SOILS WORKSHOP, Open Space (OS) and Mountain Parks (MP), 9/16/98
With Mike Petersen, NRCS, Greeley, and Professor Gene Kelly, CSU

We will meet at Cherryvale at 10:00 am, Wednesday morning for introductions and a brief discussion of the goals for the workshop. We hope to be on the road by 11:00 at the latest and will spend the rest of the afternoon (till 3:00 or so) in the field visiting several forest stands. We'll carry a radio, so if you want to meet us in the field you can call (Lynn or Dianne @5023).

AGENDA

1. Introductions

2. Review goals for the workshop:

*to increase our understanding of the nature of the forest and grassland soils at the grassland/montane ecotone and in the lower montane forests

*to correlate soils with plant associations

*to increase our understanding of the impacts of fire and fire suppression on these soils

*to increase our understanding of cattle and other livestock grazing over the last century on soils and vegetation, as well as the combined effects of livestock use and fire suppression

*to learn cost-effective, staff-efficient ways of monitoring soils during the implementation of the Forest Ecosystem Management Plan (thinning, prescribed burning, etc.), including soil sampling techniques, nutrient cycling, and soil erosion

3. Field trip: visit several forest sites that represent different soils and plant associations, as well as the site of a 1995 prescribed burn (Lindsay).

4. Review and wrap up at the end of the day.

HANDOUTS

1. Agenda
2. Plant Associations
3. Soils
4. Fire Effects
5. Maps

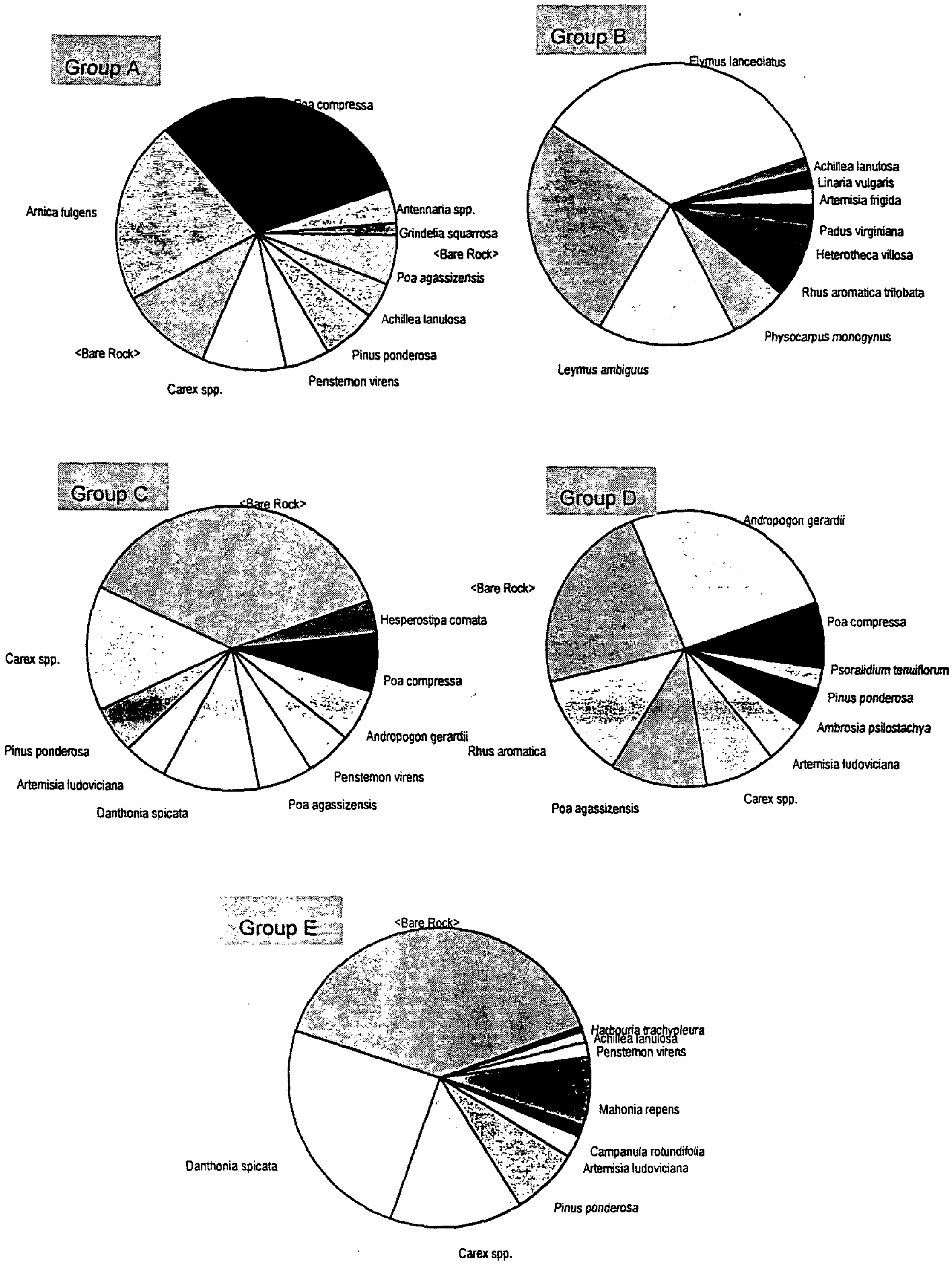


Figure 4. Dominant species of the five groups.

BCOS TWINSPAN RESULTS

123 samples
Pinus ponderosa PIPOS
Carex sp. CASP
Artemisia ludoviciana ARLU
Penstemon virens PEVI3
Achillea lanulosa ACLA5
Cerastium strictum CEST3
Drymocallis fissa DRFI3
Achnatherum nelsonii ACHNEL
Ribes cereum RICE
Opuntia macrorhiza OPMA2 & Muhlenbergia montana MUMO (sparse but wide spread)

† + clay, + graz, -slope — 61 | † + timb, + litt, + burn — 62

61

☛ Hypericuim perforatum HYPE
☛ ((Poa compressa)) POCO
Rhus aromatica RHART

† + graz, + north, -slope — 24 | † + SE/SW, + slope — 37

24

☛ Arnica fulgens ARFU3
Senecio integerimus SEIN2
Galium sp. GASL
Lomatium orientale LOOR
Neolopia *campestris* NEOCAM
((Taraxacum officinalis)) TAOF
((Eremogone fendleri)) ERFE3
((Aster porteri)) ASPO5
((Antennaria sp.)) ANSP
((Symphoricarpos occ#1*)) SYAL2

Group A

LINDSAY
LIN/JEFF (NE,SE,SW)
STENGEL
ELDO (1, 5,15)

37

☛ Hesperostipa comata HECO
((Schizachyrium scoparium)) SCSC

3 — † + NW, + slope

☛ Oxytropis sericea OXSE
Elymus lanceolatus ELLA3
Leymus ambiguus LEYAMB
Packera cana PACA15
Nepeta cataria NECA2
Physocarpus monogynus PHMO5
Adenolinum lewisii ADLE

Group B

PINEBROOK

17 — † + litter, + sand, -elev, -regen

((Symphoricarpos occ#2*))
[(Danthonia spicata)]
Leymus ambiguus LEYAMB

Group C

could be transitional between A, D, & E

-LIN/JEFF (NW,SW)
-LOWSH
-MRL
-S-
-WITT
-WATER
-LIN/JEFF (NW)
-WATERTANK

17 — † + clay, + elev

☛ (Andropogon gerardii) ANGE
☛ Psoralidium tenuiflorum PSTE5
((Poa agassizensis)) POAG
Dalea purpura DAPU5
Sorghastrum avenaceum SOAV2
Ratibida columnifera RACO3
Bouteloua curtipendula) BOCU
(Yucca glauca) YUGL

Group D

D-1
-D1/81
-D-2
-D3D4

62

☛ Danthonia spicata DASPP
☛ Harbouria trachypleura HATR
☛ Ceanothus fendleri CEFE
☛ Pseudotsuga menzesii PSME
((Mahonia repens)) MARE3

Group E

PWRLINE
+S-
SNSH
ST-
+WITT
ELDO (10)

☛ This symbol is used to mark the indicator species identified by TWINSPAN
The number of samples in each division is at the top of each column.
Single parenthesis = (xxxxx) = center in a moderately wide distribution
Double parenthesis = ((xxxxx)) = center in a broad distribution
Bracketed parenthesis = [(xxxxx)] = secondary center in moderate distribution

*Symphoricarpos occidentalis and Danthonia spicata in Group C seem to have two nodes of distribution in different groups, this might be an artifact of divisive classification. However Group C may be an ecotone or successionally transitional to A, D, or E based on the following characteristics; Danthonia spicata in group C vs. E is an isolated node of higher cover, and S. occidentalis is found in high frequency in groups A & C, and Andropogon gerardii cover is relatively high in groups D & E.

† This symbol identifies the environmental factors that the DISCRIM program identified as correlated with the TWINSPAN division.

The following table presents the average cover of the indicator species identified by TWINSPAN and includes a matrix that can be used as a key to identify the grouping of a specific site in the field.

Table 1. Key to the Classification Groups

		Percent Average Cover of TWINSPAN Indicator Species.					
			Group ID				
			A	B	C	D	E
Arnica fulgens	>3%	A	**5.22**		P		0.02
Poa compressa	>5%	ACD	**7.35**	0.5	***1.53***	***1.38***	0.32
Hypericum perforatum	>0.5%	AD	**0.59**		P	**0.26**	P
Oxytropis sericea	P	B		**P**			
Elymus lanceolatus	>5%	B		**18.17**	P	0.09	0.03
Leymus ambiguus	>5%	B		**8.17**	0.53		0.13
Hesperostipa comata	>1%	CD	P	P	**0.82**	**1.47**	0.16
Andropogon gerardii	>5%	D	0.61		1.41	**9.29**	0.52
Psoralidium tenuiflorum	>1%	D	0.04		P	**1.26**	0.18
Danthonia spicata	>3%	EC	0.11		**2.56**	0.53	**5.07**
Ceanothus fendleri	>1%	E	0.04		P	P	**0.58**
Harbouria trachypleura	>0.5%	E	P	P	P	P	**0.06**
Pseudotsuga menzesii	>1%	E	0.11		P	P	**0.93**
			Group ID				
			A	B	C	D	E
Arnica fulgens	>=3%	A					
Poa compressa	>=3%	A					
Poa compressa	P	ACD					
Hypericum perforatum	P	AD					
Oxytropis sericea	P	B					
Elymus lanceolatus	>=3%	B					
Leymus ambiguus	>=3%	B					
Hesperostipa comata	P	CD					
Danthonia spicata	P	CE					
Danthonia spicata	>=2%	E					
Andropogon gerardii	>=5%	D					
Psoralidium tenuiflorum	P	DE					
Ceanothus fendleri	P	E					
Harbouria trachypleura	P	E					
Pseudotsuga menzesii	P	E					
	TOTAL						

To use the key, mark a one in each of the open cells for each species cover category that is present. Tally the totals at the bottom of each column. The classification goes to the group with the highest score. Ties are possibly successional or ecotonal samples that should be subjectively assigned based on observable trends of the indicator species. This simple key was tested against the TWINSPAN classification and 83/123 (67%) of the samples were correctly assigned, 24/123 (20%) were in a tie that included the classification group assigned by TWINSPAN, and 16/123 (13%) were assigned to a different group. This key is a coarse first-approximation guide, but should be useful for initial vegetation mapping efforts. Figure 4 shows the ten most important species or ground cover (not including litter) for each of the five groups.

PSA/ PA	SPECIES	COMMON NAME	LIFEFORM	SOIL	REGENERATION	FIRE
PA	*Achillea lanulosa*	Western yarrow	geophyte	thin; sandy gravelly loams	seed; rhizomes	cover and frequency generally increase
PA	*Acnatherum nelsonii*	Nelson's Needlegrass	hemicrptophye	sandy loam, loam, clay loam	seed mainly; also tillers	detrimental early summer; recovers slowly
	Ambrosia psilostachya coronopifolia	Western ragweed	geophyte	various but often has low organic matter and low fertility	seed; rhizomes	fire resistant; may increase
D	*Andropogon gerardii*	Big bluestem	geophyte	moist; fertile; silt and clay loam	rhizomes; seed	spring burning favors; summer burning harms
	Anisantha tectorum	Cheatgrass	therophyte	various	seed	early spring harms; late summer favors
A	*Antennaria sp.*	Pussytoes	hemicryptophyte	loam, clayeyloam and clay-textured soils	seed; stolons	killed by moderate and severe fire; may increase with fire suppression
A	*Arnica fulgens*	Meadow arnica				
PA	*Artemisia ludoviciana*	Sagewort	chamaephyte	various	seed; rhizomes	moderately resistant; may increase
	Aster porteri	Porter's aster				
D	*Bouteloua curtipendula*	Sideoats grama	hemicryptophyte; geophyte	various	seed; rhizomes	bunchgrass type benefits
	Bromus japonicus	Japanese brome	therophyte	various, inc. Sand, sil, clay	seed; requires a moist substrate	fire tends to reduce, except in wet years
	Campanula rotundifolia	Harebell				
PA	*Carex pensylvanica heliophila*	Sunsedge	geophyte	infertile	seed; rhizomes	summer favors
E	*Ceanothus fendleria*	Buckbrush	chamaephyte			
PA	*Cerastium strictum*	Mouse-ears				
D	*Dalea purpurea*	Purple prairie clover	hemicryptophyte	various	seed	fire stimulates germination of seed
CE	*Danthonia spicata*	Poverty oatgrass	chamaephyte	poor, sandy, rocky	seed	appears to be fire-adapted
PA	*Drymocallis fissa*	Cinquefoil				
BC	*Elymus lanceolatus*	Thickspike wheatgrass	geophyte	sand, sandy loams, and loam	seed; rhizomes	fire-tolerant; spring fire harms

A	*Eremogone fendleri*	Desert sandwort				
A	*Galium sp.*	Bedstraw				
	Grindelia sp.	Gumweed				
E	*Harbouria trachypleura*					
BCD	*Hesperostipa comata*	Needle-and-thread	hemicryptophyte	dry, sandy, gravelly, or rocky	seed	severely damaged; most harmful midsummer
ABC D	*Hypericum perforatum*	St. Johnswort			seed; rhizomes	appears to be fire-adapted
BC	*Leymus ambiguus*	Colorado wild rye	hemicryptophyte	coarse-textured, shallow	seed; tillering; rhizomes	increases except in spring burns
A	*Lomatium orientale*	Salt-and-pepper				
E	*Mahonia repens*	Holly-grape	chamaephyte	sandy loams, silts, shales, sandstones, limestones, granitics	seed; rhizomes	fire tolerant; usually survives all but severe fires
PA	*Muhlenbergia montana*	Mountain muhly	hemicrptophye	infertile, coarse, loamy	seed	takes several years to recover
A	*Neolepia campestris*	Fieldcress				
PA	*Opuntia macrorhiza*	Prickly-pear				
	Padus virginiana	Chokecherry	phanerophyte	wide range except for heavy clay	rhizomes; seed	top-killed but sprouts vigorously; may increase
PA	*Penstemon virens*					
	Pinus ponderosa	Ponderosa pine	phanerophyte	clay loams to sandy loams	seed	extremely well-adapted beyond the pole stage
D	*Poa agassizensis*	Mountain bluegrass	geophyte	various; best on well-drained loams or clay loams rich in humus	seed; rhizomes	damaged in spring and fall
ABC D	*Poa compressa*	Canada bluegrass	geophyte	infertile, poorly drained	seed; rhizomes	late spring fire is most damaging
E	*Pseudotsuga menziesii*	Douglas-fir	phanerophyte	wide variety	winged seed	mature trees fire resistant
	Psoralidium tenuiflorum	Wild alfalfa				
D	*Ratibida columnifera*	Prairie coneflower	hemicryptophyte	sandy loam, loam, clayey loams; gravelly and sandy soils	seed; rhizomes	sensitive when actively growing

ABC D	*Rhus aromatica*	Three-leaf sumac	phanerophyte	wide range from nearly bare rock to sand and heavy clay	seed; rhizomes	readily sprouts after fire and other disturbance; typically increases
PA	*Ribes cereum*	Wax currant	phanerophyte	various	seed; weak ability to sprout from crown	most plants killed; reestablished by seed
BCD	*Schizachyrium scoparium*	Little bluestem	hemicryptophyte	sandy to clay-loam	seed; tillers; rhizomes	summer burning significantly reduces cover; late spring best
A	*Senecio integgerimus*	Spring senecio				
D	*Sorghastrum avenaceum*	Indiangrass	geophyte	deep, moist soil; heavy clays to coarse sands	seed; rhizomes	decreases with fire suppression; spring fire best
AC	*Symphoricarpos sp.*	Snowberry	geophyte; phanerophyte	loams and sandy loam soils are best	seed; rhizomes	survives low to moderate intensity fire
A	*Taraxacum officinalis*	Dandelion	hemicryptophyte	various	seed; sprouts from caudex	harmed by late spring fire; usually increases
	Tragopogon dubius major	Salsify				
D	*Yucca glauca*	Soapweed yucca	phanerophyte; geophyte	coarse gravel, sand or porous loam	seed; rhizomes	usually fire tolerant

SOILS

"A soil classification or map is not an ecological classification if the relationship of the classes to the vegetation of the area is unknown. Similarly, a vegetation map is not an ecological classification unless the interrelationships between the vegetation types and the environmental factors is known." (Barnes, et al. 1982 quoted in Johnston 1997 draft)

The relationship between the plant associations/subassociations and soils in OS forests are illustrated in Table 1 and Table 2 below.

OTHER ENVIRONMENTAL FACTORS

aspect
elevation

PLANT GROWTH-FORMS

The growth-forms of plants affect their ability to survive fire and other disturbances, especially in relation to the position of the "perennating tissue" or growth tissue that is inactive during cold and/or dry seasons.

GROWTH-FORM	Definition
Phanerophytes	trees, shrubs (taller than 25 cm), and woody plants with buds well above the ground surface, fully exposed to the atmosphere
Chamaephytes	dwarf-shrubs and semishrubs and small succulents under 25 cm in height
Hemicrytophytes	perennial herbs; perennating tissue is at the soil surface
Geophytes	perennial herbs; underground perennating tissues (such as bulbs, corms, tubers, or rhizomes) that are more fully protected from the aboveground climate
Therophytes	short-lived annual or ephermeral herbs; survive unfavorable seasons (or years) as seeds; dominate in deserts

% of hemicrytophytes
% of geophytes
fire-adapted ecosystem

Table 1. Soil Conservation Service Soil Types for OS 1997 Inventory Forest Stands (Moreland and Moreland 1975).

Baller stony sandy loam	a narrow, north-south ridge associated with PSA E (lower montane) and PSA C	a mollisol or **grassland soil**; 9-35 % slopes; 5500-6500 ft.; 7700 acres (3.2%); **shallow, well-drained** soils formed on upland ridges in loamy residuum weathered from **sandstone**; native vegetation: midgrasses and scattered ponderosa pine and Rocky Mountain juniper; lots of stone on surface and throughout profile; rapid permeability; available water capacity is low; roots can penetrate to 10 to 20 inches; runoff rapid, erosion hazard high
Colluvial land	only on stand D-3/D-4 and D1/81	5800 acres (2.4%); long, narrow valleys; variable soils; surface layer mainly a sandy loam; underlying material ranges from loamy sand to clay; shallow to deep; receives runoff from adjacent slopes; erosion hazard is high; stones and cobbles on the surface
Goldvale-Rock outcrop complex	mostly associated with PSA E (lower montane) on all the west-central stands and Witt-E, and Witt-NE, among others	an alfisol, or **timbered soil**; 9-55% slopes; 5900-6700 ft.; 2900 acres (1.2%); **deep, well-drained** soils that formed on mountainsides in loamy **alluvium**; native vegetation: mainly ponderosa pine and Douglas-fir; moderate permeability; available water capacity high; roots can penetrate 60" or more: moderately permeable; runoff rapid; erosion hazard high
Juget-Rock outcrop complex	associated with PSA E and PSA C on Sunshine, Witt-NW, Witt-S, and Witt-W	a mollisol, or **grassland soil**; 9-55% slopes, 6300-8200 ft.; 20,700 acres (8.5%); **shallow, somewhat excessively drained** soils; sandy residuum weathered from **granite**; native vegetation at lower elevations: ponderosa pine and grass; rapid permeability; available water capacity is low; roots can penetrate less than 20"; take in water readily, but they retain only limited amounts for plant use becuase of shallow depth to bedrock; runoff is rapid; erosion hazard is high
Nederland very cobbly sandy loam	associated mainly with PSA A, mostly at the southern end of the forest stands (Stengel, Lindsay, Lindsay-Jeffco), but also some central (Lower Shanahan and Watertank) stands	a mollisol, or **grassland soil**; 1-12% slopes; 5500-6500 ft.;11,700 acres (4.8%); **deep, well-drained** soils that formed on old high terraces and alluvial fans; developed in loamy alluvium that contains many cobblestones and other stones; native vegetation: mainly tall grasses and mid grasses; moderate permeability; available water capacity for the profile is moderate; roots can penetrate to a depth of 60 inches or more; runoff is slow to medium; erosion hazard slight; used for range and pasture
Sixmile stoney loam	Dakota Ridge	an entisol, or **young soil** with no horizons; slopes 10-50%; 5800-6600 ft.; moderately **deep, well-drained soils** formed on upland ridges and side slopes in calcareous loamy residuum weathered from **shale**; native vegetation: mainly mid grasses; moderate permeability; available water capacity is moderate to high; roots can penetrate 20-40 inches; runoff is rapid; erosion hazard is high

TABLE 3:2. ***General Terms Used to Describe Soil Texture in Relation to the Basic Soil Textural Class Names***

U. S. Department of Agriculture Classification System

General Terms		Basic Soil Textural Class Names
Common Names	**Texture**	
Sandy soils	Coarse	Sandy Loamy sands
Loamy soils	Moderately coarse	Sandy loam Fine sandy loam
	Medium	Very fine sandy loam Loam Silt loam Silt
	Moderately fine	Clay loam Sandy clay loam Silty clay loam
Clayey soils	Fine	Sandy clay Silty clay Clay

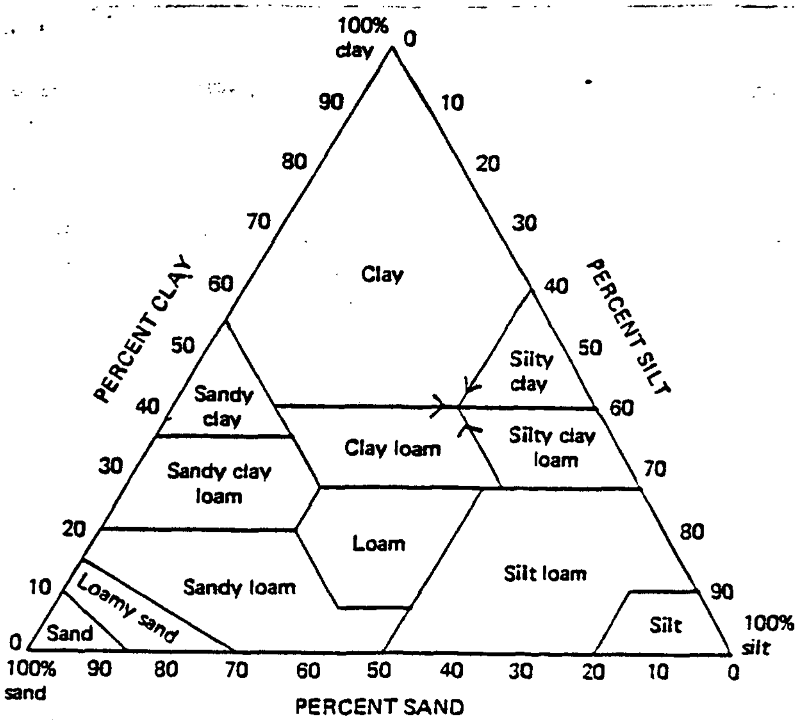


FIGURE 3:5. Relationship between the class name of a soil and its particle size distribution. In using the diagram the points corresponding to the percentages of silt and clay present in the soil under consideration are located on the silt and clay lines, respectively. Lines are then projected inward, parallel in the first case to the clay side of the triangle and in the second case parallel to the sand side. The name of the compartment in which the two lines intersect is the class name of the soil in question.

FIRE EFFECTS ON SOIL AND WATER

Chandler, C., et al. 1991. Fire in Forestry, Volume I, Forest Fire Behavior and Effects. Krieger Publishing Co., Malabar, Florida.

"The effects of fire on the chemical and physical properties of forest soils will vary from nil to profound depending on the type of soil, the moisture content of the soil, the intensity and duration of the fire, and the timing and intensity of postfire precipitation. In completely mineral soils, heat transfer takes place through conduction and vapor transport downward from the exposed surface, whereas soils with a high organic content may actually support combustion to significant depth."

Factors that influence the impacts of fire:

soil moisture content:
- specific heat
- thermal conductivity

moisture content of litter and duff layers:
- usually more important than moisture of mineral soil itself

fire intensity:

light:	max. surface temp. 100 to 250 degrees C
	temp. 1 to 2 cm below the surface below 100 degrees C
	"black ash": charred remnants of the litter and duff layer
moderate:	surface temp. 300 to 400 degrees C
	temp. at 1 cm depth 200 to 300 degrees C
	temp. at 3 cm 60 to 80
	temp. at 5 cm 40 to 50
	significant amount of bare soil where litter and duff burned completely
severe:	surface temp. 500 to 750 degrees C
	temp. at 1-2 cm 350 to 450
	temp. at 3 cm 150 to 300
	temp. at 5 cm 100 or less
	"white ash": complete combustion of heavy fuels
	mineral soil at the surface changes color

Factors that influence nutrient cycling:

decomposition of clay minerals
- shift toward larger particle size and higher erodibility in burned soils

conversion of complex organic structures into simple inorganic residues
increased pH of acid soils
decreased organic matter on the soil surface
loss or redistribution of nitrogen or short-term increase in nitrogen after fire
increased nutrient availability and increased nutrient vulnerability to loss by leaching
phosphorus in litter and leaves lost as fine ash particles
available forms of phosphorus in soil increase in some areas and for lower intensity fires

Factors that influence plant-soil-water relations after fire

removal of canopy cover:

- decreased interception of water by leaves
- increased insolation on forest floor
- increased evaporation by wind

removal of surface litter and duff:

- increased soil percolation and/or overland flow
- reduction in organic matter
- reduction in soil porosity and decreased soil percolation
- increased soil erosion

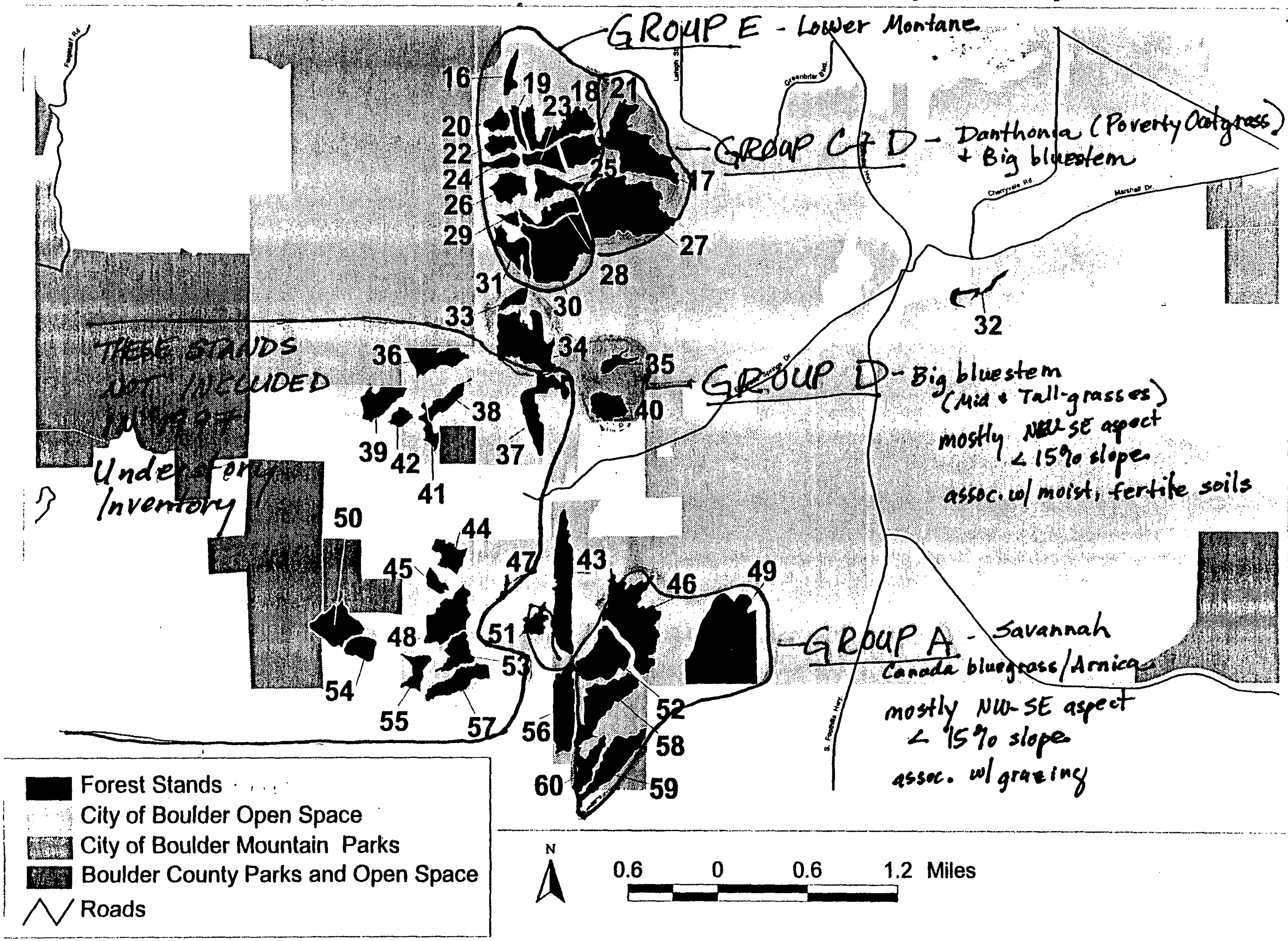
extent of surface erosion depends on:

- storm intensity rates
- nature of soils
- steepness and length of slopes

Factors that influence hydrologic processes after fire:

moderately increased annual streamflow
markedly increased peak stormflow
some decrease in water quality
increased sediment loads
stream chemistry altered
increased water temperatures may occur when streamside vegetation is burned

City of Boulder Forest Stands (South)



City of Boulder Forest Stands (North)