Natural Sources of Nitrogen and Phosphorus for Grass Growth[1]

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Fertility is essential for grass growth. The amount of nitrogen and phosphate available often regulates production within the limits of available moisture. Recent studies of fertilizer applications on ranges have demonstrated that greater production is possible with greater fertility.

Since grass grows year after year without fertilization, it is reasonable to assume that there are some natural sources of fertility.

Nitrogen

The large and continual loss of nitrogen establishes that there is a source of nitrogen. Losses of nitrogen occur both from the soil, and from the vegetation, both growing and dead. Leaching by both surface run-off and percolating waters cause a loss of nitrates. Volatilization is a factor (Lyon, Buckman, Brady; Black, 1952). The carry away of nitrogen by the grazing animal is particularly important.

Information that would establish the source of nitrogen and the amount that is needed, is lacking. Ideas accumulated from various sources indicate that the amount of nitrogen available to the grass plant on the range is greater than is generally realized. Possibly 100 pounds of nitrogen per acre, or more, may be available annually on ranges capable of producing 1 animal unit month of carrying capacity per acre.

What are some possible sources of nitrogen?

Legumes have been known to fix large amounts of nitrogen. A report from New Zealand (Hafenrichter, 1957) cites that as much as 600 pounds of nitrogen per acre can be fixed on pastures with white clover (*Trifolium repens*). Possibly where native legumes make up a considerable portion of the cover they are an important source of nitrogen. Even poisonous legumes such as locos (*Astragalus, Oxytropis*) and lupines (*Lupinus*) may be of value on the range from the standpoint of nitrogen fixation. Many ranges have few or no legumes. Ranges without legumes seem to produce as much as do those with legumes.

Is lightning a source of range nitrogen? Only small amounts of nitrogen have been shown to fall with rain or snow. It is of the magnitude of five pounds or less, where thunderstorms are frequent (Lyon, Buckman and Brady, 1952). The amount of

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nitrogen supplied from lightning seems small compared to the amount needed to grow grass.

A *hidden* source of nitrogen is frequently referred to. The following are examples of such references.

McGinnies and Retzer (1948) have stated: "Vigorous range plants need nitrogen, phosphorus and potassium. When ranges are in good condition, these essential elements are usually available in adequate quantities." McGinnies and Retzer associate fertility with range in *good* condition.

Voight (1951) has stated: "Until organic matter accumulates and fertility is partially restored by *reaction* of *grasses* and *forbs*, there seems little chance of better grasses and forbs becoming established." What kind of a *reaction* of grasses and forbs does Voight have reference to that restores fertility?

Connaughton (1948) states: "The forage was too closely cropped, the plants lost vigor, less and less organic matter was produced to be returned to the soil. Fertility in turn declined." Is there perpetual motion in the nitrogen cycle? With greater production, in terms of carrying capacity, wouldn't the losses of leaching, volatilization and carry away be greater? Wouldn't fertility decline with greater production, instead of increase?

Hormay (1956) has recommended resting the range for a year or two at a time to restore production. Would such a rest be necessary to provide an accumulation of fertility?

Clements (1949) states: "The ecologist looks upon grassland in general and the prairies and plain in particular as almost inexhaustible reservoirs of soil fertility ..." Where did the fertility come from to fill the reservoirs, with sixty million bison and other wild animals grazing on the plains?

There are factors in established range management practices that provide and restore fertility. The factors seem to be associated with ranges in healthy, good condition.

There is a type of nitrogen fixation that may be providing most of the nitrogen for range growth. Lyon, Buckman and Brady (1952) reported that 42 pounds of nitrogen accumulated in the soil on plots kept in grass with all of the residues remaining. The amount of nitrogen that accumulated in the soil would be only a part of the nitrogen fixed. The amount lost from the plant residues through volatilization and leaching is not accounted for.

Conditions on the range are favorable for nonsymbiotic fixation. Millar (1955) reports that nonsymbiotic fixation is favored by lime, phosphate, aeration, a supply of highly carbonaceous organic matter and a lack of available soil nitrates.

The supply of carbonaceous organic matter may be the regulating factor (Thompson, 1952). Just how or where the bacteria carry on their fixation is not well understood. It is conceivable that the bacteria use for energy the carbonaceous organic matter of the replaced grass roots and possibly the litter that accumulates on the soil surface. Healthy range grasses replace an enormous amount of their extensive root system every year (Stoddart and Smith, 1955).

The theory of nonsymbiotic fixation explains many of the established range practices. A supply of carbonaceous organic matter for energy is necessary. Limited utilization provides organic matter in the roots produced and the litter that accumulates on the surface. It has been shown that close utilization practically stops root production (Weaver, 1926). Could the restriction of nitrogen fixation be an important factor in too close a utilization?

Root and top growth are dependent upon adequate fertility. McGinnies and Retzer (1948) state: "Important amounts of fertility are returned to the soil by decaying herbage after grazing." Nonsymbiotic fixation apparently doesn't supply enough nitrogen for each year's growth. Some nitrogen needs to be left in the ungrazed cover to maintain fertility. "When the harvestable portion of the range is gone, however, there is a residue that must be left if the range is to continue normal production." (Stoddart and Smith, 1955).

Factors that favor growth, particularly root growth, would favor nitrogen fixation. Rogler and Lorenz (1957) reported that two years of fertilization with 90 pounds of nitrogen each year did more to improve range condition and increase production than six years of complete isolation from grazing. The applied nitrogen increased the supply of accumulated organic matter by stimulating growth. With increased organic matter, nitrogen fixation increased.

Organic Matter

It has been established for arable soils that the level or amount of nitrogen determines the amount of organic matter that will accumulate (Millar, 1955). Having nitrogen available for organic matter accumulation may explain the upgrading of range from light utilization, and the deterioration in range condition from over utilization. McGinnies and Retzer (1948) state: "A vigorous grass range owes its existence to the soil stability, fertility, and reasonably favorable soil moisture conditions maintained by the grass cover. If the stand of grass has deteriorated, growing conditions are less favorable ..." The soil organic matter becomes depleted as the grass stand deteriorates. The nitrogen is used up in growth and there is not enough fixation for replenishment.

It is conceivable that grasses that produce more roots would enhance greater nitrogen fixation and a faster build up of organic matter.

Manure

Sampson (1928) reported that one third less range was required for sheep where they spend only one or two night on the same bed ground. The manure contains about 80 percent of the fertility value of the grass consumed. Loss of manure-fertility in brush and tree areas, and bedding and camping areas constitutes a direct loss to grass production.

The fertilizing value of the manure is much greater when green grass is being grazed. The fertility value of manure from the grazing of mature grass is low. Phosphates are readily leached out of mature forage (Stoddart and Smith, 1955). This is also true of nitrogen. In the spring and summer the grass is highly nutritious (Morrison, 1956), being well supplied with protein (nitrogen) and phosphorus. The young plants gorge on nitrogen and hold it for later use. (Allison, 1957).

Light applications of fertility from manure are almost impossible to obtain. Woodhouse, Peterson, and Lucas (1957) reported that up to 700 pounds of nitrogen per acre are applied in bovine urine spots. In areas where the stock collect, the rate of application is greater. If manure accumulates until a supply of soil nitrates develops, nitrogen fixation is retarded (Bear, 1948).

With the carry away of fertility by the grazing animal the soil becomes depleted in nitrogen and phosphorus. Without fertility the grasses are not able to produce root-carbonaceons organic matter for nonsymbiotic fixation. The carry-away loss of fertility is particularly acute during the times when the grass is green. Where moisture is available for continual growth (as in snow drift areas), almost all of the fertility is removed with the grazing of the continually green grass.

Phosphates

There are some natural sources of phosphate supply. Soil organic matter has been shown to cause unavailable phosphate to become available (Thompson, 1952). Increasing the soil organic matter increases the amount of available phosphate.

Deep rooted plants are able to obtain nutrients, chiefly calcium and phosphorus from the lower soil horizons and deposit them in the surface horizons as constituents of leaves and stems(Weaver, 1926). Pieters (1927) reported that sweet clover *(Melilotus alba)* is able to secure potash and phophates from ground which corn makes almost no growth whatever. Similar effects have been shown for alfalfa. Alfalfa is able to absorb mineral from rock phosphate and feldspar that is not readily available to wheat or corn. Native legumes undoubtedly have properties of absorption similar to alfalfa and sweet clover.

Some phosphate is carried over in the plant residue.

Measure of Fertility

"The best yardstick we have of soil fertility is relative yield," Davies (1952). Range fertility production can be measured in carrying capacity and animal gains—on a sustained basis.

In this area (southwestern Montana) range production can be increased on favorable sites by plowing out the native cover and sowing to orchard grass *(Dactylis glomerata)* and alfalfa (Miles, 1954). Ground that has a productive capacity of one animal unit month when in good condition native range, will produce three animal unit months of grazing when sown to alfalfa and orchardgrass.

With plowing and reseeding the source of nitrogen changes from nonsymbiotic fixation to symbiotic. Waksman (1952) reports that a much smaller expenditure of energy is required for symbiotic fixation. About three times as much carbohydrate energy is required for nonsymbiotic fixation as is required for symbiotic.

Love and Williams (1956) report that in California, introduced range clovers increased production two to six times and caused a desirable change in the grass composition.

Summary

Sustained production on the range under proper management proves that there is a source of range fertility. The nitrogen lost in different ways, volatilization, leaching, carry-away by grazing animals, is replenished. The amount of nitrogen available annually for grass growth appears to be considerable.

Either lightning or legumes are considered to fix too little nitrogen on most ranges to be of significance. Numerous references to an obscure or hidden source of nitrogen are cited. There appears to be ample nitrogen on ranges that are in good condition.

Nonsymbiotic fixation is considered as a possible source of range nitrogen. The full capacity of nonsymbiotic bacteria to fix nitrogen has not been determined. Conditions on the range are favorable for nonsymbiotic bacteria activity.

Carbonaceous organic matter for energy may be a limiting factor in nonsymbiotic fixation. The replaced fibrous grass roots are suggested as a possible source of organic matter as food for nonsymbiotic fixation. This theory explains present range management practices of keeping the grass plants in vigorous condition, so that they are able to continually replace their root systems. A carry-over of fertility is necessary for adequate root and top growth. Applications of commercial nitrogen are thought

to enhance root replacement and nitrogen fixation.

The supply of nitrogen is known to regulate the accumulation of organic matter. Nitrogen and organic matter accumulation may be important factors in range condition.

The loss of fertility or productive value of manure is heavy where the animals collect on bed grounds, or brush and tree areas that produce little feed. Even distribution, particularly of bobine excreta, is impossible to obtain. The fertilizing value of manure is greater where green grass is being consumed. Also, greater removal of fertility is effected where green grass is being consumed. The removal of fertility is considered to have an effect on nonsymbiotic fixation.

An increase in soil organic matter causes more phosphate to become available. Deep-rooted plants bring fertility up from the deeper soil horizons. Legumes are able to absorb phosphate more readily than other plants.

Fertility can be measured in production. A change from native grasses to cultivated legumes and grasses can increase production. When grasses are replaced with legumes, the source of nitrogen changes from nonsymbiotic fixation to symbiotic. Under favorable conditions symbiotic fixation has the capacity to fix considerably more nitrogen than nonsymbiotic. Nonsymbiotic fixation requires more energy than does symbiotic fixation.

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