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Quarterly Progress Report

Digital Processing of Landsat MSS and Topographic Data to Improve Capabilities for Computerized Mapping of Forest Cover Types

Contract No. NAS9-15508

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OVERALL STATUS AND PROGRESS TO DATE

During the past three months, several activities were conducted under this contract. These activities included:

1. A survey of the literature,
2. Planning and defining in detail the procedures for the development of the digital forestry/ topographic model, and the procedures for analyzing the combined spectral and topographic data sets,
3. Modification of available processing analysis software and development of new programs,
4. Selection of the test sites, and
5. Identification and preparation of the Landsat MSS and support (ground truth) data.

The results of these activities are presented in the following sections.

Literature Survey

Scientific interest in plant zonation on mountain slopes is very old, dating back at least to the writings of Tournefort in 1717 (Clements, 1905). However, the important early work on the zonation of vegetation, particularly with reference to altitude, was done by Merriam (1890),Shreve (1915, 1920) and Daubenmire (1943). A review of the available literature indicated the lack of a model to topographically (including elevation, slope and aspect) describe the distribution of vegetation zones. Past studies have usually involved only altitude and only a few recognized two aspect classes (north and south) to describe to topographic distribution of vegetation zones.

Ecological studies in the western coniferous forests have demonstrated the existence of vegetational gradients with altitude, soil moisture conditions, parent materials, climate, and other ecological factors which create a gradual sequence of changes in forest composition and structure as well as some relatively abrupt transitions from one community to another. These relationships provide evidence for the principle of species individuality, originally set forth by Gleason (1926, 1939) as the "individualistic concept of plant association". Rephrased by Whittaker and Niering (1968), it states that "each species responds to the various environmental factors involved differently from any other species, according to its own genetic structure, range of physiological tolerances, and population dynamics including effect of competition and other relations to other species".

Topography influences plant distributions indirectly through its control of many environmental parameters, including; insolation, temperature, atmospheric pressure, precipitation, relative humidity, wind velocity, evaporation, and soil characteristics. Daubenmire (1943) realized these relationships and recognized that topography accounts for most of the deviations from the ideal altitudinal gradient in climate, and from the ideal sequence of vegetation zones. However, he concluded that zones in the sense of rigidly defined altitudinal belts clearly do not exist in the Rocky Mountains, but there exists a regularly repeated series of distinct vegetation types, each of which bears a constant altitudinal or topographic relationship to contiguous types.

Many researchers have described the location and characteristics of various vegetation zones in the Rocky Mountains. Daubenmire (1943) evaluated the existing descriptions and distinguished six major vegetation zones:

Alpine tundra zone: Because of the short frost free growing season, the vegetation is limited to short grasses and sedges, hardyforbs, subalpine willows, and other low shrubby plants.

Engelmann spruce - Subalpine fir zone: The dominant tree specie include Engelmann spruce, Subalpine fir, white fir and cork bark fir. Interspersed throughout are numerous meadows, grasslands, and stands of aspen.

Douglas fir zone: The major components of the zone are Douglas fir and white fir. Stands of lodgepole or aspen may be interspersed in areas that have been disturbed (usually fire).

Ponderosa pine zone: Ponderosa pine is the dominant tree specie with an understory of grasses or Gambel oak. Aspen or Gambel oak may first revegetate disturbed areas.

Pinyon-juniper zone: The principal species include one-seed juniper, Utah juniper, Rocky Mountain juniper and pinyon pine. Understory may consist of Gambel oak, ceanothus and/or several grass species.

Oak-mountain mahogany zone: The major components include Gambel oak, mountain mahogany, manzanita, ceanothus, cliffrose and numerous species of cactus.

A summary of the literature describing the variation in topographic position for various forest vegetation types in the central-southern Rockies are included in Table I.

An evaluation of this table indicates that the major forest communities in the Rocky Mountains do not seem to vary considerably in their elevation ranges from northern Arizona and New Mexico north to central Colorado. Each vegetation type has a characteristic elevation range which is adjusted locally by a combination of slope and aspect . Several authors noted 2 distinct classes, northern and southern exposures. The warmer, drier southern exposure raises the elevation range whereas the cooler and moister northern exposures lower the elevation range.

Table I. Summary of the Literature Review.

Authors Location	Rasmussen 1941 Kiabab Plateau Northern Arizona	Pearson 1920 Southwestern Arizona/New Mexico	Merriam 1890 San Francisco Peaks, Northern Arizona	Whitfield 1933 Pikes Peak Central Colorado	Woodbury 1947 South-Eastern Utah	Marr 1961 Boulder, Colorado	Fleming 1975 San Juan's SW Colorado
Alpine terrain Zone	-	above 11,500	above 11,500	above 11,500	North: above 10,000 South: above 11,000	above 11,300	above 11,500
Engelmann Spruce and Subalpine fir zone	above 8,200 *	9500 to 11,500	9200 to 11,500	9000 to 11,500	North: 7000 to 10,000 South: 8000 to 11,000 *	9,300 to 11,000	10,000 to 12,000
Douglas and white fir zone	North down to 6,800	8300 to 9500	8200 to 9200	8000 to 9000		8000 to 9000	North: 6,500 to 9,000 South: 7,500 to 10,000
Ponderosa Pine zone	6,800 N down to 6500 S up to 8,800	6700 to 8300	7000 to 8200	6500 to 8000	North: 5000 to 7000 South: 7000 to 8000	6000 to 7000	North: 6,250 to 8,000 South: 7,000 to 9,500
Pinyon-juniper zone	5500-6800 S up to 7250 N 5000-6500	5000 to 6700	6000 to 7000	below 6500	North: 4000 to 5000 South: 4000 to 7000		North: 5000 to 6500 South: 5000 to 7000
Oak-mountain Mahogany	4500 to 5500	3000 to 5000	4000 to 6000	-	North: - South: -	-	North: - South: -

* not recognized as distinguishable communities
- not included in study

Digital Topographic Model and
Analysis of Combined Spectral and Topographic Data

During Dr. Roger M. Hoffer's (Principal Investigator) visits to LARS and through extended conference phone calls involving Dr. Hoffer, Mr. Mike D. Fleming (Senior Analyst), and Dr. Luis A. Bartolucci (Project Manager), the details of the procedures to develop the forestry/topographic model and to conduct the analysis of the combined spectral and topographic data sets were thoroughly discussed.

To develop the digital forestry-topographic model, available reference data on the distribution of the various forest species will be utilized in conjunction with the digital topographic data to obtain frequency distribution curves for major forest species as a function of the different topographic parameters, i.e. elevation, slope, and aspect. The resulting statistics will then be used as input to a multivariate classifier which will classify the digital topographic data into a "potential forest cover map".

The combined sets of spectral and topographic data (digital topographic data registered onto Landsat MSS data) will be processed and analyzed using various classification techniques.

Programming Activities

A student programmer has been hired under this contract to assist the analyst in the development of support software and modification of existing processors that will be required during the different stages of this investigation. To date, the programmer has been primarily involved in becoming familiar with the LARSYS software package and he is presently starting to develop the "results tape field description cards" program.

Test Site Selection

Two test sites to be utilized in this study were selected and delineated as illustrated in Figure 1. The larger test site (975,581 hectares) is referred to as the San Juan test site, and the smaller one (541,502 hectares) is referred to as the Southern San Juan test site.

Available Data

The data sets to be used in this investigation have been already identified and compiled. The spectral data (Landsat MSS) have been geometrically corrected and re-scaled to a 1:24,000 scale. These data cover the entire San Juan and Southern San Juan test sites. In addition, the digital topographic data have been registered onto the Landsat multispectral scanner data. A description of all the spectral and topographic data available at LARS is given in Table II. The characteristics of the two combined (spectral and topographic) data sets that will be used in this investigation are described in Table III.

The support data required in this study has been compiled also, and they consist of orthophotos, aerial photography, forest type maps, and U.S.G.S. 7½ minute

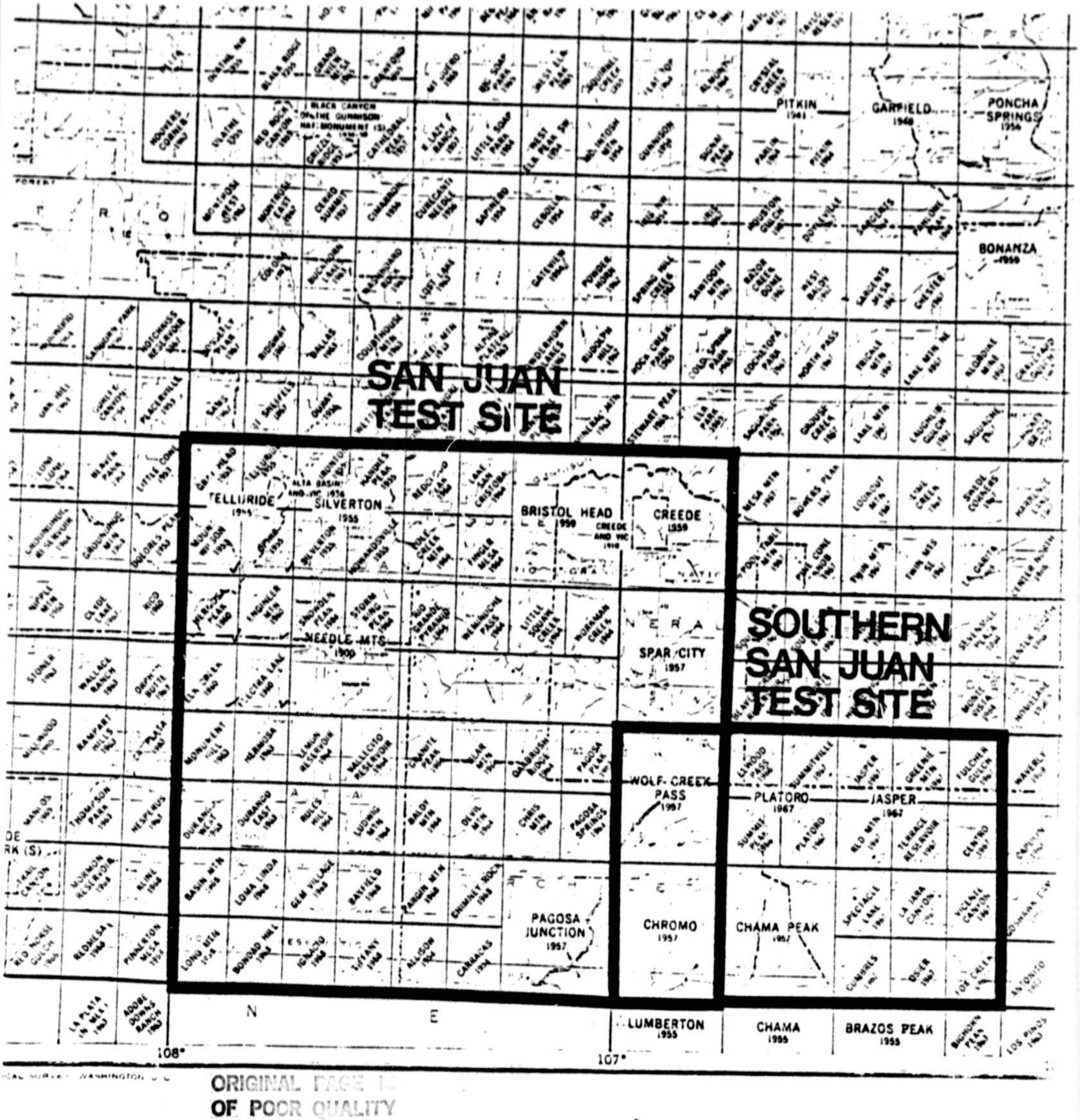

Figure 1. Location of the San Juan and Southern San Juan, Colorado test sites.

Table II. Digital Landsat MSS and Topographic Data Available for this Investigation.

Test Site	Run Number	Lines/ Inter.	Columns/ Inter.	Date	Data Comments	Number of Channels
San Juan	73034300	1-2340/1	7-3232/1	6/5/73	ERTS-uncorrected-entire frame	4
"	01	1-1398/1	1-1512/1	6/5/73	ERTS-G.C.-1:24,000-west half	4
"	02	1-1398/1	1-1512/1	6/5/73	ERTS-G.C.-1:24,000-east half	4
"	03	1-1398/1	1-1512/1	6/5/73	ERTS (1-4) + SKYLAB (5-17)	17
"	04	1-1398/1	1-1512/1	6/5/73	ERTS(1-4) + SKYLAB (5-17)+ELEV(18)	18
"	08	1-1398/1	1-1512/1	9/3/73	ERTS(1-4) - G.C. 1:24,000?	4
"	09	1-1398/1	1-1512/1	9/3+8/8/73	ERTS(1-4) + SKYLAB (5-18)	18
"	11	1-1398/1	1/1512/1		SKYLAB(1-13) + TOPO(14-18)	18
"	14	1-1398/1	1-1512/1		Principle components(of 73034311)	4
"	17	1-1398/1	1-1208/1		SKYLAB(1-13) + TOPO? (14-18) (11 above) G.C. display	18
"	18	1-331/1	1-256/1		non-vect. subset(of 11) (Lemon watershed)	18
"	73121801	1-1762/1	1-1404/1		TOPO (Elevation)	1
"	73088611	1-1570/1	1-1558/1	6/5/73	SKYLAB	13
"	73127101-03	1-2313/1	1-2506/1	8/8/73	SKYLAB	14
"	73057700	1-2340/1	7-3232/1	9/3/73	ERTS(1-4): uncorrected-entire frame	4
"	02	1-1417/1	1-1508/1	9/3/73	ERTS(1-4): G.C.-1:24,000 printer	4
"	03	1-1417/1	1-1508/1	9/3/73	ERTS(1-4):+Gradients (5-8) (of 02)	8
"	04	1-1417/1	1-1508/1	9/3/73	ERTS(1-4)+Gradients (5-8) (of 02)	8
"	05	1-1075/1	1-1712/1	9/3/73	ERTS(1-4)+elevation (5) (of 00)	5
"	06	1-1074/1	1-1712/1	9/3/73	ERTS(1-4) + TOPO(5-8) (of 00)	8
"	07*	1-1398/1	1-1512/1	9/3/73	ERTS(1-4) + TOPO (5-9)	9
Southern San Juan	73069304	1-915/1	1-1274/1	9/20/73	ERTS(1-4) + TOPO (5-9) G.C. 1:24,000	9

*Digital data generated by combining the first four channels of Run 73034309 (spectral data) and the last five channels of Run 73034311 (topographic data).

Table III. Digital Landsat MSS and Topographic Data Selected for this Investigation.

	San Juan Test Site	Southern San Juan Test Site
LARS Run Number	73057707*	7306069304
Lines/Interval	1-1398/1	1-1915/2
Columns/Interval	1-1512/1	1-1274/2
Data	9/3/73	9/21/73
No. of Channels	9	9
Data Comments	ERTS(1-4) + topo (5-9)	ERTS(1-4) + topo (5-9)

*Digital data generated by combining the first four channels of Run 73034309 (spectral data) and the last five channels of Run 73034311 (topographic data).

quadrangle sheets. Figure 2 shows the location of the available orthophotos (solid black squares), U.S.G.S. topographic sheets (solid black dots), and type maps (rectangles). Table IV gives the location and characteristics of the available aerial photography.

Table IV. Available Aerial Photography.

Area Covered	Scale	Type	Date
San Juan test site	1:120,000	CIR	8/4/73
Southern San Juan test site	1:60,000	CIR	6/25/75
Platoro Quadrangle	1:15,840	Color	9/29/73

PERSONNEL STATUS

Currently, the people directly involved in this project are:

Name	Position	Effort
R. M. Hoffer	Principal Investigator	15%
L. A. Bartolucci	Project Manager	25%
M. D. Fleming	Senior Analyst	50%
C. Hamilton	Programmer	50%
C. Mettes	Secretary	15%

EXPECTED ACCOMPLISHMENTS

It is envisioned that by the end of the next reporting period, the first part of Phase I (see Statement of Work in the contract), i.e., the development of the "topographic distribution model" will be completed. Also, during the next reporting period, the results of a field verification trip to the test sites will be included.

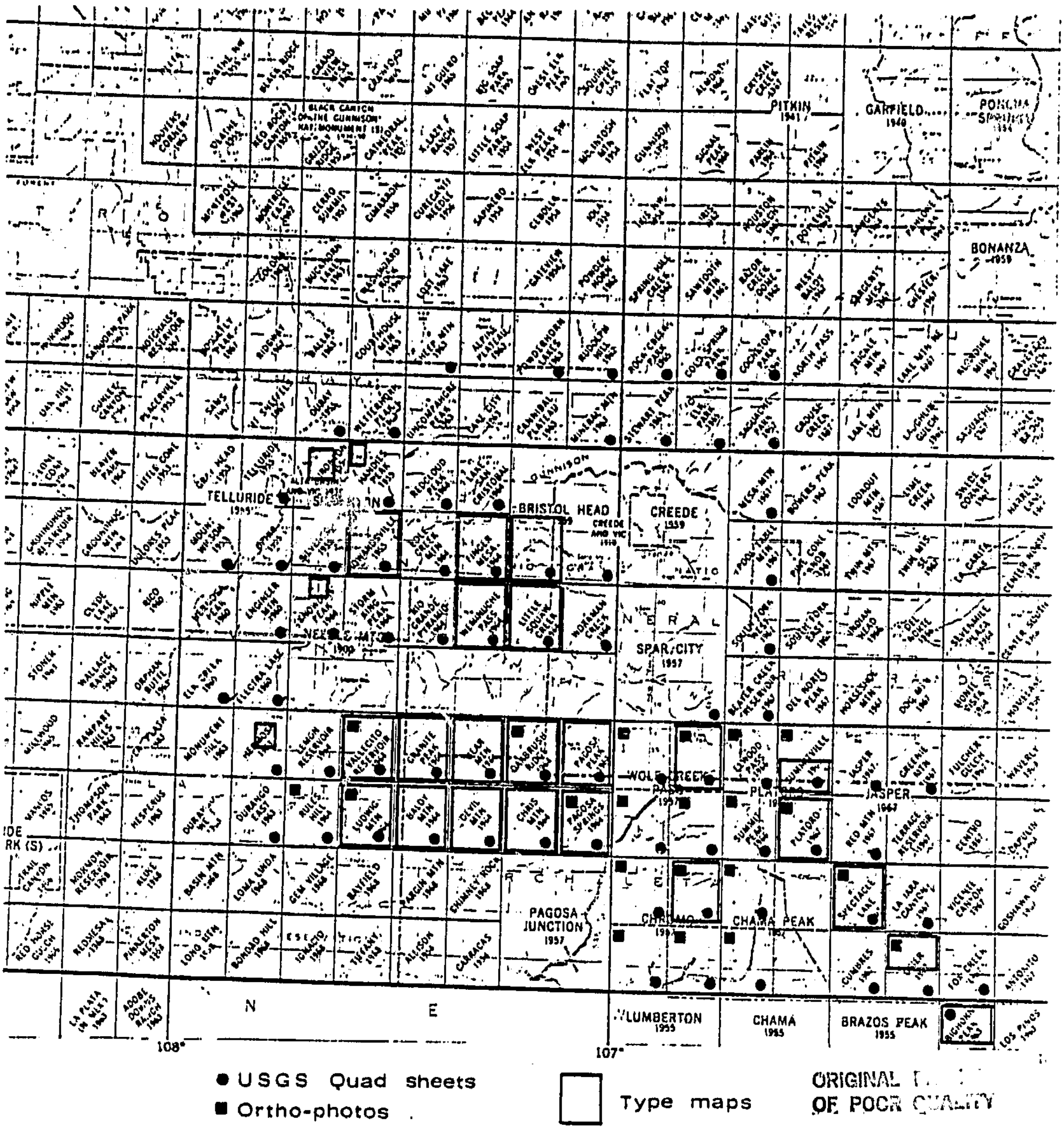

Figure 2. Location of available support data for both the San Juan and Southern San Juan test sites.

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