# DISTRIBUTION OF ORGANIC MATTER RESERVE IN A DESERT SHRUB COMMUNITY



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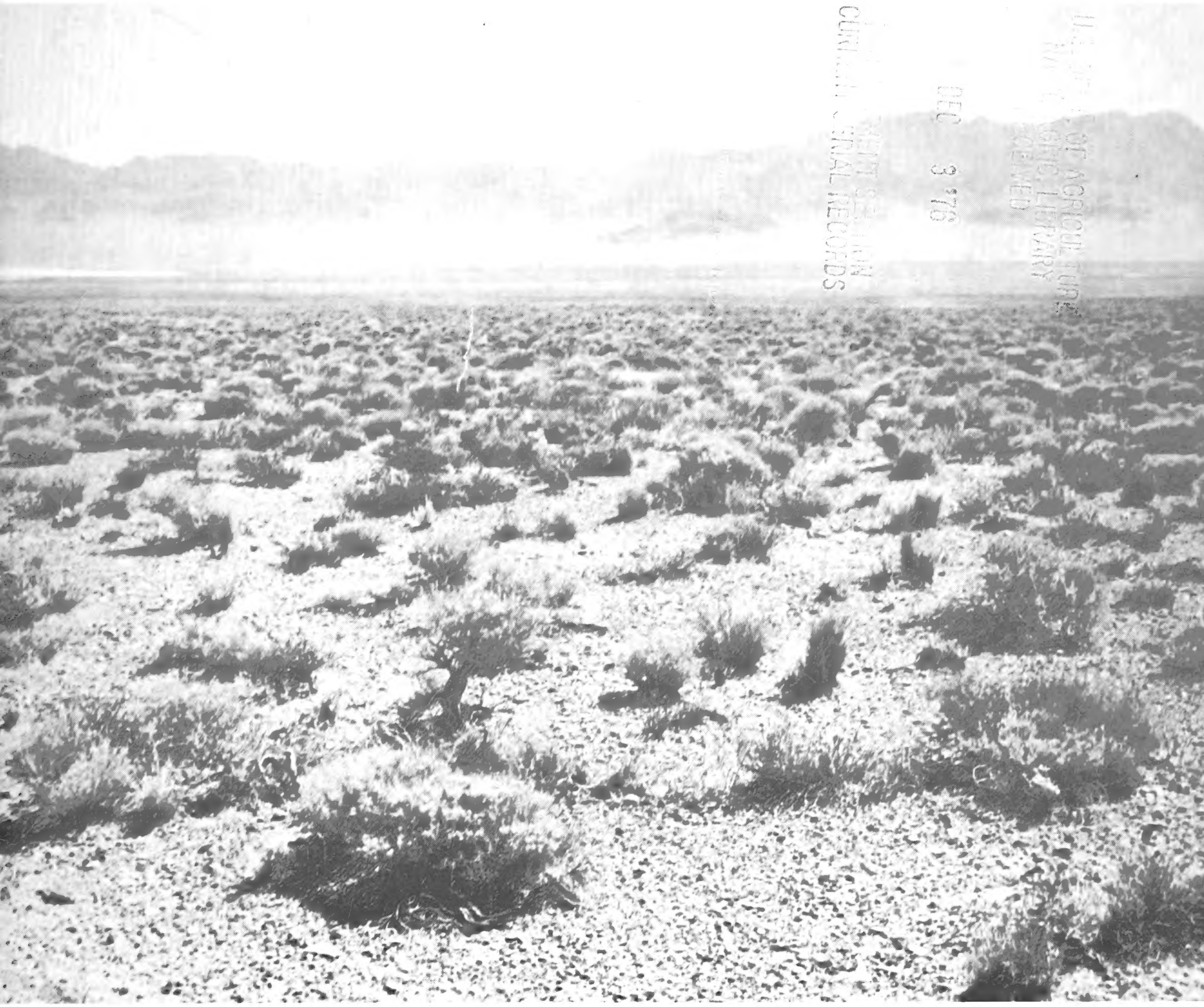

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# ABSTRACT

In a community of widely spaced perennials, mostly shrubs, in the cold desert of western Utah, total accumulated organic mass (excluding the small amount of humus) is about 1,770 g./m.$^2$. Of this total, 240 g. are above the ground and 1,530 g. below. Of the latter, 295 g. is underground litter. About half of the 1,235 g. of roots are in the surface 30 cm. of the soil, about 0.3 of them in the second 30 cm., 0.15 in the third, 0.03 in the fourth, and 0.01 of them occur below 120 cm. to about 135 cm. Coarse roots ($>$2 mm. in diameter) are found only in the immediate vicinity of plants and are unimportant below the 15-cm. depth. Fine ($<$0.5 mm. in diameter) and medium size roots have a much more even horizontal distribution at all depths. A gross estimate of net primary productivity for this desert site (average annual precipitation = 154 mm.) is 258 g./m.$^2$, 28 g. above the ground (probably a good estimate) and 230 g. below the ground (a calculation based on some necessary assumptions).

# INTRODUCTION

The growing interest in dynamic community ecology over the past 20 or so years has provided an increasing volume of data on the productivity, accumulation, and turnover rates of organic matter for a number of terrestrial ecosystems. Although methods of study vary and most reports give only gross estimates of the parameters, the values reported are of such relative magnitude for each ecosystem that they fall rather consistently into a rational global pattern (Rodin and Basilevich 1968). Most of the available information on Temperate Zone deserts is from Central Asia. In North America, Chew and Chew (1965) studied the productivity of a warm desert in southeastern Arizona, but their data on accumulated organic matter are incomplete, except for that of one species. Pearson (1965) gives estimates of biomass above and below the ground in his study of productivity of a cold semidesert steppe in eastern Idaho. In an investigation of nitrogen cycling, Bjerregaard (1971) determined the biomass of two salt-desert shrub communities in northern Utah.

Because of sampling problems, the underground portion is the least known part of terrestrial ecosystems, especially in communities of woody perennials, where much of the plant material is contained in coarse roots concentrated in small areas near trees or shrubs. We present here data obtained from a study made with another objective (soil moisture movement) in mind, and use them to show the amount of accumulated biomass (including dead material), and its three-dimensional distribution in a cold desert shrub community in the eastern part of the Great Basin. Earlier studies of the response of vegetation to grazing were conducted in the same area; the productivity data from these studies, in conjunction with our data, enable us to estimate a turnover rate for organic material on this site.

The mass of accumulated organic matter is at its annual minimum at the end of winter, just as the growing season starts. Because this is a desert of woody perennial plants, where the minimum of organic matter reserve is several times greater than the annual increment and the breakdown of litter is slow, the magnitude of the minimum probably varies little from year to year. Although the annual increment does vary considerably, being dependent upon a variable annual precipitation (Hutchings and Stewart 1953), the rate of decomposition, which is also dependent on moisture, varies similarly. From the known history of the study area, we assume it to be near a steady state of productivity and decay.

# THE STUDY AREA

The study site is on the lower part of a stable and ancient, gently sloping (2 percent) alluvial fan, 0.4 km. from the headquarters of the Desert Experimental Range in southwestern Millard County, Utah. Elevation is 1,600 m.

The area has not been grazed by domestic animals since 1934, and it is thought that livestock use prior to that time did not materially change the natural composition of the plant cover. The period of exclusion of livestock now exceeds the average lifespan of all perennial grasses and shrubs of the cover type, except possibly *Eurotia lanata*.

The largest native herbivores are jackrabbits, which are rare in this habitat. The most abundant mammals are kangaroo rats and pocket mice, both primarily seed eaters, and deer mice, which are more omnivorous. Pocket gophers are present but infrequent. Mammalian herbivores probably consume no more than 1 or 2 percent of the plant growth. Small omnivorous birds are in the area yearlong, but they are not abundant. Invertebrate consumers of live vegetation are mostly found in the roots. Termites are occasionally found in woody litter. Ants are rare.

Winters are cold (average temperature for January is -3.5° C.) and summers are warm (average temperature for July is 23.3° C.). Precipitation, which averages 154 mm. annually, is sporadic, and intervals of 1, 2, or more months without rainfall can occur at any season. Early spring is the only season in which soil moisture is consistently adequate year after year for some plant growth. The accumulated winter moisture usually wets the soil to a depth of at least 25 cm.; occasionally it penetrates to twice and, rarely, to three times that depth or deeper. More than half the moisture from summer rains is retained near the surface, where it evaporates quickly. However, in most years, storms at one or two times during the growing season put moisture to depths favorable for renewal of plant growth. In 1965, the wettest summer on record (38 years), the dry soil was recharged five times, to depths of 38, 15, 18, 38, and 23 cm. (Brewster 1968). In a typical year, the soil is dry most of the time after the short period of spring moisture. The water table lies 145 m. below the ground surface.

The soil, a Typic Calciorthid, is sandy loam overlain by a thin pavement of fine and medium gravels. A weak felt of filamentous algae, scarcely detectable to the unaided eye, occupies the soil surface between the gravels to a depth of about 2 mm. (This element's contribution to total organic mass is minor and is not included in this study.) The top soil horizon, 0 to 7 cm., has a fine-platy, somewhat vesicular structure. Below this, to 30 or 40 cm. (wavy, abrupt lower boundary), the soil is without structure, loose, and single-grained. Both of these horizons contain a few fine and medium gravels. They have a bulk density of 1.35 g./cm.$^3$. Their light color is evidence of little humus accumulation. Immediately below is a strongly developed white calcic horizon, hard where particles are fine, more fragile where they are clean, coarse sand. This horizon extends to an irregular lower boundary 75 to 115 cm. below the surface. Its texture varies considerably over short distances. The original stratification of the alluvium is obvious. Most strata are comprised of sands and finer particles; some have high percentages of medium or coarse gravels embedded in the finer material. Noncemented lenses of sorted coarse sand or fine gravel occur irregularly. Textural and structural heterogeneity have resulted in irregular distribution of roots in this horizon. Roots can be absent from hard and massive portions, but abundant in the loose sand lenses or immediately beneath some of the larger gravel particles or cobbles. Below the calcic horizon, the alluvium is stratified sand and gravelly or cobbly sand along with occasional thin (2 to 6 cm.) laminations of lime-cemented fine material; the lowest of the laminations was seen at a depth of 150 cm. in a pit 185 cm. deep.

The open cover of discrete plant units is dominated by *Atriplex confertifolia* (Torr. and Frem.) S. Wats., a rounded shrub 20 to 30 cm. high. The subshrub *Eurotia lanata* (Pursh) Moq. and the bunchgrass *Oryzopsis hymenoides* (Roem. and Schult.) Ricker are subdominant. Other perennial shrubs and herbs are infrequent. Annuals, among them *Salsola kali* L., *Halogeton glomeratus* (Bieb.) C. A. Meyer, and *Machaeranthera canescens* (Pursh) A. Gray, are never abundant in this ungrazed perennial cover and do not appear in some years. The woody species are winter-deciduous. About 15 percent of the ground is shaded by standing plant material, of which half is dead crown cover.

Underground material was sampled from plots selected for homogeneity of cover. Small patches of uncommon or irregularly occurring species were purposely avoided, as were sites of current or recent burrowing by kangaroo rats and pocket gophers.

# METHODS

Root samples were taken in 1965 and 1966 merely to determine the relative amounts of roots at different levels in the rhizosphere. Alternate layers 7.5 cm. thick were taken from soil columns 20 cm. by 46 cm. (area 1 $ft.^2$). All columns were sampled to a depth of 67.5 cm., and two of them to the maximum rooting depth, which was 112 cm. in the columns sampled. (A few fine roots were seen to a depth of 135 cm. in one soil pit on the site, and a lone dead herbaceous root, 3 mm. in diameter at the 183-cm. level, was seen in another pit.) Roots were sieved from soil over a 6-mm. screen. Many of the finer roots, dead and fragile, were lost through the screen. The roots retained were separated from gravels by flotation in water, then rinsed on a No. 80 sieve, oven-dried at 75° C. for 24 hr., and weighed.

In April 1970, when new top growth started to appear, we harvested the plant material above the ground, and below the ground to a depth of 22.5 cm. The weight of this material provides an estimate of the absolute amount of accumulated organic matter above that depth. The total accumulation at greater depths can be extrapolated from this estimate by using the earlier data. A wire 4.5 m. long, marked at 15-cm. intervals, was stretched along the ground in each of three 1.5- by 6.0-m. plots. Using a mapping frame as a guide, we mapped the plots freehand to show each plant and wire. All plant material, living, standing dead, and litter, was gathered from the plots, separated by species, air-dried, and weighed. Weights were adjusted to an ovendry basis. No attempt was made to separate living from dead wood. *Atriplex* and *Eurotia* typically have much dead wood in the crowns unless they are young plants. Older living stems are often alive only along one side; the major part of the wood of these structures is dead and weathered. We estimate that no less than 60 percent of the wood of living shrubs is dead; i.e., "attached litter." Of course, all herbaceous material from previous years was dead.

Running samples of 30 contiguous soil blocks, each 15 cm. long, were taken along one side of each wire. The blocks were 7.5 cm. wide and 7.5 cm. thick and were taken at three depths: 0 to 7.5 cm., 7.5 to 15.0 cm., and 15.0 to 22.5 cm. Roots and other organic material were separated from the soil by flotation, skimming, and decanting. The mixture of water, soil, and roots (and underground litter) was first stirred to permit separation of solid parts. The rapidly settling sand carried some of the lighter material to the bottom; so the process was repeated until virtually all organic material had been removed. Fecal matter and long-dead, partly decomposed plant parts waterlogged readily and lost buoyancy, but such material was recovered in the repeated decanting.

The samples of organic matter were rinsed over the sieve to remove any silt still attached, then ovendried, and weighed. The material was separated into underground shoot parts of grasses, coarse roots (>2.0 mm. in diameter), medium roots (0.5 to 2 mm. in diameter), and "fine roots and other material," and the four parts were weighed. A small portion of the "fine roots and other material" was sorted into fine roots (<0.5 mm. in diameter) and litter by means of a teasing needle and a small brush. Weights of these parts were used to calculate the weights of the respective fractions in the original sampling units. The material took on moisture during separation, so the sorted weights were readjusted to ovendry weights. Grass bases comprised only 1.25 percent of the weight of organic matter in the upper soil layer; their weight is included with that of coarse roots in the presentation of results.

The coarse roots were the short taproots of shrubs (only four were encountered in the 1,350- by 7.5-cm. area of the sample) and first-order branch roots. These root types had a pronounced taper. The larger grass roots, essentially cylindrical, mostly fell near the lower limit of the medium-root class. Taproots of annuals, which taper, also were mainly in the middle-sized class. When dry, all feeder roots were in the fine-root class; the fine roots were characteristically much branched, with frequent angular axial deviation. Most were fragile and presumably dead when the sample was excavated.

The productivity data we present are calculated from estimates of annual yields of total green growth (herbaceous material, and the leaves, fruits, and twigs of shrubs) reported by Hutchings and Stewart (1953) for 20 large pastures lying 1 to 8 km. from our sampling site. Yields were estimated by the method of Pechanec and Pickford (1937). As will be brought out in the discussion, these data typify productivity of a wide area of similar climate, soils, and vegetation, including the site of our study.

The underground sampling layers (7.5 cm. thick) are given Roman numeric designations for the purpose of discussion. Layer I is the first below the surface. Organic mass below the ground is expressed as g./m.$^2$ for each 7.5-cm. increment, regardless of the area of original sampling unit.

# RESULTS

Because of the sampling technique, the 1965-1966 sample provides only the relative vertical distribution of root mass. Variation of root weights is high for layer I (table 1), as is to be expected in an open plant cover of widely spaced individuals. Coarse and medium roots were more abundant in some sampling units than in others even though sample columns had been located so as not to be directly beneath aerial plant crowns. Root weights in layer V are also quite variable. Some units contained more of the calcic, sometimes gravelly, horizon that begins in this level than others did. Layer III, which is in a soil horizon homogeneous throughout the sample and deep enough to be relatively free of the influence of plant spacing, is the least variable. Variation in the seventh and deeper layers reflects the stratification and irregular calcification of the alluvium.

Weights of roots (by size class) and of other organic material in the three upper levels sampled in 1970 are shown in table 2. Total root weights are similar for these levels, but the proportion of coarse roots diminishes rapidly with increasing depth (from 71 percent in layer I to 3 percent in layer III).

Fine roots constituted 16 percent of the mass of roots in layer I. They were much more common in the lower part of this layer than near the surface. In layer II, fine roots comprised 75 percent of the total roots and in layer III they were 80 percent of the total roots.

Because almost all coarse roots are near scattered shrubs, variation of coarse root weights is high in the surface horizon and remains high in samples of this small unit size (0.0113 $m.^2$) for the three layers (table 3). Horizontal distribution of fine roots is much more even at all levels. Because fine roots comprise the major portion of the total roots in layers II and III, horizontal variability of total roots drops off rapidly (fig. 1).

Table 1.--*Relative weight of roots in various soil layers 7.5 cm. thick. (A substantial portion of the fine roots is not included in these values)*[1]

| Layer | Depth | Units in sample | Weight with std. error |
|---|---|---|---|
| | ---*Cm.*--- | | ---*G./m.*$^2$--- |
| I | 0 - 7.5 | 6 | 77.1±30.7 |
| III | 15.0- 22.5 | 6 | 76.0± 7.0 |
| V | 30.0- 37.5 | 6 | 63.3±13.3 |
| VII | 45.0- 52.5 | 6 | 45.2± 7.7 |
| IX | 60.0- 67.5 | 7 | 28.6± 6.8 |
| XI | 75.0- 82.5 | 3 | 23.2± 7.7 |
| XII | 82.5- 90.0 | 2 | 3.3± 1.3 |
| XV | 105.0-112.5 | 2 | 2.7± 1.7 |

[1]Area of sampling unit: 0.092 m.$^2$.

Table 2.--*Mean weights, with standard errors, of roots and underground litter in the first three 7.5-cm. layers below the ground surface*[1]

| Layer | Coarse roots | Medium roots | Fine roots | Total roots | Underground litter |
|---|---|---|---|---|---|
| | - - - - - - | - - - - - - | *G./m.*$^2$ | - - - - - - | - - - - - - |
| I | [2]122.0±46.2 | 17.0±3.0 | 26.9±2.3 | 165.9±48.2 | 177.2±16.5 |
| II | 15.3± 6.1 | 28.2±2.4 | 130.4±4.4 | 173.9± 9.2 | 29.2± 3.5 |
| III | 4.8± 1.9 | 26.3±1.3 | 121.2±3.7 | 152.3± 4.7 | 20.9± 1.4 |

[1]Area of sampling unit: 0.0113 m.$^2$; 90 units in each sample.
[2]Underground shoot parts of grass comprise 2.8 percent of weight of coarse roots in layer I.

Table 3.--*Coefficients of variation (standard deviation ÷ mean) of root weights*[1]

| Layer | Coarse | Medium | Fine | Total roots |
|---|---|---|---|---|
| | - - - - - - | - - - - - - | *Percent* | - - - - - - |
| I | 357 | 164 | 81 | 274 |
| II | 377 | 81 | 32 | 50 |
| III | 373 | 46 | 29 | 29 |

[1]Area of sampling unit: 0.0113 m.$^2$.

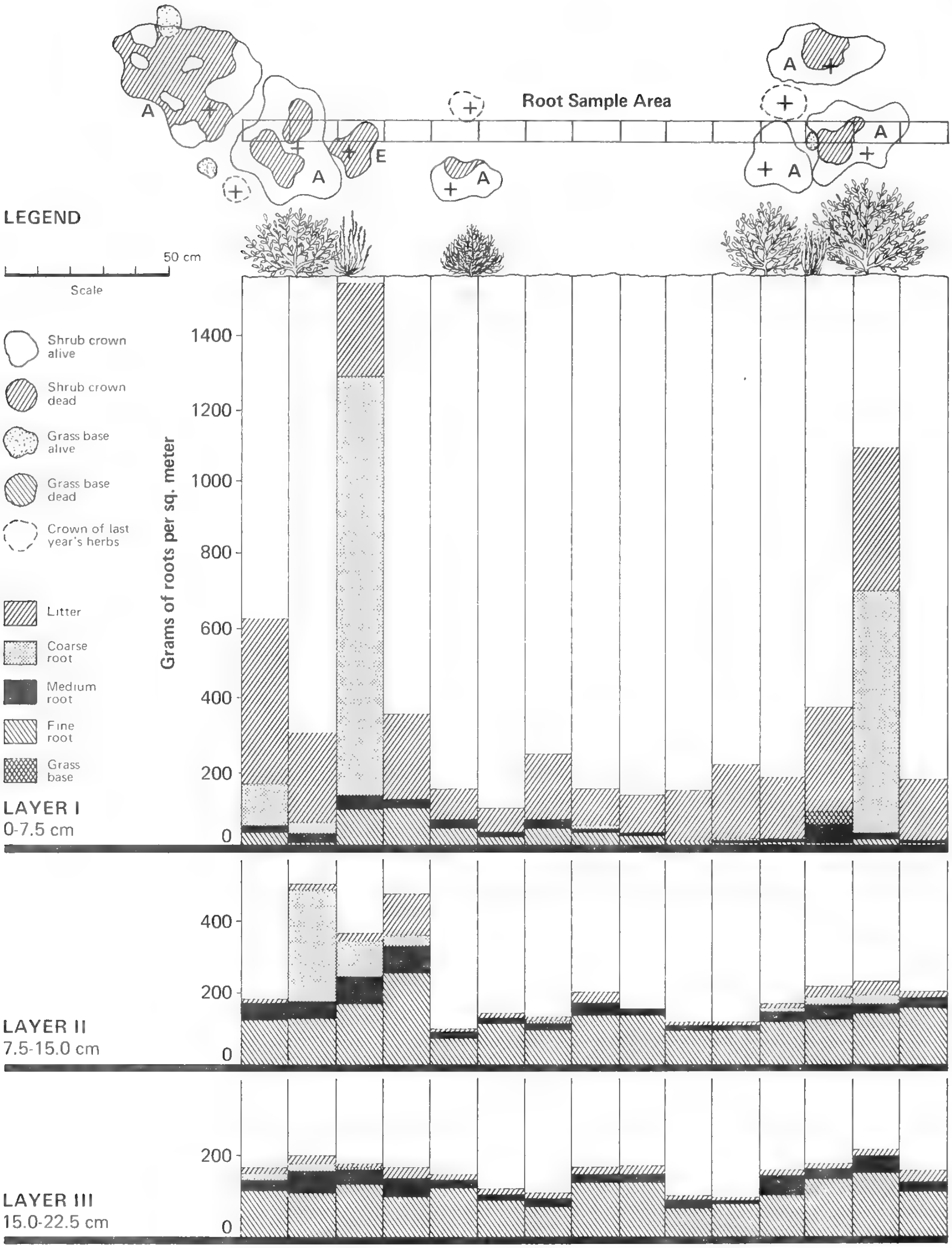


*Figure 1.--Map of part of a plot (at top) showing shrub and weed crowns and bunchgrass bases. Bar graph (below) shows weight of underground material in three 7.5-cm. depth-increments of the sample area indicated directly above on the map. A,* Atriplex confertifolia; *E,* Eurotia lanata; *+, root crown or point of attachment of shrubs and broadleaved herbs. No taproots were intercepted in this segment of the underground sample.*

In layer III, variation among total root weights or weights of any of the size classes is still associated with the proximity of perennial plants. Average weights were computed by layer for all sampling units within 30 cm. of the edge of a living or dead shrub crown or grass base (n = 48) and for those farther away (n = 42). For layer III, total weight of roots nearer the plants was 172 g./m.$^2$; roots farther away averaged 129 g./m.$^2$. The difference due to position of sample is highly significant (analysis of variance). However, this difference is considerably less in layer III than at shallower depths. In the surface layer, where variances, as well as means, are significantly different, roots nearer the plants weighed 275 g./m.$^2$; roots farther away weighed only 38 g./m.$^2$.

The underground litter is mostly near the surface, where its weight exceeds that of roots (table 2). Its horizontal distribution at that level is related to plant location (fig. 1). In layer III, litter makes up less than an eighth of the mass of organic material and its dispersion does not depend on proximity to plants on the surface.

Most of our so-called underground litter originated above the ground. Such litter was matter barely worked into the soil surface by animal activity, especially under shrub crowns, or was fine parts of surface litter overlooked in our harvest of aboveground material. Over 85 percent (our cursory estimate) of the recognizable part of the underground litter in layer I was comprised of leaves, empty shells of fruits and seeds, small spines, and parts of twigs. Some matter of obvious root origin, such as cortical slough, was sorted out as litter, but bare stelar fragments of fine roots were included as root material. A few macroscopic remains of insect parts were seen: body segments, appendages, and empty pupa cases. These amounted to but a slight fraction of the identifiable litter. Fecal material of three kinds constituted the remainder: rabbit and small rodent droppings; smaller pellets (more polygonal than circular in cross section, some light-colored, some dark), presumed to be from insect larvae; and finely pulverized loose particles of fibrous woody frass. The last kind was the most important element of litter in layers II and III, although leaves and fruit husks were found at both levels. Upon reexamination, a few unusually high values for underground litter in the data for the two lower levels were found to be due to concentration of small rodent feces, although no existing burrows were intercepted in the sample.

The harvest of aboveground matter (living, standing dead, and litter) weighed 240 g./m.$^2$ of ground surface. Such matter was composed of the following in the proportions listed: *Atriplex*, 63 percent; *Eurotia*, 11 percent; other shrubs, 1 percent; perennial grass, 2 percent; other herbaceous material, 6 percent; miscellaneous unsorted litter, 17 percent. The last named was comprised mostly of leaves, fruits, and fine woody material; a few rabbit pellets were also found in it. On the area harvested, there were 2.4 living and 1.3 standing dead shrubs per square meter, and 0.7 living and 0.5 dead perennial herbs.

# DISCUSSION

## Underground Accumulation

If we interpolate root-mass values for layers not sampled in 1965 and 1966 (as in fig. 2), it becomes apparent that about half the roots (living and dead) are in the top 30 cm. of the soil, about 30 percent in the second 30 cm., 15 percent in the third, 3 percent in the fourth, and 1 percent at depths below 120 cm. This profile differs from that described by Pearson (1965) in the *Artemisia*-grass semidesert of eastern Idaho (annual precipitation = 270 mm.), where 80 percent of the root mass was in the top 20 cm., 18 percent in the second 20 cm., and 2 percent in the third, which rested on bedrock.

If we assume that the earlier sample underestimated total root mass in the fourth and deeper layers to the same degree it did for layer III, then an approximation of the profile of root distribution can be extrapolated from results of the later sample (the curve in fig. 2). In layer III and below, coarse roots comprise a negligible fraction of the total roots, and the relation of medium to fine roots appears to have reached a constant ratio: 0.21 in layer II, 0.22 in layer III. Our estimate of total root mass for the profile is summarized by 30-cm. increments in table 4. Total mass of living and dead root material in the profile is calculated to be about 1,235 g./m.$^2$, of which 75 percent is fine roots. Bjerregaard (1971) determined a root mass of 1,313 g./m.$^2$ in a community dominated by *Atriplex confertifolia* about 350 km. north of our study site.

An additional 297 g. of litter brings the total underground mass to about 1,532 g./m.$^2$ (13,670 lb./acre). For the calcic horizons below layer III, we assume half as much litter relative to roots as was in layer III, because rodents, which transport much of what we call underground litter from above, do not work those horizons. If our guess is correct that 85 percent of the litter nearer the surface is derived from aerial plant parts, only 135 g./m.$^2$ of the underground litter originated beneath the surface.

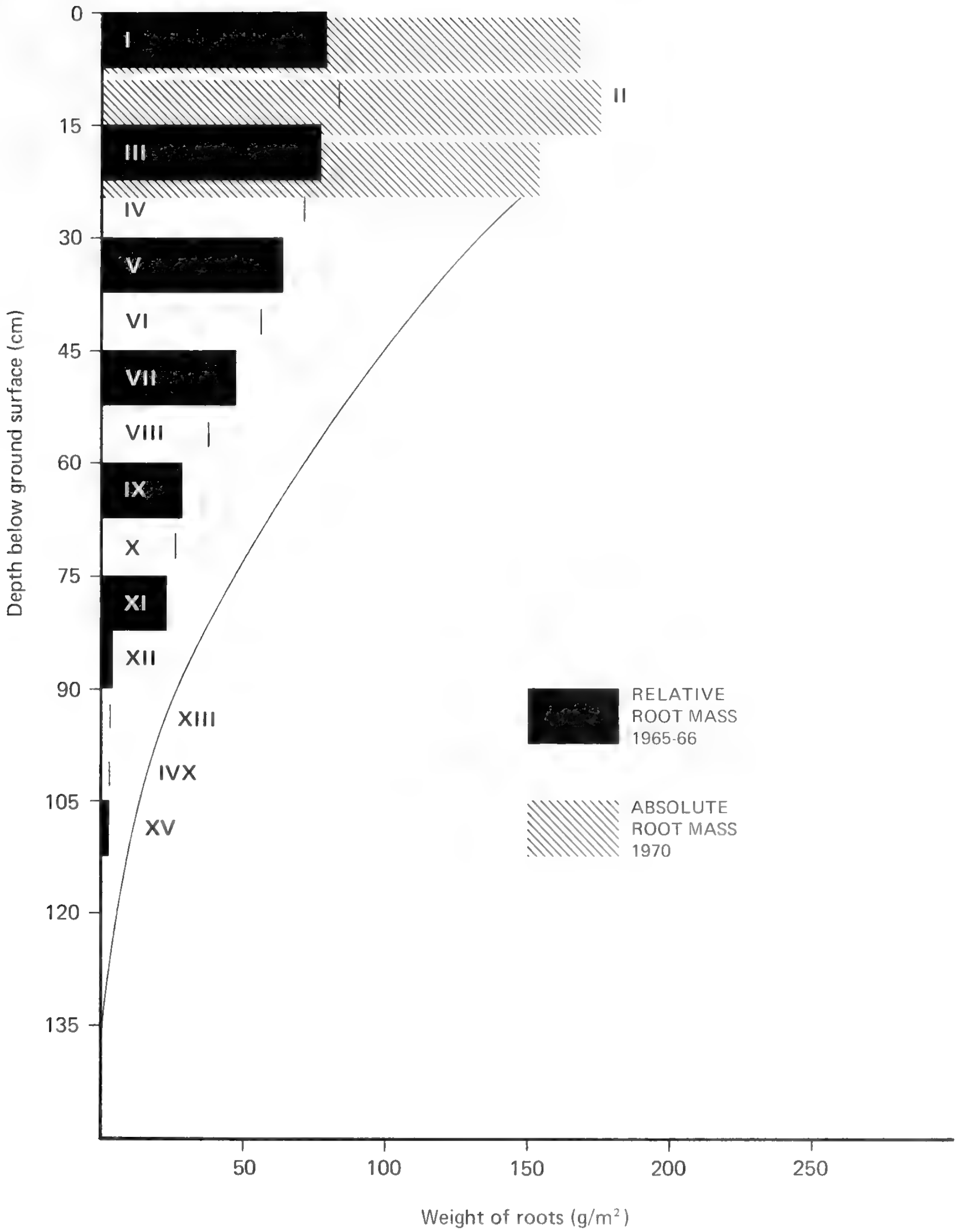


*Figure 2.--Vertical distribution of total root mass. The short vertical lines are interpolated values for layers not sampled in 1965-1966. The curve is an approximation of minimum root mass distribution at depths greater than 22.5 cm., not sampled in 1970.*

Table 4.--*Calculated mass of organic reserve in a cold desert shrub ecosystem*

| Level (cm.) | Root | Other | Total |
|---|---|---|---|
| | | g./m.² | |
| Aboveground[1] | 0 | 240 | 240 |
| Below ground | | | |
| 0-30 | 631 | 244 | 875 |
| 30-60 | 380 | 38 | 418 |
| 60-90 | 177 | 13 | 190 |
| 90-120 | 36 | 2 | 38 |
| >120 | 11 | <1 | 11 |
| Total | 1,235 | 538 | 1,772 |

[1]Maximum height of shrubs is about 30 cm. Occasional grasses and annual weeds reach 45 cm. Total depth of vegetal layer, therefore, about 170 cm.: 35 cm. aboveground, 135 cm. below ground.

## Aboveground Accumulation and Productivity

About a third of the mass of 240 g./m.$^2$ of organic material above the ground was unattached litter. Of the mapped shrubs, 35 percent were completely dead, and half of the crown cover of the living shrubs was dead. As we noted earlier, part of the wood of living stems is dead and weathered; so the total living perennial aerial part of the biomass probably constitutes no more than 35 g./m.$^2$ of the total accumulated organic matter above the ground. The accumulation of top-derived material includes an additional 162 g. sorted out from the underground samples. Therefore, the total accumulation from aerial parts is about 400 g./m.$^2$ compared to the 1,370 g./m.$^2$ we estimate to have accumulated from underground parts.

Hutchings and Stewart (1953) reported the average annual productivity of air-dry green matter in 20 pastures near our study area to be 219 lb./acre (24.5 g./m.$^2$). During the 12 years of their study, the productivity ranged from 75 to 468 lb./acre (8.4 to 52.5 g./m.$^2$). We believe that their average value can be applied with some modification to our site. From Hutchings and Stewart's unpublished field data we determined the yields of two of the closest pastures (both lightly grazed) to be 25.3 g./m.$^2$. Ungrazed plots within the pastures have had yields similar to the pasture yields in the fewer years they were sampled. Several other ungrazed areas in the same kind of community in the same valley and in other valleys of western Utah and eastern Nevada have average yields[1] (3, 4, or 5 years) that range from 13.6 to 44.3 g./m.$^2$; average for all was 24.4 g./m.$^2$.

Although these productivity data are not from the immediate site of our standing crop data, they are really more useful to our purpose than just 1 or 2 years' productivity determination on the site. This is because as organic matter accumulates over several years, productivity ought properly to be expressed as an average over several years, especially where its annual variation is as broad as it is on this desert.

[1]Unpublished data in the files of Intermountain Forest and Range Experiment Station.

If we take the air-dry value of 24.5 g., adjust it to ovendry (23 g.), and add a probable 15 percent (erring on the high side) for annual wood growth, and another 5 percent for leaves, seeds, and small annual weeds that undoubtedly were lost before yield estimates were made (in the fall), we calculate the net annual increment of aerial growth to be around 28 g./m.$^2$. If we are correct in assuming a steady state of minimum organic reserve, the average period of turnover for the 400 g. of recognizable aboveground plant material must be about $400 \div 28 \approx 14$ years. Rate of litter decomposition depends upon the composition of tissues, the most ligniferous tissues being the last to lose their identity (Van der Drift 1965). That breakdown of litter is slow in an arid climate was apparent in our harvest of aboveground material, where four age classes of dead stems of the succulent annual weed *Salsola* were distinguishable by degree of weathering. *Salsola* was not present on the site in 1966, so some of this herbaceous material had weathered at least five winters without losing its identity.

## Underground Productivity and Turnover

Decay of organic matter is more rapid below the ground surface where humidity is high for a longer period than above the ground and the habitat therefore more favorable for micro-organisms and the small animals active in litter breakdown. Because of the difficulties encountered in assessing the underground operations of ecosystems, little information is available regarding subterranean productivity (Dahlman and Kucera 1965). Most of what has been reported is incomplete or, as is true here, is based in part on experience or assumption (Newbould 1968). Based on our estimate that 75 percent of the root mass is made up of roots less than 0.5 mm. in diameter, a rate of turnover of underground material two, three, or perhaps more times that of the aboveground parts seems plausible. If we take 2.5 as the factor (i.e., 0.4 of the turnover time of aboveground decomposition), the average period of breakdown of root-derived matter would be about 6 years. Then, if minimum mass of organic reserve is at equilibrium between productivity and decomposition, the average annual net underground productivity is in the neighborhood of (1,235 g. root + 135 g. root-derived litter) $\div$ 6 = 230 g./m.$^2$.

## Comparisons With Other Studies

Most studies of productivity of terrestrial ecosystems with which we are familiar approach their determination by measurement of growth, often for the separate plant organs, through the growing season (Whittaker 1962; Ovington, Heitkamp and Lawrence 1963; Wiegert and Evans 1964; Dahlman and Kucera 1965; Pearson 1965; Chew and Chew 1965; and others). For the subterranean fraction, they are either incomplete or depend to some degree on assumptions. An exception is the study by Dahlman and Kucera, who were concerned specifically with root productivity of a prairie. These and the studies summarized by Rodin and Basilevich (1968) analyze the organic material in a number of ways, which makes it difficult for us to make direct comparisons among their results and ours.

Litter seems to be an ill-defined fraction of organic matter accumulation (Rodin and Basilevich 1967, p. 5). Some reports recognize only 1 year's litter fall; others ignore it. Underground litter from aerial plant organs, never mentioned in the literature, may be an exceptional phenomenon, peculiar to the desert. As in our study, the living root mass is usually not separated from the dead, although by our terminology, at least the dead roots no longer attached to living plants should be considered underground litter. At present, we have no clearcut concept of what constitutes aboveground litter. Certainly any loose-lying material is litter, and so is the last year's herbaceous material, even that still standing. (Shoot material of some desert herbs can accumulate for several years without falling; perhaps it disintegrates in place.) If old, standing dead, herbaceous matter is litter, then also are standing dead shrubs. And, if dead shrubs are litter, then so, too, are dead branches and twigs on living plants, and perhaps even dead wood in living branches. For perennial woody communities, whether desert or forest, such terms as biomass accumulation and standing crop ought to be defined as including all matter not fragmented beyond recognition; i.e., everything short of humus. It seems that there is no more distinct point in the turnover process at which to place the boundary.

No value of aboveground productivity reported for North America is near our low value of 28 g./m.$^2$. In Chew and Chew's (1965) warm desert, the aboveground productivity value was 131 g./m.$^2$; on Pearson's (1965) steppe, it was 123 g./m.$^2$. In a community similar to Pearson's, Blaisdell (1958) determined average aboveground productivity over a 13-year period to be 92 g./m.$^2$. Ovington and others (1963) reported a net productivity of 93 g./m.$^2$ for the aerial part of a Minnesota prairie. Rodin and Basilevich (1967) list six Asian desert communities where annual turnover of aerial parts ranges from 15 to 44 g./m.$^2$.

Our value of about 260 g./m.$^2$ for total annual productivity above and below the ground is in the same order of magnitude as Pearson's 240 g./m.$^2$, and the Eurasian values, which were 122 for a dwarf semishrub desert, 250 for a subtropical desert, and 420 for dry steppes (Rodin and Basilevich 1968).

The minimum for total organic matter accumulation in the herbaceous prairie of Ovington and others (1963) occurred in early May, and was 616 g./m.$^2$; 211 g. of it, nearly all dead material, was aboveground. This figure is much lower than our minimum for the woody desert. Our estimate was 1,770 g./m.$^2$, of which 205 g. was dead and 35 g. alive aboveground, and a total of 1,530 g. dead and alive below the ground. Other studies either fail to include dead material in biomass values, or report only an annual value for litter fall.

The following features of organic matter occurrence and disposition on this desert of woody perennial plant cover are significant: (1) The low productivity of aboveground biomass; (2) the high proportion of aboveground dead matter, a result of slow litter breakdown; (3) low ratios for both productivity and matter accumulation of aerial to subterranean portions of the respective totals; (4) the movement of top-derived litter into the soil before it loses its identity; and (5) the uneven horizontal distribution of underground organic matter in the upper layers of the rhizosphere.

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1972. Distribution of organic matter reserve in a desert shrub community, USDA Forest Serv. Res. Pap. INT-130, 15 p., illus. (Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.)

Of the total accumulated organic mass (about 1,770 g./m.$^2$) in a cold desert shrub community in western Utah, 13.5 percent is above the ground. About half the root mass is in the top 30 cm. of soil, 30 percent in the second 30 cm., 15 percent in the third 30 cm., 3 percent in the fourth 30 cm., and 1 percent below 120 cm. to about 135 cm. Coarse roots are found only under or near plants, fine roots are rather evenly distributed horizontally at all depths; they are most abundant in the 7.5- to 15-cm. layer, but few are found in the 0- to 7.5-cm. layer.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah, (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with University of Nevada