# N O T I C E

# BIOGEOCHEMICAL PROCESSES IN SAGEBRUSH ECOSYSTEMS: INTERACTIONS WITH TERRAIN

SEMI-ANNUAL REPORT
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Pamela Matson          NASA-Ames Research Center
William Reiners        University of Wyoming
Laurence Strong        Technicolor Government Services, Inc.

I.   Recapitulation of objectives

   A.   Original proposal

      1.   <u>Objective 1.</u>  Describe the vegetational pattern on the landscape and elucidate controlling variables.

      2.   <u>Objective 2.</u>  Measure the soil properties and chemical cycling properties associated with the vegetation units.

      3.   <u>Objective 3.</u>  Associate soil properties with vegetation properties as measured on the ground.

      4.   <u>Objective 4.</u>  Determine the long-term effects of conversion from sagebrush dominance to grass dominance.

      5.   <u>Objective 5.</u>  Develop remote sensing capabilities for vegetation and surface characteristics of the sagebrush landscape.

      6.   <u>Objective 6.</u>  Develop a system of sensing snow cover and indexing seasonal soil water availability.

      7.   <u>Objective 7.</u>  Develop relationships between temporal TM data and vegetation phenological and physiological status changes.

   B.   Revised proposal

      1.   Revised objectives

         a.   <u>Objective 1.</u>  Describe the vegetational pattern on the landscape and elucidate controlling variables.

         b.   <u>Objective 2.</u>  Measure the soil properties and chemical cycling properties associated with the vegetation units.

         c.   <u>Objective 3.</u>  Associate soil properties with vegetation properties as measured on the ground.

         d.   <u>Objective 4.</u>  Dropped

         e.   <u>Objective 5.</u>  Develop remote sensing capabilities for vegetation and surface characteristics of the sagebrush landscape.

         f.   <u>Objective 6.</u>  Develop a system of sensing snow cover and indexing seasonal soil moisture.

         g.   <u>Objective 7.</u>  Develop relationships between temporal TM data and vegetation phenological state.

      2.   Task eliminations by UW group

         a.   biomass estimations of vegetation (except as measured with capacitance meter)

  b. physiological measurements on plants
  c. soil moisture measurements (except for % moisture content)
  d. reduction in depth (from 120 cm to 15 cm) and number of profile horizons (from 7 to 2) for estimates of soil pools
  e. conversion effects
  f. ground-based snow survey (USFS data available)

 3. Reorganization of UW work by major categories and responsibility

  a. vegetation (WAR)
  b. soil processes (ICB)
  c. transport (WAR)

## II. Vegetation

 A. Sampling design for vegetation relationships to biochemistry and slope position

  1. 6 parallel transects across Loco Creek Watershed 60 m apart (see map)

  2. Plots located randomly along lines within each 60 m line segment

   a. omissions occurred when plots fell in grass conversion plots or the riparian zone. Result: 89 plots

  3. At each plot, 4, 400 cm line intercept lines were established 1.5 m apart oriented perpendicularly to the transect line.

  4. Vegetation cover was estimated to, and centered on, the nearest cm on 12-17 June.

   a. This was the period of peak flowering among cushion plants and many forbs
   b. Grasses were aggregated to a degree because of their variable stages of development and non-identifiable states to include these classes: Poa, Leucopoa, Festuca, Koeleria, Agropyron, Stia, unknown grass, unknown sedge
   c. Bare ground and dead sage skeletons were treated as ground cover units
   d. Erodability indices were recorded at each plot

  5. Data on flora and apparent dominance were gathered in the riparian zone and the nearest nivation circque by Mary Nabors on 23 August 1985.

 B. Sampling design for TM analysis

  1. Field data collection to support analysis of TM data was accomplished from June 22 to August 28th. Color infrared aerial photography acquired by a U2 on June 12, 1985 was used to locate and identify several vegetation communities. Forty sites where the USFS has collected long term ground cover were located in the field, delineated on aerial photos and ground photos of current conditions taken.

  2. Quantitative measurements of ground cover and phytomass production were made at six 30-by-30m primary sample units (PSUs) to characterize these variables at the scale of the Thematic Mapper. Sample units were selected

# Sampling Design
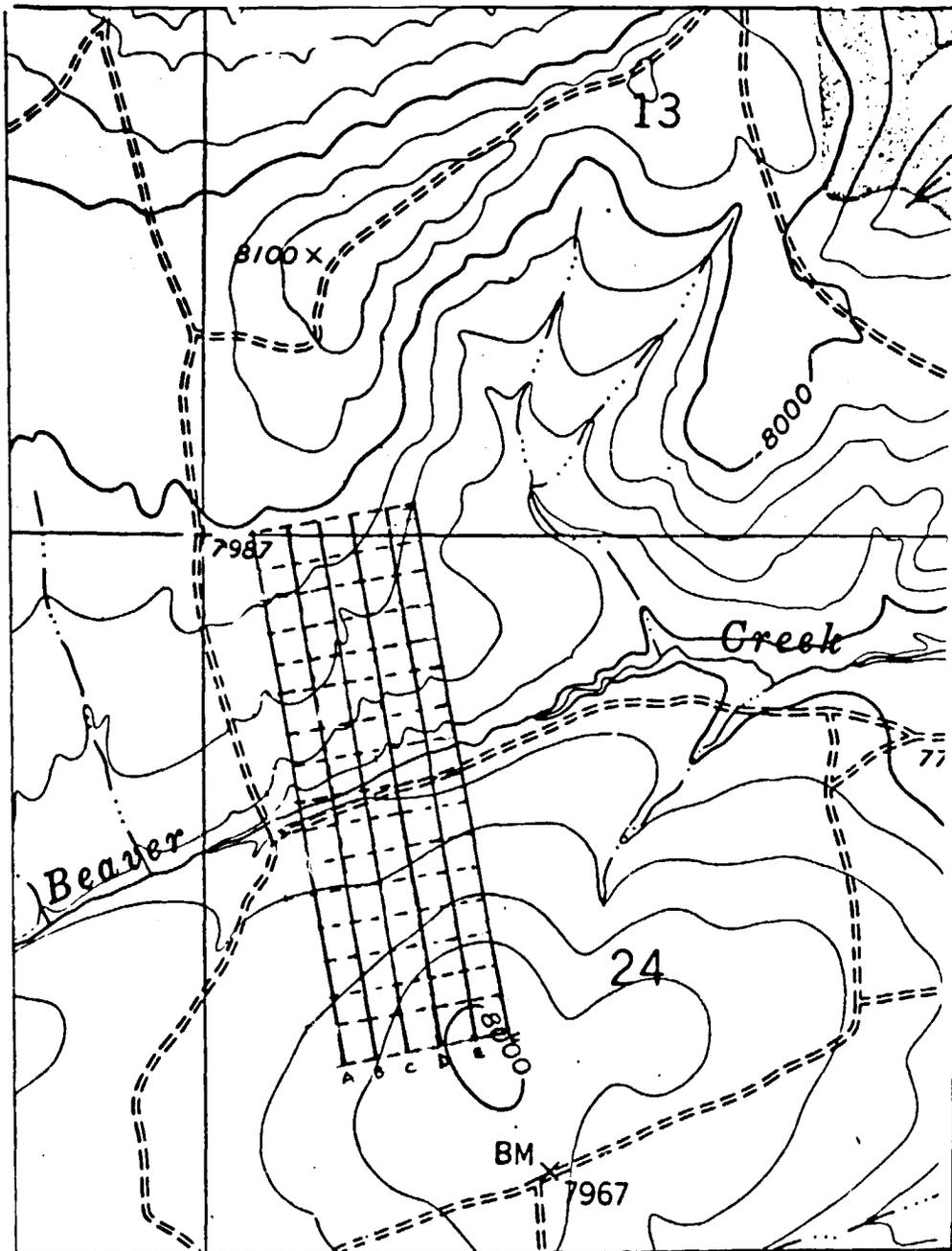


TRANSECT

GRID UNIT,
60 m SEGMENTS

to represent maximum variability in the sagebrush communities. Three sites were located in mountain big sagebrush communities; one site had an abundance of lupine, and the other two were a fence line contrast of gazing treatments. Three sites represented a gradient in low sagebrush communities; one site was dominated by black sagebrush, another by a mixture of black and Wyoming sagebrush, and third site was dominated by Wyoming sagebrush. The data collected at each PSU included capacitance meter measurements and clipped plots for estimating phytomass production, line-intercept measurements of shrub canopy coverage, ocular estimates of coverage for grasses, forbs, and litter, bare ground, erosion pavement and rock within 20-by-50cm quadrats, and shrub height measurements. This data and the vegetation/biogeochemistry maps discussed in Section II will provide a data base for correlation with spectral data.

3. Dr. David Sturges (USFS) has agreed to provide 1985 phytomass production data for two basins in the study area. The USFS will also provide meteorological measurements including precipitation, snow accumulation, air temperature, wind speed and direction, and solar radiation. Data collected in previous years, including soil water content and soil survey data, also have been provided.

C. Data analysis

1. Line intercept data were converted to % cover.
   These data are available for each plot. In addition, data were aggregated for each plot in the categories: 1) total shrub cover, 2) total grass cover, 3) total cushion plant cover, and 4) total non-cushion forb cover.

2. % cover data from all plots were entered into an agglomerative hierarchical clustering analysis (BMDP2M) using the chi-square statistic for distance measure and centroid linkage. This analysis was run twice, once with all species (and bare ground), and once with each of the 3 sage sp., total grass, total cushion plants, total non-cushion forbs, bare ground, and Purshia.

D. Results

1. Detailed cover data

2. Tentatively accepted vegetation classes

   a. Artemesia nova (16 plots)
   b. grass-Artemesia nova (7 plots)
   c. Artemesia nova-grass-cushion plant (10 plots)
   d. mixed short Artemesia-grass (12 plots)
   e. Artemesia tridentata subsp. wyomingensis (8 plots)
   f. Artemesia tridentata subsp. wyomingensis-grass (10 plots)
   g. Artemesia tridentata subsp. vaseyana-grass (14 plots)
   h. Artemesia tridentata subsp. vaseyana (12 plots)

E. Phenological recording

1. A numerical system for characterizing shrubs, forbs and grasses was worked out by WAR and used along the F line for every overpass date except one

during the summer. Data were collected on 9 June, 27 June, 8 July, 25 July, 23 August, 17 September. This data will be used to meet Objective 7.

F. Landscape characterization and mapping

1. Boundaries between vegetation classes have been located through the use of observations and auxiliary photos. All necessary measurements have been collected, but contour map is not yet finished.

2. Measurements for wind exposure scalar have been collected, but not incorporated.

3. Prepare ms. (hKO lead).

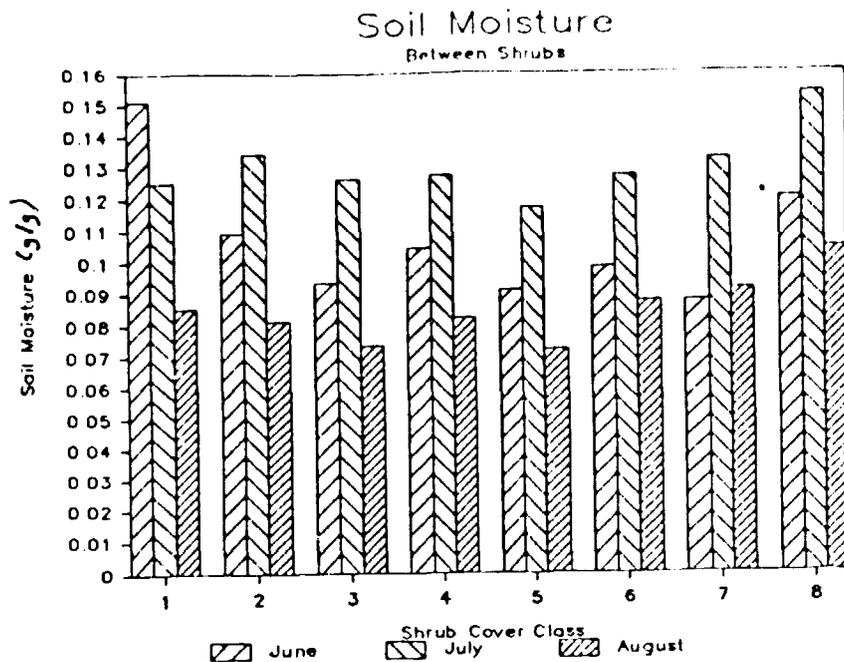4. Scale up to large areas with LLS.

G. Work remaining

1. Contour map completion and mapping of vegetation type.

2. Multivariate analysis of vegetation over landscape (using contour map and wind exposure scalar).
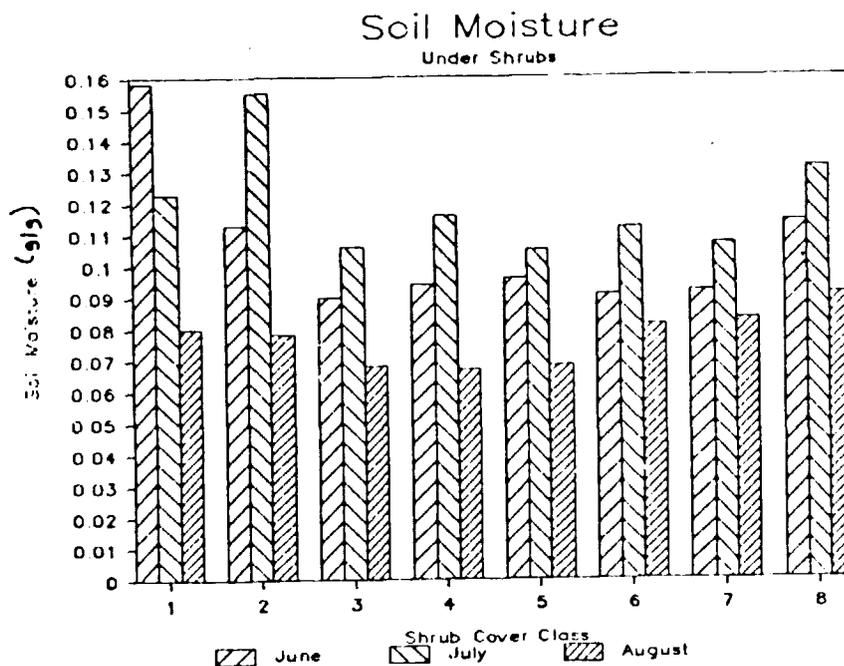
3. Manuscript on vegetation patterns.

III. Soil Processes

A. In situ, net mineralization rates

1. Design

a. Vegetation plots were visually stratified into 6 types (previous to vegetation sampling). Within each type, 5 plots were randomly chosen for intensive soil process studies.

b. For all sampling within these plots, there were 3 replicates between shrubs and three replicates under shrubs.

2. Methods

a. Buried bags were placed in each plot on June 1, July 1, and August 1 for 30 days. These were at a depth of 5-15 cm.
b. Nitrate, ammonium, and available phosphorus (by the sodium bicarbonate extraction method) were measured at the beginning and end of each incubation period.

3. Results

a. The 30 plots fell out into the 8 vegetation classes designated in the vegetation study.

b. Net ammonification, nitrification, and N-mineralization have been calculated, and means are shown in Figures 1-6. Soil moisture was highest in the July buried bags (Figs, 1 and 2) due to rainfall just

## Soil Moisture
### Between Shrubs

Soil Moisture (g/g)

0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0

Shrub Cover Class

June    July    August

## Soil Moisture
### Under Shrubs

Soil Moisture (g/g)

0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0

Shrub Cover Class

June    July    August

Figures 1 and 2.   Soil moisture at landscape positions grouped into
eight shrub cover classes: 1-- Artemesia tridentata ssp. vaseyana,
2-- A. tridentata ssp. vaseyana mixed with grasses. 3-- A. tridentata
ssp. vaseyana, A. tridentata ssp. wyominensis, and grasses, 4-- A.
tridentata ssp. wyomingensis, 5-- A. tridentata ssp. wyomingensis mixed
with grasses, 6-- A. nova, 7-- A. nova mixed with grasses, and 8-- A.
nova, grasses and cushion plants.  Figure 1 represents soil moisture
at between-shrub positions within these shrub cover classes, and Figure
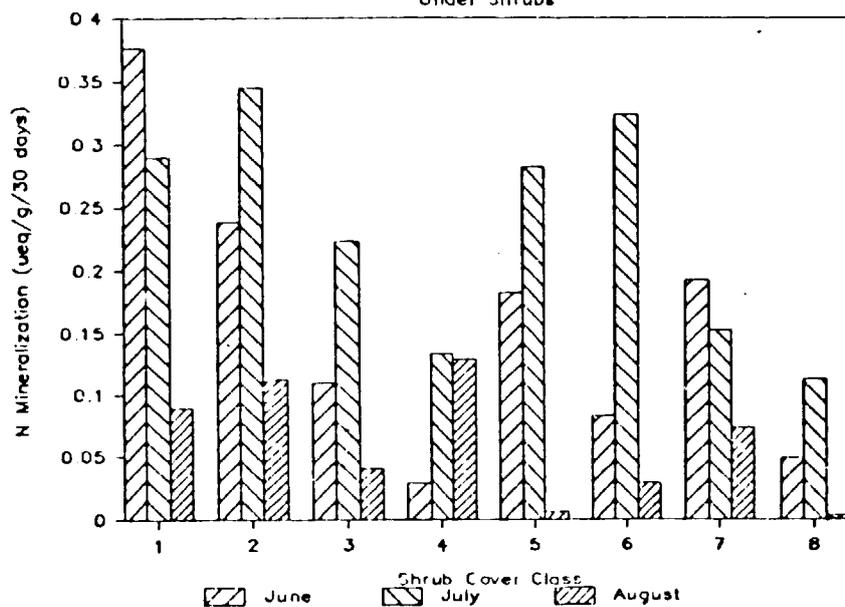2 represents the under-shrub positions.

N Mineralization
Between Shrubs
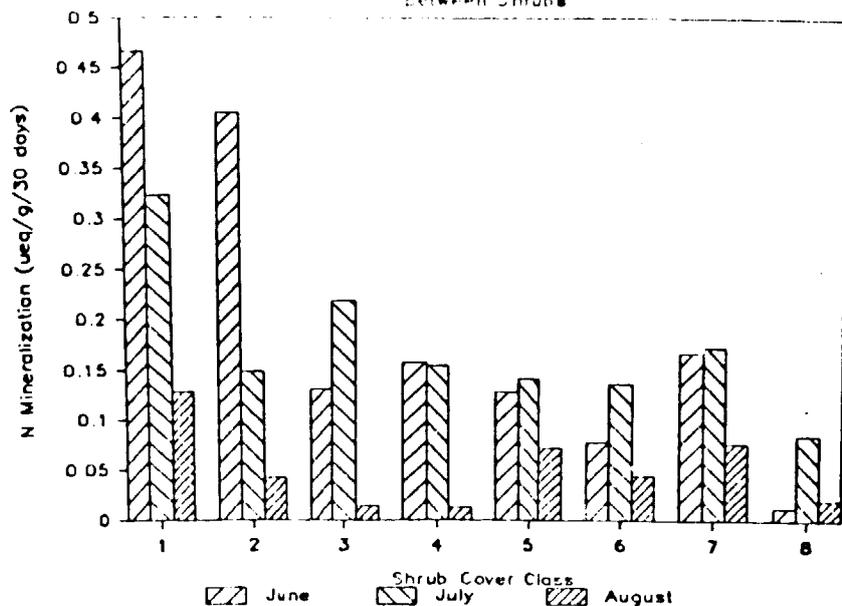


N Mineralization
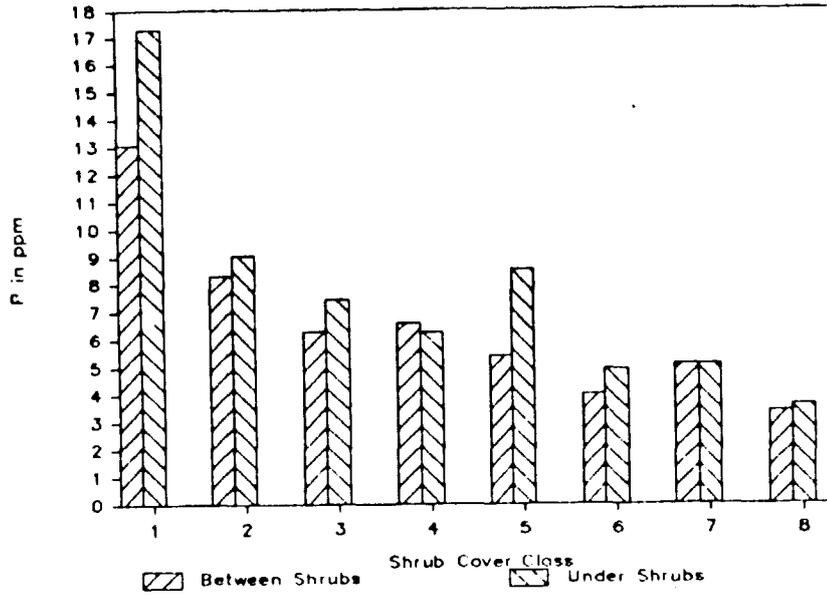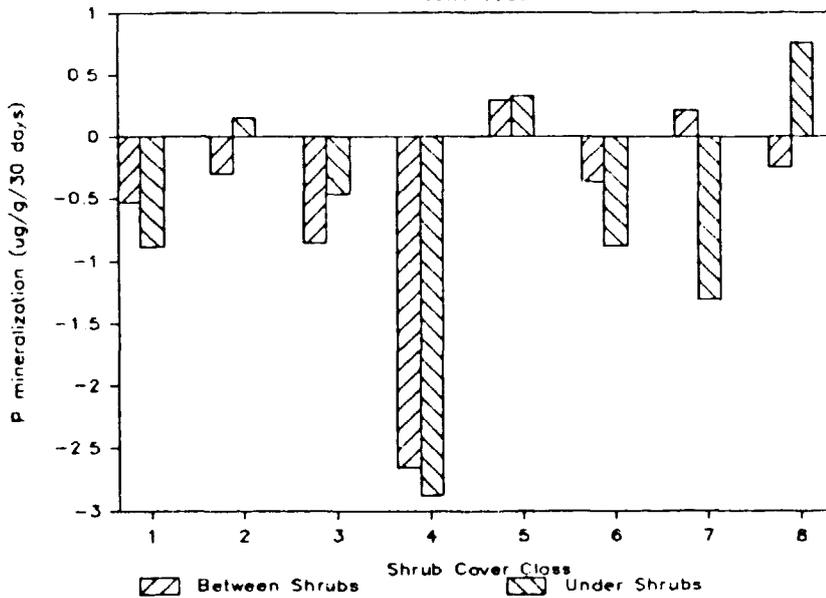Under Shrubs

Figures 3 and 4. Nitrogen mineralization rates at landscape positions grouped into the eight shrub cover classes described above. Figure 3 represents N mineralization rates at between-shrub positions within these shrub cover classes, and Figure 4 represents the under-shrub positions.

## Available P
### June 1985



## P mineralization
### June 1985



Figures 5. and 6. Available phosphorus and phosphorus mineralization for the month of June at landscape positions grouped into the shrub cover classes described above. Within shrub cover classes, the data are stratified into between-shrub and under-shrub positions.

prior to sample collection and incubation. The exception was the _Artemesia tridentata_ ssp. _vaseyana_ shrub cover class (#1), which probably had received the highest snow melt in June. Both the _Artemesia tridentata_ ssp. _vaseyana_ shrub cover class and the _A. tridentata_ ssp. _vaseyana_-grass shrub cover class seem to have had more soil moisture than the other shrub cover classes in June. There were no consistent trends in between shrub vs. under shrub soil moisture.

Nitrogen mineralization rates (Figs. 2 and 3) were closely related to soil moisture, in that they were generally highest in July and lowest in August, with the exception of the _A. tridentata_ ssp. _vaseyana_ shrub cover class. Mineralization rates in June were clearly highest in the _A. tridentata_ ssp. _vaseyana_ shrub cover classes (1 and 2), and lower in the _A. tridentata_ ssp. _wyomingensis_ and _A. nova_ shrub cover classes. There were not consistent differences between shrub positions (under and between) in any month.

June available phosphorus content (Fig. 5) was highest in the _A. tridentata_ ssp. _vaseyana_ shrub cover class (1), and generally, decreased in the direction of the _A. nova_ shrub cover classes. There was generally more available P under shrubs than between shrubs.

Net phosphorus mineralization rates (fig. 6) for the month of June were calculated as the differences in sodium bicarbonate extractable P at the beginning and end of the incubation. There were apparently no patterns in P mineralization either among shrub cover classes or between shrub positions. Our P mineralization index reflects both net biological P mineralization processes and inorganic processes which fix P to soil complexes. More detailed studies would be necessary to separate the patterns of biological and inorganic processes across the landscape.

B. Laboratory net and gross mineralization rates

1. Design

   a. Three of the vegetation classes determined in the vegetation study were chosen for intensive study. These were the Artemesia tridentata ssp. vaseyana type, the Artemesia nova type, and the intermediate Artemesia tridentata ssp. wyomingensis type. These are essentially representative of toeslopes, exposed ridges, and midslopes, respectively. Three plots in each of these vegetation types were randomly selected from the subset of 89 vegetation plots which were used in the buried bag studies and which were restricted to the south slope (north-east facing) of the study site.
   b. Within each of these 9 plots, 3 replicate subsamples were taken from 0-5 cm between shrubs, 0-5 cm under shrubs, 5-15 cm under shrubs, and 5-15 cm between shrubs.

2. Methods

   a. A subsample to each replicate was buried for 30 days to be used for determining net N and P mineralization, as described above.
   b. The rest of the samples were used for laboratory incubations. The

three replicates were composited, and each composite was amended with 15-N and incubated for 0, 5, 15, and 30 days. The following chemical analyses have been or will be made:

NH4, NO3 and 15N content:  Day 0, 5, 15, 30
microbial biomass N, 15N, and C:    5, 15, 30
carbon respired                     5, 15, 30
available phosphorus        0,        30
microbial phosphorus                  30
total N, P, and C                     30

See the experimental plan for details.

3.  Results

   a.  Using the above data we can calculate:
       net and gross N mineralization rates
       net P and C mineralization rates

   b.  We can test for differences among vegetation types and between microsites using an analysis of variance for each depth. We will test all of the rates and all of the pools in this way.

C.  Soil pool estimates

   1.  Collection design

      a.  The same design was used as for the buried bag studies, The same 30 plots were cored at two depths, 0-5 cm and 5-15 cm, and in two positions, between and under shrubs.
      b.  Two replicated cores were collected from each depth-microsite combination in each plot.

   2.  Analyses

      a.  C (by culometry)
      b.  total N (block digestion-auto analyzer)
      c.  total P (same)
      d.  texture (Bouyoucos method)

D.  1986 experiments

   1.  Test for effects of substrate quality versus site characteristics.

      a.  Translocate surface soil (both under and between) in buried bags between 5 vegetation types for each of 3 months. Cross-compare N and P net mineralization from each of the 5 types along the environmental gradient represented by each type. Bring all materials up to an initial common moisture level (field capacity).

   2.  Test for seasonal changes in the environmental gradient with long term buried bags in each of five locations, withdrawing bags each month and inserting fresh bags each month to separate environmental conditions from substrate change effects.

E.   Work remaining

   1.   15N diffusions and 15N determinations (III, B)

   2.   Digestions for total N and P (III, C), and analysis of carbon.

   3.   Data entry and statistical analyses for field nitrogen cycling measurements (III,A)

   4.   Extrapolation of rates and pools to

      a.   vegetation units of intensive grid area
      b.   larger scale landscape units

   5.   1986 experiments

IV.  Transport Processes

   A.   The processes which are involved in transport of material into and out of sagebrush sites include, wind movement (potential vs. actual definition), stepwise sheetwash, periodic rill wash, shrub island particle capture, lithologic control of SW-facing slope, and altithermal terrace breakdown and floodplain accumulation. Our intent is to measure net erosion, and we do not intend to separate out the above processes.

   B.   Sampling design

   1.   LEMI stakes

      a.   1 stake was randomly located in corridors between vegetation transects in each 60 m transect unit
      b.   22 additional stakes were systematic-randomly located in obvious erosional features in the same area

   2.   Original plan  The original intent was to install deep-seated rods at each position with which to take periodic measurements via a LEMI (Linear erosion measurement instrument) to estimate net surface change. Those data would be organized in terms of local topographic features to develop a statistical model of surface change in that landscape.

      a.   It was discovered that rods could not be driven into even the soft sandstone satisfactorily so the LEMI approach was abandoned.

   3.   Revised plan  The same stakes and the same statistical approach is followed but with 137Cs estimates of long-term surface movement.

      a.   2, 20 cm samples were collected at each stake position in September 1985 for a total of 150 samples.
      b.   Samples were sieved for fine earth and oven dried
      c.   Samples are being counted for 137Cs in a gamma counter over winter 1985-86
      d.   Statistical modeling will be done over winter 1986-87

C.    Extrapolation of slope movement results to larger landscape units with LLS.

D.    Other possible collections and experiments

1.    depth stratification for 137Cs
2.    fluorescent sand grain experiments for testing actual vs. potential erosion

V.   Remote sensing of vegetation and surface characteristics

A.    1.    Data acquisition. Quads 3 and 4 of path 35 row 31 were sufficiently free of
clouds (< 30%) for 5 dates of the 11 acquisitions between April 1 and
September 15, 1985 (Table 1).

2.    Selection of control points for image-to-image registration of the data was
accomplished using the block correlation method.  An affine transformation
of the approximately 190 control points for each date, resulted in subpixel
residual mean square errors.  Inspection of the coefficients of the
transformation equations revealed only the constant terms for samples were
important.  Constant terms for samples varied from 50 to 79 samples among
the dates.  Thus, image-to-image registration of the five dates was
accomplished by offsetting images by the sample constant term.  Quads 3 and
4 were united for each date.  These registered and united TM data provide a
data base consisting of a time series of TM data from May 22 to July 26
1985.  The data base provides coverage of the Stratton Sagebrush Hydrolog/
Study Area and the distribution of sagebrush steppe from Saratoga, Wyoming
south along the North Platte River drainage to the Colorado border.

B.    USGS 7.5 min digital elevation tapes for the Jack Creek Reservoir and Middlewood
Hill quads were acquired.  The two quads provide coverage of the Stratton
Sagebrush Hydrology Study Area and will be used to model the illumination
geometry during each of the TM acquisitions.

C.    Work remaining

Development of vegetation coverage and phytomass indices, and the construction
of vegetation maps.

IV.   Development of a system of sensing snow cover and indexing seasonal soil water

A.    1.    Cloud cover on the April dates of the Landsat-5 TM acquisitions and a
conflict with the Space Shuttle for use of TDRS on May 6, 1985 resulted in
no TM imagery of the study area prior to May 22, 1985.  By May 22 snow had
melted from all areas except the largest drifts.  A search for cloud free
acquisitions earlier in 1985 was unsuccessful.  Investigation of TM
acquisitions in 1984 also show clouds for all dates except January 1 and
February 2.  TM data for these dates has been ordered from EROS.

2.    The possibility of using Landsat-4 MSS data to supplement the late spring
scenes is being considered.

B.    Plans are being formulated for presentation to Dr. David Sturges for USFS
assistance in the collection of ground snow measurements in the spring of 1986.

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Table 1.  Status of TM data requested for 1985.

| April | 4 | 1985 | Clouds |
|-------|----|------|--------|
|       | 20 |      | Clouds |
| May   | 6 |      | Shuttle conflict with TDRS |
|       | 22 |      | Received |
| June  | 7 |      | Received |
|       | 23 |      | Received |
| July  | 9 |      | Received |
|       | 25 |      | Received |
| Aug   | 10 |      | Status unknown |
|       | 26 |      | Clouds |
| Sept  | 11 |      | Clouds |

VII.  Investigator meetings

  A.  First Investigators Meeting, September 10-11, 1985.  Laramie, Wyoming

  B.  Second meeting planned for March 11-15.  NASA-Ames Research Center

VIII.  Presentations

  A.  Presentation of plan at TM-AO Investigators Meeting, September 12-13, 1985.
      Indianapolis, Indiana

  B.  Planned presentation in Global Biogeochemistry Symposium, INTECOL Meetings,
      August 11-16, 1986.  Cornell University