Second Semi-Annual Progress Report

NASA Prime Award No. NAS 5-28766 to
South Dakota State University

Modeling Energy Flow and Nutrient Cycling in
Natural Semiarid Grassland Ecosystems with
the Aid of Thematic Mapper Data

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

1.0 Objectives

1. To model energy flow and nutrient cycling as affected by herbivory on selected intensive sites along gradients of precipitation and soils, validating the model output by monitoring selected parameters with data derived from Thematic Mapper.

2. To model herbivore production along gradients of soils and herbivory, validated with data derived from TM in a spatial data base.

2.0 Availability of TM Data

Following sale of the landsat system to EOSAT, NASA provided 4 full TM scenes from 1985, hoped to be able to provide a few scenes for 1986, but was unable to make any promises of data. On this basis and with hopes for a solution to the problem before 1987, plans were made to reduce field sampling intensity where possible in 1986 and increase it in 1987 with a corresponding redistribution of funds from 1986 to 1987 as noted later in this report. In early August, 1986, in telephone conversations with Locke Stuart and Maria Mackey of the Landsat Support Office, we learned that at least 15 TM scenes would be made available and that, hopefully, there would be more. Twelve quadrants have now been ordered, in retrospect, on the basis of cloud cover, data quality, and dates of ground sampling. Others will be ordered as the data are catalogued.

3.0 Modeling (William J. Parton, Jr., Colorado State University)

The SPUR model from Agricultural Research Service became available for use in June 1986. A User's Guide is now available, but documentation is still in press. A draft copy is available on loan from ARS in Fort Collins, however. This model will soon be verified for the three sites.

Development of the NREL model has continued. This model has been verified, using historical data, for the Cottonwood Range and Livestock Research Station and for the Central Plains Experimental Range. The nutrient cycling submodel is being interfaced with the rest of the model now. As examples of the model output, five time traces from the Cottonwood verification runs are shown.

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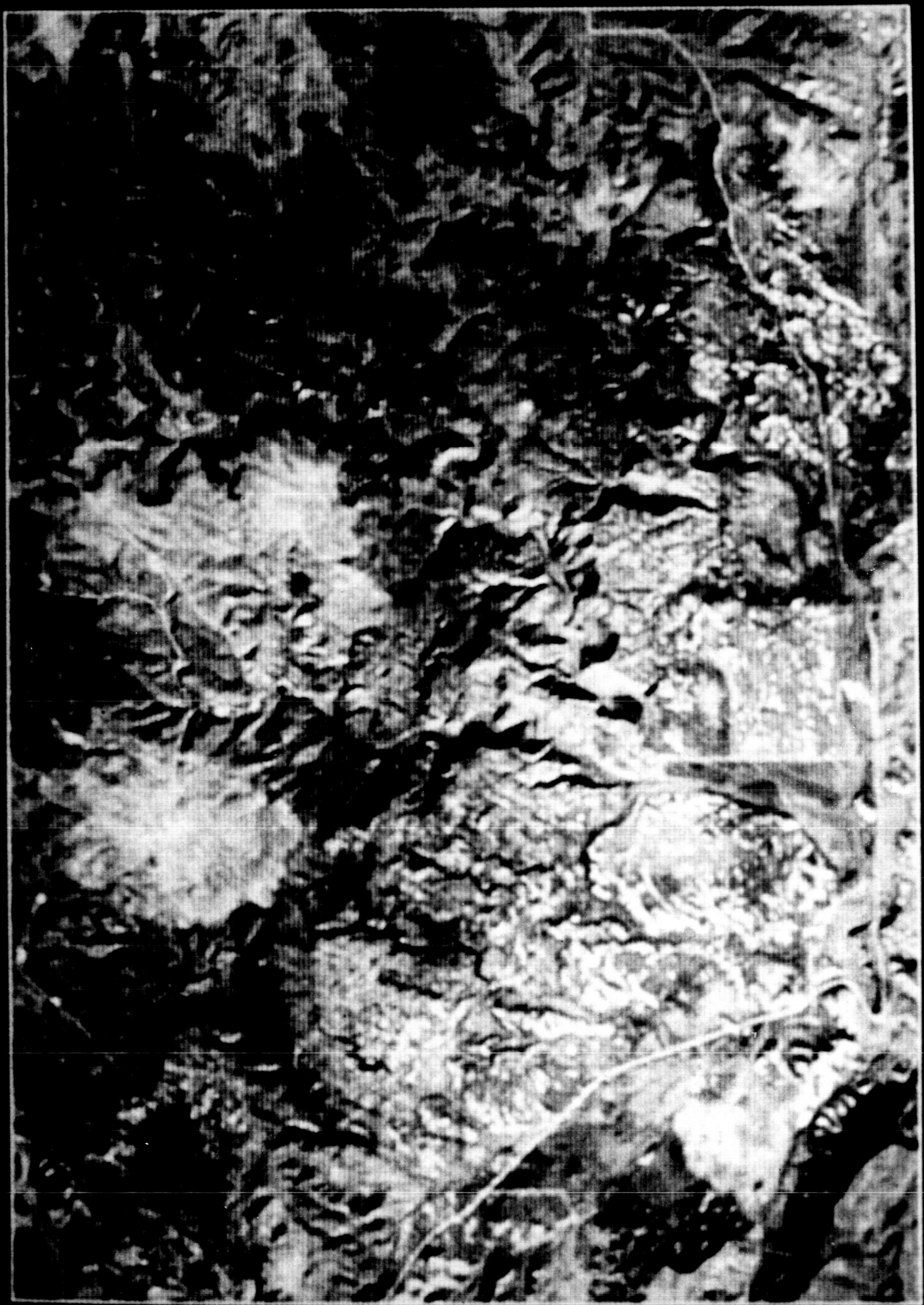
7.5 MIN. USGS QUAD, NRSC, UNIV. OF NEBRASKA

COTTONWOOD NE, SOUTH DAKOTA
Color Infrared Image Map from LANDSAT TM of 7/11/85
Red=band 4, Green=band 3, Blue=band 2

7.5 MIN. USGS QUAD, NRSC, UNIV. OF NEBRASKA

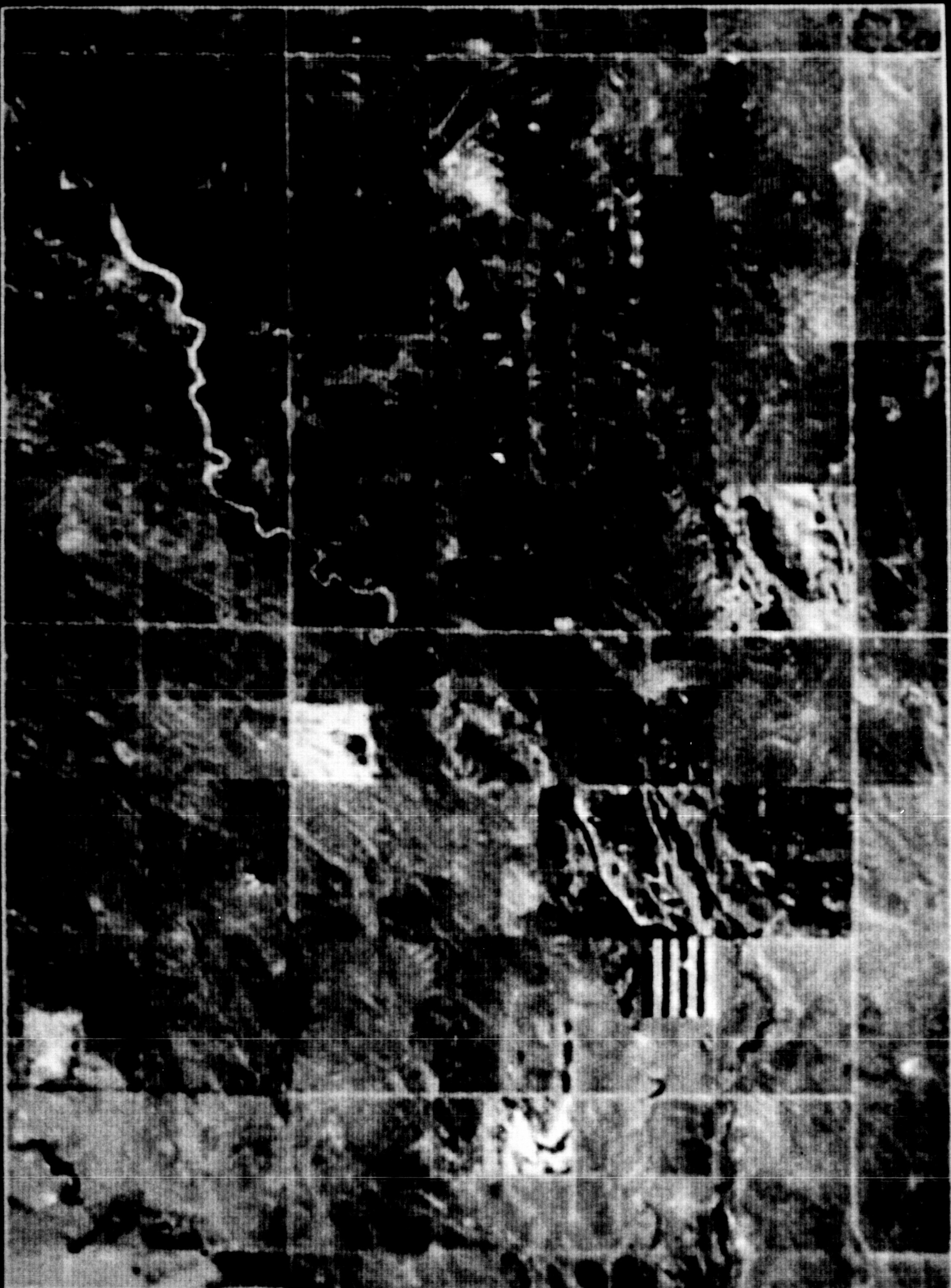


WINDCAVE, SOUTH DAKOTA

Color Infrared Image Map from LANDSAT TM of 9/20/85

Red=band 4, Green=band 3, Blue=band 2

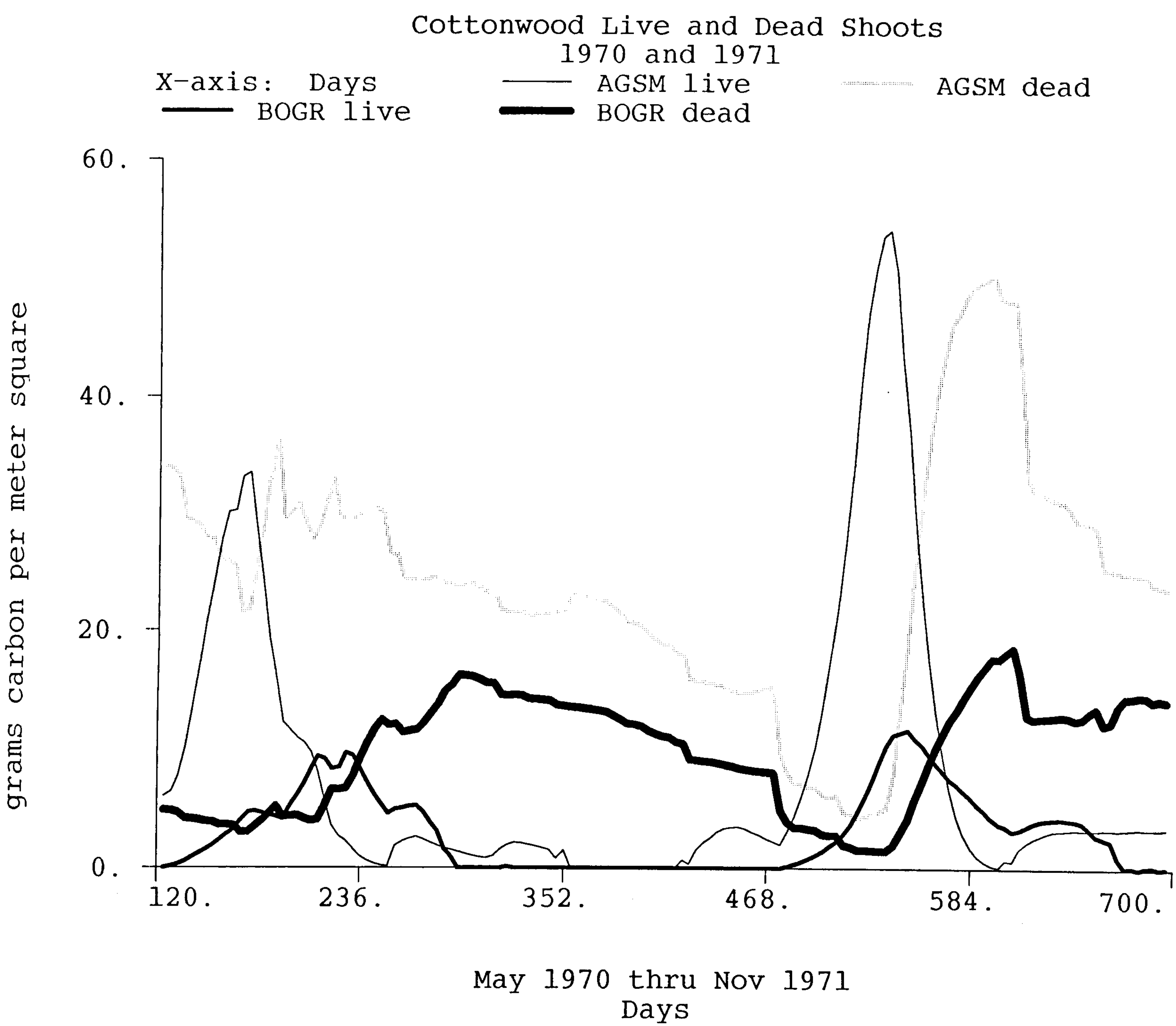
7.5 MIN. USGS QUAD, NRSC, UNIV. OF NEBRASKA

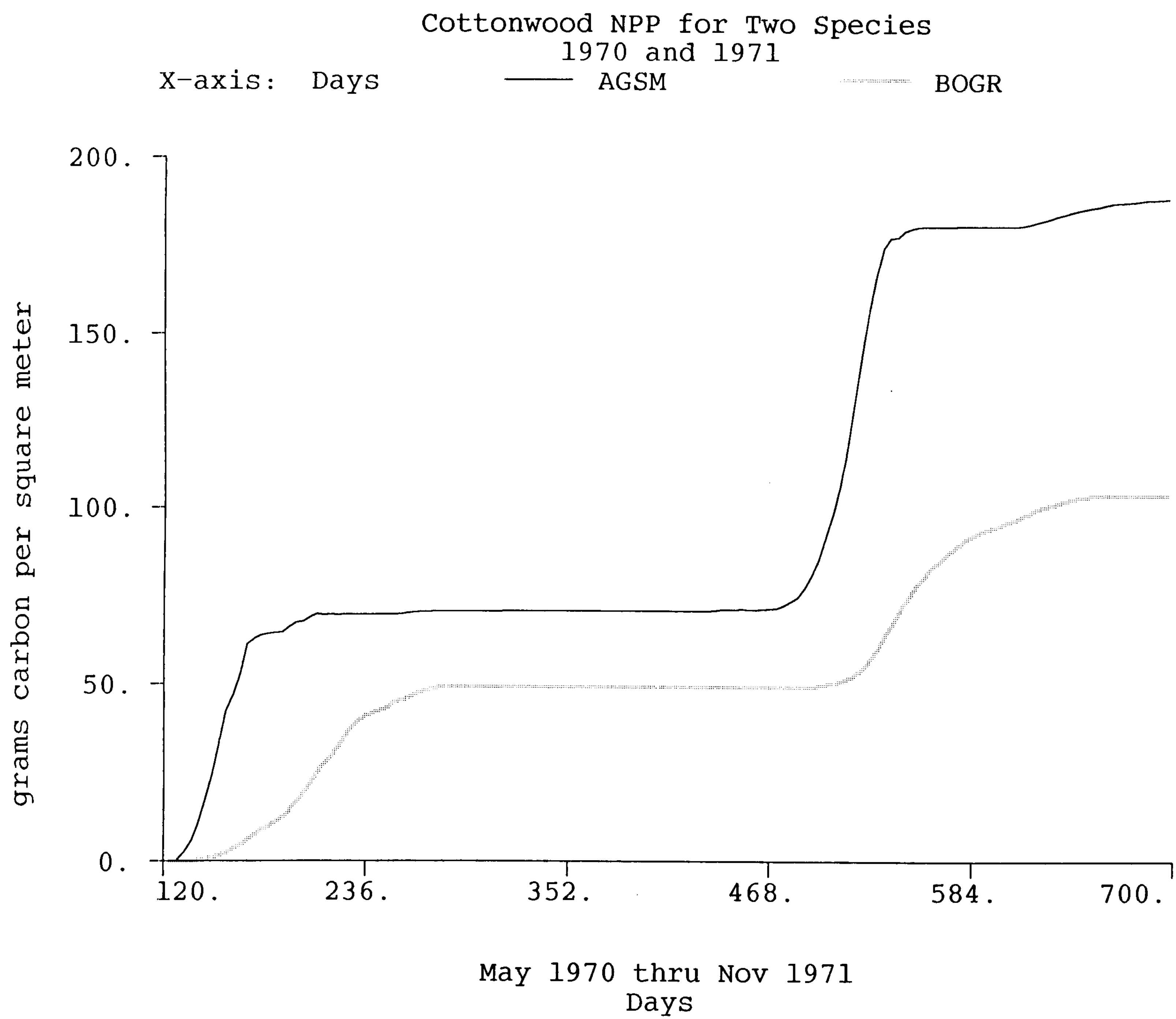


CHALK BLUFF SW, COLORADO

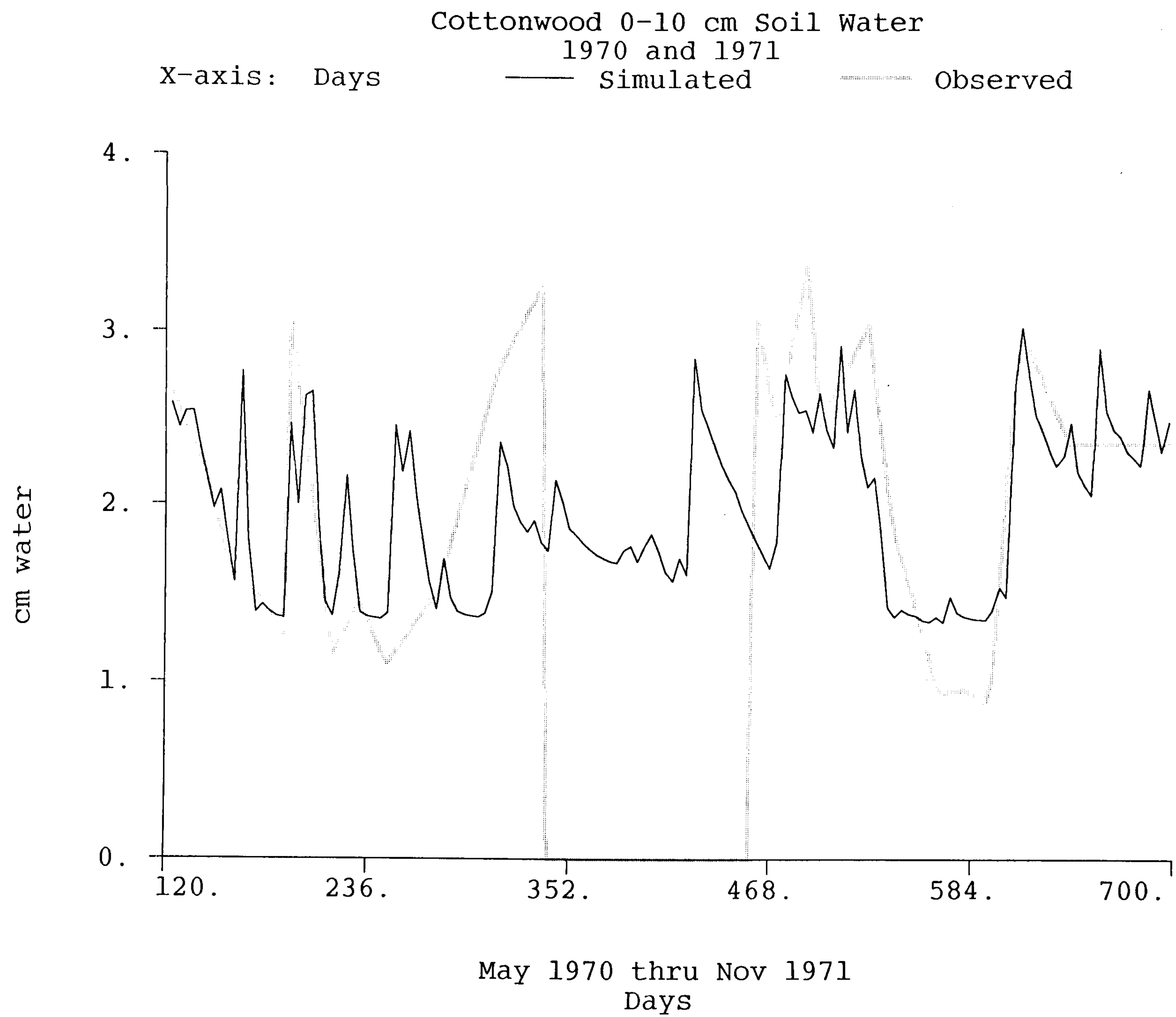
Color Infrared Image Map from LANDSAT TM of 9/15/85

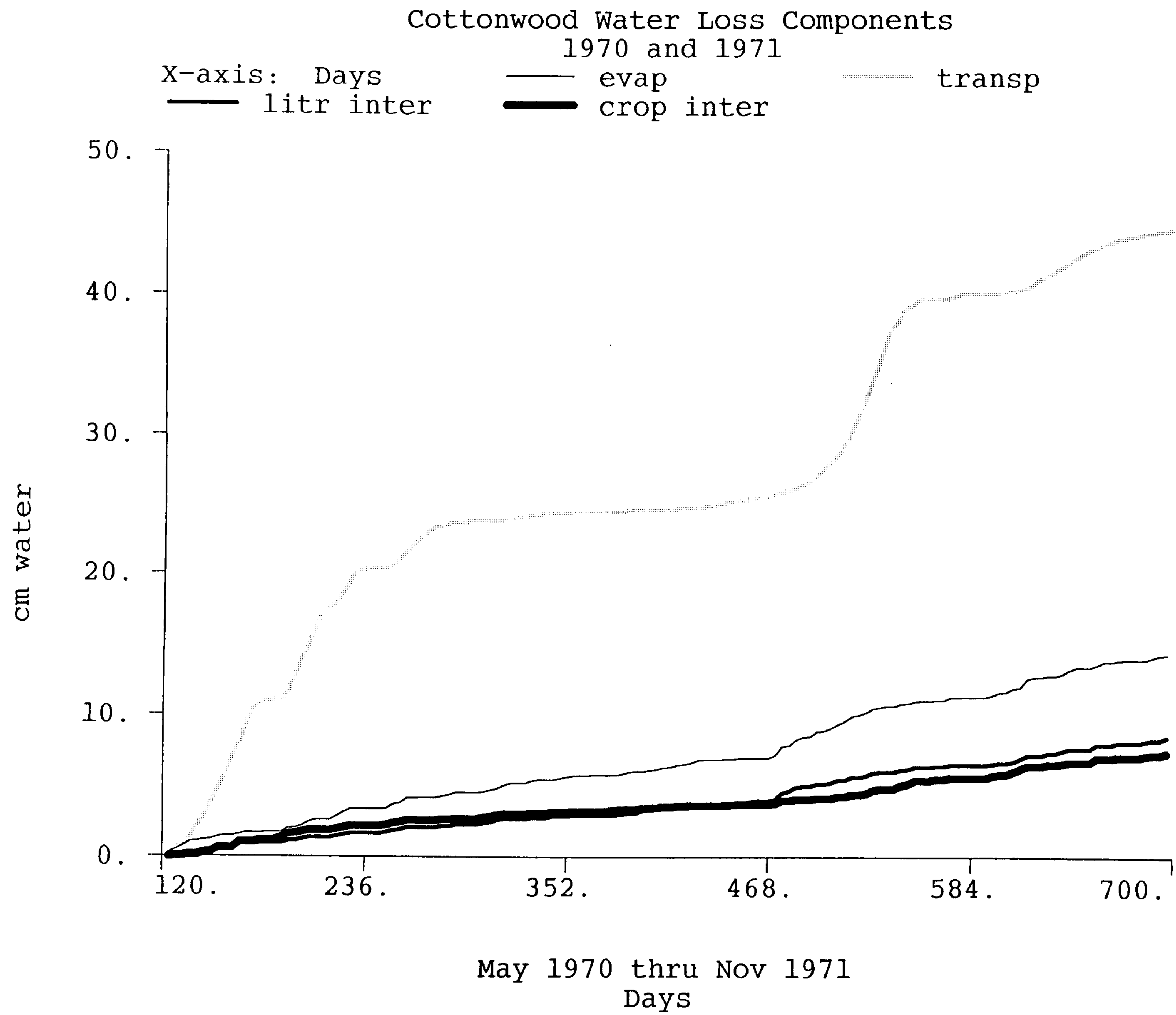
Red=band 4, Green=band 3, Blue=band 2

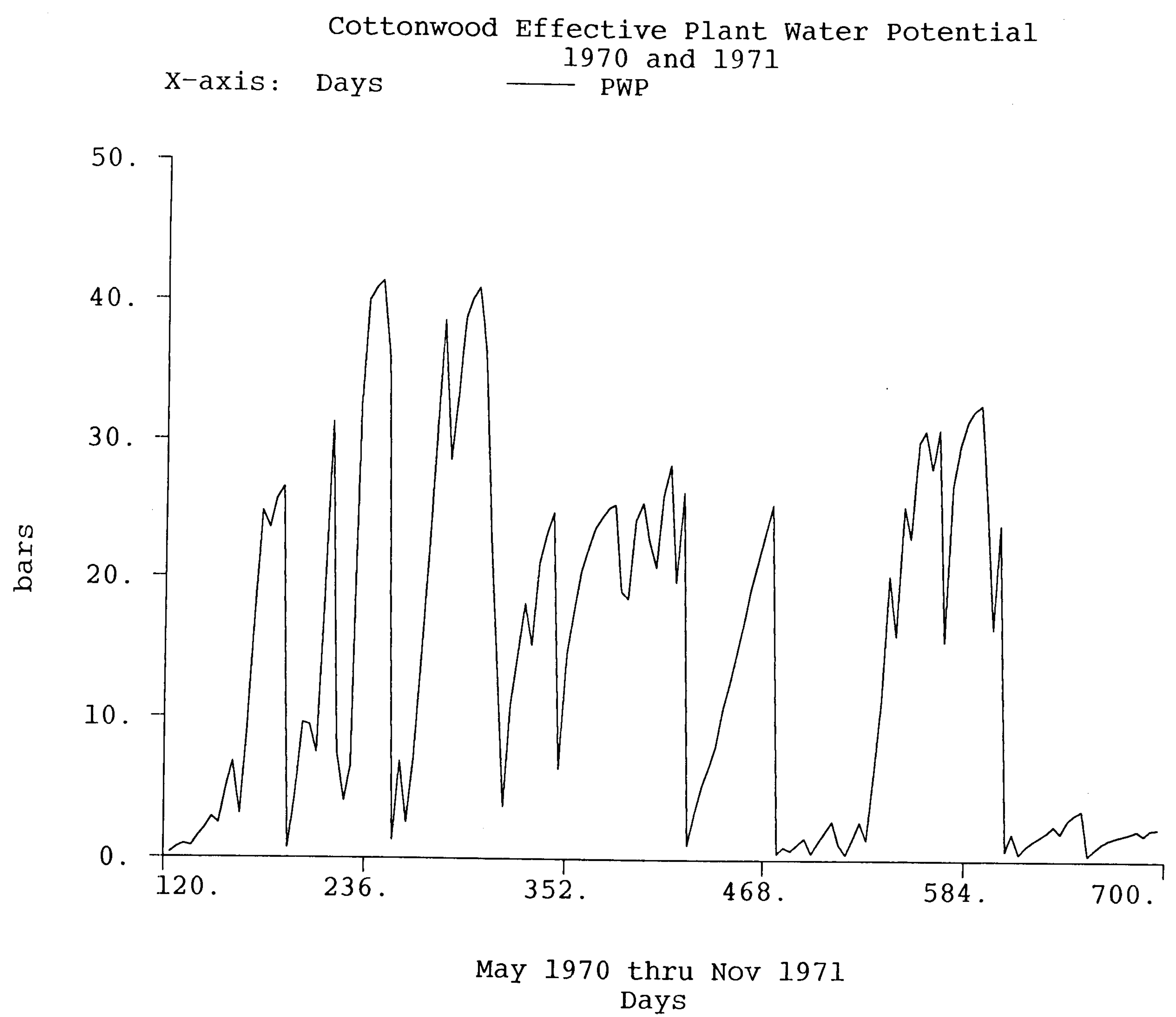

Cottonwood Live and Dead Shoots
1970 and 1971
X-axis: Days
BOGR live
AGSM live
BOGR dead
AGSM dead
grams carbon per meter square
60.
40.
20.
0.
120.
236.
352.
468.
584.
700.
May 1970 thru Nov 1971
Days



Cottonwood NPP for Two Species
1970 and 1971
X-axis: Days
AGSM
BOGR
grams carbon per square meter
200.
150.
100.
50.
0.
120.
236.
352.
468.
584.
700.
May 1970 thru Nov 1971
Days


Cottonwood 0-10 cm Soil Water
1970 and 1971
X-axis: Days
Simulated
Observed
4.
3.
2.
1.
0.
cm water
120.
236.
352.
468.
584.
700.
May 1970 thru Nov 1971
Days


Cottonwood Water Loss Components
1970 and 1971
X-axis: Days
evap
transp
litr inter
crop inter
50.
40.
30.
20.
10.
0.
cm water
120.
236.
352.
468.
584.
700.
May 1970 thru Nov 1971
Days



Cottonwood Effective Plant Water Potential
1970 and 1971
X-axis: Days
PWP
50.
40.
30.
20.
10.
0.
bars
120.
236.
352.
468.
584.
700.
May 1970 thru Nov 1971
Days

A large portion of the time was spent in modifying the model to run on the NREL VAX 730 and the SUN work stations and to interface with the improved abiotic submodel.

4.0 Image Processing and Geographical Information Systems (Lee D. Miller, University of Nebraska Lincoln)

Fourteen quadrants of TM data from 1985 have been translated from 6250 to 1600 bpi tapes and the study areas located in the TM quadrant. Considerable variation in location and some errors in coding were found. However, it appears that each study location should appear in only one quadrant of a TM scene. Data from all seven bands were registered and rectified to 7.5 minute quadrangle maps, and then natural color and simulated color infrared image maps were prepared of Cottonwood NE, and Cottonwood quadrangles for the Cottonwood site; of Wind Cave, Pringle, Cicero Peak and Mt. Coolidge quadrangles for the Wind Cave National Park site; and of Chalk Bluffs SW and Dover quadrangles for the Central Plains Experimental Range site. In order to include all of the sites on one image, image maps rectified to a fifteen-minute quadrangle were prepared for the Wind Cave National Park, and 7.5 x 15-minute image maps were prepared for the Cottonwood Range Livestock Research Station areas and the Central Plains Experimental Range areas. These image maps will form the base to which data for the Geographical Information System (GIS) and subsequent TM data for each site will be rectified. Simulated color infrared image maps for Cottonwood NE for July 11, 1985, and Wind Cave and Chalk Bluffs SW for mid-September, 1985, are shown in this report.

Digital line graphs and digital elevation model tapes have been ordered. The published soil survey for the Chalk Bluffs SW and Dover, Colorado quadrangles, and the research soil survey for portions of the Central Plains Experimental Range are being digitized. The research soil survey for the Cottonwood Range and Livestock Research Station is being digitized. Copies of the soil surveys for Jackson County and Wind Cave National Park in South Dakota have been obtained, even though they are still in press, and these are being entered into the GISs. A research soil survey for the study areas in Wind Cave National Park is planned for 1987. Locations of fences, water, extent and duration of occupation of prairie dog colonies, cultivated fields, and introduced pastures have been or will be obtained and will be entered in the GISs.

The Mapping and Image Processing System (MIPS) has been further developed and improved so that data handling is rapid and efficient for all formats of landsat data. MIPS has been extended to support the multispectral video image and data processing so that the 6 channels of digitized video data can be imported into MIPS and processed with any of the functions which it includes. The SPUR model written in Fortran is being translated into the C language and is about half completed. SPUR will be integrated into MIPS and used to simulate ecosystem operation aggregates of the spatial variation classified by MIPS.

5.0 Field Studies (James K. Lewis, Colorado State University)

5.1 Wind Cave National Park (J.K. Detling, Colorado State University)

Data were collected from two replicate prairie dog colonies. Gradients of disturbance by prairie dogs were separated into four levels ranging from uncolonized to severely disturbed. The delineation of the four levels of disturbance (treatments) was made on the basis of historical data on duration of colonization, density of burrows, and on the nature of the plant community. Ten 0.25 m^2 plots were clipped per treatment per replication at each sampling date inside and outside of cages. Data included standing crops of live, recent dead, and old dead vegetation by functional groups. Samples were taken at four dates: May 19-21, June 23-25, July 28-30, and September 2-3, 1986. These samples are being processed in the laboratory. Available data on animal densities, chemical composition of vegetation and soils, and weather data from the park headquarters will be made available to the principal investigator.

5.2 Cottonwood Range and Livestock Research Station (A.F. Schlundt, South Dakota State University)

Data were collected from two replicates of three range condition classes on two soils inside and outside of exclosures using weight estimation controlled by double sampling. Standing crops and dry matter percentages of live, recent dead, and old dead vegetation by major species groups were determined during the week of June 6, June 22-24, July 29-August 1, and August 11-15, 1986. Additional sampling is planned for mid to late October. An Exo-Tech 100 4-channel radiometer was used in the sampling. These data are being processed in the laboratory. Pastures were grazed with yearling steers which were weighed at 28-day intervals during the season. Weather, vegetation, animal, and soils data will be sent to the principal investigator as they are completed.

5.3 Central Plains Experimental Range

5.3.1 Crow Valley Livestock Association (Marvin C. Shoop, Agricultural Research Service)

Standing crops and dry matter percentages were determined by plant species and species groups using weight estimation with double sampling in which every fifth plot was clipped on two different projects. In the atrazine project, atrazine-treated pastures were compared with controls in two replications with 32 ha pastures grazed moderately by yearling cattle. One replicate had significantly larger amounts of shrubs than the other. Data were collected outside of cages June 2-3, July 1-2, July 28-30, August 25-26, and in mid October. Data were collected inside cages at the end of the season. Cattle were weighed monthly.

In the intensity of grazing project, 130 ha pastures were grazed heavily, moderately, or lightly by yearling heifers from May 22 through October 16. Replicated key areas of about 4 ha were delineated and sampled as described above on July 2-3, July 28-30, August 25-26, and in mid October. Cattle were weighed every six weeks.

Weather, vegetation, and animal data will be sent to the principal investigator as they are completed.

5.3.2 Long Term Ecological Reserve - Shortgrass Steppe (William K. Lauenroth, Colorado State University)

Due to the uncertainty of the availability of TM data for 1986 and due to the availability of pertinent data from on-going projects, no funds were expended in 1986. Data from the following projects will be available from 1986. More extensive collections are planned for 1987.

5.3.2.1 Efficiency of Water Utilization (Visiting Scientist, Liang Yimin)

Five different plant communities on different soils were studied. Measurements were made in three temporary exclosures (blue grama/saltbush, blue grama/buffalograss, and a seeded stand of introduced crested wheatgrass) and two permanent exclosures (western wheatgrass/saltbush and blue grama/half shrub communities). Standing crops of mulch and live, recent dead, and old dead vegetation were determined by major species by clipping on May 14, June 18, July 17, August 14, and September 15-18, 1986. Belowground standing crop of roots was determined at one date. Soil water was determined in 10 cm increments to 90 cm at two-week intervals. Soil water was determined gravimetrically in the upper 30 cm and with the neutron probe in the deeper layers. Detailed physical and chemical analyses of soils are being conducted.

5.3.2.2 Environmental Stress Study (Daniel Milchunas, Colorado State University)

Areas disturbed either by long-continued heavy grazing or by long-term exclusion from grazing were compared on swales and ridge positions with three replications during years with different weather patterns. The pattern in 1986 was a dry year following a dry year. Density and basal cover were measured by species and for total vegetation.

5.4 Aerial Instrumental Package (James K. Lewis, Colorado State University)

A multi-stage sampling scheme was planned for model validation, consisting of data from ground (stage one), low-flying aircraft (stage two), and satellite (stage three). The low-flying aircraft of stage two carried an aerial instrument package consisting of a multispectral video camera, a portable spectroradiometer system, and a photographic camera with color or color infrared film. An infrared thermometer and recorder were planned, but not budgeted, and we were unable to obtain suitable equipment on lease or loan.

A Xybion MSC-02 multispectral video camera with six rotating filters was purchased. Four of the filters matched the band pass of the first four TM bands as closely as possible. One was filtered to remove wave lengths longer than 0.43 um and one was a broad band filter passing light extending over the full range of sensitivity of the video camera. The camera was equipped with Fuji zoom lens, 12.5 to 75 mm. A Panasonic AG 2400 portable VHS video recorder and a JVC TM-22U portable video monitor was purchased.

The spectroradiometer system used consisted of a Spectron CE590 portable data analyzer with two Spectron CE 390 spectroradiometer heads (a wide band, .400 to 1.080 um, and an ultraviolet .200 to .440 um) and a portable oscilloscope (Non-Linear Systems MS-230 Miniscope). This system measures reflectance in 256 bands with the first two and last two devoted to parity checks. This equipment was leased from the University of Nebraska. A device was made to target the heads on one-cm^2 homogeneous areas from a tripod to develop spectroreflectance curves of known components of the landscape.

A 70 mm Hasselblad 500 EL with 80 mm f 2.8 Planar lens was borrowed from the Remote Sensing Institute at South Dakota State University. Problems were encountered with batteries and with magazines. A 35 mm Nikon F-3 with MD-4 motor drive and Nikkor 105 mm f 2.8 lens was purchased and the Hasselblad used as a backup camera.

An aircraft mount was built to fit on the seat rails of any Cessna and extend out the right door. The Federal Aeronautics Administration approved the mount in mid July for use with the Cessna 210 Turbo owned by CSU to be flown with the right front seat and right door removed. This mount held the video camera, one spectroradiometer head, and either the Hasselblad or the Nikon camera. The instrument operator sat on the right seat in the second row. An instrument rack was borrowed from the Atmospheric Sciences Department at CSU and mounted in place of the left seat in the second row. This rack held the video recorder, the video monitor, the Spectron CE 590 and the miniscope. Because wind noise prevented conversation between the pilot and the instrument operator, an intercom was added. The instruments were bore-sighted and temporally synchronized using a battery-powered relay separated from the spectroradiometer data analyzer with a diode. The relay energizes all instruments, the camera trigger on the CE 590 starts the video and triggers the Nikon as the spectroradiometer cycles. Cycling continues with one scan and a 35 mm exposure every 7 seconds until the magnetic tape on the CE 590 is full or until 36 exposures have been made on the Nikon.

An IBM-AT compatible computer, the HP Vectra 45, was purchased for data processing. The Vectra was chosen because of the Hewlett Packard reputation for quality, the claim for AT hardware and software compatibility, and because of a 38% discount to CSU, which made the Vectra the clear choice among name-brand AT compatibles.

A digitizer board was purchased from Xybion (ImCap 01) with software to digitize the video images and display them using a Vectrix VXPC-B board and an Electrotome ECM 1311 color monitor. The Mapping and Image Processing System developed by co-investigator Lee Miller will be used for video image and data processing. Image and data processing and statistical analyses will be done by Lewis at CSU.

A number of problems have developed with the aerial instrument package. The very new state-of-the-art mutispectral camera did not perform as expected and has been returned to the factory twice. The image capture board also malfunctioned and was repaired by the factory. As noted above, problems were encountered with the Hasselblad camera and it was replaced with a Nikon. The wideband CE 390 head began to operate erratically and has been returned to the factory for repair. The Vectrix VXPC-B board was not compatible with the Vectra monochrome monitor.

Data were taken over the Central Plains Experimental Range on July 14, August 1, and October 10, and over Cottonwood and Wind Cave on July 29. Additional flights are planned for the fall as soon as the equipment is ready.

Funds are being sought from other sources to improve the aerial instrument package by adding a Loran C navigation system, a lap-top computer and an electronics package to synchronize the instruments and record on the lap-top disks. A gyroscope may be added later.

Our objective with the aerial instrument package is to incorporate high spatial and spectral resolution with precise ground location into the stage 2 sample data on areas large enough to be related with statistical precision to the stage 3 landsat TM data.

5.5 Field Data Processing (James K. Lewis, Colorado State University)

Data from the field sites and from the aerial instrument package will be placed onto D-Base III Plus and analyzed statistically with the SAS System Release 6.02 for microcomputers and with Statgraphics using the HB Vectra. Data from the field sites are expected in late fall. Files and programs are being developed to be ready for the data when it arrives.

6.0 Data Integration (James K. Lewis, Colorado State University in cooperation with the other investigators)

Plans are being made with the various investigators for integration as data from modeling, field sites, aerial instruments, and satellite become available.

7.0 Deviations from the Project Plan

7.1 Budget Carryover

Since this was a lump sum contract, some freedom was exercised in scheduling activities between years. The uncertainty of the availability of TM data as explained in section 2.0 caused adjustments in the scheduling of work, especially on the field sites. Sampling for chemical composition of the vegetation at each field site was postponed from 1986 until 1987 and the analyses were delayed for a year. Ongoing research under the Long-Term Ecological Reserve-Shortgrass Steppe at the Central Plains Experimental Range was used and the funds carried over for more detailed studies during 1987. Instrumentation problems in the aircraft instrument package reduced the number of flights that could be flown. Discounts on equipment bids resulted in less expenditure for items designated equipment. For these reasons, there were budget carryovers from 1986 to 1987 from South Dakota State University, Colorado State University, and the Crow Valley Livestock Association.

7.2 Equipment

Technology is progressing so rapidly that it is very difficult to remain current. Purchase of some items of equipment were delayed in the expectation of new developments. Furthermore, prices have been falling rather rapidly. The following items of equipment are needed for the activities of the Principal Investigator for efficient operation of the project. Estimated costs are very approximate. Funds are not adequate to purchase all of the equipment listed. Priorities will be assigned according to need and purchase opportunity. No additional funds are being requested.

IBM AT compatible (clone) with 50 mb hard disk	$2500
Optical disk drive or, if not, feasible interactive open reel tape drive	3500
Slide digitizing system	3000
Color printer or film recorder	3000
Color monitor for HP Vectra	650

A second computer is needed because of the volume of work associated with data processing, statistical analyses, word processing, chart preparation, and the image and data processing for the aerial instrument package. Also, some of the modeling will be done on the microcomputer. The Hewlett Packard Vectra was advertized as being hardware and software compatible with the IBM AT. No exceptions were known at the time of purchase. However, some have now developed which we are trying to work around. Operation would be easier and more efficient with a second micro-computer.

Digitized data from the six channels of the multispectral video camera for two scenes require one megabyte of storage. Data are collected at the rate of one megabyte every fifth of a second during use in flight. While it is possible to select scenes to be digitized from the tape, we are still inundated with data. Furthermore, we have no data backup. It is expected that some five companies will display optical disk drives at the COMDEX show in November. The typical disk is expected to store 500 to 800 megabytes. Drives are expected to cost about $3500 and be available in the spring. If these expectations do not develop, we can meet our needs less efficiently with interactive open reel tape drives for a similar cost.

We are obtaining very high resolution 35 mm color slides from the aerial instrument package. These images need to be digitized to provide data that can be incorporated into the stage two samples. At present we have no way to do this.

At the present time we have no way to produce images from the computer in our laboratory. This can be done with a high quality color printer or with an electronic film recorder.

A color monitor for the HP Vectra is needed for use with statistical and graphics packages.

7.3 Scheduling of Semi-Annual Progress Reports

This semi-annual progress report was delayed so that the progress of data collection during 1986 could be reported more completely. The next report is planned for April to document more completely the progress of data processing and planned details for 1987 data collections.

James K. Lewis

James K. Lewis
Principal Investigator
October 31, 1986