breaks P.A.
(Rhus aromatica ssp. trilobata/Stipa spp.) Sandstone Breaks P.A.):

Cf. Skunkbrush/Bluebunch wheatgrass P.A. (Rhus trilobata/Agropyron spicatum P.A.)	Johnston (1984)
Cf. Mountain mahogany/Needle-and-thread P.A. phase Skunkbrush sumac (Cercocarpus montanus/Stipa comata P.A. phase Rhus trilobata	Johnston (1984)

Note that mountain mahogany is highly palatable to deer.

SCS Range Sites that are similar are Shaly Foothills #212 and Sandstone Breaks #53.

Vegetation

Vegetation cover of the Steep/Sparse M.U. is very low to moderate and may be less than 5% on Shale Barrens. Litter is negligible. Bare soil and/or rock cover are very high, usually over 70%. In addition to the three species that characterize this M.U., other species with high constancy that are common in the existing vegetation are needlegrass (green or western, (Stipa occidentalis), cheatgrass, Japanese brome, blue grama, side-oats grama (Bouteloua curtipendula), Spanish bayonet (Yucca glauca), false buckwheat (Eriogonum brevicaule) particularly on shale, and skunkbrush sumac particularly on sandstone. An unidentified species of milk-vetch (Astragalus sp.) with reflexed flowers or sweet vetch (Hedysarum boreale) is also common. Other species often seen on the Steep/Sparse M.U. are snakeweed and prickly-pear (Opuntia sp.).

Site

All of the Steep/Sparse M.U. on Open Space lands is located at or below the forest-grassland ecotone and between the elevations of 5400 to 5900 ft. (1645 to 1798 m). All of this M.U. is excessively drained and very dry as compared to the other vegetation types of this study.

The Shale Barrens P.A. is on fine soil often with abundant rock fragments whereas the Sandstone Breaks P.A. is on cobbly or stony, sandy soils. Both are located on soils mapped by the SCS as Renohill loam, which are described

as fine loams over shallow sandstone that are often steep. Terrace escarpments also are mapped by the SCS at some of the Steep/Sparse M.U. Sixmile stony loam underlies some of the sandstone breaks.

Distribution and Disturbance

Adjoining most of this M.U. is Mid-height or Mixed Height Grassland on less dry sites. All the examples of this M.U. except the most extreme Shale Barrens and the area on Boulder Memorial show signs of overgrazing.

4.2.2 Short Grassland (Map Unit S)

In this map unit are Short Grasslands dominated by blue grama and/or buffalo grass that do not fit any other map unit description. Most areas are located on the plains or below 6000 ft (1830 m) of elevation.

Short Grasslands on Boulder Open Space lands are plant communities that are the result of disturbance or overutilization of Mid-height, Mixed Height or Xeric Tall Grasslands. They do not comprise PNV for Boulder Open Space lands. Therefore their vegetation and site characteristics vary, but most are on level to gently sloping sites and none are on poorly drained sites.

Short Grasslands always contain abundant invaders such as cheatgrass or golden aster; they have signs of past or recent overgrazing such as livestock trails and a high percentage of bare soil; and comparison with adjacent properties usually indicates that a fenceline or land use change separates the short grassland from a recognizable plant association.

For example, on Rudd West, a Short Grassland dominated by blue grama, sun

sedge (Carex heliophila) and golden aster is on a site that is a continuation of the Rudd East upland that supports (recognizable though degraded) xeric tall grassland. Red three-awn, and June-grass (Koeleria macrantha) are locally common and mid-height grasses are scattered. Rudd West was heavily overgrazed before it was acquired by the City Open Space Department. The soil map unit on these areas is Nederland very cobbly sandy loam, which typically supports Xeric Tall Grasslands in the Boulder area. Clark et al. (1980) mapped similar plant communities on the nearby Rocky Flats property.

Or, on the plateau on Andrus, cheatgrass, buffalo grass, blue grama and western wheatgrass codominate a site that is disturbed by prairie dog activity and livestock grazing. The soil is a Nunn clay loam, a fine soil which typically favors buffalo grass when the vegetation receives repeated, heavy disturbance and is dominated by western wheatgrass if undisturbed.

Short Grasslands are usually found as a mosaic with a more disturbed map unit (e.g., Agricultural Field, on Van Vleet) or a less disturbed map unit (e.g., Mid-height Grassland, on Boulder Valley Ranch). Small areas of Short Grasslands are unmapped inclusions within other grasslands, which typically also comprise the adjacent vegetation.

4.2.3 Mid-Height Grassland (Map Unit G)

Map Unit G contains both Mid-height and Mixed height Grassland P.A.s. The dry Mixed height Grasslands are widely distributed below the forest-grassland ecotone. They typically have mid-height species such as western wheatgrass codominating with short grasses such as blue grama. In and above the ecotone in the montane zone, Mixed height Grasslands are characterized by mountain

muhly (Muhlenbergia montana) in association with blue grama. Mid-height Grasslands dominated by western wheatgrass (Agropyron smithii), Kentucky bluegrass, or Canada bluegrass are a type of grassland common on Open Space properties that are found on moist sites, particularly in and below the forest-grassland ecotone. Sandy areas within the grasslands at and below the ecotone may be dominated by sand dropseed (Sporobolus cryptandrus). Also included in this M.U. are any degraded Xeric Tall Grasslands that no longer support enough tallgrasses to be mapped as "X".

Synonymy

For the Western Wheatgrass-Blue grama Mixed height grassland P.A. (Agropyron smithii-Bouteloua gracilis Mixed Height grassland P.A.):

Western Wheatgrass Mixed Prairie P.A. (Agropyron smithii Mixed Prairie P.A.)	Baker (1984)
Cf. Needle-and-thread Mixed Prairie P.A. (Stipa comata Mixed Prairie P.A.)	Baker (1984)

For the Western wheatgrass Mid-height Grassland P.A. (Agropyron smithii Mid-height Grassland P.A.):

Western wheatgrass Montane Grassland P.A. (Agropyron smithii Montane Grassland P.A.)	Baker (1984)

Relevant SCS Range site descriptions are Loamy Foothill #202 and Clayey Foothill #208.

Synonymy to the above with the P.A.s named by Johnston (1984) is unclear, perhaps because most of the work on which his P.A.s are based did not survey the same areas around Boulder as the work reported here. Johnston's (1984) naming is based on the studies of Hanson and Dahl (1956), Hess (1981), Moir (1969) and Terwilliger et al. (1979). All these workers found

needle-and-thread to be dominant at many localities, whereas the data for the Open Space properties show only minor areas dominated by needle-and-thread. Perhaps this is because needle-and-thread is a notable decreaser with cattle grazing. Another possible explanation is that the site characteristics favorable to this grass (especially coarse, somehwat dry to somewhat moist soils) favor Xeric Tall Grassland in the study area because of the relatively moist local climate (see section 2.1).

However, three P.A.s of Johnston (1984) are related to the Mid- and the Mixed height Grassland P.A.s:

Needle-and-thread/Western wheatgrass P.A. (Stipa comata/Agropyron smithii P.A.)	Johnston (1984)
Needle-and-thread/Blue grama P.A. (Stipa comata/Bouteloua gracilis P.A.)	Johnston (1984)
Western wheatgrass/Blue grama P.A. (Agropyron smithii/Bouteloua gracilis P.A.)	Johnston (1984)

For the Mountain muhly/Blue grama Montane Grassland P.A. (Muhlenbergia montana/Bouteloua gracilis Montane Grassland P.A.):

Mountain muhly Montane Grassland P.A. (Muhlenbergia montana Montane Grassland P.A.)	Baker (1984)
Mountain muhly/Griffiths' wheatgrass P.A. (Muhlenbergia montana/Agropyron griffithsii P.A.)	Johnston (1984)

Relevant SCS Range Sites are Cobbly Foothill #313 and Shallow Loam #230. Most Open Space areas with common mountain muhly are mapped as savannah or ponderosa pine forest (see following sections).

Vegetation

Total vegetation plus litter cover in the existing vegetation of the Mixed height and Montane Grassland P.A.s is usually low to medium, with typical values between 40 to 70%. The non-vegetated ground is usually bare soil in the Mixed height Grassland P.A. areas on Open Space lands, reflecting the fact that they have been overgrazed. The non-vegetated ground is usually gravel or cobble in the Montane Grassland P.A., reflecting the coarse nature of the parent material. Total vegetation plus litter cover in the existing vegetation of the Mid-height Grassland P.A. is usually very high, reflecting the relatively mesic site.

The dominant species are indicated in the name of each P.A. Common species with high constancy throughout the M.U. are green or western needlegrass, June-grass, cheatgrass, Japanese brome, Louisiana sagebrush (Artemisia ludoviciana). The Mid- and Mixed height Grassland P.A.s commonly have slimflower scurfpea (Psoralea tenuiflora), and on steep or rocky sites frequently have sunflower (Helianthus pumilus) and Spanish bayonet. The Mid-height and Montane Grassland P.A.s have common Griffiths' wheatgrass on steep slopes. Important species in the Montane and Mixed height Grassland P.A.s are side-oats grama, dryland sedges (especially sun sedge) and golden aster. Local areas of dominance by needle-and-thread and by buffalo grass (on fine-textured, overgrazed sites) are found in the Mixed height Grassland P.A. Red three-awn is typically present and often common in this P.A. The Mid-height Grassland P.A. is often codominated by Kentucky or Canada bluegrass and includes scattered tallgrasses and skunkbrush sumac on steep or rocky soils and western snowberry (Symphoricarpos occidentalis) on moist, fine-textured soils.

Intergradations between the P.A.s are not unusual, especially in the forest-grassland ecotone. Species diversity is often high, with mixtures of plains and montane species.

Site

The Mid-height Grassland M.U. is mapped throughout the study area primarily below about 6200 ft (1890 m) and occurs on various sites. The Mixed height Grassland P.A. is on well drained, dry to somewhat dry sites primarily on the plains while the Mid-height Grassland P.A. is on moderately well drained to somewhat poorly drained, moist to somewhat moist sites in the ecotone and on the plains. The Mid-height Grassland P.A. is typically found on toeslopes, in concavities, or on mesic side slopes in the ecotone. Nice examples are found on the Dunn 1 and lower Erni properties.

Soils of the Mixed and Mid-height Grassland P.A.s are usually deep, but also shallow, are derived from various parent materials, and range from clay to very fine sandy loam. Sixteen SCS soil map units support these two P.A.s: Colby silty clay loam, Colby-Gaynor association, Gaynor silty clay loam, Heldt clay, Kutch clay loam, Manvel loam, Nunn clay loam, Nunn sandy clay loam, Nunn-Kim complex, Renohill loam, Renohill silty clay loam, Samsil clay, Samsil-Shingle complex, Terrace escarpment (on lower slopes), Valmont clay loam, and Weld loam.

As noted above, most Open Space areas supporting mountain muhly are Ponderosa Pine Savannahs or Forests. The Flatirons Vista property, which supports the lowest elevation mountain muhly populations in the study area, typifies favorable soils for this grass and contains small areas dominated by mountain

muhly and blue grama. The Nederland very cobbly sandy loam is well drained, coarse, and has many rock fragments.

Distribution and Disturbance

The Mid-height Grassland M.U. is found adjacent to all the other M.U.s found at and below the forest-grassland ecotone. Especially in the ecotone, it often exists in a mosaic with Xeric Tall Grasslands.

Livestock grazing and prairie dog activity have substantially disturbed the vegetation of the Mid-height Grassland M.U., particularly the Mixed height Grassland P.A., which is reflected in an abundance of invaders and increasers at many localities (see section 2.2.)

4.2.4 Xeric Tall Grassland (Map Unit X)

This M.U. is characterized by the dominance of little bluestem (Schizachyrium scoparium) and big bluestem (Andropogon gerardii) with an understory of shortgrasses and midgrasses (but not dominated by Kentucky or Canada bluegrass). Blue grama and side-oats grama are the typical understory species. Xeric Tall Grasslands are fairly common on the Open Space lands with the exception of the northeastern properties.

Synonymy

For the Xeric Tall Grassland P.A.:

Big Bluestem-Side-oats grama-Blue grama-Little bluestem Xeric Tallgrass Prairie P.A. (Andropogon gerardii-Bouteloua curtipendula-Bouteloua gracilis-Schizachyrium scoparium Xeric Tallgrass Prairie P.A.) — Baker (1984)

Big bluestem/Little bluestem P.A. Johnston (1984)
(Andropogon gerardii/Schizachyrium scoparium P.A.)

Another Xeric Tallgrass P.A. identified by Baker (1984) that may be present on the Flatirons Vista property has mountain muhly instead of side-oats grama, but the vegetation was not in good enough condition to recognize the P.A. Relevant SCS range site descriptions are Cobbly Foothill # 213 and possibly, Sandstone Breaks #53. The Colorado Natural Heritage Inventory (1982) summarized information about this P.A. because it is of special concern (see next section).

Vegetation

Cover by vegetation plus litter is high in the Xeric Tall Grassland P.A., with vegetation cover typically over 60% and litter over 30%. Cover by rocks typically is less than 5% to 10%. Bare soil cover is very low except on overgrazed sites. In addition to the four dominant species indicated in its name, this P.A. usually contains the following species with measurable cover and high constancy: June-grass, sun sedge, slimflower scurfpea, sandwort (Arenaria fendleri), wild tarragon (Artemisia dracunculus), winged eriogonum (Eriogonum alatum), and Spanish bayonet. Sometimes present are other, scattered tallgrasses - switchgrass (Panicum virgatum) and yellow Indiangrass (Sorghastrum nutans). Usually present are diverse herbaceous species often found in grasslands of the Mid-height M.U. However, dense cover by Kentucky bluegrass or Canada bluegrass is typically the result of disturbance of Mesic Tall Grasslands, which are found on moister sites than Xeric Tall Grasslands.

Site

The Xeric Tall Grassland P.A. is common on the Open Space properties between about 5500 and 6100 ft (1676 and 1859 m), on sites which provide well drained, somewhat dry to somewhat moist conditions. It is particularly extensive on the old alluvial deposits along South Boulder Creek in the southwestern part of the study area. Although no pristine stands were located on Open Space properties, Erni, Dunn 1, Wells, Yunker and other localities provide good examples of this P.A.

The Xeric Tall Grassland P.A. is found primarily on cobbly and stony loams of various textures, which are often deep, but also shallow. Soils mapped by the SCS that support Xeric Tall Grasslands are: Baller stony sandy loam, Colluvial land, Hargreave fine sandy loam, Nederland very cobbly sandy loam, Peyton-Juget very gravelly loamy sands, Sixmile stony loam, Terrace escarpments (on upper slopes), and Valmont cobbly clay loam.

Distribution and Disturbance

Xeric Tall Grasslands often border and intermix with the Mid-height Grassland M.U. on their drier sites and with the Mesic Tall Grassland M.U. on their moistest sites. Ponderosa Pine Forests border the Xeric Tall Grasslands at their upper elevations. In the forest-grassland ecotone, ponderosa pines are invading some Xeric Tall Grasslands (see sections 5 and 6), and Skunkbrush Grasslands primarily support a Xeric Tallgrass understory.

Continued overgrazing of Xeric Tall Grasslands leads to mid-grass or short grass dominance, as illustrated in the example presented in section 4.2.2. Existing vegetation ranges from slightly to heavily disturbed.

4.2.5 Mesic Tall Grassland (Map Unit L)

Mesic Tall Grasslands have abundant big bluestem, switchgrass, yellow Indiangrass or little bluestem and occupy poorly drained sites, especially in the South Boulder Creek drainage. Nearly pure stands of big bluestem or switchgrass are not unusual. Other graminoids such as Baltic rush (Juncus balticus and sedges (Carex spp.) may be common, but as long as the tallgrasses provide over 25% relative canopy cover, the vegetation is mapped as Mesic Tall Grassland. Prairie cordgrass (Spartina pectinata), which is typical of the wet prairies in the midwestern United States, dominates at a couple of the wetter tallgrass localities, e.g., on THP west and east.

Synonymy

Big bluestem-Switchgrass-Little bluestem-Yellow Indiangrass Mesic Tallgrass Prairie (Andropogon gerardii-Panicum virgatum-Schizachyrium scoparium-Sorghastrum nutans Mesic Tallgrass Prairie P.A.)	Baker (1984)
Big bluestem-Yellow Indiangrass (Andropogon gerardii-Sorghastrum nutans)	Johnston (1984)

Also, Moir (1969) and the following two SCS Range Sites refer to this P.A.: Wet Meadow #38 and Overflow #36.

Vegetation

Cover by vegetation and litter is very high. In addition to the six graminoids that were noted at the start of this section, others that are locally abundant in this P.A. on Open Space properties are prairie dropseed (Sporobolus heterolepis) and sand dropseed. Several species that indicate disturbance are widespread: Kentucky bluegrass, Canada bluegrass and common

timothy. A number of forbs and mid and short grasses common in the Mid Height Grassland M.U. may be present in small amounts.

Site

Mesic Tall Grasslands are found primarily below 5700 ft (1737 m) on poorly drained, very moist to wet sites having a shallow water table. They are typically located on alluvium adjacent to South Boulder Creek, often on cobbly loams over gravelly sand. Moir (1969) also reported this P.A. on some deep clayey soils adjacent to ponderosa pines, which appear to be the meadows within the forests on Debacker and Culberson. Soils mapped by the SCS that support Mesic Tall grasslands are mostly Niwot soils and some Loveland soils.

Distribution and Disturbance

Mesic Tall Grasslands often border and intermix with Xeric Tall Grasslands on their drier sites and with Wetlands and Riparian vegetation on their wetter sites. Agricultural Fields are also common neighbors. A number of the Mesic Tall Grasslands are hayed and all have been grazed, although some of the latter areas are in good condition, notably on Church, THP, and Yunker.

Although natural vegetation patterns are treated in section 5, discussion of the Mesic Tall Grasslands is presented here. Mesic Tall Grasslands that are the natural vegetation type now exist on Burke 1, Gebhart, and Van Vleet, but are not in healthy condition. The only Mesic Tall grassland that is now in healthy condition on Open Space properties and has an equivalent natural vegetation is on THP west. The Mesic Tall Grasslands on Church and Yunker are apparently supplied with moisture from irrigation ditches. Neither SCS soils

mapping nor topography predict that this P.A. would exist at these sites. It is unclear whether the Mesic Tall Grassland on THP east is also the natural vegetation or it is maintained by irrigation. Aerial photos and field visits show the THP east area below an irrigation ditch and separated from the riparian vegetation of South Boulder Creek by Xeric Tall Grassland. However, the Xeric Tall Grassland is also more heavily disturbed than the Mesic Tall Grassland. Also, the SCS soils mapping for THP east indicates that Mesic Tall Grassland is not the natural vegetation; however, THP east soils may have inclusions different than the mapped soil.

The tall grasslands of the Boulder area have recently received increased attention, for example in the designation of the Tallgrass Natural Areas by the State of Colorado and City of Boulder. Existing tall grasslands are probably relicts of more widespread tall grasslands that were common in the region during the cooler, wetter climates of the Pleistocene and are now considered the natural vegetation of the prairie in Midwestern United States. Both types of tall grasslands are listed as plant associations of special concern by the Colorado Natural Heritage Inventory (1984). However, both Xeric and Mesic Tall Grasslands were recognized in the ecological literature as early as 1914 (Vestal 1914) and Xeric Tall Grasslands are now known throughout the Colorado foothills from the Wyoming to the New Mexico border as well as from western Kansas (see Colorado Natural Heritage Inventory 1982). Mesic Tall Grasslands are known in Colorado only from the foothills area of Boulder and Jefferson Counties and the Republican River drainage of Kit Carson and Yuma Counties. They have been documented in the eastern parts of Oklahoma, Nebraska and Kansas (see Colorado Natural Heritage Inventory 1982a).

4.2.6 Wetland (Map Unit W)

Wetlands are typically dominated by baltic rush and sedges and also include local areas of cattails (Typha latifolia), spike-rush (Eleocharis macrostachya), foxtail barley (Hordeum jubatum), and inland saltgrass (Distichlis spicata). The latter areas are usually underlain by saline/alkaline soils. Wetlands cover a small percentage of the Open Space properties primarily on the plains.

Synonymy

For the Inland saltgrass Salt Meadow P.A.
(Distichlis spicata ssp. stricta Salt Meadow P.A.):

Inland saltgrass Salt Meadow P.A. (Distichlis spicata var. stricta Salt Meadow P.A.)	Baker (1984)
Inland saltgrass-Alkali sacaton-(Western wheatgrass) Salt Meadow P.A. (Distichlis spicata var. stricta-Sporobolus airoides-(Agropyron smithii) Salt Meadow P.A.)	Baker (1984)
Inland saltgrass/Alkali sacaton-Western wheatgrass P.A. (Distichlia stricta/Sporobolus airoides-Agropyron smithii P.A.)	Johnston (1984)

For the Foxtail barley Grassland P.A.
(Hordeum jubatum grassland P.A.):

Foxtail barley Plains Grassland P.A. (Hordeum jubatum Plains Grassland P.A.)	Baker (1984)

For the Spike-rush Wetland P.A.
(Eleocharis macrostachya Wetland P.A.):

Spike-rush Wetland P.A. (Eleocharis palustris Wetland P.A.)	Baker (1984)
Common spike-sedge/Sedge P.A.	Johnston (1984)

(Eleocharis macrostachya/Carex sp. P.A.)

For the Baltic rush/Sedge Wetland P.A.
(Juncus balticus/Carex sp. Wetland P.A.):

Baltic rush Wetland P.A. (Juncus balticus Wetland P.A.)	Baker (1984)
Nebraska sedge/Baltic rush P.A. (Carex nebraskensis/Juncus arcticus P.A.)	Clark et al. (1980)
Baltic rush/Sedge P.A. (Juncus balticus/Carex sp. P.A.)	Johnston (1984)

For the Three-square Wetland P.A.
(Scirpus americanus Wetland P.A.):

Three-square Wetland P.A. (Scirpus americanus Wetland P.A.)	Baker (1984)
American bulrush/Sedge P.A. (Scirpus americanus/Carex spp. P.A.)	Johnston (1984)

For the Broad-leaved Cattail Wetland P.A.
(Typha latifolia Wetland P.A.):

Common Cattail Wetland P.A. (Typha latifolia Wetland P.A.)	Baker (1984)
Cf. Common Cattail/Common arrowhead P.A. (Typha latifolia/Sagittaria latifolia P.A.)	Johnston (1984)

Relevant SCS Range Sites are Salt Flat #34, Overflow #36 and Wet Meadow #38.

Vegetation

The Wetland M.U. contains diverse plant associations that are best understood in relation to site characteristics. Individual stands of a P.A. are often small and exist in a mosaic with other wetland P.A.s., reflecting the variable depth of the water table as well as the growth patterns of the dominant

species.

Excluding the P.A.s that have standing water as "cover", ground cover by vegetation plus litter is very high on undisturbed sites. Even on many disturbed sites, vegetation plus litter cover is high, except that it includes invaders and increasers. Exceptions to the high cover are found on saline/alkaline sites, particularly in areas of inland saltgrass where prairie dogs are active (e.g., Klein/Hoover Hill property), and on the dried-up lake beds of Mesa Reservoir, or the McKenzie playa, which support salt-tolerant plants such as goosefoot (Chenopodium sp.).

The dominant species are already named in the preceding list of P.A.s and synonyms. Cover by other species is typically very low. On disturbed wetlands, in addition to the invaders of wet sites named in section 2.2, other invaders found include chicory (Cichorium intybus), orchard-grass (Dactylis glomerata), wild liquorice (Glycyrrhiza lepidota), prickly lettuce (Lactuca serriola), dock (Rumex sp.), and cocklebur (Xanthium strumarium).

An unusual playa wetland for the region is located on the McKenzie property. It is the only known locality in Boulder County for three species of plants: four-leaved clover fern (Marsilea mucronata), slender plantain (Plantago elongata), and mousetail (Myosurus minimus).

Site

Most wetlands on Open Space properties are located below 5700 ft (1737 m) on lowlands that are poorly drained and are wet to very wet. All have a shallow water table that is maintained by very slow moving or stationary water.

Observations of the Open Space properties agree with prior descriptions of Wetland P.A. site characteristics (e.g., Johnston 1984). Of the six Wetland P.A.s, the Foxtail Barley and Inland Saltgrass P.A.s are typically the least wet and most tolerant of saline/alkaline soils. Spike-rush and Baltic Rush/Sedge P.A.s are on sites that remain moist to wet throughout the growing season. The Three-Square P.A. "prefers" sandy, non-alkaline, non-saline sites that are just above the water table. Broad-leaved Cattail vegetation is the wettest P.A. and typically flooded throughout the summer.

Soils mapped by the SCS at the wetland sites are typically deep, clayey, and often saline and alkaline. The main SCS soil map unit is Longmont clay, with small areas of Loveland and Niwot soils.

Distribution and Disturbance

The most extensive wetland area on the Open Space properties is on Boulder Valley Ranch. The Baltic rush/Sedge P.A. is the most widespread wetland P.A. on the Open Space properties and is often accompanied by the Spike-rush P.A. The least common wetland type is the Three-square P.A., which was found on Andrus, Church and THP. The Inland saltgrass P.A. was found on Andrus, Boulder Valley Ranch, Church, Hart-Jones, Klein-Hoover Hill, Mann, and McKenzie. The Broad-leaved Cattail P.A. was found on Andrus, Boulder Valley Ranch, Erni, Flatirons Industrial, Mesa Reservoir, Neuhauser, Rudd East, and Short-Milne.

Wetlands are often found in a mosaic with the Mesic Tall Grassland P.A. and Riparian P.A.s. Neighboring vegetation is usually these two P.A.s or the Mid-height Grassland M.U. or Agricultural Fields.

All the Wetland areas on the Open Space properties have been grazed or disturbed by human-related activities.

4.3 SAVANNAH

4.3.1 Skunkbrush Grassland (Map Unit H)

This shrub savannah type is usually codominated by skunkbrush sumac and an understory intermediate between that of the Tall Xeric and Mid-height Grassland P.A.s, with the shrubs contributing between about 5% and 25% relative canopy cover. Shrub grasslands (and Ponderosa Pine Savannah) are best represented in the southwestern part of the study area, probably because of the extensive, gradual slopes that lie there within the elevations of the forest-grassland ecotone. Included in this M.U. are small areas of shrub grasslands that are dominated by other shrub species of the Mountain Shrubland M.U. An unusual shrub grassland on the Ertl property is also included in this M.U.

Synonymy

For the Skunkbrush sumac/Big bluestem Shrub Grassland P.A.
(Rhus aromatica ssp. trilobata/Andropogon gerardii Shrub Grassland P.A.):

Cf. Mountain mahogany-Skunkbrush sumac/ Big bluestem P.A. (Cercocarpus montanus-Rhus trilobata/ Andropogon gerardii P.A.) — Baker (1984)

Relevant SCS Range Site descriptions are Shallow Foothill #204, Rocky Foothill #206 and probably Shallow Loam #230.

For the Sand sagebrush/Sand dropseed P.A. (*Artemisia filifolia*/*Sporobolus cryptandrus* P.A.):

Sand sagebrush/Sand dropseed-Blue grama P.A. (*Artemisia filifolia*/*Sporobolus cryptandrus*-*Bouteloua gracilis* P.A.)	Jones (1963)
Cf. Sand sagebrush/Sand bluestem P.A. (*Artemisia filifolia*/*Andropogon hallii* P.A.	Johnston (1984)

Vegetation

In the Skunkbrush Grassland P.A., typical cover by vegetation plus litter is very high. Sometimes, there is measurable cover by rocks, which may constitute up to 10% of the ground area. Species that are typically dominant or have high constancy in addition to those in the name of the P.A. are: little bluestem, Kentucky bluegrass, and Canada bluegrass. Often present as common species are blue grama, side-oats grama, and Japanese brome. Other species that contribute measurable cover in some stands include western wheatgrass, Spanish bayonet, and prickly-pear. In sum, the Skunkbrush Grassland P.A. resembles a mixture of the Mid-height and the Xeric Tall Grassland P.A.s with the addition of a taller, open shrub layer.

In the existing vegetation of the Sand Sagebrush/Sand Dropseed P.A., typical cover by vegetation and litter is moderate. This may reflect the large amount of disturbance as well as the sandy substrate on most of the Ertl property. The two species named in the P.A. are constants and are common to dominant. Species with high constancy that may be locally dominant or common include sand-reed (*Calamovilfa longifolia*), blue grama, wild tarragon, bushy eriogonum

(Eriogonum effusum), four-winged saltbush (Atriplex canescens), skunkbrush sumac, and Spanish bayonet.

Site

The Skunkbrush Grassland P.A. is best represented between the elevations of 5700 to 6200 ft (1737 to 1890 m) on the southwestern Open Space properties. It is on well drained sites that are somewhat dry to somewhat moist.

The Skunkbrush Grassland P.A. is located on soils that are typically stony or cobbly sandy loams that are shallow to deep. It is located on soils mapped by the SCS as Baller stony sandy loam, Colluvial land, Nederland very cobbly sandy loam, and Valmont cobbly clay loam.

The Sand Sagebrush/Sand Dropseed P.A. is found on the Open Space lands only on the Ertl property at the base of the cliffs and occupies a soil mapped as the Ascalon-Otero complex, which is sandy loamy.

Distribution and Disturbance

The Skunkbrush Grassland P.A. typically intermixes and adjoins with Xeric Tall Grassland below and Ponderosa Pine Savannah and Ponderosa Pine Forest above. Moist adjacent sites support the Mountain Shrubland or Mid-Height Grassland M.U.s. Small, steep (unmapped) areas represent the Skunkbrush/Needlegrass Sandstone Breaks P.A. Although pristine areas were not located, Skunkbrush Grasslands apparently are not heavily disturbed by humans.

As noted above, the Sand Sage/Sand Dropseed P.A. is found only on the Ertl property of the Open Space lands and is heavily disturbed.

4.3.2 Ponderosa Pine Savannah (Map Unit V)

Ponderosa Pine Savannahs support scattered trees typically amidst Tall Xeric, Mid-height or Skunkbrush Grassland M.U.s, with relative canopy cover of the pines between about 5% and 25%. They are most common in the forest-grassland ecotone, particularly on the southwestern Open Space lands.

Synonymy

Ponderosa Pine Savannahs represent very open stands of all the Ponderosa Pine P.A.s with the exclusion of the most mesic P.A.s. (with understories dominated by spike fescue (Leucopoa kingii) or ninebark (Physocarpus monogynus)). The pine P.A.s most likely to exist as savannahs are characterized by bluegrasses, tallgrasses or mountain muhly. Livingston (1952) reported similar "savannahs" in the Black Forest of Colorado northeast of Colorado Springs. No unique P.A. is recognized here for the Ponderosa Pine Savannah M.U.

Relevant SCS Range Site descriptions are Shallow Foothill #204, Rocky Foothill #206, and Shallow Loam #230.

Vegetation

As noted above, vegetation resembles that of the drier Ponderosa Pine P.A.s (see next section) except that the tree canopy is very open and vegetation plus litter cover less ground. Bare ground and rocks often cover 35% of the ground area.

At some localities, Pine Savannahs represent grasslands being invaded by trees, while other areas are not apparently in such transition. Some

savannahs will clearly remain very open due to the rock outcrops at the site.

Site

Ponderosa Pine Savannahs are found primarily in the forest-grassland ecotone between the elevations of 5700 to 6200 ft (1737 m to 1890 m), particularly on the southwestern properties. They occupy well drained, somewhat dry to somewhat moist soils that are typically stony or cobbly sandy loams and may be shallow or deep.

Soils mapped by the SCS on the Pine Savannah sites are Baller stony sandy loam, Colluvial land, Juget-Rock outcrop complex, Nederland very cobbly sandy loam, Pinata-Rock outcrop complex, Rockland, and Valmont cobbly clay loam.

Distribution and Disturbance

Ponderosa Pine Savannahs typically have distribution and disturbance characteristics similar to those of Skunkbrush Grasslands (see preceding section).

Areas of this M.U. include rock outcrops that support very open pine cover, e.g., on McCann and Boulder Memorial, and are mapped in a mosaic of Cliff and Pine Savannah.

4.4 FOREST/WOODLAND/SHRUBLAND

4.4.1 Ponderosa Pine Forest (Map Unit P)

Ponderosa Pine Forests and woodlands are mapped where the pine trees comprise at least 20 to 25% relative canopy cover. Forests with codominant Douglas-fir are included if the Douglas-fir contributes less than about 75% relative tree canopy cover. Ponderosa pine forests are extensive above an elevation of approximately 6000 ft (1830 m).

Synonymy

Eight P.A.s are listed here, although more or less may eventually be recognized after additional data are collected. Hess (1981) pointed out that the habitat types in the ponderosa pine series are not exclusive and that futher investigation of ponderosa pine forests is justified. Findings from the Boulder Open Space properties support Hess's view.

For the Ponderosa pine/Bluegrass C.T.
(Pinus ponderosa/Poa spp. C.T.):

Cf. Ponderosa pine/Sun sedge P.A. (Pinus ponderosa/Carex heliophila P.A.)	Baker (1984) Johnston(1984) see Kovacic (1983)
With a PROPOSED Skunkbrush Sumac phase	see Peet (1980)

For the Ponderosa pine/Big bluestem P.A. (called the Tallgrass P.A.)
(Pinus ponderosa/Andropogon gerardii P.A.):

Cf. Ponderosa pine/Little bluestem-Western wheatgrass P.A. (Pinus ponderosa/Andropogon scoparius-Agropyron smithii P.A.)	Johnston (1984)

Previously reported in Montana, Nebraska and South Dakota.
See Livingston (1952) in Colorado.

For the Ponderosa pine/Scribner's needlegrass P.A.
(Pinus ponderosa/Stipa scribnerii P.A.):

Ponderosa pine/Scribner's needlegrass P.A. (Pinus ponderosa/Stipa scribnerii P.A.)	Baker (1984)

For the Ponderosa pine/Sedge P.A.
(Pinus ponderosa/Carex sp. P.A.):

Cf. Ponderosa pine/Ross's sedge P.A. Pinus ponderosa/Carex rossii P.A.)	Johnston (1984) Hess (1981)

C. pityophila was found in several stands, but definitive identification of many of the sedges could not be made because few plants bearing flowers were located. Thus it is not unlikely that both the sedges C. pityophila and Ross's sedge may be present. Also, definitive identification of C. pityophila versus sun sedge was not possible in most cases, although the former tyically occupies very open and not closed canopy forests.

For the PROPOSED Ponderosa pine/ Oregon grape P.A.
(Pinus ponderosa/Mahonia repens P.A.):

Oregon grape also is an understory species in the Pine/Mountain muhly and Pine/Ninebark P.A.s below. It could be treated as a phase of the Pine/Mountain Muhly P.A.

For the Ponderosa pine/Mountain muhly P.A.
(Pinus ponderosa/Muhlenbergia montana P.A.):

Ponderosa pine/Mountain muhly P.A. (Pinus ponderosa/Muhlenbergia montana P.A.)	Baker (1984)
Ponderosa pine-Douglas-fir/Mountain muhly-Arizona fescue P.A. (Pinus ponderosa-Pseudotsuga menziesii/Muhlenbergia montana-Festuca arizonica P.A.)	Johnston(1984)

For the Ponderosa pine/Spike fescue P.A.
(Pinus ponderosa/Leucopoa kingii P.A.):

Ponderosa pine-(Douglas-fir)/Spike fescue P.A. (Pinus ponderosa-(Pseudotsuga menziesii)/Leucopoa kingii P.A.)	Baker (1984)
Ponderosa pine/Spike fescue P.A. (Pinus ponderosa/Hesperochloa kingii P.A)	Johnston (1984)

For the Ponderosa pine/Ninebark P.A.
(Pinus ponderosa/Physocarpus monogynus P.A.):

Cf. Douglas-fir-(Ponderosa pine)/Ninebark P.A. (Pseudotsuga menziesii-(Pinus ponderosa)/ Physocarpus monogynus P.A.)	Baker (1984)
Cf. Ponderosa pine/Ninebark P.A. (Pinus ponderosa/Physocarpus monogynus P.A.) Previously reported in Wyoming.	Johnston (1984)

This P.A. occurs on limited areas of the Open Space lands and could be treated as a phase of the Douglas-fir/Ninebark P.A.

A negligible area of Ponderosa pine/Mountain mahogany P.A. (Pinus ponderosa/Cercocarpus montanus P.A.) is located on the Kassler property adjacent to the mountain mahogany stand discussed in section 4.4.5.

Relevant SCS Range Sites are Shallow Loam #230 (for the Mountain muhly P.A.) and Ponderosa Pine Woodland.

Included in this M.U. are community types which are the result of logging or other disturbance and have understories dominated by golden aster, poverty oat-grass (Danthonia spicata), mullein (Verbascum thapsus), or cheatgrass.

Vegetation

In spite of widespread disturbance of the ponderosa pine forests, natural vegetation patterns are usually discernible.

Tree and understory canopy cover vary widely amongst the pine P.A.s. Tree cover is typically open to very open in the drier communities, i.e., the Bluegrass C.T. and Tallgrass P.A., open to closed in the intermediate P.A.s, and closed in the most mesic P.A.s, the Spike fescue and Ninebark P.A.s. The Mountain muhly P.A. also often has very open tree cover.

Understory cover ranges from total ground cover by vegetation plus litter to as low as 40%. Little bare ground and rocks are usually exposed in the Tallgrass, Sedge, Spike fescue, and Ninebark P.A.s. Three P.A.s often have over 20% cover (and sometimes up to about 50% cover) by gravel or rocks: Scribner's needlegrass, Oregon grape and Mountain muhly. However, amount of cover varies widely even within each P.A., and particularly within the Bluegrass C.T. Needle litter typically comprises the vast majority of the ground cover in any stands with a closed tree canopy, especially in the Sedge and Spike sedge P.A.s.

Other tree species include Rocky Mountain Juniper (Juniperus scopulorum), which is often found scattered throughout the P.A.s except in the Sedge, Spike sedge, and Ninebark P.A.s, and Douglas-fir, which is frequently found in the five more mesic pine P.A.s.

The understory of the six pine P.A.s that are named for herbaceous species typically only have scattered shrubs. The Pine/Bluegrass C.T., however, contains rocky areas that have common skunkbrush sumac. The Pine/Bluegrass C.T. and Pine/Tallgrass P.A. typically have noteworthy cover by Kentucky and Canada bluegrasses. Common species include blue grama, sedge (often sun sedge), and wax currant (Ribes cereum). The Pine/Tallgrass P.A. has an

undergrowth dominated by big and little bluestems and looks like a mixture of the Xeric Tall Grassland P.A. and the Mid-height Grassland M.U. Various other species found in these grasslands are also common in these two driest pine P.A.s., e.g., western wheatgrass, needle-and-thread, Spanish bayonet, and Louisiana sagebrush.

Intermediates between the five following ponderosa pine P.A.s are not unusual, but there are many clear examples of each: Pine/Scribner's needlegrass, Pine/Sedge, Pine/Oregon grape, Pine/Mountain muhly, and Pine/Spike fescue. Stands of each P.A. have an understory dominated by their namesake species, with additional, lower cover often contributed by the namesake species of the other four P.A.s. Additional common to scattered species include bluegrasses, blue wild-rye (Elymus glaucus), needlegrasses, cheatgrass, bottlebrush squirreltail (Sitanion hystrix), June-grass, cinquefoil (Drymocallis fissa), fringed sagebrush, Fremont's geranium (Geranium caespitosum), whisk-broom parsley (Harbouria trachypleura), wax currant, and common Juniper (Juniperus communis). Also, blue grama, little bluestem, and and sulfur-flower (Eriogonum umbellatum) are often present in open ponderosa pine stands, and Griffiths' wheatgrass and Colorado wild-rye (Elymus ambiguus) on steep, rocky slopes, i.e., in the Pine/Scribner's needlegrass, Pine/Oregon grape and Pine/Mountain muhly P.A.s.

Scattered shrubs seen especially in the Pine/Oregon grape and Pine/Mountain muhly P.A.s include rose (Rosa sp.), kinnikinnik (Arctostaphylos uva-ursi), chokecherry (Prunus virginiana var. melanocarpa), and boulder raspberry (Rubus deliciosus). There are areas of local dominance by golden aster and buckbrush (Ceanothus fendlerii), particularly in the Pine/Mountain muhly P.A.

The Pine/Scribner's needlegrass P.A. was listed as a P.A. of special concern by the Colorado Natural Heritage Inventory (1984). The findings reported here plus those of Hess (1981) indicate that Scribner's needlegrass is not uncommon in and north of the Boulder area on dry, rocky summits in the montane zone.

The Pine/Ninebark P.A. resembles the Douglas-fir/Ninebark P.A. and the Ninebark P.A. in the Mountain Shrubland M.U., (see section 4.4.5), but with the addition of a tree canopy, of Oregon grape in the understory, and with lower shrub canopy coverage.

Site

The Ponderosa Pine M.U. is found primarily above 5800 ft (1768 m) and typically above 6000 ft (1829 m), with some extending down to 5550 ft (1691 m) on north facing slopes. It occurs on well to excessively drained soils that are somewhat moist to moist. The P.A.s in this M.U. were listed from driest to moistest in the preceding synonymy.

Substrates of the Ponderosa Pine M.U. range from rock outcrops to gravelly, usually sandy loams that are shallow to deep. SCS map units that underly this M.U. are: Baller stony sandy loam, Fern Cliff-Allens Park-Rock outcrop complex, Goldvale-Rock outcrop complex, Juget-Rock outcrop complex, Nederland very cobbly sandy loam, Peyton-Juget very gravelly loamy sands, Pinata-Rock outcrop complex, Rock outcrop, and Sixmile stony loam.

Typical site characteristics and locations of the Ponderosa Pine P.A.s are summarized here. All the P.A.s except the Spike sedge and Ninebark are usually located on non-north facing slopes. The Bluegrass C.T. and Tallgrass

P.A. are found at the lowest elevations on the driest pine sites. Nice examples are found on the Culberson and Abbey properties. The Scribner's needlegrass P.A. is found throughout the pine forests on the Open Space lands on dry, rocky ridges, and on dry, rocky, high and convex slope positions on moderate to steep grades. The Sedge P.A is found on gentle to moderate sites that may have scattered rocks and is exemplified on the Wells property. The Oregon grape P.A. is on very rocky to very cobbly, moderate to steep slopes and can be seen on the Debacker, Wells, and Boulder Memorial properties. The Mountain Muhly P.A. is on gravelly to very gravelly, gentle to steep slopes. Examples are situated on the Flatirons Vista and Barute properties. Ponderosa pine P.A.s that are typically found on north facing slopes are the Pine/Spike fescue P.A. and the Pine/Ninebark P.A. The latter is found as the lowest elevation forest on rocky, north facing sites. Examples of the former can be seen on the Kassler, McCann and Boulder Memorial properties, and the latter on the Wells property.

Distribution and Disturbance

The Ponderosa Pine M.U. typically lies at higher elevations than adjacent savannahs and Xeric Tall Grasslands and at lower elevations than the Douglas-fir M.U.

As noted above, the Ponderosa Pine M.U. has been disturbed by infestations and fire, as well as logging, and other human-related activities.

4.4.2 Cliff (Map Unit C)

The sparse vegetation present on cliffs is typically composed of shrubs such

as wax currant and chokecherry, which are often accompanied by some coniferous trees. Cliffs cover very small areas of the Open Space properties and are located primarily above the forest-grassland ecotone.

Synonymy

For the Wax currant/Chokecherry Cliff P.A.
(*Ribes cereum*/*Prunus virginiana* var. *melanocarpa* Cliff P.A.):

Colorado wild-rye Montane Grassland P.A. (*Elymus ambiguus* Montane Grassland P.A.)	Baker (1984)
Colorado wild-rye/Wax currant P.A. (*Elymus ambiguus*/*Ribes cereum* P.A.)	Johnston (1984)

Vegetation

Massive and fragmented rock is the predominant cover in this P.A. Vegetation usually covers less than 10% of the ground area and sometimes up to about 20 to 25%. The two namesake species have high constancy and relative cover. In and above the forest-grassland ecotone, other important species are Colorado wild-rye and cheatgrass, whereas cliffs below the ecotone have skunkbrush sumac as a constant. Other species often seen are ponderosa pine and Rocky mountain juniper. Additional species occasionally seen include Scribner's needlegrass and Douglas-fir (above the ecotone), and shrubs of the Mixed Mountain Shrublands. Differences in species dominance from Hess (1981) may possibly be explained by the lower elevations and the inclusion of sedimentary rock cliffs in this study.

Site

Cliffs were observed at all elevations of the Open Space lands on various

aspects, although most are located above about 5800 ft (1768 m). The site is excessively to well drained, with the plants occupying relatively moist crevices and shelves in the near vertical rocks. According to Hess (1981), soils are skeletal, very shallow, and sandy loamy. SCS map units include Goldvale-Rock outcrop complex, Juget-Rock outcrop complex, Pinata-Rock outcrop complex, and Rock outcrop.

Distribution and Disturbance

See Talus M.U.

4.4.3 Talus (Map Unit T)

The rocky debris at the base of cliffs on some of the southwestern Open Space properties supports variable densities of woody plants, with Douglas-fir and mountain maple frequently dominating. Total vegetation cover in the Talus M.U. is under 20 to 25%, or else the area is mapped as forest or shrubland.

Synonymy

For the Talus P.A.:

Cf. Colorado wild-rye Montane Grassland P.A. (Elymus ambiguus Montane Grassland P.A.)	Baker (1984)
Cf. Colorado wild-rye/Wax currant P.A. (Elymus ambiguus/Ribes cereum P.A.)	Hess (1981) Johnston (1984)

Vegetation

Douglas-fir and mountain maple have relatively high cover and constancy in this P.A., which is dominated by trees and shrubs. Overall, species composition is quite variable although Ponderosa pine, chokecherry, wax flower

(Jamesia americana), and pericome (Pericome caudata) are also common. Other species include Rocky Mountain juniper, wax currant, raspberry (Rubus idaeus), and smooth sumac (Rhus glabra). Hess (1981) noted the possibility of recognizing a Douglas-fir phase within his Cliff P.A.

At the edge of Talus slopes on recently vegetated sites are commonly found native Kentucky and Canada bluegrasses, Griffith's wheatgrass, cheatgrass, Oregon grape, and wax currant.

Site

The Talus M.U. occupies steep, bouldery sites found above 6400 ft (1950 m) that are excessively to well drained, but are apparently providing very moist conditions for plant growth. Soils resemble those of Cliffs, but are typically deeper. SCS map units are the same as for Cliffs.

Distribution and Disturbance

Talus typically is mapped adjacent to and in a mosaic with the Douglas-fir M.U., which occupies the better vegetated bouldery sites. The Ponderosa Pine M.U. may also adjoin Talus. In contrast, Cliffs (some too small to map) are found adjacent to various other M.U.s, but particularly next to the Ponderosa Pine M.U.

There has been little to no disturbance of Talus and Cliff areas on the Open Space properties observed in this study.

4.4.4 Douglas-Fir Forest (Map Unit F)

This M.U. contains several forest P.A.s dominated by Douglas-fir and shrubs, and includes stands with ponderosa pine contributing up to about 25% of the forest canopy coverage. The Douglas-fir M.U. is located at the higher elevations of the Open Space lands, mostly on the southwestern properties.

Synonymy

For the Douglas-fir/Oregon grape P.A.
(*Pseudotsuga menziesii*/*Mahonia repens* P.A.):

Cf. Douglas-fir/Oregon grape P.A. (*Pseudotsuga menziesii*/*Mahonia repens* P.A.) Previously reported in Wyoming.	Johnston (1984)

For the Douglas-fir/Ninebark P.A.
(*Pseudotsuga menziesii*/*Physocarpus monogynus* P.A.):

Douglas-fir-(Ponderosa pine)/Ninebark P.A. (*Pseudotsuga menziesii*-(*Pinus ponderosa*)/*Physocarpus monogynus* P.A.	Baker (1984)
Douglas-fir/Ninebark P.A. (*Pseudotsuga menziesii*/*Physocarpus monogynus* P.A.)	Johnston (1984)

For the Douglas-fir/Wax flower P.A.
(*Pseudotsuga menziesii*/*Jamesia americana* P.A.):

Douglas-fir-(Ponderosa pine)/Wax flower-Ninebark P.A. (*Pseudotsuga menziesii*-(*Pinus ponderosa*)/*Jamesia americana*-*Physocarpus monogynus* P.A.)	Baker (1984)
Douglas-fir/Cliff jamesia P.A. (*Pseudotsuga menziesii*/*Jamesia americana* P.A)	Johnston (1984)

For the Douglas-fir/Mountain Maple P.A.
(*Pseudotsuga menziesii*/*Acer glabrum* P.A.):

Douglas-fir/Mountain Maple P.A. Johnston (1984)
(Pseudotsuga menziesii/Acer glabrum P.A.)

Vegetation

Total cover by vegetation plus litter is variable within this M.U. and within each P.A. However, understory cover is usually 10 to 35% of the ground area underneath a closed tree canopy and litter covers the rest of the soil. Rocks typically comprise 10 to over 30% of the ground cover in the Douglas-fir/Oregon grape and Douglas-fir/Wax flower P.A.s., and little ground cover in the Douglas-fir/Ninebark P.A. The Douglas-fir/Mountain maple P.A. characteristics differ from the other P.A.s in this M.U., with sparse litter, and understory and overstory cover ranging from that of the Talus P.A. to very high cover. Only in the Douglas-fir/Mountain maple P.A. does bare soil or rock cover as much as 75% of the ground area.

In some stands in this M.U., ponderosa pine comprises a minor part of the tree canopy. In the understory of the Douglas-fir P.A.s, the namesake shrub species clearly dominates, and is accompanied by other shrubs, particularly the three shrubs named in the other Douglas-fir P.A.s. Intermediates between the P.A.s are not uncommon. Chokecherry is also an important species. Excluding the Douglas-fir/Mountain maple P.A., additional species often seen include: Spike fescue, sedge, bottlebrush squirreltail, cinquefoil, common juniper, rose, wax currant and boulder raspberry. The Douglas-fir/Mountain maple P.A. often has no cover by such additional species.

Site

Practically all of the Douglas-fir M.U. is located above 6400 ft (1890 m) on

north facing slopes or on very steep or protected talus slopes. The lowest Douglas-fir M.U. was on a very steep north facing slope at 6000 ft (1830 m). All of this M.U. is excessively to well drained but has a very moist environment for plants.

Substrates of the Douglas-fir M.U. range from boulders to deep, gravelly, sandy loams. Soils mapped by the SCS under this M.U. are Juget-Rock outcrop complex, Fern Cliff-Allens Park-Rock outcrop complex, and Rock outcrop.

Typical site characteristics and locations of the Douglas-fir P.A.s are summarized here. Site steepness apparently bears a relation to the moistness of the site. The least mesic P.A., Douglas-fir/Oregon grape, is found on gentle to moderately steep, rocky, north slopes, for example, on the Wells property. The Douglas-fir/Ninebark P.A. is on steep, northerly slopes, while the moister Douglas-fir/Wax flower P.A. is typically located on very rocky to bouldery, steep to very steep, north slopes or protected, lower canyonsides. Examples of the former can be seen on the Schnell property and the latter on the Campbell property. The Douglas-fir/Mountain maple P.A. is found on extremely steep rocky to bouldery sites that adjoin the Talus M.U. and is exemplified on the Wells property. The most severe sites lack undergrowth.

Distribution and Disturbance

The Douglas-fir M.U. adjoins the Talus and Ponderosa pine M.U.s.

Human disturbance in this M.U. ranges from virtually none in the Douglas-fir/Mountain maple P.A. to frequent cut stumps and fire signs (of unknown origin) in the Douglas-fir/Oregon grape P.A.

4.4.5 Mountain Shrubland (Map Unit M)

Mountain shrub thickets are characterized by a number of species that thrive on mesic soils, such as American plum (Prunus americana), chokecherry, ninebark, mountain maple, and hawthorn (Crataegus spp.). Often accompanying the preceding species is the versatile shrub, skunkbrush sumac. Smooth sumac (Rhus glabra) colonizes mesic, rocky sites. Included in this M.U. are small areas of western snowberry, particularly on mesic, fine soils, and frequently codominating with mid-height or tallgrasses. Also included in this M.U. is a dry shrubland P.A. dominated by mountain mahogany and found only on the Kassler property.

Synonymy

For the Mountain Mahogany/Griffiths' wheatgrass P.A.
(Cercocarpus montanus/Agropyron albicans var. (griffithsii P.A.):

Mountain mahogany/Wheatgrass P.A. (Cercocarpus montanus/Agropyron dasystachyum ssp. albicans P.A.)	Baker (1984)
Mountain mahogany/Griffiths' wheatgrass (Cercocarpus montanus/Agropyron griffithsii P.A.)	Johnston (1984)

For the Western snowberry P.A.
(Symphoricarpos occidentalis P.A.):

Western snowberry/Canada bluegrass M.U. (Symphoricarpos occidentalis/Poa compressa M.U.)	Clark et al. 1980

For the Mixed Mountain Shrublands, which include several P.A.s:

Prior work includes discussion of the shrub species (e.g., Vestal 1917), and the naming of the hawthorn series and one related P.A., the Mountain

mahogany-Skunkbrush sumac/Big bluestem P.A. (see section 4.3.1) (Baker 1984). Data collected here indicate that there are at least three P.A.s and possibly six. In the following discussion six P.A.s are recognized, including three that could be treated as phases of the American plum-Chokecherry/Skunkbrush Sumac P.A.: the Hackberry, Hawthorn and Smooth sumac P.A.s. The first dominant species in the P.A. name will be used to identify the P.A.

Hackberry P.A.
(Celtis reticulata) P.A.)

Hawthorn P.A.
(Crataegus erythropoda-C. succulenta P.A.)

American plum-Chokecherry/Skunkbrush Sumac P.A.
(Prunus americana-Prunus virginiana var. melanocarpa/Rhus aromatica ssp. trilobata P.A.)

Smooth sumac P.A.
(Rhus glabra) P.A.

Ninebark-(Chokecherry) P.A.
(Physocarpus monogynus-(Prunus virginiana var. melanocarpa) P.A.)

Mountain maple/Chokecherry-Ninebark P.A..
(Acer glabrum/Prunus virginiana var. melanocarpa-Physocarpus monogynus P.A.)

Relevant SCS range sites are Shallow Foothill #204 for the Mountain Mahogany P.A. and Rocky Foothill #206 for the Mixed Mountain Shrublands.

Vegetation

Cover by vegetation plus litter is variable but often high in this M.U. It includes consistently very high values in the Snowberry, Hackberry and Hawthorn P.A.s to values that range from moderate to very high in the Mountain maple P.A. and the Smooth sumac P.A., in which rocks, and to a lesser degree bare soil, typically comprise 20% and often up to 50% of the ground cover. In

the Mountain maple P.A., the tree-like maples often comprise a large proportion of the vegetation cover, while lower vegetation layers may have low to high cover. The other P.A.s in this M.U. often have very low cover by bare soil or rocks but may have up to about 20% cover by rocks, or in cases where the shrub cover is not very high, by bare soil.

Relative contribution by shrubs versus herbaceous species also varies. The Mountain mahogany and Snowberry P.A.s have a well developed grass layer whereas the other P.A.s in this M.U. often have a sparse graminoid layer. However, American plum P.A. stands with an open shrub canopy consistently have a well developed grass layer and some of these that are dominated by skunkbrush intergrade with the Skunkbrush Grassland P.A..

Structure of the P.A.s range from short shrublands (typically less than a meter tall) in the cases of the Snowberry and Smooth sumac P.A.s to tall shrublands (typically over two meters) in the cases of the Hackberry and Hawthorn P.A.s to the tree-like Mountain Maple P.A. Although only a few stands of the latter P.A. were located, they were strikingly consistent in vegetation structure, as well as in species composition and site characteristics. The Mountain mahogany P.A. is a medium height shrubland, with most shrubs between one and one-half to two meters tall. The American plum and Ninebark P.A.s are usually tall shrublands but may be short.

Although intermediates between the P.A.s are not uncommon, the namesake species are typically the clear dominants in each P.A. In the American plum P.A., not all the namesake species are always present and some stands contain only plum, chokecherry or skunkbrush sumac. In the Ninebark P.A., American

plum may dominate in addition to the ninebark.

In the Mountain mahogany/Griffiths' wheatgrass P.A., Canada bluegrass is common and other species in the existing vegetation include Kentucky bluegrass, sun sedge, needle-and-thread, Japanese brome, pussytoes (Antennaria rosea), sulfur-flower, Spanish bayonet and prickly-pear. In the existing vegetation of the Snowberry P.A., codominant with the western snowberry are Kentucky and Canada bluegrasses and timothy. Common species with high constancy are big bluestem, pink bergamot (Monarda fistulosa var. menthaefolia), ninebark, and skunkbrush. Other species include western wheatgrass, sedges, poverty oat-grass, needlegrasses, golden banner (Thermopsis divaricarpa), chokecherry, and wax currant.

Local thickets of the Hawthorne and Hackberry P.A.s resemble the American plum P.A., which they typically adjoin and which are described below.

The American plum-Chokecherry/Skunkbrush sumac P.A. has various species that may be common in the existing vegetation. Kentucky and Canada bluegrasses show high constancy. Other herbaceous species include tallgrasses, needlegrasses, Japanese brome, and cheatgrass in open shrub stands. Shrub species with low constancy or cover include rose, wax currant, boulder raspberry, pin cherry (Prunus pennsylvanica), and all the other namesake species of the other P.A.s in this M.U.

The species in the Smooth sumac P.A. resemble the American plum P.A. as described above except that Oregon grape may be common.

In the Ninebark-(Chokecherry) P.A., bluegrasses are common and other shrubs of

the Mixed Mountain Shrublands may be present. The vegetation of the Mountain maple P.A. resembles that of the Ninebark P.A., but with an additional tree-like layer of maples.

Site

The Mountain Shrubland M.U. typically occupies small, scattered areas throughout the Open Space lands, and is most common in the forest-grassland ecotone. It is found in concavities or seeps, on north facing slopes, and in small drainages. With the exclusion of the Mountain Mahogany P.A., it occurs on very moist, usually moderately well drained soils. The Mountain Mahogany P.A. occurs on a somewhat dry, gravelly, coarse, excessively drained soil on a north facing, convex slope on the Kassler property. Because its site characteristics differ from those of the rest of the M.U., the Mountain Mahogany P.A. will be treated separately and generalizations about the M.U. will not apply to it unless specified.

Soils of this M.U. are often shallow, coarse and rocky, with the exclusion of the Snowberry P.A., which occupies fine soils. SCS map units that underly the Mountain Shrubland M.U. are Baller stony sandy loam, Colluvial land, Goldvale-Rock outcrop complex, Nederland very cobbly sandy loam, Pinata-Rock outcrop complex, Rock outcrop, Terrace escarpments, and Valmont cobbly clay loam. The Mountain mahogany P.A. occupies the Juget-Rock outcrop complex, which is derived from residual, granitic parent material.

Typical site characteristics and locations of the P.A.s are summarized here. The Snowberry P.A. occupies fine textured, level or concave soils that receive runoff whereas most of the P.A.s occupy moderate to steep, rocky, coarse

textured soils. Most examples of the Snowberry P.A. were found on the southwestern properties, e.g., Dunn 1 to Wells. In and below the forest-grassland ecotone, the American plum, Hawthorn, and Hackberry P.A.s occupy seeps on steep slopes, some north slopes, and many of the small drainages. The American plum P.A. is the most widely distributed type in the M.U. and can be seen on the following properties: Boulder Valley Ranch, Boulder Memorial, Kassler, Stengel 2, etc. Examples of the Hawthorne and (less common) Hackberry P.A.s are found on Boulder Memorial and, respectively, on Rudd East and Wells, and on Ertl and Dunn 2. The Smooth sumac P.A. is found in and above the ecotone on very rocky, often steep sites that it is apparently colonizing. Examples can be seen on Dunn 1 or Debacker.

The Ninebark P.A. is located in the upper ecotone on north facing slopes and in many small drainages in the forest zone. Examples are found on Abbey, Schnell, and Whittemyer. The Mountain Maple P.A. is also found in the upper ecotone on north facing slopes, but only at limited locations, on very steep, very rocky to bouldery sites and extending up into the coniferous forests in a few drainages. Examples are found on Culberson, Debacker, Kassler, and Wells.

Distribution and Disturbance

The Mountain Shrubland M.U. borders all the other vegetation types on the Open Space lands, most frequently bordering the types that are common in the forest-grassland ecotone.

Often adjoining the Ninebark P.A. at its higher elevation is the Douglas-fir/Ninebark P.A. Typically adjoining the Mountain maple P.A. at its higher elevations is the Douglas-fir/Mountain Maple P.A., and below in

drainages is often similar vegetation that also includes box-elder (Acer negundo) and other riparian species.

Disturbance of some Mountain Shrubland areas is considerable, but many show few signs of grazing or other human-related activities.

Particularly to the north and south of the study area, on dry coarse soils, mountain mahogany is common at elevations below ponderosa pine forests and above grasslands. Mountain mahogany or Gambel oak (Quercus gambelii) occupy a comparable altitudinal zone in other parts of the east slope of the Colorado Front Range. The limited presence of a submontane shrub zone in the Boulder area is not well understood, but may be attributed to locally steep topographic and moist meteorological conditions that allow ponderosa pines to extend down to grassland vegetation (e.g., see Cooper 1984).

4.4.6 Riparian Forest/Shrubland (Map Unit R)

This M.U. contains several P.A.s dominated by deciduous trees and shrubs and found along creeks and drainages. Included are forests, woodlands and shrublands with overstories of cottonwood (Populus spp.), willow (Salix spp.), and river birch (Betula fontinalis). The first two communities are located on the plains and into the forest-grassland ecotone, while the latter is located in and above the ecotone.

Synonymy

For the River birch P.A.
(Betula fontinalis P.A.):

Narrow-leaved alder-River Birch Montane Riparian P.A. Baker (1984)
(Alnus incana ssp. tenuifolia-Betula occidentalis

Montane Riparian P.A.)

Thinleaf alder-River birch/Willow P.A. (Alnus tenuifolia-Betula fontinalis/Salix spp. P.A.) — Johnston (1984)

Some river birch stands may resemble two different P.A.s, listed below. The latter two in the following list are synonymous.

Cf. Thinleaf alder/Field horsetail P.A. (Alnus tenuifolia/Equisetum arvense P.A.) — Hess (1981)

Cf. Narrowleaf cottonwood/Coyote willow P.A. (Populus angustifolia/Salix exigua P.A.) — Hess (1981)

Cf. Narrowleaf cottonwood/Coyote willow-River birch P.A. (Populus angustifolia/Salix exigua-Betula fontinalis P.A.) — Johnston 1984)

For the Sandbar willow P.A. (Salix exigua P.A.):

Sandbar willow/Sedge Plains Riparian P.A. (Salix exigua/Carex spp. Plains Riparian P.A.) — Baker (1984)

Coyote willow-Willow/Bluegrass P.A. (Salix exigua-Salix spp./Poa sp. P.A.) — Johnston (1984)

For the Plains cottonwood/Willow P.A. (called Foothills Cottonwood) (Populus deltoides ssp. monilifera-Salix spp. Foothills P.A.):

Plains cottonwood-Peachleaf willow/Coyote willow/Prairie cordgrass* P.A. (Populus deltoides ssp. monilifera-Salix amygdaloides/Salix exigua/Spartina pectinata* P.A.) — Baker (1984)

Plains cottonwood-Rio Grande cottonwood-Fremont cottonwood/Peachleaf willow-Coyote willow P.A. (Populus sargentii-P. wislizenii-P. fremontii/Salix amygdaloides-S. exigua P.A.) — Johnston (1984)

Vegetation

Total cover by vegetation plus litter is very high in this M.U. except in some areas where the vegetation has been heavily disturbed.

In addition to the namesake species, important species in the River Birch P.A. are narrow-leaved alder, narrowleaf cottonwood, and willows (including sandbar and S. depressa ssp. rostrata). Because narrowleaf cottonwood was not often found dominating river birch in this study, all the river birch dominated vegetation is treated in one P.A. (see synonymy). Other species often seen include western snowberry, chokecherry, mountain maple, box-elder, Canada bluegrass, field horsetail, bracken (Pteridium aquilinum), and cow parsnip (Heracleum sphondylium). In the existing vegetation of the Sandbar Willow P.A., widely scattered cottonwoods and (exotic) Russian-olive trees (Eleagnus angustifolia) may be present. Sometimes other willows or western snowberry or herbaceous species such as sedges are important.

The existing vegetation of the Foothills Cottonwood P.A. has narrowleaf cottonwood and willows (especially sandbar) as dominants in addition to plains cottonwood. Other important, woody species are numerous and include Populus X acuminata, (exotic) crack willow (Salix fragilis), box-elder, and all the native woody species noted above in this paragraph as well as important species of the Mixed Mountain Shrublands (see section 4.4.5). Poison ivy (Toxicodendron rydbergii), rose, or currants (Ribes spp.) are often present. Typical herbs include sedges, rushes, bluegrasses, orchard-grass, smooth brome, field horsetail, golden banner, Pacific aster (Aster chilensis), and purple meadow-rue (Thalictrum dasycarpum).

The Foothills Cottonwood P.A. includes diverse stands which are intermediate between those of the eastern plains and the lower montane zone (Johnston 1984). Although disturbed, the Cottonwood Grove on Boulder Creek is one of the few remaining stands of the Foothills Cottonwood P.A. in the region that

exemplifies its potential structural complexity. Both understory and overstory are structurally and floristically complex, and the density of each layer appears inversely related. The presence of many exotic species typifies the highly disturbed state of the existing vegtation of the Foothills Cottonwood P.A. seen in this study. At its upper elevations, this P.A. intergrades with the River Birch P.A. and mesic Mountain Shrublands.

Site

The Riparian M.U. is found throughout the study area along creeks and drainages, but is more extensive on the plains than above the forest-grassland ecotone. All of this M.U. is wet to very moist, somewhat poorly drained, and with a shallow water table maintained by flowing water.

Soils of the Riparian M.U. are shallow to deep, and typically are loamy alluvium over gravel and sand. SCS map units are typically Loveland and also Niwot soils. This M.U. occurs on benches and floodplains adjacent to waterways.

The most widespread Riparian P.A. on the plains, Sandbar Willow, occurs along irrigation ditches and on wet, young soils. Examples are found on Neuhauser, Rudd East, and Short-Milne. The Foothills Cottonwood P.A. grows along the creeks in the study area below about 6000' (1830 m), and is found adjacent to creeks with water speeds intermediate between the creeks of the eastern plains and the lower montane zone. Soils are often sandy, shallow, and gravelly. Nice examples are located on Burke 1, Cottonwood Grove, and Dunn 1.

The River Birch P.A. is common above about 6100 ft (1859 m), above the

elevations supporting the Sandbar Willow and Foothills Cottonwood P.A.s. It typically occupies a narrow area having deep soils and was seen along medium to small drainages, including examples on Debacker, Culberson, and Wells. Smaller drainages support thickets of mountain shrubs that also occupy moist upland sites (see section 4.4.5).

Distribution and Disturbance

On the plains, the Sandbar Willow and Foothills Cottonwood P.A.s often form a mosaic with Wetland M.U.s and are typically heavily disturbed. In the lower montane zone, the River Birch P.A. often alternates with areas of mesic Mountain Shrublands along a drainage and is typically only slightly disturbed.

4.5 DISTURBED AND CULTIVATED LAND

4.5.1 Building (Map Unit B)

The Building M.U. includes all areas covered by buildings, pavement, and graded dirt and gravelled surfaces. It accounts for a very small proportion of the City Open Space lands, and is usually located on the plains.

4.5.2 Disturbed Land (Map Unit D)

The Disturbed Land M.U. is dominated by invaders or "weeds", cannot be identified as a plant association, and is not currently used for agricultural purposes, including grazing. Usually located on the plains, this M.U. includes abandonned croplands ("go-back" fields) and lands recently disturbed. Species often found include those noted in section 2.2.1 with the

addition of other ruderal species.

4.5.3 Agricultural Field (Map Unit A)

The Agricultural Field M.U. includes fields planted in crops and forage, as well as native vegetation that is grazed or hayed to an extent that the native vegetation type is no longer identifiable.

Hayland species include smooth brome, alfalfa (Medicago sativa), and sweet-clover (Melilotus spp.). Areas of crested wheatgrass (Agropyron cristatum) are also in this M.U. Overgrazed native vegetation mapped as agricultural is dominated by invaders and increasers, especially blue grama and annual bromegrasses (see sections 2.2 and 4.2.2).

All areas are located below the forest-grassland ecotone. Richardson 2, Jenik, and Teller are examples of croplands and Van Vleet has areas of hayed and of grazed Agricultural lands.

4.5.4 Open Water (Map Unit O)

The Open Water M.U. includes ponds, lakes, and reservoirs, which are typically situated on the plains.

5.0 RESULTS AND DISCUSSION: VEGETATION ON THE OPEN SPACE PROPERTIES

Some of the vegetation information collected in this work is best summarized by property or group of properties. In this section are comments on vegetation or floristic features, and a summary of treeline and natural vegetation (NV) on the Open Space lands. The properties are organized into fifteen (15) groups on the bases of physical proximity, similarity in existing vegetation and land use, and similarity in natural vegetation. For convenience, the groups are numbered and named for the single property that is the largest, is centrally located, or is most representative of the group. The order of discussion of the groups is clockwise starting on the plains. Prediction of natural vegetation utilized SCS soils maps and soils information shown in Table 5-1 as well as knowledge of land use and existing vegetation.

5.1 VEGETATION

5.1.1 Group 1 - Teller

Group 1, or the Teller group, is located on the plains north of Baseline Road, and supports vegetation that is heavily altered by humans. In this group are the following properties: Eccher, Green, Jenik, Minnitrista, Richardson 2, and Teller. The predominant M.U. is Agricultural Field.

Based upon the SCS soils maps, the NV on most of Eccher, Richardson 2, and Teller would be Mid-height Grassland to Xeric Tall Grassland. The NV on Jenik, Green, and Ministrista would be Mid-height Grassland except that the latter two have been recontoured by humans and contain irrigation ditches.

Table 5-1: Typical Natural Vegetation on SCS Map Units in the Boulder Area

This table is based on observations of vegetation made in this study as well as information from SCS Range Conservationist Harvey Sprock. In order to make a more readable table, third letters in the SCS map units (Moreland and Moreland 1975) are not shown here. Since most soils are at least moderately well drained and moderately deep, selected typical features show only exceptions to this general pattern, as well as showing soil texture. A "?" in the table indicates that there were no direct observations in this study of the specified NV on the soil map unit, but that the NV M.U. shown is probable. Additional NVs for a specific soil M.U. are possible. NV M.U.s are listed alphabetically by symbol within a soil.

SOIL SYMBOL, NAME	TYPICAL FEATURES	TYPICAL NATURAL VEGETATION SYMBOL, NAME
Ac, Ascalon & Ao, Ascalon-Otero complex	sandy loam	? G, Mid-height Grassland ? X, Xeric Tall Grassland
Ba, Baller stony sandy loam	stony sandy loam, shallow	H, Skunkbrush Grassland M, Mountain Shrubland P, Ponderosa Pine Forest V, Ponderosa Pine Savannah X, Xeric Tall Grassland
Co, Colby silty clay loam & Ct, Colby-Gaynor complex	silty clay loam	G, Mid-height Grassland
Cu, Colluvial land	variable, often rocky sandy loam	H, Skunkbrush Grassland M, Mountain Shrubland V, Ponderosa Pine Savannah X, Xeric Tall Grassland
Fc, Fern Cliff-Allens Park-Rock outcrop	rock outcrop	F, Douglas-Fir Forest P, Ponderosa Pine Forest
Ga, Gaynor silty clay loam	silty clay loam	G, Mid-height Grassland
Gr, Goldvale-Rock outcrop complex	rock outcrop	C, Cliff ? F, Douglas-fir Forest M, Mountain Shrubland P, Ponderosa Pine Forest T, Talus ? V, Ponderosa Pine
Ha, Hargreave fine sandy loam	fine sandy loam	X, Xeric Tall Grassland

Table 5-1 continued

He, Heldt clay	clay	G, Mid-height Grassland
Jr, Juget-Rock outcrop complex	rock outcrop, shallow, excessively drained	C, Cliff F, Douglas-fir Forest M, Mountain Shrubland-only Mountain Mahogany P.A. P, Ponderosa Pine Forest T, Talus V, Ponderosa Pine Savannah
Ku, Kutch clay loam	clay loam	G, Mid-height Grassland
Lo, Longmont clay	clay, salty, alkaline, poorly drained	W, Wetland
Lv, Loveland soils	gravelly sandy, somewhat poorly drained	L, Mesic Tall Grassland R, Riparian W, Wetland
Md, Manter sandy loam	sandy loam	? G, Mid-height Grassland ? X, Xeric Tall Grassland
Me, Manvel loam	loam	G, Mid-height Grassland
Nd, Nederland very cobbly sandy loam	very cobbly sandy loam	G, Mid-height Grassland-only Mountain Muhly P.A. H, Skunkbrush Grassland M, Mountain Shrubland P, Ponderosa Pine Forest X, Xeric Tall Grassland V, Ponderosa Pine Savannah
Nh, Niwot soils	somewhat poorly drained	L, Mesic Tall Grassland R, Riparian W, Wetland
Nn, Nunn sandy clay loam	sandy clay loam	G, Mid-height Grassland
Nu, Nunn clay loam	clay loam	G, Mid-height Grassland
Nv, Nunn-Kim complex	clay loam	G, Mid-height Grassland
Pg, Peyton-Juget very gravelly loamy sands	very gravelly loamy sands	P, Ponderosa Pine Forest X, Xeric Tall Grassland ? V, Ponderosa Pine Savannah

Table 5-1 continued

Pr, Pinata-Rock outcrop complex	very stony loamy fine sand	C, Cliff M, Mountain Shrubland P, Ponderosa Pine Forest T, Talus V, Ponderosa Pine Savannah
Re, Renohill loam	loam	E, Steep/Sparse Vegetation G, Mid-height Grassland
Rn, Renohill silty clay loam	silty clay loam	G, Mid-height Grassland
Ro, Rock outcrop	rock outcrop, very shallow	C, Cliff F, Douglas-fir Forest M, Mountain Shrubland P, Ponderosa Pine Forest T, Talus
Sa, Samsil clay & Se, Samsil-Shingle complex	clay, shallow	G, Mid-height Grassland
Sm, Sixmile stony loam	stony loam	E, Steep/Sparse Vegetation P, Ponderosa Pine Forest X, Xeric Tall Grassland ? V, Ponderosa Pine Savannah
Te, Terrace escarpment	cobbly, stony, shallow	G, Mid-height Grassland-on lower slopes M, Mountain Shrubland X, Xeric Tall Grassland
Va, Valmont clay loam	clay loam	G, Mid-height Grassland
Vc, Valmont cobbly clay loam	cobbly clay loam	H, Skunkbrush Grassland M, Mountain Shrubland P, Ponderosa Pine Forest X, Xeric Tall Grassland V, Ponderosa Pine Savannah
We, Weld fine sandy loam	fine sandy loam	? G, Mid-height Grassland ? X, Xeric Tall Grassland
WI, Weld loam	loam	G, Mid-height Grassland

5.1.2 Group 2 - Ertl

Group 2, or the Ertl group, is located on the plains north of Baseline Road and supports special flora and plant communities in spite of the fact that most of it is heavily altered by humans. Kaufmann and Ertl (or, the White Rocks Natural Area) are the two parcels in this group. The single largest M.U. is Agricultural Field.

Rare plant species on the Ertl parcel were discussed in section 2.1.2 and the locally unusual Sand Sagebrush/Sand Dropseed P. (in M.U. H) was described in section 4.3.1.

Based upon the SCS soils map, the Agricultural Lands in this group are likely to support NV that is Mid-height to Xeric Tall Grassland. The NV on all other vegetated areas are expected to be the same as the existing vegetation, except that the Wetland on Ertl is likely to have NV of Mesic Tall Grassland.

5.1.3 Group 3 - McKenzie

Group 3, or the McKenzie group, is located on the plains north of Baseline Road, is heavily altered by both humans and prairie dogs, and contains a variety of Wetlands, including saline areas. In this group are the following properties: Andrus, Belgrove, Hart-Jones, McKenzie, and Reynolds. Agricultural Field and Mid-height Grassland are the major M.U.s.

A playa in the northwest corner of the McKenzie property supports some unusual plants, and was described in section 4.2.6.

Based upon the SCS soils map, the NV on the following areas is predicted to be

Mid-height Grassland: all of Andrus except the very southwest and southeast, all of the northern part of McKenzie except for the playa, Belgrove north of Fourmile Canyon Creek, and most of Hart-Jones. Reynolds and the southern parts of McKenzie and Belgrove are predicted to support Xeric Tall Grassland NV. The Agricultural Field M.U. on southern Andrus is likely to support NV of Mesic Tall Grassland or Wetland. The only Riparian Forest would be on Belgrove.

5.1.4 Group 4 - Cottonwood Grove

Group 4, or the Cottonwood Grove group, is located on the plains north of Baseline Road along Boulder Creek, is heavily to moderately disturbed, and is primarily Riparian and Wetland, with some Agricultural M.U. Properties in this group are: Arnold, Cottonwood Grove, Flatirons Industrial, Short-Milne, and Valmont Industrial.

Vegetation and floristic studies of the Cottonwood Grove have been carried out by Dr. Jane Bock and Maureen O'Shea Stone (personal communication) at the University of Colorado, Boulder (see section 4.4.6)

Based upon the SCS soils map, the NV of this group is similar to the existing vegetation, with the replacement of most Disturbed and Agricultural M.U.s by Riparian or Wetland M.U.s, and with the exception of that part of Short-Milne that is a reclaimed gravel pit. It is likely that Mesic Tall Grassland would be present in the NV at some existing Wetlands.

5.1.5 Group 5 - Van Vleet

Group 5, or the Van Vleet group, is located on the plains primarily south of Baseline Road along South Boulder Creek, is heavily to moderately disturbed,

and contains most of the Mesic Tall Grassland NV in the study area. Seven properties are in this group: Burke 1, Burke 2, Gebhart, Hedgecock, Neuhauser, THP, and Van Vleet. Agricultural Field and Mesic Tall Grassland are the major M.U.s. Groups 4 and 5 together contain most of the Riparian M.U.

A couple of interesting aspects of the existing vegetation will be noted here. First, the Riparian area on Burke 1 contains nice examples of hybridization between plains and narrow-leaved cottonwoods. Also, some rare orchids are found on this property (Bill Jennings, personal communication, 1985). Second, the mosaic of drier and wetter vegetation on the Hedgecock property offers a good example of the difficulty of determining whether land use or site factors explain the vegetation pattern, although it appears to be the latter in this case.

Based upon the SCS soils map, NV of Mesic Tall Grassland is expected on the following properties: all of Gebhart, Burke 1 and 2 excluding the Riparian M.U. and the very southeast corner of Gebhart; most of Van Vleet west of McGinn Ditch and South Boulder Creek; and THP West and Hedgecock where Mesic Tall Grassland is the existing vegetation. Some discussion of Mesic Tall Grassland NV on THP East is found in section 4.2.5. Riparian NV is expected at the existing Riparian areas. Xeric Tall Grassland is the predicted NV on all areas where it now exists plus the very southeast corner of Gebhart, and on Van Vleet east of McGinn Ditch and South Boulder Creek. Some small areas of Mid-height Grassland are expected on fine, upland soils.

5.1.6 Group 6 - Yunker

Group 6, or the Yunker group, is located on the plains south of Baseline Road,

is heavily to lightly disturbed, and is predominantly Mesic and Xeric Tall Grassland. Properties in this group are: Church, Klein-Hoover Hill, Gallucci, Short, and Yunker.

The Short property has an interesting mosaic of wetter and drier vegetation types that correspond to slight topographical differences. The factors causing the mosaic of Wetland (including Inland Saltgrass) and Mesic Tall Grassland on Klein-Hoover Hill are not clear. Localized prairie dog activity and irrigation ditch seepage may be contributing factors.

Based upon the SCS soils map, NV on most of this group is Xeric Tall Grassland with areas of Mid-height Grassland on fine soils on western Klein (now Agricultural Field), and small areas on Yunker and Gallucci. Other discussion of this group is found in sections 2.2 and 4.2.5.

5.1.7 Group 7 - Rudd East

Group 7, or the Rudd East group, is located south of Baseline Road and east of Colorado 93, is heavily to moderately disturbed, and contains the lowest elevation extension of the forest-grassland ecotone in the area and on Open Space lands. Properties in this group are Richardson 1, Rudd East, Salstrand and Twelve Sixty Five Co. Although Xeric Tall and Mid-height Grasslands account for much of the land area, woody vegetation is also conspicuous.

The NV of this group is expected to resemble the existing vegetation, but with the exclusion of the Short Grasslands. However, the full extent of the Ponderosa Pine Savannah and Forest NV is unknown. Good pine reproduction was observed on many rocky areas on Rudd East that now support Skunkbrush

Grassland. Although the extent of most mapped areas of ponderosa pines changed imperceptibly between 1937 and 1980, Rudd East supports one area of pines that advanced significantly. It is the savannah area west of Marshall Lake bordering the western property boundary. The difference between the 1937 and 1980 extent of this savannah resembles the difference between the green area on the 1965 USGS topographic basemap and the savannah area on the existing vegetation map.

5.1.8 Group 8 - Flatirons Vista

Group 8, or the Flatirons Vista group, is located west of Colorado 93 and south of Colorado 398 at the southernmost extent of the Open Space lands, is heavily to moderately disturbed, and exemplifies the forest-grassland ecotone but with few shrub-dominated areas. Properties in this group are Dunn 2, Flatirons Vista, Rudd West, and Stengel 2. Mid-height Grassland is the most extensive M.U. Xeric Tall Grasslands cover areas of Dunn 2 and Rudd West, while Ponderosa Pine Forest and Savannah cover areas of Flatirons Vista and Stengel 2.

The latter properties are of interest for several reasons. They support the lowest elevation examples of mountain muhly dominated vegetation in the study area, and as noted before in section 2.2, they are one of the few areas not hit by mountain pine beetle infestation. Soil factors resemble those of Rocky Flats to the southeast. The Short Grassland on Rudd West contrasts strikingly to the neighboring Xeric Tall Grassland on Rudd East and is apparently due to past overgrazing.

The predicted NV in this group differs from the existing vegetation only in

the following ways: The Short Grasslands on Rudd West and the mosaics of Mid-height/Short Grasslands have NV of Xeric Tall Grassland. However, the area of Short/Mid-height Grasslands mosaic has NV of Mid-height Grassland. The full extent of Ponderosa Pine Forest and Savannah NV is unclear, since there have been some minor increases in extent and density of pines that have advanced Savannah and Forest boundaries since 1938. However, it appears that the pines now occupy almost all of the areas that have Savannah or Forest NV.

5.1.9 Group 9 - Stengel 1

Group 9, or the Stengel 1 group, is located west of Colorado 93 and north of Colorado 398, is slightly (especially Dunn 1) to moderately disturbed, and represents a forest-grassland ecotone with extensive shrublands. Properties in this group are Dunn 1, Frasier Farms, and Stengel 1. Xeric Tall Grassland and Skunkbrush Shrub Grassland are the most extensive P.A.s, but Mid-height Grassland, Wetland, Ponderosa Pine Forest and Savannah, and Mountain Shrubland all cover noticeable areas.

The existing vegetation in this group is apparently similar to the NV, but with the Agricultural Field on Dunn 1 probably having NV of Mesic Tall Grassland. No significant changes in treeline since 1938 were found with one exception. Increases in density of the very widely scattered pines present in 1938, which occurred primarily before 1965, have produced the Ponderosa Pine Savannah just northnortheast of Stengel Mesa.

5.1.10 Group 10 - McCann

Group 10, or the McCann group, is located at the southwestern extent of the

study area, is slightly to not disturbed, and extends from the lower forest boundary up into the mesic Douglas-fir M.U., which is more extensive in this group than in any other. Properties in this group are Barute, Campbell, Culberson, Debacker, and McCann. Ponderosa Pine Forests are the other main M.U., and areas of Mountain Shrubland and Talus are evident.

The existing vegetation in this group is apparently similar to the NV. No measurable changes in treeline since 1938 were found.

5.1.11 Group 11 - Wells

Group 11, or the Wells group, is located just south of Table Mountain in the southwestern part of the study area, is moderately to not disturbed, and extends from the forest-grassland ecotone up into the central Ponderosa Pine zone. Properties in this group are Abbey, Wells, and McStain. Ponderosa Pine Forests predominate and all the other woody M.U.s of the ecotone and lower montane zone are represented.

A very small but striking area of Mesic Tall Grassland is located along the road to the water tank on the Wells property, and is probably the result of water seepage. Within the Ponderosa Pine Forests and Savannahs, several sedge specimens were identified, and both sun sedge and Carex pityophila were found, but not always in the expected sites, i.e., with the latter in the open forest and the former in the closed forest. More investigation of the sedges in the Ponderosa Pine M.U. is needed.

The existing vegetation in this group is apparently similar to the NV. No significant changes in treeline since 1938 were found, with the exception of

two small openings in the pine forests in 1938 on southeast Wells that are now mapped as forest or savannah.

Taken together, groups 9, 10 and 11 contain all of the Talus M.U., most of the Ponderosa Pine and Douglas-fir Forests, and much of the Ponderosa Pine Savannah, Skunkbrush Grassland, and Mountain Shrubland on the Open Space properties.

5.1.12 Group 12 - Kassler

Group 12, or the Kassler group, is located southwest of downtown Boulder, is slightly to not disturbed, and contains primarily north facing slopes that extend from the ecotone up into the ponderosa pine zone. Properties in this group are Collins, Kassler, Merraset, Overlook, Schnell and Tippit. Shrublands and forests predominate on the rocky substrates typical of this group.

The Kassler property contains the only area of Mountain Mahogany P.A. on the Open Space lands in this study, as well some ferns that grow only on granitic rocks.

The existing vegetation in this group is apparently similar to the NV. No measurable changes in treeline since 1938 were found.

5.1.13 Group 13 - Boulder Memorial

Group 13, or the Boulder Memorial group, is located northwest of downtown Boulder, is slightly to heavily disturbed, exemplifies the vegetation patterns on the first hogbacks above the plains, and extends up into the ponderosa pine zone. Properties in this group are Boulder Memorial, Cunningham, Hutchinson,

Sanitas, Smith, Spring Valley, Summers, and Whittemyer. While the latter property is primarily Ponderosa Pine Forest, the other properties in this group support grasslands and various woody communities typical of the ecotone.

The existing vegetation in this group is apparently similar to the NV, although the NV of the Short Grassland is likely to be Mid-height or Shrub Grassland. The only noteworthy change in treeline since 1938 is an increase in a Pine Savannah on Boulder Memorial due to a slight increase in tree density. On Whittemyer, forests have become denser and some meadows within the pines have increased (presumably due to logging).

5.1.14 Group 14 - Erni

Group 14, or the Erni group, is located west of Broadway (US 36) and north of Two Mile Canyon, is slightly (south of Lee Hill Road) to heavily disturbed, and extends from the plains up to the first hogbacks, which support Ponderosa Pine M.U.s. Properties in this group are Erni, Gilbert, Leach-Arnold, Moore, Mann, Parsons, Proper, and Wonderland Lake. The main M.U.s are Mid-height and Xeric Tall Grasslands, and there are small areas of Mountain Shrubland.

Vegetation and floristic features of note include several areas of Steep/Sparse Vegetation, one of which (on Mann) supports Bell's twin-pod (see section 2.1.2); and a burn on Erni.

The existing vegetation in this group is apparently similar to the NV. There are no changes in treeline since 1938, with the exception of a few of the small, existing Ponderosa Pine Savannahs, which supported only very widely

scattered pines in 1938.

5.1.15 Group 15 - Boulder Valley Ranch

Group 15, or the Boulder Valley Ranch group, is the northernmost group in this study, is located on the plains east of US 36 (Broadway) and west of Boulder Reservoir, and is quite heavily disturbed by humans and prairie dogs. Properties in this group are Boulder Land, Irrigation and Power; Boulder Valley Ranch; Boulder Warehouse; and Lore. The single most extensive M.U. is Mid-height Grassland, there are noteworthy areas of Wetland and Agricultural Field, and small areas of Steep/Sparse Vegetation and Mountain Shrubland.

Based on the SCS soils map, the NV includes the existing Wetland and is predominantly Mid-height Grassland, with the following exception: Xeric Tall Grassland is predicted to be the NV on: Lore excluding the very northerly slope; the adjacent, northernmost part of Boulder Valley Ranch; the southwestern corner of Boulder Valley Ranch and a narrow continuation onto Mesa Reservoir; and the northwest part and a narrow band of southwestern Boulder Land, Irrigation and Power. The existing areas of Steep/Sparse Vegetation and Mountain Shrubland are predicted to be the NV.

5.2 TREELINE

Treeline is considered here coincident with the boundaries of Ponderosa Pine Savannah or coniferous forest. Historic treeline as discerned from 1937 and 1938 aerial photographs was compared to existing vegetation and to green (forested) areas on the USGS topographic basemaps produced in 1965 and 1966. Some interpretation of the green areas was necessary, since the USGS

apparently mapped green areas where trees comprise over about 15% cover whereas pine savannahs in this work may be mapped down to 5% tree cover.

In general, there were few or small changes in historic treeline between 1937/1938 and 1980. Apparently, forest recovery from the heavy initial disturbance of the 19th Century settlement period was accomplished by 1937 on most City Open Space lands. Only two sites (both savannahs) experienced significant advancement of trees: on Rudd East west of Marshall Lake at the western property boundary, and on Stengel 1 northnortheast of Stengel Mesa. Some minor increases in tree density that extended savannah boundaries were seen on another area of Rudd East, three areas of Flatirons Vista, and one area of Boulder Memorial. The sites experiencing tree invasion have coarse, rocky soils that are often Nederland very cobbly sandy loam which support Xeric Tall Grasslands. Also seen between 1937 and 1980 were some increases in forest density. The observations reported here are consistent with the results of other studies (see section 2.2.3).

6.0 MANAGEMENT RECOMMENDATIONS

This study provides the basis for making management recommendations for the City of Boulder Open Space properties, but it was beyond the current scope of work to make specific recommendations, for instance, concerning fire or grazing on specific properties. General discussion of disturbance factors is presented in section 2.2. A different kind of limitation of this study concerns the management practices on adjoining public lands, that is, City of Boulder Mountain Parks and Boulder County Open Space lands. Management of all public lands must be coordinated in order to achieve the best results, and an inventory of all the public lands should ideally precede the formulations of specific management policies. Thus the following comments are directed at selected topics that arose in the course of this study and are not a comprehensive discussion of management issues or options.

First, annual monitoring of range and pastureland site conditions is necessary in order to document vegetation changes as they relate to management practices. SCS range survey methods have been developed and are widely used for such purposes. Site trends are based upon measurements of percent plant species composition and condition classifications taken over a series of years. Furthermore, a long range management plan for the Open Space lands is needed so that site condition and trend can be evaluated against a meaningful goal. Goals for specific properties should be part of the long range management plan.

A holistic management approach is needed: i.e., one that considers ecosystem and species characteristics and health, as well as human use, such as for

livestock grazing or recreation. The management program recently developed by the City Open Space Department for range and pastureland utilizes such an approach (D. Antonio 1986, personal communication).

Protection of riparian vegetation should be a high priority. Riparian ecosystems are a scarce, valuable, and shrinking resource in the West, and are sensitive to disturbance (e.g., see Johnson et al. Coords. 1985; Kusler et al. 1983; Thompson and Strauch 1985). Livestock grazing should be very carefully managed on all areas of Cottonwood Forest on the City of Boulder Open Space lands in order to allow vegetation recovery from past overuse.

Continued management efforts should be directed at improving the condition of all properties that show deterioration due to poor management of grazers. As noted in section 2.2, between 1976 and 1983, management practices directed at improving range conditions on Open Space lands resulted in substantial improvements in condition while still allowing livestock use. Of particular concern are properties with Mesic Tallgrass natural vegetation that are not in healthy condition, e.g. the south end of Gebhart, and part of Van Vleet. Such areas should not be forgotten while all attention focuses on the Mesic Tall Grasslands that are in healthy condition and have been designated as Natural Areas (see section 4.2.5).

Two other aspects of management of the tall grasslands on Open Space lands will be briefly discussed here. First, irrigation ditch seepage is apparently supplying water that supports Mesic Tall Grasslands on the Church, Yunker, and possibly the THP East properties. However, since some of these areas have now been designated as Tallgrass Natural Areas, any changes in their moisture

regime should be carefully evaluated.

Second, although invasion of Xeric Tall Grasslands by ponderosa pines is occurring, these grasslands do not appear to be threatened by ponderosa pine advances, which was a concern expressed by some Open Space personnel. Treeline advances since 1938 have been nonexistent on many properties, small on a few Open Space properties, and substantial only at two locations. Local site conditions, especially drainage and soil texture, are primary influences on the suitability of the grasslands for coniferous trees. In some areas, an open ponderosa pine canopy with a Xeric Tall Grassland understory is apparently a stable association (see sections 4.3.2 and 4.4.1). Also, Xeric Tall Grasslands are distributed throughout the East slope of the Colorado Front Range. However, disturbance history as well as recent disturbance affect the likelihood of tree invasion into neighboring grasslands (see section 2.2).

7.0 SUMMARY

The motivation for this vegetation inventory is to provide the basis for improving the management and preservation of the City of Boulder Open Space lands. The purposes of this work are to identify, characterize, and map the vegetation types; carry out a floristic inventory; relate the natural vegetation to environmental factors, particularly disturbance and soil factors; investigate changes in historic treeline; predict the potential natural vegetation; and make management recommendations. The work was carried out in 1984 and 1985. Reconnaissance survey methods like those of Baker (1982) were used.

Natural vegetation on the City of Boulder Open Space lands is quite diverse, ranging from very dry Shale Barren Grasslands through wet Mesic Tall Grasslands to very moist Mountain Shrublands and Douglas-fir Forests. Excluding Short Grasslands and Agricultural Fields, vegetated Map Units (M.U.s) typically support existing vegetation that is recognizable as plant associations (P.A.s), although human activities have affected virtually all of the vegetation.

In the last century, livestock grazing and logging were widespread. Fires are important natural events, although their frequency and characteristics are altered by humans. Other natural disturbances include floods, windstorms, erosion, slumping, infestations, and grazing by native herbivores. Other human-related disturbances include forest management, mining, quarrying, agriculture, mowing for hay, irrigation, construction of trails, roads and structures, and recreational use. Thus the existing vegetation

characteristics reflect both the rich disturbance history of the lands as well as site factors.

Site factors that are most important in determining vegetation patterns affect plant-available moisture: elevation (affecting precipitation and temperature); site drainage and water capacity (especially affected by slope position, steepness, soil depth, and soil texture); and aspect (especially in and above the forest-grassland ecotone).

The forest-grassland ecotone occupies elevations between approximately 5700 and 6200 ft (1737 and 1890 m) and contains a concentration of shrub-dominated communities as opposed to the grasslands predominating at lower elevations and the coniferous forests at higher elevations. However, a well-defined, sub-forest, altitudinal zone dominated by shrubs is absent from the study area.

Most poorly drained and riparian sites are located in and below the ecotone and typically support characteristic graminoids (including Mesic Tall Grassland communities), and deciduous shrub and tree communities, respectively. Often, in and above the ecotone, Ponderosa Pine Forests occupy very rocky, coarse soils while neighboring, finer soils support grasslands. Above the ecotone, Douglas-fir Forests are found only on very moist sites that are often on steep, rocky, north facing slopes. Treeline advances since 1938 have been negligible or small on most of the Open Space properties, and have occurred significantly only at two locations which have cobbly coarse soils. Such soils are also a "preferred" substrate for Xeric Tall Grasslands, which are found in the ecotone down into the grassland zone, where western

wheatgrass predominates on finer soils.

The M.U.s that were studied are listed below from drier to wetter vegetation types within each physiognomic category:

I. Less disturbed map units

A. Grassland
- E, Steep/Sparse Vegetation
- S, Short Grassland
- G, Mid-height Grassland
- X, Xeric Tall Grassland
- M, Mesic Tall Grassland
- W, Wetland

B. Savannah
- H, Skunkbrush Grassland
- V, Ponderosa Pine Savannah

C. Forest, woodland and shrubland
- P, Ponderosa Pine Forest
- C, Cliff
- T, Talus
- D, Douglas-fir Forest
- M, Mountain Shrubland
- R, Riparian Forest/Shrubland

II. Disturbed and cultivated map units

- B, Building
- D, Disturbed Land
- A, Agricultural Field
- O, Open Water

In the thirteen M.U.s representing natural vegetation, a total of thirty-nine P.A.s were recognized. Of the thirty-nine P.A.s, twelve described here are new P.A.s, but closely resemble other P.A.s or vegetation types reported in prior work. These twelve P.A.s are in the following M.U.s: Steep/Sparse Vegetation, Skunkbrush Grassland, Ponderosa Pine Forest, Cliff, Talus, Douglas-fir Forest, and Mountain Shrubland. Several P.A.s described here have not been previously reported in Daubenmire habitat type work nor have closely

related vegetation types been found in the literature. Of particular note are the following Mountain Shrublands:

Skunkbrush sumac/Big bluestem Shrub Grassland P.A.
(Rhus aromatica ssp. trilobata/Andropogon gerardii Shrub Grassland P.A.)

American plum-Chokecherry/Skunkbrush sumac P.A.
(Prunus americana-Prunus virginiana var. melanocarpa/Rhus aromatica ssp. trilobata P.A.)

Ninebark-(Chokecherry) P.A.
(Physocarpus monogynus-(Prunus virginiana var. melanocarpa) P.A.)

Mountain maple/Chokecherry-Ninebark P.A.
(Acer glabrum/Prunus virginiana var. melanocarpa-Physocarpus monogynus P.A.)

Although full characterization of many of the P.A.s on the Open Space lands will require more data, the P.A.s most in need of study are in the Ponderosa Pine Forest and Mountain Shrubland M.U.s.

The formulation of specific management recommendations for the Open Space lands was beyond the scope of this study, but some management needs became obvious in the course of this work. The most comprehensive needs are for annual monitoring of rangeland site conditions in order to document vegetation changes as they relate to management practices, and for a holistic, long range management plan that will provide meaningful, site-specific goals.

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