Technical Report No. 170

CELLULOSE AND LITTER DECOMPOSITION AND EVOLUTION OF CARBON DIOXIDE FROM SOILS AT THE COTTONWOOD SITE, 1971

Robert M. Pengra

Bacteriology Department

South Dakota State University

Brookings, South Dakota

GRASSLAND BIOME

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ABSTRACT

The measurement of carbon dioxide was neither quantitative nor reproducible, and our method for the coming season will be the standard one decided upon by the biome microbiologists.

Although certain trends could be seen and some correlation could be demonstrated between moisture, temperature, and the rate of litter and cellulose decomposition, our data are not such that we can draw any meaningful conclusions from them. Here also, refinement of methods for the coming season will be made.

CARBON DIOXIDE MEASUREMENT

The alkali absorption method for determining the amount of CO_2 evolved from a given soil surface area was used at the Cottonwood Site during the 1971 growing season. Results are extremely variable and inconclusive. No reportable CO_2 evolution data are available due to the extreme variability of results.

CELLULOSE AND LITTER DECOMPOSITION

Introduction

Experimental procedure for the sampling year 1971 was similar to that set forth in Technical Report No. 126 detailing the work done at the Cottonwood Site in 1970. Cellulose filter paper and standard litter were again used in an attempt to standardize sample materials between sites. Additional native organic materials were tested for decomposition this year. It is expected that differences in the driving variables between sites will make intersite comparisons difficult.

Materials and Methods

Western wheatgrass (*Agropyron smithii* Rydb.) litter was placed above ground June 5, 1971, and removed monthly. Representative washed roots were placed below ground monthly beginning June 4, 1971, and removed in September and October 1971. Representative mulch was placed above ground in July and August and removed monthly. Representative shortgrass (*Buchloe dactyloides* Nutt.) and (*Bouteloua gracilis* Lag.) litter was placed above ground on June 5, 1971, and removed monthly. All samples were placed in bags of nylon net having a mesh size of 30 squares/cm^2. Bags of each material were emplaced to ensure availability of one sample from each of three transects from each of two replications per sample date for the high (ungrazed) and low (grazed) range condition exclosures.

All prepared bags were weighed and the weights recorded prior to emplacement. Six soil samples were taken from the high range condition exclosure and six from the low range condition exclosure and analyzed for soil organic content. The organic content of the 12 soil samples was found to average 7% with the maximum variance from this average being less than 2%. Thus, a 7% correction factor was added to the weight of mineral soil to arrive at a weight of total adhering soil in the following formula:

wt of filter paper lost = original filter paper wt -
[final filter paper and soil wt - (residual ash + organic
content of soil)].

Filter paper has less than 0.001% ash. This formula was modified for use with the other organic materials by ashing a "homogenous" portion of the material to determine mineral content. The original weight was then reduced to correct for the mineral content.

If during decomposition studies we are to be able to use loss in weight as a measure of energy in the system, then we must know that litter weight is closely correlated with energy content. If large differences in mineral content of organic matter occur, then it is likely that this will give a false picture of energy stored and therefore lost during decomposition. In some materials, i.e., animal bone, this material may, in fact, represent a relatively large amount of stored energy; and therefore, corrections for mineral matter will not be simple.

One group of filter paper samples was placed in the ground on October 3, 1970. All other samples were emplaced in the spring of 1971.

Results and Conclusions

All decomposition is expressed as milligrams lost per gram of original material per day. Results of all decomposition investigations are depicted graphically. The range from high to low results has been plotted to indicate the extreme variability of the data. Because of this variability, in most cases, no attempt should be made to extrapolate between points on the graphs.

Generally, aboveground decomposition data showed less variation than belowground data. Perhaps this results from inherent differences in above- and belowground positioning rather than from class of decomposable material.

The initial decomposition rate is high and tends to drop off as more readily decomposed material is mineralized, with the exception of filter paper which is virtually pure cellulose.

Fig. 1 depicts soil water at the Cottonwood Site from April through September. The decomposition rate was initially high in June, dropping off, and then increasing with the precipitation which raised soil water in late August and September. Peaks and troughs of the soil water and decomposition graphs roughly coincide. Other factors not monitored due to lack of "micromet" data, which would influence decomposition rate, include soil temperature, air temperature, and humidity in the microenvironment immediately above the soil surface.

Fig. 2, 3, 4, and 5, depicting decomposition rates for western wheatgrass litter, standard mulch, shortgrass litter, and standard bluestem (*Andropogon gerardi* Vitm.) litter, respectively, show decreasing rates of decomposition as we move from mid- to late summer into mid- to late fall. Differences in decomposition rates between these diverse materials may be accounted for by differences in chemical composition of species and amount of "decay" present

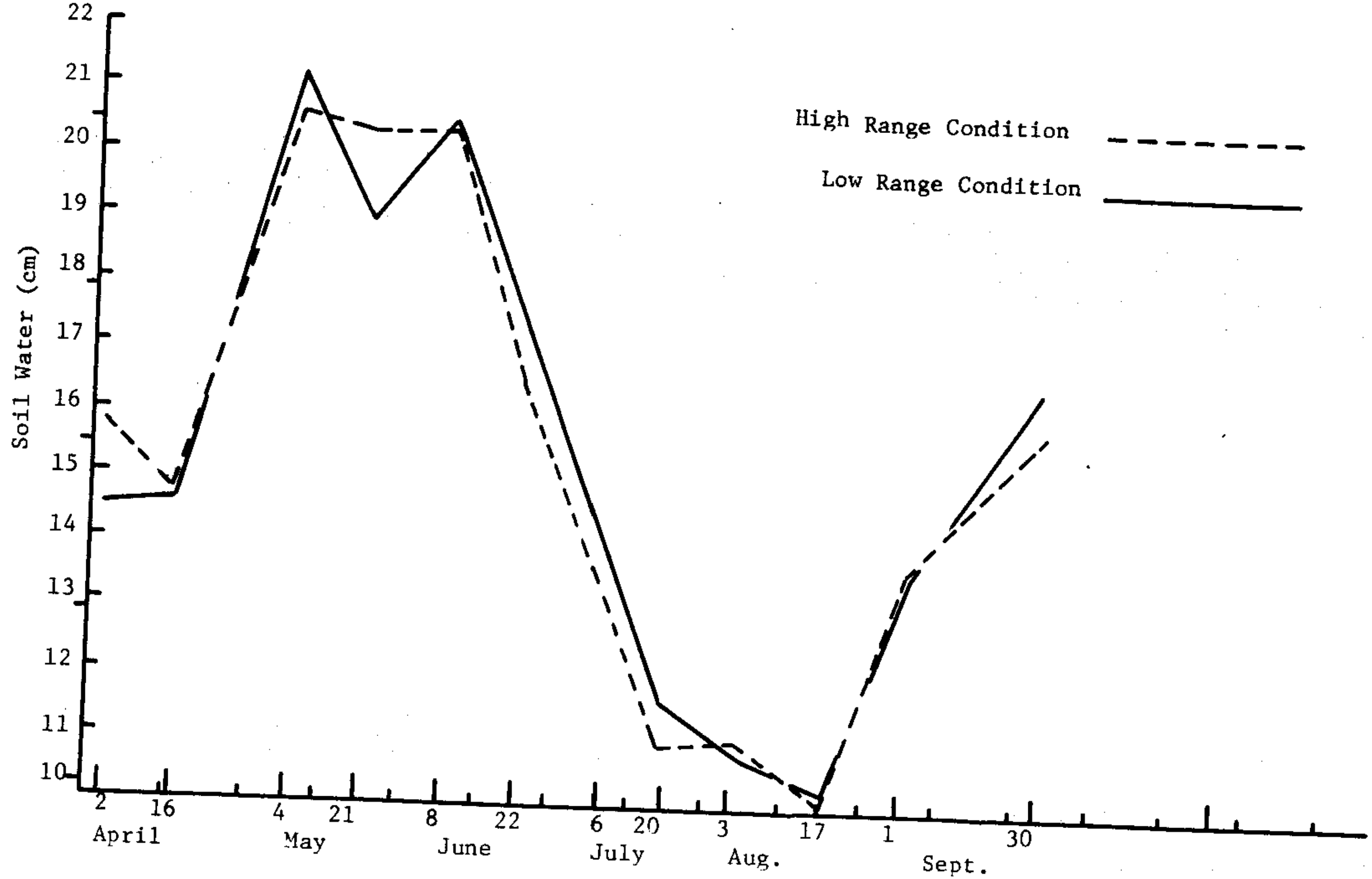

Fig. 1. Soil water (0-60 cm) at the Cottonwood Site, 1971.

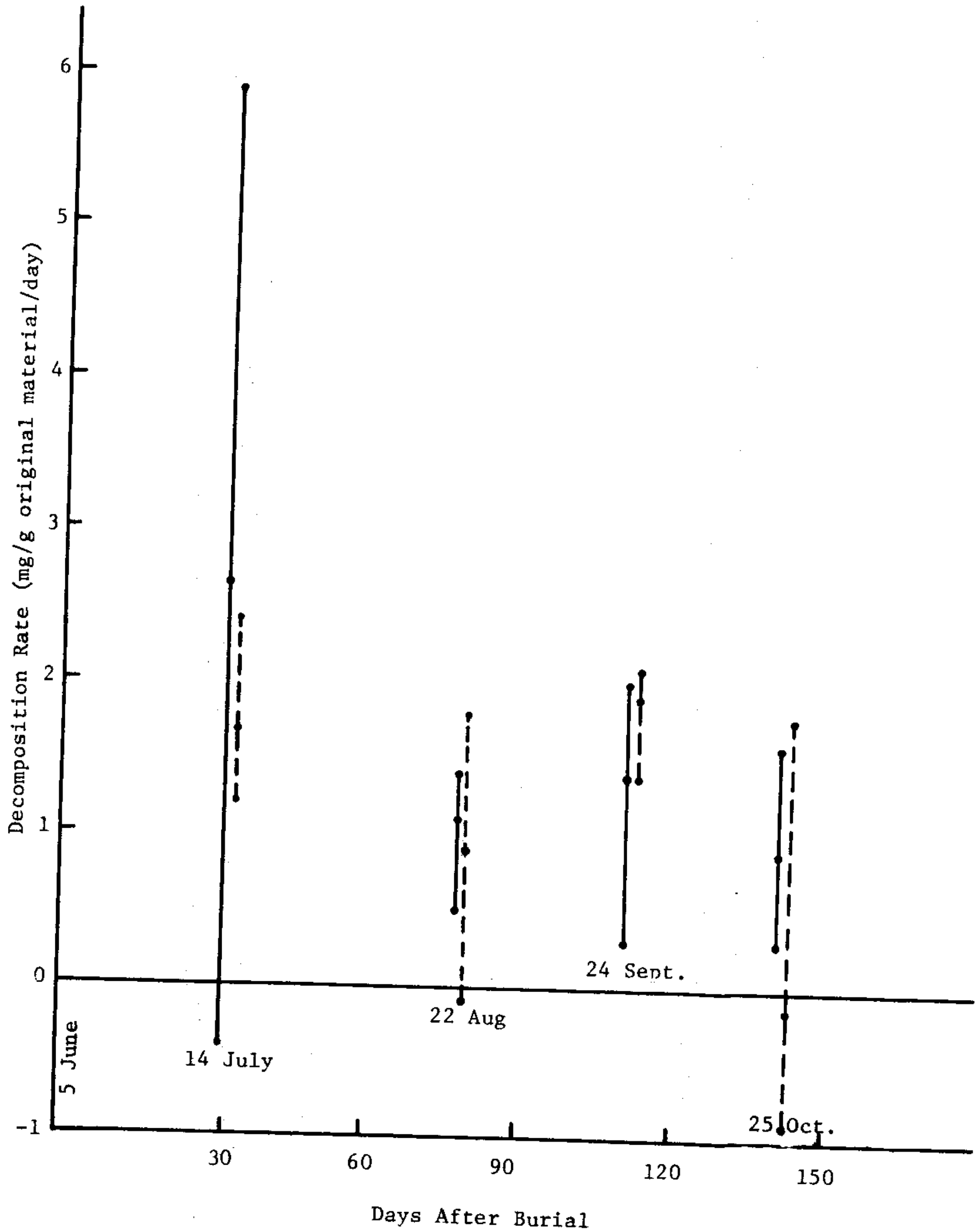

Fig. 2. Decomposition of western wheatgrass litter above ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent the maximum, minimum, and average loss for six samples.

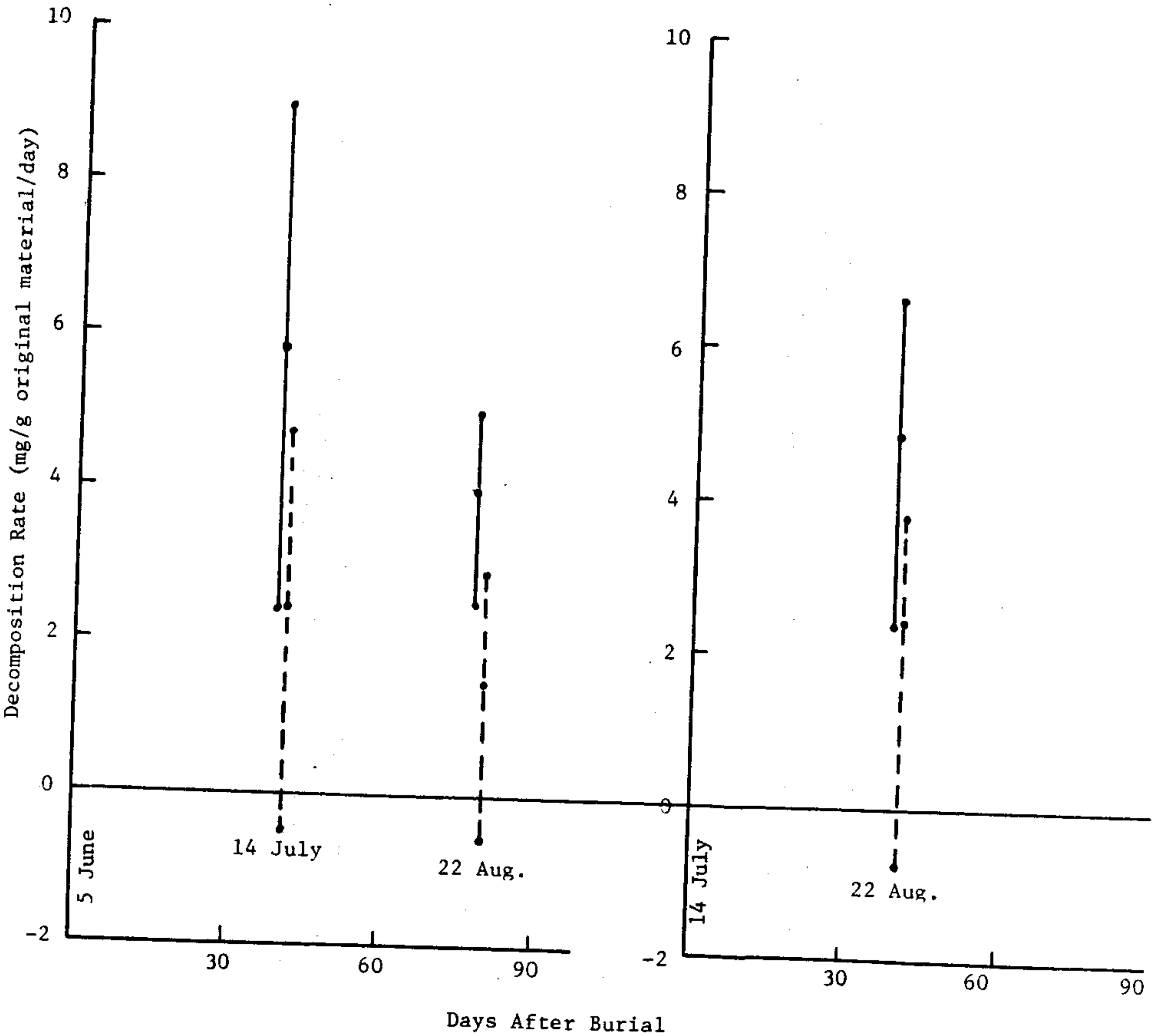

Fig. 3. Decomposition of mulch above ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent the maximum, minimum, and average loss for six samples.

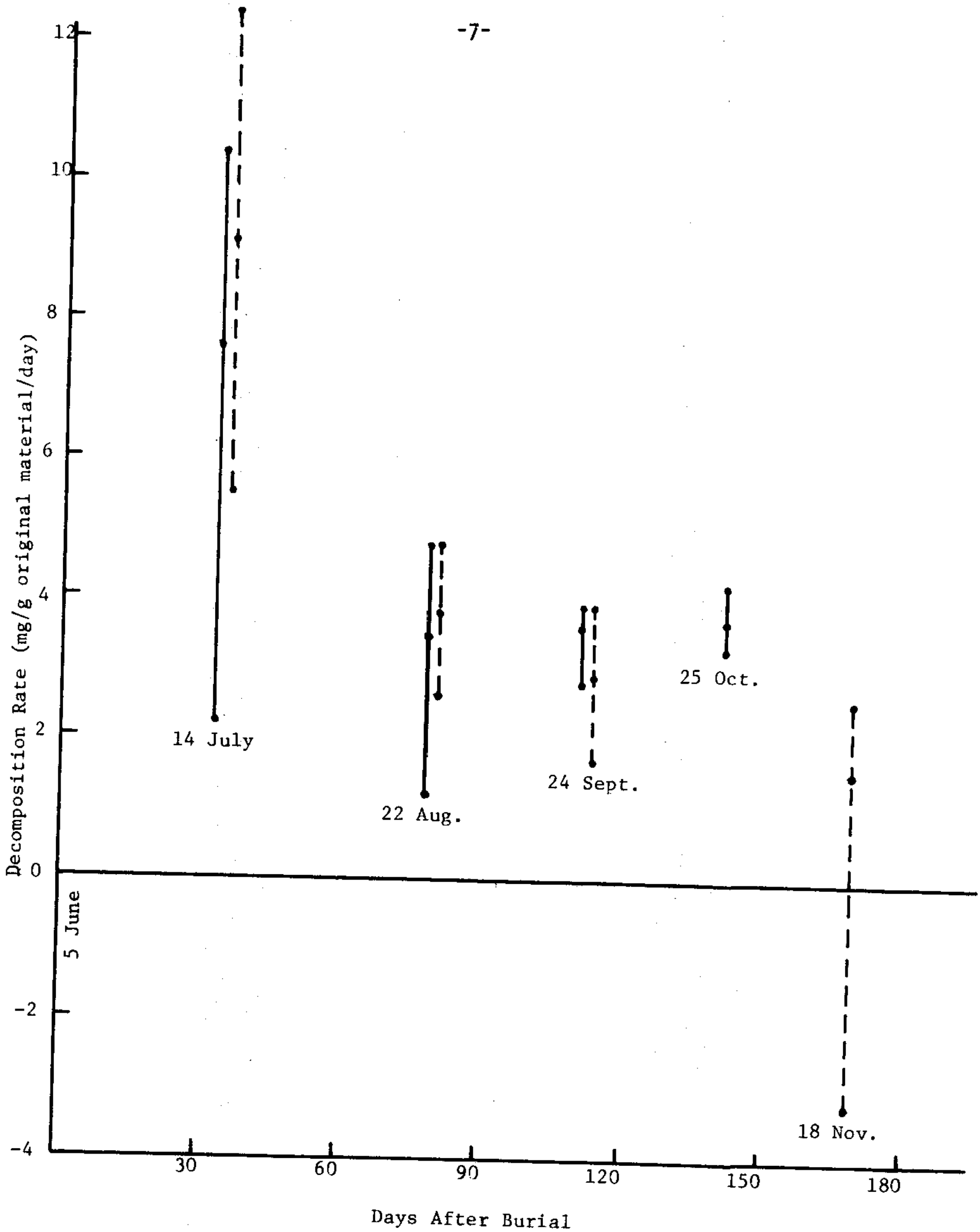

Fig. 4. Decomposition of shortgrass litter above ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent the maximum, minimum, and average loss for six samples.

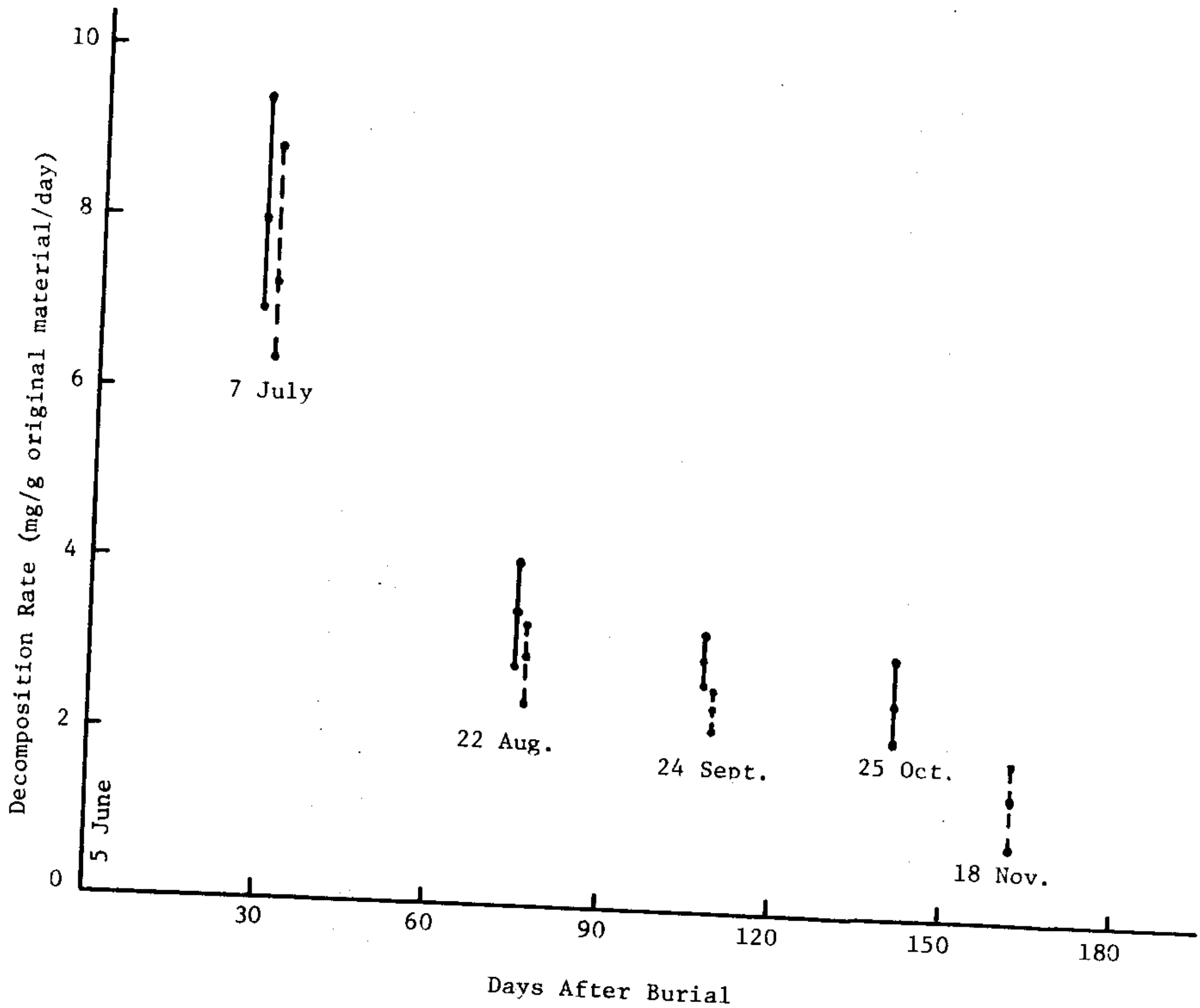

Fig. 5. Decomposition of bluestem litter above ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent the maximum, minimum, and average loss for six samples.

in the samples when they were placed. Variability of results between samples of like composition may be caused by many factors. Difficulty is experienced in preventing fine particles from falling out of the mesh after weighing and before placing the sample. Likewise, fine, partially broken down material adheres to intruding leaves and stems of plants growing on the sample plots and is lost when the sample bag is retrieved. Loss of sample weight may be offset at times by the addition of extraneous material intruding itself into the sample and being collected with it. Homogeneity of sample material is costly and difficult to obtain. It may be assumed that mixtures of material are never truly identical and are, therefore, subject to different decomposition rates.

Filter paper, above and below ground, and roots placed below ground have produced some perplexing problems. In all cases the samples in these series have evidenced "negative decomposition rates" or, in effect, a gain of weight from time of emplacement to end of summer. The trend was that filter paper samples for the low range treatment showed a lower rate of decomposition than those from the high range treatment. The aboveground filter paper samples, Fig. 6, display less variation than the belowground filter paper samples, Fig. 7 and 8.

Fig. 8 contains the data from filter paper left in the ground over winter. As would be expected, little decomposer activity was detected from October 1970 to April 1971. Whatever activity was detected was probably accomplished during short periods of "warmer" weather when the soil was not solidly frozen. Rapid decomposition rates were experienced with the onset of warm weather and spring rains.

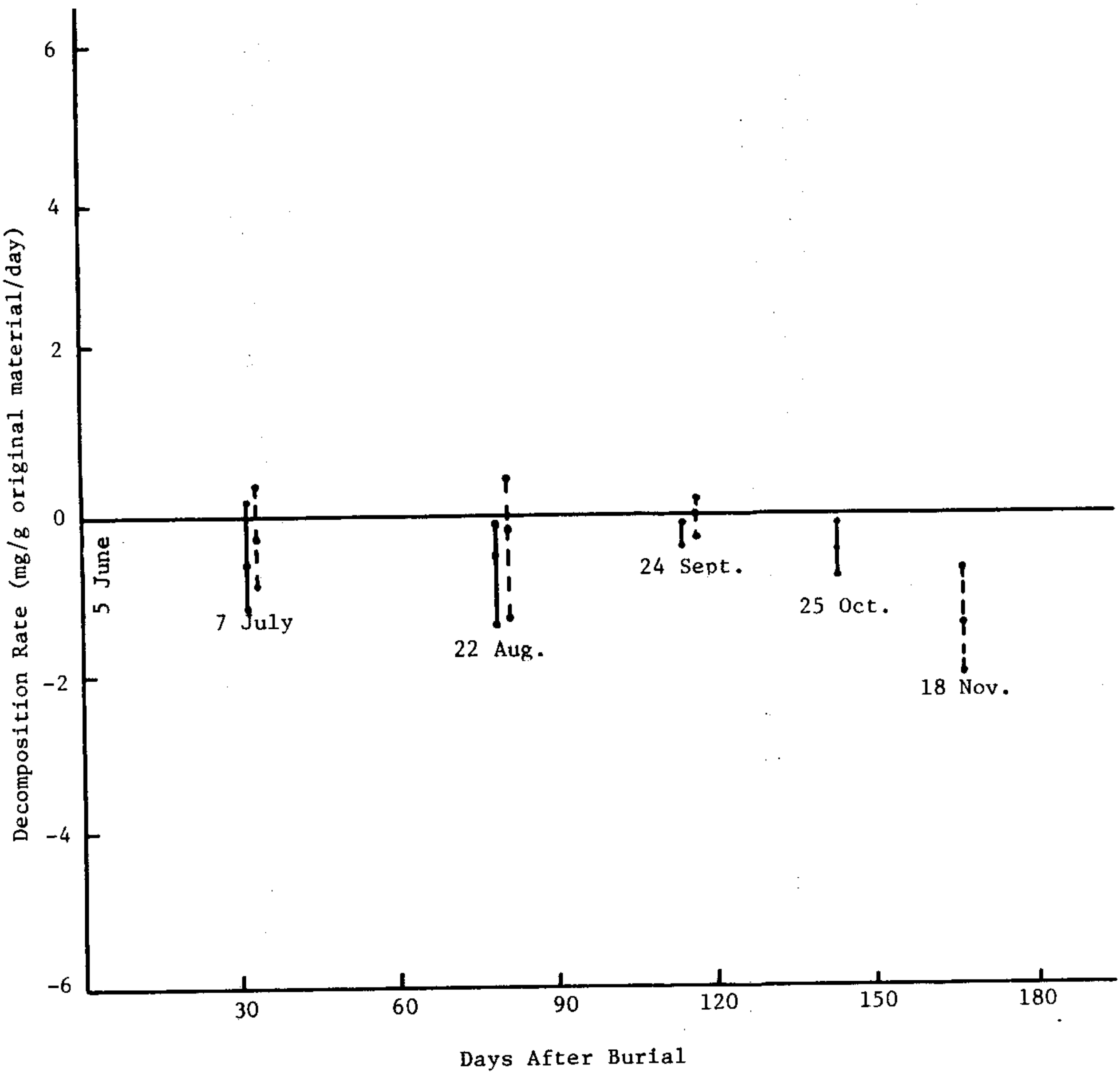

Fig. 6. Decomposition of filter paper above ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent the maximum, minimum, and average loss for six samples.

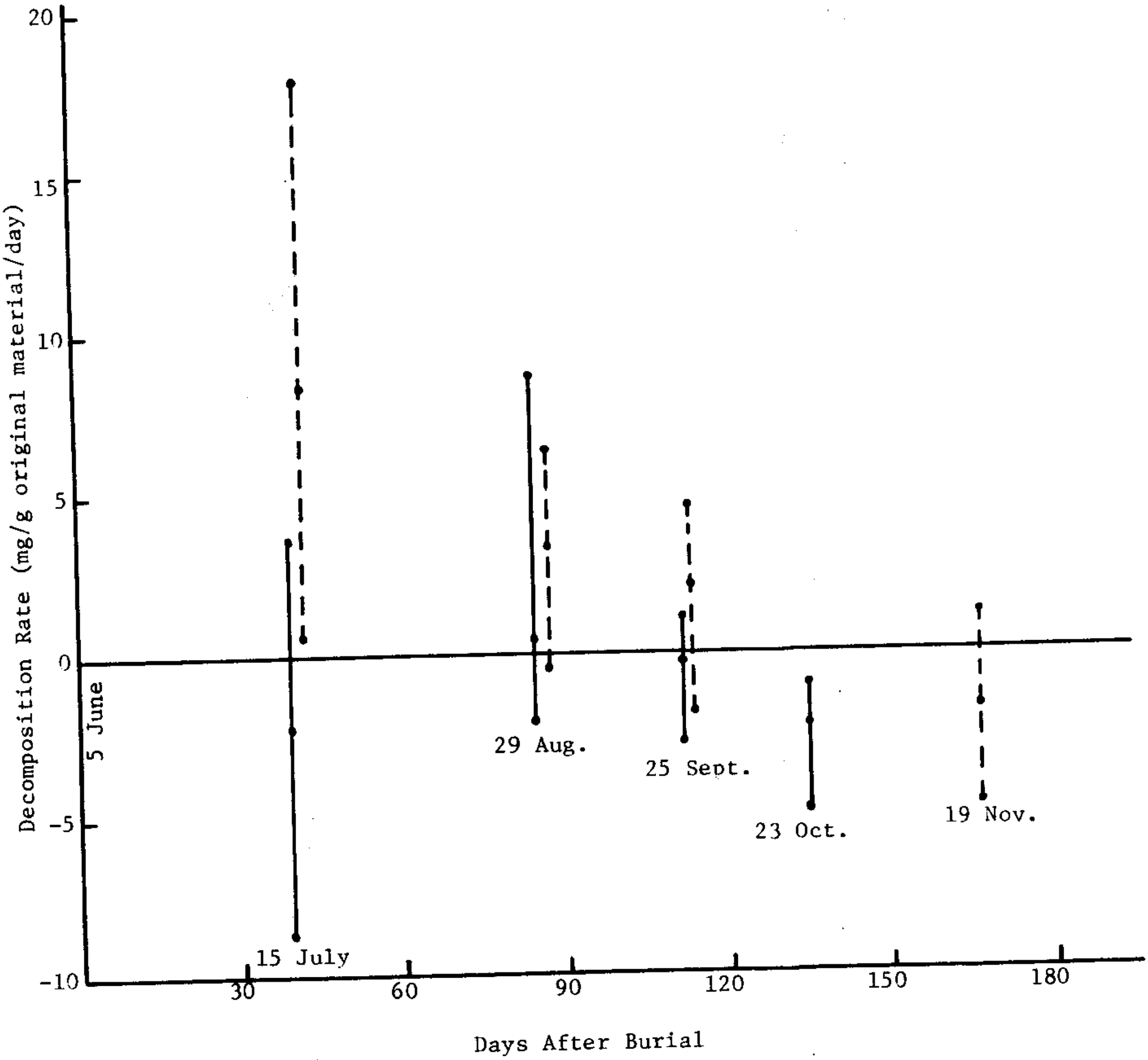

Fig. 7. Decomposition of filter paper below ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent maximum, minimum, and average loss for six samples.

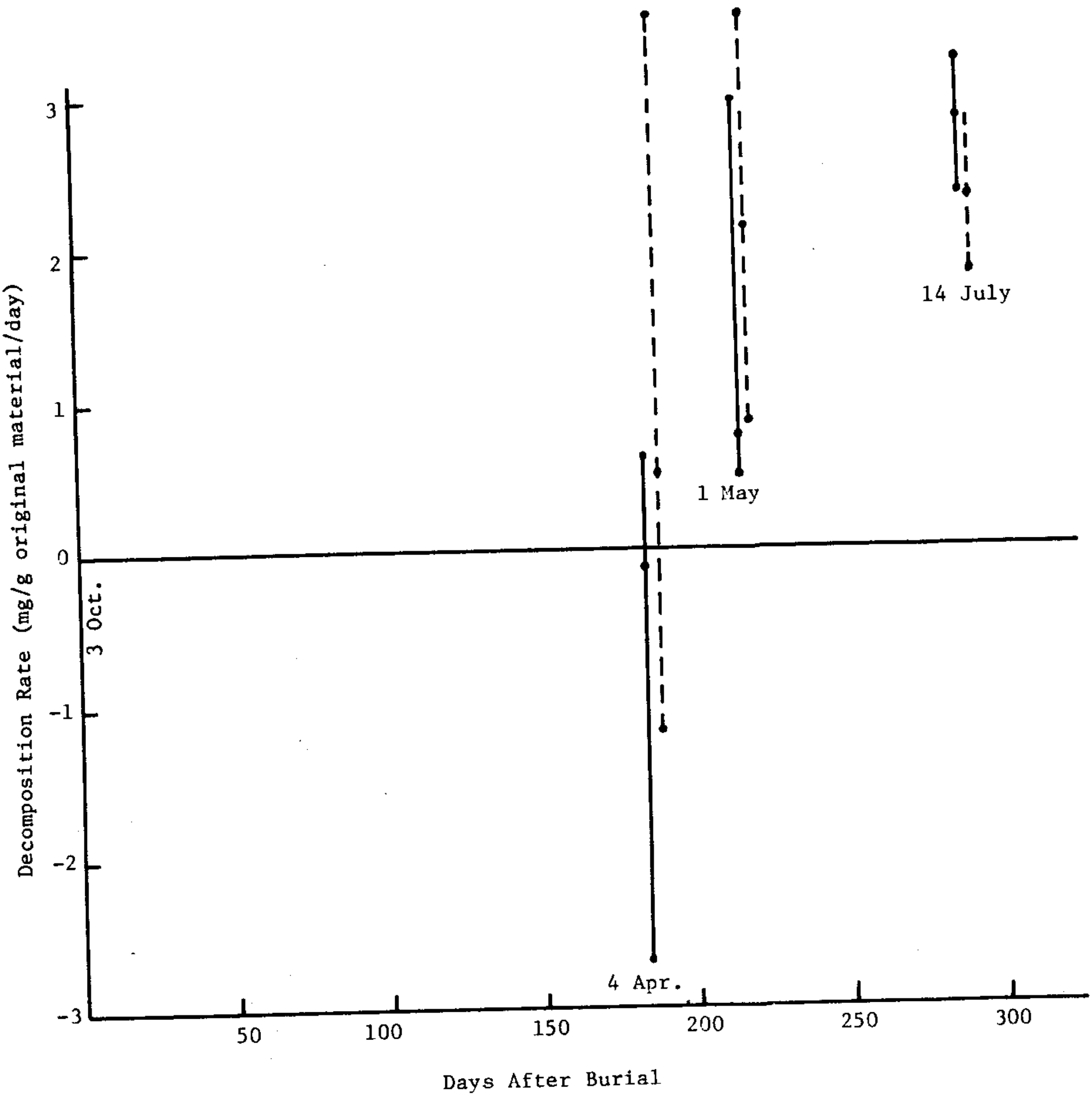

Fig. 8. Decomposition of filter paper below ground for 1971. The solid line represents low range condition, and the dashed line represents high range condition. The three points represent maximum, minimum, and average loss for six samples.

Fig. 9 and 10 illustrate the fate of roots placed below ground monthly and removed monthly. With this sample material the high range treatment gave a more rapid decomposition rate than the low range treatment.

Speculation about the cause for "negative decomposition rates" has been rampant. Experimental results have been consistent enough to rule out the human, mechanical factors inherent in any experimental procedure as being responsible for this phenomenon. Perhaps the weight of microorganisms invading the samples or living roots may be partially responsible.

Variability between samples of the same material in the case of washed roots may be attributed to intrusion of additional roots which would be hard to differentiate from sample roots. Certainly washed roots are not natural, and some mineral material may be leached out in the washing process which may have changed the decomposition rate or total decomposability of the roots.

Much has been learned from the 1971 study at Cottonwood. The following recommendations are made based on this knowledge.

Efforts to diversify sampling procedures and materials should be discouraged. Economics and time considered, effort should be directed toward maximizing numbers of samples of one or two sample materials. Filter paper and possibly native litter are recommended. Extreme care should be used to prepare a homogenous sample of the native litter. The number of samples should be increased, employing only one or two materials to enable the researcher to remove two sample bags per transect on each sample date instead of one. This should help to reduce the variability. Nylon bags containing no sample should be utilized as controls to check for changes in bag weight. Sample bags should be randomly chosen for removal.

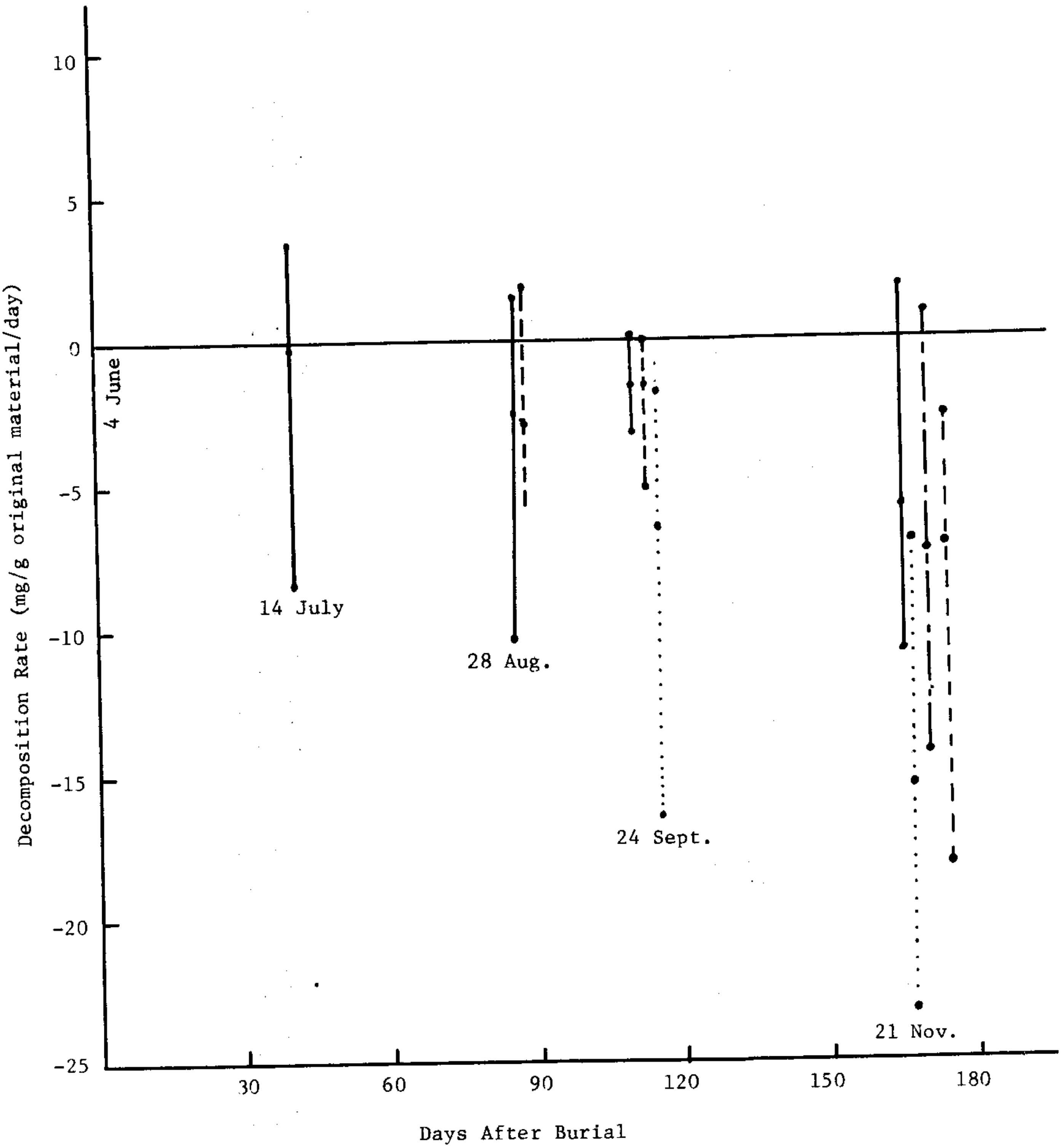

Fig. 9. Decomposition of roots below ground in high range condition for 1971. The solid line represents material emplaced on 4 June; the dashed line, material on 14 July; the dotted line, material on 28 August; and the dot-dash line, material on 24 September.

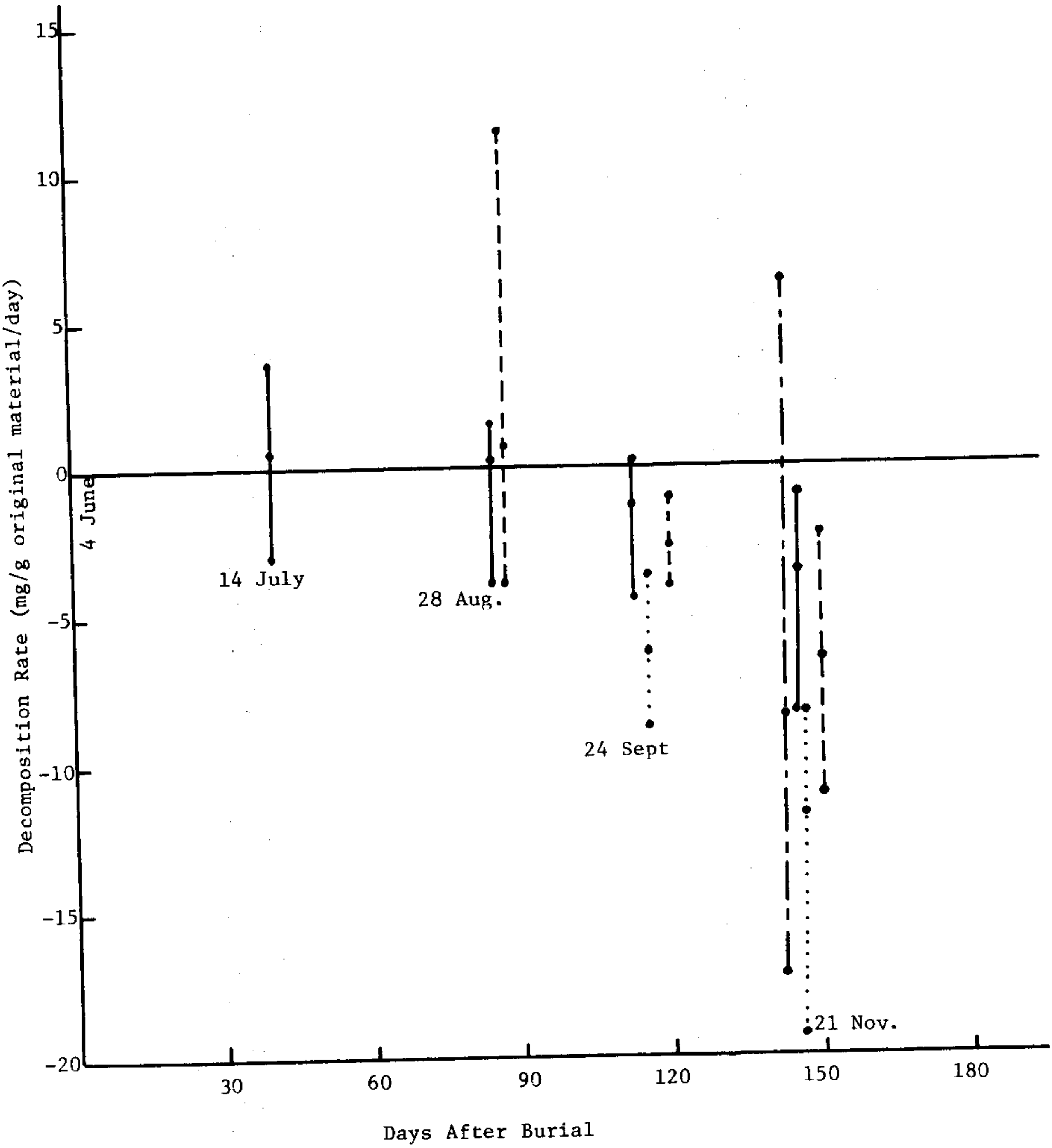

Fig. 10. Decomposition of roots below ground in low range condition for 1971. The solid line represents material emplaced on 4 June; the dashed line, material on 14 July; the dotted line, material on 28 August; and the dot-dash line, material on 24 September.

LITERATURE CITED

Turner, J., and R. M. Pengra. 1971. Decomposer studies at the Cottownwood Site. U.S. IBP Grassland Biome Tech. Rep. No. 126. Colorado State Univ., Fort Collins. 15 p.

APPENDIX I

FIELD DATA

Microbiology/Decomposition for Cottonwood

The following data were collected at Cottonwood Site as part of data set A2U4004 for 1971. The data were collected on data form NREL-40. Note that columns 10 through 19 contain organic matter proportion rather than plot size as indicated on the form.

IBP

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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
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

SAMPLE MATERIAL
1 Cellulose
2 Litter
3 Standing dead
4
5

EXAMPLE OF DATA

```
         1         2         3         4         5         6
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