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The Application of ECOSYM Vegetation Classifications to Rangelands Near Price, Utah[1]

by

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and
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ABSTRACT

The present vegetation and potential vegetation classifications proposed as components of the ECOSYM wildland inventory system were applied to a 30-square mile study area containing a variety of vegetation types. Keys and synopses of the classification units obtained are given and the units are mapped over the study area. The two ECOSYM vegetation classifications are compared with other management-oriented vegetation classifications. Limitations of all these classifications are discussed in relation to the purposes of the ECOSYM inventory system.

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I. Present Vegetation

A. Introduction

Present vegetation was designed to serve as one of the seven ecosystem components of ECOSYM, an information storage-retrieval system for the inventory and management of wildlands. Like other ECOSYM components, the present vegetation classification is hierarchical to provide quick computer access to the data base (digitized maps or discrete plots) at the desired level of resolution. More information on the larger context of ECOSYM can be found in Davis and Henderson (1976).

The basic premise of ECOSYM is that a wide range of management information (i.e., range production, erosion or wildlife abundance) can be more economically modelled from a common data base than measured directly. Thus the purpose of the vegetation classification is general; it is used not only for inventory of vegetation itself, but to organize vegetal parameters useful in predicting plant production, erosion, wildlife abundance, etc. This basic premise was tested in 1975 and 1976 on a 2 X 25 mile study area running west from Price, Utah onto the Wasatch Plateau. Part I of this report applies the ECOSYM present vegetation classification to 104 plots measured on the eastern half of the study strip during the summer of 1976.

B. Methods

1. Study area

This report covers a 2 X 14 mile strip running west from Price (sections 24 and 25, T 14 S, R 9 E, Carbon County, Utah) to Castle Valley Ridge, the eastern edge of the Wasatch Plateau (in sections 22 and 27, T 14 S, R 7 E, Carbon County, Utah). The extreme western end near Castle Valley Ridge (about 2960 m elevation, 100 cm annual precipitation) is occupied by subalpine forest, dominated by *Abies lasiocarpa*, *Picea engelmannii*, *Populus tremuloides* and *Pseudotsuga menziesii*. The terrain descends rapidly into a mountain brush zone (dominants are *Quercus gambelii* and *Amelanchier utahensis*) which fades into a descending series of broad level benches (2300 m and below) dominated by *Artemisia tridentata* and various grasses. A network of large canyons dissect the shale-derived landscape, with the slopes dominated by *Pinus edulis*-*Juniperus osteosperma* woodlands. The east end near Price (1700 m, 25 cm annual precipitation) rests on the nearly level floor of Castle Valley which is covered by a sparse salt desert shrub vegetation dominated by *Atriplex confertifolia*.

2. Plot location

First a systematic grid of potential plot locations was established. On 1:24,000 scale 15-minute USGS topographic maps the center of each of the sixteen 40-acre lots per section was marked. The two different crews collecting data used different selection procedures past this point. One crew sampled a systematic subset of the 16 possible locations per section. In each of 22 contiguous sections (a strip 2 X 11 miles, from sections 23 and 26, T 14 S, R 9 E, West through sections 19 and 30, T 14 S, R 8 E) four plots per section were located at the center of the southwest quarter of each quarter section. The transfer of plot centers from the map onto the ground was judged accurate to within 20 meters. If a 1,000 m^2 area circle (twice plot size) around the systematic plot center contained visible discontinuities of vegetation or environment, plot center was moved the minimum distance necessary to achieve the required scale of homogeneity. At no time did the distance moved exceed 80 m, this distance being roughly 10% of the between plot distance. The westernmost two miles of the study area were sampled by a different crew, due partly to accessibility problems. These 16 plots were randomized within the systematic grid of 16 possible locations per section.

3. Plot measurements

Plots were circular and slope corrected to equal 500 m^2 of level area (long axis of the ellipse running downslope). The percent canopy cover of every species present was visually estimated by Daubenmire's (1959) method to the nearest percent if total, relative or absolute cover of the species was $\leq$ 10%, or to the nearest 5% if the cover was greater than 10%. All species present but having less than 1% cover were recorded as 0.3%. The canopy cover of forest trees was subdivided into three different DBH classes (<1 dm, 1-3 dm, >3 dm). Canopy cover of *Juniperus osteosperma* and *Pinus edulis* was not subdivided by DBH or recorded separately by species. Instead, all pinyon-junipers on a plot were recorded in the age-form classification of Blackburn and Tueller (1970). Numerous physical site measurements, soil descriptions and density counts of important species were also made, but only canopy cover is used in the following classification.

4. Classification procedure

Species cover data from all plots were punched onto computer cards for manipulation by two programs written specifically for the following procedure. ASSTAB lists the data as an association table and computes the percent constancy of each species entered. (Constancy is the percentage of plots on which the species is present.) Arranging the total species list into groups by life form facilitated keying plots through the higher order, divisive section of the ECOSYM classification down to cover type. Preliminary cover types were assigned using the minimum number of species (of the same life form as the assigned physiognomic type) to obtain a minimum of 80% relative cover of the total cover of that life form. If more than one combination of the minimum number of species gave greater than 80% relative cover, the combination that maximized cover was assigned. Species of <20% relative life form cover were included in preliminary cover type names, to be later dropped from the final name (following Henderson and West, 1977) if found to be consistently less than 20% of total life form cover. Next, the association table was reordered by preliminary cover type. Groups of less than three plots were considered too small to recognize as separate classificatory units. These plots in groups of less than three were isolated from the remaining agglomerative part of the classification process, then reconsidered after final units were formed. Such plots could conceivably be lumped immediately into more prevalent cover types if differences were trivial.

Within each physiognomic type, a similarity matrix was run which compared each combination of two plots. This program was run twice for each physiognomic type using two different similarity indices:

a) n = the number of species of greater than 1% absolute cover in either plot.

$$IS_{\text{Henderson}} = \frac{1}{n} \sum_{i=1}^{n} \left(\frac{2X \text{ minimum } (a_i, b_i)}{a_i + b_i}\right)$$

a_i, b_i are the absolute cover of the "i"th species on plots a and b. This is a modified floristic index suggested by Jan Henderson. All species above the cutoff point are weighted equally.

b) $$IS_{\text{Motyka}} = \frac{\sum_{i=1}^{n} (2X \text{ minimum } (a_i,\ b_i))}{\sum_{i=1}^{n} (a_i + b_i)}$$

where n equals the total number of species present in either plot. This considers all species present (> 0% cover) in either plot and weights them proportionally to their cover. Both indices run from 0 to 1, inclusive.

The divisively proposed cover types within each physiognomic type were tested by averaging the indices of all comparisons within a preliminary cover type and averaging indices of each between group comparisons.

Whenever the average within group similarity of a preliminary cover type was not greater than all between group comparisons involving it (on either index), the preliminary, divisively defined cover type was reconsidered (possibly split further, but usually lumped). For example, five preliminary shrubland cover types of $n \geq 3$ were defined by the divisive criteria. The matrix of all possible plot-plot comparisons using index IS_H is illustrated in Table 1. These plot-plot indices are averaged within and between proposed groups in Table 2.

Table 1. All possible similarity comparisons between plots in divisively defined shrubland cover types of n $\geq$ 3. Similarity index is 15_H.

Amelanchier utahensis-Artemisia tridentata	1088	1																									
	1092	2	.31																								
	1296	3	.29	.15																							
Artemisia tridentata-Chrysothamnus viscidiflorus	1094	4	.26	.27	.16																						
	1133	5	.23	.28	.13	.40																					
	1232	6	.10	.16	.15	.30	.22																				
	1204	7	.30	.23	.27	.54	.37	.36																			
	1316	8	.10	.12	.14	.34	.31	.46	.27																		
	1320	9	.12	.05	.13	.35	.24	.49	.38	.51																	
	1322	10	.13	.08	.08	.32	.31	.29	.37	.40	.61																
	1354	11	.17	.12	.22	.24	.14	.35	.40	.41	.35	.21															
	1360	12	.09	.14	.09	.32	.25	.44	.32	.69	.49	.47	.42														
	1396	13	.16	.07	.26	.22	.30	.28	.32	.47	.41	.37	.36	.40													
	1472	14	.12	.05	.25	.25	.13	.29	.21	.25	.30	.22	.18	.17	.33												
Artemisia tri-dentata-Gutierrezia sarothrae	1242	15	.14	.06	.13	.25	.19	.35	.29	.27	.65	.39	.28	.34	.29	.10											
	1392	16	.11	.06	.37	.16	.11	.16	.13	.22	.21	.22	.23	.20	.42	.19	.23										
	1198	17	.13	.06	.10	.18	.17	.21	.21	.25	.46	.41	.14	.30	.33	.16	.41	.19									
	1584	18	.10	.05	.23	.21	.15	.16	.16	.27	.21	.21	.14	.20	.32	.26	.11	.17	.28								
	1661	19	.08	.11	.12	.21	.21	.29	.23	.35	.39	.24	.29	.43	.32	.15	.26	.17	.27	.27							
Artemisia tridentata	1532	20	.15	.06	.17	.18	.15	.06	.19	.18	.26	.23	.24	.18	.28	.09	.25	.23	.39	.26	.21						
	1621	21	.07	.08	.11	.10	.10	.17	.09	.30	.20	.13	.16	.21	.18	.10	.16	.12	.12	.22	.25	.24					
	1657	22	.09	.09	.11	.12	.12	.15	.10	.28	.21	.16	.19	.21	.25	.07	.19	.15	.16	.25	.36	.33	.54				
Atriplex confertifolia-Gutierrezia sarotarae	1811	23	.13	.02	.35	.04	.08	.07	.10	.14	.19	.12	.14	.13	.25	.22	.16	.37	.14	.11	.15	.11	.09	.09			
	1853	24	.02	.00	.03	.02	.03	.02	.03	.08	.05	.05	.08	.07	.11	.01	.14	.17	.11	.10	.14	.07	.03	.08	.20		
	1887	25	.03	.02	.09	.07	.06	.05	.10	.11	.09	.10	.18	.18	.21	.05	.19	.24	.13	.10	.19	.17	.04	.09	.34	.42	
	1893	26	.02	.02	.12	.02	.04	.06	.05	.11	.07	.05	.09	.05	.14	.05	.09	.16	.08	.18	.12	.15	.06	.11	.27	.43	.42

Table 2. Average similarity coefficients by groups.

			1	2	3	4	5
Amut-Artr	n=3	1	.25				
Artr-Chvi	n=11	2	.16	.34			
Artr-Gusa	n=5	3	.12	.24	.25		
Artr	n=3	4	.10	.17	.22	.37	
Atco-Gusa	n=4	5	.07	.09	.15	.09	.35

This shows the Artr-Gusa preliminary cover type is more similar to the Artr-Chvi cover type than to itself. Lumping these two groups yields:

Table 3. Average similarity coefficients by groups.

			1	2	3	4
Amut-Artr	n=3	1	.25			
Artr-Chvi	n=16	2	.15	.29		
Artr	n=3	3	.10	.19	.37	
Atco-Gusa	n=4	4	.07	.11	.09	.35

Finally, in the judgement of the local classifier familiar with the area, the proposed cover type must be sufficiently different to warrant its isolation as a separate unit. Divisively defined cover types, even as modified by group similarity comparisons, may still be too narrowly defined compared to the definition of Henderson and West (1977). In the example above, the *Artemisia tridentata* cover type is a post-cultivation disclimax of the *Artemisia tridentata-Chrysothamnus viscidiflorus* cover type, and was lumped into it at the suggestion of Henderson.

Once cover types were decided, stands and species were reordered and run through ASSTAB to give an association table for each cover type. Henderson and West (1977) define the community type to be an agglomerative group at the same level as the European association. In defining associations, plots are ordinated to maximize distributional overlap of species of intermediate constancy (within cover type, $10 \leq c \leq 60$, in Mueller-Dombois and Ellenberg, 1974). Differential species have a constancy of ≤ 10 percent outside of the association for which they are characteristic species, and $\geq$ 50 percent within their association as defined by Mueller-Dombois and Ellenberg (1974). It follows that these differential species are neither ubiquitous nor rare within their cover type.

Since range management activities are normally directed toward the species important at a given location, a classification unit based on understory species of coincident distribution but negligible cover may give little information about the species actually managed. Consequently, for the first attempt at classification at the community type level, plots were ordered in association tables according to percent cover of those understory species dominant or important. A tentative community type group was considered too narrowly defined if it could show neither (1) a noticeably greater cover of some species present in other community types, nor (2) a characteristic species in the sense defined above. Groups that passed this test were run on the SIMIL similarity program under each of the two indices. Cases where a between group average similarity was equal to or greater than a within group similarity on either index were suspect, and usually resolved by lumping since splitting left no characteristic species for each group in either the dominance or presence-absence sense described above.

No attempt was made to classify plots at the phase level or lower. Vegetal or floristic differences insufficient to merit cover type or community type distinction would be logical candidates for phase distinction.

Once community types were appropriately ordered in an association table, cover or presence-absence data of the dominant or characteristic species which best separated the community type units were synthesized into a field key to community types. All plots, including those previously dropped once n became < 3, were run through the key, with the classification results included in section IC5. The relatively simple cutoff criteria of the field key to not duplicate the polythetic agglomerative process used in establishing the different community types. Hence some plots used in originally definining the ranges of community types (i.e., in group similarity calculations) do not fit the key. Conversely, simplified cover type cutoff criteria admit some previously excluded plots.

C. Results

The actual classification of the 104 plots in this study was simplified from the described procedure due to the previous application of these techniques by Simone and Henderson (1977) in a survey of U. S. Forest Service land adjacent to the western portion of the study area. Their approximately 800 reconnaissance plots, the derived community types, and summarized field key were considered in the present plot classification.

The following section contains a hierarchical key to all community types mapped on the study area. A community type was considered mappable when it (1) contained 3 or more plots from either the plots measured in this study, the inventory of the Manti-Lasal National Forest by Simone and Henderson (1977), or the combined universe of both, and (2) was represented in the present study area by at least one map area of 10 or more acres. The community types map and the mapping rules used comprise Appendix A. To explain the origin of the key endpoints below, all classification units used are qualified by the following superscripts:

1). Established by 3 or more plots in this study

2). Represented by less than 3 plots in this study, but established by Simone-Henderson (1977) or a combination of these two sources.

3). Not represented in plots done in this study; established by Simone-Henderson (1977). These all occur in the extreme west and of the study area.

All numbers for percent cover of individual species refer to aerial canopy cover, as defined by Daubenmire (1959). In the key, diagnostic cover percentages can be either relative or absolute. For plots where the sum of all individual species covers is less than 100 percent, relative cover is intended. Figures should be interpreted as absolute cover for plots where the sum of individual covers equals or exceeds 100 percent. Plots in or near the study area that do not fit in this classification should be interpreted as either inclusions in a map unit or variants that are exceptions to this particular system and intensity of classification.

1). Key to physiognomic types (life form dominating the community)

1a). Tree canopy cover $\geq$ 5%. ("Tree is here defined as single stemmed woody species whose potential height equals or exceeds that of mature, normal-sized _Quercus gambelii_. "Canopy" is defined in the community sense, and includes only that tree cover which equals or overtops the next tallest life form, be it shrubs or herbs.)

2a). Dominant tree layer composed of species of tree habit: *Picea*, *Abies*, *Pseudotsuga*, *Populus* . . . . Forest physiognomic type[1], p. 10

2b). Dominant tree layer composed of dwarf trees of species which may exhibit a shrubby growth habit on sub-optimal sites: *Quercus gambelii*, *Pinus edulis*, *Juniperus ostesperma* . . . . Woodland physiognomic type[1], p. 11

1b). Trees absent, or tree canopy < 5%.

3a). Total shrub coverage (including half shrubs) ≥ 25%, and shrub layer codominating with or overtopping herbs. . . Shrubland physiognomic type[1], p. 12

3b). Shrub cover < 25%, or herbs overtopping shrub layer . . . . Herbland physiognomic type[1], p. 13

2. Key to formations (a more narrow generalization of habit and habitat of dominants): No key given. Formations formed by agglomeration of cover types, accepted by concensus. See classifications synopsis, page

3. Key to cover types (dominant overstory species).

3(A). Forest Physiognomic type. All cover percentages refer only to trees of one dm. DBH or greater, to limit consideration to canopy trees.

1a). One tree species has at least 80% of total tree cover. This species referred to as the "predominant member of the forest canopy."

2a). *Abies lasiocarpa* predominant member of tree canopy . . . . *Abies lasiocarpa*[3] Cover type, p. 13

2b). *Pseudotsuga menziesii* or *Populus tremuloides* the predominant member of the canopy.

3a). *Pseudotsuga menziesii* predominant member of canopy . . . . *Pseudotsuga menziesii*[1] Cover type, p. 14

3b). *Populus tremuloides* predominant member of canopy . . . . *Populus tremuloides*[2] Cover type, p. 14

1b). No single tree species with 80% of canopy cover, but total cover of the 2 most important species is $\geq$ 80%. These two species herein referred to as "codominants" of the forest canopy.

  4a). Abies lasiocarpa one of the codominants.

    5a). Picea engelmanii a codominant . . Picea engelmannii-Abies lasiocarpa[2] Cover type, p. 15

    5b). Not as above.

      6a). Populus tremuloides a codominant. . . . . Abies lasiocarpa-Populus[2] tremuloides Cover type, p. 15

      6b). Pseudotsuga menziesii a codominant . . . . Abies lasiocarpa-Pseudotsuga menziesii[2] Cover type, p. 16

  4b). Abies lasiocarpa not a codominant of canopy

      7a. Abies concolor a codominant of canopy. . . . . Abies concolor-Pseudotsuga menziesii[3] Cover Type p. 16

      7b. Populus tremuloides a codominant, not A. concolor . . . . Populus tremuloides-Pseudotsuga menziesii[3] Cover type, p. 16

3(B). Woodland Physiognomic type. Cover percentage refers to all individuals of the species, regardless of size.

1a). Quercus gambelii cover $\geq$ 80% total cover of all woodland trees (Q. gambelii, Pinus edulis, and Juniperus osteosperma). . . . . Quercus gambelii[1] Cover type, p. 17

1b). Pinyon + juniper cover $\geq$ 20%.

  2a). Pinus edulis cover $\geq$ 80% of total woodland tree cover. . . . . Pinus edulis[1] Cover type, p. 17

2b). Juniperus osteosperma + Pinus edulis cover ≥ 80% of total woodland tree cover . . . . Pinus edulis-Juniperus osteosperma[1] Cover type, p.17

Additional cover types that might be justified by more intensive sampling include a Quercus gambelii -Pinus edulis Cover type, and a Juniperus osteosperma Cover Type

3(C). Shrubland Physiognomic type. "Total shrub coverage" is the sum of all individual species coverages, including halfshrubs. Due to the large number of shrub species in the study area, estimating the coverage of prospective dominants relative to total shrub cover is tedious. To facilitate field use, the following key to shrub cover types is artificial in that diagnostic coverages (interpreted as absolute cover) were chosen to assure 80% dominance in about 80 to 90% of the cases where the same cover type is indicated by complete calculations. Resorting to a relative interpretation of the diagnostic cover criteria (% of total community cover) will correctly identify (in most cases) plots which do not fit the key first time through, especially for depauperate stands. Dubious cover type identifications can be checked to see if the indicated overstory dominant(s) account for roughly 80% of the shrub cover, or in a looser sense, describe the shrub dominants adequately.

1a). Amelanchier utahensis cover ≥ 10% . . . . Amelanchier utahensis-Artemisia tridentata[1] Cover type p.18

1b). A. utahensis cover <10%

2a). Cercocarpus montanus cover ≥ 10% . . . . Cercocarpus montanus[3] Cover type, p. 18

2b). C. montanus cover <10%.

3a). The sum of Artemisia tridentata and Chrysothamnus viscidiflorus coverages ≥ 20%. . . Artemisia tridentata-Chrysothamnus viscidiflorus[1] Cover type, p.18

3b). Atriplex confertifolia and Gutierrezia sarothrae both present, the sum of their coverages ≥ 15% . . . . Atriplex confertifolia-Gutierrezia sarothrae[1] Cover type, p.19

Sarcobatus vermiculatus, Atriplex cuneata, and A. corrugata are locally important overstory plants on the salt desert near Price. A sufficiently high plot density would justify additional cover types with these plants as overstory dominants.

3(D). Herbland physiognomic type.

1a). Poa sandbergii cover ≥ 15% . . . . Poa sandbergii Cover type[3], p. 19

1b). Poa sandbergii cover <15%.

2a). Elymus salina cover ≥ 25% . . . . Elymus salina Cover type, p.19

2b). The sum of Oryzopsis hymenoides, Agropyron smithii, and Bouteloua gracilis ≥ 30% . . . . . Oryzopsis hymenoides-Bouteloua gracilis Cover type, p.19

4. Key to community types (cover type label of overstory dominant(s)/ indicator or dominant of understory association). For plots in the forest physiognomic type that do not fit the key first time through because of depauperate understory (though total community cover ≥ 100%), halve all cover criteria and start again at the correct cover type.

Abies lasiocarpa[3] COVER TYPE

At least 2 of the following species present with at least 1% cover each: Symphoricarpos oreophilus, Berberis repens, Pachistima myrsinites, and Rosa nutkana, or any one present with at least 5% cover . . . . Abies lasiocarpa/ Berberis repens[3] community type

Pseudotsuga menziesii[1] COVER TYPE

1a. *Cercocarpus ledifolius* at least 5% cover. *Elymus salina* usually present. *Cercocarpus montanus* may replace *C. ledifolius* in some areas . . . . *Pseudotsuga menziesii*/*Cercocarpus ledifolius*[3] Community type

1b. Not as above.

  2a. *Acer glabrum* at least 5% cover . . . . *Pseudotsuga menziesii*/*Acer glabrum*[2] Community type

  2b. *A. glabrum* <5% cover. At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana*, or any one with at least 5% cover . . . . *Pseudotsuga menziesii*/*Berberis repens*[2] Community type

Populus tremuloides[2] COVER TYPE

1a. *Quercus gambellii* ≥ 10% cover . . . . *Populus tremuloides*/*Quercus gambellii*[3] Community type

1b. *Quercus gambellii* < 10%.

  2a. *Physocarpus malvaceus* ≥ 5% . . . . *Populus tremuloides*/*Physocarpus malvaceus*[2] Community type

  2b. *P. malvaceus* < 5%.

    3a. At least 2 of the following species present with at least 5% cover each: *Symphoricarpus oreophilus*, *Berberis repens*, *Pachistima myrsinites* and *Rosa nutkana* . . . . *Populus tremuloides*/*Symphoricarpos oreophilus* - *Berberis repens*[3] Community type

    3b. At least 2 of the following species present with a single or combined cover of at least 10% (normally much greater) *Symphoricarpus oreophilus*, *Lathyrus lanzwertii*, and *Bromus marginatus*, *Bromus ciliatus* may replace *B. marginatus* in some areas . . . *Populus tremuloides*/*Bromus marginatus*[2] Community type

Picea engelmannii-Abies lasiocarpa[2] COVER TYPE

1a. At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana*, or any one of these species with at least 5% cover . . . . . *Picea engelmannii-Abies lasiocarpa/Berberis repens*[3] Community type

1b. *Ribes montigenum* at least 3% cover *Osmorhiza chilensis* usually present . . . . *Picea engelmannii-Abies lasiocarpa/Ribes montigenum*[2] Community type

Abies lasiocarpa - Populus tremuloides[2] COVER TYPE

1a. *Physocarpus malvaceus* at least 5% cover . . . . . . *Abies lasiocarpa-Populus tremuloides/Physocarpus malvaceus*[2] Community type.

1b. Not as above.

- 2a. At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana*, or any one of these species with at least 5% cover . . . . *Abies lasiocarpa-Populus tremuloides/Berberis repens*[3] Community type.

- 2b. Not as above. *Ribes montigenum* at least 3% cover. *Osmorhiza chilensis* usually present . . . . *Abies lasiocarpa/Populus tremuloides/Ribes montigenum*[2] Community type

Abies lasiocarpa - *Pseudotsuga menziesii*[2] COVER TYPE

1a. *Acer glabrum* at least 5% cover . . . . *Abies lasiocarpa-Pseudotsuga menziesii/Acer glabrum*[2] Community type

1b. *A. glabrum* 5% cover. At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana*, or any one of these species with at least 5% cover . . . . *Abies lasiocarpa-Pseudotsuga menziesii/Berberis repens*[3] Community type

Abies concolor - *Pseudotsuga menziesii*[3] COVER TYPE

At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana*, or any one of these species present with at least 5% cover . . *Abies concolor-Pseudotsuga menziesii Symphoricarpos oreophilus-Berberis repens*[3] Community type.

Populus tremuloides - *Pseudotsuga menziesii*[3] COVER TYPE

1a. *Physocarpus malvaceus* at least 5% cover . . . . . . *Populus tremuloides-Pseudotsuga menziesii/Physocarpus malvaceus*[3] Community type

1b. *P. malvaceus* < 5% cover. At least 2 of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana* or any one of these with at least 5% cover . . . . *Populus tremuloides-Pseudotsuga menziesii/Symphoricarpus oreophilus-Berberis repens*[3] Community type

Quercus gambellii COVER TYPE

1a. *Cercocarpus montanus* and *Amelanchier utahensis* with combined coverage of at least 10% . . . . *Quercus gambellii Cercocarpus montanus-Amelanchier utahensis*[2] Community type

1b. Not as above

  2a. *Artemisia tridentata* at least 5% cover . . . . *Quercus gambellii*/*Artemisia tridentata*[2] Community type

  2b. *Artemsia tridentata* <5% cover. At least two of the following species present with at least 1% cover each: *Symphoricarpos oreophilus*, *Berberis repens*, *Pachistima myrsinites*, and *Rosa nutkana* or any one of these species with at least 5% cover. . . . . *Quercus gambellii*/*Symphoricarpus oreophilus-Berberis repens*[3] Community type

Pinus edulis COVER TYPE[1]

Elymus salina ≥ 10% . . . . *Pinus edulis*/*Elymus salina*[1] Community type

Pinus edulis - *Juniperus osteosperma*[1] COVER TYPE

1a. *Agropyron cristatum* ≥ 15% . . . . *Pinus edulis* - *Juniperus osteosperma*/*Agropyron cristatum*[1] Community type

1b. *A. cristatum* < 15% cover. *Elymus salina* cover and *Oryzopsis hymenoides* cover ≥ 10% . . *Pinus edulis-Juniperus osteosperma*/*Elymus salina*[1] Community type

Amelanchier utahensis - *Artemisia tridentata*[1] COVER TYPE

Poa fendleriana, *Antennaria concinna*, *Erigeron engelmannii* present . . . . *Amelanchier utahensis* - *Artemisia tridentata*/*Poa fendleriana*[1] Community type

Cercocarpus montanus[3] COVER TYPE

Elymus salina ≥ 10% . . . . *Cercocarpus montanus*/*Elymus salina*[3] Community type

Artemisia tridentata - *Chrysothamnus viscidiflorus*[1] COVER TYPE

1a. *Elymus salina* at least 30% cover. *Bouteloua gracilis* not ≥5%. *Artemsia tridentata*-*Chrysothamnus viscidiflorus* *Elymus salina*[2] Community type

1b. Not as above.

  2a. *Symphoricarpus oreophilus* at least 20% cover . . . . *Artemisia tridentata*-*Chrysothamnus viscidiflorus* *Symphoricarpus oreophilus*[3] Community type

  2b. *S. oreophilus* < 20%.

    3a. *Poa fendleriana* ≥ 10% . . . . *Artemisia tridentata*-*Chrysothamnus viscidiflorus*/*Poa fendleriana*[2] Community type

3b. *P. fendleriana* < 10%.

4a. *P. fendleriana* < 10%, *Bouteloua gracilis* ≥ 15% . . . . *Artemisia tridentata-Chrysothamnus viscidiflorus/Bouteloua gracilis* Community type

4b. Not as above.
The following grasses with a single or combined coverage of at least 20%, *Stipa lettermannii*, *Stipa columbiana*, *Bromus marginatus*, *Agropyron trachycaulum*, *Elymus glaucus*, *Melica bulbosa*, *Poa curta*, *Poa pratensis*, *Poa nevadensis*. Most common associate is *S. lettermannii* . *Artemsia tridentata-Chrysothamnus viscidiflorus/Stipa lettermannii* Community type

Atriplex confertifolia - *Gutierrizia sarothrae* COVER TYPE

Hilaria jamesii cover and *Oryzopsis hymenoides* cover ≥ 15% . . . . *Atriplex confertifolia-Gutierrizia sarothrae/Hilaria jamesii* Community type.

Oryzopsis hymenoides - *Bouteloua gracilis* cover type

Oryzopsis hymenoides - *Bouteloua gracilis* community type.

Elymus salina cover type .... *Elymus salina* community type.

Poa sandbergii cover type . . . . *Poa sandbergii* community type

5. Synopsis of classification units.

Parentheses enclose the map code of the classification unit.

FOREST (1)

- Subalpine mesophytic (1-1)
  - Picea engelmannii - Abies lasiocarpa (1-1-2)
    - Pien-Abla/Berberis repens (1-1-2-3)
    - Pien-Abla/Ribes montigenum (1-1-2-4)
  - Abies lasiocarpa (1-1-3)
    - Abla/Berberis repens (1-1-3-3)
  - Abies lasiocarpa - Pseudotsuga menziesii (1-1-4)
    - Abla-Psme/Acer glabrum (1-1-4-5)
    - Abla-Psme/Berberis repens (1-1-4-2)
  - Abies lasiocarpa - Populus tremuloides (1-1-5)
    - Abla-Potr/Physocarpus malvaceus (1-1-5-1)
    - Abla-Potr/Berberis repens (1-1-5-3)
    - Abla-Potr/Ribes montigenum (1-1-5-2)

- Montane mesophytic (1-2)
  - Pseudotsuga menziesii (1-2-1)
    - Psme/Cercocarpus ledifolius (1-2-1-4)
    - Psme/Acer glabrum (1-2-1-1)
    - Psme/Berberis repens (1-2-1-3)
  - Abies concolor - Pseudotsuga menziesii (1-2-8)
    - Abco-Psme/Symphoricarpus oreophilus-Berberis repens (1-2-8-1)
  - Populus tremuloides-Pseudotsuga menziesii (1-2-6)
    - Potr-Psme/Physocarpus malvaceus (1-2-6-1)
    - Potr-Psme/Symphoricarpus oreophilus-Berberis repens (1-2-6-2)
  - Populus tremuloides (1-2-5)
    - Potr/Quercus gambellii (1-2-4-7)
    - Potr/Physocarpus malvaceus (1-2-5-5)
    - Potr/Symphoricarpus oreophilus-Berberis repens (1-2-5-1)
    - Potr/Bromus marginatus (1-2-5-4)

WOODLAND (2)

- Montane (2-2)
  - Quercus gambelii (2-2-1)
    - Quga/Cercocarpus montanus-Amelanchier utahensis (2-2-1-1)
    - Quga/Artemisia tridentata (2-2-1-3)
    - Quga symphoricarpus oreophilus-Berberis repens (2-2-1-2)

- Pinyon-Juniper (2-3)
  - Pinus edulis (2-3-1)
    - Pied/Elymus salina (2-3-1-1)
  - Pinus edulis-Juniperus osteosperma (2-3-4)
    - Pied-Juos/Agropyron cristatum (2-3-4-2)
    - Pied-Juos/Elymus salina (2-3-4-3-)

SHRUBLAND

- Montane mesophytic (3-2)
    - Amelanchier utahensis - Artemisia tridentata (3-2-1)
        - Amut-Artr/Poa fendleriana (3-2-1-1)

- Mountain sagebrush (3-3)
    - Artemisia tridentata-Chrysothamnus viscidiflorus (3-3-1)
        - Artr-Chvi/Elymus salina (3-3-1-3)
        - Artr-Chvi/Symphoricarpus oreophilus (3-3-1-2)
        - Artr-Chvi/Poa fendleriana (3-3-1-7)
        - Artr-Chvi/Bouteloua gracilis (3-3-1-8)
        - Artr-Chvi/Stipa lettermannii (3-3-1-6)

- Montane xerophytic (3-4)
    - Cercocarpus montanus (3-4-2)
        - Cermo/Elymus salina (3-4-1-1)

- Lowland xerophytic(3-5)
    - Atriplex confertifolia - Gutierrizia sarothrae (3-5-1)
        - Atco-Gusa/Hilaria jamesii (3-5-1-1)

HERBLAND (4)

- Benchland grasslands (4-4)
    - Elymus salina (4-4-1)
        - Elymus salina (4-4-1-1)
    - Oryzopsis hymenoides-Bouteloua gracilis (4-4-2)
        - Oryzopsis hymenoides-Bouteloua gracilis (4-4-2-1)

- Subalpine xerophytic grassland (4-2)
    - Poa sandbergii (4-2-3)
        - Poa sandbergii (4-2-3-1)

II. POTENTIAL VEGETATION

A. Introduction.

The economic intent of a resource inventory is to compare the value (production, standing crop, or composition) of some potential vegetation to the value of existing vegetation. Many different natural or man-altered plant communities are possible at a given location and could be compared to the existing vegetation. The potential community of greatest usual interest would be the one of maximum economic value under a defined use or combination of uses. Such a plant community often cannot be specified. On public lands managed for economic yield, dollar values are difficult to assign for many uses (recreation, watershed), and the mix of multiple uses of public land changes through space and time.

To avoid these problems, natural resource planners and economists commonly accept a biological definition of potential vegetation such as habitat type.

B. Methods

The most important information necessary for establishing a habitat type classification based on potential vegetation are relict areas of climatic (or edaphic, topoedaphic) climax vegetation as defined by Daubenmire (1952, 1968). Climax shrub stands and grasslands are more difficult to identify and interpret than forests due to the obscurity or lack of woody age records. Also, successional trends toward competitive exclusion are less evident in smaller life forms than in trees (Daubenmire, 1968, p. 54). Of 104 plots measured in this study, at most 3 or 4 have near-climax vegetation. The study area was heavily overgrazed in the early 1900's, with only steep, rapidly eroding slopes possibly escaping this disturbance.

Without the availability of many reference areas of relictual vegetation, the following inferences of climax vegetation are made from existing literature and personal familiarity with the study area. The westernmost two miles of the study area were mapped to the series group, series, or habitat type level by Simone and Henderson (1977), using mostly forest habitat types recognized by authors in other areas. Considerations leading us to establish seven additional habitat types over the eastern portion of the study area are included in the results section

C. Results

The first 14 units are those mapped on the eastern 4 sections (U.S. Forest Service land) of the study area by Simone and Henderson (1977). Forested areas are classified to habitat type level, with other areas classified to series or zone level only. Their work provides no key or descriptions and we cannot further elaborate their units. Keys to habitat types in the _Abies lasiocarpa_ and _Picea englemannii-Abies lasiocarpa_ series are available in Kerr (1977).

We propose 6 additional habitat types and one additional series for the eastern 12 miles of the study area. The climatic, edaphic, and competition factors (or their indicators) separating these units are not well enough known to be reduced into a key. Considerations leading to the establishment of each habitat type are discussed after the habitat type name and map code number.

Subalpine mesophytic forest series group (1-1)

- Picea engelmannii-Abies lasiocarpa series (1-1-2)
  - Pien-Abla/Ribes montigenum habitat type (1-1-2-3)
  - Pien-Abla/Berberis repens habitat type (1-1-2-4)
- Abies lasiocarpa series (1-1-3)
  - Abla/Berberis repens habitat type (1-1-3-3)

Montane mesophytic forest series group (1-2)

- Pseudotsuga menziesii series (1-2-1)
  - Psme/Berberis repens habitat type (1-2-1-3)
  - Psme/Cercocarpus ledifolius habitat type (1-2-1-4)
- Populus tremuloides series (1-2-5)
  - Potr/Bromus spp. habitat type (1-2-5-4)
- Populus tremuloides-Quercus gambelii series (1-2-7)
  - Potr-Quga/Symphoricarpus oreophilus-Berberis repens h.t. (1-2-7-1)
- Abies concolor series (1-2-8)
  - Abco/Symphoricarpus oreophilus-Berberis repens h.t. (1-2-8-2)

Montane woodland series group (2-2)

- Quercus ganbelii series (2-2-1)

Montane mesophytic shrub series group (3-2)

Mountain sagebrush shrub series group (3-3)

- Artemisia tridentata-Chrysothamnus viscidiflorus series (3-3-1)
  - Artr-Chvi/Purshia tridentata habitat type (3-3-1-1)

Montane xerophytic shrub series group (3-4) Cercocarpus spp. dominating.

Subalpine xerophytic grassland series group (4-2)

Seven new map units are proposed below, six at the habitat type level and one at the series level

Quercus gambelii-Amelanchier utahensis/ series (2-2-3)

Quercus gambelii-Amelanchier utahensis/Artemisia tridentata habitat type (2-2-3-1)

Under optimum conditions, Quercus gambelii can form a nearly closed canopy over the landscape. The factors limiting the expansion of Quercus clones at the lower elevational end of its range are unknown.

On upper Wiregrass Bench (2230-2400 m) this oak presently shows a weak preference for shallow, stony soils on slopes of any aspect, but is found on all exposures, slopes, and soil types. Few of these clones show any evidence of recent burning. Larger, peripheral trunks averaged 40-70 years old, with trunks at the clone center usually 20-40 years older (130 years maximum age counted). Since central trunks were always older than perimeter trunks, it is tempting to speculate that with the defined lack of fire (habitat type definition), clones would expand until they became contiguous, or were limited by lack of water (assuming water potential is equalized among all trunks). If this latter situation is more likely at the xeric end of its range, the spaces between clones (especially on deep, loessal soils) would be occupied by the more xeric _Amelanchier utahensis_ and _Artemisia tridentata_.

Amelanchier utahensis series (3-2-1)

Amelanchier utahensis/Artemisia tridentata habitat type (3-2-1-1)

Below the drought limit of _Quercus gambelii_, but where it is apparently too cold for juniper-pinyon, _Amelanchier utahensis_ is the potential overstory dominant. Once a few stems surpass the browse line, individual plants form a large canopy of many stems. Individual stems can live over 120 years. Plant longevity and fire sensitivity are unknown. We have never observed _Amelanchier utahensis_ to form a continuous closed canopy, and it apparently cannot exclude the sagebrush-grass understory from competitive pressure alone in this climatic regime. Monospecific stands of regularly-spaced serivceberries are found only on small, steep, actively eroding shale sites (lacking stones), where soil movement and water relations contribute to understory removal.

Juniperus osteosperma - Pinus edulis Series (2-3-4)

Juniperus osteosperma - Pinus edulis/Agropyron spicatum inerme - Oryzopsis hymenoides habitat type (2-3-4-6).

Work by Tausch (1977) shows that junipers and pinyons outcompete all other life forms in the use of moisture. At climatic climax, only a light scattering of forbs and grasses remain. SCS "excellent condition" on such sites (Mason, 1971) contradicts this only because it assumes a pre-settlement fire frequency. Conforming with the definition of habitat type, we map all land below 2.8 degrees Centigrade annual mean minimum temperature (Randles, 1949), and above salt desert conditions in the juniper-pinyon series of climax vegetation. Two types of climax understory are likely. On level mesa tops, deep wind-deposited (or sandy if shallow over sandstone) soils would support understories dominated by Agropyron spicatum inerme, or Oryzopsis hymenoides on drier benches. The Elymus salina and Bouteloua gracilis locally common on these benches today (beneath Artemisia tridentata) have probably increased from overgrazing. Associated forbs would include Penstemon lentus, Pedicularis centranthera, and Cryptantha sp.

Juniperus osteosperma-Pinus edulis/Elymus salina habitat type (2-3-4-5).

On canyon slopes of greater than roughly 20% slope, soils are torriorthents derived from the Mancos shale. Due to its stature and rhizomatous habit, Elymus salina is the only grass capable of maintaining its position on the unstable soil. Severe gully and sheet erosion inhibit the trend toward stand closure and regular spacing of trees evident on level sites, allowing some shrubs (Ephedra viridis, Cowania mexicana, and Cercocarpus montanus) at climax. Associated forbs include those listed above. Of all the habitat types mapped in this report, Juos-Pied/Elsa has the greatest percentage of its area in climax or near climax states. Due to summer drought, continual erosion, the resultant lack of surface fuels, and fire suppression by man, many south-facing slopes will no longer carry a ground fire sufficient to kill trees and return the site to an earlier successional stage.

Atriplex confertifolia - Ceratoides lanata Series

Atriplex confertifolia-Ceratoides lanata/Oryzopsis hymenoides habitat type (3-5-2-1)

The juniper-pinyon series stops on the floor of the Castle Valley due to the low annual precipitation (270 mm) and salty substrate. The possible climatic dominants on this moderately salty soil (Chipeta and Persayo series, usually less than .32% soluble salts above 17 inch depth) incluee Atriplex confertifolia and Ceratoides lanata (both plants thriving below .7% salt above 5 foot depth according to Gates, Stoddart, and Cook (1956)). Historical records of this area are slight and so far produce no clue as to which of these species were more important. Autecological and synecological studies have so far shown no consistent differences large enough to predict relative abundance in climax. Ceratoides lanata and Atriplex confertifolia retain adjacent positions in all ordinations presented by Branson, Miller, and McQueen (1976). A.confertifolia is by far the more abundant now, but associated species indicate previous overgrazing sufficient to kill off a dominant winterfat population. In presettlement times, Ceratoides may have been more important due to a greater longevity than A. confertifolia. We have seen large, dead Ceratoides stumps of apparently great age excavated by gullies. Norton (1977) speculates that cover and relative dominance changes between these two species at the Desert Experimental Range are caused by the inherently shorter longevity of shadscale. For these reasons, and because complete competitive exclusion is unlikely due to the scale of edaphic variation, both shrubs are included in the series name. *Hilaria jamesii* and *Oryzopsis hymenoides* are presently the most important understory plants. Both appear equally able to tolerate the salinity levels found within the series, but *Hilaria* has undoubtedly been increased by grazing (West et al 1967) that decreased *Oryzopsis*.

Atriplex corrugata Series (3-5-3)

Atriplex corrugata habitat type (3-5-3-1)

Atriplex corrugata is found on very salty, shallow soils lacking a water table (soil conductivity equalling 17 mmho/cm according to Branson, Miller and McQueen, 1976). On convex topography with parent shale lacking any gravel pavement or pediment remains, erosion apparently equals the rate of shale disintegration beneath 10 to 15 inches of soil, and site ameloiration through further soil development is impossible. Gypsum crystals are common on the soil surface. Such locations support climax, monospecific stands of *A. corrugata*. This habitat type was also reported near Cisco, Utah, by West and Ibrahim (1967).

Atriplex cuneata can be present in xeric (or overgrazed) *A. confertifolia* stands, and codominating with *A. corrugata* in sites too mesic for a species in this latter condition and on steep shale slopes. *A. cuneata* was not mapped as a climax series because of the insignificant area it presently dominates, and uncertainty about its successional relationship to the other *Atriplex* shrubs.

<u>Sarcobatus vermiculatus</u> series (3-5-4).

This tall shrub is restricted to seasonal drainages where salty water tables are available at least part of the year. Average profile salinity (unstated depth) of <u>Sarcobatus</u> stands sampled by Branson, Miller, and McQueen (1976) was 11 mmho/cm. While the climax status of a greasewood overstory in approximate topographic sites is clear, the presettlement understory and climax understory are unknown. This part of the study area has been public domain used as a stock driveway for almost 100 years, altering the groundlayer vegetation beyond speculation.

III. Discussion

A. Relation of ECOSYM vegetation classifications to other American, management-oriented vegetation classifications

1. SCS range site and condition.

While ECOSYM divides existing and potential vegetation into two separate classifications, the SCS inventory system is based on a combined vegetation-environment classification (Shiflet, 1975). The disaggregation of ECOSYM data reflects its design as a general purpose information system for predicting a wide range of events. In contrast, SCS range site/condition is a specific purpose inventory of data relevant to management of livestock grazing. The upper level of the SCS system is a classification of inferred potential vegetation. The units differ from Daubenmire habitat types (as used in ECOSYM), which are restricted to only climatic or topoedaphic climaxes (Daubenmire, 1952) and are identified by indicator species. SCS "range sites" of potential vegetation are best guesses at broad scale patterns of relatively stable presettlement vegetation which admit fire (dis)climaxes and animal (dis)climaxes, and are identified by macroclimate and soil. In the SCS system, present vegetation is classified by its similarity to the inferred presettlment "site" vegetation, which was always more desirable for domestic grazing, though not always as productive.

The trend from poor to excellent condition is not a successionally consistent direction, since the "excellent condition" presettlement reference can be seral or climax. In Utah, Mason (1971) defines desert range sites (where fire is not a factor) as "excellent condition" at climatic climax. In sagebrush sites within the pinyon-juniper zone, pinyon-juniper sites, and possibly some mountain brush sites, seral stages are rated as excellent condition and climax stands (with more woody and less herbaceous biomass) as poor condition. This classification of "range condition" (present vegetation) is objective and repeatable using the SCS methods, and it can give a good idea of the recent trend of vegetation suitability for grazing (which is in part a result of recent management). But "range site" and "condition" alone do not provide a tangible picture of which species are present (especially shorter life forms). The problem is: Classifying existing vegetation as successional stages of an inferred climax requires that there be a very few kinds and severities of disturbance, and that the vegetation show a deterministic, predictable, linear successional resonse to these disturbances. The SCS system assumes that (1) disturbance from the climax is caused by domestic overgrazing, fire suppression, and erosion, that (2) climate does not change, and (3) the universe of plant genotypes available does not change. Monoclimax thinking prevails. While possibly acceptable for a regional, specific purpose inventory system, such assumptions are not realistic for a national, general purpose inventory of existing vegetation.

The ECOSYM system does contain most of the information summarized in the SCS system, and could fulfill a similar function, although probably less efficiently. The potential vegetation, climate, and soils ECOSYM components contain in disaggregate form essentially the same information contained in range site.The ECOSYM conditionclass level of the present vegetation classification is roughly analogous to the SCS range condition concept in distinguishing four successional stages, though these stages are not yet specifically defined as range condition.

In summary, the ECOSYM present vegetation classification system appears to be more suitable than the SCS system for organizing general purpose vegetation information for a variety of potential uses. ECOSYM appears able to provide a specific purpose grazing land vegetation inventory as accurate as the SCS system, though possibly less efficiently.

2. U.S. Forest Service Region 4 range inventory

The U. S. Forest Service (1969) Region 4 range inventory procedures also provide specific purpose data for managing domestic livestock grazing, and as such is not designed as a general purpose vegetation classification. It contains four hierarchical levels of information:

- Vegetation type
  - Suitability class
    - Condition
      - Trend

The Region 4 handbook presents 12 vegetation gypes (grassland, sagebrush, browse-shrub, etc.) without further description or keys for identification. The vegetation type unit is roughly equivalent to the ECOSYM formation level. Nine suitability classes for livestock grazing describe season and type of grazing use. Though there is no equivalent classification unit in ECOSYM, the same information could be inferred from climatic and cover type. Both condition and trend contain soil and vegetation data which are not aggregated. Here only the vegetation information is concerned. Sixty percent of the vegetation condition rating is determined from two numbers; the proportion of annual production in "desirable" and "intermediate" classes. Individual species are classified into desirable, intermediate, or undesirable categories, and the category may change above a certain relative abundance (% of annual production). The grazing desirability rating of the species does not change with vegetation type or habitat type (unlike SCS). This 60% portion of the vegetation condition rating is an absolute rating of utility of the species composition for grazing, not a comparison relative to site potential. The other 40% of the vegetal condition rating is the percent of potential annual production which is present in desirable and intermediate plants. Site potential is taken from empirical USFS curves which consider soil characters and vegetation type. The ECOSYM present vegetation classification does not contain information directly comparable with "condition." Community type, phase, and condition class classification units contain species abundance information that could approximate the species composition part of "condition". Present vegetation and habitat type data could conceivably be used to predict the percent of potential forage presently produced.

Trend data for vegetation is recorded as upward, downward, or neutral, from one-time observations of plant dispersion and vigor. No one-time measurement analagous to trend currently exists in ECOSYM, but it could be easily added.

In summary, information contained in higher levels of the USFS Region 4 range inventory system is also contained in ECOSYM. The continuous measure of condition as defined by USFS (or SCS) would be difficult to duplicate exactly from ECOSYM vegetation units, although broader classes of this scale could likely be modeled from ECOSYM data. Presently, no ECOSYM units carry information similar to the USFS trend observation though such information could be easily added.

The habitat type approach is gaining popularity for the inventory of forested lands. Extension of this method onto rangelands will raise many of the problems mentioned in sections IIA1 and IIID2.

3. Bureau of Land Management

Reorganization of BLM inventory procedures is still in progress. This review is current as of August, 1977. The fundamental BLM inventory unit is the habitat site, which is defined as a combined unit of topography, existing vegetation, soils, and accessibility. Each unique site is mapped on photos at a scale of 1/24,000. Present plans (BLM, 1977) call for numerous soil and vegetation data to be taken on each site. But how sites or their underlying data are classified or otherwise reduced and organized has not been yet proposed.

One assumption common to both the SCS and proposed BLM inventories is that a mapped phase of a soil series will have only one type of climax vegetation. This is not likely to be true in the Texas Cross Timbers area, where it was first hypothesized by the SCS. In this area, the phase of the series represents topographically caused microclimates within broad macroclimatic zones of gentle gradients. In mountainous terrain, the increased importance of physical factors and processes and decreased importance of biological processes in soil development suggest a weaker correlation between soil morphology and potential vegetation.

4. Ecoregions, and Land Systems Inventory

Ecoregions (1976) and Land Systems Inventory (Wendt and Arnold 1972, Wendt, Thompson and Larson 1975) are treated together here. Though presently being developed by two different groups, they share a common approach of similarly defined hierarchical levels. Classification units combine geology, landform, climate, soils, and potential vegetation by unstated map rules so that recovery of individual components is impossible. These systems are less suitable than ECOSYM for large scale inventory or predictive models. Bailey (1977) designed Ecoregions as a heuristic device for higher level administrative summary. For example, within what regional area can similar management problems and solutions be generalized, or what is the domain of a recently developed range productivity model? Bailey (1977) does not anticipate the practical definition or application of levels below the "landtype association," a unit containing several habitat types and several soil great groups. LSI applied this same landtype association unit to the Boise National Forest (Wendt, Thompson, and Larson, 1975) at a scale of 1/500,000 on the final published map. They described the landtype association as a unit designed to be mapped on photos at scales of rom 1/60,000 to 1/125,000 resulting in map polygons from 1 to 25 square miles in area. The entire Boise National Forest (2.8 million acres) contained 16 landtype associations which were condensed into 9" land capability groups." Each capability group was rated on six land uses (timber, forage, water yield, wildlife habitat, etc.) on a qualitative five point scale from very low to high.

Ecoregions, LSI, and ECOSYM are all designed as general purpose inventory systems. Ecoregions and LSI are designed for smaller scale, administrative summary, and are presently excluded from larger scale general purpose inventory by lack of specific mapping rules which would allow recovery of the individual components (vegetation, soil, climate, etc.) necessary for specific purpose models.

B. Management applications of the ECOSYM present vegetation component

The efficiency of the ECOSYM vegetation classification in providing information necessary for management decisions is difficult to assess ithout first specifying information needs. Intuitively, a classification organizing general purpose vegetation data (like ECOSYM) will suffer when compared to a specific purpose classification designed for the question at hand. The kind of vegetation information most often needed for natural resources management decisions is, in order of increasing specificity: (1) Community structure, which is usually required at a smaller scale than the following kinds of information. This is useful for predicting animal and plant habitats (Grainger, 1977, and Gephart, 1978), landscape sensitivity to development (Gropper, 1977), and erosion (Wigington, 1977). Complete physiognomic data would approximate a forest profile diagram, or a family of curves of life form cover (or density) versus height. The complete data would be reduced to the desired parameters by an appropriate specific purpose model. (2) More specific information on the relative or absolute abundance of individual species is necessary for larger scale management for example either the manipulation of a slow growing crop (lumber) or a faster flowing resource (range forage). Woody plants are inventoried by standing crop and productivity, smaller life forms by productivity alone. Theoretically an optimal information system could record these parameters directly or indirectly model the abundance or productivity of more important species. (3) Thirdly, knowledge of community dynamics or functions are necessary to decide among various manipulation schemes to attain a desired result. This type of information is the most diverse and consequently difficult to classify or otherwise convey. The scale this information is required in is also quite variable.

The ECOSYM classification of existing vegetation approximately follows the above hierarchy of scale/specificity, and is evaluated below. Physiognomic type does separate communities by life form of the dominants (tallest species). A woodland physiognomic type classification tells us that woodland species dominate, and the absolute (relative in depauperate plots) cover of woodland species is $\geq$ 5%. While this level of information is gross, it can still be useful for broad predictions of wildlife abundance, competitive relationships of forage species, etc. Formation gives a rough, qualitative idea of the appearance (family level) of the dominant plants. The local manager familiar with the country would be able to more distinctly imagine community physiognomy as qualified by cover type (species level identification of the overstory dominants) and community type (indicator of understory association), especially if the ecology of the label species is known. Condition class as a successional indicator (characteristic species of understory association could have the same value) could quantitatively clarify the absolute cover of various synusia or species, as do the diagnostic key cover values in a minor way. But it is to be expected that cases will arise when the inferred or predicted structural information of interest will not be accurate enough to model a higher order parameter (i.e., nest density).

Information involving abundance or productivity of individual species (other than in a cover sense as above, i.e., standing crop or net productivity) would be contained directly (by minimum diagnostic cover criteria) in the key identifying cover type and community type, and by inference in all levels of classification. While productivity or standing crop predicted from the classification units could be further qualified by ECOSYM soil and climate information, and the relationship would be weak tostrong depending on the scale and complexity of the phenomenon modeled, the ECOSYM vegetation data by itself gives essentially a qualitative picture. For models of forest and range productivity using ECOSYM vegetation data (and other ECOSYM x's) see Kerr (1977) and Roberts (1977).

A third general vegetation information need, lumped into community dynamics or function, is conveyed by the lower levels of the ECOSYM vegetation classification. Information in this category of proven importance to natural resource management includes phenology of plant productivity or reproduction, year to year variability in these parameters, reaction of one or several species successionally to a specified natural or management disturbance, etc. Of course no general purpose information system can hope to provide or predict everything of interest in community dynamics. Hence a locally knowledgeable land manager may best expect qualitative inference (of possibly quantifiable range) from vegetal information alone. This is because only a few taller dominants, understory indicator, and possibly condition class are named. Taxonomic actors and the habitat stage are only vaguely known, even including other ECOSYM parameters (x's). Species of subdominant abundance are at best inferred, as is site history. While not exciting, this degree of resolution is no less than that of existing specific purpose classifications, i.e., SCS range site/condition, USFS, etc. Powerful x's for predicting dynamic y's of interest vary locally. Many are not known presently.

C. Integration of present vegetation with other ECOSYM components

If the above opinion, that information in vegetation classes is relatively coarse in comparison to the most specific information needs, is true, then what of the precision gained by including additional ECOSYM components in a specific purpose model? Two examples are the forest and range productivity models of Kerr (1977) and Roberts (1977). Comparing vegetation sum of squares to total model SS and to total SS gives an idea of the importance of the vegetation classes, and the degree of model improvement by adding other ECOSYM components (x's). While the confidence or accuracy of these predicted y's may be low in an absolute sense, these y's are eventually intended for use as class midpoints in economic summary/inventory equations such as:

$$\text{total annual AUM's} = \quad \Sigma\, A_i \bar{P}_i$$

where $\bar{P}_i$ is the average productivity per area of land type i and A_i is the total area of land type i (Workman, 1976). These economic equations do not attempt to predict the variance of the final statistic, only its mean. Hence "best guesstimates of class means" are all that is required of Y's predicted from ECOSYM components. What is the most efficient (within budget) inventory system to predict total landscape productivity (actual and potential) using either classified or continuous data? A concensus of answers to this question from the many different natural resource fields is important to the design of an appropriate general purpose information system, but as yet this question has not been addressed. In summary, the improvement of predicted y's by including additional ECOSYM x's is variable depending on place, scale and nature of the question, and the competence of the investigator.

D. Conceptual and methodological problems of the proposed classifications

1. Present vegetation

a. Conceptual problems

Potential problems are discussed in decreasing hierarchical order.

Hierarchical classification is a common feature of general purpose vegetation classifications designed to be used over a wide area. Commonly, these systems make the first, upper level divisions on vegetation physiognomy and structure (Fosberg, 1956, and Küchler, 1967). With such a system lower level information can be scrambled or buried by a higher level classification. For example, two plots identical except for slightly different forest tree canopy coverages (4 vs 6%) would be split at the physiognomic type level in ECOSYM, and consequently be placed in different community types at the level intended to organize taxonomic data. If not independent information organized at different levels is confounded. In a practical sense, this problem is reduced by computer access to ECOSYM units; recovery of any information split into many different units is speeded up. A second compensating factor is that, as pointed out in Section IIIB, plant floristic and abundance changes tend to follow community physiognomy at a larger scale. Floristic data is more conveniently stored beneath physiognomic data than vice versa.

Formation units show the problem common to many agglomerative classes; no clear concept of what information is being organized or why. Units are accepted by concensus in the lack of specific divisive criteria.

Cover type (dominant(s) comprising 80% of the synusia named in the physiognomic type) is an expansion of the consociation concept (Mueller-

Dombois and Ellenberg, 1974, p. 172). It contains information important to management, namely the dominant plants of the dominant life form. The mostly divisive definition of this unit make it relatively tangible. But in species rich communities, or synusia of shorter life forms and greater diversity, the dominance approach to classification falls apart. A species list containing 80% relative life form cover is then too long and cumbersome as a classification label.

Community type level is intended to refine cover type with information from understory layers. How is understory information best organized? Two alternatives are to summarize the understory by its dominant(s) or by indicator species (sociation vs. association, Mueller-Dombois and Ellenberg, 1974, page 172-173).

The dominance approach is the simplest and most tangible. The n most abundant understory species could be ranked, or enough species to comprise x% of the understory cover are listed (this latter option gives problems in species rich areas, as described for cover type). The original definition of community type understory label (Henderson, 1976) was simply "the single understory dominant." This approach has the advantage of focusing on lifeform dominants which are usually the species managed on rangelands. But restricting the understory label to one or two most abundant species can create units which separate on the landscape at an inconveniently large scale. This results in a proliferation of community type units and the mapping of composite, mosaic map units. In productive areas of impoverished floras (i.e., boreal forest), single species dominance patterns can be useful summaries at a profitable management scale. The application of this tentative community type definition to the eastern 13 miles of the study area (R 8 E and east) resulted in 31 community type units versus 13 defined by the understory association approach defined below. While the more numerous units of the dominance approach can be assumed to give greater resolution, they were: (1) difficult to map at a scale of 1/30,000, requiring many inclusions and mosaics within the 10 acre minimum map area size. This would be especially true for species rich and man-altered landscapes. (2) So numerous as to greatly complicate any multiple regression modeling which included community type.

In an attempt to broaden the community type concept, Henderson and West (1977) opted for an understory label species which was the "indicator" of the understory association. This carried the assumption that the number of associations in an area was less than the number of potentially dominant species. The problems of this approach have already been encountered by the proponents of the Braun-Blanquet floristic classification. The technique of determining associations equally weights all differential species and ordinates them on an unknown, complex, indirect environmental gradient. Already this tends toward a vegetation-environment classification which is contrary to the stated goals of the ECOSYM present vegetation classification (Davis and Henderson, 1976). This tendency is likely a consequence of the Forestry bias toward more mesic, resilient, less disturbed ecosystems classified by understory unions (Daubenmire, 1952). A more fundamental problem with this approach is that the relative distribution of species on the gradient changes over location - hence the indicator value of species change over space. Where does one association end and another begin? Present Daubenmire-style habitat type classification of forest lands tends to extend the geographic range of already named associations to extremes by allowing different species of the same genus to replace association members over space, if the modified association maps on relatively similar parts (i.e., north slopes) of the new landscape. The objection of wide ranging, genetically variable indicator species confounding classified vegetation information is also valid against dominance defined understories. But at least dominance definition directly inventories the likely objects of range management, instead of indirectly referencing them (see IB4). Another problem of the association approach is that patterns of plant association tend to be most visible in climax, mesic communities and least visible on man-altered, dry landscapes.

Apart from the above question of understory classification is the question of vegetation scale in relation to plot size, and its effect on classification. The 500 m^2 plots used in this study were large compared to individual size in most plant species. But some individual plants were larger than plot size yet smaller than the minimum size map polygon area (10 acres).

On the broad benches at 2300 meters elevation, a 500 m^2 plot placed inside a large Quercus gambelii clone would classify as Quga/Symphoricarpus oreophilus-Berberis repens. Placed near the edge of a clone, or considering several neighbor clones as a whole, it would classify as Quga/Artemisia tridentata. Plant cover averaged over a 10 acre block would include sufficient Amelanchier utahensis between oak clones to classify as Quga/Amelanchier utahensis. How are such areas to be mapped? Inclusion rules simplify the possible mosaic combinations in some cases, relegating minor types to inclusions. Larger plot size as vegetation scale demands, or establishing minimum individual patch size for mosaic inclusions are possible solutions.

Phase has been tentatively proposed as containing the same type of information contained in community type, but at a greater resolution. It therefore suffers the uncertainties explained above for community type.

b. Methodological problems

How should plots be placed on the landscape to most efficiently sample vegetation? Samples to build specific purpose models are reasonably restricted to the universe of potential model application. This requires the judgement of the investigator. For general purpose vegetation inventory, some objective scheme is necessary to minimize bias. Smartt and Grainger (1974) evaluated the accuracy with which several plot-placement designs represented aerial extent of units on a vegetation map. Stratified systematic unaligned sampling was found superior to both stratified random and systematic sampling, with random placement being least accurate.

Unclear methods for agglomerative steps in determining cover types and community types can hinder acceptance of the ECOSYM vegetation classification. The cover types definition of "individual species usually $\geq$20% relative cover and usually totaling $\geq$80% relative life form cover" is difficult to translate into clear, objective methods. The divisive procedure explained in the methods section is an objective start, but too narrowly defines the cover types, leaving many intermediate plots. The subsequent group similarity comparison procedure is unambiguous, initiates some lumping, with the final groups having meaning in a floristic and vegetational sense, but still too narrowly defined for management use. What rules are appropriate for further lumping of groups of more than three plots but still not "useful" (i.e., the Artr preliminary cover type, page 7)?

For cover types above and community types, merely passing the group similarity comparisons on both indices is not a sufficient test for optimal classification. Many different arrangements of the same data would achieve this result. With a more exacting definition of community type, mechanical synthesis of (at least preliminary) community types from stratified cover types is the next logical step. Computer programs which synthesize community types by Braun-Blanquet methods include those by Leith and Moore (1971), and Ceska and Roemer (1971). Efficiency of several semi-computerized vegetation classification techniques were evaluated by J. J. Moore et al (1970), who found a Braun-Blanquet tabular rearrangement procedure and a clustering routine equally efficient of computer time in giving essentially the same results. Pursuing these two classification routines would force a more specific definition of community type, hopefully resulting in a repeatable methodology for their synthesis.

There will always be the final decision of which community types are useful in a management sense. Further tests which can be made to clarify the subjective decision as to which are useful general purpose units include (1) direct ordination of classified plots on various environmental gradients, to see if they separate tangibly on some known or knowable factor, (2) mapping the derived units on the landscape to see if they separate at a usable scale, and (3) using vegetation as an "x" in models predicting ecosystem attributes important to management. A low r^2 for the vegetation x implies it is either redundant with some other x, out of scale with the y predicted, a poor specific purpose classification, or unimportant, depending in part on the regression model used.

2. Potential vegetation

a. Conceptual problems

The two established concepts of potential vegetation in natural resource management are Daubenmire's concept of habitat type (Daubenmire, 1952, 1968) and the SCS concept of range site (Shiflet, 1975). As mentioned in Section IIIA1, range sites are based on presettlement vegetation irrespective of successional status. Daubenmire originally (1952) defined habitat type as climatic, edaphic or topoedaphic climax, though popularity has broadened its use since then. The choice of the habitat type concept for use in ECOSYM reflects the forestry bias of the system's designers and clients, the greater tangibility of this definition in communities where long-term woody records are available, and the ecological sophistication of Daubenmire's work compared to that of the SCS.

Daubenmire's definition of habitat type is not the climax plant community, but the land capable of supporting it. As such, it is intended not as a vegetation classification but as a combined classification of local environment as perceived by plants. Foresters have recently accepted habitat type as a classification of ecosystem dynamics on which to generalize management activities (Pfister, 1976, also see Section IIIB). Daubenmire organizes habitat type on similarity of perceived successional endpoints. Units hopefully show, by analogy, similar successional responses to the types of disturbances implicit in the classification.

Much of the appeal the habitat type concept has to land managers is the great information hopefully reduced to a short label of 2 or 3 species names. This is possible in Daubenmire's study area due to the low species richness in trees and the trend toward competitive exclusion in the overstory. But not all environments are homogeneous in relation to climax overstory species at plot scale, let alone a suitable mapping scale. For example, floodplain microrelief can prevent competitive exclusion resulting in a multispecies climax canopy. Problems naming understory unions were discussed in Section IIID1a.

b. Methods

Several problems arise in applying the habitat type concept to rangelands. In lower elevation terrain, environmental gradients paralleling topography are less steep. Ecotones are broader. Steep topography encourages spotty resource use, and natural distrubance leaving areas of relictual vegetation which are necessary for building a habitat type classification. Rangelands have often been completely used by stock, leaving no reference areas of climax vegetation. Arid rangelands are less resilient to disturbance than mesic forests, and successional patterns are difficult to detect. Age structure of herbs and most desert shrubs cannot be determined.

E. Summary

Any classification or information storage-retrieval system can be evaluated only if the type of information to be handled is known. Davis and Henderson (1976) identified three general forms of questions that ECOSYM was designed to answer, but the logical next step of deciding what information is needed in each of the components (i.e., vegetation) to best answer anticipated questions was not discussed in the classification report (Henderson and West, 1977). Granted, the choice of vegetal predictors in local, specific purpose models is a difficult, expensive process, and the choice of general purpose predictors for a wider variety of questions and locations is more difficult. This is especially true considering the lack of powerful, place-independent theories of ecosystem structure and function. Given our profession's lack of clear ideas of what measures best summarize plant communities through which mechanisms, and the parallel lack of attention in the ECOSYM vegetation classifications to the question of which community measurements might best model the desired phenomena, the choice of general, descriptive, hierarchical vegetation classifications is understandable and reasonable. The descriptive mode requires a hierarchical design to circumvent the question of scale of information, i.e., generality versus specificity.

The two ECOSYM vegetation components (present and potential vegetation) include most all the information collectively contained in systems previously designed for the inventory and management of vegetation. General purpose vegetation information needs as we perceive them (section IIIB) are addressed by the ECOSYM present vegetation classification in an appropriate hierarchical order. Although canopy cover, relative height, and life form were chosen for the present vegetation classification primarily for their convenience of measurement and precedence in other classifications, the utility of the resulting units in predicting community productivity is considered in Kerr (1977), and Roberts (1977). In the proposed ECOSYM classifications, information on ecosystem dynamics is split, appearing as inferred climax in potential vegetation, and succsssional stage in present vegetation. For consistency of inferred climax, present and potential vegetation should be mapped at the same time. Expansion of the habitat type concept from its original domain to other ecosystems will present major problems of principle and application. Along with problems mentioned above, improving the summary of ecosystem dynamics vis a vis natural and management disturbances is a major research need. Hopefully, better vegetation inventory methods will grow from the issues discussed in this report.

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V. APPENDICES

APPENDIX A: Present Vegetation - Community Types

This map is reduced from a preliminary map made in the field using an earlier, narrower definition of community type. The western 2.5 miles of this map were drawn by Simone and Henderson as part of an inventory of the Price District, Manti-LaSal National Forest. Map polygons of less than 10 acres are not mapped, but treated as inclusions in larger map areas. Inclusions of greater than 20% of the polygon area were treated as mosaics, with the percentage of different mosaic elements estimated to the nearest 10%. A listing of the numerical identification codes to community types can be found in section IC5 of the text.

APPENDIX B: Potential Vegetation - Community Types

The westernmost 2.5 miles of this map are taken from an inventory of the Price district of the Manti-LaSal National Forest by Simone and Henderson (1977). This section includes some areas mapped only to some more general unit above habitat type. The remainder was mapped from photos. Due to the speculative nature of these units, no mosaics were mapped although inclusions of habitat types do exist. Code numbers to mapped habitat types are found in section IIC of the text.