E7.4-10323
CR-136814

PLAN FOR THE UNIFORM MAPPING OF EARTH RESOURCES AND ENVIRONMENTAL COMPLEXES FROM SKYLAB IMAGERY

EREP INVESTIGATION #510

Period Covered: January 1, 1974 to January 31, 1974

Contract Number: NAS9-13286

Principal Investigator
Charles E. Poulton
Earth Satellite Corporation

Technical Monitor: Mr. Clayton Forbes
Lyndon B. Johnson Space Center

Monthly Plans and Progress Report

EarthSat Number: G-089

E74-10323) PLAN FOR THE UNIFORM MAPPING OF EARTH RESOURCES AND ENVIRONMENTAL COMPLEXES FROM SKYLAB IMAGERY Monthly Plans (Earth Satellite Corp., Berkeley, Calif.) 31 p HC $4.75 CSCL 08B G3/13 N74-17106 Unclas 00323

PLAN FOR THE UNIFORM MAPPING OF EARTH RESOURCES AND ENVIRONMENTAL COMPLEXES FROM SKYLAB IMAGERY

OVERALL STATUS

Natural Vegetation Analog Study

A complete descriptive and narrative legend as completed to date is included as Appendix I. Tertiary level legend units (based on physiognomic-structural features) have been completed for all types. Quaternary (first floristic) level units are being prepared for various natural and cultural vegetation units as work proceeds with them.

Three photo interpreters were tested on their ability to identify and discriminate vegetation analogs intra-regionally on Skylab II S190A color infrared prints (scale 1:500,000). The results of this testing have been described in past reports (Nos. 10 and 11).

Interpretation testing followed a set procedure. Five sample plots (training sets) of irregular shape and size (60 to 80 acres) of each analog included in the test were plotted on a 1:500,000 color infrared S190A print adjacent to the testing frame. Descriptions of each sample analog were provided to each interpreter in the form of a dichotomous key and related to the sample plots located on the sample S190A color infrared print. Appendix II shows this key as used in this interpretation testing. Color infrared and natural color aerial oblique and color ground oblique 35mm slides of each analog were included with the key to familiarize each interpreter with each analog.

Table I shows omission-commission errors at the quaternary level of detail. These results are discussed in reports number 10 and 11.

Table I

OMISSION-COMMISSION ERRORS ON PHOTO INTERPRETATION OF NATURAL VEGETATION ANALOGS ON SKYLAB II S190A COLOR INFRARED (L:500,000) PRINTS OF THE COLORADO PLATEAU TEST AREA

Analog	Ground Truth																Total Seen by Interpreter	Commission Errors
	324.6	324.7	312.3	325.5	341.3 < 40% cover	341.3 > 40% cover	425.5	342.6	342.7	341.6	342.8	343.7	315.4	910	210	280		
324.6	13	5	2	2	1			3									26	13
324.7	4	26		6	8		2										46	20
312.3	7	1	24	1		1		2									36	12
325.5			1	17	7	4	5										34	17
341.3 <40% cover		1		5	7	8			1	2		1					25	18
341.3 >40% cover					1	14				2		5					22	8
425.5						2	25										27	2
342.6								25			2						27	2
342.7						1			14	1	3	2					21	7
341.6				1					7	41		4					53	12
342.8									2		15	1	4				22	7
343.7									3		11	6					20	14
315.4											1		21				22	1
910														15			15	0
210															15		15	0
280																15	15	0
Total Plots	24	33	27	32	24	30	32	30	27	46	32	19	25	15	15	15		
Omission Errors	11	7	3	15	17	16	7	5	13	5	17	13	4	0	0	0		

Skylab III S190A transparencies have been received at the EarthSat office. These data cover the Sierra-Lahontan and Colorado Plateau test areas. Enlarged color infrared prints of this August imagery have been ordered for interpretation testing.

Rice Analog Studies

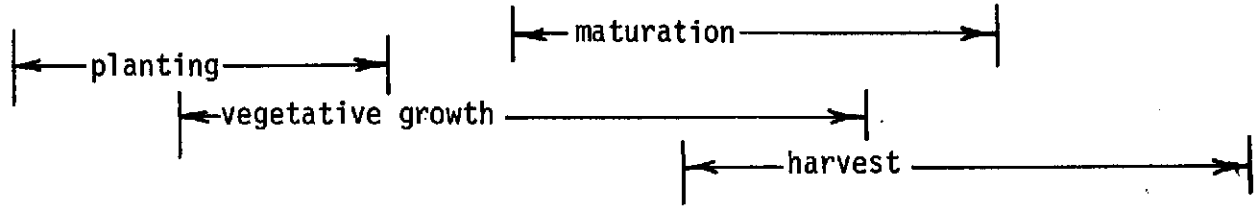
Skylab III imagery has been received for California test sites and for the Louisiana Coastal Plain. However, the Louisiana coverage is too far to the west and our ground test sites are not covered. It is not feasible to acquire new ground truth matching this location. A synopsis of the imagery on hand for the California test site is shown in Table II This table also shows the general phenological periods and the approximate ranges of dates they include. This table indicates that timing of the two sequential coverages from Skylab II and Skylab III are excellent because they imaged the late planting, early vegetative growth period and the late maturation, mid-harvest period. Thus there should be a high potential for exploiting the multidate aspects of the Skylab II and Skylab III imagery.

Due to the receipt of the various black-and-white bands in negative form only, densitometric readings, as explained in our previous monthly report (#11), are being repeated utilizing negatives from both dates. This procedure has been temporarily suspended because of problems with the VP8 image analyzer.

Having received the Skylab III data, training fields are being identified for single date and multidate rice identification analysis. The fields are being identified as to crop type or field condition using

Table II Synopsis of Skylab imagery received at EarthSat office and comparison of dates of coverage with rice phenology (+= positive transparency; -=negative transparency).

Imagery	April	May	June	July	August	September	October	November
SL 2								
S190A 9x9 CIR			+					
S190A 9x9 Color			+					
S190A 9x9 B&W (4 bands)			+ -					
S190A 70mm CIR			+					
S190A 70mm Color			+					
S190A 70mm B&W (4 bands)			+ -					
SL 3								
S190A 70mm CIR						+		
S190A 70mm Color						+		
S190A 70mm B&W (4 bands)						-		
S190B 5x5 CIR						+		
S190B 5x5 Color						+		



EarthSat acquired ground data and large scale photography as well as NASA provided aircraft support photography. The fields are being chosen with the object of providing the potential interpreter an accurate sample of the range of variability in field appearance both for single dates and between dates.

After discussion with ASCS personnel it was decided that more accurate rice acreage determinations could be made using the NASA provided aircraft support photography than by relying on farmer reported acreages. Using 1:30,000, 24" focal length CIR photography, rice fields are being identified, carefully delineated, and transferred to an equal-area paper target for area determination with the VP8 image analyzer. This rice acreage determination is being done for the entire area of each of the four sub-sample units. The areas determined will then be used as a standard to judge the accuracy of acreage determination from the Skylab imagery by the same method.

TRAVEL PLANS

No travel is planned to either natural vegetation study area or the agricultural test site.

PERSONNEL

No changes in personnel have occurred since the last reporting period.

PROBLEMS

Skylab II S190A 9 x 9 inch enlarged transparencies of the four black-and-white film types were reproduced in negative form for the Colorado Plateau test area and in positive form for the Sierra-Lahontan test area. As a result, interregional ratioing experiments of this

material cannot realistically be accomplished. It would be desirable to receive these same 9 x 9 inch enlarged transparencies of Skylab III imagery in negative form for the Sierra-Lahontan area as well.

Skylab III, S190A, 70mm CIR coverage of the Sierra-Lahontan test area on 11 August 1973 (Roll #27) shows an inconsistency from frame 54 to frame 55. Starting with frame 55 and continuing through frame 58, the image appears to be underexposed. The other 5 film types exhibit similar problems. This apparent exposure variability causes severe problems in testing our interregional analog hypothesis. Is the problem on the original photography or due to processing? Skylab III imagery obtained of the Sierra-Lahontan test area on 12 September 1973 is northwest of our actual ground truth sites and we cannot at this time afford extra ground truth missions to this area. Therefore, resolution of the problem is most important for successful interregional analysis of analogs.

PLANS FOR NEXT REPORTING PERIOD

Photo interpretation of Skylab III S190A color infrared prints will be conducted. The 0.8 to 0.9 micrometer and 0.6 to 0.7 micrometer S190A film transmittance values will be ratioed to determine interregional correlation of vegetation analogs.

APPENDIX I

Symbolic and Technical Legend Classes

EARTH SURFACE AND LAND-USE FEATURES

PRIMARY CLASSES

100 - BARREN LAND
200 - WATER RESOURCES
300 - NATURAL VEGETATION
400 - CULTURAL VEGETATION
500 - AGRICULTURAL PRODUCTION
600 - URBAN AND EXTRACTIVE INDUSTRY

900 - OBSCURED LAND

SECONDARY CLASSES

100 - BARREN LAND
- 110 - Playas, dry, or intermittent lake basins
- 120 - Aeolian barrens
- 130 - Rocklands
- 140 - Shorelines, beaches, tide flats, and river banks
- 150 - Badlands
- 160 - Slicks
- 170 - Mass movement
- 180 - Man-made barrens
- 190 - Undifferentiated complexes of barren lands

200 - WATER RESOURCES
- 210 - Ponds, lakes, and reservoirs
- 220 - Water courses
- 230 - Springs, seeps, and wells
- 240 - Lagoons and bayous
- 250 - Estuaries
- 260 - Bays and coves
- 270 - Oceans, seas, and gulfs
- 280 - Snow and ice
- 290 - Undifferentiated complexes of water resources

300 - NATURAL VEGETATION
- 310 - Herbaceous types
- 320 - Shrub/scrub types
- 330 - Savanna-like types
- 340 - Forest and woodland types
- 390 - Undifferentiated natural vegetation

400 - CULTURAL VEGETATION
- 410 - Cultural herbaceous types
- 420 - Cultural shrub/scrub types
- 430 - Cultural savanna-like types
- 440 - Cultural forest and woodland types
- 490 - Undifferentiated cultural vegetation types

500 - AGRICULTURAL PRODUCTION
- 510 - Field crops
- 520 - Vegetable and truck crops
- 530 - Tree, shrub, and vine crops
- 540 - Pasture
- 550 - Horticultural specialties
- 560 - Non-producing fallow, transitional, or idle land
- 570 - Agricultural production facilities
- 580 - Aquaculture
- 590 - Undifferentiated agricultural production

600 - URBAN AND RESOURCE EXTRACTION
- 610 - Residential
- 620 - Commercial and services
- 630 - Institutional
- 640 - Industrial
- 650 - Transportation, communications, and utilities
- 660 - Resource extraction
- 670 - Open space
- 690 - Undifferentiated urban

900 - OBSCURED LAND
- 910 - Clouds and fog
- 920 - Smoke and haze
- 930 - Dust and sand storms
- 940 - Smog
- 990 - Undifferentiated obscured land

TERTIARY CLASSES

100 - BARREN LAND

- 110 - Playas, dry or intermittent lake basins
- 120 - Aeolian barrens (other than beaches and beach sand)
  - 121 - Dunes
  - 122 - Sandplains
  - 123 - Blowouts
- 130 - Rocklands
  - 131 - Bedrock outcrops (intrusive & erosion-bared strata)
  - 132 - Extrusive igneous (lava flows, pumice, cinder and ash)
  - 133 - Gravels, stones, cobbles & boulders (usually transported)
  - 134 - Scarps, talus and/or colluvium (system of outcropping strata)
  - 135 - Patterned rockland (nets or stripes)
- 140 - Shore-lines, beaches, tide flats, and river banks
- 150 - Badlands (barren silts and clays, related metamorphic rocks)
- 160 - Slicks (saline, alkali, soil structural, non-playa barrens)
- 170 - Mass movement
- 180 - Man-made, land fill
- 190 - Undifferentiated complexes of barren lands

200 - WATER RESOURCES

- 210 - Ponds, lakes, and reservoirs
  - 211 - Natural lakes and ponds
  - 212 - Man-made reservoirs and ponds
- 220 - Water courses
  - 221 - Natural water courses
  - 222 - Man-made water courses
- 230-270, and 290 - No tertiary classes to date.
- 280 - Snow and ice
  - 281 - Seasonal snow cover
  - 282 - Permanent snow fields and glaciers

300 - NATURAL VEGETATION

- 310 - Herbaceous types
  - 311 - Lichen, cryptogam, and related communities
  - 312 - Prominently annuals
  - 313 - Forb types
  - 314 - Grassland, steppe, and prairie
  - 315 - Meadows
  - 316 - Graminaceous marshes
  - 317 - Tule marshes
  - 318 - Bogs
  - 319 - Undifferentiated complexes of herbaceous types
- 320 - Shrub/scrub types
  - 321 - Microphyllous, non-thorny scrub
  - 322 - Microphyllous thorn scrub
  - 323 - Succulent and cactus scrub
  - 324 - Halophytic shrub
  - 325 - Shrub steppe
  - 326 - Sclerophyllous shrub
  - 327 - Macrophyllous shrub
  - 328 - Microphyllous dwarf shrub
  - 329 - Undifferentiated complexes of shrub/scrub types
- 330 - Savanna-like types
  - 331 - Tall shrub/scrub over herb layer
  - 332 - Broad-leaved tree over herb layer
  - 333 - Coniferous tree over herb layer
  - 334 - Mixed tree over herb layer
  - 335 - Broad-leaved tree over low shrub layer
  - 336 - Coniferous tree over low shrub layer
  - 337 - Mixed tree over low shrub layer
  - 339 - Undifferentiated complexes of savanna-like types
- 340 - Forest and woodland types
  - 341 - Conifer forests
  - 342 - Broadleaf forests
  - 343 - Conifer-broadleaf mixed forests and woodlands
  - 349 - Undifferentiated complexes of forest and woodland types

390 - Undifferentiated natural vegetation - No tertiary classes to date.

400 - CULTURAL VEGETATION

410 - Cultural herbaceous types
411-419 - Tertiary levels duplicate those of NATURAL VEGETATION (300)

420 - Cultural shrub/scrub types
421-429 - Tertiary levels duplicate those of NATURAL VEGETATION (300)

430 - Cultural savanna-like types
431-437, 439 - Tertiary levels duplicate those of NATURAL VEGETATION

440 - Cultural forest and woodland types
441-443, 449 - Tertiary levels duplicate those of NATURAL VEGETATION

490 - Undifferentiated cultural vegetation types - No tertiary classes to da

500 - AGRICULTURAL PRODUCTION

510 - Field crops
511 - Cereal and grain crops
512 - Forage crops
513 - Sugar crops
514 - Drug, flavoring, and spice crops
515 - Oil crops
516 - Rubber crops
517 - Fiber crops
519 - Undifferentiated field crops

520 - Vegetable and truck crops
521 - Legume crops
522 - Salad, green, and cole crops
523 - Cucurbit crops
524 - Solanaceous crops
525 - Root, tuber, and bulb crops
526 - Perennial vegetable and fruit crops
529 - Undifferentiated vegetable and truck crops

530 - Tree, shrub, and vine crops
531 - Shrub, vine, and bramble fruits
532 - Deciduous tree fruits
533 - Citrus tree fruits
534 - Evergreen tree fruit crops
535 - Deciduous nut crops
536 - Evergreen nut crops
537 - Beverage crops
539 - Undifferentiated tree, shrub, and vine crops

540 - Pasture
541 - Herbaceous pasture
542 - Shrubby pasture

550 - Horticultural specialties
- 551 - Flower stock
- 552 - Shrubbery stock
- 553 - Tree stock
- 554 - Mixed stocks
- 559 - Undifferentiated horticultural stocks

560 - Non-producing fallow, transitional, or idle land
- 561 - Fallow cropland
- 562 - Plowed cropland
- 563 - Leached cropland
- 564 - Harvested stubble fields
- 565 - Entrapped, idle, or abandoned land

570 - Agricultural production facilities
- 571 - Meat production
- 572 - Dairy production
- 573 - Fowl production
- 574 - Small animal production
- 575 - Specialty animal production
- 576 - Plant production

580 - Aquaculture
- 581 - Hatcheries
- 582 - Shellfish beds

590 - Undifferentiated agricultural production - No tertiary classes to date

600 - URBAN AND RESOURCE EXTRACTION

610 - Residential
- 611 - Tract homes
- 612 - Tenement and apartment homes
- 613 - Planned unit developments
- 614 - Mobile homes
- 615 - Mixed housing
- 619 - Undifferentiated residential

620 - Commercial and services
- 621 - Wholesale trade facilities (Foodstuffs, dry goods, etc. with indoor storage)
- 622 - Wholesale trade facilities (Hardware, machinery, etc. with outdoor storage)
- 623 - Retail trade facilities (Foodstuffs, dry goods, etc. with indoor storage)
- 624 - Retail trade facilities (Hardware, machinery, etc. wtih outdoor storage)
- 625 - Personal, professional, repair, and recreational service facilit
- 626 - Cultural services
- 629 - Undifferentiated commercial and services

630 - Institutional
- 631 - Public and private educational facilities (including religious schools with no connection to a major chapel)
- 632 - Religious facilities (including religious schools associated with a major chapel)
- 633 - Health facilities
- 634 - Governmental institutions
- 635 - Military facilities and reservations
- 636 - Conventional cemeteries
- 639 - Undifferentiated institutional facilities

640 - Industrial
- 641 - Light industries and assembly industries
- 642 - Heavy industries

650 - Transportation, communications, and utilities (and their rights-of-way)
- 651 - Rail transit facilities
- 652 - Motor vehicle transport facilities
- 653 - Marine transport facilities
- 654 - Air transport facilities
- 655 - Communications facilities
- 656 - Power production facilities
- 657 - Utilities (distribution and transmission)
- 658 - Sewer and solid waste facilities
- 659 - Undifferentiated transportation, communications, and utilities

660 - Resource extraction
- 661 - Sand and gravel
- 662 - Rock quarries
- 663 - Petroleum, gas, and related
- 664 - Coal, peat, and related
- 665 - Chemical, fertilizer, and non-metalic minerals
- 666 - Metals
- 669 - Undifferentiated extraction resources

670 - Open space and recreational facilities
- 671 - Designated natural open space
- 672 - Recreational open space
- 673 - Recreational facilities
- 674 - Memorial parks
- 675 - Buffer open space
- 679 - Undifferentiated open space

690 - Undifferentiated urban - No tertiary classes to date.

MACRORELIEF

1.0 - Flat lands (Prominent slopes $<10\%$)
- 1.1 - Non-dissected
- 1.2 - Dissected

2.0 - Moderately undulating to rolling lands (Slopes 10 - 25%)

- **2.1** - Non-dissected
- **2.2** - Dissected

3.0 - Hilly lands (Slopes < 25%, <1,000' relief, smooth slopes, simple drainage systems)

4.0 - Mountainous lands (Slopes, relief, and complexity greater than in 3.0)

LANDFORM FEATURES

1.0 - Depressional or wet lands, non-riparian

- **1.1** - Intertidal zone
- **1.2** - Swamps and marshes
- **1.3** - Seasonally ponded basin

2.0 - Bottomlands, riparian

- **2.1** - Stringer or narrow bottomlands
- **2.2** - Wide valley bottoms, substantial flood plains
- **2.3** - Seasonal streambeds and washes

3.0 - Planar surfaces

- **3.1** - Fans and bajadas
- **3.2** - Terraces
- **3.3** - Gently undulating to rolling uplands, plateaus, table-lands and mesas
- **3.4** - Pediments

4.0 - Aeolian featured landscapes

5.0 - Slope Systems (Slope classes according to the following table, class is the one-hundredths 0.0X digit).

Slope Range %	Slope Class Digit
Simple Slope Systems	
0 - 5	.01
5+ - 15	.02
15+ - 30	.03
30+ - 50	.04
50+ -100	.05
<100	.06

Slope Range %	Slope Class Digit
Complex Slope Systems	
0 - 30	.07
0 - 50	.08
0 - 100+	.09
15 - 50	.09

The 0.X digit in each case is reserved for landform feature subclass. The slope classes may be added to any appropriate landform feature class by the notation 0.0X, e.g., 4.03; 6.08; 3.22.

Descriptive Legend for Selected Classes

Primary Classes

100 - BARREN LAND: Barren land is somewhat relative but it is intended to cover all situations where the earth surface is essentially barren, rock, gravel, or mineral soil. It is impossible to specify a vegetational cover percentage threshold for barren land. For example, a talus slope with a few shrubs around the periphery or rarely within the talus would still be a barren land class. Desert vegetation will cause the most problem. If the natural ecosystem in a desert climate is sparsely vegetated, it would fall into one of the desert classes, usually symbol 320, even though total percentage ground cover may be well under 10 percent. The more common barren land classes in the desert scene are desert pavement or gravel cover falling into class 133, playas class 110, badlands 150, or slicks 160. Barren lands in desert environments should be almost completely devoid of any vegetation. Commonly in the desert uplands there are scarps, talus, and colluvia, class 134. To the casual observer, many of these will appear essentially barren but if they support a scattered vegetation uniformly throughout the area of steep desert slopes, they should carry an appropriate 300 class.

200 - WATER RESOURCES: Include all ground surface areas covered by natural or man-made water surfaces--streams, lakes, reservoirs, snow and ice, canals, enclosed aqueducts, and other water bodies lacking a surface vegetational cover. This class includes lakes and ponds with heavy "algal bloom" but not ponds with a floating or moderately dense, emergent vegetational covering.

300 - NATURAL VEGETATION: This class includes natural or native vegetation consisting of essentially indigenous species or introduced species that have become essentially naturalized to the region and that have found an ecological niche as though they were a part of the original vegetation. This class includes all successional stages in the natural vegetation. In mapping and identification, one should avoid trying to map the presumed "climax" or eventual equillibrium vegetation. Map and identify vegetation as it exists at the time imagery was obtained. The postulation of climax areas comes later as an interpretation of the basic inventory.

400 - CULTURAL VEGETATION: This class provides for the culturally introduced and intensively managed vegetations where the management objective is essentially maintenance of a permanent stand subsequently managed and manipulated through ecological rather than agronomic principles. The class is designed primarily to provide for seeded range where the intention is permanency of stand and the planted forest, e.g., grass seedings in a shrub steppe land or savanna land and planted coniferous forests in a hardwood forest area.

Some would argue this class should be in primary category 500, agricultural production. We prefer the class 400 because, generally, foresters and range managers prefer to identify these intensively treated areas as forests and rangeland respectively.

Removal of woody overstory species on potential rangeland, range seedings and clear-cut forests allowed to revert to natural successional patterns are classed in the appropriate 300 category. These types are treated as seral vegetation. If, however, such areas were additionally planted to exotic species not initially natural to the site, they would then be classed under the appropriate 400, cultural vegetation, category.

500 - AGRICULTURAL PRODUCTION: These are land areas cleared of the natural vegetation and managed by agronomic principles for production of food, fiber or fodder crops. The class includes any land areas or structures and facilities directly related to intensive agricultural practices. These agricultural lands are characterized by the relatively constant manipulation by man through control of the vegetation and micro-environment (fertilization, irrigation, etc.).

This class includes the permanent pasture managed for maximum yield by fertilization, irrigation and periodic renovation. These are pastures generally included within or in juxtaposition with the crop field boundary also meeting the above criteria.

Forests or woodland windbreaks and woodlocks included within the cropland area would be treated by the appropriate 300 or 400 subclass if the units are of mappable size.

600 - URBAN AND RESOURCE EXTRACTION: Without a long title, semantics leads to misunderstanding about this class. It includes all urban, industrial, and resource extraction activities that have modified the natural landscape. The class also includes lands allocated to open space but where man has modified the environment through agronomic, horticultural, or landscaping activities.

Natural areas of mappable size located within urban areas would be treated under the appropriate 300 class. If they were planted forests or woodlands used as open space or for screening with the urban-industrial environment, they would be treated as appropriate 400, cultural vegetational subclasses.

900 - OBSCURED LAND: This class is intended to provide for those portions of remotely sensed imagery in which the earth's surface is essentially obscured by clouds and other atmospheric obstruction. It is used primarily where it becomes necessary to account for 100% of the image frame area.

Secondary Classes

100 - BARREN LAND: Experience has shown that barren land subclasses should never go beyond tertiary level and frequently it is unnecessary to go beyond the secondary class. To do so makes the barren land class redundant with geological information where the latter is assessed as a component of the physical environment or land surface.

Practically all of the secondary classes under 100 are self-explanatory. Problems most frequently arise with class 150 badlands and class 180 man-made barrens or land fills. Badlands are generally best identified by their intricate drainage patterns and usually irregular slopes and relief although many present a smoothly sloping relief. This class is intended to provide primarily for those barren lands derived from silty and clayey materials or from relatively easily weathered rocks that may produce an intricately grotesque or spire-like series of relief features.

Class 180 should be restricted to man-made land fill and not confused with extractive industry classes that typically generate barren lands, e.g., open pits mining, which fall under class 660, an industrial category.

200 - WATER RESOURCES: These secondary subclasses are all self-explanatory or defined in standard dictionaries. The main divergence of this legend system from others in use is the inclusion of snow and ice, 280, as a sub-category. This seems far more logical to us than separating snow and ice at primary levels as is sometimes done. By inclusion as a subset it permits easy agglomeration of all water resource features in a study area or watershed.

300 - NATURAL VEGETATION:

310 - HERBACEOUS TYPES: That vegetation (annual, biennial, or perennial) which in aspect is dominantly herbaceous--including any or all grasses, grass-like plants, forbs, and non-vascular or vascular cryptogams. Other growth forms of vegetation may be present but they are decidedly subordinate in terms of aspect.

320 - SHRUB/SCRUB TYPES: All types of shrubs are the prominent vegetation. These usually form a closed or nearly closed layer so that the herbaceous layer is subordinate. The herbaceous ground layer of this vegetation is highly variable but can be important. The aspect is one of a prominently low woody vegetation.

330 - SAVANNA-LIKE TYPES: The world literature in no way agrees on the definition of a savanna. We have thus been somewhat arbitrary in phrasing the following descriptive definition that seems to fit most temperate and many tropical situations where the expression savanna has been used to describe the unique community. In contrast to some tropical writers, we are not including the tall grass, sparse overstory with a dense shorter grass understory as savanna. This latter belongs in the 310, herbaceous class. Vegetation consisting of sparse, taller woody plants interspersed somewhat regularly throughout

by a more dense low shrub or herbaceous layer to give a distinct two-storied community.

We have tested many percentage cover thresholds in the tall woody layer to differentiate or characterize the savanna. Most of these have been difficult to apply consistently because of variation in the size of the individuals in the tall layer. The larger the size, the more widely they can be dispersed and still present an accurate savanna-like aspect. We therefore prefer not to specify such thresholds but to say that the vegetations should be savanna-like in their appearance or aspect to match as closely as possible the intent of the above description.

340 - FOREST and WOODLAND TYPES: The tree layer forms the dominant vegetational feature. This layer often forms a closed canopy over a variety of subordinate vegetation types.

400 - CULTURAL VEGETATION: The secondary classes for cultural vegetation are the same as those presented above for class 300.

500 - AGRICULTURAL PRODUCTION:

510 - FIELD CROPS: Cereals, grains, forage, drugs, spices, fiber crops and other field crops which are the dominant land use.

520 - VEGETABLE and TRUCK CROPS: Legumes, leafy vegetables, roots, tubers, bulbs, cucurbit, solanaceous, and perennial vegetable crops (including other herbaceous crops such as fruit crops) are in this category.

530 - TREE, SHRUB, and VINE CROPS: Fruit, nut, and beverage crops with tree, shrub, or vine growth forms.

540 - PASTURE: Any intensively managed land (fertilized, irrigated and/or renovated or appropriate) utilized for grazing or browsing, with or without periodic mechanical harvest. A pasture may be harvested as a "permanent" crop or managed as a temporary lay in a crop rotation plan.

550 - HORTICULTURAL SPECIALTIES: Artificially planted and maintained flower, shrub, or tree stock. This includes nursery stock, flowers (whether grown for seed, rootstocks, corns, bulbs, tubers, or blooms), and other herbaceous horticultural plants occurring in various sized production lots.

560 - NON-PRODUCING FALLOW, TRANSITION, or ENTRAPPED LAND: Fallow plowed (or variously worked), and leached cropland including harvested fields; included here are abandoned or idle croplands, fields, and pastures as well as entrapped lands that are isolated from effective agricultural production by being surrounded or blocked from access by class 600 lands.

570 - AGRICULTURAL PRODUCTION FACILITIES: At all but the largest of inventory scales, these features usually represent point data, i.e., of non-mappable size but they may be particularly important to annotate, especially in complete land-use inventories. Structures and facilities utilized for animal or plant production (except fisheries, see class 580) make up this category. Barns, sheds, holding pens, and greenhouses are examples.

580 - AQUACULTURE: Fish and shellfish hatcheries or other structures, rearing areas, and production ponds are included in this category.

metal ores, timber, and other materials. These heavy industry sites are usually associated with concentrations of raw materials, transportation facilities, power sources, and waste products.

660 - TRANSPORTATION, COMMUNICATIONS, AND UTILITIES: Highways and railways make up the two basic transportation means that require stationery routings visible on remote sensing images. Facilities related to all transportation types are included in this category (seaports, airports, runways, railroad terminals, bus terminals, highways, roads, etc.). Resource transportation facilities that are non-mobile themselves are included in this category (oil pipelines, gas, electricity and airwave facilities).

670 - RESOURCE EXTRACTION: Surface and subsurface mining facilities are included in this category. Areas of reserves and future operations are included in other land-use or resource categories. Where resource areas cease to be in a raw extractive state the activities and structures are classed in the Industrial category. Gravel, earth, clay, oil, coal, metals, and gas are examples of resource types.

680 - OPEN SPACE: Land areas in intensive or low intensity use may be included in this category. Activities and facilities requiring significant land area that is the dominant or the major prerequisite to the activity itself are included in this category. Parks, ski areas, golf courses, cemeteries and other open lands are included in this category. The open space far exceeds the proportion of area occupied by structures required for related activities.

900 - OBSCURED LAND:

910 - CLOUDS AND FOG: Naturally occurring water vapor obscuring the land surface.

920 - SMOKE AND HAZE: Natural or man-caused smoke or haze dense enough to obscure the land surface.

930 - DUST AND SAND STORMS: Sand, silt and/or clay particles born aloft and dense enough to obscure the land surface.

940 - SMOG: Man-caused particulate matter, vapors, chemicals and other smog substances suspended in the atmosphere densely enough to obscure the land surface.

Tertiary Classes

310 - HERBACEOUS TYPES:

311 - LICHEN, CRYPTOGAM, and RELATED COMMUNITIES: Areas with lichens, masses, liverworts, algae, fungi, vascular cryptogams and any other non-woody non-angiospermous plants occurring as the dominant vegetation. This class is primarily used in arctic and alpine tundra conditions. Lichen covered rocklands should be classed 130, not 310.

312 - PROMINENTLY ANNUALS: Areas often devoid of vegetation during much of the year with more or less dense annual plants growing during certain seasons of favorable precipitation. This class usually possesses a gramineous aspect.

313 - FORB TYPES: Biennial or perennial broadleaved herbs forming the dominant vegetation. This class does not include prominence of grasses, grass-like plants, and vascular cryptogams.

314 - GRASSLAND, STEPPE, and PRAIRIE: Any land area dominated by grass vegetation. Tall grass prairies, short grass prairies, desert grasslands, "midgrass plains", bunchgrass, and grass dominant steppes are all included in this category.

315 - MEADOWS: Areas dominated generally by species of Gramineae (grasses) or Cyperaceae (and related families, sedges and rushes, grass-like) where soil moisture conditions fluctuate greatly from one season to the next but tend toward mesism.

316 - GRAMINACEOUS MARSHES: Hygric (very wet) vegetation dominated by mixtures or dense stands of individual grass species.

317 - TULE MARSHES: Hygric (very wet) vegetation dominated by Juncaceae (rushes), Cyperaceae (sedges), Typhaceae (cattails), or other aquatic and sub-aquatic angiosperms (seed plants).

318 - BOGS: Hygric vegetation dominated by Sphagnum and/or other mosses, cryptogamic or bog inhabiting plants.

320 - SHRUB/SCRUB TYPES:

321 - MICROPHYLLOUS, NON-THORNY SHRUB/SCRUB: Small-leaved, non-thorny, small shrub or scrub species occurring as the dominant overstory vegetation type. Microphyllous desert shrublands are the dominant areas with these vegetation types.

322 - MICROPHYLLOUS THORN SHRUB/SCRUB: Small-leaved, thorny shrub or scrub species occurring as the dominant overstory vegetation. This category includes desert thorn scrub predominantly.

323 - SUCCULENT and CACTUS SCRUB: Cactaceae (cactus), Euphorbiaceae (cactus-like), and other succulent plants occurring as the dominant vegetation type.

324 - HALOPHYTIC SHRUB: Salt tolerant shrubs occurring as dominant vegetation type predominantly in playas, alkali flats and other soils with high salt contents. This class includes such genera as Atriplex, Eurotia, Gravia, and Sarcobatus.

325 - SHRUB STEPPE: Artemisia, Chrysothamnus, Purshia, Cowania and other shrubs occurring as the dominant vegetation over a subdominant or co-dominant stand of grasses (including some forbs) in the understory.

326 - SCLEROPHYLLOUS SHRUB: Shrublands with leathery-leaved, evergreen species adapted to xeric and mediterranean environments occurring as the dominant vegetation. This category includes chaparral (Quercus, Arctostaphylos, Ceanothus, Cercocarpus) and chamise types (Adenostoma-Salvia).

327 - MACROPHYLLOUS SHRUB: Large-leaved, deciduous shrubs occurring as the dominant vegetation; including Salicales (willows), Rosales (rose), Aceraceae (maple), Shepherdia, Symphoricarpos (snowbush), and some Ericales (heaths).

328 - MICROPHYLLOUS DWARF SHRUB: Small-leaved shrubs forming the dominant vegetation type; including ericaceous arctic and alpine heath vegetation and shrub bogs. This is predominantly an arctic-alpine class.

330 - SAVANNA-LIKE TYPES:

331 - TALL SHRUB/SCRUB OVER HERB LAYER: Tall shrubs and scrubby tree species occurring over a predominantly herbaceous layer that is co-dominant with or more prominent than the shrub/scrub vegetation.

332 - BROAD-LEAVED TREE OVER HERB LAYER: Evergreen, semi-deciduous, or deciduous angiosperm tree species over herbaceous vegetation.

333 - CONIFEROUS TREE OVER HERB LAYER: Coniferous tree species over herbaceous vegetation.

334 - MIXED TREE OVER HERB LAYER: Coniferous and angiospermous tree species over an herbaceous layer, with either predominating but neither tree type $<20\%$ cover.

335 - BROAD-LEAVED TREE OVER LOW SHRUB: Evergreen, semi-deciduous, or deciduous angiospermous tree species over low shrub layer.

336 - CONIFEROUS TREE OVER LOW SHRUB: Coniferous tree species over a low shrub layer.

337 - MIXED TREE OVER LOW SHRUB: Coniferous and angiospermous tree species over a low shrub layer, with either predominating but neither tree type $<20\%$ cover.

340 - FOREST and WOODLAND TYPES:

341 - CONIFER FORESTS: Forested areas of cone-bearing trees dominated by any Coniferales or Taxales.

342 - BROADLEAF FORESTS: Deciduous, semi-deciduous, or evergreen angiospermous (flowering) forest species.

343 - CONIFER-BRAODLEAF MIXED FOREST and WOODLAND: Any conifers and Taxales and broadleaf angiosperms mixed in a dense forest growth or more open woodlands. Cover of the conifer-broadleaf mixture may vary from 20-80% to 80-20%, respectively.

APPENDIX II

PHOTO INTERPRETATION KEY FOR SKYLAB II S190A COLOR INFRARED PRINTS OF THE COLORADO PLATEAU TEST AREA (108226)

1. Non-vegetated areas

   2. Water Resources

      3. Ponds, lakes or reservoirs

      3. Snow and ice

   2. Obscured land;smoke, haze, or clouds

1. Areas not covered by water, snow, ice, clouds or haze.

   Soil or rock surfaces.

   4. Areas with vegetation cover. Vegetation dominated by herbaceous species.

      5. Moist Sedge Vegetation Type--dominated by sedges (Carex spp.) and other grasslike or grass species along with many herbs and forbs. This vegetation type is indicative of very moist to water-logged soils. Often small ponds, bogs, marshes, or stream courses are associated.

      5. Semidesert Annual Grass & Forb Vegetation--dominated by annual plants (Atriplex, Bromus, etc.) during the growing season but with some perennial grasses (Oryzopsis hymenoides, Hilaria) and perennial Atriplex. Occurs in washes and disturbed sites at low elevations.

   4. Areas with vegetation dominated by woody shrubs or trees.

      6. Vegetation dominated by shrubs.

         7. Semidesert, salt-tolerant vegetation on alluvial slopes and terraces.

            8. Greasewood Vegetation Type--dominated by greasewood (Sarcobatus vermiculatus) on alkaline soils at low elevations (below 6000 feet). Most common in washes.

8. Saltbush Vegetation Type--dominated by various species of Atriplex. Occurs on alkaline slopes, cliffs, and benches at low elevations (below 6,000 feet).

7. Shrub-steppe vegetation occurring on deep alluvial soils.

9. Big Sagebrush Vegetation Type--dominated by big sagebrush (Artemisia tridentata). Occurs on alluvial slopes and deep, hear-neutral soils at elevations of 6000 to 8000 feet.

9. Cabled and reseeded Benchlands--where extensive stands of pinyon-juniper and oakbrush occurred, man has destroyed the woody vegetation and reseeded the areas with grasses and other forbs suitable for grazing. These sites generally exhibit linear or near linear boundaries that are in marked contrast to the natural vegetation types surrounding them.

6. Forest and woodland vegetation, broadleaf, conifer, or mixed.

10. Areas dominated by coniferous forests.

11. Ponderosa Pine Forest Vegetation Type--dominated by ponderosa pine (Pinus ponderosa). These forests occur at elevations between 7000 to 8000 feet. Best development occurs on level terrain where a moderately dense understory growth of scrub oak (Quercus gambelii) occurs.

11. Areas dominated by or sparsely covered by pinyon-juniper vegetation.

12. Pinyon-juniper Woodland Vegetation Type--dominated by Pinyon pine (Pinus edulis) and Utah juniper (Juniperus osteosperma). Cover values of these species are high (>50%). Soils are deep and a dense understory of scrubby oak, snowberry (Symphoricarpos), serviceberry (Amelanchier), and other plants grows beneath the pinyon-juniper canopy.

12. Pinyon-juniper Woodland Vegetation Type--dominated by Pinyon pine (Pinus edulis) and Utah juniper (Juniperus osteosperma). Cover values of these species are low (<30%). Soils are shallow and stony. Little understory vegetation occurs at these sites.

10. Areas dominated by broadleaf forest species or mixed broadleaf/conifer forest species.

    13. Riparian forests at intermediate-to-low elevations (7000 to 4000 feet). Riparian Cottonwood and Willow Vegetation Type--phreatophytic Populus species and Salix species dominate along permanent flowing streams both at high and low elevations. These plant communities occur as narrow bands following stream courses.

    13. Non-riparian broadleaf or mixed broadleaf/conifer species.

        14. Forests with aspen as a dominant or co-dominant element of the forest.

            15. Aspen Vegetation Type--extensive forests and clumps (clones) of quaking aspen (Populus tremuloides) occur throughout the intermountain West. These stands occur from 8000 to 10,000 feet elevation and possess lush understory growth. Various color shades (reds on infrared film and greens on natural color film) give considerable variability to this vegetation type.

            15. Spruce-fir/Aspen Vegetation Type--codominated by spruce (Picea engelmannii), fir (Abies lasiocarpa), and aspen. Mixed stands occur from 9000 to 10,000 feet due to natural succession from disturbance→to aspen→to mixed spruce-fir/aspen→to stable spruce-fir forests.

        14. Forests or woodlands without aspen. Oakbrush Vegetation Type--dominated by Gambel's oak (Quercus gambelii). Extensive stands of small (10 to 20 feet) scrub oak occurs adjacent to aspen, ponderosa pine, and pinyon-juniper vegetation types depending upon elevation and topography. Numerous open grassland meadows occur between thickets of oakbrush making a complex mosaic pattern on the landscape.