OREGON STATE UNIVERSITY CORVALLIS, OREGON 97331

SCHOOL OF AGRICULTURE and AGRICULTURAL EXPERIMENT STATION Reply to: Department of Soil Science

November 10, 1972

E72-10182
CR-128331

MEMORANDUM

TO: Mr. Edward W. Crump, Technical Officer

FROM: Gerald H. Simonson, U. N. 619, Oregon State University

SUBJECT: Progress report for period ending October 31, 1972, of SR-345, "Comparative Evaluation of ERTS-A Imagery for Resource Inventory in Land-use Planning."

Overall Objectives:

1. Use a multi-discipline team approach to determine features that can be successfully monitored by ERTS-A imagery for resource inventory, planning, land-use zoning and resource development.

2. Using carefully selected sample areas, develop a comprehensive resource inventory mapping system for use in planning, zoning, and resource development.

Progress during this reporting period included compilation and organization of ground truth data and observations in the primary study area of Crook County; resource inventory legend development; assembly and testing of color enhancement equipment; development and adaption of programs for digital data processing; and quick-look evaluations of initial ERTS-1 imagery for Oregon.

Several weeks were spent in the Crook County area by team members to obtain documentation of soils, vegetation, geologic, and other resource inventory data through contacts with local land management agency personnel and systematic observations in the field. Several of these trips were timed to coincide with dates of ERTS or U-2 Imagery. Adaption of the resource legend system to local conditions proceeded during these field trips. Cooperative arrangements with local planners and other potential data user groups were completed and further work with these people is pending upon receipt of ERTS and aircraft imagery for the area.

ERTS Image Descriptor Forms have been completed and filed for all frames received as of October 21. This initial evaluation of image content is conducted as a multidiscipline team effort. Additional frames are being reproduced as 9 x 9 paper prints in quadruplicate from positive transparencies of band 5 as they are delivered, and image descriptor forms are being filed on a continuing basis. We

(E72-10182) COMPARATIVE EVALUATION OF ERTS-A IMAGERY FOR RESOURCE INVENTORY IN LAND-USE PLANNING Progress Report, period ending 31 Oct. 1972 G.H. Simonson (Oregon State Univ.) 10 Nov. 1972 22 p CSCL 08G G3/13 00182 Unclas

N73-10361

have reorganized the Earth Resources Vocabulary on the basis of subject matter to facilitate use. An example of the reorganized format is attached (Appendix A).

We have developed a "Quick Look Evaluation Form" for team determination of image interpretability and information content. A completed example is enclosed (Appendix B). We intend to complete one of these forms as a team task for all new ERTS-1 imagery received and to fill out an abbreviated form for repeat imagery where marked changes in resource features are evident. This is the start of in-depth visual interpretation by individual team members. It is a mutally beneficial training and learning exercise for the group; and by doing the quick-look analysis on a state-wide basis, we will learn how better to proceed with our intensive study area, develop new information relevant to state-wide planning, iron out a diverse spectrum of interpretation problems, better learn the limitations and potentials of the imagery and improve on our effectiveness as a team.

In addition, this quick-look evaluation will be filed in our Environmental Remote Sensing Applications Laboratory (ERSAL) where it will be made available to other university and government research scientists, to federal and state agency personnel, to Councils of Government, and county planners who are potential users of the ERTS-1 data and who request copies of the Quick Look Evaluation from ERSAL.

Imagery has not been available for our Crook County test site to date. In lieu of this, we have performed a successful trial of team mapping and interpretation on ERTS frame #1021-18145-5. An example of the result is presented as Appendix C (set of overlay maps for Pendleton area). This entire task, requiring only approximately 40 man hours by team members and covering an area of 100 square miles, presents a synthesis of resource information never before drawn together on such a large area, although at a highly generalized scale, in the Northwest. This work was done, using only the MSS-5 band, and at a scale of 1:1,000,000. We are confident that more in-depth study of color enhanced material enlarged to a scale of about 1:250,000 will greatly refine the information base for land-use planning.

In this same frame area, even casual comparison of sequential imagery has revealed some localized changes in agricultural land use, e.g. new irrigated areas developed within the elapsed time of just 36 days. Similarly, certain kinds of forest harvest practice can be very effectively monitored in terms of total areas affected and location of activity.

For the period 1 July to 1 November the Computer Center's effort has focused on the reformatting of the digital imagery into segments and

structures that are compatible and can be used more efficiently on local hardware and operating systems. Several programs are operational and others, dealing primarily with on-line disk storage, are under development.

Digital imagery from NASA was not available during the above period; however, through the courtesy and cooperation of the University of Oregon's Chemistry Department some high-flight imagery was digitized and is being used as test data. After consultation with other members of our ERTS team, two sets of digital imagery taken over the primary Oregon test site were ordered.

In mid-August a visit was made to the School of Forestry's Remote Sensing Laboratory at Berkeley. As a result of this trip a copy of the pattern classification program (CALSCAN) used at Berkeley was obtained. This program was originally developed at LARS, and work is under way to implement its use on the Oregon State CDC 3300 computer.

The assignment of personnel, supply requisition, and bookkeeping procedures required to initiate the data processing phase of the project have been completed.

The portion of this multidisciplinary project directed by Dr. Herzog in Electrical Engineering will now be referred to as the Pictorial Information Extraction and Enhancement Laboratory (PIXEL). The initial areas of activity of PIXEL include the following:

Programming is well underway for reformatting the digital tapes from ERTS into a form suitable for more economic operation on our computer system. Special attention is being placed on the ability to extract selected segments of the digital data for detailed analysis. Programming has begun on a group of computer programs to provide statistical data concerning the mean, standard deviation and pictorial magnitude histogram for each channel of information provided by the MSS. Specifications for a program to compute covariances in anticipation of a principal component analysis have also begun. Two programs have been written to provide a line printer gray scale output of selected segments of ERTS data. A "rough look" program provides the user an opportunity to determine data coordinates of areas of interest in conjunction with photographic reproductions. A "fine look" program uses maximum resolution for selected subsets of data. As of October 31, 1972, no ERTS computer tapes have been received. The delay in receiving this requested data has not allowed our development program to produce any preliminary results with real data.

Work in our primary test area of Crook County has been somewhat delayed to date by slowness in delivery of ERTS and NASA aircraft imagery for this area. The extremely dense negatives received so

far have caused us some problems in obtaining satisfactory prints locally and Newton rings on the 70 mm positives have delayed our work with color enhancement equipment. These problems were previously reported by letter on October 25 and the 70 mm positives have been retrospectively reordered.

We have been told that our 9 x 9 support aerial photography taken in July and August will be delivered soon and we have retrospectively ordered ERTS imagery from the initial passes over Crook County. We also have just received a standing order that includes a frame covering Crook County. With anticipated delivery of the above imagery, these problems should no longer impede our progress and we expect to proceed with compilation of our resource and land use inventory in Crook County in the next reporting period. Delivery of the digital data is also expected soon so that computer analyses can proceed.

One data request form was submitted to GSFC/NDPF on October 16, for ERTS Imagery from the initial RBV and MSS orbits not sent to us under our standing order.

GHS:dh

Attachments: Appendices A, B, C

cc: Contracting Officer, Code 245
Project Scientist, Code 650
Scienctific Monitor, Code 650
NASA Science & Technical Information Facility

Appendix A

EARTH RESOURCES VOCABULARY
(From Table 4-2 NASA ERTS Data Users Handbook)

I. Natural Vegetational Features

Brush
Chaparral
Desert
Dormant Vegetation
EEO (excellent example of) keyword
Forest
Grass
Grassland
Hardwood Forest
Kelp
Lumbering Area
Marsh
Marsh Coastal
Marsh Salt
Mature Vegetation
Meadow Land
Muskeg
Pasture
Prairie
Rain Forest
Rangeland
Scrub
Steppe
Timberline
Tundra

II. Physical Landscape Features

Alluvial Plain
Alluvial Terrace
Arroyo
Badland
Barrens
Basin
Bedrock
Braided Stream
Butte
Catchment Area
Cinder Cone
Coastal Dune
Delta
Desert
Divide
Dune
EEO (excellent example of) keyword
Erosion
Fan
Fault
Fire Damage
Flood Plain
Glacier
Interlacing Drainage
Lake
Lake Bed
Lava
Mountain
Pediment
Peninsula
Plain
Plateau
Playa
Playa Lake
River
Salt Flat
Shallow Water
Snow
Soil
Stream
Terrace
Tidal Flat
Valley

III. Agricultural Features

Agriculture
Alfalfa
Burned Fields
Canal
Cereal Grains
Cropland
EEO (excellent example of) keyword
Forest Plantations
Grass (including Grass Seed Crops)
Harvested Forests
Lumbering Areas
Mature Vegetation
Meadowland
Orchards
Pasture
Plowed Field
Rangeland
Reservoir
Soil
Vegetation
Vineyard

IV. Cultural Features
(Urban, Industrial, & Transportation)

Agricultural Processing
Airfield
Bridge
Canal
Catchment Area
City
Dam
EEO (excellent example of) keyword
Highway
Industrial Area
Manufacturing
Metropolitan Area
Power Distribution
Residential Area
Smog
Smoke
Suburban Area
Urban Area

2 Nov 1972

Appendix B

IMAGE QUALITY AND INTERPRETABILITY SUMMARY
Oregon Remote Sensing Imagery

TYPE: (X) ERTS-1; ( ) U-2/RB-57; ( ) Other Aircraft. DATE OF IMAGERY: 13/Aug/72

FRAME NO(S).: 1021-18145-5 Pendleton

LOCATION: 45°57' N; 118°40' W;
(Center of Frame) (other descriptive location information)

BAND/FILM-FILTER: MSS-5 TYPE OF PRODUCT: ✓ Transp. 9.5x9.5
(pos., neg., trans., print)

INTENDED SCALE: 1:1,000,000 APPARENT SCALE: 1:
(how checked)

MOISTURE CONDITION: Dry
(dry; wet; recent ppt.; snow w/ percent of frame covered)

INTERPRETABILITY AND INFORMATION CONTENT: For following features...

Feature	Interpretability	Feature	Interpretability
Barren Land	C	Agricultural Cropping	A
Playas	—	Crops green & growing	A
Eolian Barrens	C	Crops harvested, dormant or fallow	A
Rocklands	—	Landforms, Descriptive	A
Water Resources	A	Landforms, Genetic	B
Ponds, Lakes & Reservoirs	A	Flatlands	C
Water Courses	A/B	Undulating/Rolling Lands	B
Bays, Coves & Estuaries	A	Hilly Lands	B/A
Oceans, Seas & Gulfs	—	Mountainous Land	B/A
Snow & Ice	—	Geological Features Bedrock Geology	C
Natural Vegetation	B	Tectonics	A-B
Wetland/Aquatic	—	Rock Types	C
Tundra	—	(Kind: Local Stratified)	
Forest & Woodland	A	Soils	C
Rangeland, Grassland/Shrub	A	Patterns & Boundaries	B/C-D
Rangeland, Arid/Desertic	—	Color/Surface/Reflectivity	C/D
Vegetational Resource Use, (F)/(R)	A/C	By Inference/Association only	A/B
Depressive Production Factors	—	Obscured Earth Resources	—
Urban and Industrial Lands	C	Clouds	A 1%
Residential	C	Dust	—
Business/Industrial	D	Smoke	—
Transportation	C	Smog	—
Highways	C	Haze	—
Railroads	D		
Airfields	D		

REMARKS: If any, check (X) and use back of page. INTERPRETER: C. A. Hamilton

INSTRUCTIONS: See over. DATE EXAMINED: 2 1/Nov. 172

Staff
ERSAL - 1
rev. 20 October 1972

INSTRUCTIONS: The primary purposes of this form are (1) to mark the beginning of a team interpretation effort and (2) to inform other potential users of the probable information content of the imagery.

When repeat coverage is evaluated, limit notations to those features that have changed. Amplify notations in REMARKS below as per individual judgement and disciplinary need.

Generally, evaluations of separate ERTS frames should not be combined into one sheet. Evaluation of highflight frames may be combined into one evaluation form per flight line. Evaluation of conventional-altitude imagery will usually be made by flight lines rather than by frames. Evaluation of multispectral imagery of the same area should usually be performed on separate forms for each spectral band unless deviations of other bands from the best visible red band can be adequately handled in the REMARKS section.

When rating interpretability, place a dash (-) in the space for items evident but not scored; thus, blank means "not evident" or "not occurring in frame area". Score interpretability according to the following classes:

A = Readily interpretable with confidence, little chance of significant error.
B = Interpretable with moderate confidence, errors probably not serious.
C = Interpretable part of the time, substantial uncertainty or errors significant.
D = Interpretation little better than a guess or dependent on intimate ground familiarity with the specific area being interpreted, strongly dependent on convergence of evidence.

REMARKS: Square and strip clearcuts evident in forest areas. Excellent for monitoring new irrigation development. Very likely hay and pasture highly photo-identifiable. Rangeland vs. cropland easily distinguished. Pattern evident in forested areas associated with forest-brush-grassland communities. Broad vegetational density classes possible to set up in the forested area

Cereal grains and fallow field patterns clear. Cereal grains not individually identifiable. In irrigated area would be easy to establish about 4 current productivity classes on tone differences Could determine irrigated crop areas probably producing cereal grains, if any in area, or fallow, recent harvest, etc.

May be very difficult to separate grasslands from sagebrush lands, except possibly on color reconstitution. Good area to study altitudinal "green wave" in spring. Could make a very good land use map. Excellent for monitoring changes in agriculture, range, forest borders, forest cutting.

Anthony Lakes burn (forest area) may be evident, not confirmed.

Wind influenced soil areas seem evident along Columbia River.

Some fault lines suggested in Blue Mountains.

Excellent for drainage pattern studies.

Numerous major roads and possibly one power line shows.

EEO Soil Pattern, Eolian
EEO Irrigated Agriculture, New

Fallow Field

Key Words

1. Forest
2. Grassland
   Rangeland
   Lumbering Area
   Mountain
   Plateau
4. River
   Cropland
   Alfalfa
3. Cereal Grains
   City
   Highway
   Urban Area
   Agriculture

APPENDIX C

TEAM MAPPING AND INTERPRETATION OF ERTS 1 FRAME 1020-18145-5

Vegetation and Land Use

Geology and Geomorphology

Timber Density

Soils

Legend Narrative for Pendleton Frame

13 August 1972

314 Bunchgrass Steppe -

Moderately undulating to rolling uplands and low hills. Dominated by Idaho fescue, Bluebunch wheatgrass, and Sandberg's bluegrass. Unable to distinguish between the Idaho fescue grasslands and the Bluebunch wheatgrass-Sandberg's bluegrass grasslands with this spectral band and date of imagery. The extent of enroachment by agricultural lands has nearly reached the limit due to shallow and poorly adapted soils. Upper limits of this type border on shrubland-grassland complexes and Ponderosa pine types on more rugged hills and mountains.

314/327 Bunchgrass Steppe/Snowberry, Hawthorne, Chokecherry, Rose -

Canyons and foothills of the Blue Mts. Shrublands occur in the bottoms and on the more protected slopes. Idaho fescue occurs on the protected slopes and Bluebunch wheatgrass and Sandberg's bluegrass in the more exposed areas. Lower limits of this complex are adjoining the extensive agricultural land and the upper limits are the Ponderosa pine and fir type.

325 Shrub Steppe -

Very gently rolling lowlands. Dry sites with sandy to silt loam soils. Dominant shrubs are Big Sagebrush, Bitterbrush, and Rabbitbrush. They occur in both pure and mixed communities. Fire and heavy past grazing have strongly modified these vegetations. The herbaceous layer is very sparse. This type has limited value as grazing land due to the sparsity of the vegetation but is adaptable to agriculture using new irrigation techniques. The upper limit of the type is bounded by dryland agriculture on the silt loam, loessal soils of the uplands.

341.08 True fir and related coniferous species -

High elevation, less dissected uplands of the Blue Mts., in more mesic, high snowfall areas. Dominant trees are Grand fir and Lodgepole pine and Douglas fir which occur in dense thickets giving a very dark tone to the image. Understory vegetation is dominated by deciduous low growing shrubs to form a simple complex of communities that cannot be individually identified on the MSS-5 imagery.

341 A complex, needle-leaf forest area consisting of Ponderosa pine, Douglas fir, true fir and Lodgepole pine communities. They occur in patterns too intricate to map at this scale on the dissected and rolling uplands of the Blue Mts. The types dominated by Ponderosa pine occur on the more xeric, dissected and exposed sites. The true firs and Douglas fir become dominant on the protected slopes and rolling uplands, with Lodgepole pine also on the uplands. The understory is generally dominated by a herbaceous layer, mainly grasses, in the Ponderosa pine areas with the understory in the true fir, Douglas fir, and Lodgepole pine areas being dominated by low-growing deciduous shrubs.

410 Cover Crops, Field and Seed -

Deep sandy loam soils on gently undulating lowlands. This area is newly developed agricultural lands using new sources of water from the rivers and modern irrigation techniques. The majority of the crops are small cereal grains, forage (legumes), potatoes, and sugar beets. Varieties of crops cannot be determined at this scale on the MSS-5 band.

411 Cereal and Grain Crops -

Deep loessal loam and sandy loam soils on undulating and moderately dissected lowland ranging from the low shrubland to the higher grasslands and foothills of the Blue Mts. This is a well established agricultural pattern, with the land being rotated from wheat to fallow in alternate years. Some dry land peas are grown in the higher elevations where the moisture regime allows. More recently, there has been some land put under irrigation and some attention has been given to forage crops as well.

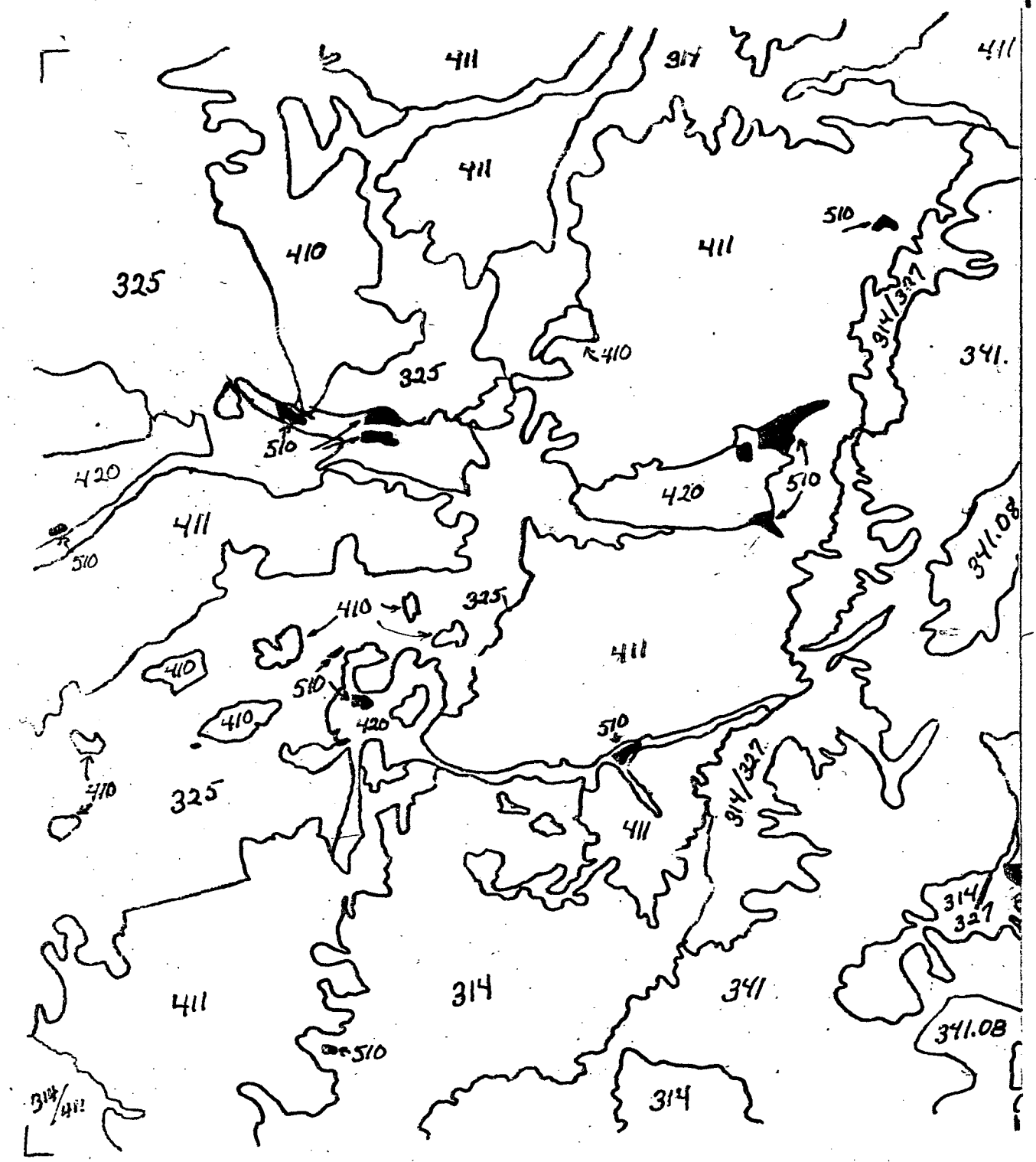
420 Row Crops, Vegetable -

These areas are silt and silt loam soils on old terraces and flood plains of river valleys. The agriculture here is highly diversified ranging from cereal grains, forage crops and row crops to onions, asparagus and melons among other horticultural specialties including orchards.

314/411 Bunchgrass Steppe/Cereal and Grain Crops

A complex of the previously described (314 & 411) areas. This particular area is somewhat more marginal for agricultural suitability as the fields are located on ridges and protected slopes where the accumulated soils are deep enough to support cropping.

510 Residential areas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Quick-look report, Pendleton frame, 1021-18145-5

Oregon-ERTS, Geology Group

The area of the Pendleton frame is almost entirely underlain by the Columbia River Basalt of Miocene age. Small patches of older rocks are present in the southwest and southeast corners. Near La Grande small areas of granitic rock belonging to these older units may be distinguishable on the imagery. The Columbia River Basalt itself is gently folded into broad anticlines and synclines trending from about east-west in the northwest corner of the frame (Saddle Mountains anticline) to northeast in the southeast corner (Blue Mountains anticline). The basalt is also cut by numerous faults which are shown on the sketch labelled "Pendleton Fractures". Numerous surficial deposits are present on top of the basalt. In the Pasco basin, the Ringold Formation accumulated in Pliocene time as a basin fill. South of Umatilla lake, deposits developed during the Pleistocene. The Palouse Formation, a loess deposit largely derived from glacial sediments, blanketed nearly the entire area at one time. In places north of Walla Walla more than 50 ft. has accumulated, and determines the landscape surface pattern. Southwest of Pendleton only a few feet are present and are much less evident.

In the sketch maps included in this report some compromise has been sought between a pure image interpretation and feature identification based on prior knowledge. The procedure adopted was to map the image first and then to attempt to identify the distinctions with geology and geomorpholgy known for the area. The value of the available sidelap stereo, which covers about 90% of the frame, cannot be over emphasized. In fracture mapping the stereo frequently allows one to identify a fault with certainty by distinguishing the scarp or by topographic offsets associated with the feature. Without stereo, faults and joints are nearly always indistinguishable. On both maps greater detail is available to be mapped at a larger scale than could be included herein.

The legend scheme used for the map of geology and geomorphology enclosed is a modification of the scheme intended ultimately to be digital. Letters are used for this combined and regionally specific version to avoid confusion. This legend follows with brief descriptive notes.

Legend, Pendleton Frame, Geology and Geomorphology

M High Relief

Mm Mountainous areas: largely Columbia River Basalt bedrock with mature drainage developed. High drainage density. Rectangular drainage pattern to intermediate between rectangular and dendritic.

Ms Scarps: very steep slopes, often fault scarps. High drainage density with a parallel pattern.

Mc Canyons: deeply cut canyons (not differentiated within Mm). Includes scabland on this frame. High drainage density with a parallel pattern.

H Moderate Relief

Hh Hilly: maturely dissected areas with nearly the entire surface in slopes. High drainage density, largely dendritic pattern.

Hb Bedrock dip slopes: youthful dissection of areas with largely even surfaces. Dip direction shown by parallel pattern of consequent streams. Moderate to low drainage density.

Hd Depositional slopes: alluvial fans, bajadas, talus, colluvium. Little dissection and low drainage density.

L Low Relief

Ll Low, rolling hills: thick loess deposits with very high drainage density. Basic drainage pattern modified by superimposed fine textured, wind oriented ridges.

Lb Shallow bedrock areas: youthful dissection of areas with largely even surfaces. Moderate to low drainage density. Dendritic pattern.

Ld Modern dunes: active sanddunes. Light colored with no drainage. Wind oriented pattern.

Le Blowouts on scabland and lake sediments. Light colored wind oriented patterns. Impossible to distinguish scabland and lake sediment materials.

Ls Scabland: identification difficult. (Le and Ls refer to areas north and south of Columbia River near Umatilla. These dark areas are difficult to interpret clearly, perhaps beeause scabland is such a unique feature.)

F Very Low Relief

Fa Alluvial bottom lands: flood plain and low terrace alluvial sediments. Heavy agricultural use adjacent to rivers and streams. No drainage except major stream.

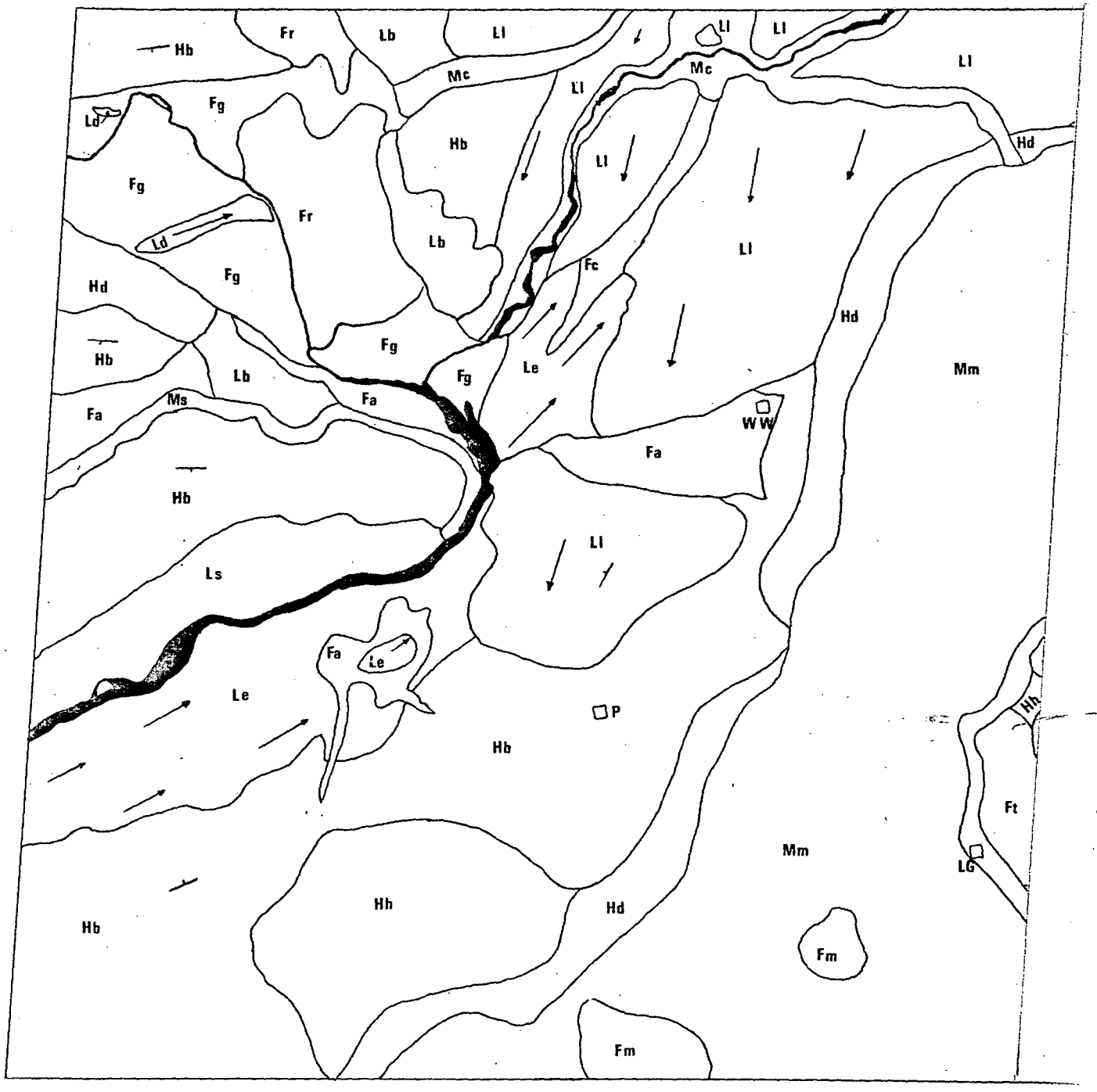
Ft Tertiary lake beds. Much like Fa. Distinguished by prior knowledge, wider extent, and presence of lip to old lake area.

Fm Flats of high mountains: probably loess and/or volcanic ash, may have minor alluvial sediments. Light colored areas of low drainage density.

Fr Ringold Formation: Approximate outcrop area distinguished by prior knowledge. Much like Fa.

Fc Spokane flood channel: area without drainage pattern between areas of thick loess (Ll). Linear, channel-like pattern.

Fg Pleistocene sands and gravels of Pasco basin. Little or no drainage and little agricultural use. Internal patterns may be meaningful if have prior knowledge.



PENDLETON GEOLOGY AND GEOMORPHOLOGY

LEGEND

Wind direction

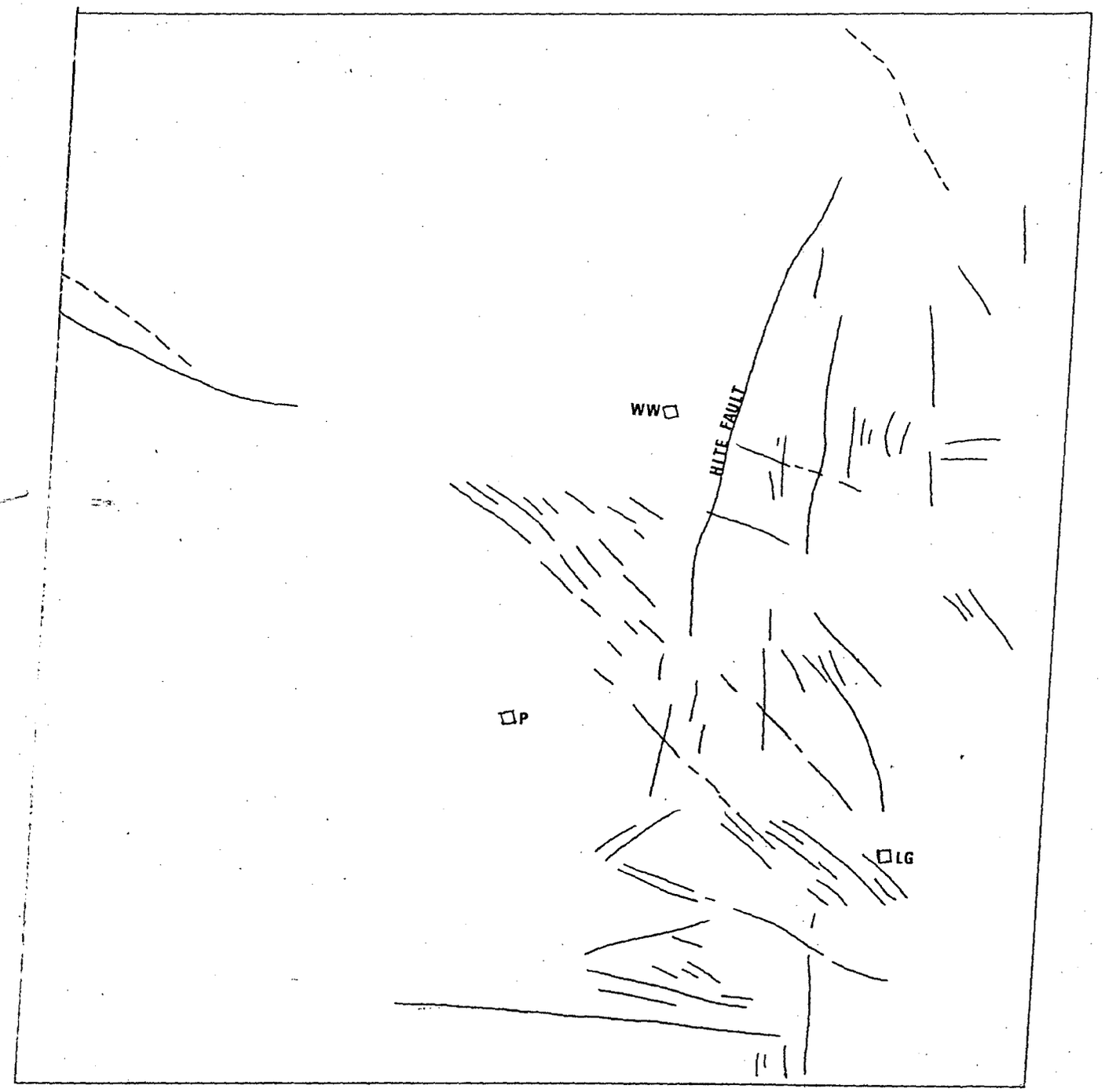
Approximate bedrock attitude

Town

N

SCALE

10 0 10 20 mi



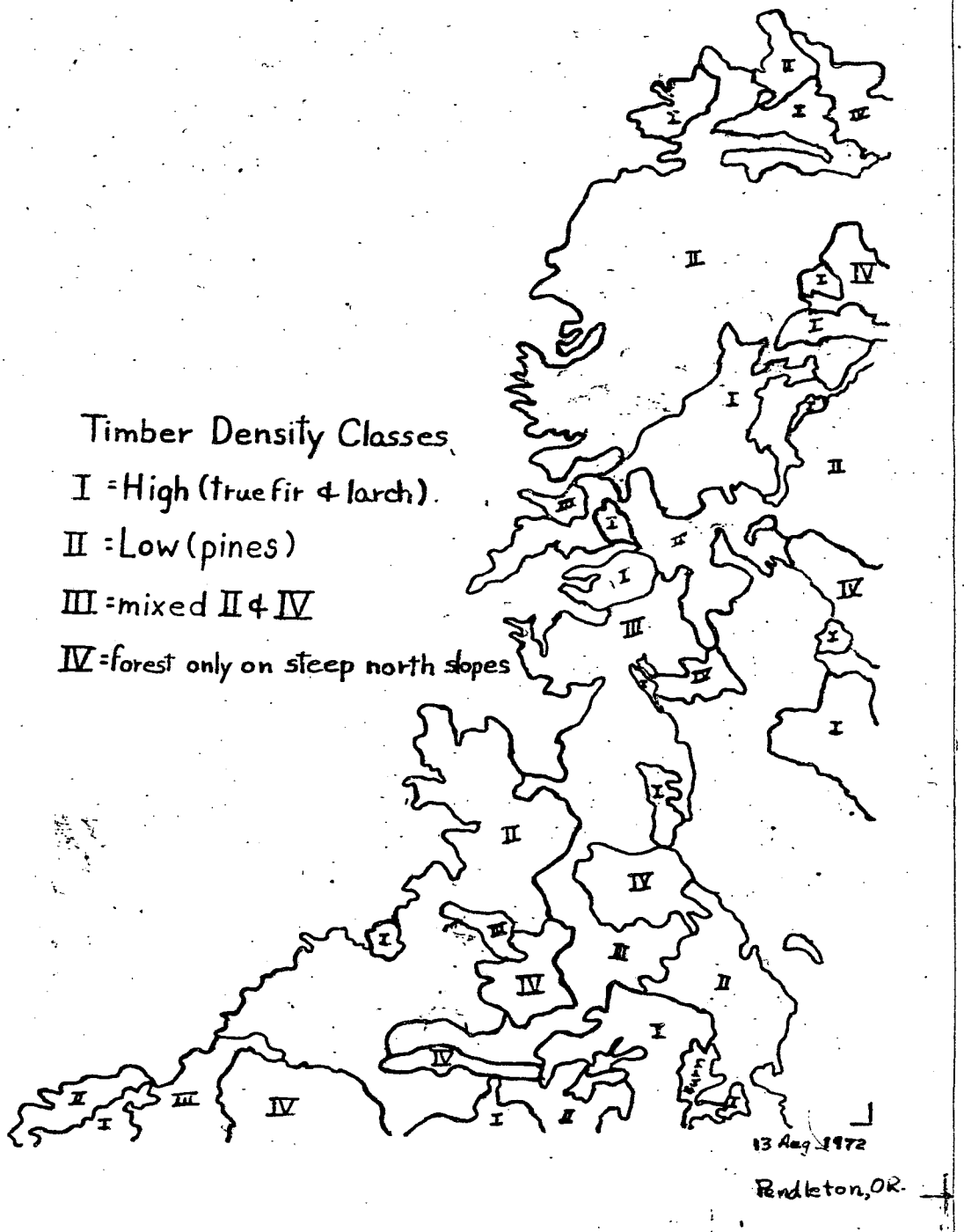
PENDLETON FRACTURES

FORESTRY INTERPRETATIONS

1. On a 9" x 9" positive (red band) of the Pendleton frame (1021-18145-5) dated August 31, 1972, we have delineated all the forested land (Blue Mountains) and have further subdivided the forest into four categories based on vegetation density. These density differences are related to elevation, temperature and moisture which in turn are related to the different forest types (species composition). The forest lands occupy elevations from 3500 to 6500 feet with the true-fir, larch and small amounts of lodgepole and ponderosa pines in the upper elevations and mostly lodgepole and ponderosa pine with lesser amounts of Douglas-fir and larch at the lower elevations. This type map was done with the aid of a stereoscope making use of the sidelap of an adjacent pass. We can definitely see a small amount of relief in the stereo model. However, the big advantage of using the stereoscope is probably due to what we call binocular reinforcement.

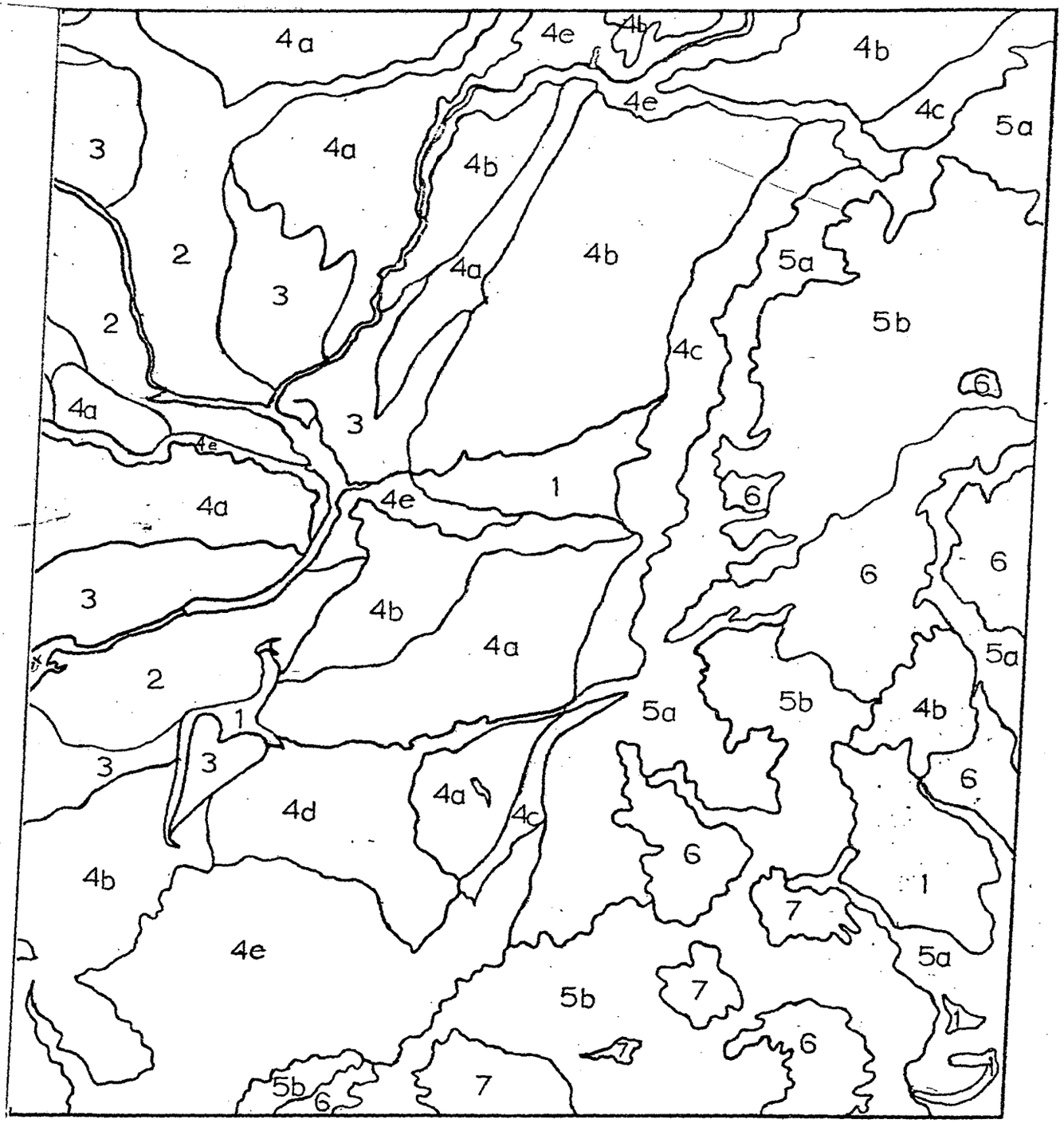
2. We have built a workable color combiner. So far we have been able to separate out at least two different forest types in the Blue Mountains which appear to be major species differences which are not discernable on any one of the four bands viewed singularly. Due to the lack of "ground truth" in this area we can only guess as to what species we are separating. This is not the area of our project but we started with this frame before Crook County coverage arrived--where we do have some "ground truth."

3. Clear-cuts can be observed in all four bands as well as a portion of the highway from LaGrande to Pendleton, Oregon.


Timber Density Classes
I = High (true fir & larch).
II = Low (pines)
III = mixed II & IV
IV = forest only on steep north slopes
13 Aug 1972
Pendleton, OR.

Generalized Soil Map of Frame 1021-18145-5, Oregon-Wash. 13 Aug. 1972

The accompanying generalized soil map of the August 13 Pendleton frame (1021-18145-5) was made by delineating discernibly different areas on the 9 inch black and white print. The delineations reflect vegetative cover, land use patterns and land forms. Soil itself rarely contributes directly to this image (light grey, linear sand dunes near the Columbia River are an exception). These visible features were correlated with existing ground truth (soil maps) to determine which soils were predominant in each area. No additional magnification was utilized.



Soil Map of Frame 1021-18145-5 Oregon-Washington

N

Legend for Generalized Soil Map of Frame 1021-18145-5 13 Aug. 1972

Symbol

1. Recent Alluvium and associated terrace soils
   Yakima, Hermiston, Esquatzel, Umapine and Stanfield series in the Columbia Basin
   La Grande, Imbler, Alicel, and Hot lake series in the Grande Ronde Basin

2. Spokane-flood deposits, scoured bedrock, and associated, wind-transported, sandy soils
   Ephrata, Rupert, and Timmerman series, plus Rockland

3. Sandy and silty soils from lake deposits, partly reworked by wind
   Hezel, Quincy, Taunton, Sagehill series

4. Soils formed in loess
   a. Nearly level to gently rolling
      Walla Walla, Ritzville, Shano series
   b. Rolling hills
      Walla Walla, Ritzville, Starbuck series
   c. Rolling hills, dark colored soils
      Athena, Palouse and Waha series
   d. Steeply Rolling hills
      Condon, Walla Walla, Walvan and Lickskillet
   e. Canyons and Scarps
      Lickskillet, Walla Walla, Condon, Walvan and Bakeoven series

5. Deeply dissected Blue Mountains
   a. Very dark brown grassland soils
      Waha, Hurwal, Palouse and Rock Creek series
   b. Brown and dark brown forested soils
      Klicker, Couse and Snell series

6. Light colored, forested soils of the Blue Mountain Plateau
   Tolo, Helmer and Klicker series

7. Shallow and very shallow, stony soils of Blue Mountain Basin
   Rock Creek, Ukiah and Waha series