


1973

Decomposition and Mineralization in an Artemisia Tridentata Community in Northern Nevada

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1973 PROGRESS REPORT

DECOMPOSITION AND MINERALIZATION IN AN
ARTEMISIA TRIDENTATA COMMUNITY IN NORTHERN NEVADA

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ABSTRACT

Rates of sagebrush leaf litter weight loss differ among samples, although similar rates often occur in the same time intervals. Time in the field is also a factor. Negative weight loss is discussed. Carbon dioxide evolution during most sampling dates differs significantly among samples, but seems independent of the length of time samples are in the field. Negative CO₂ evolution represents an unsolved problem. Correlation of decomposition with meteorological variables may elucidate some patterns. Microhabitat similarity and dissimilarity are considered.

INTRODUCTION

The purpose of this project is to determine the rate of breakdown of big sagebrush (*Artemisia tridentata* Nutt.) litter in the field under monitored environmental conditions. The 1973 effort represents a continuation of the work initiated in 1972 with the addition of certain objectives as itemized in the Objectives section. In 1974 the work will continue and expand to include decomposition in a shadscale (*Atriplex confertifolia*) community.

In July, 1973, the study plot was destroyed by a large range fire. A new site was selected in August, 1973, and work is continuing at the new location.

OBJECTIVES

The objectives for 1973 included continuing the two-year research study initiated in March, 1972. Specifically the objectives were to:

1. Determine the rate of breakdown of big sagebrush leaves through monitoring weight loss of samples placed in the field (for details of the original research design see RM 73-39, Comanor and Prusso, 1973).
2. Monitor the amounts of carbon dioxide released from these samples during the year.
3. Monitor the environment utilizing standard weather instruments in order to correlate litter breakdown and carbon dioxide release with standard meteorological measurements.
4. Examine the microhabitat to obtain some idea of the variability present.
5. Determine nitrogen content of litter samples over time.

New projects initiated in the field in 1973 were:

1. A study to determine the rate of breakdown of buried root and stem material on a weight basis.
2. A study to determine the *in situ* breakdown of stem and twig litter on the ground on a weight basis.

EXPERIMENTAL DESIGN

The original study site (Plot 04) was located southwest of the intersection of U.S. 395 and California 70 in Plumas County, California, at an elevation of about 1540 m. The site was adjacent to an Agriculture Research Service (USDA) enclosure. Samples of air-dried leaf litter (four sub-samples of 2 g each) were placed in the field throughout

1972 and in January and February, 1973. From January through July, 1973, these samples were returned to the lab for determination of weight loss and nitrogen content. Selection was random from within the group of samples placed in the field during any prior month (Comanor and Prusso, 1973).

The new site (Plot 03) is located 10 km north of the University of Nevada, Reno, at the northwest end of Sun Valley, Washoe County, Nevada, at an elevation of 1650 m.

The leaf litter samples were also used for monitoring carbon dioxide release. At the original site (04), the samples selected usually included some which had been in the field the better part of the year, as well as fairly fresh samples. At the new site (03), such options were not possible because of the short period during which the samples were in the field.

Root and stem litter samples were buried at the original site on May 23, 1973. Burial depths were 5 and 10 cm, exposures were on the north and south sides of shrubs. Three sets of two replicates each were placed in the field. The basic research design is:

| | |
|-------------------|----------|
| | <u>N</u> |
| Exposures (N,S) | 2 |
| Depths (5, 10 cm) | 2 |
| Recovery Times | 3 |
| Replicates | <u>2</u> |
| | 24 |

The above sample design was duplicated at the new site (03) on September 15, 1973. Samples were buried under arbitrarily selected plants of big sagebrush where canopies were large enough to allow burial of samples on both the north and south sides.

METHODS

LEAF LITTER SAMPLES

The sagebrush leaves which were used for the study were obtained adjacent to the study plot two weeks prior to their placement in the field. These were air-dried in the laboratory. Twelve 2 g samples were sewn into bags and placed in the field each month for the first year. Samples remained in the field 1,2,3, . . . , 12 months. They were then

returned to the lab, cleaned of the extraneous material, air-dried and weighed, after which they were oven-dried at 45 C for 48 hr and re-weighed (DSCODE A3UCH01). Unlike the original research design, all leaf litter samples were placed simultaneously in Plot 03 on August 15, 1973.

BURIED ROOT AND STEM SAMPLES

Root and stem material from big sagebrush shrubs were collected at the original site, returned to the laboratory, air-dried and sewn into 1 x 2 dm polyester bags with 1²mm mesh. Each bag was divided into six sections. Two g of root or stem material were placed into each section. The size classes for the material were as follows:

| | |
|------------------|----------------|
| 1. Fibrous Roots | 0.25- 0.85 mm |
| 2. Branch Roots | 0.95- 3.55 mm |
| 3. Roots | 6.15-16.10 mm |
| 4. Twigs | 1.45- 3.65 mm |
| 5. Branch Stems | 3.85- 7.40 mm |
| 6. Stems | 11.00-24.55 mm |

Results from this study will be available in the 1974 annual report.

SURFACE STEM SAMPLES

Two g of stem material from each of the three size classes listed above were sewn into thirty 1² dm bags and were placed on the ground under big sagebrush. In this case, the stems of the different size classes were mixed together.

MICROHABITAT TEMPERATURE MONITORING

In order to obtain data on the variability of the litter-soil microhabitat, temperatures were monitored over a 24-hr period once a month through July 16, 1973. Monitoring was done with a manually operated 12-channel YSI telethermometer. Temperature probes were placed in the following microhabitats (A3UCH02):

1. Under the shrub canopy, on the litter mound
 - (a) Litter, on the surface
 - (b) Litter, buried
 - (c) Litter, bottom -- soil surface
 - (d) Soil -- buried 5 cm
 - (e) Soil buried 10 cm
2. Edge of shrub canopy, on the litter mound (the transition zone)
 - (h) Litter, on the surface
 - (i) Litter, buried
 - (j) Litter, bottom -- soil surface
 - (k) Soil -- buried 5 cm
3. In the openings between shrubs
 - (o) Litter, on the surface
 - (p) In diffuse litter, when present

- (q) Litter, bottom -- soil surface
- (r) Soil -- buried 5 cm

4. Other microhabitats

- (ba) On the litter sample bag
- (bc) Under the litter sample bag
- (ta) On the surface of *Tortula ruralis* clumps
- (tc) In *T. ruralis* rhizoids

METEOROLOGICAL MEASUREMENTS

Precipitation was monitored at both Plots 04 and 03 by use of a plastic rain gauge set at a level just above the sagebrush canopy (A3UCH06). Temperatures and relative humidity were measured using standard hygrothermographs. One of these was placed in a standard weather shelter while the second hygrothermograph was placed under a sagebrush plant (north side). The strip charts for temperature (A3UCH07) and relative humidity (A3UCH08) are being read by Ecology Center personnel at Utah State University. Similarly, strip chart data for solar insolation (A3UCH09) are being read. These data were read on drums with a seven-day rotation.

TOTAL NITROGEN

Total nitrogen content of the leaf litter of samples in the field between March, 1972, and July, 1973, was determined by the microKjeldahl method as presented by Jackson (1958) and Bremner (1965), modified for plant material. Oven-dried (45 C) leaves were ground sufficiently to pass a 0.4 mm screen and weighed into approximately 0.5 g portions, then wrapped in cigarette paper. After drying a minimum of two days, these samples were digested using copper (Cal-Pak Powder #2, Gunning Method) and a selenium catalyst (Hengar Selenized Granules). Distillation was carried out using a boric acid trap with the distillate being titrated with a 0.01 N sulfuric acid standard using N-point indicator.

RESULTS AND DISCUSSION

This section of the report deals with results of the study at Plot 04 from March, 1972, to July, 1973.

WEIGHT LOSS (AS A FUNCTION OF TIME)

During the time period of the study (March, 1972, to July, 1973) all 2-g leaf litter samples showed an overall decrease of weight (A3UCH01). Those placed in the field during the March to July interval, 1972, had a final weight ranging from 0.94 to 1.1 g. Thus, their average weight loss after one year is about 50%.

The rates of weight decrease (represented by curve slopes) differed among samples (Fig. 1). Some (April, June) show a relatively slow rate followed by a more rapid rate; others (September, January) show a rapid rate initially. With the exception of the January (1974) sample, all samples showed

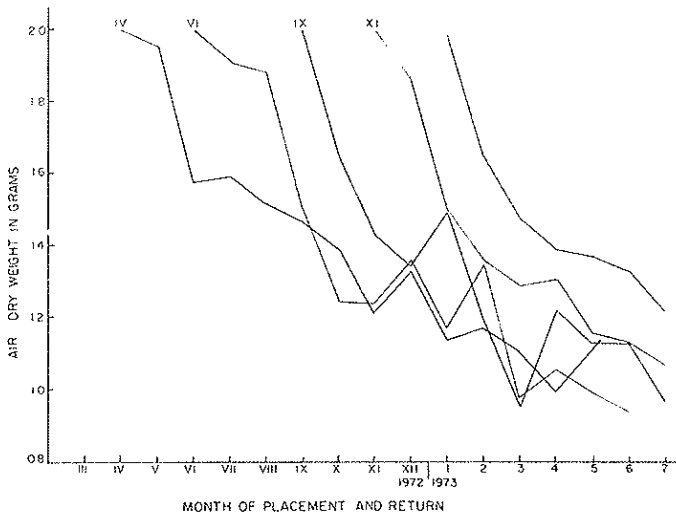


Figure 1. Air-dry weights of selected samples returned from the field on a monthly basis.

a weight gain at some point after they were placed in the field; The January sample was out only six months when the study ended. The weight gain was very small: 0.02 g for The November sample, but reached 0.25 g for the March sample (not shown). In some cases (e.g., June) the increase in weight occurred on more than one occasion.

In order to compare rates of weight change as a function of time in the field (in contrast to the time of placement into the field), all curves of weight change were plotted as though they were placed into the field simultaneously (Fig. 2). This shows many periods during which different samples had equivalent and rapid rates of weight decrease. Less steep, but similar, rates of decrease also occur frequently. In addition, periods of minor decrease (or weight gain) occur at certain noticeable time intervals. Seven of the 12 samples respond this way in the four-five month period. Five of the seven samples in the field in the nine-ten month period respond this way also.

The following interpretations of this phenomenon are possible: (1) these "plateaus" are coincidental in occurrence and have no causal basis; (2) it represents similar responses to different time periods of unfavorable environmental conditions; therefore, the plateaus are not intrinsically linked to any one month after placement; (3) it represents times of accumulation of fungal biomass whose turnover of the litter substrate is slow; (4) these plateaus reflect an intrinsically limiting factor residing in the litter-organism complex itself, a time-dependent factor which is independent (at least to a degree) of the outside environmental conditions.

Noticeable weight gains occur in the five-six, six-seven, and seven-eight month intervals (Fig. 2). These gains may represent an error of some sort or periods of growth of fungal biomass in excess of litter substrate broken down. If the latter is true then the "fungal biomass accumulation"

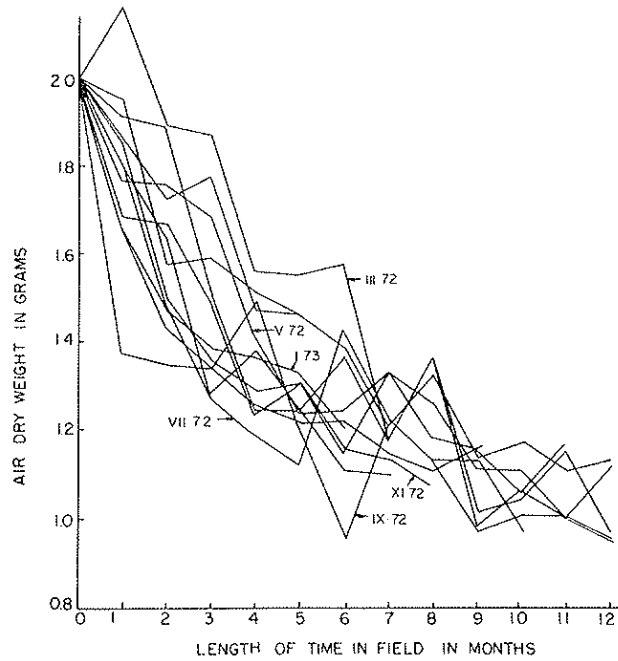


Figure 2. Comparison of air-dry weights of all samples returned from the field on a monthly basis; all samples plotted as though placed in the field at the same time.

may be: (1) partly time-dependent (i.e., time for population growth); (2) linked to the removal of a limiting factor, such as one which limits population accumulation; (3) the result of a factor causing build-up but not removal of the fungal biomass; (4) related to periods of favorable environmental conditions, when a proportionately large fungal biomass in relation to turnover exists.

The decrease in the curve slopes as well as weight gain may be attributed to the same cause, although this represents only one possible interpretation of the data. We postulate that these weight gains are real and represent an increase in fungal biomass in the samples.

Whatever the explanation for variability within the study period for any sample, the trend of the curves is clear. In most cases, an initially rapid rate of weight decrease is followed by a tapering-off of the curve slopes. This curve would fit an expected curve for substrate breakdown without limiting conditions. Variations, of course, exist in the trend of the curves plotted. However, the curves seem to indicate that -- given enough periods of adequate environmental conditions (including a litter configuration conducive to the presence of fungi) -- litter decay is essentially a time- and substrate-dependent function (Fig. 3).

WEIGHT LOSS (AS DEPENDENT ON ENVIRONMENTAL CONDITIONS)

These analyses will help in selecting the plausible explanations presented in the preceding section. Three of

the DSCODES represent the checking, reading and adjusting of more than a year's collection of hygrothermograph (A3UCH06, max/min temperature; A3UCH07, temperature; A3UCH08, relative humidity) and pyranograph strip charts (A3UCH09). Because of the amount of labor involved, the data are not yet available for analysis.

A comparison of decrease in sample weights (A3UCH01) and total precipitation (A3UCH06) is presented in Figure 4. Each month includes weights of all samples returned from the field at that time, regardless of the length of time in the field. The four months with the greatest precipitation did

not correspond with the greatest sample weight loss. This is especially true for the December-January period. This was an extremely cold period (one temperature minimum reached -38 C). Temperature can be assumed to be the limiting factor here. The monthly weight losses for November, February and March of about 0.12-0.15 g are associated with periods of cool temperatures while adequate moisture was present.

The maximum weight losses (about 0.2 g) were in June (warm temperature, 5.1 mm rain) and October (mild temperatures, 28.2 mm rain). Although some moisture must be required for decomposition, no minimal amount of precipitation required can be detected from the figure. Part of this lack of good correlation may be due to the collection of rainfall data, i.e., it is reasonable to assume that some evaporative loss occurred from the rain gauge (read weekly). If one requires an estimate for minimum rainfall associated with a mean decomposition of, say, 0.15 g, one might select the value of 7.5 mm. This involves simplification and is a rough estimate only. The interaction of temperature and moisture are obvious but the pattern is not clear-cut. Associated with warming temperatures in April-June is an increase in mean weight loss. The greatest weight loss of any samples in this period, however, was in the coolest month, April. The ranges of the weight changes, especially weight gains, confuse the picture. These ranges are considerable for many months. This again suggests a time-dependent weight loss, independent (to some degree) of the environmental conditions, at least as measured on the "meso" level. Note the weight loss (and gain) during July of both years when there was no recorded rain (Fig. 4).

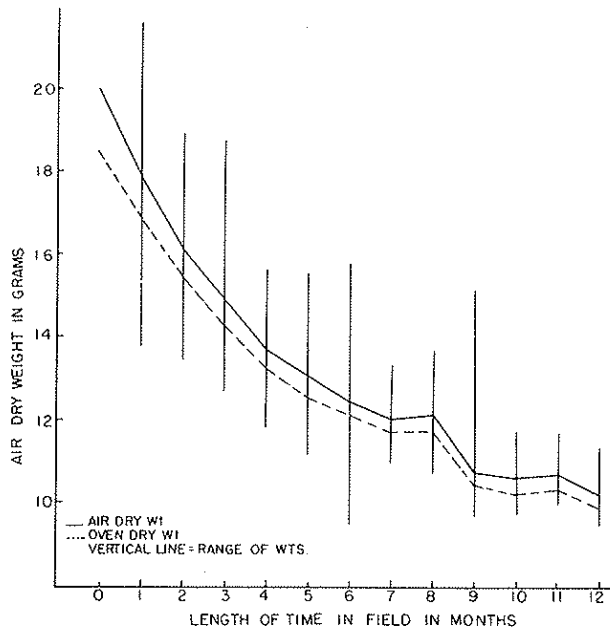


Figure 3. Means and ranges of air- and oven-dry weights of all samples based on length of time in field.

AIR- DRY VS. OVEN-DRY SAMPLE WEIGHTS

Fresh weights (immediately on return from the field), air-dry weights, and oven-dry weights of the same samples

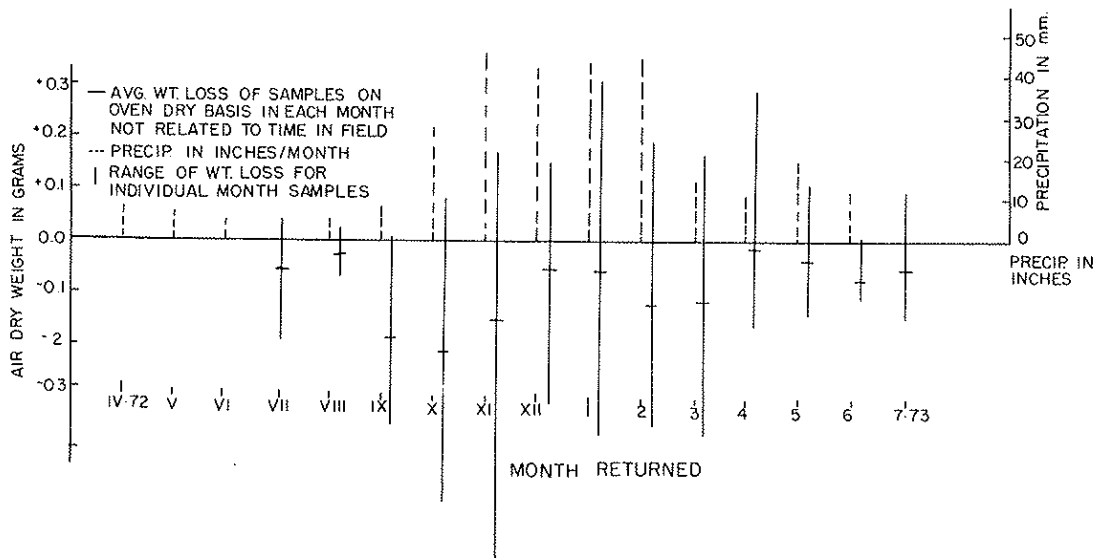


Figure 4. Comparison of monthly precipitation with change of air-dry weights for all samples returned each month.

were compared (A3UCH01). All fresh-weight data vs. air-dry weight data ($c = 0.566$) and vs. oven-dry weight data ($c = 0.535$) showed poor correlations ($n = 36$) and obtaining fresh-weight data was abandoned.

Air-dry weight vs. oven-dry weight were taken for the duration of the study ($n = 116$) and showed excellent correlation ($c = 0.994$). Figure 3 shows this relationship. Air-dry weights were originally used to avoid an artificial treatment of the litter prior to placing it in the field. Since air drying samples provides consistent results (given uniform laboratory preparation) and avoids damage to the substrate, we recommend this approach in litter decomposition studies.

MICROHABITAT SAMPLING TIMES

Sampling times were compared for the days during which hourly temperature readings were taken (A3UCH02). That is, correlation coefficients between times for specific dates were generated, considering microhabitat temperatures as repeated observations.

An examination of the correlation matrices for the different days reveals a wide range of correlation values, even for adjacent time periods. The longest sequences of high correlation coefficients among times is observed at night. For example, all times in the 2300-0300 period (5 hr) in the correlation matrix for August 29-30, 1972, were highly correlated with one another (≥ 0.99). The same level of correlation was observed in the 2100-2400 and 0300-0600 periods (4 hr each). At ≥ 0.95 , all times from 2200-700 were correlated. The matrices of all dates used reveals such a "block" of highly correlated time period.

This is not meant to imply that the temperatures did not change. The temperatures during the night will obviously trend downward as shown in Figure 5. What it suggests is that, given the microhabitats investigated, sample temperatures can be taken in the "early night period" (i.e., 2200 hr) and again in the early morning before sunrise (i.e., 0500) without sacrificing the accuracy desired in such a study as this one. Simple linear regression could then be used to predict the temperatures at intermediate times. Given manually-operated microhabitat temperature-sensing equipment and limited time, this will be an important saving.

MICROHABITAT TEMPERATURE MEASUREMENTS

Temperatures were measured in different habitats during one 24-hr period a month over the study period (August 29, 1972-July 14, 1973) at Plot 04 (A3UCH02). The correlation matrix developed compares lists of temperatures measured in the microhabitats at comparable times for all daily periods used:

| | A | B | C | H | I | O | P | Q | BA | BC | TA | TB | TC | CA |
|----|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| A | | | | x | x | o | o | | | | o | o | x | - |
| B | | | x | x | x | o | | | | x | x | x | o | |
| C | | | | x | - | x | o | | | | o | x | x | * |
| H | | | | | * | - | o | | | | x | o | x | - |
| I | | | | | | * | * | * | | | o | o | o | - |
| O | | | | | | | - | * | - | * | * | o | - | - |
| Q | | | | | | | | | | o | o | o | o | * |
| R | | | | | | | | | o | | o | * | o | |
| BA | | | | | | | | | | o | o | o | o | |
| BC | | | | | | | | | | | * | * | o | o |
| TA | | | | | | | | | | | | * | o | - |
| TB | | | | | | | | | | | | | o | - |
| TC | | | | | | | | | | | | | | - |

* ≥ 0.95
 o ≥ 0.90
 x ≥ 0.80

(Refer to the Experimental Methods section for the identification of microhabitats presented above.)

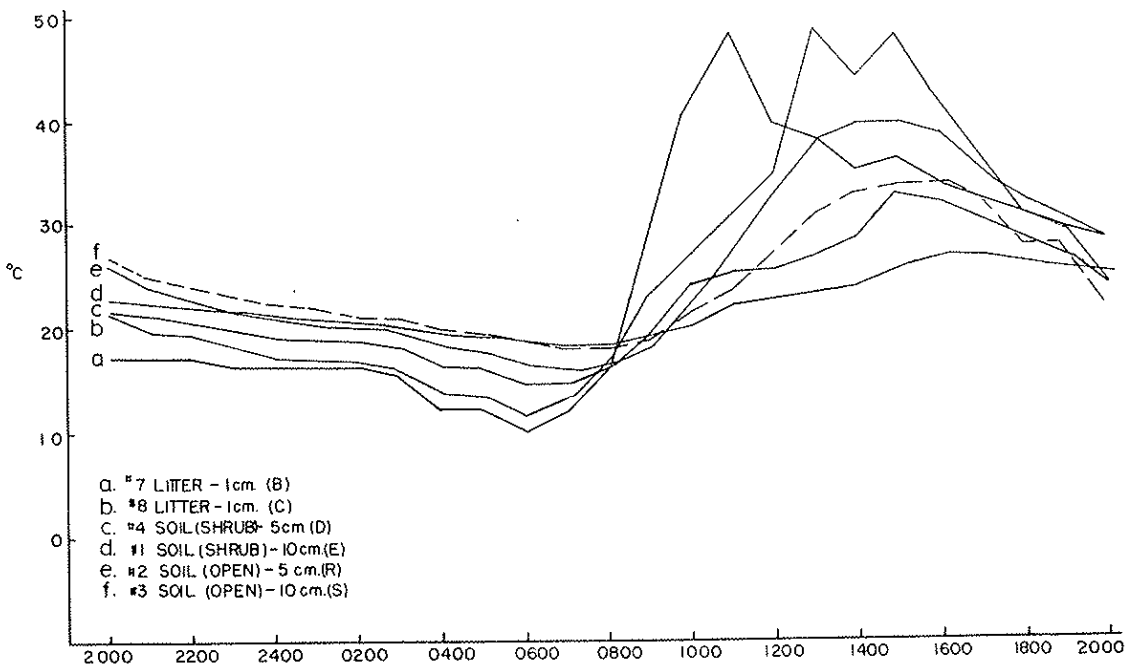


Figure 5. Litter and soil microhabitat temperature data for August 29-30, 1972.

Temperatures for similar microhabitats located in a horizontal spatial arrangement usually showed a high correlation (e.g., litter surface whether under the shrub [A, H] or in the opening [O]). Considering the microhabitats vertically (i.e., in profile) also reveals many high correlations among temperature data, at least over a short vertical extent (H, I), (O, P), (TA, TB, TC).

Some microhabitats do not share high correlation values. For example, the litter surface (A) vs. sample litter-bag surface (BA) ($c = 0.69$), and inside the litter (B) vs. below the sample litter bag (BC) ($c = 0.70$), have correlation values less than might be expected. The latter correlation suggests a risk in substituting litter temperature data for sample litter-bag temperature data. Conversely, correlating sample litter-bag weight loss (or carbon dioxide evolution) with litter temperatures must be done with this level of reliability in mind. Nevertheless, many microhabitat temperature regimes are highly correlated with one another.

To test the significance of these correlation values, temperature data from very similar microhabitats were compared with one another. The Chi-square test (the Z statistic was used) indicates that we cannot disprove that the data analyzed are not the same. If the fact that the entire study period (vs. individual days) was used in the analysis is not a problem, our interpretation is that the microhabitat temperature data from any of the specific microhabitats monitored below can be substituted for temperature data of other, equivalent, microhabitats. We are, of course, assuming certain precautions are taken (e.g., not comparing data from north exposures with data from south exposures in winter, etc.) and that values for temperature data from different exposures (i.e., east vs. west) "balance" out for any microhabitat or set of equivalent microhabitats.

$$\begin{aligned} J &= Q = BC = TC \\ B &= C = I = J \\ B &= I \end{aligned}$$

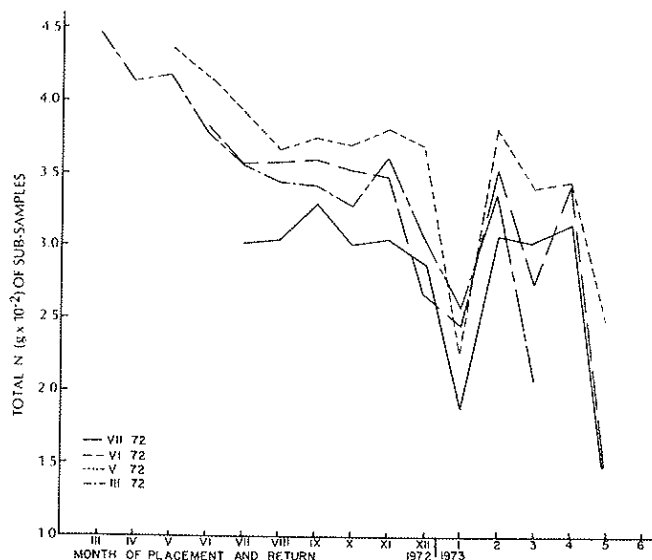


Figure 6. Total nitrogen content of subsamples returned from the field on a monthly basis.

Examination of the data reveal that not all microhabitat temperature data can be substituted as indicated above. For example, temperature data from the groups of microhabitats presented below cannot be considered equivalent. Note that these microhabitats might be considered equivalent on cursory examination, i.e., they are either surface or near surface, etc.

$$\begin{aligned} H &= O = BA = TA \\ I &= P = BC = TB = TC \\ D &= R \end{aligned}$$

In general, however, it seems that temperature data from certain microhabitats may be used to approximate temperatures in other microhabitats. It must be kept in mind that such substitution cannot be practiced indiscriminately.

NITROGEN CONTENT OF LEAF LITTER SAMPLES

Total nitrogen content of the samples during the study period was determined (A3UCH05; Fig. 6). The initial values for the samples varied (they were collected at different times). The overall trend of the curves is a decrease through December 15, 1972, and a pronounced decrease of N-content in the December 15-January 17 period. As noted earlier, this was a very cold period. Curve slopes are similar and very steep in the April 17-May 17 period.

The presence of such pronounced changes in N-content in the samples during the two periods indicated implicates the environment as the determining variable(s). To check out the possibility that the nitrogen loss was determined more by time in the field than by the environment, the nitrogen data were plotted as though the samples were placed in the field simultaneously (Fig. 7).

The greatest decrease in nitrogen content occurs in samples which had been in the field nine-twelve months (Fig. 7). The number of months was different for each sample; however, we feel that barring sample treatment error, the environmental conditions determine the absolute rate of nitrogen loss. The time element may be influential *sensu* a minimal time in the field before rapid nitrogen loss occurs.

Since the absolute values of total nitrogen content varied among samples, the data were plotted on a comparable basis (i.e., initial leaf nitrogen content = 100%; Fig. 8). This figure supports the view that the trends presented in Figure 6 are real, as are the two periods of pronounced nitrogen loss.

One unresolved problem is evident in the data. The increase in nitrogen content between the two low points on the curves (Figs. 6 and 8) occurs in samples which were in the field when the samples analyzed from that period had low values. It would seem that all samples in the field beyond this point should have lower values, but they do not. What would cause this increase is not clear.

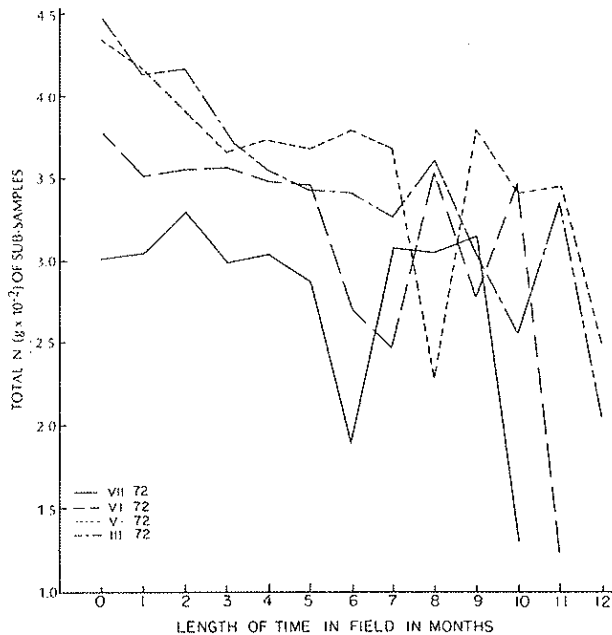


Figure 7. Comparison of total nitrogen content of subsamples returned monthly from the field; samples plotted as though placed in field at the same time.

CARBON DIOXIDE EVOLUTION

Analysis of variance was used to determine the variability of CO_2 evolution (A3UCH03) among samples which were placed in the field at different times. Samples were monitored for a one-three day period. Twenty-four periods were monitored. Carbon dioxide evolution among samples for most periods was significantly different ($F \geq 0.95$; $n = 23$). In most cases, it was very highly significant ($F \geq 0.999$; $n = 13$).

It is obvious that evolution is highly variable among samples which have a different history in the field. Therefore, the researcher should not be surprised to find that CO_2 evolution varies among samples of different (or unknown) ages.

Carbon dioxide evolution for samples placed in the field at different months was monitored throughout the study period. The per-day values measured in mg varied. For samples monitored over one 24-hr period, high values of 20 mg were occasionally obtained. Some samples monitored over a two-day period obtained values of almost 50 mg. In many cases the values were negative, i.e., the sample values were less than the control values.

Carbon dioxide per-day evolution for samples placed in the field in any month vary over the study period (Fig. 9). In some cases, general trends are evident. For example, evolution from samples placed in July increases to a maximum in November and decreases into the spring. The June samples likewise show signs of a general increase into

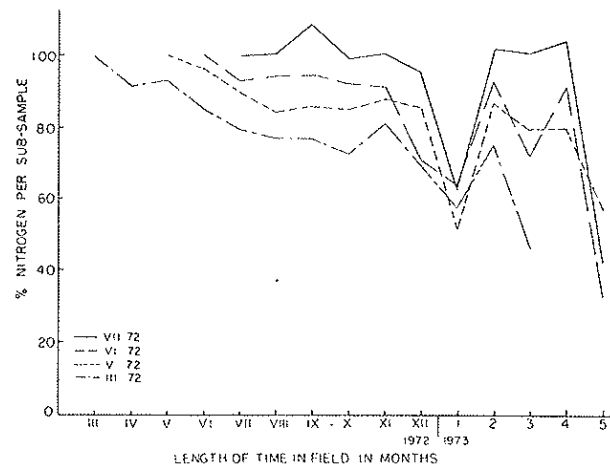


Figure 8. Total nitrogen remaining in subsamples as a percentage of total nitrogen present originally.

December, decreasing throughout the spring. The highest values for the October samples occur in the March-May period. However, these higher values are associated with low values also. Samples placed in January do not show the trends evident in other samples: 0-10 mg from February through June. Carbon dioxide evolution of December samples shows an erratic pattern. March samples show a general increase; however, these samples were not monitored until after they had been in the field six months.

Correlation of these data with meteorological data (strip chart data) may help explain some of these patterns. It is interesting to note that CO_2 evolution during the cold December-January period (when measured) was of an order of magnitude that was within the range of values existing in the moist-cool fall and spring periods.

Many of the values for CO_2 evolution were negative (Fig. 9; these data are plotted on the X axis as values of 0). The reason for this is not clear. In an attempt to correct for possible experimental error, all titration end point values were re-examined. That is, values for samples which were higher than the controls, as well as control and experimental values which were aberrant, were discarded. The adjusted data were compared to the original data. In three cases, the F-test changed from significant to highly significant to non-significant. In most cases, the change was of a minor order (Fig. 10). In spite of the small shifts in the experimental values, we recommend the use of adjusted data because values which are obviously divergent (even if determined to be so subjectively) may obscure the general trends of the data.

Carbon dioxide evolution per day was examined in terms of length of sample-time in the field. Such comparison obscures the trends evident for the samples as presented in Figure 9. Decomposition cannot, therefore, be considered entirely time-dependent since some trends reflecting the history of the samples were evident. It appears that carbon dioxide evolution may be dependent upon the quantity and

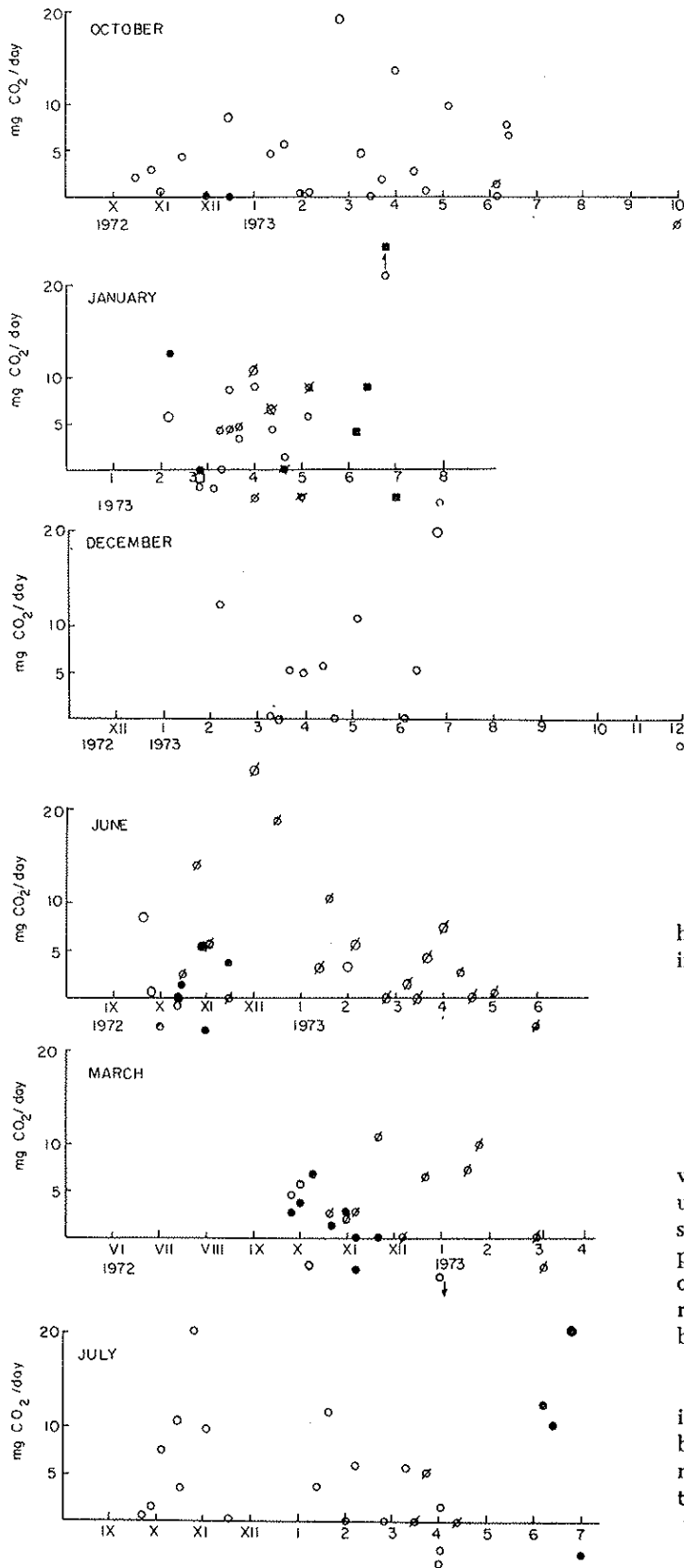


Figure 9. CO₂ evolution/day of 6 leaf litter samples monitored during study period. Month of field placement is indicated; symbols represent values identified by dates returned from the field.

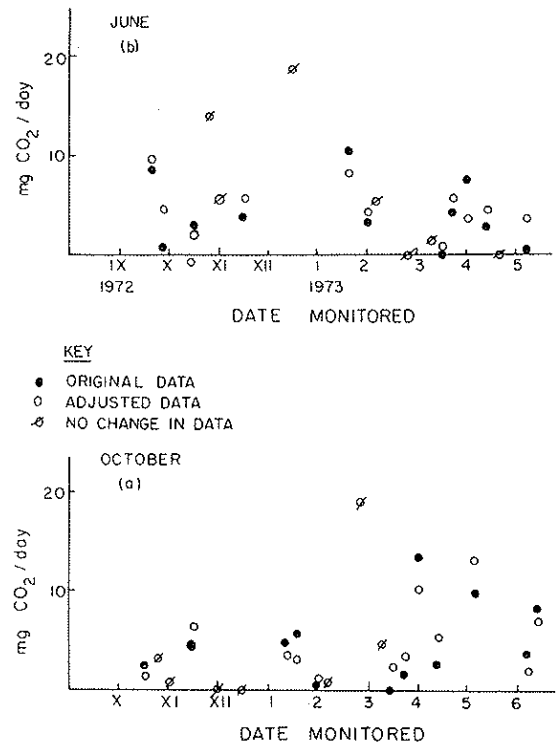


Figure 10. Adjusted values (o) and original values (●) for CO₂ evolution/day during the study.

history of the samples as controlled by conditions obtaining in the field at the time of measurement.

EXPECTATIONS

ARTEMISIA TRIDENTATA

On January 20, 1974, 96 bags containing 2 g of leaf litter were placed in the field at Plot 03. Forty-eight were placed under big sage canopies on the north sides; 48 on the south sides. These will be retrieved monthly during 1974, providing weight loss data (at a different site and time) for comparison with the 1972-73 data. The north vs. south results should provide a range of breakdown rates which can be used in the modelling process.

Monitoring of carbon dioxide release from litter samples in Plot 03 will continue throughout 1974. In addition to the bagged leaf litter samples, stem litter samples will be monitored. Data from these studies may then be compared to similar studies done at the Jornada site.

Buried root and stem litter samples as well as stem material on the ground surface will be collected during 1974 and weight loss determined. This extends the study on leaf decomposition to other plant organs.

As in 1972-73, in 1974 meso- and microhabitat meteorological variables will continue to be monitored. The results of the 1973 study demonstrate the need for more analysis of the litter moisture regime. This will be a focus of the work in 1974.

ATRIPLEX CONFERTIFOLIA

The basic field study of monitoring leaf litter bags for weight loss and carbon dioxide evolution has been expanded to include shadscale (*Atriplex confertifolia*). This study was initiated on February 15, 1974, at the Central Nevada Field Station of the University of Nevada's College of Agriculture, near Austin (Plot 05). Additionally, the shadscale litter "mounds" will be analyzed for decomposition rates as a function of microhabitat temperature and soil moisture. This will hopefully be related to shrub parameters and extrapolated to decomposition at the community level.

LITERATURE CITED

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