Technical Report No. 35

FIELD DATA COLLECTION PROCEDURES FOR THE COMPREHENSIVE NETWORK 1970 SEASON (REVISED)

Coordinated by Norman R. French

Comprehensive Network Director

GRASSLAND BIOME

U. S. International Biological Program

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INTRODUCTION

One of the primary objectives of the Comprehensive Network is to obtain data from a variety of grassland types which will permit testing of the method and results of models emanating from the efforts at the Intensive Site. A second and equally important objective is to evaluate function and structure of the grassland ecosystem under various environmental conditions. To achieve these objectives a series of sites was selected through the cooperative efforts of scientists at a number of universities and research institutions. Each of these sites fulfills a minimum set of requirements that are necessary in order to obtain comparable information from the different environments represented.

In order to make operating plans based on these specific objectives of the Comprehensive Network, three meetings were held in 1969. The purpose of these meetings was to lay plans for methods of sampling, data reporting, and analysis that could be applied in investigations of each trophic level of interest at all sites involved. The utility of the data obtained during the first season's effort in the Comprehensive Network will be a direct result of the achievements of those meetings, and of the cooperative endeavors of all participating investigators. If the objectives of the Comprehensive Network program are to be attained, then it is essential that the work at different sites be as nearly comparable as possible. Only if this plan is followed can comparisons of the function and structure of the grassland ecosystem under widely differing environmental conditions be made. Likewise, the generality of the ecosystem model and the comparative value of results from the investigations at the Intensive Site will hinge on the applicability of these data obtained from the Comprehensive Network Sites. For these

reasons, the methods and techniques are being spelled out in detail in this manual. It will be distributed to all investigators, and should be available to all field workers who are involved in this program. It is important not only that the manual be followed in the field effort during the first season, but it is also important that the problems encountered in the field operation during this first season be documented for later improvement of this manual. For this reason, all users are requested to furnish information of their experiences to the Comprehensive Network Director.

BASIC DESIGN

Whenever possible, each site in the Comprehensive Network will consist of at least one grazed and one ungrazed treatment with two replicates for each treatment. Ideally, these areas should be sufficiently large so that all types of sampling planned in the Comprehensive Network studies can be made within each area (about 30 acres or 13 hectares). Each treatment and replicate should be conspicuously labeled in the field so that all workers may clearly identify their data sheets. Each area should be mapped and marked with stakes to facilitate location of sampling points.

BASIC FIELD DATA

A general information form may be used to record information concerning the site and conditions at the time of sampling. Although this information will not become a part of the data in the information storage and retrieval system, it will be useful reference material in case there are questions concerning weather conditions at the time of sampling, time required for sampling, etc. A sample form follows.

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GENERAL INFORMATION SHEET

Site_____ Date_____ Time_____ Investigators _____

Type of study and methods _____

Treatment _____ Plot: Size _____ Shape_____ Number_____

Weather: Temperature_____ Wind _____ Cloud_____

General comments _____

Average time requirements: Locating sample plots or quadrats _____

Ranking _____ Clipping _____ Coring_____

Trap setting _____ Baiting _____ Checking _____

Sequential day of trapping or sampling _____

Burying/retrieving samples _____

Other _____

Additional measurements taken: _____

Remarks: _____

NREL-OD NATURAL RESOURCE ECOLOGY LABORATORY - COLORADO STATE UNIVERSITY - PHONE (303) 491-5571 - FORT COLLINS, COLORADO 80521

For convenience and rapidity of processing data, standard field data sheets will be utilized at all sites. The sheets are designed for ease of recording raw data in the field, and for convenience of transcribing these data to punched cards for machine processing. The data sheets are color coded by data type for convenience of handling and sorting. White and other light colors have been avoided for field use because of reflectance in bright light and resulting eye discomfort. The forms are bound together at the bottom, to prevent their movement by wind when the top is secured by a clip board.

Each set of data must be accompanied by certain identifying information. These basic data occupy the first 19 columns of an 80-column punched card, and are outlined below (X's indicate number of characters to be punched).

XX TYPE OF DATA - code for aboveground biomass, litter, small mammal, etc.

XX SITE - code for ALE, BISON ... PANTEX

XXX INITIALS - for initials of *Field Worker* recording the data

XXXXXX DATE - two spaces each for day, month, and year, in that order

X TREATMENT - code for type of treatment

X REPLICATE - taken from marker sign at field plot

XXXX PLOT SIZE - quadrat or plot size (for vegetation the length of the side of a square quadrat, i.e., 0.50, 0.25 m, or area in hectares for birds, mammals, i.e., 3.24, 10.5)

HERBAGE DYNAMICS - ABOVEGROUND BIOMASS

Sampling Methods

Aboveground biomass refers to standing live plant material and standing dead plant material. Sampling sites will be located randomly within

replicates. The sample size is recommended to be 0.5 m^2. The dry weight rank method of estimating biomass is recommended. A total of five to ten quadrats should be utilized initially to rank, clip, weigh, and evaluate total herbage yield by species for each replicate. Ten times as many plots should be ranked only. An alternative method is to clip and weigh all quadrats. If all plots sampled are to be clipped and weighed by species, then 20 plots should be used to obtain an estimate of the variance for determining the accuracy of the method, unless this estimate has already been obtained by previous sampling. When a quadrat is clipped, the material removed will be separated by species (for all species contributing more than 5% of the total herbage biomass), oven-dried, and weighed. Clip everything standing. Do not include litter. Separate standing dead by major species, where possible.

For the dry weight rank method, rank 10 times as many plots as are clipped. Rank each species (1, 2, 3, 4, etc.) according to its estimated relative contribution to the total plant biomass in the quadrat. The advantage of this method is that it allows an increase in sample size with less than a proportional increase in the total effort involved. The optimum ratio of plots clipped to plots ranked may vary with time and with stage of growth in the grassland. The optimum ratio can be computed on the basis of the results from the previous sampling. The optimum ratio of clipped to unclipped quadrats will be provided in the computer output returned to the investigator which summarizes the data from the previous sampling. Data forms are designed to include all the required information. The form labeled ABOVEGROUND BIOMASS must be sent in to the data processing laboratory immediately after field and lab work are completed. That form will contain the information required for determination of the optimum ratio for the next sampling period.

Aboveground biomass will be sampled *biweekly* during the period of active growth and monthly during the dormant season. Plant material should be dried for 24 hours at 65°C. Clipping height for aboveground material is ground level. Separation into crowns and stems is optional.

Accuracy

The objective is to obtain an estimate of the mean herbage yield with a standard error no greater than ±10% of the mean at the 80% level of confidence. When sample data are available, the number of plots required for this degree of precision can be calculated.

Dry weights will be recorded to the nearest 0.01 g.

Data Recording

A sample field sheet for the recording of data follows. A copy of the original form will be immediately forwarded to the Natural Resource Ecology Laboratory where it will be transcribed onto punched cards and analyzed according to the design for preliminary analysis of field data. Results of this analysis must be returned to the field investigator prior to the next sampling period.

The following information will be recorded:

XXX QUADRAT NUMBER - number assigned to particular quadrat by the investigator (This number should be unique for the TREATMENT.)

X CLIP-RANK - code to indicate whether the quadrat was clipped, clipped and ranked, or ranked only

X GROWTH FORM - code for stage of growth or type of plant (This is part of the identification and should not be omitted.)

XX GENUS - first two letters of generic name

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FIELD DATA SHEET - ABOVEGROUND BIOMASS

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CLIP-RANK	GROWTH FM.	GENUS	SPECIES	SUBSPECIES	PHENOLOGY	RANK	SACK NO.	DRY WT.	SPECIAL	DRY WT. SP.
			Day	Mo	Yr															
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25	27	29-30	31-32	34	36-37	39-40	42-45	47-52	54-57	59-64

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Vertebrate - Collection
- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

PHENOLOGY
- 01 Germinated or sprouted
- 02 Early vegetation
- 03 Prebud
- 04 Bud stage
- 05 Early bloom
- 06 Mid-bloom
- 07 Full bloom
- 08 Late bloom
- 09 Milk stage
- 10 Dough stage
- 11 Ripe seed
- 12 Past ripe
- 13 Stem cured
- 14 Vegetative regrowth
- 15 Regrowth flowering
- 16 Regrowth ripe seed
- 17 Standing dead
- 18 Winter dormant

CLIP RANK
- 1 Harvested
- 2 Harvested and ranked
- 3 Ranked

GROWTH FORM
- 1 Perennial grass
- 2 Annual grass
- 3 Sedge, rush, etc.
- 4 Annual forb
- 5 Biennial forb
- 6 Perennial forb
- 7 Half-shrub
- 8 Shrub
- 9 Tree
- 0 Miscellaneous

XX SPECIES - first two letters of species name (if plant is identified only to genus, then put first three letters of generic name in genus-species spaces; if unidentified, use MISC)

X SUBSPECIES - this is a tie-breaker to be used only in case genus and species abbreviations fail to distinguish all plants (Use number in this column to distinguish between different MISC categories.)

XX PHENOLOGY - code for stage of development of plant (including standing dead)

XX RANK NUMBER

XXXX SACK NUMBER

XXXXXX DRY WEIGHT - include decimal point

XXXX SPECIAL COLLECTION - sack number for special material collected separately (seeds, flowers)

XXXXXX DRY WEIGHT SPECIAL - dry weight of special collection (include decimal point)

Preliminary Analysis

After field data are received at the Natural Resource Ecology Laboratory, the following information will be returned to the field investigator:

1. For each replicate within treatments:
   (a) biomass (dry weight) by quadrats clipped
   (b) biomass in grams m^{-2} as $\bar{x} \pm s$ for replicate
   (c) biomass in grams m^{-2} as $\bar{x} \pm s$ by major species
   (d) percent composition by species

(e) standing dead biomass in grams m^{-2} as $\bar{x} \pm s$ for replicate

(f) optimum ratio (dry weight rank only).

2. For each treatment:

(a) biomass (dry weight) in grams m^{-2} as $\bar{x} \pm s$ for treatment

(b) biomass (dry weight) in grams m^{-2} as $\bar{x} \pm s$ by species

(c) percent composition by species

(d) standing dead biomass in grams m^{-2} for treatment.

After preliminary checking of the data, analyses will proceed. For the dry weight rank procedure the data from the field sheets provide information on the observed dry weight proportion of each plant species on the clipped plots and the proportion of times that each species was assigned each rank. The rank data are combined to provide a rank-proportion value for each species, that is, the proportion of times that the species receives a particular rank. To use these weight-proportion data in obtaining estimates of the weights of different species in the replicate, matrix methods are used to arrive at a set of multipliers which gives results most nearly like those results obtained from the clipped plots. In other words, the weight proportions sum of squares deviation is minimized (Hughes 1969).

Our objective in the aboveground biomass sampling is to estimate the total biomass within 10% of the true total biomass with probability .80. In other words, we are willing to risk that one time in five, our absolute error may exceed the allowable limits.

When a number (N) of plots are clipped, and the plant material is dried and weighed, the mean weight of herbage per plot, or per unit area, and its associated variance will be calculated. From these preliminary data, a

sample size, n, for the area being estimated can be calculated for the next sampling period which will give an estimated total biomass within 10% of the true total biomass with probability .80. The method of computation is:

$$n = \frac{t^2 s^2}{d^2}$$

where $d^2 = (\bar{x} \cdot 0.1)^2$

and $t = 1.38$ if $N = 10$

$= 1.35$ if $N = 15$

$= 1.33$ if $N = 20$

$= 1.32$ if $N = 25$

$= 1.31$ if $N = 30$

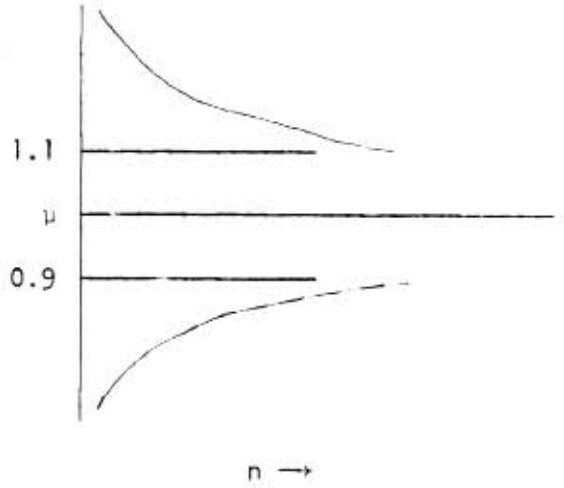
$= 1.30$ if $N = 40$ to 60

$= 1.29$ if $N > 60$

In determining optimum sample size, we must decide on some reasonable confidence limits; i.e., we must be willing to accept a certain probability of error. If we are working at the 95% confidence level, then if an item X is drawn from a normal distribution, the probability is about 0.95 that X lies between $\mu-1.96\sigma$ and $\mu+1.96\sigma$. Since we do not know mu and sigma (parameters), we must use our estimate or mean and its standard error. When we do not know the value of 1.96σ, the t distribution enables us to compute confidence limits on the basis of s, our estimate of σ. Note that the t distribution is expressed in units of $s/\sqrt{n}$ (Snedecor and Cochran 1967, p. 61). By using this standard error, we get a confidence interval which is a function of n. Therefore, we can set a value for the confidence interval, and solve for n. In our case:

$$CI = x \pm t_{0.1}\ s/\sqrt{n} = f(n)$$

A plot of the standard error around mu with increasing sample size should show two lines (+ and -) which form an envelope about mu which converges as sample size increases.



We want to know at what value of n this envelope is within ±10% of mu. If we look at the standard deviation, which is not a function of n but is an estimate of a parameter of the population, we would find that with increasing sample size the envelope would bounce around and would converge only to the true variance of the population.

Applying what we have just said about using the t distribution and substituting s for sigma, we can convert Cochran's method for estimating sample size (Snedecor and Cochran 1967, p. 516) to the formula given on page 8. From Snedecor and Cochran

$$\text{allowable error} = \frac{2\sigma}{\sqrt{n}}$$

Note again the use of the square root of n. Our allowable error is expressed as a fraction of the mean. Substituting, and squaring

$$n = \frac{4\sigma^2}{(x \cdot 0.1)^2}$$

He is using 2σ as a convenient approximation of 1.96σ, the 0.95 level of probability. When we substitute s and the t distribution to get our desired confidence interval, we get

$$n = \frac{(t_{0.1})^2 s^2}{d^2}$$

where $d = \bar{x} \cdot 0.1$.

Required Turnaround Time

Sampling is to be done biweekly during the growing season and monthly at other times of the year, where possible. Because the dry weight rank method requires modification of sample size based upon results of the previous sampling period, it is essential that the results of preliminary analysis be in the hands of the field investigator at the time sampling is to be done. In other words, turnaround time must be two weeks maximum during the growing season and monthly at other times of the year. If the investigator finds errors, he should report them so that the data may be reanalyzed.

HERBAGE DYNAMICS - LITTER

Sampling Methods

The same sites will be utilized for collection of litter that were used for clipped plots in the aboveground biomass studies. The plot size, therefore, is recommended to be 0.5 m^2. Litter will be collected separately in a bag for drying and weighing. Take it all, it is better to collect too much than too little. Material will be oven-dried at 65°C

and weighed. To determine the amount of sand and mineral material present after weighing, the sample should be ashed and the weight of the residue recorded. This weight will be subtracted from the original value in the machine processing of the data. Add material that was collected by the D-VAC if the same plot was used for insect studies. Weights should be determined to the nearest 0.01 g.

Data Recording

A sample field data sheet for litter collection follows. The information to be recorded is:

XXX QUADRAT - this number should correspond to the number used on the forms for ABOVEGROUND BIOMASS and INVERTEBRATES if the sampling is taken in the same plot

X TYPE OF LITTER COLLECTION - code for distinguishing between total material of quadrat, part of material from quadrat (material from D-VAC must be added), cleared plot for estimating rate of fall from standing dead, nylon litter bag, etc.

XXXX SACK NUMBER

XXXXXX DRY WEIGHT OF LITTER AND SACK - to nearest 0.01 g (record decimal point)

XXXX SACK WEIGHT

XXXXXX ASH WEIGHT - weight of material after ashing

XXXXXX PREVIOUS DATE - for computation of time interval between weighings if litter bags or other types of samples used

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FIELD DATA SHEET - LITTER

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	TYPE	SACK NO.	DRY WT.	SACK WT.	ASH WT.	PREVIOUS DATE			
			Day	Mo	Yr										Day	Mo	Yr	
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25	27-30	32-37	39-42	44-49	51-52	53-54	55-56	

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- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

TYPE
- 1 Quadrat, total
- 2 Quadrat, part
- 3 Cleared plot
- 4 Litter bag

HERBAGE DYNAMICS - BELOWGROUND BIOMASS

Sampling Methods

Belowground biomass will be sampled by collection of soil cores. Cores should be collected at one-month intervals during the growing season and at two-month intervals, if possible, during the remainder of the year. One core will be taken in each clipped quadrat. The soil samples from the core will be divided according to soil horizons down to a depth of at least 30 cm. The uppermost sample (A horizon) will be subdivided into two 5 cm intervals. At greater depths the core will be divided into 10 cm intervals within soil horizons. The total length of the core should be sufficient to account for at least 90% of the root material in the soil profile. In order to remove roots from soil core segments, each sample will be washed over a 32-mesh screen (500 μ), oven-dried at 65°C, weighed to the nearest 0.01 g, ashed, and the residue weighed. In processing of soil cores, consideration should be given to the requirements of the INVERTEBRATE studies and the MICROBIOLOGY investigations.

Data Recording

A sample field data sheet for recording results of belowground biomass follows. The information required is

XXX QUADRAT - the same number as used to identify quadrat on other data forms

XXX CORE DIAMETER - to nearest 0.1 cm

X HORIZON - code for soil horizon

XXX TOP DEPTH - depth to top of segment, cm

XXX BOTTOM DEPTH - depth to bottom of segment, cm

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FIELD DATA SHEET - BELOWGROUND BIOMASS

D TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	CORE DIAM.	HORIZON	TOP DEPTH	BOTTOM DEP.	LENGTH	WASH WT.	DRY WT.	ASH WT.	CROWN DRY WT.
			Day	Mo	Yr													
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-23	25-27	29	31-33	35-37	39-41	43-47	49-54	56-61	63-68

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TREATMENT
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- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

ORIZON
- 1 AO
- 2 A
- 3 B
- 4 C

XXX LENGTH - total length of segment, cm

XXXXX WASH WEIGHT - air dry weight of roots from core

XXXXXX DRY WEIGHT - of roots from core segments

XXXXXX ASH WEIGHT - weight of residue after ashing

XXXXXX CROWN DRY WEIGHT - if crowns are collected separately

VERTEBRATES - SMALL MAMMALS

Sampling Methods - Live Trapping

Small mammal populations will be sampled by marking, releasing, and recapturing animals in a grid of live traps. The grid will consist of 12 x 12 stations, with two traps per station. Stations will be 15 m apart. The grid will cover an area of 6.8 acres (2.8 hectares). The traps will be left open and prebaited for five consecutive days. There will follow five consecutive days of trap-mark-release. The entire grid will then be shifted one-half the diagonal distance between traps (10.6 m) so that most traps then occupy the centers of the squares of the original grid. This means that each pair of traps will be moved diagonally one-half the distance to the next station, and the outside lines will be shifted slightly outside the previous boundaries of the grid. Following this, there will be another five consecutive days of trap-mark-release. The reasons for shifting the trap locations will be discussed under the section entitled Preliminary Analysis.

Rodents will be marked by a system of toe amputation and/or with numbered metal ear tags. A toe can be removed by clipping with a pair of fine pointed scissors or with fingernail clippers. The incision should be made cleanly and at the base so as to remove the entire toe. If only a portion of the toe is removed, it is sometimes difficult to recognize on recapture. In addition,

natural amputations sometimes occur and these can be confused with toe-clips that are not cleanly made. Fig. 1 shows the method to be used. Looking at the underside of the animal, the feet are read from left to right and top to bottom to give the four digits of the identification number, one digit per foot. The toes on each foot are read from left to right. If there are four toes on the foot, then there are four possible numbers that can be assigned to that particular digit, 1, 2, 3, or 4. If there are five toes on the foot, there are five possible numbers. Animals with toes like the illustration will provide a possible 899 different combinations of four-digit numbers to be assigned to that species. This requires clipping of no more than one toe per foot. In the case of a natural amputation, which occurs after marking, there will be two toes missing from the foot. In such cases, that digit of the identification number is indicated as a 9. This system often permits the original identity of the animal to be determined without confusion.

Sampling Methods - Snap Trapping

A separate grid will be operated for the purpose of obtaining an estimate of the population by the removal method. The grid will be located in similar habitat but at a considerable distance from the live trapping grid. The grid will be the same size (12 x 12 stations with two traps per station, and a distance of 15 m apart) as the live trapping grid. The traps will be pre-baited for a five-day period. The traps will then be operated for 10 days, and after the fifth day of trapping the traps will be shifted diagonally so that they occupy the locations that were previously the centers of the squares formed by the trap lines of the grid, as explained for live trapping. Traps will be operated twice daily and all animals will be removed and saved for

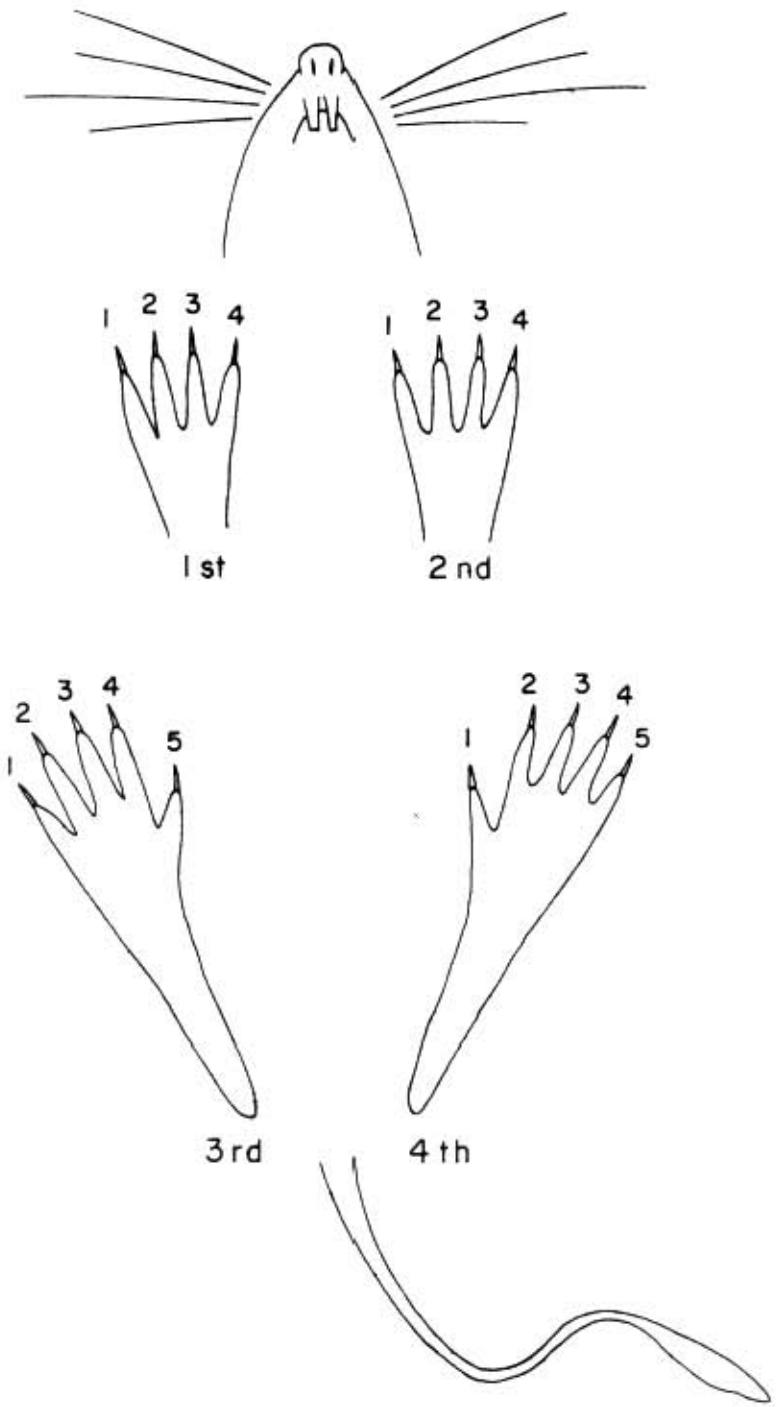

Fig. 1. Four-digit number for rodent marking.

autopsy. At autopsy the animals will be weighed and measured, the testes of the males will be measured to the nearest millimeter, both length and width. For females, the condition of the mammary glands and the reproductive tracts will be recorded. *Nulliparous* females give no evidence of ever having been pregnant (no embryos, placental scars, corpora lutea, or lactation). *Primiparous* females are, or have been, pregnant at least one time (pregnant, but no additional placental scars; one set only of placental scars and/or corpora lutea). *Multiparous* females are, or have been, pregnant more than one time (pregnant, with additional set(s) of placental scars and/or lactation; two or more sets of placental scars and/or corpora lutea). The condition of the mammae will be noted. *Nipples* may be small (non-lactating, nulliparous females); enlarged but not prominent (non-lactating, parous females); or enlarged and prominent (lactating, parous females). The *total number of embryos* will be recorded, including those that appear to be abnormal or resorbing. The number being *resorbed* will be recorded separately, and will include only those embryos which are distinctly smaller, and undergoing tissue lysis and disorganization. The *embryo length* will be recorded as the crown-rump length in millimeters of the embryo as it lies in its normal position. The total weight of the embryos and reproductive tract combined, will be recorded to nearest 0.01 g. Numbers of new and old *placental scars* will be recorded. New scars are distinguished by plentiful blood supply to the implantation site and/or a large amount of dark pigment deposited at the site. Old scars are distinguished by lack of blood supply, and fainter pigmentation. The number of *corpora lutea* can be determined from the intact ovaries by examining the surface of the ovaries for firm, spheroidal, pinkish to yellowish structures.

Both eyes of each specimen will be preserved in 10% neutral Formalin and labeled. The eyeballs should be punctured to allow penetration of the preservative. Later determination of the dry weight of the paired lenses will be used in estimation of the relative ages of the animals. Total stomach contents of up to 25 individuals of each major species will be dried and sealed in an envelope and labeled.

Sampling Methods - Pocket Gophers

An index of pocket gopher density will be obtained by counting the mounds that these animals produce in a given period. The live trapping grid or the snap trapping grid may be utilized in this portion of the study. The objective is to erase by kicking, raking, or otherwise smoothing out the existing pocket gopher mounds, and then counting the mounds that develop during the following 48-hour period. This should be done at least twice and can be done twice within the same area. Two days after the mounds are erased, the area should be carefully examined and all new mounds noted. The mounds can then be erased for the beginning of the second sampling period. Records should be kept according to square subdivisions of the trapping grid. This divides the area into 11 x 11 or 121 sample plots. Trapping and removal of all gophers on the snap trap grid may be substituted for this procedure. This would require setting a gopher trap at each active mound each night of the 10-day trapping period.

Accuracy

The accuracy of the live trapping technique for small mammals is undetermined. There are procedures for evaluating the variance of the estimates obtained. The magnitude of the variance will depend on the sample size, and

therefore on the density of the population under investigation. Three separate estimates of the small mammal population density will be determined from the data obtained by live trapping and snap trapping grids. Data on the pocket gophers will provide an index of the population density for these species. Further effort will be required to relate density indices to actual population densities.

Data Recording - Live Trapping

A sample data sheet for the recording of live trapping results follows. Separate sheets will be used by different observers, or on different days, or as continuation sheets if more than one is required on any one day.

XX GENUS - first two letters of the generic name

XX SPECIES - first two letters of the species name

X SUBSPECIES - single letter to be used only as a tie-breaker in case previous columns fail to separate two species

X CONDITION - used to indicate whether an animal escaped or is in poor condition; leave blank if normal

X MARK - this is the condition of the mark on the animal; blank if normal

XXXX NUMBER - four-digit identification of the individual (see toe-clip diagram)

X MALE - this column indicates breeding condition of male animals

X FEMALE - this column indicates breeding condition of females

XXXXX WEIGHT - weight in grams if animal is weighed in field (to nearest 0.1 g)

X MOLT - condition of molt, blank if not evident

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FIELD DATA SHEET - VERTEBRATE - LIVE TRAPPING

DA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	GENUS	SPECIES	SUBSPECIES	CONDITION	MARK	NUMBER	MALE	FEMALE	WEIGHT	MOLT	LOCATION		PREVIOUS NO.
			Day	Mo	Yr														Row	Col	
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-22	23-24	25	27	29	31-34	36	38	40-44	46	48-49	51-52	54-57

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Vertebrate - Collection
- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

MALE
- 0 Adult, non-breeding
- 1 Subadult, non-breeding
- 2 Juvenile, non-breeding
- 3 Adult breeding ?
- Subadult breeding ?
- Juvenile breeding ?
- 6 Adult breeding
- 7 Subadult breeding
- 8 Juvenile breeding
- 9 Undetermined

FEMALE
- 0 Adult, vulva inactive
- 1 Subadult, vuvla inactive
- 2 Juvenile, vulva inactive
- 3 Adult, vulva turgid
- 4 Subadult, vulva turgid
- 5 Juvenile, vulva turgid
- 6 Adult, vulva cornified
- 7 Subadult, vulva cornified
- 8 Juvenile, vulva cornified
- 9 Pregnant

CONDITION
- 0 Normal
- 1 Escaped
- 2 Torpid
- 3 Dead

MOLT
- 0 No evidence
- 1 Post-juvenile
- 2 Post-subadult
- 3 Adult (vernal)
- 4 Adult (autumnal)
- 5 Molt of unknown stage
- 6 Undetermined

MARK
- 0 Normal
- 1 Unmarked
- 2 Ear tag
- 3 Toe Clip
- 4 Ear tag and toe clip
- 5 Natural amputation

XX ROW - location of capture identified by number of row in grid

XX COLUMN - number of column in grid

XXXX PREVIOUS NUMBER - in case of a natural amputation, the old number of the animal

Data Recording - Snap Trapping

Three field sheets are required for recording of data from sacrificed animals taken in the snap trap grid. One is an EFFORT form, and allows population estimates to be corrected for traps that were not effective in sampling (sprung but empty).

The SNAP TRAP EFFORT form requires that the trap status be indicated, according to the code on the form, for each of two traps at each station.

Additional data on animals captured in the snap trap grid is recorded on the sheet for MAMMAL COLLECTION. Information included is:

XX TRAP DAY - sequence in trapping period, day 1 through 10

XXXX GRID TRAP - location of capture by row and column (1 through 12)

XX GENUS - first two letters of genus name

XX SPECIES - first two letters of species name

X SUBSPECIES - tie-breaker, if required

XXXXXXX SPECIMEN NUMBER - number assigned by collector (letters and/or numbers)

X MARK - source of specimen and type of mark, according to code

XXXX LENGTH - total length, mm

XXX TAIL - tail length, mm

XXX FOOT - hind foot, mm

FIELD DATA SHEET - SNAP TRAP EFFORT

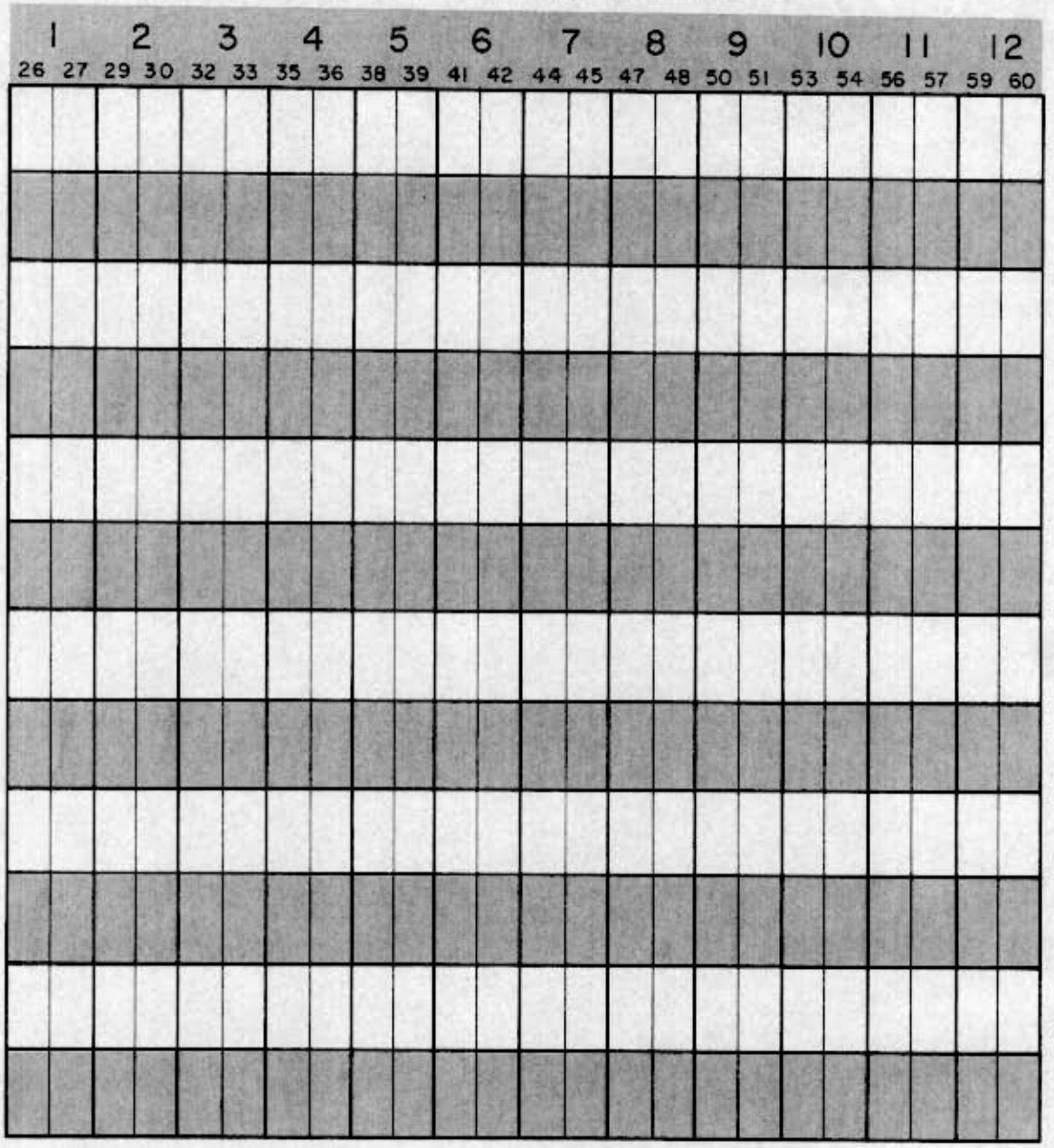
DT TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	TIME
			DAY	MO	YR				
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-24

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Mammal - Collection
- 13 Snap Trap Effort
- 14 Mammal Reproductive
- 20 Avain Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avain Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

TRAP STATUS
- 0 Set
- 1 Animal
- 2 Sprung-empty
- 3 Trap missing



FIELD DATA SHEET - MAMMAL COLLECTION

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	TRAP DAY	HOUR	GRID TRAP		GENUS	SPECIES	SUBSPECIES	SPECIMEN NUMBER	MARK	LENGTH	TAIL	FOOT	EAR	WEIGHT	MOLT	PARASITES	STOMACH WEIGHT	FOOD	EYE LENS	SPECIMEN	MAP REFERENCE		
			Day	Mo.	Yr.						Row	Col																	TWN	RNG	S
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-22	23-26	27-28	29-30	31-32	33-34	35	36-42	43	44-47	48-50	51-53	54-56	57-61	62	63	64-66	67	68	69	70-72	73-75	76-77

MARK
0 None
1 Snap-trap grid, unmarked
2 Snap-trap grid, marked
3 Live-trap grid, unmarked
4 Live-trap grid, marked
5 Other trapping

MOLT
0 No evidence
1 Post-juvenile
2 Post-subadult
3 Adult (vernal)
4 Adult (autumnal)
5 Molt of unknown stage
6 Undetermined

PARASITES - EYE LENS
0 Not saved
1 Preserved

SPECIMEN
0 Not saved
1 Skin
2 Skull
3 Skin and skull
4 Skeleton
5 Liquid preservative

FOOD
0 None
1 Stomach only
2 Cheek pouch only
3 Both

DATA TYPE
01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Mammal - Collection
13 Snap Trap Effort
14 Mammal Reproductive
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology-Decomposition
41 Microbiology-Nitrogen
42 Microbiology-Biomass
43 Microbiology-Root Decomposition
44 Microbiology-Respiration

SITE
01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT
1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

XXX EAR - ear from notch, mm

XXXXX WEIGHT - weight in grams, to nearest 0.1 g

X MOLT - pelage condition, according to code

X PARASITES - 1 if collected

XXX STOMACH WEIGHT - wet weight in grams, to nearest 0.1 g

X FOOD - indicate collection, according to code

X EYE LENS - 1 if collected

X SPECIMEN - type of specimen preserved, according to code

XXXXXXXX MAP REFERENCE - Township, Range, and Section

Additional data on internal anatomy of specimens collected is recorded on the field sheet entitled MAMMAL REPRODUCTIVE. This sheet is a continuation of the last, and therefore 42 columns are identical to the previous information on the specimen. Additional data required, beginning in column 44:

X EXTERNAL - testes descended into scrotum

XXXXX TESTES - length and width, mm

X EPIDIDYMUS - condition, according to code

X SEMINAL VESICLES - condition, according to code

X EXTERNAL - ?

X MAMMARY - condition, according to code

X PUBIC SYMPHASIS - condition, according to code

XX NORMAL EMBRYOS - numbers, in left and right horns

XXX EMBRYO LENGTH - crown-rump length, mm

XX RESORBING - number disintegrating, left and right

FIELD DATA SHEET - MAMMAL REPRODUCTIVE

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	TRAP DAY	HOUR	GRID TRAP		GENUS	SPECIES	SUBSPECIES	SPECIMEN NUMBER	MALE					FEMALE																						
			Day	Mo.	Yr.						Row	Col					EXTERNAL	TESTES		EPIDID	SEM VES	EXTERNAL	MAMMARY	PUBIC SEM	NORMAL EMBRYOS		EMBRYO LENGTH	RESORB		SCARS NEW		SCARS OLD		CORPORA LUTEA		TRACT WEIGHT	CORP ALB	SPEC SOURCE
																		LN	WD						L	R			L	R	L	R	L	R	L	R			
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-22	23-26	27-28	29-30	31-32	33	34	35	36-42	44	45-47	48	49	50	51	52	53	54	55	56	57-59	60	61	62	63	64	65	66	67	68-72	71	72

MALE
- 0 Adult, non-breeding
- 1 Subadult, non-breeding
- 2 Juvenile, non-breeding
- 3 Adult breeding ?
- 4 Subadult breeding ?
- 5 Juvenile breeding ?
- 6 Adult breeding
- 7 Subadult breeding
- 8 Juvenile breeding
- 9 Undetermined

FEMALE
- 0 Adult, vulva inactive
- 1 Subadult, vulva inactive
- 2 Juvenile, vulva inactive
- 3 Adult, vulva turgid
- 4 Subadult, vulva turgid
- 5 Juvenile, vulva turgid
- 6 Adult, vulva cornified
- 7 Subadult, vulva cornified
- 8 Juvenile, vulva cornified
- 9 Undetermined

SEMINAL VESICLES
- 0 No observation
- 1 Minute
- 2 Small
- 3 Well developed

EPIDIDYMUS
- 0 No observation
- 1 Not convoluted
- 2 Slightly convoluted
- 3 Convoluted

MAMMARY
- 0 No observation
- 1 Small
- 2 Large
- 3 Lactating

SOURCE
- 1 Snap trap grid
- 2 Live trap grid
- 3 Other trap line
- 4 Misc. collection

PUBLIC SYMPHASIS
- 0 No observation
- 1 Closed
- 2 Slightly open
- 3 Open

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Mammal - Collection
- 13 Snap Trap Effort
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- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology-Decomposition
- 41 Microbiology-Nitrogen
- 42 Microbiology-Biomass
- 43 Microbiology-Root Decomposition
- 44 Microbiology-Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hoyt
- 07 Mapland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

NREL - 14

XX NEW SCARS - recent placental scars, left and right

XX OLD SCARS - old placental scars, left and right

XX CORPORA LUTEA - number visible on surface of each ovary, left and right

XXXXX TRACT WEIGHT - grams of total intact reproductive tract, including embryos

X CORPORA ALBICANS - total number visible

X SPECIMEN SOURCE - origin of specimen, according to code

Preliminary Analysis

The data from small mammal trapping will be evaluated to obtain at least three separate estimates of population density. The reasons for this approach lie in the assumptions upon which the sampling methods are based. The mark-release-recapture method assumes the population is not changing in size during the sampling period. Since the estimate is biased if this occurs, all samples must be returned to the population. This method also assumes that marked and unmarked animals are equally susceptible to capture. This is an unanswered question, and the characteristic will vary among species. The removal method is used because it is free of the last assumption. Data from the mark-release-recapture method will be analyzed according to the frequency of recaptures, which is sensitive to changes in population size, and by the Lincoln-Peterson method of estimation, which is insensitive to changes that result from mortality (as long as mortality affects equally the marked and unmarked cohorts).

Results from the live trapping grid will be used to estimate the population density by means of the modified Lincoln Index (see Eberhardt 1969).

The first five days of trapping may be considered the marking period, and the second five days the sampling period. The estimate is obtained as follows:

$$N = \frac{(n_1 + 2n_2)(n_1 + n_2)}{2n_2}$$

In this formula N is the population estimate, n_1 is the number of animals captured in both periods, n_2 is all other animals captured.

Data from the snap trapping grid will be evaluated to provide a second estimate of the population size based on the rate of removal of animals. If a graph is prepared with the size of the catch for individual nights on the y axis and the total number of animals captured and removed from the grids on the x axis, a straight line drawn through the points representing nightly captures when projected to the x axis will designate the point at which no more animals can be removed, that is, the total population. Actually, the method employed in analysis of the data will be the method of least squares which provides an estimate of population by means of the regression (for details, see Zippin 1956).

A third estimate of the population size will be obtained by evaluation of the frequency of recaptures in the live trapping grid. The method utilizes the numbers of animals captured once, twice, three times, etc., and assumes that a distribution fitted to the actual observed frequencies of capture can be extended to estimate the zero class, those that were not captured. Since frequencies of recapture often follow a geometric distribution, this is used as the basis for a model for the purpose of estimating the total population

(see Edwards and Eberhardt 1967). The proportion in each class, if multiplied by the total population number (N), would give the number of recaptures (n_x) in that class:

$$n_x = Npq^x$$

where p and q = 1 - p are parameters of the geometric distribution, and n_x is the number of animals captured x times. Taking logarithms gives:

$$\log n_x = \log (Np) + x \log q$$

which is the familiar form of the regression equation. Fitting by the method of least squares, the slope of the regression line is an estimate of log q, and since q = 1 - p, an estimate of N can be obtained. An alternative is to use the antilog of the intercept (Np), which is an estimate of n_0, the number of animals not captured.

Required Turnaround Time

It seems unlikely that any modification of this sampling method would be advisable until results are in from all the different areas representing the different species of animals under examination, and the different population densities to be evaluated during the first season. With these results on hand, a comparison of the precision of the estimates and the conditions under which the estimates were made may enable us to determine those factors to which our analytical efforts are most sensitive.

VERTEBRATES - AVIAN POPULATIONS

Sampling of avian populations will be done by a group of investigators covering a number of different Comprehensive Network Sites.

Sampling Methods

Avian populations will be censused during the early nesting period at each site in a 26.1 acre (10.6 hectares) area. This area will be grided with marker stakes at 61 m intervals for reference points. The breeding birds of this area will be flushed several times over a three-day period. The locations of individual birds will be noted on a grid map of the area. From the points where individuals are flushed, the outlines of breeding territories will be drawn on the map. On the basis of this, the breeding population of the sample area will be established. Information will also be obtained from these data on species composition and, along with weights of birds collected elsewhere, biomass per unit area.

A general index of bird density in the region will be obtained by two roadside censuses conducted on consecutive days. The census will cover a specific route at each of the sites. The route will be censused at a particular time of day. Observations will be made at a total of 50 stops along a 24.5-mile route. The stops will be one-half mile apart. At each stop all birds observed during a three-minute observation period will be recorded. During the three-minute period, a circle one-quarter mile in radius will be observed. Any birds noted in this location during this time period will be recorded. At the end of the roadside census on a particular date the records will be compiled on a summary sheet. These records made by the investigators working on avian populations will be supplemented when possible by similar counts taken on an opportunistic basis by local site personnel.

Specimens will be collected at some distance from the study area for determinations of weight and food habits. Crop, stomach, and lower digestive tracts will be removed and preserved in 5% or 10% Formalin for laboratory analysis.

Accuracy

The flushing census of a limited area provides a precise determination of the density of nesting birds for that area. The roadside census provides an index of avian population density over a wide area of more variable habitat.

Data Recording - Flushing Census

A sample field data sheet for recording the exact movements of a few birds in a limited area follows. From this information the movements of particular individuals can be plotted, or the relative positions of territories can be outlined.

Data Recording - Road Census

Observations by species will be recorded for each of the up to 50 stops on the road census on the attached sheets. Stops are selected for uniformity of habitat. Avoid special microhabitats, such as streams. Each sheet provides positions for recording the results from ten stops. Five sheets will be required for tabulating results from one census. Each of the five sheets will be totaled separately, and the results tabulated in five columns of a summary sheet. *Only the summary sheet will be submitted to the Natural Resource Ecology Laboratory.* A sample summary sheet follows. Information to be recorded is:

X	GROUP - general group of birds
XX	GENUS - first two letters of generic name
XX	SPECIES - first two letters of species name
X	SEX - leave blank if undetermined

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FIELD DATA SHEET - AVIAN FLUSH CENSUS

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	GROUP	GENUS	SPECIES	SUBSPECIES	BASELINE SIZE	Y-AXIS SIZE	CONVERSION	HOUR
			Day	Mo	Yr										
1-2	3-4	5-7	8-9	10-11	12-13	14	15	17	18-19	20-21	22	23	24	25-27	28-31

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FIELD DATA SHEET - AVIAN ROAD COUNT

GROUP	GENUS	SPECIES	SEX	STATIONS																			
				_1	2	3	4	5	6	7	8	9	0	_1	2	3	4	5	6	7	8	9	0

GROUP
0 Waterfowl
1 Falconiform
2 Galli- and Gruiform
3 Charadriiform
4 Doves, owls, nighthawks, woodpeckers
5 Flycatchers, swallows, jays, titmice, wrens
6 Thrashers, bluebirds, gnatcatchers, pipits
7 Shrikes, starlings, vireos
8 Icterids
9 Fringillids

SEX
0 Unknown
1 Male
2 Female

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FIELD DATA SHEET - AVIAN ROAD COUNT SUMMARY

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	GROUP	GENUS	SPECIES	SEX	PAGE TOTALS					NO. STOPS	
			Day	Mo	Yr								1	2	3	4	5		
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21	23-24	26-27	29	31-32	34-35	37-38	40-41	43-44	46-48	

DATA TYPE

01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
Microbiology - Biomass
43 Microbiology - Root Decomposition
44 Microbiology - Respiration

SITE

01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TREATMENT

1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8

XX PAGE TOTALS, 1 - summary of records on first sheet (stations 1-20)

XX 2 - summary of records on second sheet (stations 21-40)

XX 3 - summary of records on third sheet (stations 41-60)

XX 4 - summary of records on fourth sheet (stations 61-80)

XX 5 - summary of records on fifth sheet (stations 81-100)

XX NUMBER OF STOPS - total number of stations at which species occurred

Data Recording - Avian Collections

Information from birds collected in the field will be recorded on three data forms. Any one or all may be used, according to the information required by the investigator. The first data form provides for recording data on the INTERNAL parts of the bird.

X GROUP - general group of birds

XX GENUS - first two letters of generic name

XX SPECIES - first two letters of species name

X SUBSPECIES - code for tie-breaker, if required

XXXX SPECIMEN NUMBER - number assigned by collector, when associated with initials (columns 5-7) provides unique identification for specimen

XXXX TIME - 0001 to 2400, time of collection

XX STATE - first two letters of state name, except as otherwise indicated in key; if state name is two words, then first letter of each

XXXX COUNTY - first four letters of county name

XXX TOWNSHIP - two letters plus number (T4N)

XXX RANGE - two letters plus number (R3W)

XX SECTION

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FIELD DATA SHEET - AVIAN COLLECTION - INTERNAL

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	GROUP	GENUS	SPECIES	SUBSPECIES	SPEC. NO.	TIME	STATE	COUNTY	TWNSHP	RANGE	SECTION	HABITAT	CAPTURE	SEX	BROOD PATCH	GONAD		FOLLICLE	OVIDUCT	SKULL OSS.	CROP	STOMACH	BURSA	FAT			SPECIMEN
			Day	Mo	Yr																			LENGTH	WIDTH							Subcut-Ant	SubcutPost	Visceral	
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21	22-23	24-25	26	27-30	32-35	36-37	38-41	42-44	45-47	48-49	51-52	53	55	56	57-60	61-64	65-68	69-70	71	72	73	74-75	76	77	78	79

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
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- 20 Avian Flush Census
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- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

CAPTURE
- 0 Not noted
- 1 Gun
- 2 Mist net
- 3 Trap
- 4 Found dead

BROOD PATCH
- 0 Not noted
- 1 Feathers dropped
- 2 Vascular
- 3 Edematous
- 4 Regressing
- 5 No evidence

STATE
- AK Alaska
- AZ Arizona
- CT Connecticut
- MD Maryland
- ME Maine
- MN Minnesota
- MS Mississippi
- MR Missouri
- NV Nevada
- TN Tennessee

FAT
- 0 Not noted
- 1 None
- 2 Little
- 3 Moderate
- 4 Much
- 5 Extreme

SKULL
- 0 Not noted
- 1 Quarter or less
- 2 Half or less
- 3 Three-quarters or less
- 4 Up to fully oss.

SPECIMEN
- 0 Not saved
- 1 Skin
- 2 Skeleton
- 3 Skin & skeleton

HABITAT
- 0 Not noted
- 1 Grassland
- 2 Grass-forb
- 3 Savannah
- 4 Shrub-steppe
- 5 Deciduous
- 6 Coniferous
- 7 Riparian

CROP/STOMACH
- 0 Not noted
- 1 Empty
- 2 Quarter
- 3 Half
- 4 Three-quarters
- 5 Full

GROUP
- 0 Waterfowl
- 1 Falconiform
- 2 Galli- and Gruiform
- 3 Charadriiform
- 4 Doves, owls, nighthawks, woodpeckers
- 5 Flycatchers, swallows, jays, titmice, wrens
- 6 Thrashers, bluebirds, gnatcatchers, pipits
- 7 Shrikes, starlings, vireos
- 8 Icterids
- 9 Fringillids

SEX
- 0 Unknown
- 1 Male
- 2 Female

XX	HABITAT
X	CAPTURE - method of collection
X	SEX
X	BROOD PATCH
XXXX	GONAD LENGTH - mm, (total mass for female)
XXXX	GONAD WIDTH - mm
XXXX	FOLLICLE - largest, mm
XX	OVIDUCT DIAMETER - mm
X	SKULL OSSIFICATION
X	CROP - 1 if collected
X	STOMACH - 1 if collected
XX	BURSA - external length
X	FAT, SUBCUTANEOUS ANTERIOR
X	FAT, SUBCUTANEOUS POSTERIOR
X	FAT, VISCERAL
X	SPECIMEN

A separate AVIAN COLLECTION form will be used for recording of EXTERNAL characteristics and measurements of the bird. The information to be recorded is:

X	GROUP
XX	GENUS
XX	SPECIES
X	SUBSPECIES
XXXX	SPECIMEN NUMBER
X	SEX

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FIELD DATA SHEET - AVIAN COLLECTION - EXTERNAL

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	GROUP	GENUS	SPECIES	SUBSPECIES	SPECIMEN NUMBER	SEX	DEVELOPMENT	AGE	AGE UNITS	WEIGHT	WING LENGTH	TAIL LENGTH	BILL			TARSUS	MIDDLE TOE	
			Day	Mo	Yr																Length	Height	Width			
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21	22-23	24-25	26	28-31	32	34	35-36	37	39-43	45-49	51-55	57-60	61-64	65-68	70-74	76-79	

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Vertebrate - Collection
- 20 Avian Flush Census
- 21 Avian Road Count
- 22 Avian Road Count Summary
- 23 Avian Collection - Internal
- 24 Avian Collection - External
- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SEX
- 0 Unknown
- 1 Male
- 2 Female

DEVELOPMENT
- 0 Not noted
- 1 Nestling
- 2 Juv. or imm.
- 3 Subadult
- 4 Adult

AGE UNITS
- 0 No observation
- 1 Hour
- 2 Days
- 3 Weeks
- 4 Months
- 5 3 months
- 6 Years

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

GROUP
- 0 Waterfowl
- 1 Falconiform
- 2 Galli- and Gruiform
- 3 Charadriiform
- 4 Doves, owls, nighthawks, woodpeckers
- 5 Flycatchers, swallows, jays, titmice, wrens
- 6 Thrashers, bluebirds, gnatcatchers, pipits
- 7 Shrikes, starlings, vireos
- 8 Icterids
- 9 Fringillids

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

X	DEVELOPMENT
XX	AGE - a two-digit number
X	AGE UNITS - units of age estimate, see key
XXXXX	WEIGHT - one space is for decimal
XXXXX	WING LENGTH - mm, wrist to tip of longest primary
XXXXX	TAIL LENGTH - base of central rectrices to tip of longest
XXXX	BILL LENGTH - outer rim of nostril to tip
XXXX	BILL HEIGHT - at nostril
XXXX	BILL WIDTH - at nostril
XXXXX	TARSUS
XXXX	MIDDLE TOE

An additional AVIAN COLLECTION form is provided to record data on the condition of the *plumage*. The information will be recorded only for selected feathers and feather tracts. The condition of the molt will be noted for the 1st, 5th, and 9th right primaries, for the 1st, 5th, 7th, and 9th right secondaries, and for the 1st, 3rd, and 6th right rectrices. The generation or plumage of the same flight feathers will then be noted. The condition of the molt for specific feather tracts of the body will follow.

Preliminary Analysis

Results of the flush census technique will be plotted on a map of the area showing the territory occupied by individual birds. On the basis of the average area of the territories, an estimate of population density will be computed. Biomass will be estimated utilizing weights of specimens collected.

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FIELD DATA SHEET - AVIAN COLLECTION - PLUMAGE

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	GROUP	GENUS	SPECIES	SUBSPECIES	MOLT										GENERATION OF REMIGES & RECTRICES										BODY PLUMAGE													
												Prim,rt			Sec,rt				Rect,rt			Prim,rt			Sec,rt				Rect,rt			Crown	Nape	Auricular	Cervical	Int scap	Dorsal	Pelvic	Humeral	Sternal	Abdominal	Femoral	Crural	Marg cov	Sec cov	Prim cov
			Day	Mo	Yr							1	5	9	1	5	7	9	1	3	6	1	5	9	1	5	7	9	1	3	6														
1-2	3-4	5-7	8-9	10-11	12-13	14	15	17	18-19	20-21	22	24	25	26	28	29	30	31	33	34	35	37	38	39	41	42	43	44	46	47	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
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- 10 Vertebrate - Live Trapping
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- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

BODY PLUMAGE
- 0 No observation
- 1 No molt
- 2 Some follicles molting
- 3 Incomplete replacement

GROUP
- 0 Waterfowl
- 1 Falconiform
- 2 Galli- and Gruiform
- 3 Charadriiform
- 4 Doves, owls, nighthawks, woodpeckers
- 5 Flycatchers, swallows, jays, titmice, wrens
- 6 Thrashers, bluebirds, gnatcatchers, pipits
- 7 Shrikes, starlings, vireos
- 8 Icterids
- 9 Fringillids

GENERATION
- 0 No observation
- 1 Juvenal
- 2 1st basic (=1st winter)
- 3 2nd basic (=2nd winter)
- 4 Adult (generation unknown)

MOLT
- 0 No observation
- 1 Old
- 2 Dropped
- 3 Pin
- 4 Quarter grown
- 5 Half grown
- 6 Three-quarter grown
- 7 Full and unsheathing
- 8 New

INVERTEBRATES

Sampling Methods

Invertebrate sampling will be conducted to obtain quantitative estimates of numbers and biomass of major groups. The area of the sample is to be 0.5 m^2. A trap will be used that can be set down rapidly over the sample area to contain the flying insects present (the Quick Trap). A total of 20 sample areas per treatment is recommended. The interval will be biweekly (to correspond with the vegetation sampling). Sampling will be done between the hours of 10 AM and 4 PM, with consideration for weather conditions. Material will be removed from the trap by means of a D-VAC vacuum insect net, with a modification for use with this trap. The nozzle of the D-VAC will be moved at a fairly constant rate within the vegetation and debris in the sample area. The rate will be such that it takes three to five minutes for removal of material from the trap. Sorting of the material thus collected will be done in two stages. In the field, separation by major groups of conspicuous invertebrates will be done immediately. Litter and debris in the bottom of the sample bag will then be returned to the laboratory for processing and more detailed separation. After the final separation the litter remaining will be saved for use by the vegetation samplers. It will be saved with identification according to quadrat, replicate, and treatment. It will be lyophilized or oven-dried at 60°C for 24 hour and then weighed either in the insect laboratory or by the vegetation samplers. Quantities of invertebrate material will be determined by count of individual organisms. Then a selected representative number of each major group will be separated, oven-dried, and weighed. The number in this sample and the ovendry

weight will be recorded for determination of biomass. Sample arthropods from soil cores collected in the study of belowground biomass will also be processed as part of the invertebrate studies.

Accuracy

Sufficient samples will be taken to provide an estimate of the mean numbers of insects per unit area with a standard error no greater than 10% of the mean.

Data Recording

A sample field data form follows:

XX	QUADRAT - same number used in vegetation studies if same quadrat used
X	TROPHIC LEVEL - this refers to the group of insects according to the key provided
XXXXX	HOST - name code for host plant (see Aboveground Biomass for code)
XXX	ORDER - first three letters of the order name
XXX	FAMILY - first three letters of the family name, if known
XX	GENUS - first two letters of the genus name, if known
XX	SPECIES - first two letters of the species name, if known
X	SUBSPECIES - tie-breaker, if required
XX	LIFE STAGE - refers to developmental stage of the insect in the sample
XXXXXX	TOTAL NUMBER - total count of insects of this group in the sample

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FIELD DATA SHEET - INVERTEBRATE

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	TROPHIC	HOST	ORDER	FAMILY	GENUS	SPECIES	SUBSPECIES	LIFE STAGE	TOTAL NO.	DRY WT.	NO. WEIGH
			Day	Mo	Yr															
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	20-21	23	25-29	31-33	35-37	39-40	42-43	45	47-48	50-55	57-62	64-66

DATA TYPE
- 01 Aboveground Biomass
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- 25 Avian Collection - Plumage
- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- 43 Microbiology - Root Decomposition
- Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TROPHIC
- 0 Unknown
- 1 Plant feeding (tissue)
- 2 Plant feeding (sap)
- 3 Plant feeding (pollen and nectar)
- 4 Plant feeding (seed)
- 5 Predator
- 6 Parasitoid
- 7 Parasite
- 8 Scavenger
- 9 Non-feeding stage

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

LIFE STAGE
- 00 Undetermined
- 10 Adult
- 20 Pupae
- 30 Egg
- 40 Nymph or Larva
- 41 Nymph or Larva, early
- 42 Nymph or Larva, middle
- 43 Nymph or Larva, late
- 50 Instar
- 51 Instar, 1st
- 52 Instar, 2nd
- 53 Instar, 3rd

XXXXXX DRY WEIGHT - ovendry weight to nearest .01 g of subsample from total

XXX SUBSAMPLE NUMBER - the number of insects used in the dry-weight determination

Preliminary Analysis

The data will be analyzed to provide mean and standard deviation of the numbers and the biomass of invertebrates by trophic level for each treatment area sampled.

Required Turnaround Time

Sampling will be conducted on a biweekly basis during the growing season. Because the sample size required may be affected by the accuracy of the estimate on a previous sampling, the preliminary analysis should be completed and back to the investigator in the field within the two week period.

MICROBIOLOGY - BIOMASS

Sampling Methods

Biomass of microorganisms in the soil will be determined by direct counts of samples. Samples will be obtained from the soil cores taken in the below-ground plant biomass studies. A composite sample for the replicate will be obtained from each of the core segments taken from the soil horizons. The composite sample will be formed from 10 to 20 g of soil from each of the core samples of a given depth throughout the replicate. Subsamples from the top 5 cm of the A horizon will be combined as will subsamples from the second 5 cm of the A horizon, and likewise the subsamples from the B horizon and

from the C horizon will be combined. This makes a total of at least four samples for evaluation of microbial biomass from each replicate within treatments. The composite sample will be thoroughly mixed, and portions will be removed for microscopic examination. Samples should be taken at selected intervals during the growing season, perhaps monthly or bimonthly. Bacterial counts will be made according to the method outlined by D. Parkinson in the IBP Manual on Microbiological Methods (in preparation). Fungal hyphal lengths will be determined according to the agar-film method of Thomas, Nicholas, and Parkinson (1965). The following modifications to this method may be made:

1. 1 g soil samples (diluted in 100 ml agar-water suspension) may be used in preparation of the films
2. No stain applied to the soil-agar films
3. Phase-contrast microscopy for observation of films.

Data Recording

A sample data form for recording information on biomass of microorganisms follows:

X	HORIZON - code for soil horizon
XXX	DEPTH TO TOP OF CORE - cm
XXX	DEPTH TO BOTTOM OF CORE - cm
XXXXX	WEIGHT OF SOIL FROM CORE - to nearest 0.1 g
XXXX	WEIGHT OF MICROSAMPLE - to nearest 0.1 g
X	TYPE - code for type of microbiological material
XXX	COUNT or LENGTH - the number (of spores) or length (of hypha) in the microscope field

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FIELD DATA SHEET - MICROBIOLOGY - BIOMASS

C A TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	HORIZON	DEPTH, TOP	DEPTH, BOTTOM	CORE WT.	SAMPLE WT.	TYPE	COUNT-LENGTH	TYPE	COUNT-LENGTH	
			Day	Mo	Yr													
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21	23-25	27-29	31-35	37-40	42	44-46	48	50-52	

DATA TYPE
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- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

YPE
- 1 Bacteria
- 2 Bacterial spore
- 3
- 4
- 5 Fungus

HORIZON
- 1 AO
- 2 A
- 3 B
- 4 C

X TYPE

XXX COUNT or LENGTH

Etc.

MICROBIOLOGY - DECOMPOSITION

Sampling Methods

Rates of decomposition will be evaluated by putting sample material in nylon net bags as containers and placing these in the soil for later recovery and drying, weighing, and ashing to determine the rate of loss of sample material. Sample material may be cellulose filter papers or litter or other organic material. The sample will be placed at a depth of 5 to 7 cm in the soil, or at the depth where plant roots are most abundant. Samples should be placed in the soil at monthly intervals during the growing season and retrieved at monthly intervals. A sufficient number should be placed in each replicate so that at least three may be recovered at each time interval. Upon collection the sample material will be removed from the nylon bag and oven-dried at 60°C (plant material) or 90°C (cellulose filter paper) for 24 hours. The sample material will be weighed, then ashed, and the ash weighed for determination of the amount of sand and mineral material weighed with the original sample. At the same time a sample of soil should be similarly dried, ashed, and weighed to determine the loss of organic material and carbonates from soil upon ignition. Ashing will be at 600°C for four hours.

Data Recording

A sample data sheet for recording information on decomposition of organic material follows:

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FIELD DATA SHEET - MICROBIOLOGY - DECOMPOSITION

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	MATERIAL	DEPTH	DATE BURIED			NO. DAYS	WT. ORIGINAL	WT. RETRIEV.	WT. IGNITION	SOIL WT.	SOIL. IGNIT.
			Day	Mo	Yr						Day	Mo	Yr						
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21	23-24	26-27	28-29	30-31	33-35	37-41	43-47	49-53	55-59	61-65

DATA TYPE
- 01 Aboveground Biomass
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- 30 Invertebrate
- 40 Microbiology - Decomposition
- 41 Microbiology - Nitrogen
- 42 Microbiology - Biomass
- Microbiology - Root Decomposition
- 44 Microbiology - Respiration

SITE
- 01 Ale
- 02 Bison
- 03 Bridger
- 04 Cottonwood
- 05 Dickinson
- 06 Hays
- 07 Hopland
- 08 Jornada
- 09 Osage
- 10 Pantex
- 11 Pawnee

TREATMENT
- 1 Ungrazed
- 2 Lightly grazed
- 3 Moderately grazed
- 4 Heavily grazed
- 5 Grazed 1969, ungrazed 1970
- 6
- 7
- 8
- 9

SAMPLE MATERIAL
- Cellulose
- 2 Litter
- 3 Standing dead
- 4
- 5

X	SAMPLE MATERIAL - code for the type of material in the bag
XX	DEPTH - cm
XXXXXX	DATE OF BURIAL - two spaces each for day, month and year, in that order
XXX	NUMBER OF DAYS
XXXXX	ORIGINAL DRY WEIGHT - to nearest 0.1 g
XXXXX	WEIGHT AT RETRIEVAL - (dry)
XXXXX	WEIGHT AFTER IGNITION
XXXXX	SOIL SAMPLE WEIGHT
XXXXX	SOIL WEIGHT AFTER IGNITION

MICROBIOLOGY - RESPIRATION

Sampling Methods

Samples for evaluation of soil respiration will be taken from the soil cores in the same way that samples were collected for evaluation of microbial biomass. The samples will be used to evaluate CO_2 evolution in closed chambers and with varying conditions of temperature and moisture. This index of microbial activity can then be extrapolated to field conditions by utilizing the data that will be accumulated on field soil moisture and field soil temperature. Soil respiration will be measured in the field, where possible, and efforts will be made to distinguish between respiration by belowground plant parts and by microorganisms.

MICROBIOLOGY - NITROGEN

Sampling Methods

Samples will be obtained from the soil cores in a similar manner to those obtained for the determination of microbial biomass. Samples will be saved

for a quantitative test of the soil organic nitrogen. This will be performed before and after incubation of the subsample to evaluate the rate of loss of nitrogen from the soil due to microbial activity.

MICROBIOLOGY - ROOT DECOMPOSITION

Sampling Methods

Roots can be labeled using radioactive carbon by exposure of the plants to an atmosphere of $^{14}CO_2$. A large fraction of the carbon assimilated by leaves will be translocated to the roots. In the area where the roots have been labeled, soil cores can be taken at regular intervals, and the roots as well as the organic material in the soil can be analyzed for content of ^{14}C. This will give an indication of the rate of death and decomposition of plant roots *in situ*. For details of the method, see Dahlman and Kucera (1968).

MICROCLIMATOLOGY

Sampling Methods

Measurements will be made at the Comprehensive Network Sites of the climatic variables which are considered "driving forces" by the ecosystem modellers. These are factors that are known to be related to organism physiological processes, though they may not necessarily include the means by which the organisms are coupled to the environment. The objective is not to make a detailed study of microclimate, nor to evaluate detailed models of organic processes, but to evaluate those factors related to biological productivity and trophic level transfer rates. Sensors that are commercially available will be used. A single recording system for each site with analog

signal input, an analog to digital converter, and multichannel digital recording on magnetic tape will be utilized. All sensors will be read and results recorded at hourly intervals. The instruments can run unattended, although they will be checked and calibrated as frequently as possible. The magnetic tape will be replaced monthly and forwarded to the Natural Resource Ecology Laboratory for machine transcription into the IBP Grassland Biome Information Storage and Retrieval System. The rain gage and hygrothermograph charts will be changed weekly. Readings of maximum-minimum thermometers and sling psychrometers will be made daily if possible. These latter instruments will be housed in a Standard U. S. Weather Bureau shelter. The reading from standard instruments will be for comparison with standard measurements made at U. S. Weather Bureau stations.

Data Recording

The following data will be recorded hourly (the frequency is determined by the sensor to be read most often, in this case temperature):

1. Soil moisture - thermocouple psychrometers at 2.5, 25, and 75 cm below soil surface, with one additional in the A horizon
2. Soil heat flux - one heat flux disc at 8 cm (3 inches)
3. Temperature - wet bulb temperature at 1 m above vegetation canopy; dry bulk temperature at 1 m above canopy height, + 2.5 cm, -2.5 cm, -25 cm, -75 cm of the soil surface.
4. Wind - integrating atmometer at 1 m above canopy
5. Net radiation - 1 m above canopy.

The following readings will be taken weekly or as opportunity permits.

1. Precipitation - standard recording rain gage

2. Snow depth and density
3. Temperature and humidity from hygrothermograph
4. Wet bulb and dry bulb temperature from sling psychrometer.

Required Turnaround Time

There is no set turnaround time for microclimatological data. Results from all stations will be accumulated in the Information Storage and Retrieval System. Printout of the raw data or summaries of the data will be provided to cooperating investigators on request.

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