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Decomposition and Mineralization in an Artemisia Tridentata Community in Northern Nevada

Peter L. Comanor

Don C. Prusso

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DECOMPOSITION AND MINERALIZATION IN AN *ARTEMISIA TRIDENTATA* COMMUNITY IN NORTHERN NEVADA

P. L. Comanor
University of Nevada, Reno

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Ecology Center, Utah State University, Logan, Utah 84322

ABSTRACT

Determination of breakdown rates of litter from *Atriplex confertifolia* (leaf litter only) and *Artemisia tridentata* (root, stem and leaf litter) is the purpose of this study which began in 1972 and will continue through 1975. Sample weights were taken of bagged sagebrush litter at the time of both placement and recovery to determine the breakdown rates in the field. These samples showed a decrease in weight during 1974, although the weight loss was less than in 1972-73. Sagebrush stem litter weight loss was 8 % for samples left out a full year. More specific results on stem and buried litter weight loss will be reported after the study is completed. Bagged shadscale litter samples were placed in the field under *A. confertifolia* canopies. These showed a continual weight loss but analyses of these data will await completion of the study in 1975. The amount of CO_2 released by microorganisms was sampled on 25 dates during the year using the "static trap" technique. These data showed only relative values of CO_2 production and it is felt the technique is inadequate. It is hoped that a better method of determining amounts of CO_2 released in the litter during decomposition will be developed.

INTRODUCTION

The purpose of this project is to determine the breakdown rate of litter from two dominant shrubs in the Great Basin Desert; shadscale (*Atriplex confertifolia*) and big sagebrush (*Artemisia tridentata*). Leaf litter was used for *Atriplex* in this study. For big sagebrush, root, stem and leaf litter were used. These studies are part of a longer term study begun in 1972 and continuing into 1975; the primary emphasis continues to be on big sagebrush.

OBJECTIVES

The objectives for 1974 were to:

1. Determine the breakdown of bagged sagebrush litter in the field through a comparison of sample weights at the time of placement and recovery.
2. Monitor this breakdown by sampling the amount of CO_2 released by microorganisms during decomposition at regular intervals.
3. Monitor the environmental conditions in the litter and at the research site throughout the year and determine the degree of correlation between standard environmental variables and breakdown rates.
4. Determine the breakdown rate of *Atriplex confertifolia* in the field during the 1974 period.

EXPERIMENTAL DESIGN

Big Sagebrush Litter

Work was carried out in the field at Plot 03 which is located 10 km north of the University of Nevada, Reno, at the northwest end of Sun Valley, Washoe County, Nevada. The elevation is 1650 m. A map of the plot is presented for reference (Fig. 1). The coverage of the important species is as follows: *Artemisia* spp., 19%; *Leptodactylon pungens*, 7%; *Ephedra viridis*, 0.2%; and *Chrysothamnus* spp., 4%.

Samples were placed below shrubs in the field and utilized as follows: 1) bagged leaf samples for weight loss during 1974; 2) bagged stem samples (on the ground surface) for weight loss and CO_2 monitoring; 3) buried root, stem, leaf and inflorescence samples for weight loss determination; 4) bagged leaf samples for CO_2 monitoring. Table 1 is the timetable for weight loss determinations.

Table 1. Timetable for the placement and recovery of bagged litter samples on the project

	UTILIZATION	PLACEMENT	RECOVERY
Big sagebrush litter:			
Leaf litter on ground surface	weight loss	January 1974	Monthly (except July)
Stem litter on ground surface	weight loss; CO_2	October 1973	January 1974, October 1974, April 1975*
Leaf litter on ground surface	CO_2; weight loss	August 1973, January 1974	August 1975, July 1975*
Buried litter	weight loss	September 1973	January 1974, September 1974, March 1975*
Buried litter at Site 02	weight loss	May 1973	September 1974, May 1975*
Shadscale litter:			
Leaf litter on ground surface	weight loss	February 1974	July 1974, October 1974, December 1974, March 1975*, May 1975*

*Projected recovery date.

Shadscale Litter

Samples were placed in the field at Plot 05, adjacent to the Central Nevada Field Station of the College of Agriculture, University of Nevada, which is located near Austin, Lander County, Nevada, at an elevation of 1785 m.

METHODS AND METHODOLOGICAL CONSIDERATIONS

Environmental variables were measured as in previous years. The methodological information is briefly summarized below. Precipitation data were collected at Plot 03 once a week in a plastic rain gauge set just above the big sage canopy (DSCODE A3UCH06). Temperature (A3UCH07) and relative humidity (A3UCH08) were recorded by means of a standard hygrothermograph set in a standard weather shelter. Solar insolation was measured with a pyranograph (A3UCH09). The strip charts were sent to Utah State University for data reading and encoding.

Weight loss data from the leaf litter were obtained monthly (A3UCH01). Weight loss data for the stem and root litter were obtained at selected time intervals, as indicated in Table 1. (For burial depths, sample size and weight, litter size classes and other details, please consult the 1973 report, Comanor and Prusso 1974.)

Shadscale leaf and bract litter were placed in 10- x 10-cm litter bags identical to those used in sagebrush studies. These were placed in the field beneath *A. confertifolia* shrub canopies in an essentially monodominant *A. confertifolia* community.

Carbon Dioxide Measurement

Microbial CO_2 evolution from bagged litter was determined using plastic food storage containers and a "static" trap. The containers are approximately 1 dm^2 (basal area). Laboratory tests indicated that the sample containers did not leak. A leak occurring in the field is easily noticed by the researcher who may find a corner of the lid up, or in the subsequent laboratory analysis of the samples when an anomalous value occurs in the data set. In the latter case, the data point must be discarded. We often maintain 1-2 plastic containers in the field during each sampling period with a corner of the container open. This provides a minimum (titration) data point value for a "leaking" plastic container, against which aberrant sample values are easily recognized.

In past monitoring, 20 ml of base (0.5 M NaOH; the static trap) were placed in a glass beaker in the plastic container in the field. Liquid was decanted into the beaker using a graduated cylinder or a dispensing head. The sample (with its

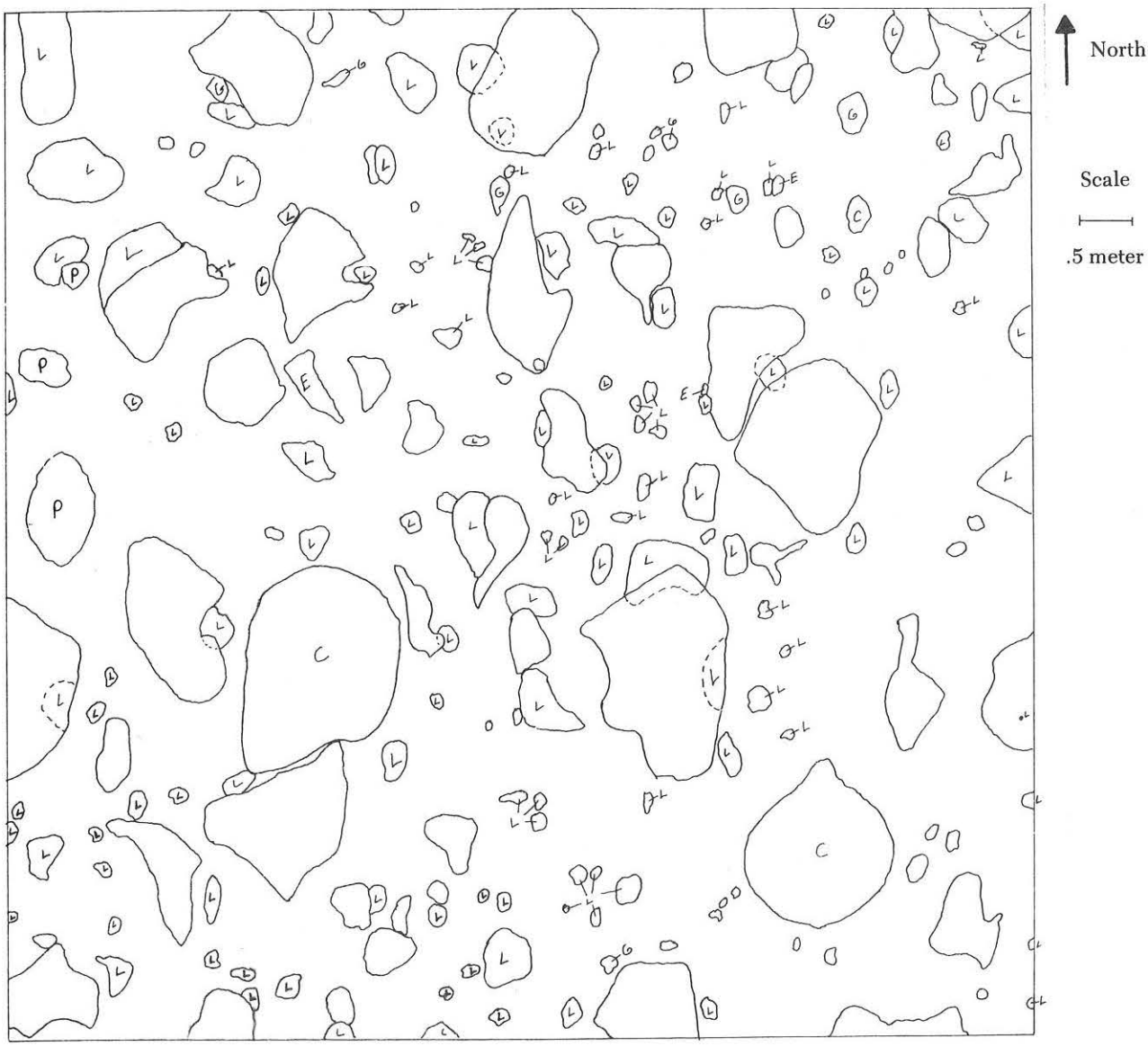


Figure 1. Crown coverage map for the area of Plot 03 used for the placement of the 1974 leaf litter samples.

absorbed CO_2) was collected by pouring it into glass vials and returning it to the laboratory. There it was fixed with 20 ml $BaCl_2$ in a glass beaker and back-titrated with 0.5 M HCl using thymolphthalein as an indicator (Coleman 1971). The difference between the mean end point for the controls and the mean end point for the samples indicates the relative amount of CO_2 absorbed.

The following modifications of this technique were used in 1974 and are recommended to the researcher using static traps for the reasons indicated:

1. The base was measured out in the laboratory using a volumetric pipette to insure accuracy.
2. Wide-mouth baby food jars were used as the trap (jars may be filled in the laboratory to ensure accuracy; the jars with absorbed CO_2 are capped in the field without transfer of sample, avoiding possible error through loss of drops of base on the jar sides and fixing and titrating in the lab takes place within the same jars, again avoiding sample transfer).
3. The jars were completely randomized, minimizing bias. Individually numbered jars were processed in a random sequence. Approximately 24 samples were used on each sample date during 1974. Markers from 1 to 24 were drawn to determine the sequence of filling, ordering in the field-sample holders (beaker boxes for one dozen beakers) and titrating. It is assumed that the nonsystematic treatment and selection of samples will prevent sampling bias. The lids are numbered to allow the investigator to keep track of the jars.
4. The basic solution concentration was changed to 0.1 M NaOH to increase sensitivity; 0.01 M solution was tried under moderately moist and warm environmental conditions in September 1974 but the sample solution became saturated in many of the traps and had to be discarded.
5. Laboratory analysis took place shortly after sampling. If possible, titration should be done immediately after samples are recovered from the field. In any case, samples were generally found to show less variation if titrated within 6 hr after being recovered. This procedure reduced the chance of laboratory error.

Weight Loss Determination of Buried Samples

One of the problems in the determination of weight loss for buried litter samples is the inclusion in the sample of extraneous material (either organic or mineral) which will change the values for sample weight loss. Alternatively, the laboratory handling of this material may result in the loss of actual litter during the cleaning process. Our laboratory experience indicates that the combined error from these two causes is minimally 5% in the case of buried stem samples and 10% in the case of buried leaf samples. (These represent the percentages of the final weights being determined.) It appears less in the case of surface samples.

The error may, of course, be reduced by the application of extreme care with sample processing. This is laborious. Techniques will be developed during 1975 to try to solve this problem.

RESULTS

Artemisia tridentata Bagged Litter

Leaf Litter

Bagged leaf litter samples show a trend of decreasing weight throughout 1974 (Fig. 2). The weights of samples picked up monthly during the year are presented in Table 2. The total weight loss between January and August (samples out seven months) was 0.315 g, or approximately 16%. The weight loss increased substantially in the fall. In the one-month period between September and October the loss was 0.6 g, 38% of the previous month's weight. (This weight loss represents 19% of the original weight for this brief period.) The weights varied among samples, but the standard deviations for each month were small (Table 2).

The weight loss was less for leaf litter samples in the field in 1974 than during 1972-73 (Fig. 2).

Surface Stem Litter

The results to date are part of a longer study (Table 1) and only provide a general picture at this time. Stem mean weight loss was about 4% for samples out three months (Table 3). For samples out one full year, the weight loss was 8%.

Buried Litter

Results are tentative at this time and are not presented. They will be presented in the 1975 annual report when the samples have been in the field for a longer sampling period.

Weight Loss Correlated with Environmental Variables

The residual air-dry weights of the bagged leaf litter were correlated with three environmental variables which were measured during the same time period. These variables were temperature, mean relative humidity and cumulative precipitation. The highest correlation value of leaf litter residual weight with any one variable was with temperature ($r = 0.437$). The r^2 for each of these three variables was low;

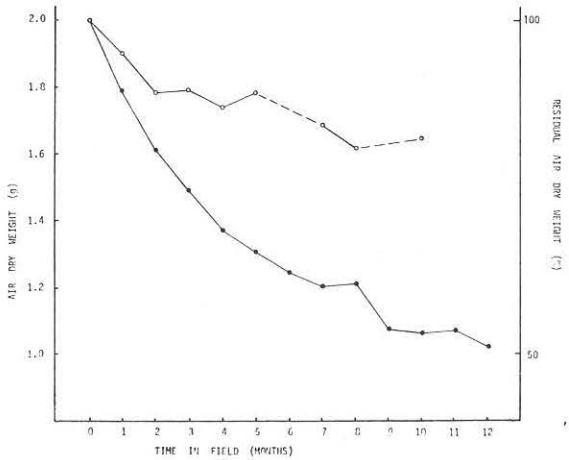


Figure 2. Residual weights of bagged leaf litter at Plot 03 during 1974.

Table 2. Air-dry weights on recovery of bagged leaf litter samples in the field during 1974

DATE RECOVERED	MONTHS IN FIELD	WEIGHT (g)	STANDARD DEVIATION	WEIGHT LOSS (%) OF ORIGINAL	WEIGHT LOSS (%) OF PRIOR MONTH
A. Big sagebrush[a]					
February	1	1.902	0.022	5	5
March	2	1.786	0.039	11	6
April	3	1.793	0.039	10	b
May	4	1.739	0.082	13	3
June	5	1.785	0.079	11	b
July[c]	6	---	---	--	-
August	7	1.684	0.082	16	-
September	8	1.614	0.046	19	4
October[c]	9	---	---	--	-
November	10	1.648	0.016	18	-
B. Shadscale[d]					
July	5	1.826	0.180[e]		
September	7	1.625	0.071		
December	10	1.511	0.085		

a All big sagebrush litter placed in the field in January 1974.
b A weight gain was indicated, therefore no calculation made here.
c Samples not recovered this month.
d All shadscale litter placed in the field in February 1974.
e One bag of the litter sample had a weight 2.0g. For an n=3 (discarding that sample), $\bar{x}$ = 1.742 ±0.067g.

they were all < 0.2. When all variables were handled together, the $r^2 = 0.639$. The multiple regression equation is:

$$Y = 8.136 + 0.0129\,A - 0.0797\,B - 0.5814\,C, \text{ where}$$

Y = air-dry (residual) weight
A = temperature (°C)
B = relative humidity (%)
C = precipitation (inches)

Shadscale Bagged Litter

Shadscale bagged litter shows a continuous weight loss throughout the study period (Table 2). The analysis of these data will await the completion of the extended study period into 1975 (Table 1). The initial design (for completion of the study in 1974) was modified because of the extremely dry conditions prevailing in the area throughout most of 1974.

Carbon Dioxide

The amount of CO_2 absorbed in the static traps in the plastic containers was determined by titration as noted in the "Methods" section. The time the samples were in containers in the field was adjusted to 24 hr. The milligrams of CO_2, as determined by titration, were calculated according to Coleman (1971). When the CO_2 absorbed in the containers with litter samples exceeded that absorbed by the controls (plastic containers without litter samples), the results were positive; that is, indicating CO_2 production by the samples. Hereafter, the greater absorption of CO_2 in the samples than in the controls will be referred to as "positive production." On many occasions the CO_2 absorbed in containers with litter samples was less than the absorption indicated in the controls. This situation will be referred to as "negative production" in the text. The subject is treated more fully in the "Discussion" section.

For purposes of analysis, the samples were broken down into three categories: older leaf litter (placed in the field in August 1973), newer leaf litter (placed January 1974) and stem litter (placed October 1973). Selected dates when CO_2 was trapped in the field were chosen for presentation (Table 4). The results presented are relative (i.e., an "x" for positive production and a "-" for negative production). The CO_2 produced (in mg·CO_2/24 hr) may be calculated from data on A3UCH03.

Table 3. Air-dry weights on recovery of bagged big sagebrush stems in the field during 1974. (All samples placed in the field October 1973)

Initial wt (g)	(January 1974) Final wt (g)	Weight Loss (%) of Original	Initial wt (g)	(October 1974) Final wt (g)	Weight Loss (%) of Original
6.123	5.889	3.8	6.212	5.743	7.6
6.069	5.954	1.9	6.144	5.612	8.7
6.155	5.869	4.7	6.136	5.601	8.7
6.059	5.833	3.7	6.049	5.469	9.6
6.014	5.823	3.2	5.988	5.293	11.6
2.062	2.016	2.2	3.738	3.648	2.4
2.004	1.868	6.8	2.030	1.850	8.9
	Mean Percent Weight Loss:	3.76 g		Mean Percent Weight Loss:	8.20 g
	Standard Deviation:	1.64 g		Standard Deviation:	2.84 g

Table 4. Relative CO_2 production for samples representing three litter types for selected sampling dates during 1974

SAMPLE ID	DATE IN FIELD	SAMPLING DATE 0113[a]	0117	0125	0221	0227	0321	0328	0425	0529	0711	0808	1031	1107	1114	1123
B	Aug. 1973	x[b]	x	--		x										
A	" "	--[c]		--	-	x			x							x
D	" "	x	x	x			-	x[e]			x	x	x	x	-	
L	Jan. 1974				-[d]		-[d]	x	x	-	x	x				
E	" "				x								x	x	x	
K	" "												x	x	x	
S4	Oct. 1973				-	x	x	-		-	x	-	x			x
S5	" "				x	x	x	x	x	-	x	x	x	x	x	

a The sampling date is indicated by the number of the month followed by the day, ie: 0113 is Jan. 13, 1018 would be Oct. 18, etc.
b x=positive production
c A - indicates negative production; a -- indicates a large negative production.
d Sample M data.
e Sample C data.

On many of the dates shown (Table 4) some samples show positive production (e.g., B on January 13) while other samples show negative production (e.g., A on January 13).

On other dates, all samples monitored show positive production (e.g., April 25, November 7). Of all sample dates in 1974 (N = 25) positive production for all samples occurred on 11 days (44%). No one sample showed positive production for all sample dates nor were the results consistent within sample types. Older leaf litter showed both negative and positive production on the same sample date (e.g., January 25), as did newer leaf litter (e.g., February 21) and stem litter (e.g., February 21). A sample may have had positive CO_2 absorption one week and negative the next (e.g., B on January 17 vs. January 25; L on March 21 vs. March 28; S4 on February 21 vs. February 27).

DISCUSSION

Weight Loss correlated with Environmental Variables

The weight loss for the 1974 study period was less than in previous studies. This is clearly shown in Figure 1. The loss for an equivalent period of time for samples in the field in 1972-73 (an average for all samples, regardless of time of placement) was more than double that of the litter bag weight loss in 1974. This can be attributed chiefly to the fact that 1974 was a very dry year. In spite of this, the highest correlation of weight loss was with temperature. (This was also found for the unpublished analyses of 1972-73 data.) This may be partly attributable to the more clear-cut measurement of the temperature variable and its more general pervading effect on biological phenomena in the

above-ground situation. Moisture in the litter, on the other hand, is inadequately measured by either hygrothermograph or rain gauge. The moisture data will have to be reexamined before adequate interpretation of the use of general relative humidity or cumulative precipitation data in modeling the effect on the litter component may be adequately understood.

The stems lost 4% weight in a three-month period. When out a year (four times longer) the weight loss was only 8% (Table 3). The more rapid weight loss corresponds to the moist winter period. This winter rate of weight loss was not sustained throughout the rest of the year. The stem litter microbial decomposer populations are undoubtedly responding to the dry soil surface environment, with its lack of moisture input in the form of rainfall during most of the spring, summer and fall of 1974.

Carbon Dioxide

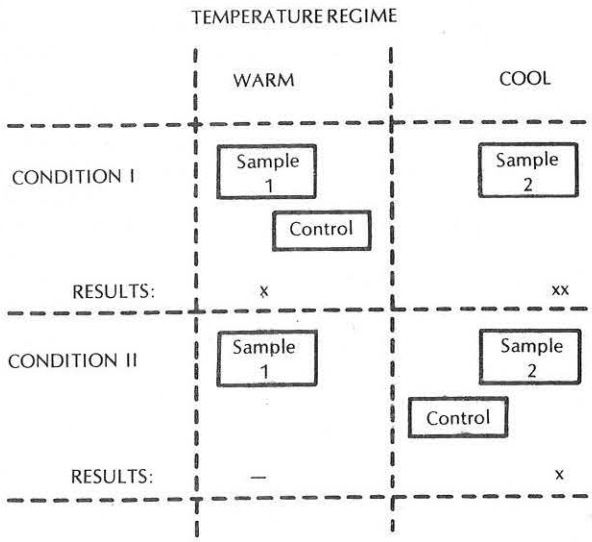
The reliability of the data generated by the static trap technique is questionable. Samples were collected in the field on 25 dates during the year. According to the data, on six of these dates (24% of the total) the mean CO_2 production by the controls was greater than that of the mean for all samples combined. On eight sample dates (32% of the total) some litter samples showed positive production while others did not. Should the investigator accept the data for positive production while discarding the negative data? Is it not equally plausible that the controls were aberrant? For this latter case only samples with a proportionately larger production would "overcome" the unreal production values for the controls. This might also mean that some of the litter samples with negative production values really had positive values, but not very much so; i.e., the production was obscured by the control data. How does the investigator determine the correct situation?

The production data were subjectively scrutinized at some length in an attempt to deal with these questions. Some investigators have artificially shaded their litter samples in the field in order to provide a relatively uniform among-sample environment (Staffeldt and Vogt 1974). Our samples were not artificially shaded, since a study objective was to obtain CO_2 production from litter under essentially "natural" conditions. We would rule out experimental error as an explanation of the sample variability. Nor would we expect CO_2 was being consumed by the litter samples; no algae were ever observed in the litter samples. Of the approximately 24 plastic containers with traps used in the field on each sample date, four to six (16-25%) were controls. Four litter bags make up each sample. When one of these bags showed CO_2 production that was much greater than the others, the datum was discarded before analysis. The container was assumed to have leaked in CO_2-rich ambient air under these circumstances. Thus, all analyses of within-sample production data were run on fairly "tight" data. (In any decision involving a conflict of data interpretation, we chose the more conservative production figures.) In spite of this, some samples showed positive and others negative production on the same day. All samples were located in the same area; therefore, the general climatologic conditions were essentially the same. All would have been more or less subject to the same moisture conditions after a rain, the same general dessication on windy days, etc.

The technique itself needs more critical examination. It is considered inadvisable to use it during a change in barometric pressure (Coleman 1971). It thus appears sensitive to pressure, which would change the equilibrium point for CO_2 in the basic solution during (and especially at the end of) the sampling time. Since the plastic containers are closed, the sun striking the containers will increase the temperature within. An increase in temperature will decrease the solubility of CO_2 (Hodgman 1962). On most occasions our samples were picked up in the late morning, after the sun was already out for some time. Since the controls are localized in one area of the plot, they occupy an area with greater environmental homogeneity than is possible for the combined litter samples. Most litter samples are under different shrubs, or if under the same shrub, have different exposures. Although the sagebrush community is reasonably homogeneous, the different shrubs do not have equal crown-foliage distribution. Thus the microhabitats among litter bags (and sample containers) must differ. This difference appears to contribute, in large part, to the variation in CO_2 production data. For example, litter samples S4 and S5 are located beneath adjacent shrubs. However, sample S4 receives more early morning sun in the early spring than sample S5. If the solution heats, releasing absorbed CO_2, this might explain the lower production of S4 (relative to the controls) vs. the good production of S5 (Table 4) during that time period. A similar explanation seems reasonable for samples A, B and D on January 25. These samples were picked up at 1300 hr, after a good deal of morning sun. Sample D is located beneath a denser shrub canopy with a western exposure. It is the only one of the three samples with a positive CO_2 production (Table 4). This explanation is incomplete without considering the controls. In this case, they were placed in a narrow area between two shrubs adjacent to D. They would have received little insolation, remained fairly cool and "held" a modest amount of CO_2. This amount was apparently greater than that held in solution in the trap of S4, but less than that of S5. To avoid systematic error, the controls were placed in different locations within the plot on different sampling dates.

Cloud cover will affect the temperature in the plastic containers. A solid cloud cover will create a more uniform environment among samples; "hot spots" in the plot should not occur. A cloudy day would also be more effective than an artificial covering as convectional currents in the plot on a sunny day will still allow some lateral movement of heat to the containers. The interaction of cloud cover and microhabitat may confound the data. For example, a cloud cover arriving late in the morning (after some sun has warmed an east-facing sample) may prevent samples exposed normally to the sun later in the morning from heating to the same degree. Samples picked up in the afternoon will probably exhibit a high degree of variability because of this.

It becomes extremely difficult to sort out the exact microenvironmental conditions of the collecting system on different occasions. Whether the controls were cooler or warmer than different samples appears to be a critical concern. The temperature could change the amount of CO_2 in the control containers. The controls appear to have been cooler on certain dates than several of the samples. On January 13, March 21, April 12, May 29, September 24 and October 24 some of the litter samples showed less production than the controls (all did on May 29, Table 4). This negative production has nothing to do with decomposition, but is a result of the errors inherent in the collecting system arrangement. For discussion, a simple model is proposed below relative to the material above. It is assumed in this model that: 1) the microorganisms are tolerant to the range of temperatures obtained; 2) the production rate is constant within the range obtained; and 3) moisture is not limiting. These conditions probably do not hold for the conditions in the field during the time of experimentation. The terms "warm" and "cool" are for convenience, chosen to represent the general conditions for explanation.



Condition II is proposed as the explanation for the difference between sample A and sample B on January 13 (Table 4). Condition I holds for almost all samples obtained during the fall period, as well as A vs. B on February 27, specifically. It is probable that conditions I and II are really along a gradient of quasi-equilibrium points at different temperatures for the CO_2 in solution. Thus, a small amount of CO_2 production in a container with litter (presumably caused by decomposition) might not even be detectable under condition II.

Without data on the temperature and pressure within the individual sample containers, no determination of the exact amounts of CO_2 produced seems possible. These data were not obtained in this study. This is the reason no absolute figures have been presented in this paper. The data indicate only relative amounts of CO_2 production and, unfortunately, the CO_2 is relative to variable control conditions.

This leaves some basic questions unanswered: What data are usable? What is the meaning of the data generated? The fact that the production was consistently positive in the fall and for the same samples measured through this period, indicates that CO_2 production is a real phenomenon and reflects, to some degree, the result of environmental factors on the litter-microbial system. For example, sample K showed positive production on October 31, November 7 and November 14. Production was very high for the first two dates, and low for the latter (1/16 of the value of production on November 7). The litter was damp on October 31, wetter on November 7 (after a rain) and drying out on November 14.

The key to the system here appears to be the level of biological activity (which is controlled by the microhabitat of the samples before and during monitoring). In the forest, with continuously moist conditions, the level of moisture will support continual biological activity, producing a fairly high amount of CO_2. These high amounts of CO_2 are readily discernible as well as shifts in quantity. In essence, the great production obscures the inherent variability in the monitoring system itself.

We suggest that in an ecosystem with irregular periods of moisture and dryness (i.e., the desert) that a small amount of CO_2 production will be seriously affected by immediate environmental conditions in the monitoring system. Relatively small production values will not necessarily be clearly discernible against a variable (control) background. In the fall, however, when conditions are more favorable to production over longer, continuous periods, the magnitude of the production can overcome the "production" of the controls.

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